ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

EVOLUTION OF PARATRANSIT SYSTEM AND ITS IMPLEMENTATIONS IN TURKEY: POTENTIAL DESIGN AND TECHNOLOGY IMPACT ON AMELIORATING THE DOLMUŞ-MINIBUS

M.Sc. THESIS

Arzu Hüsniye TOKER ÖZKURT

Department of Industrial Product Design

JUNE 2012

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

EVOLUTION OF PARATRANSIT SYSTEM AND ITS IMPLEMENTATIONS IN TURKEY: POTENTIAL DESIGN AND TECHNOLOGY IMPACT ON AMELIORATING THE DOLMUŞ-MINIBUS

M.Sc. THESIS

Arzu Hüsniye TOKER ÖZKURT
(502081919)

Department of Industrial Product Design

Thesis Advisor: Prof. Dr. Alpay ER

JUNE 2012

İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

PARATRANSİT SİSTEMİN EVRİMİ VE TÜRKİYE'DEKİ UYGULAMASI: DOLMUŞ-MİNİBÜS KAVRAMININ İYİLEŞTİRİLMESİNDE POTANSİYEL TASARIM VE TEKNOLOJİ ETKİSİ

YÜKSEK LİSANS TEZİ

Arzu Hüsniye TOKER ÖZKURT
(502081919)

Endüstri Ürünleri Tasarımı Bölümü

Tez Danışmanı: Prof. Dr. Alpay ER

HAZİRAN 2012

Arzu Hüsniye Toker Özkurt, a **M.Sc.** student of ITU **Graduate School of Science Engineering and Technology** 502081919, successfully defended the **thesis** entitled "**EVOLUTION OF PARATRANSIT SYSTEM AND ITS IMPLEMENTATIONS IN TURKEY: POTENTIAL DESIGN AND TECHNOLOGY IMPACT ON AMELIORATING THE DOLMUŞ-MINIBUS"**, which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor : **Prof. Dr. Alpay ER** ....
İstanbul Technical University

Jury Members : **Y. Doç. Dr. Gülname TURAN** ....
İstanbul Technical University

Doç. Dr. Azime TEZER ....
İstanbul Technical University

Date of Submission : 4 May 2012
Date of Defense : 7 June 2012

To my family,

FOREWORD

At the first place, I would express my gratitude to esteemed instructor, Prof. Dr. Alpay Er, for his tremendous support, guidance and encouragement throughout this research study. I feel lucky and take pride in being his student.

I would also kindly thanks to all the members of the Department of Industrial Product Design at Istanbul Technical University especially the examining committee members for their comments, suggestions and for their excellent initiatives in my academic development.

Furthermore, I owe my thanks and regards to colleagues and executives in Otokar A.Ş. especially Ahmet Hacıyunus and Haluk Özel for their positive attitudes and guidance not only this research study but also all through my working life. I have learned many from them, which will surely be useful in the rest of my life.

I am also grateful to my friends who enrich me with their presence, Teksin Açıkgöz Kopanoğlu, Esin Işık, Hatice Aktürk, Güzide Erdem, Göksun Özhan and Caner Özgökmen for their flame of enthusiasm that I felt the very first day I met them.

Moreover, I am thankful to all the members of my both Toker and Özkurt families for their lifelong endorsements. Their presence provided support and comfort.

Eventually, but most entirely, heartfelt acknowledgments go to my dear husband Bülent Özkurt for his endless love and patience not only during this thesis study but also during whole my life. This study would never be possible without his help and support as being an industrial designer.

May 2012 Arzu Hüsniye TOKER ÖZKURT
(Industrial Designer)

TABLE OF CONTENTS

Page

ABBREVIATIONS

ABS	**:** Acrylonitrile Butadine Styrene
ADA	**:** American with Disabilities Act
ADAS	**:** Advanced Driver Assistance Systems
APC	**:** Advanced Passenger Counter
ATC	**:** Azienda Transport Consortium
AVL	**:** Automatic Vehicle Location
CAD	**:** Computer Aided Dispatching
CAS	**:** Computer Aided Styling
CCTV	**:** Closed Circuit Television
CNG	**:** Compressed Natural Gas
DETR	**:** Department of the Environment Transport and the Regions
DLLAJ	**:** Indonesian Traffic and Road Transport Agency
DRT	**:** Demand Responsive Transit
EV	**:** Electric Vehicle
FAMS	**:** Flexible Agency for Collective Mobility Services
FRP	**:** Fiber-Reinforced Plastics
FTS	**:** Flexible Transport Services
GHG	**:** Greenhouse Gases
GIS	**:** Geographic Information Systems
GPS	**:** Global Positioning System
HEV	**:** Hybrid Electric Vehicles
Hp	**:** Horsepower
HVAC	**:** Heating Ventilating and Air Conditioning
ICSID	**:** International Council of Societies of Industrial Design
IETT	**:** İstanbul Electric Tram and Tunnel
IMM	**:** İstanbul Metropolitan Municipality
IRPTN	**:** Integrated Rapid Public Transport Network
ITS	**:** Intelligent Transport System
LCA	**:** Life-Cycle Analysis
LCT	**:** Low Cost Transport
LRT	**:** Light Rail Transit
NO_x	**:** Oxides of Nitrogen
OEM	**:** Original Equipment Manufacturer
PEM	**:** Polymer Electrolyte Membrane
PLB	**:** Public Light Bus
PM	**:** Particulate Matter
PMT	**:** Personalized Mass Transit
PRT	**:** Personal Rapid Transportation
RFID	**:** Radio Frequency Identification
ROW	**:** Right of Way

RTM : Resin Transfer Molding
SMC : Sheet Molding Compound
TRP : Transport and Routing Protocol
UK : United Kingdom
UKOME : Coordination of Transportation Department in İstanbul
ULTRA : Urban Light Transport
US : United States
USA : United States of America
UV : Ultraviolet

LIST OF TABLES

Page

LIST OF FIGURES

Page

EVOLUTION OF PARATRANSIT SYSTEM AND ITS IMPLEMENTATIONS IN TURKEY: POTENTIAL DESIGN AND TECHNOLOGY IMPACT ON AMELIORATING THE DOLMUŞ-MINIBUS

SUMMARY

In developing world, inner city road-based public transportation can be diversified a variety of physical and organizational forms. The paratransit mode of transportation is just between private car transport and conventional public bus transport. It is also called intermediate public transport because it has dual mode characteristics of fixed-road transportation with buses and flexible transportation with automobiles and has a distinctive advantage of being demand responsive transport. There are numerous vehicle and application types used within this mode of public mass transport in the world. Typically, vans, minivans or minibuses are used to provide paratransit service, but also car sharing or share taxis are important providers.

In Turkey, the concept of Dolmuş-Minibus system corresponds to paratransit mode of transportation. Actually, the word Dolmuş has a meaning of the "full" or "stuffed", as they do not depart on fixed schedules but when filled up with sufficient passengers. In this concept, there can be seen different vehicle types and stakeholders, different organizations and operations, most of which has a similar background and state of affairs.

For the time being, the evolution of dolmuş-minibus system and the vehicles used for this concept is mostly depended on and nourished from the social events, economical situations, political decisions and the changes of city structure in the country. So far, industrial design and technological developments has influenced the dolmuş-minibus evolution less than the factors mentioned above. However, there are numerous technological improvements especially on information and communication area, which can affect the next generation of paratransit system. In addition industrially designed paratransit system vehicles can be more human centered and may have rather aesthetic values in the very near future.

This research study essentially focuses to review the evolution of paratransit system and its implementations in Turkey with particular reference to vehicles and therefore find out the potential design and technology impact on ameliorating the paratransit vehicles and system. To determine the driver's and/or customer's behaviors, expectations and preferences for dolmuş-minibus vehicles design, a detailed observation of the users -both drivers and passengers- and a combination of two interview methods was carried out to elicit data in the study: structured and semi-structured interviews with open-ended questions.

PARATRANSİT SİSTEMİN EVRİMİ VE TÜRKİYE'DEKİ UYGULAMASI: DOLMUŞ-MİNİBÜS KAVRAMININ İYİLEŞTİRİLMESİNDE POTANSİYEL TASARIM VE TEKNOLOJİ ETKİSİ

ÖZET

Gelişen dünyada, şehir içi toplu taşımacılık çok çeşitli fiziksel ve organizasyonel formlarda olabilmektedir. Geleneksel şehir içi toplu taşıma türleri, güvenlik ve emniyet konularındaki noksanlar ve taşımacılık biçiminin esnek olmaması gibi hususların yol açtığı yolcu memnuniyetsizliklerinden ötürü pazarın taleplerini karşılamada yetersiz kalmışlardır. Dolayısıyla yaklaşık 40-50 yıl önce, küçük çaplı işletmeler bu açığı kapatmak için çoğunlukla da mevzuatlardaki ve yasalardaki boşluklardan faydalanarak pazara girmeye başlamışlardır. Dünyanın bir çok ülkesinde paratransit servislerin doğuşu bu şekilde olmuştur. Genel olarak paratransit sistem, taksi ve bilinen otobüs taşımacılığının arasında bir toplu taşımacılık biçimidir. Orta dereceli toplu ulaşım olarak da adlandırılmasının nedeni otobüslerdeki gibi uygun fiyatla sabit güzergahta yolcu taşımacılığı ve taksilerdeki gibi esneklik olmak üzere iki yönü karakteristiğe ve talep odaklılık avantajına sahip olmasıdır. Bu türden bir toplu taşımacılık için kullanılan; operasyon alanı ve koşullarının belirleyici rol oynadığı çok çeşitli boyutlarda araç tiplerine ve güzergah ve tarifenin esnekliğine bağlı belirlenen çeşitli uygulama tiplerine rastlamak mümkündür. Çoğunlukla 8-20 yolcu kapasitesine sahip minibüs, minivan ve van tipi hafif ticari araçlar başlıca paratransit servis sağlayıcıları olarak tercih edilmekle birlikte, bazı araç paylaşım ya da taksicilik türleri de önemli sağlayıcılardandır. Bu tür araçlar otobüslere oranla oldukça küçük olan gövde yapılarının getirdiği avantajla, hem daha az sayıda kişiye özelleşmiş ve zamandan tasarruf edilebilen bir yolculuk imkanı sağlayabilmekte, hem de şehirlerin dar sokaklarında da hızlı manevra kabiliyetlerini kullanabilmektedirler.

Dünyanın hemen hemen her ülkesinde paratransit türden taşımacılığın örnekleri mevcuttur. Her ne kadar paratransit servislerin değişik ülkelerdeki uygulamaları arasında büyük karakteristik farklılıklar varmış gibi görünse de işletme özellikleri birbirlerine çok benzerdir. En belirgin farklılıklar araç ya da uygulama biçimlerinin egzotik isimlerinden kaynaklanmakta ve servis ilkeleri şaşırtıcı bir biçimde sabit olmaktadır. Bunu yanı sıra, paratransit sistem dahilindeki araçların tasarımları ve sistemin kulandığı teknoloji düzeyi ülkeden ülkeye bazı farklılıklar göstermektedir. Örneğin, Avrupa ya da kuzey Amerika'daki gibi gelişmiş ülkelerde kullanılan paratransit araçlar daha kullanıcı odaklı tasarımlara sahiptir.

Türkiye'de paratransit tip toplu taşımacılığın karşılığı olarak nitelendirilebilecek iki farklı uygulama vardır: dolmuşçuluk ve minibüsçülük. Aslında dolmuş kelimesi "boş yeri kalmamış", "meşbu" gibi sözlük anlamına sahiptir ve sabit çalışma saatleri ile değil, yeterli yolcu ile doldurulduğu zaman yola çıkan araç olarak da kullanılmaktadır. Bunun yanı sıra paratransit tip bir toplu taşımacılıkta, çoğu benzer

geçmişe ve gidişata sahip olan farklı tipte araç ve paydaşlar ile farklı organizasyon ve işleyiş biçimlerine rastlamak mümkündür. Midibüs, minibüs, van, minivan ve hatta binek otomobiller (taksi-dolmuş uygulamaları) bunlardan en yaygın kullanılan araç türleridir. Bu araçların büyük bir kısmının sürücüleri aynı zamanda araç sahipleridirler ve genel olarak araçlar önceden tanımlanmış olan güzergahlarda çalışmak üzere ruhsatlandırılmışlardır. Esasında Türkiye'deki paratransit sistem varlığını diğer toplu ulaşım sistemlerinin yetersizliklerine ve eksikliklerine borçludur dolayısıyla da halkın ulaşım ihtiyaçlarına cevap vermek üzere yerel olarak geliştirilmiş, vatandaşların kendi buldukları bir çözüm yöntemidir.

Dolmuş ve minibus sistemlerinin benzerliklerinin yanı sıra, işletim özellikleri, çalışma ekonomileri ve araç karakteristikleri gibi birbirinden ayrıştıkları bir çok yönleri vardır. Minibüsler 14-20 oturan yolcu ile çalışma koşullarına bağlı olarak değişen çok sayıda ayakta yolcu alma kapasitesine sahip araçlardır. Diğer taraftan dolmuşlar 6-8 oturan yolcu kapasitesiyle minibüslere oranla daha rahat ve konforlu ulaşım imkanı sağlayan ve görece de daha pahalı olan toplu taşımacılık türüdür.

Bu araştırma çalışması, paratransit sistemin evrimi ve Türkiye'deki uygulamasının yeniden gözden geçirilmesine odaklanır ve özellikle de bu sistem dahilinde kullanılan araçların iyileştirilmesinde potansiyel tasarım ve teknoloji etkisinin neler olabileceğinin ortaya konulmasını amaçlar. Zaman içerisinde, dolmuşçuluk-minibüsçülük sisteminin ve bu kapsamda kullanılan araçların evrimi ülkedeki çeşitli sosyal olaylara, sistemin tüm paydaşlarını etkileyen ekonomik durumlara, yasal düzenlemelere, politik kararlara, şehir yapısının ve arazi kullanım koşullarının değişmesine bağlı olmuş ve onlardan beslenerek evrimleşmiştir. Dolmuş ve minibüslerin evrimi irdelenirken, yıllar içerisinde araç özelliklerinde gözlemlenen değişikliklerin araç operatörlerinin küçük sanayicilerle birlikte geliştirdikleri modifikasyonlardan ibaret olduğunu söylemek mümkündür. Araç imalatçıları ve firmalar ise ancak operatörlerin bu küçük çaplı çabalarını farkettikten sonra daha gelişmiş araç modellerini üretmeye ve piyasaya sürmeye başlamışlardır. Son yıllara kadar da endüstriyel tasarım ve teknolojideki gelişmeler Türkiye'de uygulanan paratransit sistemin evrimini yukarıda belirtilen faktörlerden çok daha az etkilemiştir. Oysa dolmuş-minibüs siteminin gelişimi ve iyileştirilmesi çok yönlü olmalıdır.

Türkiye'de uygulanan paratransit sistemin ve bu sistem dahilinde kullanılacak olan araçlarının tasarlanması ve geliştirilmesi için kültürün, yerel problemlerin ve ihtiyaçların, sistemin potansiyel paydaşlarının davranış biçimlerinin ve işletim safhasındaki tüm kritik elementlerinin kapsamlı bir şekilde analiz edilmesi gerekmektedir. Bu şekilde toplumun büyük kesimine hitap edebilen, minibüs ve dolmuş sisteminde kullanılabilecek araçların yaratılması mümkün olabilecektir. Ancak bir çok yerli firmada ideal araç tasarım ve geliştirme süreci, ne yazık ki, henüz profesyonel anlamda uygulanamamaktadır. Bu sebeple de ülkemizde çok başarılı ve halkın ulaşım ihtiyaçlarına tam olarak cevap verebilen minibüsler ve dolmuşlara rastlayamamaktayız. Ne var ki, doğru uygulanacak olan bir endüstriyel tasarım süreci bu tür araçların yalnızca estetik değerini artırmada ve daha insan odaklı araçlar olarak piyasaya çıkmasında değil, aynı zamanda genel kalitesini artırma ve toplam maliyetini azaltmada da çok büyük katkı sağlayabilecektir.

Genellikle estetik özellikler diye tanımlanan araçların biçimsel yapıları, kullanıcıların algılarında ve ilk bakıştaki değerlendirmelerinde en baskın etken olarak görülmektedir. Bu sebepledir ki, bir aracın ilk etkileşimde kalite ve prestij etkisi yaratabilecek olan dış görünüşü, o aracın pazar başarısının sorgulanamayan bir belirleyicisi olarak kabul edilmektedir. Zira estetik algı ya da beğeni tercihleri bir toplumun en belirgin sosyo-kültürel niteliklerinden biridir. Dolmuş ya da minibüslerin iç ve dış görünümleri müşterilerin algısını ve tatminini çok büyük oranda etkilemektedir. Bu paralelde potansiyel müşterilerin gelecekte tercih edebilecekleri araç stilini hayal etmek, yönlendirmek ve belirlemek de tasarımcıların işidir. Aslında başarılı araç tasarımları yaratmak gelişmiş imalat teknolojileri ile mümkündür ve günümüzde yeni malzemeler ve üretim yöntemleri otomotiv tasarımcılarına giderek daha fazla özgürlük sağlamaktadır. Minibüs ve dolmuşlar için en önemli tasarım kriterlerinden biri vandalizme, eskime ve aşınmalara karşı dayanıklı; geri dönüşüme elverişli olan malzeme seçimleriyle işletim, bakım ve onarım maliyetleri düşük olan araçlar yaratabilmektir. Bunun yanı sıra, paratransit araçlar için bir diğer önemli kriter de özellikle de kullanıcıların etkileşim içerisinde olduğu fonksiyonel elemanların yerleşimi ve tasarımında ergonomik kuralların uygulanmasıdır. Bu bağlamda tasarımcının amaçlarından biri de hem sürücü hem de yolcular için güvenlik, kolay kullanılabilirlik, erişilebilirlik, görülebilirlik gibi kavramların doğru irdelenmesi ve güncel araç regülasyonlarına uyulması olmalıdır.

Kısaca, sürücü profillerinin dikkatli analizi ve kullanıcıların gerçek ihtiyaçlarının belirlenmesiyle endüstriyel olarak tasarlanmış paratransit sistem dahilinde kullanılacak araçlar, çok yakın gelecekte daha işlevsel, yenilikçi, insan odaklı ve estetik olarak da katma değer yaratan araçlar olabileceklerdir. Ancak endüstriyel tasarımın dolmuş ve minibüslerin iyileştirilmesi konusundaki katkısı teknolojik gelişmelerden bağımsız olarak düşünülemez.

Paratransit tip taşımacılığın kolay ve etkin yönetimi için, bir çoğu dolmuş ve minibüs sistemine uygulanabilmesi muhtemel olan ve gerçek zamanlı araç durum bilgilerini merkezi bir istasyona iletme ve araç izleme, sürücü destek ve/veya araç otomasyon imkanı sağlama, yolcu güvenliği ve seyir emniyetini artırma ve otomatik ödeme sistemi sağlama gibi işlevlere sahip olan çok sayıda akıllı taşıt sistemi vardır. Özellikle de iletişim ve bilişim alanlarındaki yapay zeka teknolojisini kullanan bu tür sayısız yenilikler, paratransit sistemin geleceğini büyük oranda etkileyebilir. Geniş bir perspektiften bakılacak olursa, yukarıda sayılan teknoloji destekleriyle donatılmış geleceğin paratransit araç tasarımlarının da günümüz araçlarına oranla oldukça farklılaşacağını öngörmek mümkündür.

Ayrıca, yeni güç aktarım organları tasarımları, araç tahrik sitemleri ve alternatif yakıt teknolojilerinin geliştirilmesi, enerji tasarrufu avantajı getirecek ve paratransit sisteme daha sürdürülebilir bir yaklaşım kazandıracaktır. Dolmuş ve minibüsler için karbon emisyon değerlerinin düşürülmesiyle, çevreye ve insan sağlına verilen zararın azaltılması beklenmektedir. Bu bağlamda, her ne kadar geliştirilmiş "Euro" emisyon değerleri karbon salınımının azaltılmasında büyük rol oynasa da, araç tahrik sistemi için fosil yakıtlara olan bağlılığı devam ettirdiği için, sürdürülebilirliğe olan katkısı sınırlıdır. Bu dizel teknolojilerine alternatif olarak sıkıştırılmış doğal gaz, hibrit, yakıt hücresi ve batarya gibi enerji kaynaklarına sahip araç teknolojieri geliştirilmektedir. Bunlar arasından önümüzdeki on yılda dolmuş ve minibüs pazarı için en uygun olanının, gürültü ve hava kirliliğini minimuma indirebilecek, batarya ya da yakıt hücresini kullanan elektrikli araç sistemleri olduğu düşünülmektedir.

Kısaca eklemek gerekirse, yeni teknolojilerin paratransit araç pazarına girebilmesi ve başarılı olarak uygulanabilmesinin, en başta devlet olmak üzere, ulaşım hizmeti sağlayıcıları, araç imalatçıları, potansiyel müşteriler, son kullanıcılar ve yakıt tedarikçileri gibi tüm ana paydaşların kabulünü gerektirdiği kaçınılmaz bir gerçektir.

Bu tez çalışmasının sonunda dolmuş-minibüs amaçlı kullanılan bir araçta kullanıcı davranışları, beklentileri ve tercihlerinin belirlenebilmesi için, sürücüler ve yolcuların detaylı olarak gözlemlenmesinin yanı sıra, sürücüler ve/veya müşterilerle yapılandırılmış ve yarı yapılandırılmış olmak üzere iki röportaj yönteminin kombinasyonu, açık uçlu sorular sorularak gerçekleştirilmiştir. Operatörlerden gelen yanıtlar göz önüne alındığında tezin ortaya koyduğu teorik argümanların, amprik çalışmanın sonucunda da ortaya çıktığı gözlemlenmiştir. Esasında, özellikle de sürücülerin görüşleri ve bazı motor teknolojilerinin yeni araçlara entegrasyonu ile ilgili bir tezat varmış gibi görünse de, müşterilerin istekleri ne olursa olsun, araç imalatçıları, araçlarını pazara çıkarmadan önce güncel regülasyonlara uymak zorundadırlar. Endüstriyel tasarımın paratransit sistemin özellikle de araçlarının iyileştirilmesinde kısa vadede katkı sağlaması daha mümkün iken, günümüz ve gelecek teknolojisinin katkısı hem sistemin kedisi üzerinde hem de araçlar ve işletme biçimleri üzerinde olacağından daha uzun zaman alması beklenmektedir.

1. INTRODUCTION

There always has been an intimate connection between the civilized life and transport. Because, increasingly growing urban population, especially in the urban areas, requires access to business activities, health, education, employment, entertainment and many other social services and opportunities (Murray, Davis, Stimson, and Ferreira, 1998). That is, there is a need for mobility, in particular for the movement of people from their places of residence to where they must go to pursue all the activities of life.

Car is one of the greatest inventions of human technology to access these social services and opportunities. It provides private and therefore flexible and comfortable transport opportunities. Despite most positive qualities of car, today many cities in the world face serious problems caused by massive car usage. Swollen populations with high densities of personal vehicles mean major congestion, slow travel, parking difficulties, high exposure to polluted air and high mortality rates from traffic accidents. Because of these reasons, passengers are stimulated to use public transportation all over the world (World Bank, 1996).

In many developing countries, families prone to be large, thus, even if there is a car belonging to household, some members of the family are still likely to use public transport for at least some of their travel activity. One the other case especially in developing countries, although there are some people who can afford cars, at the other end of the scale there are those who are with low income levels have great difficulty to afford even the most basic form of transport (Illes, 2005). In addition, there are also people who suffer from private car usage problems such as the elderly and disabled ones. Therefore, public transport is vital for the vast majority of population without access to private transport.

Public transportation is highly inclusive issue and the systems used for it are one of the most complex large-scale systems found in modern society. Good public transportation systems have a great impact on regional patterns of development and on maintaining socially acceptable levels of quality of life (Murray, et al., 1998).

Many transportation planners have noted that cities in all parts of the world are struggling to achieve some acceptable standard of mobility (Koutsopoulos and Schmidt, 1986).

1.1 Conceptual Background

Some big cities in developing countries, there is an increasing income, car ownership levels and the resulting dispersal of activity centers and trip patterns (Enoch, Potter, Parkhurst, and Smith, 2004). Expanding of cities and dispersal of its centers increases the need of transportation demand. Public expectations for transport are increasing in both quantity and quality. The criterion for the quality expectation is generally about the minimization of the total cost and total transit time of the passengers including the waiting time by also providing the maximization of the passengers' comfort, satisfying certain regulations and some operational constraints.

In developing countries, public transport cannot handle the growing demands. There is a widening gap between what is expected of public transport and what can be delivered. The level of service and area of coverage is usually inadequate while travelling by conventional buses or too expensive while travelling by taxi-like flexible choices. Majority of the travelling public can only afford least costly means of movement (Shirkie, 1979).

These and some other reasons indicate that conventional bus services do not meet the needs of a large section of the population. More flexible and affordable forms of transit are needed to serve effectively the metropolis. Because of that, there are a rich variety of road-based public mass transport modes other than ordinary buses and taxis especially in the cities of developing countries.

In fact, many cities in developing countries have a large component of unconventional or intermediate public transport, which is also called paratransit. This type of public transport often fills the gaps in service that cannot be provided by the operators of conventional public transport (Vijayakumar, 1986). In those medium and small-sized collective consumption transport modes, the market performance is generally satisfactory thanks to its demand responsiveness advantage.

1.2 Problem Formulation

In the literature there has been some comparable terminology used for paratransit services or systems. For instance, Cervero (2000, p. 3) has adverted that, there are wide range of terms referred to paratransit, such as “low-cost transport”, “intermediate transit technologies”, “third-world transport”, “informal transport” and so on. Illes (2005, p. 19) has pointed out that paratransit is defined by using some other similar terms: “Intermediate public transport”, “unconventional forms of public transport” and “the unincorporated sector of public transport”. These and other synonymous terms have been widely used to describe part of the road-based public transport sector, which is in between fixed-road transportation with conventional buses and flexible transportation with taxis. In addition to that, Tüydeş and Özen (2008, para. 1) have emphasized that the terms “demand-driven” or “demand-responsive” are also commonly used interchangeably or in association with paratransit in the literature.

The term adopted in this thesis study is “paratransit”, due to the fact that this term best reflects the context of both Turkey case and the other cities case all over the country. In fact, it is the most dominant terminology that has been used so far in the literature. Figure 1.1 indicates where the paratransit system is among the other transport modes.

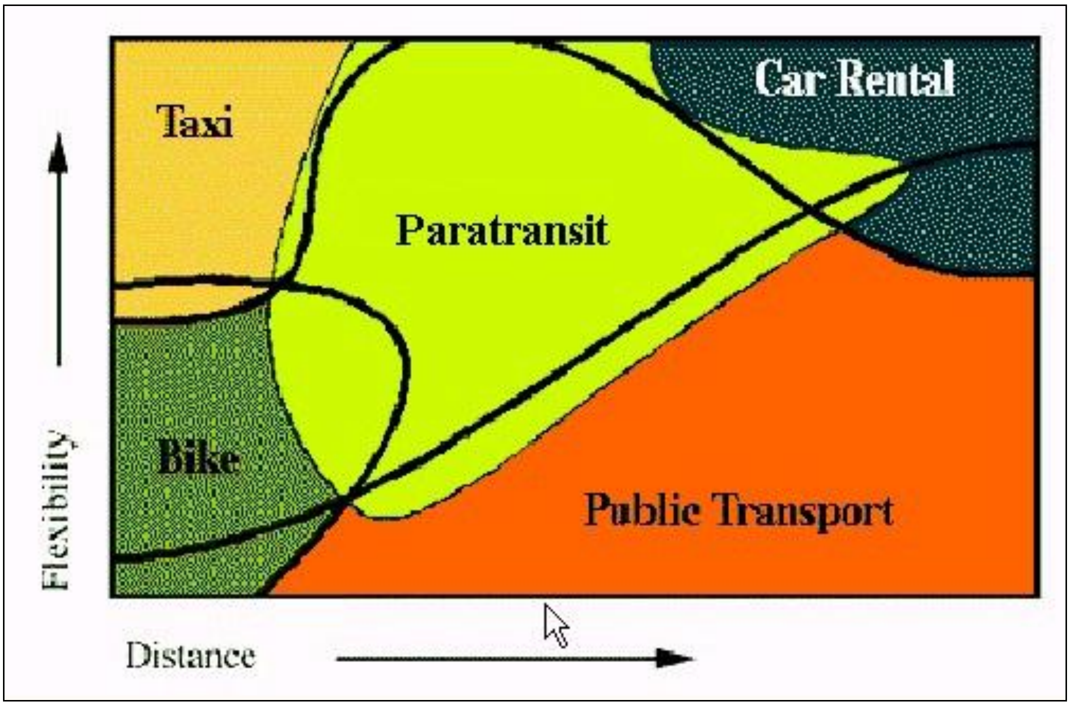


Figure 1.1 : Paratransit among the other transport modes (Kirby and Bhat, 1974).

Paratransit system is one of the main systems of public transport in many countries especially in developing ones. The paratransit has a dual mode of transport that falls between private transport and conventional bus transport. It has often with a fixed or semi-fixed route, but with the added convenience of stopping anywhere to pick up or drop off passengers and not having fixed time schedules (Cervero, 1992).

In most part of the world, paratransit services are bus-like services, which can be identified by a pre-defined, continuous, point-to point service with intermediate stops for boarding passengers; taxi-like services, which can be identified by the intermittent nature of the service and complete flexibility in passenger-determined destination.

In Turkey, the well-known system called “Dolmuş-Minibus” corresponds to paratransit mode of transportation. This system has various problems in itself that could originate from its operation, stakeholders or vehicle types used within this system. It is obvious that dolmuş-minibus system has to be the subject matter for different areas and disciplines to ameliorate this system. Especially industrial design together with engineering, city planning, sociology, economy and some other disciplines are highly related to this ignored system.

For the time being, the evolution of dolmuş-minibus concept and the vehicles used for this system is affected by numerous factors. Its evolution is mostly depended on the experienced social events, economical situations in which the country included, political decisions, regulations and the changes of the city structure in which the dolmuş system is operated. So far, industrial design and technological developments has influenced the dolmuş evolution less than the factors mentioned above.

In this study, the research problem formulated as potential design and technology impact on ameliorating the paratransit system operation and its vehicles in Turkey.

1.3 Purpose and Scope of the Study

The primary purpose of this thesis is to review current research work on paratransit with its origins and evolutions, critically assess the characteristics of existing paratransit services in Turkey with particular reference to vehicle types and therefore find out the potential design and technology impact on ameliorating the dolmuş-minibus system.

The hope also is to give greater visibility to this often ignored dolmuş-minibus sector of Turkey. Regarding this aim, the conducted field study findings and their analysis will be examined in a detailed manner in order to determine the preferences, expectations, demands and perceptions of the stakeholders who are mainly consist of purchasers, consumers and most of the time drivers. Thus, it could be understood that, how the potential stakeholders might affect the design, development process and so that the future of paratransit service vehicles.

In this manner there could be two main questions tried to be answered in the scope of this study;

- What might be the role of industrial design to ameliorate the paratransit system vehicles?
- How can current and future technology be used to improve the paratransit vehicles and operations?

This thesis also aims to answer the following sub questions in order to elaborate the main questions:

- What are the roles and the characteristics of paratransit system in society as a public transport especially in developing countries?
- How the dolmuş-minibus system and the vehicles are emerged and evolved in Turkey?
- In what way, could demand responsive transport services provide an effective public transport and access objectives within developed and developing countries?
- What could be the future role of the paratransit system in the city Council's transport and access strategies?

1.4 Structure of the Thesis

The first chapter aims to build an introductory and conceptual background to the research subject.

The second chapter of this study is devoted to the definitions, origins and the evolutions of the paratransit system in the world. The consequences of the conveyed literature review is also introduced in order to explain the historical background of the paratransit system, organizational characteristics and its different implementations throughout the world.

Then, in the third chapter, paratransit implementations in Turkey are introduced. To set the background for the following chapters, the vehicle types used for paratransit system in Turkey, the concept of dolmuş-minibus, the comparison of “dolmuş” and “minibus” concept, the emergence and the evolution of dolmuş-minibus concept are discussed with the factors that affect its evolution such as the interaction between dolmuş-minibus and city structure, social and economic situations and legal and regulatory issues. Additionally, in the last part of this chapter, the futurity of dolmuş-minibus system is also examined elaborately.

The fourth chapter initially aims to explore the possible industrial design impact on paratransit specifically for the vehicles. It is mostly about the design of paratransit vehicles with their styling, and materials and manufacturing process, human centered design approach and the future design trends of vehicles used for this system.

The fifth chapter aims to highlight the importance of current and future technology that may possible affect the paratransit. In detailed manner, intelligent public transport applications such as vehicle information and communication systems, automation and assistance systems, safety and security systems and electronic payment are introduced in the first part of the chapter. Then sustainability of paratransit system with usage of alternative energy sources is studied in the last part of this chapter.

In order to support the theoretical discussions, a field study is presented in the sixth chapter. The base for methodological decisions and the frame of the research study is given here. This chapter also includes the detailed examination of the findings of the field study and their analysis.

The concluding chapter briefly summarizes the study so that the comprehension of the big picture is reached in this last chapter. The chain of inquiries and responses that are followed through the framework of the thesis are put together. At last, the thesis is concluded with the limitations of the study and then the conveying suggestions for further studies.

2. ORIGINS, EVOLUTION AND CHARACTERISTICS OF PARATRANSIT SYSTEM

This chapter begins with the exploration of historical background of the main subject in order to elaborate the recommended research purposes and inquiries. In the first part of the chapter, origins and brief history of the paratransit system is sought. In the second part of the chapter, organizational characteristics of the paratransit system are studied. Then, in the third part of the chapter, paratransit implementations in different countries of the world have been investigated to set the key concepts for Turkey implementation cited in the following chapter.

İstanbul Technical University library and Otokar Inc. databases are the most important recourses to be searched. In order to find out necessary and sufficient information about the keywords including paratransit system, unconventional transportation, passenger mass transport, intermediate public transport and so on, numerous online recourses are scanned with either direct access or through search engines like: ITU Library online search and Google Scholar in addition with the electronic databases such as IEEEXplore, EbscoHost, Ebrary, Elsevier, Science Direct, Transit Research Board, and Wiley Inter Science.

2.1 Origins and Brief History of Paratransit System

The urban areas of developing countries have become larger and exploded both due to the shift of population from rural areas to the cities and uncontrolled expansion in the number of inhabitants for the last six decades. As also mentioned before, growing urban areas have led to the dispersing activities in the cities. Shirke (1979) has mentioned that the burgeoning cities have also caused the shortage of resources, rapidly increasing demand for transport, and rising road and facilities.

Furthermore, the car ownership and motorization have been increased rapidly since 1950s. Inadequate urban transport management, planning and land use patterns have induced regular public transport vehicles less suitable to serve (Enoch, 2005). This creates an intolerable level of traffic and congestion together with air pollution for the urban areas in most countries of the world. The incremental use of inefficient private automobile transport in thickly populated cities to meet the increased demand for urban transport has also lessened the efficiency and effectiveness of public transport (Cevero, 2000).

Briefly, the main contributory factors of the conventional public transport models have become failing in most developing countries that are rapid growth in population, particularly in the urban areas; low standards of efficiency, reliability and safety; poor enforcement of regulations and shortage of money (Iles, 2005, p.8). More importantly, due to the lack of financial and institutional capacity with the falling levels of resources to subsidize the systems, regular public transport services fail to meet the demands of the marketplace. Therefore, the market share of public transport systems has gradually started declining throughout much of the industrialized world at the turn of fifties and at the head of sixties (Enoch, 2005). As a consequence of this ineffective, inadequate and increasingly expensive public transport services the small-scale operators, legally or illegally, entered to the market in order to fill these gaps, complementing regular transit services, entering neighborhoods poorly served by formal operators, and responding promptly to shifting market demands (Cervero and Golub, 2007). So that, the primitive samples of the paratransit mode of public transportation has burgeoned throughout cities in developing worlds.

In the literature, although most of the authors and sources has mentioned that the origins of the paratransit systems in developing countries go back to six or seven decades, according to Khosa (1992a) paratransit has historically been owned and operated by black South Africans and the sector dates back to a small number of independent paratransit sedan vehicle services in the 1920s. However, between the 1920s and 1960s black entrepreneurship was subjected to complex legal restrictions in Africa, that evoked limited access to business opportunities generally, and great difficulty in acquiring operating permits for paratransit operations more specifically (Barrett, 2003; Schalekamp and Behrens, 2010).

Moreover, in most parts of the developed countries, the traditional public transport model has come under increasing pressure in the last quarter part of the 20th century.

This has many similar reasons with the ones in developing countries have faced earlier. For instance, the loss of market share due to growing car ownership, the loss of efficiency due to traffic congestion, diffusion of travel patterns linked to suburbanization, rapid and unplanned urban growth, inability of government to provide capital or operating support funds, instability in society together with economic recession are some foremost subjects why the regular and traditional public transport model has been found as full of deficiencies and pressured by most of the population in developed countries (Finn, 2008).

Especially in more wealthy countries in Europe and Australia, the provision of public transport services has remained relatively stable, even if there have been some periods of painful adjustment and ruckus in 1980s. Finn (2008) has adverted that in those times, subsidies have been increased; support had been given for capital replacement in growth areas, companies have been gradually minimized in declining markets.

When came to the later part of 20th century, the state of affairs in most of the African and Asian cities are not quite different from the developed ones. Especially the megacities of these two continents have been faced serious dropped off in the quantity and/or quality of available bus services, either due to the deterioration of the vehicle fleet and organizational capability, or through the inadequacy to expand in line with rapid urban population increase. Interestingly, in Sub-Saharan Africa and the post-Soviet countries, the degeneration and collapse of formal bus services has allowed small operators to operate without hindrance and large-scale minibus operations to become established in large urban areas as the dominant form of transport (Finn, 2008). A linked trend has become seen in rapidly expanding cities of South America where minibuses become the means by which the barrios can be served.

Technically, most of these small or large-scale operators, that started to be seen almost every part of the world in similar times, are those operating without official endorsement which is also called informal services. Usually this means, vehicles and operators do not have appropriate licenses, permits, or registration papers from public authorities to provide collective-ride services to the general public (Cervero and Golub, 2007).

Actually, the term paratransit was also improvised in seventies to cover the concept of demand responsive systems other than the informal services. The U.K. and the U.S. were among the developed countries that very early deployed systems exhibiting this service concept (Mastrogiannidou, Lois and Ziliaskopoulos, 2006). By the mid 1970's, paratransit was thought to be an answer to providing transit service for all users in areas of low-density land use and low-density demand areas where the conventional transit are not served cost-effectively (Lave and Mathias, 2000). According to Cervero (1997), the term "paratransit" was coined in the 1970s to describe the full spectrum of transportation options that fall between the private automobile and the conventional bus. Many paratransit services are flexible and ubiquitous, connecting multiple places within a region just like the automobiles, but a price far below a taxi. Additionally, paratransit is an efficient user of road space and energy resources because of its high average loads, just like the bus transit.

Rimmer (1980, p. 940) puts an explanation as: "Paratransit has triumphed over rival terms to describe the nebulousness of transport organizations, technologies, and services that lie somewhere between conventional and personal transit in price and quality."

Furthermore, especially in North America, the term "paratransit" began to be used increasingly to describe the second meaning: special transport services for people with disabilities by the early eighties. In most part of the USA and Canada paratransit services are used extensively as part of the American with Disabilities Act (ADA) (Mastrogiannidou, et al., 2006). In this respect, paratransit has become a sub-sector and business in its own right. Notwithstanding such a mode, paratransit services are operated by non-profit associations.

To sum up, in both developed and developing countries conventional and regular public transport services have numerous deficiencies in the operational issues, passenger satisfaction or the vehicle characteristics that give rise to the birth of paratransit services all around the world, such as;

- Inflexibility,

The conventional public transport with buses has higher waiting time at pick-up points. These vehicles serve a planned route and their stops are fixed and predefined. That is, they do not stop anywhere, anytime or only when passengers require.

Therefore, the conventional bus transit has slower journey time and turnaround (Adam Smith Institute, 1980).

In other words, high passenger capacity buses used for conventional public transport are inflexible in both routing and scheduling.

- Expensiveness,

The conventional public transport choices have the disadvantage and the deficiencies of being inflexible. However, taxis -the flexible ones- are one of the most expensive transit choices in the cities of both developed and developing countries, even they are used as car-sharing mode. In that manner, paratransit is a cheaper choice among the personalized mass transit even though it is relatively expensive than the conventional bus transit on a per-passenger basis (Lave and Mathias, 2000).

- Inconvenience,

The maneuverability in traffic especially within the narrow streets in a crowded urban area is not satisfactory for a high passenger capacity bus. These buses are not quick and agile. However, a low passenger capacity vehicle used for paratransit system has generally lower wheelbase, which brings it greater maneuverability.

Consequently, over time, paratransit has become more accepted, invariably because it has become a significant component of the public transport system with lots of advantage. In the majority of cases paratransit commenced as an illegal operation, which gradually become legalized and formalized (Iles, 2005).

2.2 Organizational Characteristics of Paratransit Systems

Paratransit services try to combine the social, economic and environmental policy benefits of the buses with the high quality service of the taxis in major parts of the world. In the literature lots of author has made a definition of paratransit in order to explain the basic characteristics of the system. Although their time and place are totally different, most of these explanations have almost similar meanings, such as:

Bakker (1999) defines paratransit as:

> ...transportation option that falls between private car and conventional public bus services. It is usually considered to be an option only for less developed countries and for niches like elderly and disabled people. (p. 110)

Lave and Mathias (2000) defines paratransit as:

> Paratransit means alongside transit. It includes all public and private mass transportation in the spectrum between private automobile and conventional transit. (para. 1)

Other definition pointed out by Grosso et al. (2002) is:

> Paratransit is an intermediate form of transport, somewhere between the bus and taxi and covers a wide range of transport services ranging from less formal community transport through to area-wide service networks.

One another definition of paratransit described by Mastrogiannidou et al. (2006) is:

> Paratransit is a flexible demand responsive transport system that aims to function at a cost of bus while providing personalized service as close as possible to a taxi. (para. 1)

In addition to these definitions, in a “Transportation Report” study by the Adam Smith Institute (1980) paratransit operations in major metropolitan cities in the world, such as Hong Kong, Kuala Lumpur, İstanbul, Cairo, etc., are defined as “light vehicle operations”, where “light vehicle” refers to midsize vehicles (8 to 16-passenger capacity) used in such flexible services. In the evaluation of paratransit systems in the developing countries, Cervero (2000) uses the term “informal transportation services”, which includes paratransit as well as minibuses, microbuses, motorcycles, etc. as also mentioned in the previous chapter. In this manner, paratransit plays a role of filling the service gap left by formal public transport operators. The term “dial-a-ride” is also used to refer to paratransit or demand responsive transit (DRT) services, which refers to the fact that people have to call or make a reservation in advance so that it gains advantage over taxi. Common applications of such systems are airport shuttle services and services for people with disabilities and mobility challenges (Tüydeş and Özen, 2008).

In operational terms, there are a number of paratransit-specific operational characteristics. These include type and size of paratransit vehicle; degree of route flexibility that is affected by the level of demand; degree of timetable flexibility; whether to interchange or not; level of technology; mode of booking; and for some developed countries call center technology. There are also a number of regulatory and financial issues related with licensing the operators, vehicles, drivers and routes that need to be balanced, and there are mandatory requirements if the vehicles are to be used for special needs type work, e.g. space for wheelchairs or low floor access.

In addition, there is another issue to do with the paratransit journey times becoming more prolonged as the number of passengers increases (Enoch, et al., 2004).

Vehicle types together with their service and operation modes are one of the main attributes of paratransit operations to be worked on it.

The size of vehicle is usually determined by the likely levels of demand, and secondly by the cost. Table 2.1 indicates the demand responsiveness of public transportation according to the route, vehicle, operator, passenger and the payment criterions. Wright (1986) has mentioned that in developing countries, paratransit vehicles may be pedal or motor rickshaws, converted vans and pickups, converted jeeps, shared taxis or minibuses. They carry from 4 to 20 passengers in crush conditions, with different journey speeds. The costs of higher capacity paratransit run about 10 to 20 per passenger-km; about the same as small transit buses even though there can be met extreme over loading conditions, e.g. most of less developed countries.

Table 2.1 : Demand responsiveness of public transport (Brake, et al., 2006).

Route	Fixed months in advance →		Fixed 1 hour before trip
Vehicle	Limited periods of availability →		Long periods of availability
	1 type →		Many types
Operator	Commercial →	Competitive tender →	Selected 1 hour before trip
Passenger	Special transport services →	General public only →	No restrictions
Payment	Pay on vehicle →	Season ticket →	Smart card
	Increasing demand responsiveness →		

Furthermore, paratransit operators are generally free to choose vehicles, routes, frequency, and hours of operation. However, fares may be regulated and in some cities, congested routes are barred to paratransit.

Paratransit operators adapt quickly to changing patterns of demand, that is, they are responsive to the needs of the public. Due to their small size, paratransit vehicles are able to provide frequent and viable service at low levels of demand. Often, small paratransit vehicles are the only form of transport able to penetrate the labyrinth of narrow streets sometimes found in the old parts of cities and in squatter areas (Wright, 1986).

In general manner, there could be many operational characteristic alternatives of paratransit considering its scheduling type, route type and vehicle type or origin and destination relationship and service as seen in Table 2.2.

Table 2.2 : General operational characteristics of paratransit (Enoch, et al., 2004).

Characteristic	Alternatives
Scheduling type	Fixed-schedule
	Demand-responsive
	Unscheduled
Route type	Fixed-route
	Route-deviation
	Flexible-route
Vehicle type	Minicab
	Taxi
	Minibus
	Midibus
Origin and destination relationship	One-to-one
	One-to-many
	Many-to-one
	Many-to-many
Origin and destination service	Door-to-door
	Checkpoint

As being a route type alternative, fixed route services involve scheduled arrivals at given points along pre-defined routes, almost similar to buses. Route-deviation or semi-flexible services elongate fixed-route services by allowing a certain amount of deviation from the fixed route. Another alternative, flexible routing is a further extension of route-deviation, in which the vehicle goes wherever it is required, as with taxis (Enoch, et al., 2004).

As being an origin and destination service alternative a one-to-one service operates strictly between two points, although with the potential for access and egress at intermediate points. A one-to-many service delivers passengers from multiple origins to a single destination or vice versa. A many-to-many service transports passengers between any reasonably accessible points in the service region (Enoch, et al., 2004).

In different part of the world, paratransit systems are characterized by the variety of services they offer. These may include:

- personalized door-to-door service;
- shared service with routes determined by individual passengers;
- regular service along well-defined routes that is similar to bus transit.

Personalized door-to-door services either used in low-density suburban areas such as, special purpose personal transport (employee, students, etc.) or in urban areas such as, taxis, hired vehicles, shared vehicles or most of the time car sharing operations. These are the most flexible ones among the other paratransit operations. However, they have tended to be very expensive.

Shared services or shared taxis are the ones whose routes are determined by the passengers inside the vehicle. Illes (2005) has mentioned that for many cases, paratransit type of operation may be referred to as “personalized mass transit” (PMT) or “demand responsive transport” (DRT). In that manner, shared taxi or in some countries road taxi can be the typical example and even sometimes regarded as a superior form of paratransit service. As also the name implies, this is a taxi used by at least more than one or several individuals, who are travelling between the same two points, or along the same route. The payment is generally higher than the regular services, which are alike to bus services and individually fared. The most distinguishing feature of the shared taxis from the other paratransit forms is the type of vehicle used. That is, the vehicles used for shared taxis are normally saloon cars, estate cars or multi-purpose vehicles with up to eight seats, while other regular paratransit vehicles are usually larger. In most of the countries, shared taxis may operate as a conventional taxi during most of the day, but as shared taxi during peak hours.

Regular service along well-defined routes is operated very similar to bus services. Usually the typical light vehicle service is more flexible than a bus service, and serves a planned route without fixed stops. Passengers will generally board them at well-known points, or will hail them at convenient stopping points. Passengers similarly tell the driver when they wish to alight. This makes it more personal service than conventional bus transit and more tailored to individual needs. Large numbers counter the small capacity of each vehicle. The fewer stops to set down and pick up, together with the maneuverability, make its service faster (Adam Smith Institute, 1980).

Stakeholders are other important factor in order to make a characterization of the paratransit services. In most of the times employing paratransit systems is quite difficult to be balanced that should be achieved between the involved stakeholders. Those are all the entities affecting the operation of the system. Owner or purchasers - most of the time operators -that manage the system, drivers and/or customers, local authorities and the passengers are the most important stakeholders of the system. The paratransit sector is generally made up of small-sized vehicles, owned and operated (or leased) by a single individual. Most drivers are low-skilled younger men who migrated to cities from the countryside (Cervero and Golub, 2007).

Illes (2005) explains the typical “lifecycle” of a paratransit operator as follows;

> It begins with the purchase of a vehicle, either new or second–hand, often financed from savings, or a lump sum payment on retirement from employment. The vehicle may be purchased on credit, in which case interest payments are generally high because of the risks involved in the business. The owner commences operation, usually by hiring out the vehicle to a driver for a fixed fee. The driver is responsible for paying for fuel; initially the owner’s expenses are low, confined to occasional replacement of brake or clutch linings and minor repairs, but little or no preventive maintenance. The vehicle owner usually spends most of the cash generated, either on other business ventures or on a more lavish life style; only rarely will he retain funds for future maintenance expenditure or vehicle replacement. Eventually the vehicle requires major expenditure, such as a replacement engine often incurred prematurely due to lack of basic preventive maintenance such as regular oil and filter changes. However, in many cases, the owner has insufficient funds; the vehicle is sold, and the operator goes out of business, to be replaced similar operator who will repeat the cycle. (p. 133)

Paratransit system has a number of reasons to be flourished and many advantages in terms of both drivers and the operators:

- Cost- effectiveness,

Costs are one part of whether paratransit has the potential to achieve either commercial viability or an acceptable subsidy level (Enoch, et al., 2004). Paratransit light vehicles overturn conventional ideas on the economies of scale.

As also mentioned above, the vehicles normally used for paratransit operations are relatively easy to purchase, and the capital investment is quite low than a big commercial vehicles. They are very cost-effective to run. Because, the large vehicle might carry more passengers for fuel or driver costs on a theoretical journey, but the small vehicle scores in practice. Its capital costs per seat are very much less. Generally, the light vehicle used for paratransit sectors is converted from an off-the-shelf mass production vehicle, instead of needing to be custom-made (Adam Smith Institute, 1980). These vehicles maintain lower garage costs, lower network costs and normally operate with a lower loan proportion than public sector operation. Therefore, they do not carry the same amenability of debt repayment. Additionally, those vehicles use their staff more efficiently and more flexibly, making use of part time work where demand patterns make this an obvious economy (Adam Smith Institute, 1980).

There is usually no difficulty in making profit, or any shortages in applications for licenses to operate due to the labor costs are also low.

- Easy maintainability,

Most of the paratransit vehicles are based on mass produced models, which are familiar to many mechanists. The spare parts of these vehicles are easily obtainable; while even if there are regulations governing the operation of paratransit vehicles these tend to be relatively ineffective (Iles, 2005). Therefore it can be said that majority of paratransit vehicles are cheaper and easy to maintain.

- Availability,

Operating a minibus or any kind of light vehicle requires relatively little special skill to drive compared to a full-sized bus and often no special driving license is required so that drivers are more readily available, and cannot usually demand high salaries (Iles, 2005).

Passengers are other important stakeholders of the system. According to Enoch, et al. (2004) passengers of the paratransit type of mass transportation either captive users, who by definition have restricted transport choices, and in particular have low levels of access to cars, or choice users, many of whom could have made the trip by car. There is a major contrast between choice and captive users on the important issue of price. For captive users price is a very important issue, but less so for choice users. By way of contrast, comfort and image is far more important for choice than captive users. Therefore, it can be said that captive users value bus-like attributes while choice users value taxi type attributes.

Fares together with their payment terms are other distinctive characteristics of the paratransit operations. Paratransit services are typically more expensive to provide per passenger trip than conventional bus services, while their fares are considerably lower than taxi or hired vehicles. Actually, in the ideal case, the purpose of paratransit system is to deliver a near-taxi level of service for fares that are somewhere between taxi fares and bus fares but closer to the bus fares. Therefore, being more flexible, paratransit can perform very usefully as a pilot bus service in an area until demand levels on particular routes or at particular stops can be fully ascertained and resources allocated to a fixed route service (Enoch, et al., 2004).

Cervero (1997, p. 5) has pointed out "expanded commercial paratransit services would produce lots of important benefits for the society" as listed below;

- Increase travel choices,
- Enhances mobility,
- Improve environmental conditions,
- Impose a market discipline on public transportation,
- Help stimulate advanced transit technologies.

In terms of implementation, there are still lots of questions as to how paratransit services can be effectively marketed and operated and what type of vehicle is most appropriate. Different vehicle size and type which depends on operation conditions and demand levels of operating area seems to be an inevitable solution for all over the world.

2.3 Paratransit Implementations Around the World

Almost every part of the world there are many examples of paratransit operations that have been established for many years that make a significant contribution to the transport systems without almost no public subsidy (Enoch, 2005). The paratransit sector is considerably diverse which ranges different vehicles in terms of speed, comfort, and carrying capacity (Cervero, 1997). Notwithstanding the fact that, there are also many common grounds of these schemes, arise from either their origins or operating modes and conditions.

Iles (2005) affirms that there are several forms in operating paratransit system in the world with many local names by listing them: dala-dala in Tanzania; dolmuş in Turkey; emergence taxi or ET in Zimbabwe; jeepney in Philippines; matatu in Kenya; public light bus or PLB in Hong-Kong; robot in Jamaica; silor in Thailand; tempo in Bangladesh; tro-tro in Ghana; Angkutan Kota in Indonesia and so on.

Enoch (2005) adds some more examples of paratransit system used in different parts of the world such as: Jitneys of Atlantic City, USA; the Jeepneys of Manila, Philippines; the Taxi Collectives of Havana, Cuba; the Sherut of Tel Aviv, Israel; the Kombi shared taxis of Cape Town, South Africa; the Matatu shared minibus of Nairobi, Kenya; and the Marshrutka shared minibus of Moscow, Russia.

These and some other examples of paratransit mode of public transport operated in different countries or megacities of Africa, Asia, America and European continents elaborately explained in this section.

2.3.1 Africa

As being the world's poorest continent, the paratransit sector is well established and has a history that reaches back to the first half of the 20th century in Africa (Schalekamp and Behrens, 2010). It started as black South Africans small-scale paratransit operations. However, as also mentioned in the previous section, between the 1920s and 1960s black entrepreneurship was, subject to complex legal restrictions, resulting in limited access to business opportunities generally, and great difficulty in acquiring operating permits for paratransit operations (Barrett, 2003). The Influx Control system governing black urbanization allowed, acquiring a (maximum four passenger) 'motor carrier certificate' from a Local Road Transportation Board in 1930s. A quota system allowed only a limited number of permits to be issued each year. A Road Transportation Act was imposed in 1977, which replaced the 1930 Motor Carrier Transportation Act, and provided for the issuing of 'road carrier permits' especially for the paratransit sector, defined a bus as a vehicle carrying more than nine people. Paratransit operators were thus legally authorized to increase the number of passengers they could carry from four to nine (Schalekamp and Behrens, 2010).

Following years, however; bus and train transport became increasingly expensive for both commuters and the state (through the subsidies required), and service coverage and frequencies became declined. As consequence, in the face of a growing demand for paratransit to fill gaps on scheduled public transport networks, drivers increasingly operated illegally (Barrett, 2003; Schalekamp and Behrens, 2010).

It can be said that paratransit in South Africa has grown from modest beginnings to become the largest urban public transport service provider in the country. Governments have introduced initiatives to regulate, upgrade and integrate the paratransit sector in formal public transport service provision. The most recent initiatives, the TRP of 1999 and the IRPTN program initiated in 2006, have met with significant, and often violent, resistance from the sector. The reason why the sector resisted is the flawed process through which paratransit has been engaged on their incorporation into the proposed formal public transport systems. Therefore, not surprisingly, the engagement process is at an impasse at present, and that there is little prospect for success should the current approach to paratransit formalization not be reviewed in earnest (Schalekamp, Behrens, and Wilkinson, 2010).

As also Cervero (2000) pointed out that, Africa's informal transport offerings are among the least understood in part because of the fact that there is little concerted research, which has been carried out to date. However, the well-known thing is that, South African informal transport, dubbed as the "minibus taxi industry", is notorious for its recurring bursts of deadly confrontation, commonly known as "taxi wars" or "taxi violence" which tends to be construed as its most distinctive feature (Lomme, 2009, para. 2). South Africa represents the extreme of how ruthless and deadly unregulated competition can be in the illegal paratransit world. There, rival cartels that control thousands of low-cost minibuses, or "combis", fight over the most profitable routes. There, almost literally "cutthroat competition" has taken its toll. During the 1990s, more than 2000 people died as a result of paratransit-related violence, according to official statistics. Unofficially, the toll is much higher (Cervero and Golub, 2007).

In majority especially the poorest parts of Africa, easily half or more of all passenger trips are done by micro -or mini- buses some of whom functioning mainly as peak-period supplements, as in Addis Ababa, Ethiopia ans Lusaka, Zambia. In Tanzania, they go by the name "dala-dala", in Uganda; they are affectionately called "kamuny" while in Democratic Republic of the Congo called "fula-fula" which are pick-up truck passenger services (Cervero, 2000).

Paratransit vehicles operated in Africa are usually primitively designed ones in most of ways. Both exterior and interior designs of them are not user-friendly enough. For instance, almost all of them have a very high floor to get in and off especially for priority passengers like the elderly, and most of them suffer from lack of safety issues.

Paratransit system in some other countries of Africa is examined more elaborately;

In Nigeria, paratransit services thrive in all cities to some degree in the early 1990s. This is mostly due to the fact that declining oil prices and a devalued currency which cause a sharp increase in vehicle ownership cost. Especially in Lagos, the most populous conurbation and the former capital city of Nigeria, a steady stream of used imported minibuses and some other old cars have been pressed into service as unregistered urban paratransit vehicles, locally called "kabu-kabu". The concept kabu-kabu consisted of some truck-like vehicles with wooden or metal bodywork that have high passenger carrying capacity, minibuses, shared-ride taxis and far more numbers of motorcycle taxis locally called "okada". On some roads, kabu-kabu services are the only transport services available. These services fill a market void left by deficiency and inadequacy of public bus services (Cervero, 2000).

In Kenya, the transportation scene has many parallels to other African developing countries. Converted vans and pickups are widely used as paratransit mode of public transport in some cities especially in Nairobi, the capital and largest city of Kenya. Actually, in this metropolitan city about 33% of the total public transport demand is served by "matutus", which is a general term and represent a service that developed informally (Takyi, 1990).

Matutus use various types of vehicles, in the 12-25 passenger seating range, from minibuses and vans to pickups, and typically follow formal bus routes. In Figure 2.1, there can be seen lots of matutus examples.

In addition, two, in five of matutus are owner driven, and many have drivers paid by the owner. They are profitable, paying off vehicle capital at 50% per year, but have been criticized for poor upkeep and safety features (Adam Smith Institute, 1980). In 1984, recognizing their importance to the city's transportation system, the Matutus were legalized, though most of their service parameters remained unregulated (Takyi, 1990; Cervero, 2000).

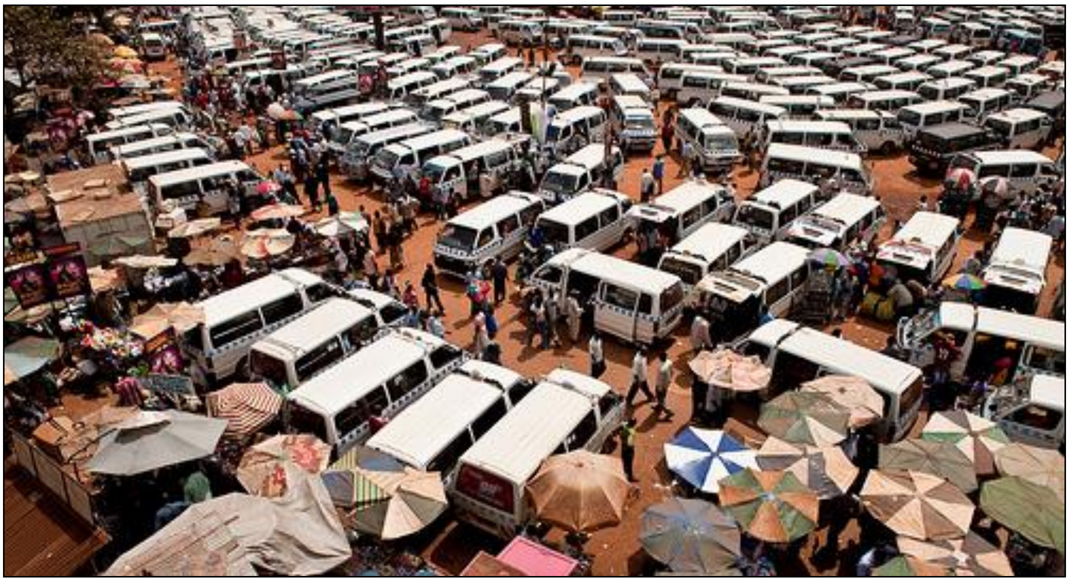


Figure 2.1 : Matutus examples from Kenya.

In Egypt and especially in Cairo, the metropolitan city of the country, a jitney service was permitted on fixed routes as a paratransit operation in the late 1970s. These vehicles, approximately 15 passenger capacities, leave well-known departure points when full. Seats vacated en route may be filled. Jitneys leave every few minutes, charging more than the conventional buses do. Despite this, they are profitable. One in five is owner-driven; many are owned by outsiders and leased to drivers. A union determines routes and fares, and charges a 5% surcharge on tickets to cover terminal facilities. The normal transport system, despite the fact that it charges less, runs up huge losses (Adam Smith Institute, 1980).

2.3.2 South Asia

Southeast Asian cities also suffer from some the worst traffic congestion anywhere. The congestion is principally a product of growth in the motorized vehicle population far outpacing road expansion. According to Cervero (2000), Asian paratransit services are both a reaction and a contributor to this congestion.

Paratransit services take many names, shapes and forms in Southeast Asia, comprising pedicabs, three-wheelers, jitneys, collective taxis and minibuses, among others. Some vehicles cater to short trips of two or three blocks, others serve intermediate-distance travel, while still others cover entire regions (Cervero, 2000). In fact, most of South Asian paratransit vehicles are poorly designed in terms of the passenger transportation criteria. Their body structure is not convenient for the safe and modern public transit modes. Especially, the doors and entrance of minibuses and jitneys, the seating units and most of other inner side elements are uncomfortable or hard to use for a large part of the public.

Paratransit system examples operated some Asian countries are elaborately examined below:

In Thailand, more specifically in metropolitan Bangkok, which has the reputation of being one of the world's gridlocked cities, the paratransit sector has helped compensate for the lack of good road hierarchy and substandard bus services. It provides supplemental capacity while also diversifying the service-price options available to the traveling public. On the streets of Bangkok, there can be found a rich mix of 14–18 passenger minibuses, pick-up trucks, and vans; 6–11 passenger micro-buses (silok lek), three-wheelers (tuk tuk, samlor), motorcycles, and pedicabs (samlor-tep). Motorcycle taxis, which have proliferated in recent years, often are found at the intersection of side streets and main arteries. They are illegal in that they are licensed under the Motor Vehicle Act as personal transportation modes, barring them from providing commercial, for-hire services (Cervero and Golub, 2007). However, bureaucratic inaction and fragmentation have prevented efforts to rationalize, regulate, and govern informal transport services in Bangkok. According to most observers, Thailand's Department of Land Transport does not care about illegal operators as long as there are not complaints over passenger safety and fair treatment. So far, the proliferation of informal operators has not reached a critical point, thus no action has been taken (Cervero and Golub, 2007).

In Indonesia, there are a wide range of vehicles, from human-powered pedicabs to minibuses, which offer regular passenger services especially in Jakarta, the capital and largest city of Indonesia. In this city, the hybrid three-wheeled motor-taxis, called "Bajajs", provide more comfortable transit more similar to a private car, while the larger three-wheeled "Bemos" and "Toyokos" carry as many as eight passengers in conditions that are more crowded. As close resemblance to paratransit operations in other Asian metropolitan areas, the larger microlets and minibuses carry 10–25 passengers in Jakarta. The city has sought to confine the slower and smaller vehicles to peripheral parts of the city and narrow roads, out of concern for safety and traffic discipline (Cervero, 2000).

Additionally, there also exist further important paratransit operations in many urban areas of the country. For instance, in Bandung, the capital city of West Java Province and one of the big cities in Indonesia, the famous mode of urban transport called "Angkutan Kota (Angkot)" is one of the paratransit operation similar to other big cities mentioned so far (Figure 2.2).

Figure 2.2 : Angkutan Kota examples in Indonesia.

Joewono and Kubota (2005) explained that 61.24% of operated public transportation in Bandung is angkutan kota which is operated by a small minibus with 12-14 seats. This situation figures the beneficial role of paratransit in this city. Almost all cities in Indonesia have this mode with its local name. Angkutan kota is a public transport for passenger with fixed route, but without fixed schedule. More specifically, it is classified as public transport mode with right of way (ROW) category and included in paratransit class (DLLAJ, 2001).

Traffic and Road Transport Agency (DLLAJ), (2001) has emphasized several advantages possesses by angkutan kota compared to others public transport modes as listed below:

- the services have high accessibility and mobility,
- operating cost is more beneficial for short trip,
- lane movement is easy and unimpeded, and
- maintenance cost relatively low.

Angkutan kota operates in Bandung can be divided in two groups, namely in fixed route and regular (majority) and unfixed route. Angkutan kota operates in fixed route generally is minibus (small van) with capacity 12 seats (DLLAJ, 2001).

In Hong Kong, informal minibus operators began circulating illegally in the 1960s (Lee, 1990). They were neither licensed nor insured for transit operations and competed directly with other formal transit services. In 1967, formal transit workers brought the informal operators into consideration by regulators as a useful component of a comprehensive transit system. The minibus system has since been formalized through a set of rules, allowing the operators to purchase licenses for operation and undergo inspections (Lee, 1990). Today, the operators can search for passengers anywhere they prefer, though most stick to the main congested areas of the city. Minibuses, which are also called Public Light Buses (PLBs) with maximum 16 seats, are operated either by individuals or by minibus companies under passenger service licenses issued by the Hong Kong Transport Department.

In Hong Kong, minibuses are composed of two types, those with red roofs as seen in Figure 2.3 and those with green roofs. Of these, the red roofs provide non-scheduled services that are purely 'demand responsive' that is, they operate flexibly subject to the market demand, and the Transport Department has no control over routes or fares. Thus, when demand is high in peak periods, or when rail or other bus services are not working properly, or even when there is bad weather, fares charged will be higher than at other times. They are also allowed to operate anywhere within their existing service areas, but not in new towns or new housing developments in Hong Kong. There are also local stopping restrictions on red roof minibuses to relieve traffic problems caused by their aggressive manner of stopping and waiting for passengers at curbside and at road junctions (Enoch, 2005). On the other hand, those minibuses with green roofs operate scheduled services on fixed routes at fares approved and regulated by the Transport Department.

In summary, the Hong Kong minibuses those with red roofs case is fascinating because it illustrates that even in perhaps the most attractive city in the world in which to operate high capacity rail and bus based public transport systems there are still significant markets to be profitably served by paratransit. Here, the important element is that paratransit vehicle drivers use their local knowledge to match the predicted demand with exactly the right number of seats (Enoch, 2005).

In Mauritius, the Indian Ocean Island, taxi-trains or shared taxis are operated as the form of paratransit sector. This operation is somehow different from the previously explained Asian countries. Taxi-trains operate on a largely interurban network, instead of on corridors in very large cities.

Figure 2.3 : Hong Kong minibus with red roof (Enoch, 2005).

The service therefore tends to operate with taxi vehicles carrying up to four passengers rather than the larger capacity minibuses. Interestingly, this mode was introduced as a result of a public policy decision rather than as a market response to a perceived gap in the transport market by commercial operators. The aim was to try to help address the problem of a severe shortage in the supply of public transport (Enoch, 2005).

In brief, first permitted licensed taxis to operate as so-called ‘taxi-trains’, which are effectively supplementary buses that are able to stop and pick up passengers along a particular route and charge separate fares of each passenger. Interestingly, the separate fares charged are set at the same level as for a bus operating the same route, despite the rather quicker and more comfortable ride offered by the taxi-train. Understandably, there are many people who prefer to wait for a taxi-train, even if a bus arrives to the same destination in the meantime (Enoch, 2005).

2.3.3 North America

Cities of the developed world also have informal services. For instance, in the USA in particular there are several paratransit examples. The operators of them tend to occupy a market niche where a more customized service is valued, but which can be operated in a low-cost manner, that is, simple systems where manual scheduling is adequate and low-cost labor.

Experiments with shared-ride taxis and jitney services in Seattle, San Diego, Indianapolis, and several other U.S. cities in the late 1970s and 1980s indicated that there was a market demand for frequent, on-call, and sometimes door-to-door services that are cheaper than exclusive-ride taxis and sometimes even public transit (Frankena and Paulter, 1984; Cervero, 1985, 1997 in pres). In Figure 2.4, a jitney example used in North America can be seen.

Figure 2.4 : A jitney example operated in North America.

Despite the fact that the paratransit system in North America is the most technologically advanced one compared to the other countries in the world, the vehicles used for paratransit are not modern and well designed. Most of North American paratransit vehicles have old style outlook.

Despite the regulatory and economic barriers, some paratransit entrepreneurs have carved out market niches that earn those profits and provide valuable transportation services. In the late 1990s and the beginning of 2000s New York City has the largest number of commuter vans of any American city. These are the vehicles of 14 to 20 passenger capacity operate both legally and illegally, on semi-fixed routes and variable schedules to subway stops and as connectors to Manhattan. In the Brooklyn borough of New York City, informal operators run a paratransit system along some busiest thoroughfares (Cervero, 1997). Operated mostly by recent immigrants from the Caribbean, these unlicensed operations compete directly with municipal bus services. The vehicle of choice, utility "Econoline" type vans, ply the main corridors of Brooklyn, taking passengers from anywhere along the route for a flat fee. Drivers also diverge from standard routes to avoid congestion, or to provide front-door delivery for a fare premium.

Furthermore, Miami currently has the second largest paratransit market in the continental United States. Besides New York and Miami, private vans and minibuses currently provide valuable feeder services to rail stations or bus terminals in San Francisco, San Diego, San Jose and other cities (Cervero, 1997). In Table 2.3 there can be seen the typology of paratransit services in America.

According to Cervero (1997), shared-ride taxis that are technically illegal yet operated by public authorities also thrive in poor, minority inner-city neighborhoods in Baltimore, Boston, Chicago, Ohama, and dozens of other U.S. cities, many providing on-call connections to supermarkets and shopping malls.

Other private paratransit services cater mainly to middle-class or professional white-collar customers. The examples of these are, San Francisco's sole surviving jitney serving the downtown financial district, Berkeley's racetrack taxi pool, Atlantic City's jitney vans and Washington, D.C.'s venerable shared-ride taxicabs.

One of the more widespread and the most popular form of private paratransit serving middle-class America is the airport shuttle-van, which in the case of the Los Angeles and San Francisco airports currently handle about 15% of all ground-access trips (Cervero, 1997). The pricing of shuttles at below taxi fares (but not that much lower) is combined with a market that presents a steady and predictable demand without particular peaks.

Table 2.3 : Typology of paratransit in America (Cervero, 1997, p. 15).

	Service Types	Service Configuration	Typical Passenger Loads	Primary Markets	Typical Regulatory Jurisdiction	Degree of Regulatory Restrictiveness
Commercial Services						
Shared-Ride Taxi	On demand Hail request	Many-to-many	3-4	Downtown, airports, train stations	City	High
Dial-a-ride						
-Specialized	On demand Phone request	Many-to-many	6-10	Elderly, Handicapped, Poor	City/ State	Low
-Airport Shuttles	On demand Phone and Hail request	Few-to-one	6-10	Air travelers	State	Low to moderate
Jitneys						
-Circulators	Regular route, fixed stops	Fixed route/ Loop (one to one)	6-15	Employees, low income, specialized	City	Moderate to high
-Transit feeders	Regular route, Hail request	Many-to-one	6-15	Employees, low income	City	Moderate to high
-Area wide	Semi-regular route, hail request	Many-to-many	6-15	Low income, Recent immigrants	City	Moderate to high
Commuter Vans	Pre-arranged, scheduled	Few-to-one	10-60	Commuters	State	Low
Employer- and Developer-Sponsored Services						
Shuttles	Pre-arranged regular route	Fixed route/ loop (often one-to-one)	15-30	Commuters, students	Local/ State	Low
Vanpools	Pre-arranged, scheduled	Many-to-one	6-15	Commuters	State	Low
Buspools	Pre-arranged, scheduled	Few-to-one	30-60	Commuters	State	Low

Shuttle services seek choice users by addressing their 'hire car' needs and they are priced accordingly. Jitneys, 15-seat vehicles, to serve specialist niche markets, and show that it is possible to have commercial paratransit occupying a more down-market position than the premium product airport shuttle (Enoch, et al., 2004).

2.3.4 South America

In Brazil, the transport sector relied heavily on privately run streetcars, with buses running on peripheral routes until the 1930s (Dourado, 1994). By the 1950s, most of the bus services were provided by small operators. A fall in demand for public transit, combined with the oil-price shocks in the early and late 1970s led to rising costs and a period of crisis for the fragile bus industry (Cervero and Golub, 2007).

In response, national policy began promoting an increase in the size and strength of the bus companies. Mergers of smaller transit companies were encouraged. New methods of fare calculations, route assignments and concessions, and difficult terms of entry into the market were created (Dos Santos and Brasileiro, 1999). In contrast to these large formal bus firms, the informal paratransit activities are made up almost entirely of owner operators. The current wave of informal paratransit activity in Brazil began around 1994. While numerous cities in the past experienced growth of informal sectors, the current wave is national in scope. Many of the most important and interesting aspects of informal transportation are exemplified in the city of Rio de Janeiro (Cervero and Golub, 2007).

Rio's paratransit operations surged in the mid-1990s in the wake of macroeconomic and structural changes happening to the Brazilian economy and society. The most important factors behind the growth of the sector were found to be the low quality of transit service, poor route connections, low levels of comfort and safety, rising fares, and increasing waiting and travel times. Despite such concerns, most researchers, while acknowledging safety, emissions and congestion problems endemic in small-vehicle transit services, support the legitimization of paratransit services (Balassiano, 1998; Torres, 1998; Cervero, 2000).

The unregulated and illegal paratransit services include "vans" and "combies". Some vans operate entirely within city boundaries, while others duplicate bus routes connecting outlying regions of the Rio de Janeiro metropolitan area with downtown destinations. The combies generally operate circulation services within neighborhoods in the Baixada Fluminense, and rarely perform line-haul type services. The line-haul vans routes include some pick up and drop off circulation within the day, in "hail and ride" fashion, and then enter the main arterials and freeways on their way to major downtown destinations (Cervero and Golub, 2007).

In Mexico the emergence of the paratransit sector is almost parallel to those Brazil examples. Particularly in metropolitan Mexico City the taxi drivers cruising to pick up multiple fares during the peak hours, called "Peseros" in the 1960s. These were originally tolerated by officials for their ability to serve peak-hour demand (Roschlau, 1981). In the early 1970s, various problems reduced bus-system capacity, prompting regulators to open up the marketplace to the Peseros (Wirth, 1997). Through the 1980s, the formal bus system slowly fell into disarray for political reasons (Wirth, 1997), and the Peseros, seen in Figure 2.5 and 2.6, catapulted in numbers to take up the demand.

Therefore, by 1990, minibuses, that are usually 24 seaters and Volkswagen combis, accounted for 50% of the over 30 million motorized trips made in the region daily up from only 10% in 1980 (Wirth, 1997; Roschlau, 1981). With this explosion came an increase in political power among minibus owners, and the entry of informal pirate operators. Today, only about half of the Mexico City's paratransit operators are legitimately licensed and insured (Cervero 1998).

As in many South American countries, paratransit system vehicles operated in Mexico are not newly designed ones. Most of them are modified from another type of vehicle and converted to a very simple minibus.

Figure 2.5 : Peseros example used in Mexico City.

Figure 2.6 : Driver area of a Peseros vehicle.

In Argentine and especially in Buenos Aires, the capital city of the country, as a paratransit operation vehicle locally called “collectivo” has grown from the 7 seats of its inception to 23 seats today (Figure 2.7). It carries three-quarters of all public transport trips. They are organized into associations for each route, called "Empresas," which set rules, schedules and fares under government supervision.

Figure 2.7 : Collectivo used in Argentina.

Collectivos are owned individually (one third by drivers) or by partnerships. They are profitable, and are the mainstay of a city of 9 million people spread over 1,500 square miles (Adam Smith Institute, 1980).

One of the most striking features of collectivos is their colorful and decorated exterior appearance, which make them easily recognizable among intense traffic. Most of these vehicles are not designed as a paratransit system vehicle; they are usually modified and accommodated for passenger transport.

In Puerto Rico, paratransit scheme vehicles named as the “publicos” are minibuses with limited to 14 seats, and charge twice the fares of conventional buses. They are publicly regulated, and are reckoned clean, reliable and fast. A 1980 study in Caguas found them making five-sixths of all public transport trips. They carry double the load factor of the big buses, and are profitable where the others are not. Most are owner driven (Adam Smith Institute, 1980).

2.3.5 Europe

Many EU countries such as Italy, Finland, Sweden, Netherlands and Belgium have employed paratransit systems, mainly funded by the European Commission. Experience from Europe indicates that strategically it is more straightforward to implement paratransit systems in regulated environments, as there is less conflict with other public transportation modes.

In addition, research commissioned by the Department of the Environment Transport and the Regions (DETR) argues that paratransit services would help to break down social exclusion. Similar initiatives have been reported in Ireland, in 1999 (Mastrogiannidou et al., 2006).

In fact, it can be said that, European paratransit system and the vehicles are the most improved ones in the world. Technological infrastructure of the system suffices for the better operational characteristics and both exterior and interior designs of the vehicles have much more user-centered approach compared to the ones operated in other Asian or African countries.

Some other European countries are studied elaborately, followed as;

In Sweden, there are rather improved paratransit sector. For instance, “Ringbuss” in Höör, situated in southern Sweden, is a paratransit vehicle, which is fully flexible within a designated zone, and is a rural dial-a-ride service feeding into, and receiving passengers from a commuter train system. The service started 1991 as a trial for two years and continued on a permanent basis thereafter. One of the objectives of the ringbuss system was to improve public transport services in the Höör municipality, and make them uniform. There were three existing types of services, basically, county public transport company services, school buses and transport services for the disabled and they were replaced by a single request service. This meant more frequent services than the previous county routes and supplementary services. Ringbuss replaced the few regional buses and some dial-a-ride taxies with two to three tours a week and low numbers of passengers (VIRGIL, 2000).

The municipality is divided into eight “Ringbuss” areas. Every area has its own timetable with between 3 and 12 buses a day, from Monday to Friday. The bus drivers, rather than a computer system, decide on the optimum route, depending on where the travelers want to be dropped off and picked up. Travelers from Höör do not need to pre-book the bus, since the bus passes four regular stops in the village. The return journey must be booked at least one hour in advance.

The fare system in ringbuss is the same as for the other public transport in the county. The public authority in the county of ‘Skane’ manages the ringbuss operation, which is run by contractors (VIRGIL, 2000).

In Italy, videobus is an on-demand midi-bus service linking a small community of users with a main public transport corridor, which is an operation that would not be economically viable using an orthodox scheduled public transport service. The service is primarily available to residents of the community, and booking is through home computer terminals supplied by the bus operator, Azienda Transport Consortium (ATC).

The scheme started operating in June 1995 to cover the village, called Borgo Panigale in Bologna, and surrounding area, although the area covered has increased slightly since that time. The service operates to a fixed route with 30 stops, 17 of which are only utilized when booked. The midi-bus is timetabled to run hourly, but only operates if booked. All of these are supplied with magnetic cards that are used to confirm payment once the user is on board the midi-bus. Booking is made through the terminals by following on-screen instructions, using simple keystrokes to choose pre-set information such as card number, day and time of trips, start and final stops, number of passengers. The reservation automatically forwarded to the midi-bus driver via an onboard LCD display and paper printout. The midi-bus also has a radio link with the dispatch center that operates the entire midi-bus network in the region. ATC operates the service under license from Emilia Romagna Region, and the Bologna Municipality. The route is serviced by one 33-seat vehicle, owned by the operator (VIRGIL, 2000).

In U.K., increasingly conventional road-based public transport with buses does not meet the needs of a large section of the population. This is because income levels and hence car ownership rise, as activity centers become more dispersed, and as trip patterns reflect this new distribution, buses become less effective and less efficient as movers of people. It is thought that one way of addressing these issues appears to be public transport systems that can operate effectively at lower levels and serving more dispersed demand than the bus. Such systems include shared taxis and demand responsive minibuses, which are collectively known as paratransit (Enoch, et al., 2004).

In 2000, the UK Government pledged in its Ten Year Plan for transport to remove or (at least) relax constraints on the development of flexible bus services and to promote a greater role for community-based services (Department of the Environment Transport and the Regions, 2000a).

Currently there are very few commercially profitable paratransit schemes operating in the UK. Perhaps the closest scheme to profitability is the newly launched Yellow Taxibus that operates between Dunfermline in Fife and central Edinburgh (Figure 2.8).

Figure 2.8 : Yellow Taxibus linking Dumferline with Edinburgh (Enoch, 2005).

Nevertheless, the Yellow Taxibus is not expected to make a profit for at least two years. Once the set up costs have been taken into account this scheme is also aiming to operate as cheaply as possible. Only the minimum level of technology is involved and the drivers employed are new to the public transport industry and only require an ordinary driving license, not a Passenger Carrying Vehicle license (Enoch, 2005).

The next level in terms of commercial viability refers to the low-tech shared taxi schemes, e.g. Lovedean Carshare in Hampshire. Average subsidy per passenger trip here is quite cheap. Once again, the routes operate in relatively compact communities and the technology, staff and vehicle costs are minimal (Enoch et.al, 2004).

In Greece, there has been conducted a survey in the rural Municipality of Philippi, that consists of 19 villages in order to develop a new generation paratransit system. There are some interesting outcomes of the survey about the perception of the users. The potential market share of the paratransit system depends on the level of service and the price. The expected output would be the users to answer that they want the level of service equal to taxi and the system to be free of charge or cost the price of the bus ticket. It is extremely interesting that about forty percent of the surveyed is willing to use the paratransit system if it costs less than the half price of the taxi (almost twenty price of the bus) while providing the exact level of service with taxi. For a system like this, it is often difficult to achieve the same level of service with taxi due to its purpose to transport simultaneously more than one passenger. Nevertheless, by looking carefully at the plot, it is observed that about thirty-five percent of the examined sample would use the proposed system if it was half the price of the taxi and the travel times were twenty-five percent more than the taxi (Mastrogiannidou, et al., 2006).

To sum up, almost without exception, paratransit is operated by individual private owners or small enterprises, is highly competitive, and is run at a profit in all over the world. The vehicles are small, as are the operating units. Even though majority is owner operated, many have owners linked to drivers by profit sharing schemes. All of them use the lower capital costs and easier maintenance of the light vehicle, to make it an effective and low-cost piece of transport equipment. They use its small size than the buses to give a more individually tailored journey, and to give a faster trip for passengers. Paratransit vehicles use its private sector operation to keep its operating and staffing practices efficient, and to keep it responsive to service needs as they develop and change. The competitive market keeps them alive to the need to court customers and to provide a service they actually want at a price that they are willing to pay (Adam Smith Institute, 1980).

2.4 Drawbacks of Paratransit

Certainly, paratransit, especially operated as informal transport, has its dark side as well. With reckless enforcement and weak regulations, odds are that unlicensed operators will engage in open warfare in the quest for customers, congested streets, and all-too-often causing accidents. They will also undermine the financial viability of legitimate and sanctioned operators. Laissez-faire transit in an environment of high unemployment is particularly dangerous. Absent accountability or enforceable standards, chaos and anarchy prevails on the streets. Not only public safety but also public health is threatened. Under-tuned micro-vehicles are often gross emitters of noise and air pollution (Cervero and Golub, 2007).

There are some arguments on paratransit potential drawbacks particularly on the nasty effects to the existing traffic.

It is sometimes argued that paratransit operations provide unfair competition to other forms of public transport. This is rarely, if ever, true. In fact, paratransit services often improve the viability of large-scale bus services by supplementing capacity during peak periods. Because of this, the size of a fleet of conventional buses, and its under-utilization during off-peak periods, is reduced. Paratransit is particularly advantageous in areas where demand is insufficient to support the use of large buses at desirable frequencies. Paratransit vehicles even the largest types of them, each with a capacity of about 20 passengers, is therefore unlikely to provide a complete alternative to bus transit along corridors where demand is too heavy (Wright, 1986).

One other argued drawback is the regularity and reliability of the paratransit operations. Since these vehicles follow no set timetable and have no fixed stops, the traveler depends on there being one coming along soon with available seats. The answer lies with numbers; sufficient licenses must be awarded to ensure a regular supply (Adam Smith Institute, 1980).

Another argument and the passenger complaints are usually about the low driving quality and safety of paratransit vehicles. The quality of drivers and the safety standard of vehicles could both be assured by published standards appropriate to the vehicles and their load. There is no reason to suppose that picking up and setting down at points of convenience causes more congestion than the obligation to pull in at fixed stops. Indeed, it allows the driver more flexibility to meet on-the-spot conditions (Adam Smith Institute, 1980).

Paratransit places very little burden on city finances and almost all the paratransit examples around the world operated with no subsidy. This is because, most of the paratransit vehicles are worn and the safety standards of them are often low. Sometimes, large numbers of paratransit vehicles can cause serious congestion, due to the fact that they care to make much more profit.

3. PARATRANSIT IMPLEMENTATIONS IN TURKEY

This chapter mainly covers the exploration of implementations of the paratransit system in Turkey in order to elaborate the recommended research purposes and inquiries. In the first part of the chapter, vehicle types used for paratransit in Turkey is sought. In the second part of the chapter, the concept of dolmuş-minibus and in the third part of the chapter the comparison of dolmuş and minibus concept has been investigated. In addition, the emergence of dolmuş concept is studied in fourth part. After explaining its emergence the evolution of dolmuş-minibus concept and the factors that influence its evolution for the time being is searched in fifth part. In that manner, the interaction between dolmuş-minibus and city structure, social and economic situations and then legal and regulatory issues are examined. At the last part of this chapter, the future of dolmuş-minibus system is discussed.

İstanbul Technical University library and Otokar Inc. databases are the most important recourses to be searched. In order to find out necessary and sufficient information about the keywords including paratransit system, unconventional transportation, minibus, passenger mass transport in Turkey, dolmuş system and so on, numerous online recourses are scanned with either direct access or through search engines like: ITU Library online search and Google Scholar in addition with the electronic databases such as IEEEXplore, EbscoHost, Ebrary, Elsevier, Science Direct, Transit Research Board, and Wiley Inter Science.

3.1 Vehicle Types Used for Paratransit in Turkey

In Turkey, paratransit system is implemented with various types of vehicles and organization modes. In general manner, midibus, minibus, van, minivan and even the passenger cars are commonly used vehicle types for paratransit operations. Table 3.1 indicates the distinctive features of the paratransit vehicles with different brand names and their technical applications. Most of these vehicles, belonging to different regulation class such as M1, M2 or M3, offer various features of passenger environment such as different seating or standing capacity and different vehicle entrance that affects the comfort and safety.

Table 3.1 : Technical features of paratransit vehicles in Turkey.

REGULATION CLASS	BODY		BRAND	PASSENGER CONDITIONS			FINANCE		
	Type	Chassis		Seating Capacity	Standing Capacity	Passenger Entrance	Maintenance Cost	Fuel Consumption	Vehicle Cost (x1000 TL)
M3 -min 8 person, - min 5 tons	Midibus	Steel Profile Structure Constructed Over Truck Chassis	IVECO M29 OTOKAR SULTAN ISUZU ROYBUS	25+1 27+1 29+1	~20-25	2 Outward Opening Two Leaves Door	Low	Poor Quality Diesel	150-180
M2 -min 8 person, - max 5 tons	Minibus	Steel Profile Structure Constructed Over Truck Chassis	OTOKAR M-2000, M-2010	14+1 18+1	~10-15	1 Outward Opening Two Leaves Door	Low	Poor Quality Diesel	85-125
			BMC LEVEND					Poor Quality Diesel	60-70
		Sheet Pressed Body	(KARSAN) PEUGEOT J9, J10				High	Euro Quality Diesel	60-80
M2 -min 8 person, - max 5 tons	Van	Mass Produced Sheet Pressed Body	MB. SPRINTER VW.VOLT FORD TRANSİT	14+1 18+1	~10	1 Sliding Door	High	Euro Quality Diesel	50-90
M1 - max 8 person	Minivan	Mass Produced Sheet Pressed Body	FORD TRANSIT S. CAB RENAULT TRAFFIC FİAT DOBLO	Max 8	-	1 Sliding Door	High	Euro Quality Diesel	50-70
M1 - max 8 person	Passenger Car	Mass Produced Sheet Pressed Body	HYUNDAİ ACCENT FİAT ALBEA TOYOTA COROLLA	4	-	2-3 Slam Door	High	Euro Quality Diesel LPG	30-50

Chases of the vehicles also may differ from each other, which usually depend on the body type and sales volume. Passenger cars such as automobiles and minivans together with vans and some newfangled minibuses have sheet pressed body while midibuses and some of minibuses use steel profile structure usually constructed over truck chassis. If the production volume is large enough such as automobiles or light commercial vehicles, manufacture of mass produced sheet pressed bodies become much more cost-efficient due to the fact that large amount in production can meet the costs of mold. In other words, the chassis type greatly influences the total cost of vehicle.

While choosing the type of vehicle among the brands, investment cost, which refers not only vehicle cost but also the maintenance cost of that vehicle and the fuel consumption values, plays an important role for the operators or drivers. Most of the paratransit vehicles are powered by diesel engines. However, in the previous models of these vehicles, drivers choose poor quality diesel, although it is very harmful for the environment and so for the health of human beings. It is possible to say that, the relatively higher cost of fuel and recent jump in especially gasoline expenditures in Turkey is of marginal significance in selecting the type of fuel. That is, most commercial vehicle operators are left almost no choice other than the poor quality diesel to make enough profit.

3.2 The Concept of Dolmuş-Minibus

In Turkey, the paratransit service is known and operated as the “dolmuş and minibus” system. Actually, the word “dolmuş” has a meaning of the "full" or "stuffed", as they depart not on fixed schedules; but when sufficient passengers have boarded. Şanlı (1981) puts forward his ideas like; if para-transit denotes an “intermediate” or “in-between” private automobile and conventional transit services, the dolmuş-minibus system is just that. The system is locally generated and it is citizens’ solution to the un-served transportation needs of people in İstanbul, providing effective service throughout the metropolitan area at reasonably low fares and with no direct demands from the public purse. It is also relatively flexible and demand-responsive and, apparently, successful in its operation. Nevertheless, the need for focus on “Para” modes of transport in developing countries is evident that, there have been only limited numbers of such studies for dolmuş-minibus system in İstanbul.

While this system in Turkey is not exactly a door-to-door paratransit application, is a good application example of a public transportation mode that is more flexible than the public bus and still more affordable compared to taxi option (Mastrogiannidou, et al., 2006). In this paratransit system, vehicles typically operate on an owner-driver model and they are licensed to run on widely defined specific routes by the local authority of the city they operate for profit. Normally the vehicles have low passenger capacity than the buses, which generally run on set routes within cities or to and from outlying towns and villages.

The dolmuş-minibus is a form of paratransit system specially categorized as hail-and-ride shared taxi, van, minibus and minivan service that operates in both urban areas and suburban areas across Turkey (Janes Information Group, 2004). In spite of the fact that this form of public transit is very commonly used in every part of the country, in the scope of this thesis, only the İstanbul case is elaborately studied in order to narrow down the subject. Because of the fact that İstanbul is the most crowded and the biggest city of Turkey and so that it hosts differentiated paratransit forms in its streets.

The dolmuşes and minibuses in Turkey also tend to be the case that similar van makes/colors are employed on particular routes. For instance, Taksim-Beşiktaş is all yellow vans, while other routes may use light blue or beige minibuses. Strictly speaking, the number of licenses is rationed for each corridor. There are formal 'terminus stops' (where drivers generally wait until they are almost full) but elsewhere along a corridor Dolmuş's stop where they are requested to do so. Additionally, there appears to be some kind of cooperative relationship occurring on a route-by-route basis as with taxi drivers (Janes Information Group, 2004).

Fares of these paratransit applications are usually set by the local authority in İstanbul, namely Department of Transportation Coordination of the Metropolitan Municipality (IMM), and are comparable to bus. Drivers always accept cash whereas on the buses either a fixed fare or pre-bought tickets are often required. Sometimes during off-peak periods, it is common for passengers to pay the fare for the empty seats for the dolmuş to depart without "filling up", if they do not want to wait for the entire car to fill up. Cooperation of passengers in passing fares forward to the driver and passing change back is customary.

The advantages that dolmuş's offer over the bus are that frequencies can be far higher in the peak and journeys tend to be quicker (Janes Information Group, 2004).

However, there are also problems. One is that while the numbers of dolmuş and minibuses have been frozen for forty years or so, the number of trips has risen dramatically as İstanbul has continued to grow (Enoch, 2005). As a result, there is a significant level of illegal operation, which has led to services being overcrowded and disputes over fares.

A second problem is that because the dolmuş and minibuses pick up and drop off passengers almost anywhere, there is a heightened risk of collisions and congestion caused by drivers veering sharply or stopping suddenly to maximize their revenue. Overall, more than half of public transport trips (400 million passengers a year) in the city are carried by around 4,000 14-seat minibuses and 16,000-orso dolmuş licensed shared taxis (Janes Information Group, 2004).

3.3 The Comparison of "Dolmuş" and "Minibus" Concept

There are actually, the most widely used, two different paratransit systems in İstanbul. Dolmuş is one of them; minibus is the other one. The distinction is important. Because the load factors and capacities, operating costs and operating areas, fares and passenger profiles of these two systems may differ substantially. However, the term "dolmuş" has rapidly become a common name for both systems in some cities like Ankara. As also Şanlı (1981) described, the current paratransit types of operation in İstanbul can be listed as follows:

- Midibus: This type of operation is provided by midibuses that larger scaled than the minibuses and small scaled than the conventional buses. The operation is generally special type of transit such as employee or student service. That is, they are used to transport employees from designated pickup points in the inner city to outlying factories or commercial centers.
- Minibus: This type of operation refers to the service provided by those vehicles defined and specially designed as minibus and duly licensed. These vehicles, particularly and commonly the minibuses, are distinguished by their light blue or beige colors and very crowded route tables hanged or written on the vehicles. The examples of this type from İstanbul can be seen as Gebze-Harem, Kartal- Kadıköy routes etc (Figure 3.1).

Figure 3.1 : A minibus example currently used in İstanbul.

- Dolmuş only: This type of operation refers to the service provided in accordance with legal requirements and definition of dolmuş-mostly station wagons usually with 3-2-2 seating arrangement -or at the will of operator- and total 6-8 passenger capacity. These vehicles are usually distinguished by their yellow color and the "dolmuş" sign placed or written on the vehicle with a specialized route code (Figure 3.2). The examples of this type from İstanbul can be seen as Taksim - Kadıköy, Eminönü- Nişantaşı, Beşiktaş- Harbiye routes, etc.

Figure 3.2 : A dolmuş example currently used in İstanbul.

- Taxi-dolmuş: This is a mix operation involving primarily taxi service and secondarily dolmuş service depending on the time and place of the operation. In certain occasions, especially when congestion and demand levels are high, the operator may switch from regular taxi operation to dolmuş operation instantly depending on the time of day or some days of the week. The examples can be seen in most part of İstanbul.

The bases of the similarities and dissimilarities of the dolmuş-minibus system are hidden in the operational aspects, economics of operation, the organization and the socio-economic profile of the drivers as well as the characteristics of the vehicles used in the operation. Indeed, a distinguishing characteristic of the dolmuş-minibus system in İstanbul is the type of vehicle used in operation. The type of vehicle distinguishes not only the dolmuş-minibus system from other forms of transport in the metropolitan area but also from one another within the system itself (Şanlı, 1981).

Actually, in the traditional manner the dolmuşes are usually yellow vans and shared cabs commuting 6-8 people at a time. These vehicles operate as share-taxi system and so provide a relatively comfortable transportation. They are usually transformed and modified from a more suitable vehicle to carry passengers. Dolmuşes are also one of the more expensive mass transport alternatives.

The other one is minibuses, which are more common, much cheaper and much easier to get access. Minibuses usually have a seating capacity for 14-20 people, and standing capacity depending on the operating condition, which means the total passenger capacity of minibuses are more than those yellow colored shared taxis, but less than a conventional public bus services. They are one of the less comfortable choices among the other paratransit modes. Indeed, as also Şanlı (1981) pointed out that, when 30 persons are forced to occupy a space that is designed for 10 or 15 passengers, a great deal will be lost in terms of the quality of the service. Passengers are feeling each other’s breathing on their necks or faces, leaning on each other or sitting on each other's lap are common scenes of minibus transport in İstanbul. Added to this is the arrogance of the driver or his aid to tell the complaining passengers to get off and take a taxi for a more comfortable ride. In addition to these explanations, Table 3.2 placed below has figured out the organizational features of paratransit implementations in İstanbul.

Table 3.2 : Organizational features of paratransit implementations in İstanbul.

Operation Type	Routes	Route Length (KM)	Operating Mode	Time Schedule	Legal Condition	Fare	Examples from İstanbul
MIDIBUS	Pre-Arranged, Regular Route	5-50	Shuttle Service School Service Employee Service	Fixed	Route rental Special license plate code (J)	Pre-Paid or Promotion	Bus Terminal Services, Employee and School Services
	Regular Route	20-60	Hail Request At Fixed Stops	Fixed		Season Ticket, Ticket, AKBİL or Cash	Şile-Harem
MINIBUS	Regular Route	4-50	Hail Request Fixed Departing and arriving point Flexible Picking up and Dropping off Points	Depends on Passenger density	Route rental Special license plate code (M)	Cash Set by Local Authority	Kadıköy-Pendik Gebze- Harem Sarıyer-Levent
	Regular Route	10-80	Hail Request Daily Country and Village Services	Fixed 2 or3 Times a Day	Route rental	Cash	-
DOLMUŞ	Semi-Regular Route	2-20	Fixed Departing and arriving point	Departs when stuffed	Route rental	Cash/ Fixed or Depends on the Distance Set by Local Authority	Bostancı-Taksim Kadıköy-Üsküdar
TAXI-DOLMUŞ	Departs from Train Stations, Piers and Central Subway Stations to passenger's destination point	-	Legally in Taxi status but operates like a Dolmuş	Departs when stuffed	Special license plate code (T)	Cash Depends on the distance	Eminönü Ferry Pier, Beşiktaş Ferry Pier, Kabataş Ferry Pier,

The fare structure in dolmuş operation is on a per-passenger basis and officially fixed for all routes. However, the dolmuş operator does exploit excessive demand situations in the absence of reasonable alternative means of transport and shifts to taxi operation or declares his service “express dolmuş”, charging almost twice the regular fare. While apparently contributing to the profitable operation of the system, such flexibility reduces the availability of service to people who are not willing to pay more than the regular fare. Even those who do pay consider the exercise unfair and resent the operation. The minibus does not enjoy such flexibility but it does fill up to almost twice its legal passenger capacity. Such overcrowding, coupled with the apparently unscrupulous driving habits and attitudes of the minibus operators, has contributed to the resentment of this system by the public (Şanlı, 1981).

Furthermore, there is a localization of the dolmuş-taxi operation within the city-proper and the minibus operation within the outlying areas. Indeed, a dolmuş or taxi vehicle is allowed to operate freely throughout the metropolitan area while the operation of the minibus on designated routes is strictly regulated and observed by the Minibus Operators' Association, the traffic officials, as well as the operators themselves. While the dolmuşes operate primarily within the densely built-up, central sections of the metropolitan area, the minibuses serve primarily the outlying sections, also providing connections between the outlying and the central sections. Hence a certain level of redundancy in transport services is provided within the central sections of the city -by the municipal bus system and the dolmuş-taxi systems- whereas in the outlying sections of the city the minibus system is the predominant means of mass transport. Additionally, while the minibuses provide service to the new growth and squatter areas and to relatively lower income groups, the dolmuş vehicles serve all income groups within the relatively central sections of the city (Şanlı, 1981). In addition, in the outlying squatter or other illegal settlement areas, larger size midibuses operate without a proper license.

Minibuses are generally operated under two main models:

- The first one is operated by a company, or subcontracted by a public transit authority. Often, individual vehicles are owned by individual drivers but operate under the same company name. Alternatively, the vehicles are owned by a single company that pays the drivers.

- Second one is private vehicles. These tend to be more overloaded than company vehicles, usually with passengers standing on feet. They are usually owned by individuals, who do not involve themselves in the day-to-day running of the taxi. Instead they either employ a driver and a conductor, who maintain and operate the vehicle.

3.4 The Emergence of Dolmuş Concept

In many of the large urban centers of Turkey, providing an acceptable level of public transportation for all income groups has long become one of the most pressing problems. Şanlı (1981) has pointed out that:

> ...A characteristic dimension of the general problem of urban transport has been the failure of the municipal bus and other government-operated public transport systems to meet the demand for the routine travel needs of the people. Primarily as a result of this situation, new -and indigenous- forms of public mass transport have appeared in most of the large cities of the country. The dolmuş-minibus system is such an indigenous form of urban mass transport in İstanbul. The system appeared and developed rapidly as a result of even more rapid increase in the un-served demand for urban movement. (p. 1)

In the early 1930s, the economic depression that terrorized the whole world especially America had also affected the Turkey severely. Taxi drivers are also the significant segments of the population who badly affected from the economic crises.

The first dolmuş of Turkey had started to operate in İstanbul with an extraordinary story in 1931. One taxi driver called Halit had a proper client who is a Jewish businessman and so he was luckier than the other drivers because of the fact that he guarantied the 80 kuruş (wages per hour) in a day from this client. Every day he took this businessman from Nişantaşı to his workplace, Eminönü. One day, the proper client expressed to the driver that he has a fall down on the job and he cannot anymore afford the taxi fare for the everyday, which is an almost 25-20 lira in a month. The businessman had proposed a new operation mode to the taxi driver: I have four more colleagues working at the same place and you will carry five people instead of only me. You will gain 20 kuruş more than the wages per hour, which will correspond to the depreciation of your vehicle. Passengers getting in the same vehicle and taking the journey at the same route will share the taxi fare among each other. This is a peculiar and unprecedented novelty until that day, but there is no financial loss for the driver and he can even apply this mode for the other hours of the day. Halit found this idea logical and said "ok" and this was the only word that the dolmuş gives birth in İstanbul (Hürriyet, February, 9, 1974).

The dolmuş concept had firstly started to operate in 1931, and İstanbul municipality had recognized the dolmuş officially in 1954, twenty three years later. The first official price plan had been given to dolmuş in that year. Interestingly, in the past dolmuş drivers were expected to be married, at least twenty five years old and morally upright person.

The first dolmuş route in İstanbul was between Taksim –Karaköy. Yellow-black checked line had been placed to the automobiles to be referred to that; it is a taxi or a dolmuş since 6, November 1931. The dolmuş and taxi distinction with the license plate has been obligatory since 1933 (Hürriyet, February, 9, 1974).

The dolmuş system owes its appearance and development to the inadequacy of the available alternative means of public mass transport: it is citizen’s solution for people’s need for movement. The system has recently become visible but, primarily as a problem of urban transport rather than solution to that problem. However, apparently, it is both; or, at least, the system’s problem emanate from the general problem of urban transport, urban development or general social economic development of the country (Şanlı, 1981).

Actually, the concept of dolmuş, is a business segment and a way of livelihood caused by the own circumstances of the country. At the end of this concept work, a service is arisen that benefits the public generally and any Public Utility Company cannot provide (Sezer, 1976).

The concept of “dolmuş” had initiated with an interesting story in İstanbul and this concept has spread swiftly to most of the cities in the country. In course of time, dolmuş has evolved till today.

3.5 The Evolution of Dolmuş-Minibus System

The evolution of paratransit system in Turkey has depended on the various factors. It is nourished from numerous resources and events while evolving. The changes or improvements in the city structure, social and economic situations related with whole stakeholders of the system, legal, regulatory and the governmental issues in the country are the most effective ones.

The evolution of paratransit vehicles particularly dolmuşes and minibuses used in Turkey are studied in depth. Below there can be seen this evolution phases by decades:

- Earlier-1960s;

When the dolmuş concept became pervaded, modified US-made automobiles were in use as a dolmuş vehicle due to their convenient bodies (Figure 3.3). The modifications were usually applied to make the vehicle longer or larger, so that they could carry more passengers. As a matter of fact, there were only imported automobiles in Turkey till the mid-1960s.

Figure 3.3 : Archaic dolmuş models operated eraly in 1960s ("wowTURKEY", 2011).

After started motor vehicle production in Turkey, a vehicle type, which is more convenient to paratransit system and particularly to be used as a dolmuş for the inner-city traffic, came onto the market: "Minibus". These vehicles, which were seemed as smaller size of buses to the public at first sight, had a capacity of eleven passengers. The minibus engine was considerably small-sized so that its fuel consumption was also quite less for the operators. Due to these reasons, the number of minibuses had become rapidly increase in all cities, even in suburban areas (Tekeli and Okyay, 1981).

The first and the most common examples of minibuses operated in early sixties, as also seen in Figure 3.4, were called "Baltaburun" among drivers as their front face looked like broadax. The brand of those archaic minibuses was Renault although they did not have any component of Renault brand except for the chassis and vehicle license. Because almost all drivers had made them modified in small industries, after they had purchased. Their differential gear, axle shaft, steering wheel, transmission box, fuel tank and even engine had changed with other brands, which were thought to be more appropriate for passenger transportation (“wowTURKEY”, 2011).

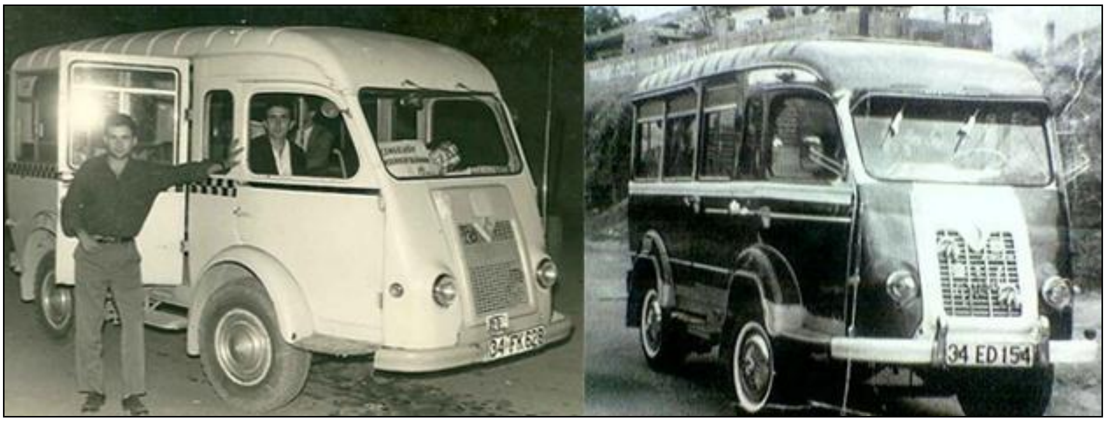


Figure 3.4 : Minibuses called "Baltaburun" among drivers operated in 1960s (“wowTURKEY”, 2011).

Minibus manufacturing in Turkey started with the efforts of some small entrepreneurs as engineer's workshop by modifiying the import vehicles. However, when the needs became increase and then these needs were realized by the firms, contract manufacturing were started. The vehicle seen in Figure 3.5 was one of the first example of this contract manufacturing. The firm "Otokar" was manufacturing the outer structure of the minibuses after imported the chassis by using their experiences gained from the production of city and intercity buses. These minibuses were called "4 köşe reno" or "otobüs kasa reno" among people in those years. The reason why people denominate them with those names was their revised outlook, which was looked like small buses (“wowTURKEY”, 2011).

By the end of 1960s more original minibuses (Figure 3.6) began to be seen in the market. In these years the firm Otokar had another contract with the two German firms namely Magirus and Deutz. That is to say, the engines were impored from the firm Deutz; the chasis and the whole body of the vehicles were imported from the firm Magirus. Therefore, the minibuses sold in the late 1960s were manufacured with the name of Magirus-Deutz. In fact, when came to 1970s, the firm Otokar had started to manufacture its own design minibuses. Although whole body, structure and the chasis of the minibuses manufactured in seventies and the next decades belong to Otokar, those vehicles were still known as by the name of Magirus or Deutz among people.

Figure 3.5 : Minibuses manufactured as contract in 1966 (Otokar database).

Figure 3.6 : *80 E 5* model minibuses launched in 1969 (Otokar database).

- 1970s;

When came to seventies, the sharp contrast between minibuses and taxi view dolmuşes has appeared especially in the big cities. Tekeli and Okyay (1981) have pointed out that: “the outlook of minibuses was quite different and peculiar and this appearance was denoted as idleness by the authorities” (p. 50).

Figure 3.7 and Figure 3.8 represent the taxi like dolmuşes operated in Istanbul during this period. These dolmuşes were resembled to the personal autos and operated as carsharing system vehicles, even though they could be classified as public transport vehicles. In Figure 3.9 a minibus example of the same period whose outlook is totally different from the dolmuşes can be seen.

Figure 3.7 : A taxi like dolmuş example in the street operated in seventies ("wowTURKEY", 2011).

Figure 3.8 : Vehicles used as Dolmuş in 1970s ("wowTURKEY", 2011).

Figure 3.9 : A minibus example of brand "Commer" ("wowTURKEY", 2011).

In this era, minibuses were produced by constructing over truck chassis and they had quite powerful engines (Figure 3.10). Some of them were four-wheel-drive (4x4) vehicles and very durable due to their sheet body structure. Therefore, most of those minibuses were used as utility vehicles for gendarmerie with small modifications or towing vehicles as they had the opportunity of travel over rough conditions. The perception of being strong bought them a name "panzer kasa" among drivers (“wowTURKEY”, 2011).

Figure 3.10 : *80 S 4,5* model minibuses launched in 1973 (Otokar database).

Furthermore, most of those archaic minibuses operated in 1970s were manufactured with two slam doors for passengers and one door for driver. However, drivers usually cancelled one of the passenger doors after they purchased and placed a stool or a portable seat so as to carry one more passenger.

In fact, towards the end of 70s, slam doors of minibuses were modified in small industries and pneumatic doors working with pistons became mounted to the vehicles by adding compressors.

Minibuses operated in seventies were quite primitive to answer the public transport need because their structural features were not convenient for comfortable and safe travel. Their seating passenger capacity as seen in Figure 3.11 was much more than the standing passenger capacity; nonetheless, they were carrying standing people. Travelling with those, old minibuses by standing position were quite hard for passengers, because the inner height of those vehicles were very low as can be seen in Figure 3.12.

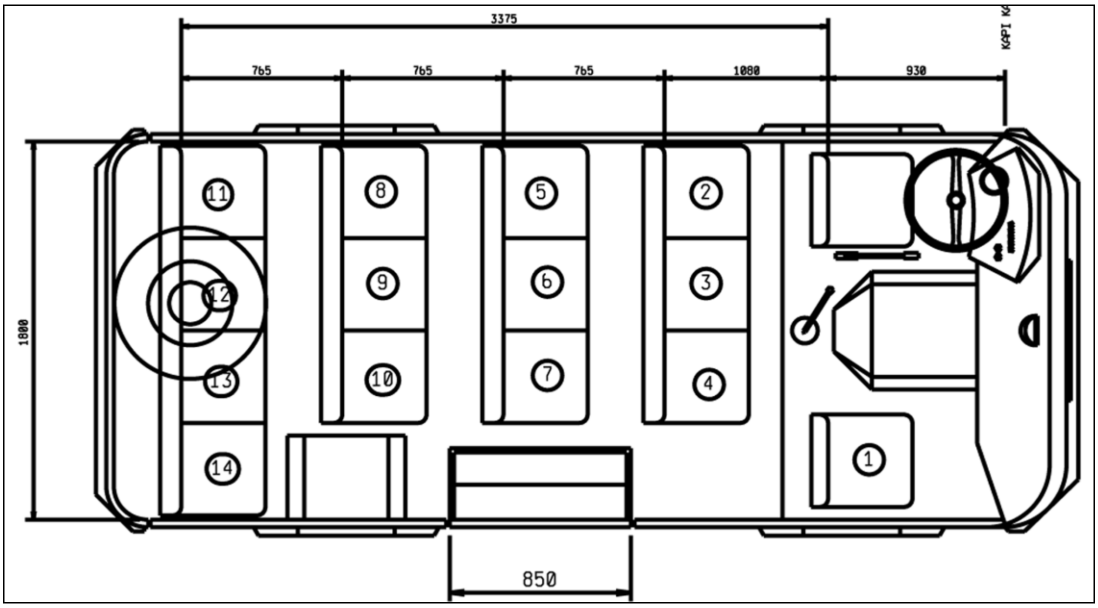


Figure 3.11 : Seating plan of *80 S 4,5* model minibuses (Otokar database).

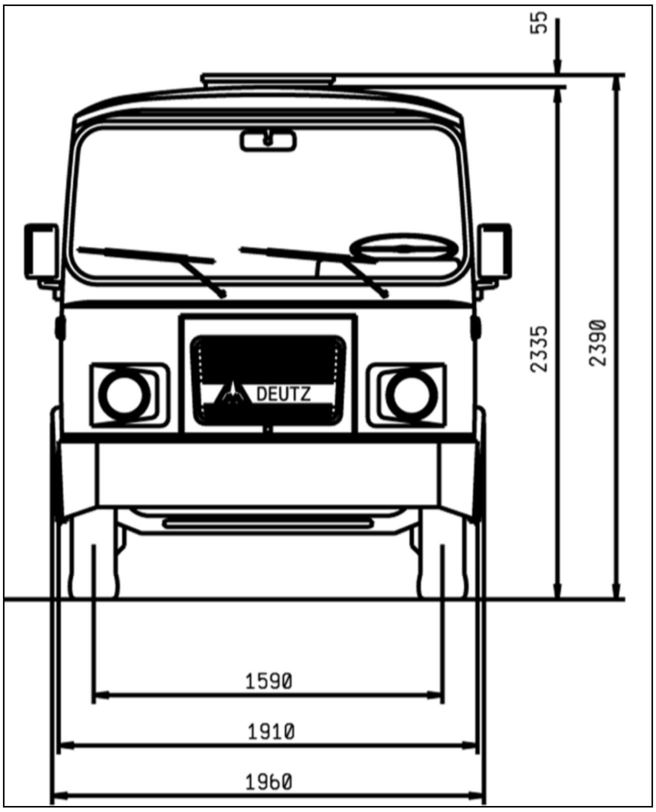


Figure 3.12 : Front view and dimensions of *80 S 4,5* model minibuses (Otokar database).

- 1980s;

In this decade, vehices operated as dolmuş still looked like as personel autos. There could not be observed a major change in their external appearance except for small dimensional modifications as seen in Figure 3.13.

Figure 3.13 : Dolmuşes operating in 1980s on the roads (“wowTURKEY”, 2012).

Unlike dolmuşes, minibuses had become change and started to be manufactured specifically to the changing demands of the public in those years. By the mid-eighties, minibuses were produced with more user-centered approach. For instance, their interior height, width and length were increased and handrails were placed in specific areas, so that they streamlined and became safer for standing passengers. In late 1980s, almost all minibuses were manufactured with pneumatic doors, that is to say, they were powered by compressed air. In Figure 3.14 there can be seen a minibus model launched in 1987. Figure 3.15 and Figure 3.16 represent the technical drawing and dimensions of same model minibus. Additionally, Figure 3.17 indicates the driver area and the passenger compartment of this minibus. Those examples from late 1980s imply that more specific minibus designs for both drivers and passengers were started to be seen on the market.

In addition, because gasoline vehicles complete their life, the first examples of diesel engine used in minibuses started to be seen in late 1980s (“wowTURKEY”, 2011).

Figure 3.14 : *80 E 5,5* model minibus launched in 1987 (Otokar database).

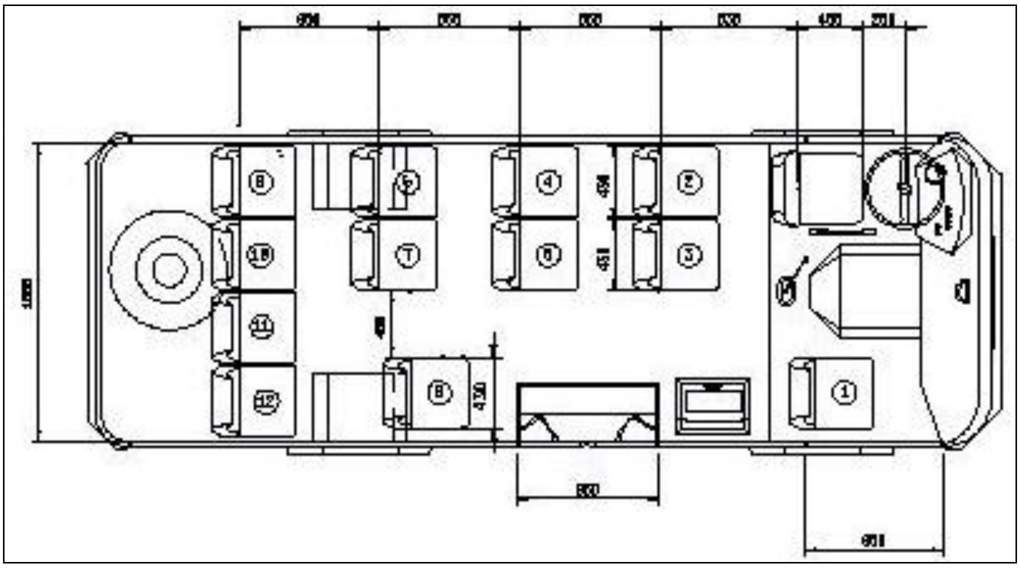


Figure 3.15 : Seating plan *of 80 E 5,5* model minibus (Otokar database).

Figure 3.16 : Driver and passenger area of *80 E 5,5* model minibus launched in 1987 (Otokar database).

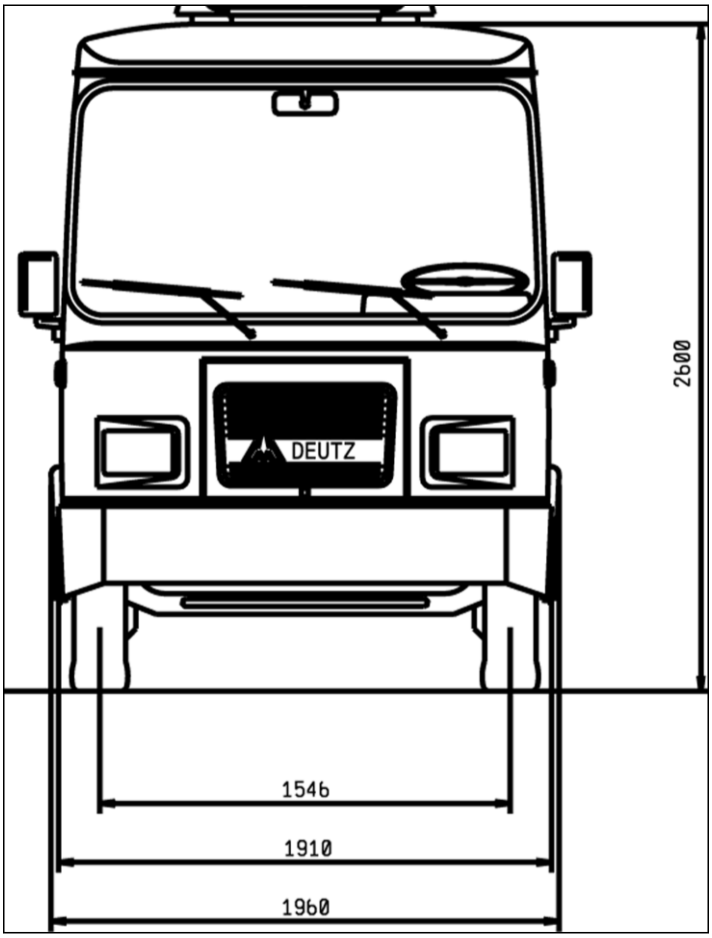


Figure 3.17 : Front view and dimensions of *80 E 5,5* model minibus (Otokar database).

- 1990s;

By the nineties, vehicles used for dolmuş concept were the most evolved ones among other paratransit options. A shift can be observed in the dimensions of those yellow dolmuşes; that is, they began to appear like commercial vehicles rather than the personal autos. Therefore, the increase in size the of dolmuşes make them approach the size of minibuses and make their passenger carrying capacity increase relatively.

Actually, after American vehicles used for dolmuş concept has created a market in previous decades, some firms has realized that, there is a specifically designed vehicle need in the market to carry passengers as dolmuş mode (Boztepe, 2008). For instance, in the early 1990s, the firm Ford Otosan had manufactured the vans namely "Transit" to be used as dolmuş. These vehicles were sold in large amounts and gained a great success in every part of the country especially in Istanbul (Figure 3.18).

Figure 3.18 : Ford Transit vehicles used for dolmuş concept in 1990s ("wowTURKEY", 2011).

Parallel to the growing population and thereby the increase of need for public transportation compared to previous decades, minibuses have evolved so as to carry more passenger. Their interior height was expanded a little more and their seating plan became to be redesigned, so that their interior environment became more spacious and they could carry more people in standing position (Figure 3.19 and Figure 3.20). Nonetheless, it can be said that, minibuses have evolved less than the dolmuş vehicles in 1990s.

Figure 3.19 : *80 S 5,5* model minibus launched in 1993 (Otokar database).

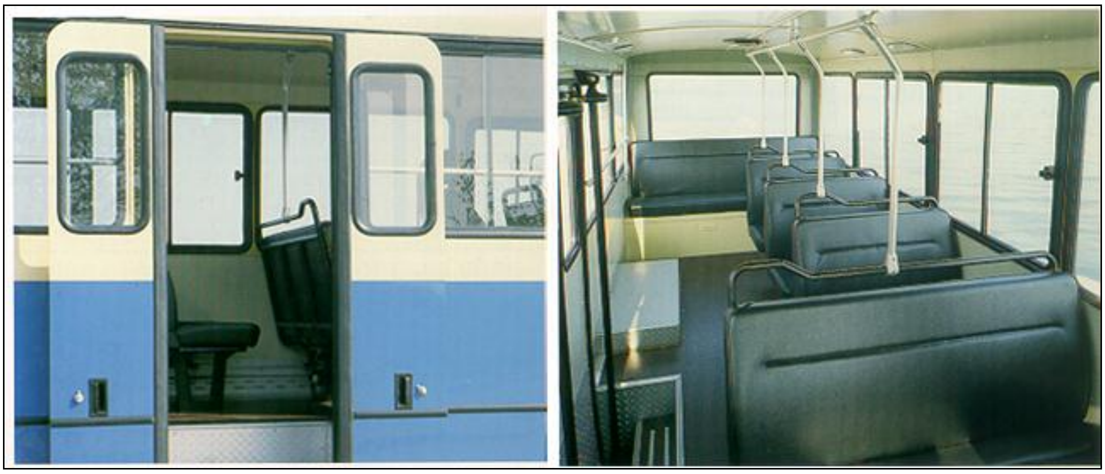


Figure 3.20 : Interior of *80 S 5,5* model minibus (Otokar database).

Furthermore, minibuses manufactured and operated in the late 1980s and during 1990s, represented an image of “nose-in-the-air”. Actually, the front side of the minibuses was seen like levitated (Figure 3.21). This extraordinary appearance was due to drivers own functional solution. In those terms, minibuses had manufactured originally with leaf suspensions, which make them hard to use in bad road conditions especially in Cobblestoned pavement. In Figure 3.22 there can be seen the leaf suspension and its layers.

If a vehicle have stiffer suspensions, then using steering wheel also become harder. In order to make these vehicles easy to use, drivers took their minibuses to a repairperson and made the suspension softer by lessening the leaf layers connected to rear axles. However, leafs had lost their camber structure over time with too many passengers’ weight and became collapse. Therefore this levitated appearance became arise (“wowTURKEY”, 2012).

Figure 3.21 : Minibuses whose front side seems like levitated.

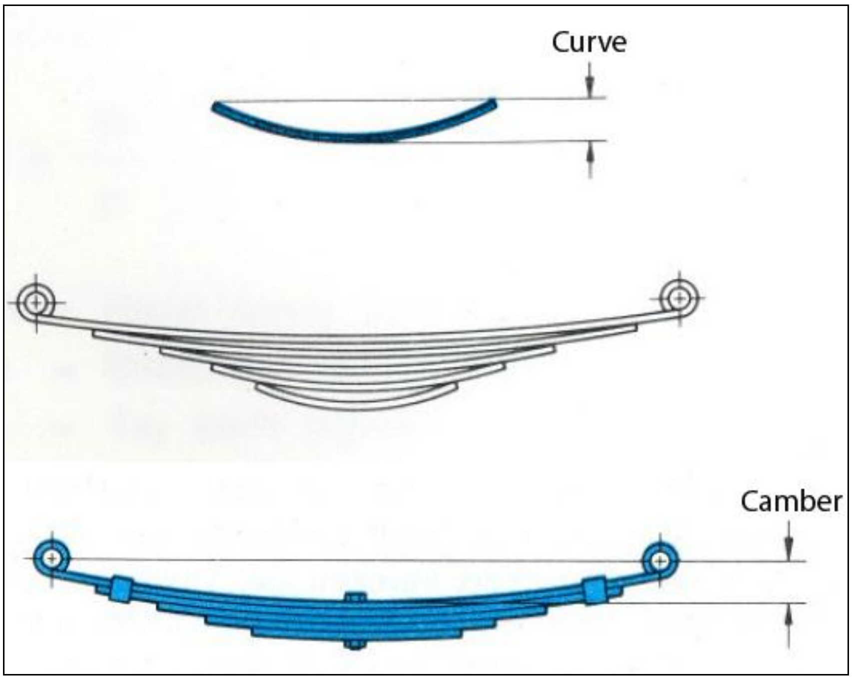


Figure 3.22 : Leaf suspension drawing and its layers used in minibuses of 1980s and 1990s (“Otobil”, 2012).

In 1990s, Otokar brand minibuses (still known as Magirus among people) was running dominantly in Istanbul and their size, especially height was much enough to carry a lot of standing passengers. Towards the end of 1990s, a modification trend in Ford Transit vans has become. Drivers who have Ford brand vans became to extend and heighten their vehicles in small industries to enter and work in minibus routes (“wowTURKEY”, 2011).

- 2000s,

By the end of this decade, vehices operated in dolmuş routes started to be changed gradually. Because the Ford Transit vans, that were the most used vehicles as dolmuş mode in Istanbul till today, started to become old-fashioned. Therefore, drivers tried to look for a new model, which would be convenient to operate as dolmuş. The brand Renault *Trafic* was the most convenient one although its seating units are not suitable and needed to be modified for such kind of public transportation (Figure 3.23 and Figure 3.24). Therefore, drivers started to use this vehicle by changing its seating units with the ones, which would be more suitable against vandalism.

Figure 3.23 : Renault *Trafic* model dolmuşes used in 2000s.

Figure 3.24 : Interior of Renault *Trafic* model dolmuşes.

M-2000 model minibuses seen in Figure 3.25 were manufactured in early 2000s by the firm Otokar. The firm successfully identified the market gap and adapted its licensed technology to local requirements (Boztepe, 2008). The design of these minibuses were not too complicated and if there occurred a problem in the vehicle drivers could easily solve it by their own efforts. Maybe because of that, these vehicles became the most preferred minibus model among drivers and so the prototypical vehicle of minibus service among public. In Figure 3.26, Figure 3.27 and Figure 3.28 there can be seen the seating plan, interior and driver area of M-2000 model minibuses.

Figure 3.25 : *M-2000* model minibus launched in 2000 (Otokar database).

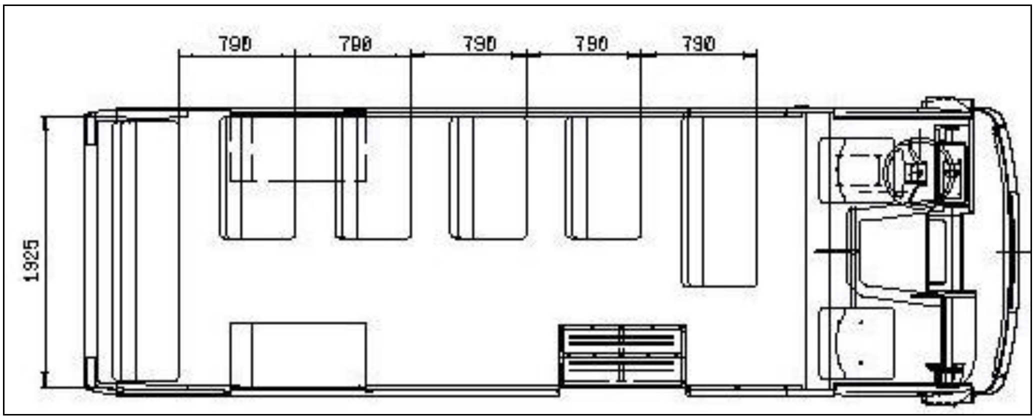


Figure 3.26 : Seating plan of *M-2000* model minibus (Otokar database).

Figure 3.27 : Interior of *M-2000* model minibus (Otokar database).

Figure 3.28 : Driver area of *M-2000* model minibus (Otokar database).

Afterwards, there have been some facelift models of the same series launched in the following years namely *M-2000 Koçum* in 2002, *M-2000 Platinium* in 2003 and *M-2000 Sport* in 2004. Actually, these different model years called with different attractive names have almost no change in the power unit, motor, transmission box and some other electronic and mechanical systems. Interestingly, although these models differ from each other with little design changes merely in form, styling and trimming details, drivers found each model better than the previous ones especially in traction, stopping distance and engine power. This shows that how design and appearance of these commercial vehicles attracts the customer perception and influences their purchasing decision.

In the late 2000s, a new model minibus with more modern and different outlook called *M-3000* has broken into the market (Figure 3.29 and Figure 3.30). For any minibus, almost all drivers and potential purchasers have never preferred separate seating units for each passenger with the aim of carrying more passengers in cramped position. On the other hand, almost each passenger prefers to travel by sitting in a separate seat allocated to whom. The seating units of *M-3000* model minibus have tried to solve this contradiction in seen Figure 3.31.

Figure 3.29 : *M-3000* model minibus launched in 2007 (Otokar database).

Figure 3.30 : Driver area of *M-3000* model minibus (Otokar database).

In addition, the dimensions of *M-3000* model were different from the ones manufactured until today. It was more in a midibus segment rather than a minibus. However, this model did not work in the market and sales figures were low than expected. Therefore, it could be understood that, this size of vehicle was not suitable for minibus system due to its cumbersome structure.

Figure 3.31 : Interior and seating units of *M-3000* model minibus (Otokar database).

- 2010-today;

When came to the last decade, changing customer needs and demands influenced the market condition. Therfore more modern and more user-friendly minibuses began to designed and come on stage. Below are the images of *M-2010* model minibus launched in 2010 by the firm Otokar (Figure 3.32 and Figure 3.33). As seen from the images, this new vehicle provides easy getting on and off with its low-floor body, reducing the time required for each cycle. Actually, this vehicle is the first low-floor minibus began to seen in Turkey, which makes it a new generation vehicle.

Furthermore, the vehicle is suitable for narrow streets and inner-city operation due to its high manoeuvrability. It also provides comfort with pneumatic spring suspension on each wheel. The ramp and the kneeling feature provide convenience to people with reduced mobility, during getting on and off. Additionally, air conditioners begin to be used for new minibuses manufactured in this decade.

Figure 3.32 : *M-2010* model minibus launched in 2010 (Otokar database).

Figure 3.33 : Interior of *M-2010* model (Otokar database).

Summary

When examined the evolution of dolmuş-minibus system, particularly referred to the vehicles evolution, it can be said that changes on vehicle types and features seen over the years have usually stem from drivers own efforts working together with proletarians from small industries. These spontaneous vehicle modifications, most of who were just for profit, were mostly occurred by observing the behaviors and habits of passengers. After the firms had realized those small operators' efforts, they started to manufacture vehicles, which were thought to be more convenient than the previous ones.

When looking at all the images shown above, it is possible to say that, till the last decades there is little or no industrial designer's touch on vehicles. This is more probably because of the fact that the importance of industrial design on paratransit vehicles has dawn on recently.

As also Şanlı (1981) mentioned, the dolmuş-minibus system in İstanbul has provided effective transport service for the majority of the city’s inhabitants; with success that cannot be disputed considering the circumstances and its environment of operation. In this study while adverting the evolution of paratransit system in Turkey both dolmuş and minibus schemes are referred.

In due course, almost three or four decades later from the emergence of dolmuş concept, the dolmuş-minibus system became visible as a problem in the eyes of the general public in İstanbul despite the effective role of it such as lower waiting time for filling, quick movement, relatively less congestion in the outlying sections of the city and the longer working hours. This is primarily due to the problems of service availability, reliability and quality in dolmuş-minibus operation. Additionally, the public’s resentment of the system is sometimes because of the conflict of interest and keen competition for the limited road surface. Actually, counter arguments have also been advanced in favor of the system. It is expressed that the appreciation of the dolmuş-minibus system as an indigenous device of urban adaptation, a people's solution to people's own needs and as a transport system that has served to fill the gap in mass transportation needs of the city (Şanlı, 1981).

In fact, there are still critical issues, which will confront both the proponents and the opponents of the system. The first issue is that of whether the system can be eliminated at all and the second one is the extent and manner of limitation or encouragement, and the organization and regulation of the system within the total system of transport in İstanbul. The second issue is predicated upon the assumption that the system could not be eliminated even if governmental policies or actions were directed towards that end. That is, the accommodation of the system, its integration within the total system of transport appears to suggest itself as a preferable alternative in the short or, possibly, even in the long run (Şanlı, 1981).

3.5.1 The interaction between dolmuş-minibus and city structure

The city and its structural evolution have a close relationship with the evolution of paratransit system in that city. Take, for example, Turkey case, when the cities enlarge, the amount of dolmuşes operating in that city also increase. At first, the dolmuşes in existing routes increase and this increment is limited when it reaches a certain amount; on the other hand, the new routes start to emerge. Some of these new routes are on the completely new passageways, while some are formed on the division of previous routes, that is, different dolmuş routes become operating on the same passageways (Tekeli and Okyay, 1981). Figure 3.34 represents these basic evolution phases of the dolmuş routes.

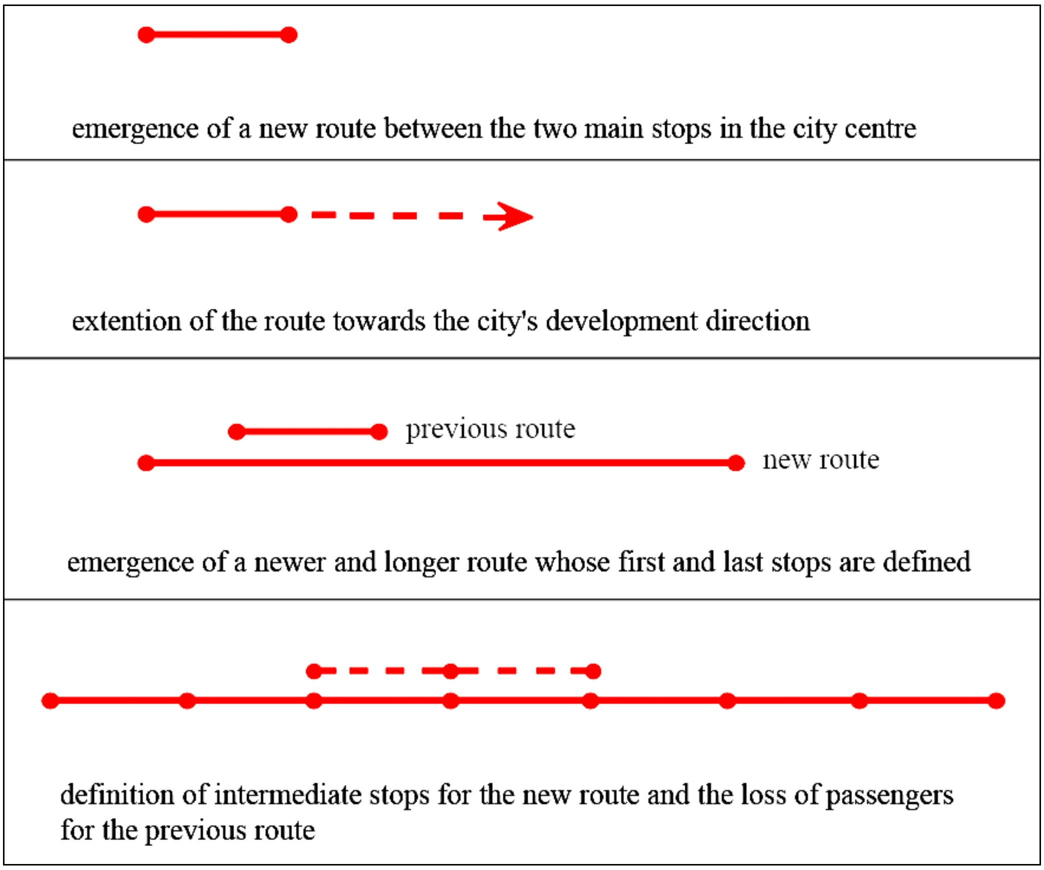


Figure 3.34 : Basic evolution phases of the dolmuş routes (Tekeli and Okyay, 1981, p. 46).

Indeed, the appearance of a new dolmuş route in the city generally occurs in a spontaneous manner. When an increase in travel demand is realized in any urbanized terrain, dolmuş/taxi operators or drivers residing in that area start to carry passengers according to demand and this operation occurs irregularly and informally. The appearance of dolmuşes and taxis moving around to carry people on special demands particularly in the rush hours of morning and evening times is the first sign of a new dolmuş route emergence (Tekeli and Okyay, 1981).

Another type of the physical appearance of a new dolmuş route is the bifurcation of the passageways. Tekeli and Okyay (1981) depicted this as seen in Figure 3.35. While the city is growing annularly, the areas left between the radial roads also grow. Therefore, the new routes emergence is anticipated by the embranchments of the passageways and old radial roads to meet the transport demands of people living in these areas.

When a dolmuş route first emerged, its stops, stations, fares and the amount of the vehicle operating on that route is usually undefined. As time pass by, a route started to be in order and a self-regulated internal organization rise while the control and force of municipality, constabulary and corporations increase over the route.

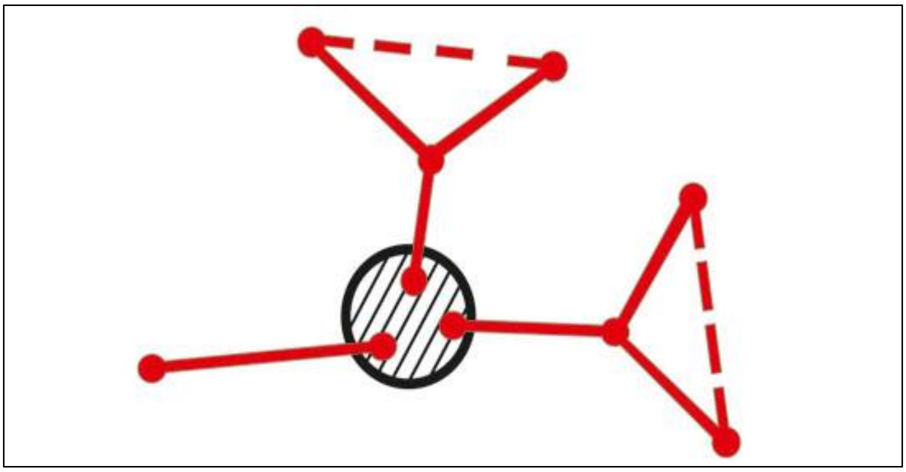


Figure 3.35 : Bifurcation of the passageways (Tekeli and Okyay, 1981, p. 46).

Tekeli and Okyay (1981) have represented the regulation and order steps of a new paratransit route as follows:

- The first step is to define the starting and finishing point of the trip and so that the first and the last station of the route. It is needed for the trip demand to put in an order. Thus, the passenger can know where to find the dolmuş.
- The second step is to ensure that the dolmuş waiting at first station will be stuffed enough. Because it is the vehicle, which departs when sufficient passengers have boarded, the first station is important. Passengers expect to get on and off anywhere, they want; on the other hand, drivers usually want to use the defined points to let passengers get off and undefined points to take

passengers. Thus, there usually occurs a contradiction between aims of controllers and features of dolmuşes.

- Another step is to define the vehicles that will operate in that route. This is commonly done by placing a signboard of the route to somewhere on the vehicle. Actually, standardization of vehicle types according to their brand name or model is also preferred to operate at the same route.
- One another step is to determine the fares that will be collected from the passengers. This is generally determined by the municipality.

As also mentioned before, size of the city is the most important factor that affects the paratransit system. Tekeli and Okyay (1981) studied the evolution of dolmuş-minibus system depending on the city size with four different examples. In the figure 3.36, it can be seen four-stage development for the cities. This figure only indicates the general tendency and each city may have discrepancy depending on its own historical improvement. At the first stage, there is a city, with a population of more than 50000, whose dolmuş route appears towards the enlargement of the city. In such a city, most likely there has not been a conventional public transport system yet. At the second stage, the city has a population between 100.000 and 150.000. Here, the paratransit operation starts from the city center towards the city enlargement areas, which are more than one direction. At the third stage, the population of the city is more than 200.000, thus, it cannot be expected that whole paratransit operation to start from one point in the city center. Usually conventional municipality buses operate at the city center or specifically around the main square.

The starting points of dolmuş routes are withdrawn from the city center to the outer edges of city and differentiation starts to occur between the routes according to the type of vehicle. The fourth stage is reached when the city population is more than 1.000.000. This size city has more than one center, and each sub-center is the starting points of paratransit system, which operates towards the suburban areas of the city.

The secondary centers usually become like vehicle change points and the trip demand is high between these sub-centers. Thus, dolmuş system, which has a tendency to create a network as the city, expands, makes the total public transportation more cost effective. Indeed, the spatial differentiation becomes more certain according to vehicle types (Tekeli and Okyay, 1981).

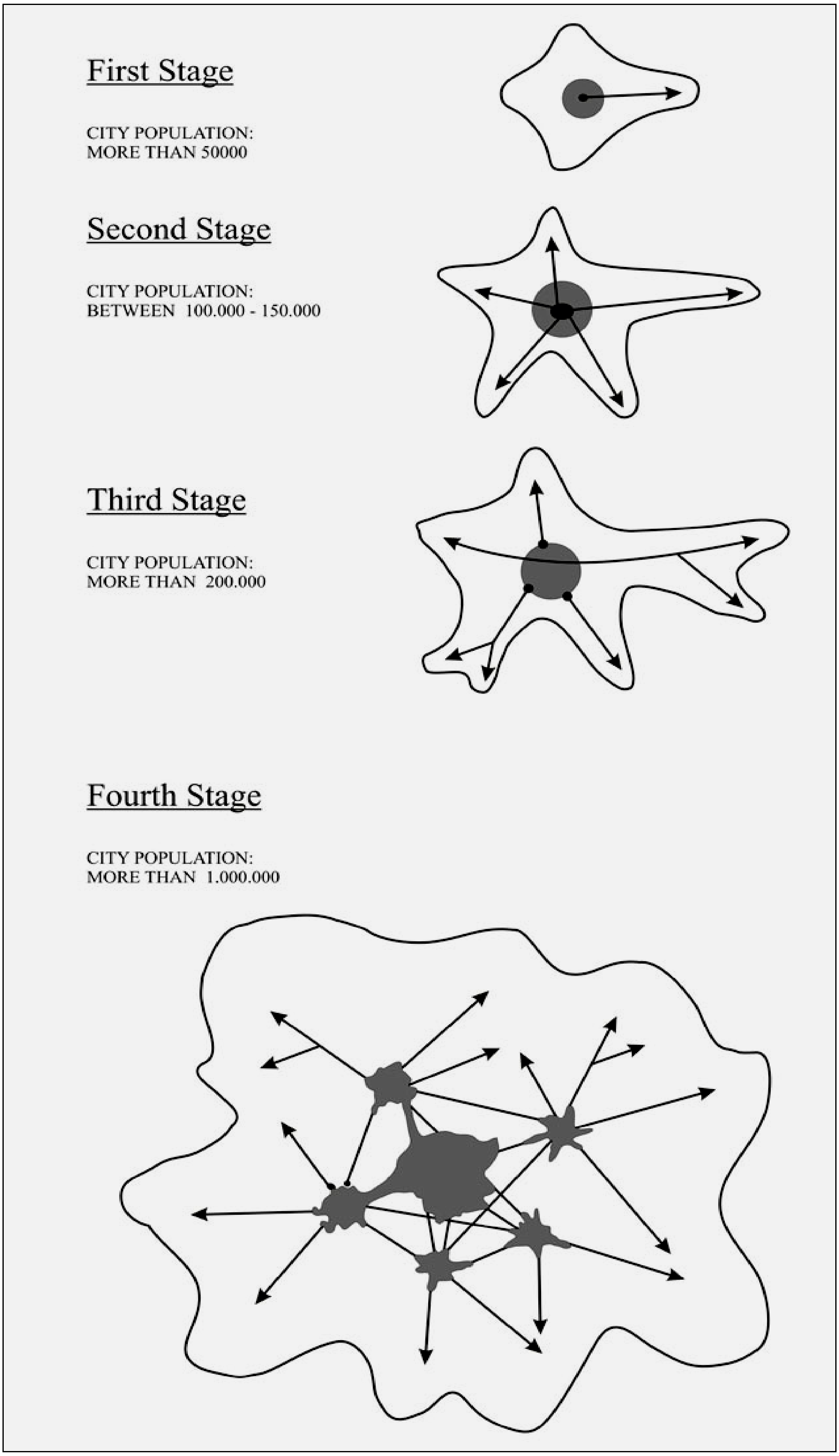


Figure 3.36 : Evolution of dolmuş-minibus system depending on city size with four-stage development (Tekeli and Okyay, 1981, p. 61).

When came to İstanbul case, it is possible to say that, there is a strong relationship between evolution of dolmuş-minibus system in İstanbul and the land use together with city development. Şanlı (1981) has pointed out that the division of the city into major sections by the two Bosporus channels and the Golden Horn, caused the development of sub-centers in all sections of the city. This is a major factor affecting the patterns of movement in İstanbul.

Şanlı has also adverted that: "the topographical conditions of the city are important which have resulted in the linear pattern of development along the coast" (p. 22). Therefore, new growth occurs along the main roads radiating outward from the centers especially on either sides of the Bosporus channels, but primarily keeping the linear East-West axis of development. These are primarily lower-middle income developments with occasional high-income developments studded within them, especially along the Marmara coast. This situation, coupled with the general congestion throughout the central sections of the metropolitan area, appears to be responsible for relatively low levels of traffic generation (Şanlı, 1981). Şanlı (1981) has also uttered that “at the periphery of central settlements the squatter settlements are found, especially in areas where topography makes it difficult for proper development, public ownership of land attracts usurpation, and the apathy or toleration of the public officials endures squatting” (p. 22).

Today, in big cities particularly in İstanbul, majority of minibus routes become operate especially to the areas of squatter settlements or suburbs other than the city centers, while dolmuş routes operate around the city center. Figure 3.37 indicates the most current map of the minibus-dolmuş routes in İstanbul. Despite the fact that, no complete map of this extensive system has been made accessible by the local government to the general public up to date; a group of people from a special organization has prepared such kind of a map seen in this figure. In this map, blue lines symbolize the minibus routes; green and orange lines represent the dolmuş routes of Anatolian and European side of the city. As can be seen from the map, yellow colored and green-colored dolmuş routes begin to condense around the Bosphorus, the Golden Horn and shorelines of the city. On the other hand, blue colored minibus routes are positioned at the periphery of central settlements of İstanbul.

Figure 3.37 : Current minibus-dolmuş routes in İstanbul (Gürdoğan, et al., 2007).

In fact, Şanlı (1981) has mentioned that: "debates on and the search for efficient and effective alternatives for the mass transport system in İstanbul will continue" (p. 4). This is necessary to determine the right time and context for the implementation of various forms of mass transport. Improvements and new studies on public mass transportation such as bus rapid transit, underground rail transit with subway and tube or light rail transit with tram aim to enhance the effectiveness of mass transit and lessen the traffic congestion to some extent. This is why minibuses are gradually tried to be taken out from the city center especially in the last decade. For instance, the minibus route, which was lying to the center of Beyazıt twenty years ago, has gradually taken out till first Aksaray and then Topkapı and now Cevizlibağ. As another example, A/01-Bayazıd-Bakırköy, which was one of the most important minibus routes of southern Golden Horn in 1980s is now a segmented and shortened route ("wowTURKEY", 2010).

In early days, when the minibus routes were abolished, the vehicles operating on these routes were not taken from traffic; they actually started to operate on a new route that was usually far from the city center. The main purpose was to create new routes that linked the suburbs to each other or suburban areas to secondary centers. Today, actually, İBB has been planning a project that aims to lessen the minibus routes in the city, whereas the dolmuş routes are increasing gradually. For instance, especially in some routes, every three minibus operators are given one public bus operation by the Municipality. The core of the city is commended to the other types of public mass transport like conventional municipality buses, subways, trams and dolmuşes.

In İstanbul, high density and relatively old stock of housing development has surrounded the centers throughout the metropolitan area. In fact, the central residential sections are so well established that any change in the pattern of development would be difficult and costly to implement (Şanlı, 1981). The enhancements in the infrastructure of the big cities somehow define the future public transportation trends. In Turkey and particularly in İstanbul, the investments of the infrastructure enhancements are too costly for any new type of transportation choice. For instance, several different mass rail transit schemes have been proposed for most of the metropolitan areas. Nevertheless, the overall benefits of those projects had to be weighed against the prohibitively high costs of implementation, therefore, only less of them are effectuated.

Since rapid transit in Turkish cities is still being developed, a dolmuş is often the only alternative. A dolmuş ride is also considered one of the most reliable forms of rapid transit in İstanbul, for being an affordable form of mass transit running almost 24 hours a day.

3.5.2 Social and economical situations

The paratransit system ideally aims to facilitate personal mobility needs and fights social exclusion while providing in some degree high quality services at a relatively low cost (Mastrogiannidou, et al., 2006). The potential users of the paratransit system could be categorized into different groups based on occupation, age, gender, etc. The attitude of each user plays an important role and is influenced by their mobility needs, financial situation, whether they own private means of transport, trip purpose and origins or destinations. The paratransit system may accommodate their mobility needs providing transportation solutions of better quality and cost. The users are obviously the most critical stakeholders and their perception will determine the market share attracted by such a system. The most important parameters determining the market share are the cost and the level of service since the comprehensible objective is to minimize the total cost (Mastrogiannidou, et al., 2006).

The dolmuş-minibus system could mostly readjust its level of service to the new developments and changes in the social and economic situations of the period in which it is operated. For example, as Şanlı (1981) also adverted, the inflation rate soared in Turkey during the very end of 1970s, following the worldwide increases in oil prices. Moreover, as it would be expected, the transportation sector was affected significantly. Costs of vehicles increased along with the cost of spare parts, fuel and costs of transportation of goods and people; so did the costs of dolmuş-minibus vehicles and license plates, costs of operation and as well as the fares. Dolmuş minibus system was also influenced by this high inflation rates. However, apparently, the system has adjusted very well to the new conditions. Indeed, it regulate the level of service and the system's capacity to adjust will prolong its operation in the absence of far more effective measures to improve the urban transport system in İstanbul and especially in absence of biased, if not hostile, attitudes of planners and policy-makers against the system. Needless to say, of course, the potential for the integration of the dolmuş-minibus system into the general system of public transportation in İstanbul still exists to be exploited (Şanlı, 1981).

As also mentioned above, the study of paratransit has close relationship with financial aspect of the user (Joewono and Kubota, 2005). The objective of the operator is obviously to ensure the financial viability of the system and depending on its corporate structure, to increase profit or social benefit.

In Turkey case, the dolmuş-minibus system is an active ingredient of urban living in İstanbul, both as a means of movement and as a socio-economic phenomenon.

A perceptive examination of the system as a socio-economic phenomenon was provided by Tekeli et al. (1976, 1981, in pres.), by Dönmezer et al. (1973) and Şanlı (1981). Additionally, a number of newspaper articles provided publicity to the problem of dolmuş-minibus system within the framework of the general problems of urban transport in İstanbul. As an example among them, Şanlı (1981) pointed out that:

> Obviously, there is more to the dolmuş-minibus system than moving a relatively large number of people in İstanbul. The system has provided gainful employment for a significant portion of the population -the owners, the drivers, the helpers, as well as those employed in the spare parts, repair, service and other related sectors of the automotive industry. The system has made remunerative use of a stock of vehicles most of which would otherwise have been scrapped. (p. 6)

The paratransit drivers provided an important public service in the city, they would always be needed; and, there would always be new drivers willing to enter the profession for various other reasons, including the absence of alternatives and paratransit operation providing for a relatively favorable economic well-being for the driver's and operator's household. Şanlı's (1981) observation on the paratransit driver is that: "the paratransit driving profession and organizational aspects of driving indicate that the favorable economics of operation ensures the driver middle-income economic status along with above-average dwelling conditions" (p. 143). This is especially important because it reflects a high level of upward mobility in living conditions and even in social status. Indeed, considering that an average dolmuş-minibus driver is a young migrant having no prior skill for a proper occupation, his status as a driver can be conceived as a considerable improvement over previous status.

The above observations also indicate a favorable economics of operation on the basis of the averages. In other words, it is plausible to say that the average earnings in paratransit operation seems to be adequate to provide an operator with a middle-income living status and savings to repay his debts on the vehicle within a few years' time if he desires to be an owner-operator. The availability of installment plans in paratransit transaction, coupled with the favorable economics of operation, tends to facilitate the entrance into dolmuş-minibus business as an owner operator; and, the majority of these operators are owner-operators even though the vehicles and especially the license plates are rather expensive (Şanlı, 1981).

The paratransit vehicle driver in İstanbul is a distinguished element of the system. He is characterized as “fatalist” but distinguished in his self-image of a tough master of a tough profession. This image is reflected even popular jokes and songs, that are dedicated to dolmuş drivers, the phrases mostly written on the back or inside of the vehicles, the music played -loudly- in the paratransit vehicles and the general attitudes of these drivers towards the passengers as well as towards one another. The broad outlines of this vivid personality are visible and the driver's self-image is apparently observed by a large section of the public (Dönmezer, 1973, p. 68).

This driver profile affects the paratransit operation in its multitude of dimensions, including service levels, service quality, organizational possibility as well as the general prospects of the paratransit system in İstanbul. Many of the visible problems of paratransit and especially minibus operation such as reckless driving, impolite or nervous behavior of the drivers and consequences of these problems such as disregard of traffic rules and accidents, could conceivably be attributed to the pressure arising from a long working day and long rush hours in operation (Şanlı, 1981).

3.5.3 Legal and regulatory issues

Paratransit systems in many cities are usually operated by individuals and small business without central control or organization. In fact, there is little or no formal regulation of paratransit operations; instead, this function is carried out by informal regulations in many countries (Wright, 1986). The fragmented, intensely competitive nature of the industry makes government regulation and control much harder than traditional public transport. In most countries, government authorities have cited problems with unsafe vehicles and drivers as justifying efforts to regulate and "formalize" paratransit operations. However, most of the time, these efforts have been limited by ignorance on the part of regulatory authorities and mistrust between authorities and operators (Schalekamp, Mfinanga, Wilkinson, and Behrens, 2009).

There are a contrast in institutional framework between the operators of conventional vehicles and paratransit and it is sharpened by the profitability of the two types; conventional buses, usually organized in large fleets and often run by the government, are seemingly difficult to maintain as a commercial enterprise whereas paratransit that is usually privately owned in small fleets is profitable. A considerable debate has arisen over which type of public transport system (conventional or paratransit) to encourage. The debate has often been confused because it involves two quite separate issues: whether the provision of public transport should be left entirely to private enterprise, and, the technical and economic benefits of different bus sizes.

Size of vehicle is a particularly important issue in the developing world because vehicles of different size are in common use and are frequently in competition with one another. While ordinary stage buses are given subsidies, medium and small transport types are operated with profits, and superior then ordinary stage bus services in terms of service level and coverage area. Although the regulatory authorities of many developing countries hope for the enforcement of the same type of control that is prevalent in the advanced countries, the performance of existing strict control in the advanced countries is far from desirable.

There are a number of regulatory, fiscal, institutional and cultural barriers at government, local authority, operator and user levels that have not yet been comprehensively investigated. These appear to be as important as the technical issues involved (Enoch, et al., 2004).

In Turkey, actually, The Highway Traffic Law provides the legal basis for the regulation of the operation of the general transport system throughout the country and in İstanbul. The law provides a broad basis without differentiating between intra and inter-city transportation. The law also does not include specific clauses related to the organization and operation of the low cost transport (LCT) system throughout the nation's cities. However, reference is made to the definitions of the vehicles and operation of the system in special by laws (Şanlı, 1981).

Mastrogiannidou, et al. (2006) claim "paratransit can positively impact environmental problems and have important implications on land use and the economy" (para. 13). The system may need to be subsidized through taxation or participation from the local market, which also involves the local, regional and central government. In most cases, because the implementation of an ideal paratransit system requires a large amount of money to be invested, the participation of the local or national government in subsidizing the system would constitute a viable solution. Therefore, public transport needs to be coordinated and planned together with land uses under the city and maybe the country planning legislation (Mastrogiannidou et al., 2006).

Take, for instance İstanbul case, it is the fact that all inner city public transport systems (the sea transportation, the commuter railroad system and the bus system) had been operated by different authorities which made the integration of transport services in İstanbul a difficult task. Furthermore, all these authorities operated in significant financial losses, which in turn discourage attempts to implement the most essential improvements or even routine maintenance (Şanlı, 1981).

Today, however, there are some studies and implementations about the optimization and integration of public mass transportation services in İstanbul. In this manner, İETT General Directorate and Coordination of Transportation Department (UKOME) are the main two organizational authorities and regulatory powers of municipality which responsible from the public mass transportation in İstanbul. Their field-offices are also empowered with similar authorities are charged to regulate general transportation and to make comprehensive urban transportation master plans, which analyze the interaction and the harmony between land use decisions of development master plans and transport structures. More specifically, Directorate of Public Transportation Services that working connected to Department of Transportation is founded by İstanbul Metropolitan Municipality. This directorate has the mission of accreditation and certification of commercial vehicles like minibus, dolmuş, taxi, taxi-dolmuş; together with planning, determination and evaluation of minibus and taxi dolmuş routes, stations and stops. It also studies about the integration with IETT and those commercial operations (“IMM: Organizations”, 2011).

Other important elements of the legal and economic environment of the low cost transport (LCT) system in İstanbul include the formal and informal associations. The Federation of the Drivers and Automobile Operators of Turkey, established in 1953 in accordance with law of Tradesmen and Craftsmen, is one of them. The main goals of this organization are to defend the rights of the drivers, to solve the problems that the drivers encounter in their professional service, to provide education and to help maintain relationships with other institutions in order to improve the general well-being of its members. The Association of Minibus Operators or Dolmuş operators are another associations which defending the rights of the specific groups of operators (Dönmezler, 1973; Şanlı, 1981; “TSOF: History and aims”, 2011). The dolmuş-minibus system has also established itself as a powerful interest group within the political arena through its formal and informal organizations to such an extent that a governmental proposal to lift the restriction on the number of license plates encountered a stiff resistance of these organizations and was rendered ineffective (Şanlı, 1981).

3.6 The Future of Dolmuş-Minibus System

It can be argued that paratransit system, which mostly refers to the dolmuş-minibus operations in Turkey, will survive and continue its success into the future for some reasons. Şanlı (1981, p. 13) has pointed out these reasons as follows:

- The possible new alternative mass transport systems would be too costly to implement in the foreseeable future.
- The possible improvements of the existing alternatives will be of limited effectiveness in the long run.
- The system is dynamic and flexible and has taken such deep roots in the society to encounter, successfully, the external threats that might have been directed at its strict regulation or survival.

Additionally, according to the consultants, the dolmuş-minibus systems would operate as feeders to support bus services or replace bus routes that are uneconomic because of the low level of demand, especially in areas of low-density development or at certain hours of operation, especially the evenings (Greater İstanbul Master Plan Bureau, 1975, p. 55).

Furthermore, the value of the license plate is a significant part of the value of a paratransit vehicle. The restriction on the number of license plate tends to increase the price of the license plate to such an extent that entrance into the sector becomes increasingly difficult or beyond the means of many of the drivers. Therefore, selective entrance due to high costs of vehicles and especially license plates will tend to ensure the profitability and continuation of operation (Şanlı, 1981).

Actually, lots of discussions about the dolmuş-minibus system is still going on, whether it is eliminated or not; it the author's opinion that, in the short run, elimination of this system seems impossible considering the benefits of dolmuş-minibus system. Additionally, livelihood of that much stakeholders is not possible in a different way, in the very near future. Therefore, the system should be ameliorated in many ways. Industrial design together with current and future technology is two of the most influential factors that may help to ameliorate the dolmuş-minibus system in Turkey.

4. POSSIBLE INDUSTRIAL DESIGN IMPACT ON PARATRANSIT

The aim of this chapter is to search, analyze and clarify the current and possible industrial design impact on paratransit system. In order to have a broadened perspective and comprehend that in what way industrial design affects the paratransit, this chapter composed of three parts. The first part of the chapter begins with design of paratransit vehicles. Here vehicle styling which is a widely used term in automotive sector and materials and manufacturing processes of the vehicles are studied in depth. In the second part of the chapter, human centered design approach for paratransit systems is sought. Then, in the third part of the chapter, future trends of paratransit vehicle design have been investigated with leading examples throughout the world to set the key concepts.

As being an industrial designer working in a company which is one of the major automotive manufacturers in Turkey and has been providing solutions to its customers both in commercial and military range, the author, sometimes witnessed and sometimes involved in the various industrial design process of commercial vehicles more specifically both interior and exterior designs of bus, midibus and minibuses. Because, the company, most of the cases, uses its own technology, design capabilities and has a power of flexible manufacturing in order to meet the customers' special requirements, most of the sources and observations used in this chapter arises from the working experiences of the author.

4.1 Design of Paratransit Vehicles

International Council of Societies of Industrial Design (ICSID) defines design as a "creative activity" whose aim is "to establish the multi-faceted qualities of objects, processes, services and their systems in whole life cycles" (“ICSID: Definition of Design”, n.d.). This definition has been made in an operational manner. ICSID has also defined the design in strategic manner such as "design is the central factor of innovative humanization of technologies and the crucial factor of cultural and economic exchange" ("ICSID: Definition of Design", n.d.). Furthermore, International Council of Societies of Industrial Design has adverted the tasks of design followed as:

- Enhancing global sustainability and environmental protection (global ethics),
- Giving benefits and freedom to the entire human community, individual and collective,
- Final users, producers and market protagonists (social ethics),
- Supporting cultural diversity despite the globalization of the world (cultural ethics),
- Giving products, services and systems, those forms that are expressive of (semiology) and coherent with (aesthetics) their proper complexity.

Therefore, the term designer refers to an individual who practices an intellectual profession, and not simply a trade or a service for enterprises (ICSID, n.d.). Industrial designers employ creative, visual and intuitive techniques in making their special contribution to the industrial design process.

In addition to these definitions, Heskett (2002) also pointed out that, one of the main focuses of industrial design is being "a cultural process that visualizes the cultural transformation of the product from one phased to another in order to answer changing conditions, needs and desires for the betterment and delight of all".

Among these definitions, the term "culture" is crucially important. Because mentioning industrial design of paratransit operations in Turkey, particularly dolmuş (and/or minibus) can be handled in two separate manners. At first, it is an industrial product, specifically *a vehicle* when looked from the global perspective. On the other hand, it is *a cultural object*, even an icon of public transportation of Turkey when looked from the local perspective. Therefore, while approaching from the designer's point of view, it should be considered that, dolmuş-minibus is a public transportation vehicle that mostly reflects the cultural meanings. In this approach, Dormer (1990) puts an explanation as "design had reached the status of being a cultural 'object' in its own right".

Furthermore, as also Boztepe (2008) adverts that industrial design both uses and makes collations its understanding of local problems, behaviors and culture in order to create products in such a way that users can see that the object so designed possesses certain cultural meanings and addresses their real needs. Similarly, Er (1993) has mentioned that, "design object brings its culture into the novel society, so not only the product but also the behaviors of the usage of the product are exported as well". It is clear that a better understanding of the local problems, behaviors and culture, and creating vehicles that possible communicate to the majority of public is one of the most essential issue while starting the design process of any public transport vehicle.

In order to create an approach for analyzing, designing and developing paratransit system vehicles especially for Turkey, the potential stakeholders, the critical parameters and the impacts related to the deployment of paratransit systems and comprise critical elements in the designing and the operating phases of the paratransit system should be elaborately identified. The users and the operators appear to be the most critical stakeholders for a successful deployed paratransit system. These two elements are critical for the viability of the system (Mastrogiannidou, et al., 2006). In the field study chapter, these stakeholders and especially their behaviors and expectations from paratransit system and the vehicles will be examined in detailed manner.

The paratransit business is a specialized and unique sector of automotive industry. At first sight, it is clearly of the automotive fraternity and so it can be said that paratransit system vehicles are the products of automotive sector. Therefore, the industrial design process of them must resemble to those majority of automobile companies. Actually, the designing processes of automobile companies are similar in certain ways. On the other hand, there are also distinctive differences between the design processes in paratransit vehicles and the other passenger cars and even intercity buses.

In fact, paratransit vehicle's physical size and the relatively small number produced annually make it more of a craft than a true automotive product. Here, Griffiths and Lewis (2001) has mentioned that "arguably, production meets craft: vehicle styling meets architecture" (p. 11). In other words, design process differences between paratransit vehicles and the automobiles are mostly arisen from the sales volume of these vehicles and the competition factors in the sector.

Until recently, paratransit vehicles are manufactured without the contribution of industrial design since the sector dominantly have engineers-focused approach especially in most of the developing countries. In recent years, nonetheless, industrial design somehow started to be an effective contributor of the vehicles in paratransit sector.

Minibuses and dolmuşes have unique operational characteristics including relatively low power-to weight ratios, high axle loads, short wheel bases that may necessitate special treatments. Therefore, the design of light vehicles particularly used for the dolmuş-minibus system, as almost all public transportation vehicles design, must consider a variety of issues. Safety and security issues for passengers and drivers, the control of ventilation, temperature and humidity, the control of noise in the passenger cabin of the vehicle and some other mechanical and electronic issues critically influence the industrial design and appearance of the vehicle.

Today, some design and styling departments of automobile companies work under the engineering department as with the Turkish companies, and some of them are directly under control of senior company management as with the abroad big automotive companies. They are closely connected with engineering and product planning departments and generally surrounded by security in order to preserve commercial confidentiality. Happian-Smith (2001) clarifies the relationship between styling and engineering departments as:

> The stylists receive information and guidance from engineering and engineering ultimately receive information from styling on the shapes they must then enable to be manufactured. Differences may affect the slant on decisions on styling issues to a greater or lesser extent. There are no companies in which an engineering department works under the control of styling, but the styling voice can be powerful, given the importance of its role in selling vehicles.

Nemeth (2005) has quoted to Bateman (2000) who has described the phases of vehicle development within the context of product life cycles (Figure 4.1). In Bateman's view, research and development activities fit into the life cycle of a system. Major phases in the development cycle are indicated as grey shaded arrows: define problem, gather data, determine feasibility, plan (define requirements, identify alternatives), analyze (evaluate alternatives), design (build prototype, test, install), implement, use (evaluate) and retire. Nemeth (2005) also adverts that "the design, prototype and test cycle may be repeated until the solution meets requirements" (p. 16). In order to create a follow-on product in time, it is necessary to complete planning before retiring its predecessor (Nemeth, 2005). Especially in automotive industry, having more sophisticated and complex products such kind of a development process is widely used.

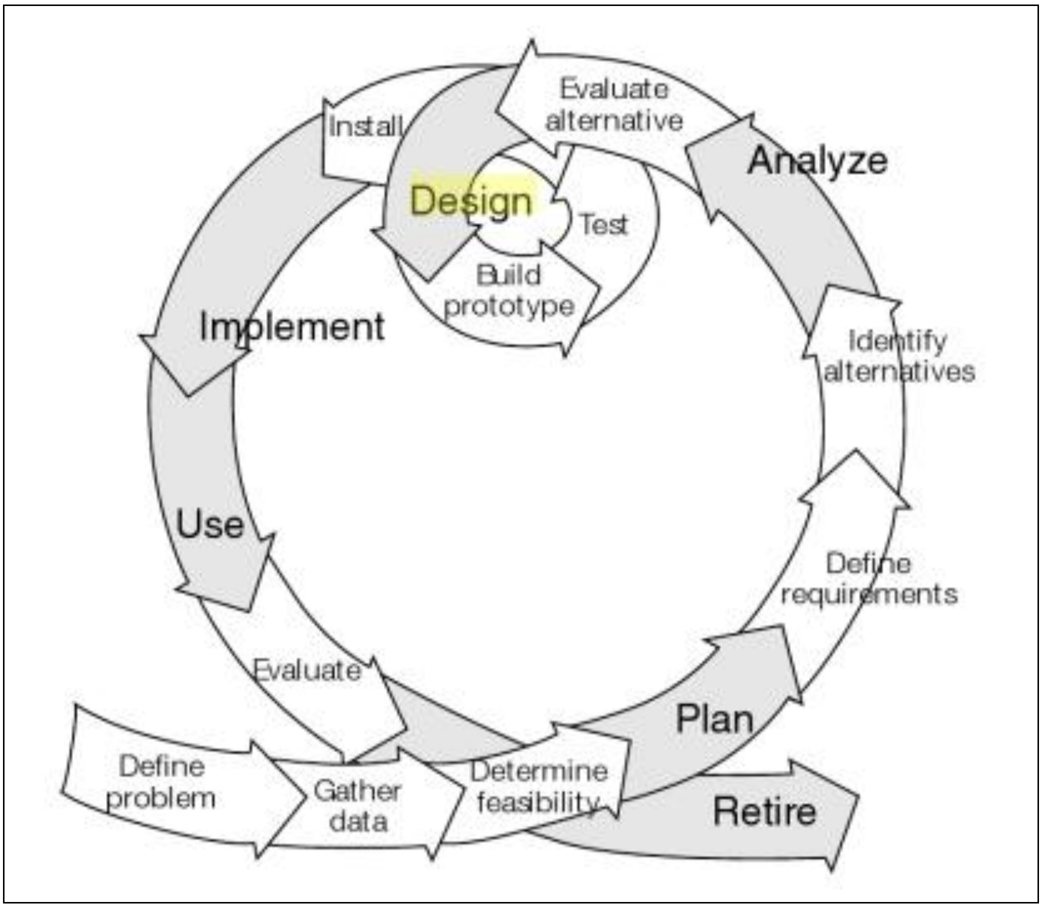


Figure 4.1 : Vehicle development process (Nemeth, 2005, p. 16).

The vehicle designing process (an ideal process) in automotive sector goes as follows:

Product planning or marketing department determines the strategies for current and future models according to short and long-term market analyses about the sales, performance and existing products of competitive companies and styling trends of targeted consumer group. This phase is known as the benchmarking process.

Based on these information, product planning or for some companies project management department prepares a written brief for the project, including the description of the needed vehicle, engines, options, model range, cost and other requirements (Happian-Smith, 2001).

When the written brief is sent to the industrial design team, they discuss to offer preliminary ideas and viable alternatives in brainstorming sessions to create the target vehicle model. In addition, in this brainstorming phase, some statements are generated, which reflect the feel of the essential requirements such as brave, futuristic, strong, chic and robust. These are derived from research in a wide range of product literature cued from architecture, fashion, jeweler, furniture, fine arts, etc. (Griffiths and Lewis, 2001).

Afterwards, designers draw lots of idea sketches to form concrete images of possible vehicles. Majority of the design directions are decided in this stage (Buonocunto, 2000). This phase, which illustrates themes in sketch form to create strong elements such as a powerful face on the front of the vehicle, a feeling of energy in the overall shape, a visual impression of safety and robustness, a clear definition for the panel section to the vehicle sides, is known as “2D work” (Griffiths and Lewis, 2001). In Figure 4.2, it can be seen some sketch examples of a vehicle idea generation process.

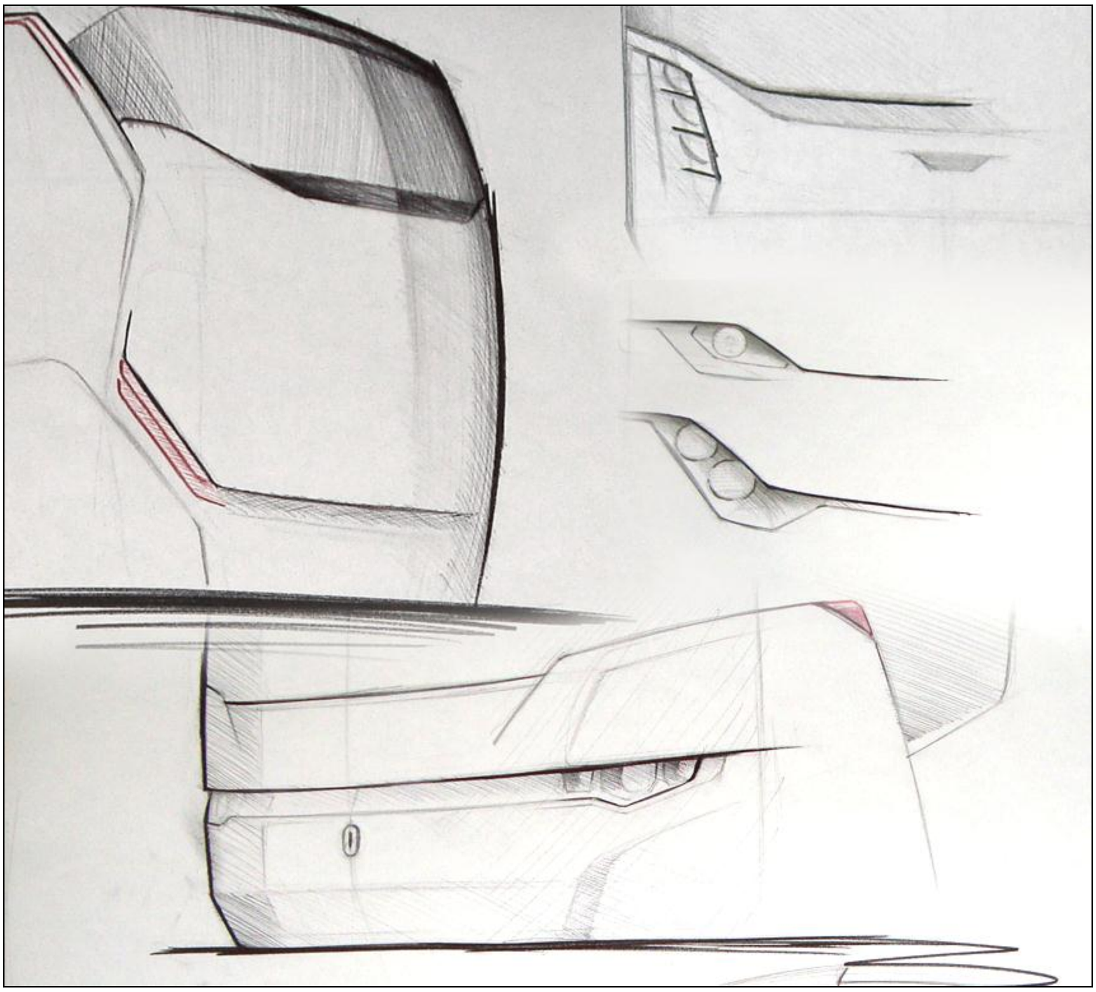


Figure 4.2 : Idea generation sketches of a vehicle design process.

Some themes developed so far are reduced to a small number of more defined sketches and renderings. After this phase, the design intent stage begins agreeing initial parameters like height, width, length, wheel positions of the vehicle, etc. As a two-dimensional representation, scaled and full sized tape drawings enhance to comprehend the size and the proportion of sections of vehicle.

Then, models are generated to turn a two dimensional model to a three-dimensional shape (Happian-Smith, 2001). These stages often start with scale clay (industrial modeling wax) models, typically 1/6, and progress to full-size, highly detailed models as also seen in Figure 4.3. Actually, the preferred theme is developed through 3D models (Griffiths and Lewis, 2001). The most remarkable and time-consuming stage of design process is the clay modeling for both interior and exterior of the vehicle. On the other hand, using clay to build models of exteriors and interiors that can be seen and touched is very essential in assessment of the design.

Figure 4.3 : Examples of clay modeling process (Otokar, 2007).

The three dimensional and full sized orthogonal drawings are prepared by engineers and modelers. Designers also build conceptual 3D computer models by using software, which is generally Autodesk Alias Studio and Surface for the automotive sector (Figure 4.4).

Additionally, while industrial design process going on, ergonomic 'hard points' (functional spaces that individual elements require in the overall structural package), the roof-mounted HVAC (Heating Ventilating and Air Conditioning) system, mirrors, glass requirements, motor packages, drive train, and other utility components are started to determine working together with the engineering department (Griffiths and Lewis, 2001). Discussions are also preceded with the many

O.E.M s (Original Equipment Manufacturer) for lots of components such as exterior lamps, seating units, etc.

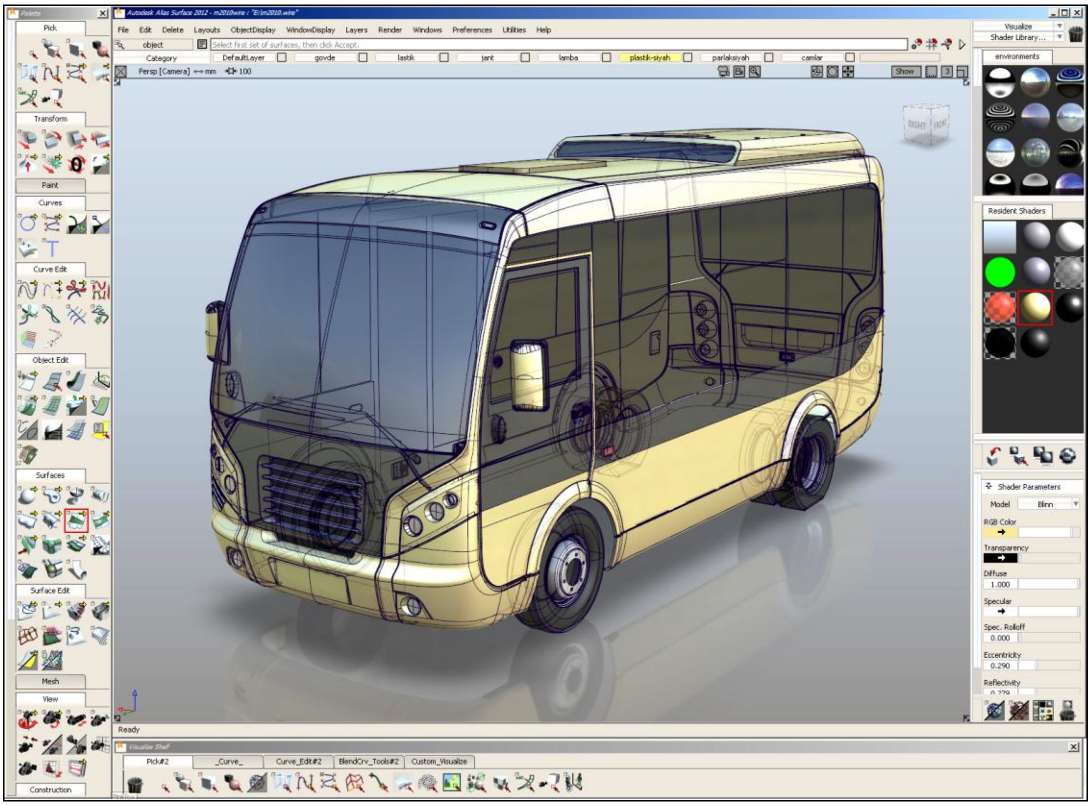


Figure 4.4 : Three dimensional minibus model built by using Autodesk Alias (Otokar, 2010).

"Design Sign-off" is achieved when there is no conflict between style and engineering issues. The final design is then accepted and further development frozen. After sign-off stage, the vehicle exterior front and rear ends (and sometimes interior too) were scanned by a laser-controlled camera and 3D cloud point data. This is just to begin developing the exterior "A" class surfacing, using an advanced computerized visualization and surfacing program. The total surface of the vehicle was developed on-screen generally in Alias (Figure 4.5). Using this program mathematical surfaces are generated for each patch and then the reflection from the virtual surfaces are calculated to confirm that visual continuity of slope and curvature have been achieved across the surface and at the patch boundaries. Finally, all the surfacing has been completed and the entire vehicle is now uniquely defined mathematically (Griffiths and Lewis, 2001).

Actually, the signed-off surface geometries are defined for the manufacturing tools to be made for the production vehicles (molds or presses, depending on whether the components are to be made from plastics, sheet metal or other materials). This also allows the first prototypes to be assembled (Griffiths and Lewis, 2001).

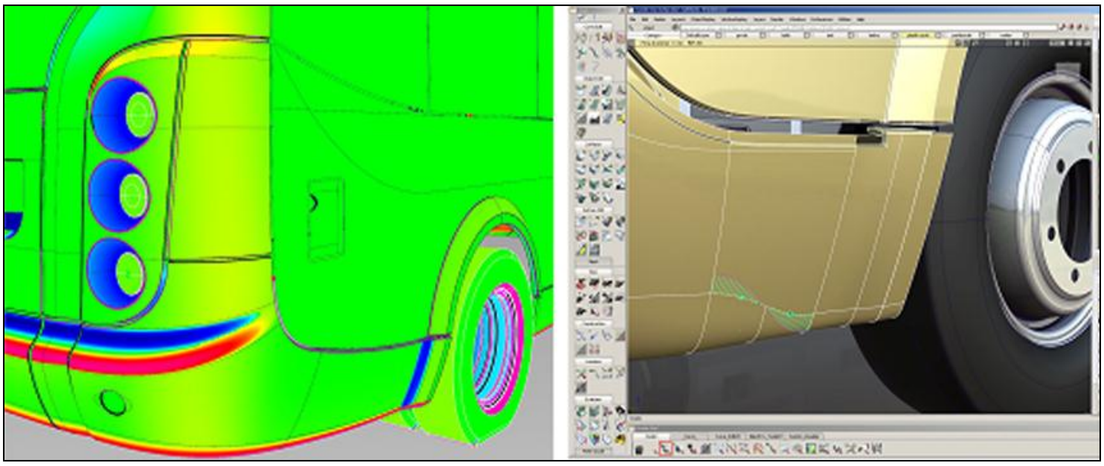


Figure 4.5 : Evaluation samples of A class surfacing for a vehicle (Otokar, 2010).

More recently, computer-aided design techniques have reversed this sequence. The full-scale clay models increasingly being cut from 3D mathematical surfaces computer-defined from the outset. Instead of making clay models, usually photorealistic renderings are used for help to narrow down and focus the design elements of the vehicle.

In fact, the vehicle design process explained above is an ideal process. Unfortunately, in most of the local companies, the vehicle design process (especially paratransit vehicles design) is not applied exactly such a professional manner. Thus, vehicles with pleasing features usually cannot be seen in the market. However, by regarding customers' well-defined and real needs and by applying professional industrial design process, a paratransit vehicle would be more and more successful in the very near future.

Khalid and Helander (2004) have offered a framework for conceptualization of customer needs through product design hierarchical features (Figure 4.6). Depending on this model, it can be said that there are three major features of a product like holistic features, functionality and styling details. Therefore, holistic impression followed by functionality and design details (styling) are perceived according to the consumer needs for a product and form the overall consumer response towards it.

Industrial design, here more specifically automotive design, is a critical component while developing of a paratransit system vehicle. Actually, it may contribute the overall quality of the vehicle both by creating an aesthetic value, and by possibly minimizing the total cost of vehicle. The former refers to the styling of the vehicle which is a term commonly used in automotive sector, and the latter may refer to the materials, manufacturing techniques and somehow the power unit of the vehicle.

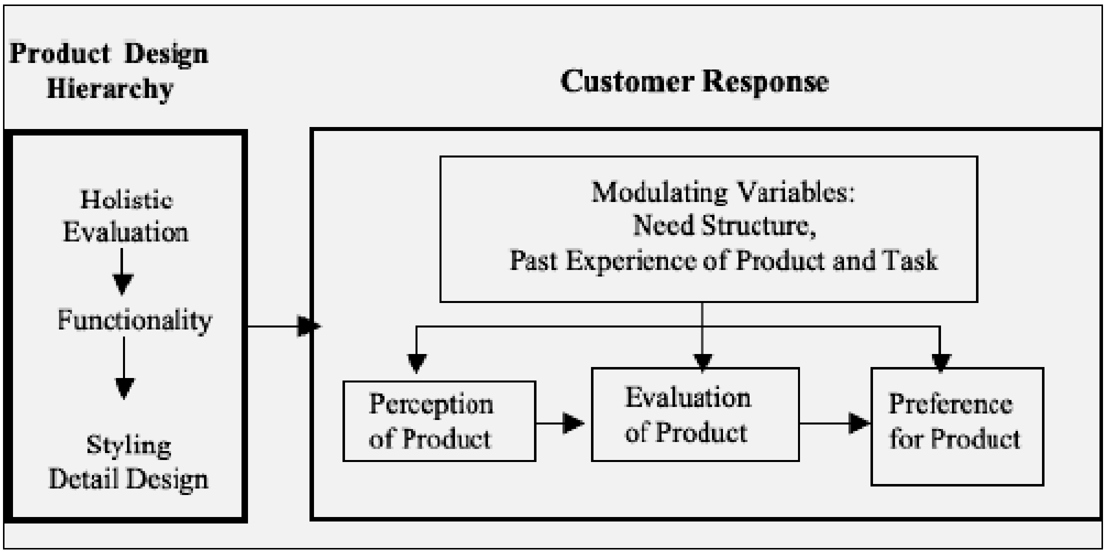


Figure 4.6 : "A framework for conceptualization of customer needs" (Khalid and Helander, 2004).

4.1.1 Vehicle styling

The signs and the information coming from the outer world reach to human brain resulting in perception of the environment. In particular, for a designed product, the most dominant signs and information are its visual properties (Bloch, 1995). These prominent visual properties of a product are formalized by the aesthetic properties that reflect the surface information (Taylor et al., 1999). The aesthetic properties introduce the fundamentals of the relationship between user and the product by initiating and determining the course of the interaction. During interaction, the information broadcast by the product is received by subjects who are exposed to the product (either intentionally or unintentionally) primarily by the sense of sight. Therefore, the visual stimulation is primary when the perception of a product is considered (Asatekin, 1997).

As also, Sevener and Asatekin (n.d.) have adverted that, "the immediate sensorial experiences transpire during the initial steps of the relationship between user and the product" (para. 1). These experiences arise from the interaction between the visual qualities and the sense of sight, inevitably influencing the emotional evaluation process of the interaction. Thus, it becomes essential to disclose the nature of the connections between the two parts of the initial interaction; user and aesthetic properties of the product (Sevener and Asatekin, n.d.).

The emotional responses that are triggered by the aesthetic values help define the attitudes towards the products in all stages of interaction (Yoshimura, et al., 2001; Tractinsky, 1997). The emotional satisfaction and the pleasurable feelings related to the products are evoked by the exposure to the aesthetics of the products and last during the usage period (Jordan, 1998).

The property 'form' is the dominant aesthetic factor in the evaluation and perception of vehicles. However, the dominance is not entirely due to appreciation of the design. It is indicated by some subjects that the design of this product is out of fashion due to its form. It is found necessary to note that the dominance of a particular aesthetic property in product perception is not always a result of its pleasurable form. Such perception decisions are generally governed by the distinct character of the aesthetic property either in a positive or negative manner (Sevener and Asatekin, n.d.).

The two aesthetic properties 'material' and 'color' have very close frequencies on the perceptions. Especially for the inner environment of a vehicle, for example, while the form covered with a leather-like material may create an impression of quality and prestige, the form covered with black and white color combination with a smooth texture or covered with chrome effect may create a modern and a futuristic impression. Similarly, designers always aim to create a roomy environment inside the vehicle. Therefore, a homogenous color scheme has often been used to create a feeling of spaciousness in an interior and make the interior more versatile with different colors and textures.

In fact, social structure is the illustrator of the users’ admiration preferences, which is parallel to the aesthetic perception of individuals. Aesthetic formation is one of the most distinct socio-cultural qualities of a population. In social dynamics, some certain aesthetic values are accepted like shapes, forms, sounds, colors, textures, proportions or combinations of these. In course of time, these socially accepted values influence the admiration structuring of an individual. Therefore, there is a strict relationship between the aesthetic perception of individuals and socially accepted aesthetic values. This relationship chain definitely affects the automotive design in that culture (Asatekin, 2005). It creates a design criterion in specific areas. Especially, in design of paratransit vehicles, that has strong local qualifications, these design criteria become more important.

Although there are some studies about styling or design specification of vehicle interiors as examples of application of Kansei engineering (Nagamachi, 2002; Tanoe et al., 1997; Ishihara et al., 1997 and Han et al., 2000), for designers, using cultural resources is not an easy and straightforward task. Boztepe (2008) has claimed that:

> ...there is always the danger of trivialization of the local culture by fostering stereotypical images or creating a temporary popular trend or fad. Also, relying on one advantage only, such as reinterpretation of local forms and symbols, may not lead to sustainable competitive advantage, as it is not hard to replicate strategy. That is, in order to contribute to the competitiveness of local companies, design has to go beyond the trivial application of cultural icons. (p. 15)

Furthermore, the physical form or appearance of a vehicle is an unquestioned determinant of its marketplace success. A good designed vehicle attracts consumers and communicates to them. In fact, a good design adds value to the vehicle by enhancing the quality of the usage experiences associated with it. Fontana, et al., (2000) has mentioned, “on the market it is currently possible to find products that have the same function and are similar in quality and price. For instance, it is very common that competitive products contain the same mechanical and electrical components”. Their differences are mainly related to details in shape. Therefore, it is possible to say that the choice of the customer is greatly affected by the vehicle's aesthetical aspects (color, shape, and so on) even if it is a commercial vehicle. These aspects are no longer highly influenced by the available production technology as in the past. This is due to the availability of new materials and production tools that allow the creation of very complex shapes, thus providing a greater creative freedom to the designers. In consideration of the increased importance of a vehicle's aesthetic aspect, shortening the development time and costs of a new vehicle is a primary goal.

The definition process of a complex-shaped vehicle is a long and complex activity involving many different aspects such as styling and engineering design. This activity usually involves tests on physical prototypes. When physical prototypes are used and modified, techniques of reverse engineering are applied for the surface reconstruction of the final version of the vehicle. Generally, each analysis phase requires several shape modification loops based on manual work as well as on computer-aided modeling tools. In all cases, at the beginning of the process, there is an idea, something similar to a conceptual shape that the stylist has in his/her own mind (Takala and Woodward, 1988; Van Dick and Mayer, 1997).

In fact, even if CAS (Computer Aided Styling) systems are heavily used in the styling departments, most of the designers still prefer to define their initial ideas on paper. In this way, the evaluation of the different alternatives is more intuitive thus avoiding these system restrictions. Only the selected idea is usually converted into a computer format so that a complete vehicle definition can be created with the aid of the available simulation and analysis tools.

Fontana, et al., (2000) have discussed that by examining the designer's activity and the way in which the shape is first represented in its overall substantial idea and then perfected, it appears that the definition of a shape is performed according to the following logical steps:

- overall shape definition, giving the vehicle global effect
- definition of local details thus providing the final complete shape of the vehicle .

During the styling activity, the shape is mainly considered from a purely geometric and aesthetic point of view, considering only a few basic engineering constraints and manufacturing requirements which are properly analyzed in the engineering design phase. According to the different phases of the design activity in styling, it is possible to identify two categories of form features in aesthetic design (Fontana, et al., 1999). These features are as follows:

- Structural features are created in the preliminary phase of design. They represent the structural entities used for defining the main surfaces of a product thus having an important aesthetic impact. Moreover, they are strongly linked to the aesthetic aspect of a product and consist in the so-called character lines (Dumenjo and Brunet, 1998). They are among the most important styling elements and are used to give a specific impression/feeling when looking at the object (e.g. the object appears sweet/aggressive).

- Detail features, created in the second modeling phase. They are applied to a surface in order to add aesthetic and functional details and to enforce the visual effects of important shape elements (Fontana, et al., 2000).

Heskett (2002) has pointed out that styling occurred to be involved only in visual creativity instead of functionality. By the historical constitution of design and designer, ‘form’ has been separated from function in a visual manner, which later causes the ‘style consultant’ to occur. Looking for new concepts and forms to be differentiated inside the market, form creating became styling. Traditionally, styling and engineering design are seen as polarized activities in product development. This tension is often evident in the products that harmony of form and function has been achieved (Wallace, 1991).

In an age when information technology is enabling professionals with varying backgrounds to represent and communicate complex ideas, it seems that this gap between engineers and industrial designers might be bridged to efficiently create concept designs that marry form and function (Smyth and Wallace, 2000).

When came to paratransit vehicle designs in Turkey, it is clear that, the appearance of dolmuş-minibus vehicle, both their exterior and interior designs, affect the perception and satisfaction of the customers. Research studies have shown that while the vast majority of drivers especially owner-drivers give importance to the aesthetic values of the vehicle, only a few of passengers pay attention to the appearance of the vehicle. That is to say, aesthetical appearance of vehicle greatly influences the purchase decision of drivers, while it has not a remarkable impact on the preference of getting on the minibus-dolmuş for the passengers. One of the best examples ever experienced is related to M-2000 model minibuses manufactured by the firm Otokar. As also mentioned in previous chapter, this minibus model was sold more than expected and was welcomed by almost all customers. Besides, the facelift models of M-2000 series, that have almost no change in the whole power unit, was found better than the previous ones especially in traction, stopping distance and engine power and so potential customers have lined up to purchase the next model. This could be one of the best evidence of how the design affects the purchase decision of drivers.

Nevertheless, one thing should be emphasized, researches conducted till today have also indicated that styling has never been the first important factor for drivers’ purchase decision. This is because of the fact that, dolmuş-minibus is a commercial vehicle which is possessed just to earn money or to make profit.

Despite the fact that there are not much examples of newly designed vehicles, when searched from the newest ones, it can be seen that drivers have tendency to buy the vehicle of which they perceived as aesthetic. In that manner, while designing the exterior of the vehicle, designers should understand the admiration preferences and so that the aesthetic perception of drivers. In fact, the vehicle design is in a state of flux hence the designer's job is to imagine the style that consumers will want in future vehicles.

Moreover, dolmuş-minibus has creates an environment with social and level of high interaction. There is an effective interaction between both passengers and drivers and passengers inside the dolmuş-minibus. Asatekin (2005) comments this social interaction inside the dolmuş as an outcome of the "trusting the human being" phenomenon. To exemplify this, the fare collection process is a good example. This process may be designed considering both passengers and the drivers. Especially this social process may be created in a better environment and the driver still care attention to the road (Asatekin, 2005). In addition, when thought of inner side of the vehicle, especially the driver's side, realizing and trying to understand the real reasons of the small ornamentations and decorations hanged or placed around the driver might be an important data for the designer. Regarding the fact that driver spends a large portion of the day in that area, the design process may be guided accordingly.

4.1.2 Materials and manufacturing processes

As also mentioned before, the aesthetic value of a commercial vehicle, particularly minibus or dolmuş has never been the most important factor in purchase decision. Most dolmuş-minibus drivers are also the owners of the vehicle and the main purpose of those vehicles is to make profit. Therefore, the terms cost, durability and the maintenance are the three most important factors for operators in buying decisions.

- Cost, may refer to both the sales price of the vehicle that has to be paid and the operational cost of the vehicle for the drivers. On the other hand, cost is one of the most important factors in the design process of a paratransit vehicle for the manufacturer. Definitely, in order to achieve targeted profit and sales figures, manufacturers usually care about the costs of whole production chain.

- Durability is an important factor for the operators although its importance is noticed after a while from the initiation of use. If most of the vehicle components quickly begin to wear out and rub off, then the life of the vehicle is short.
- Maintenance is another essential factor for any kind of commercial vehicle. Since dolmuşes or minibuses are commercial vehicles, their service and maintenance operations should be done promptly. Time loss in the service is usually perceived as the money loss. Therefore, easy and fast maintainable features of the components and availability of spare parts are the one of the most desired approach in purchase decision.

Therefore, a major design priority is to make a durable vehicle with low-purchase, low operation, and low-maintenance costs (Boztepe, 2008). Additionally, supporting a complex supplier, distributor, and service network to the operators is also necessary for the firm. Furthermore, the global automotive industry is dominated by O.E.M.'s (original equipment manufacturers). Therefore, the emphasis on cost reductions continues to be the leading focus not only for the basic industry but also at every O.E.M.s.

Pleasing designs are made possible with improved manufacturing technology. Manufacturing capabilities of automotive industry continue to improve and become more flexible; correspondingly, paratransit vehicles start to be designed with a greater freedom thanks to the flexible manufacturing methods. Erstwhile, the mostly used material and the manufacturing techniques were galvanized sheet metals that are pressed in order to create the intended form. Due to this inadequate manufacturing capability, the previous minibuses usually seemed like a bounding box. However, today types of plastics with various manufacturing methods help designers to create free form surfaces.

Fiber-reinforced plastics (FRP) together with numerous composites are one of the most commonly used material types in the public transport vehicle industry. There are a wide range of manufacturing processes and forming techniques with FRP usage. Hand lay-up and spray lay –up are two of the most used manufacturing method for the forming of exterior and interior trims of the public transport vehicles (Figure 4.7 and Figure 4.8).

Hand lay-up is one of the oldest and simplest molding technique in which reinforcing materials and catalyzed resin are laid into or over a mold by hand. These materials are then compressed with a roller to eliminate entrapped air. The process of hand lay-up is placing successive layers of reinforcement and resin into an open mold resulting in a part with one finished surface. The main advantage of this process is low investment cost. In addition to this, any types of large and small parts can be made with this method and short tooling lead time and higher glass content is possible (Manish Resins and Polymers: Technical Info, 2008). There are also some disadvantages of this process For example; hand lay-up is totally labor intensive and operator dependent process. Therefore, thickness variations and material waste are inevitable results of this method (Manish Resins and Polymers: Technical Info, 2008).

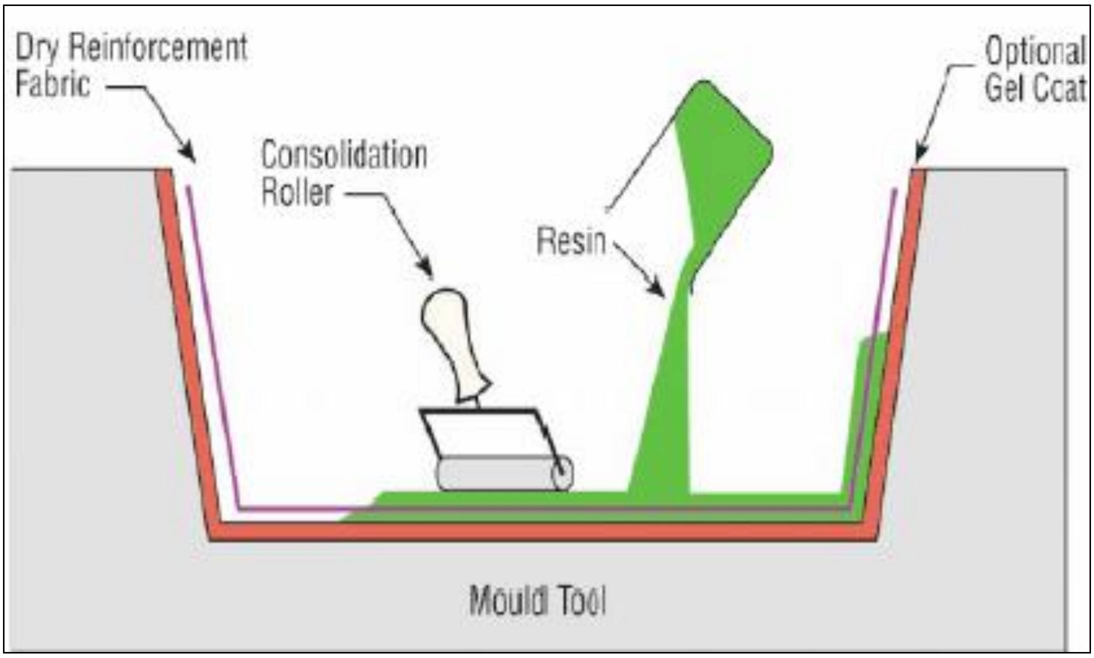


Figure 4.7 : Hand lay-up FRP forming (Cripps, 2009).

Spray lay-up method covers a number of techniques in which a spray gun is used to simultaneously deposit fiberglass and catalyzed resin on a mold. The process of spraying chopped fibers and resin, in place of mat type reinforcements, into an open mold resulting in a part with one finished surface is called spray-up (Manish Resins and Polymers: Technical Info, 2008). The main advantage of this process is higher output than hand lay-up. Any types of large and small parts can also be made with this method with short tooling lead-time. The main disadvantage of this process is higher investment than hand lay-up. Additionally, spray lay-up is also an operator dependent process and material waste is an inevitable result (Manish Resins and Polymers: Technical Info, 2008).

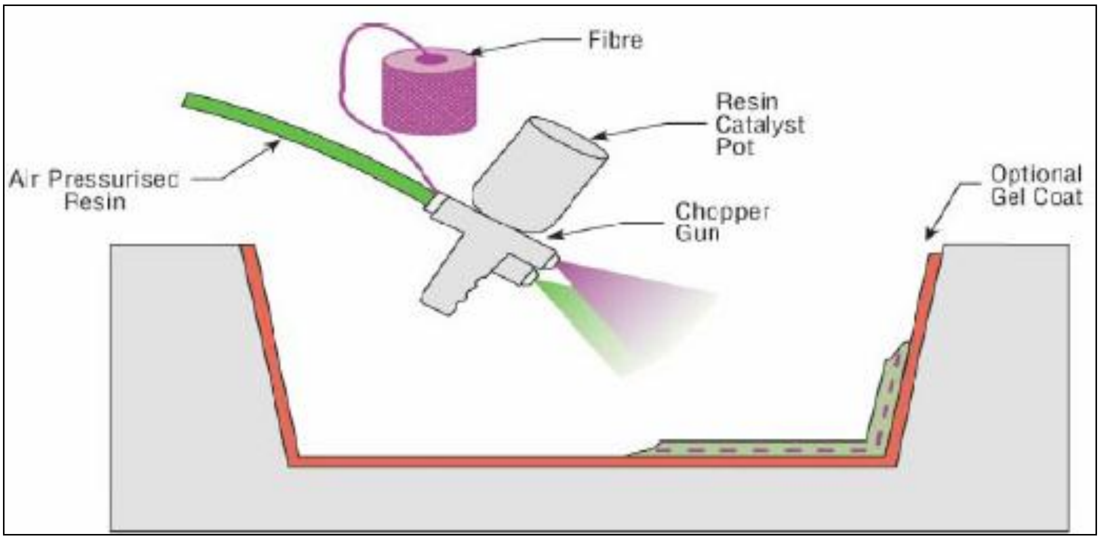


Figure 4.8 : Spray lay-up FRP forming (Cripps, 2009).

In addition to these two techniques, there are also various manufacturing methods for FRP composite material used in automotive industry. For instance, vacuum bagging, Resin Transfer Molding (RTM), pultrusion, SMC (Sheet Molding Compound), compression molding, prepregs and some other infusion processes (Manish Resins and Polymers: Technical Info, 2008; Cripps, 2009).

Since paratransit vehicles' production volume is not large enough, the composite materials whose manufacturing methods explained above, are currently preferred materials of these vehicles manufacturing. In addition, injection molding, extrusion and some thermoplastics like ABS (Acrylonitrile Butadine Styrene) vacuuming are another methods used for some interior trimming of paratransit vehicles.

Textile are also used extensively in automotive and have a potential to expand beyond the current applications. These automotive textiles, which are predominantly polyester based, but polyamide, rayons and polypropylenes are used in most of the utility areas. Additionally, alternative materials such as non-woven polyesters are being evaluated as foam replacement for laminate composites in body cloth and sometimes interior panels. This type of product is believed to be advantageous as far as seat comfort and weight reduction plus it addresses environmental issues during production and end of vehicle recycling (Gunnarsson and Shishoo, 2002).

Actually, passengers are more familiar with the textiles they physically contact during the transport experience, specifically seating upholstery. However, one inevitable issue is that ingress and egress of passengers across the seat surface may cause increased abrasion or wear on the leading edge of the seat. Textile materials are also being brought into the interiors to reduce noise and enhance the acoustic properties of the interior environment (Desmarteau and Meadows, 2004).

Three of the most critical performance standards for vehicle both interior and exterior materials are UV and light degradation, abrasion and degree of incombustibility. Polyester somehow can meet these requirements and is the predominant fiber used in the transportation industry because of these high standards. Depending on the application area of the fabrics, standards may be elevated accordingly such as the use of fabrics in a dashboard area.

For all the materials planned to use for a paratransit vehicle design, one of the most important and desirable think is to choose a material that reduces weight which increases fuel efficiency since that kind of a vehicle is owned in order to make profit. Furthermore, environmental impacts and recycling are other desired features of materials that planned to use for these vehicles. In fact, consumer usually demands an interior and exterior that maintains its appearance over the lifetime of its use or contributes to the resale value of a previously owned vehicle. All the materials used inside of the vehicle must be durable and resist vandalism, fading, tearing or soiling. Upgrading of the interior can enhance the buyer’s perception of the vehicle (Powell, 2004).

4.2 Human Centered Design Approach

In the last years, the human factor is assumed more importance in the design, engineering, production and maintenance of new industrial products. Great efforts have been done towards the definition of a product life cycle that takes into consideration ergonomic factors, or what it is called human centered design. A lot of ergonomic analysis, today, could be studied making use of instruments and any type of typical methodologies (Caputo, et al., 2001).

Ergonomics has also become an important issue in paratransit vehicles design. Wickens, et al. (1997) have pointed out “one principle of human-centered design is that each element of the system must have knowledge of the other’s intent”.

Safety and ease of use are important determinants in the design of paratransit vehicles. In order to meet these criteria, applications and components have to comply with strict ergonomic rules; on the other hand, the overall information system must be absolutely reliable (Bellotti, et al., 2005). However, the human-centered design process does not end with a well-designed interface. It should be sufficient to demonstrate achievement of the anticipated safety and efficiency benefits. While both are important, it is also necessary to address the integration of the technologies into the intended environment.

Automotive industries are strongly interested in performing evaluation tests early in the design phase. These tests involve different experts, who have to collaborate for defining a solution that simultaneously satisfies design constrains and end users’ preferences. Interior vehicle design, in fact, is not focused only on aesthetic values and safety requirements, but it is also strongly related to ergonomic aspects, which obviously require the study of interaction between the user and the vehicle components (Caruso, et al., 2011). The interaction between the ergonomic characteristics of functional elements and the user is defined as ergonomic quality. Ergonomic demands often have direct influence on form, affecting characteristics of the vehicle such as weight, texture, and shape (Buti, 1998).

As also mentioned before, the development process of vehicle interior includes the execution of several evaluation tests necessary for the optimization of the final product. Specifically, the feedback acquired during the evaluation tests performed with end users will determine the commercial success of the product. The data concerning the evaluation with end users are generally acquired at the final phases of product development, since a physical prototype of the product is necessary for the execution of such kind of tests. Notwithstanding the fact that, these data cannot be used for deeply modifying the shape of the vehicle interior and, they will be used only for designing restyling (Caruso, et al., 2011). Therefore, any design changes to the vehicle whether in form, fit, function, performance and durability should be evaluated according to procedures quality systems requirements and ergonomic features.

Although the safety standards of paratransit vehicles are often low, and large numbers of paratransit vehicles can cause serious congestion, these disadvantages can usually be overcome with a minimum of intervention (Wright, 1986). Here, well-designed regulations also play a key role.

In fact, market conduct and market failure are just two of the reasons traditionally advanced for introducing and maintaining regulatory regimes in transport. But regulations have been linked historically to other policy objectives, to do with combating wasteful competition and ensuring a high level of safety. Unregulated markets for transport are simply not in the public interest, because they do not allow for stability in the level of service or fares/rates, nor do they permit an adequate degree of co-ordination between service and modes (Button and Gillingwate, 1986, p.87).

Moreover, the paratransit sector is now able to provide very efficient, responsive vehicles at affordable fares when operators have incentives to meet users' needs. These incentives derive from the regulatory system, particularly the nature of licensing procedures and contracts. Competition is the most effective incentive; the risk of losing the right to provide service to another company tends to be the key ingredient in encouraging high quality service.

In order to explain the evolution of ergonomic aspects in a vehicle development process, it is reported the initial idea of vehicle ergonomics. Once vehicles were only required to move from one point to another in safety, today it is required the same performance but in condition of comfort avoiding tiredness and stress (Buti, 1995; Rizzo, 1998).

Caputo, et al. (2001) have emphasized that ergonomic design has to be considered like a human centered method to face the topics relating to a project. It is based on a deep knowledge of the human psycho-physiological capabilities and limitations, with reference to the machine and environments requirements. In this respect, Caputo, et al. (2001) offers a schematic approach, which could be explained as follows:

- to identify the human factors that influence comfort judgment,

- to identify the main design parameters,
- to define and to realize a specific test to measure biological and physiological human characteristics and to get the subjective evaluations related to the different values of the project parameters,
- to analyze the data obtained in the previous steps with the goal to define a model that links project parameters with comfort judgment, and
- to define final values and parameters project.

In paratransit field, one of the principal goals of ergonomic design should be to assure the best usability degree of the final vehicle. Standard ISO CD 9242 defines usability as "effectiveness, efficiency and satisfaction with which specific users reach specific objectives in given environments." This standard affirms that products do not have intrinsic usability because usability is determined by the peculiarity of user, task, environment and product features (Michellone and Levizzari, 1999; Rohmert, 1987; Buti, 1998). According to these concepts, in paratransit industry, the primary requirement should be to assure the comfort of the driver and passengers taking into account problems related to habitability, accessibility, reach ability, visibility and posture angles (Kromer, 1993; Nagel, 1999).

Moreover, the efficiency of the inner vehicle ergonomic design determines the level of the vehicle comfort and safety. A quite conceived inner vehicle devices configuration directly influences road safety since many vehicle aspects and characteristics are taken into account in the ergonomic studies such as:

- Setting of the main and secondary controls that have to be reachable and operable through simple and natural movements.
- Driver visibility that depends on general design of the interiors (i.e. seats, glass surfaces, mirrors, etc.).
- Design of a configuration that have to minimize occupant injury in case of crash.
- Design of a driver's seat that have to minimize driver fatigue.
- Types of dynamic stresses transmit from the vehicle chassis to the occupants.
- Design of the access doors (Caputo, et al., 2001).

When came to the paratransit vehicles, better seating and standing, ergonomically well designed with level-floor boarding/alighting, advance fare collection, and sometimes air conditioned interior environment, well-designed handicap access, including ability for wheelchair passengers to quickly board paratransit vehicles together with a number of other features should be considered within the framework of strict ergonomic rules in order to increase operation speeds and improve service. On the other hand, designers sometimes come up short in applying the ergonomic rules for paratransit vehicle designs. For instance, the placement of gearbox in Otokar minibuses, manufactured in 2000s, was not designed in accordance with the ergonomic rules and anthropometric measurements. In fact, the gearbox that should be placed next to the driver was placed almost behind the driver for some technical and mechanical problems. Although those problems were solved in subsequent years, new minibus models of the firm to be released were also manufactured again by placing gearbox unit behind the driver. Because, drivers have declared that when changing gears, they could also control the doors and take a fresh look at passengers who are getting on and off. Therefore, it is understood that this misplacement of gearbox unit has created a user habit.

Since the objective of the designer should be the "mobility for all" approach, consideration of ergonomic factors with minimum and maximum anthropometric measurements are crucially important in the design process. Additionally, some interior elements that come into prominence in design process of the paratransit vehicles can be listed as seating units for both driver and the passengers together with their seatbelts, steering wheel, mechanical control elements, buttons and indicators placed on the dashboard area, rear-vision mirrors/safety mirrors placed at a danger spot and etc.

Today, in order to be roadworthiness, any vehicle including paratransit vehicles have to obey some regulations defined by authorities in accordance with the zone where the vehicle will operate. In Turkey, for example, all of the vehicles used for the carriage of passengers comprising more than eight seats in addition to the driver's seat have to obey the directive of 2001/85/EC of the European Parliament and of the Council. While the principal aim of this directive is to guarantee the safety of passengers, it is also necessary to provide technical prescriptions to allow accessibility for persons of reduced mobility to the vehicles covered by the directive, in accordance with the community transport and social policies. Therefore every effort is made to improve access to these vehicles. To this end, accessibility for persons of reduced mobility can also be achieved either by technical solutions applied to the vehicle, as covered by this directive, or by combining them with appropriate local infrastructure to guarantee access for wheelchair users (Directive 2001/85 EC, 2002).

In addition, this directive portrays the obligations for the vehicles particularly their technical requirements, components and all the local areas. For example the area of the driver's compartment, the area of steps at doors and any other steps, the area swept by the door and its mechanism when it is operated and the area with all possible seats occupied followed by the remaining area for standing passengers and, if space remains, any wheelchair spaces occupied, etc.

There are also some other issues which elaborately described in this directive such as number of emergency exits (doors, windows, escape hatches, intercommunication staircase and half staircase) and technical devices facilitating the access to vehicles (e.g. ramp, lifting platform, kneeling system), if fitted and so on. Figure 4.9, Figure 4.10 a, b and Figure 4.11 a, b illustrates some examples of directives and legal requirements for vehicles.

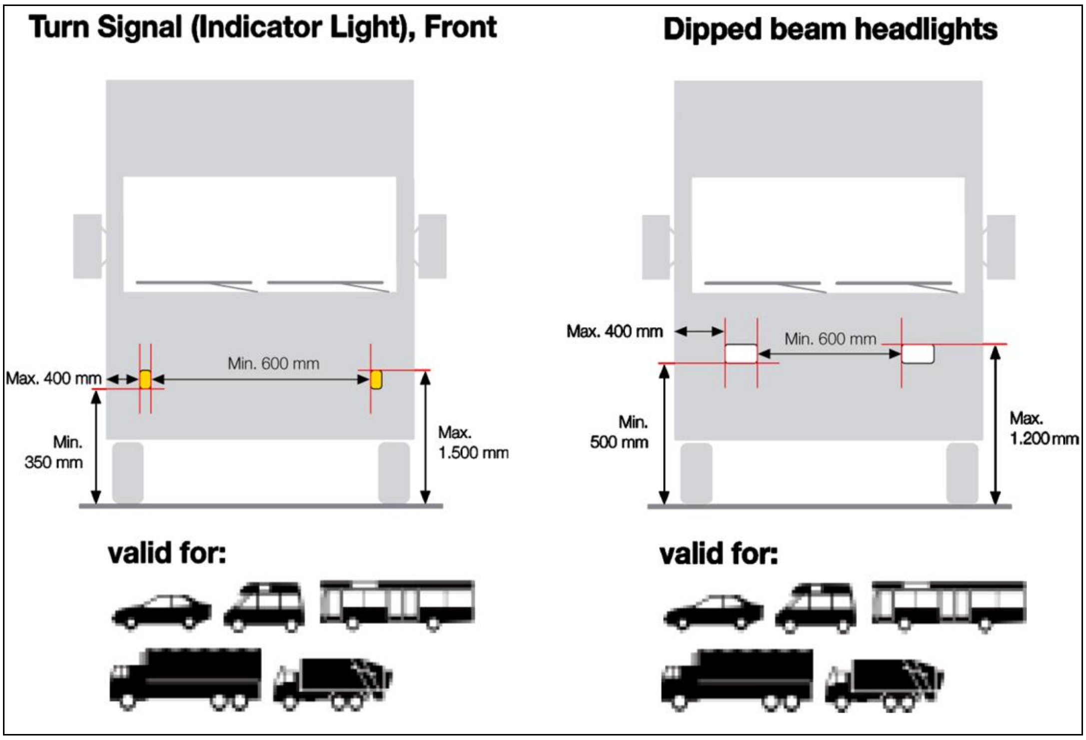


Figure 4.9 : Legal regulations for lights of vehicles (Hella KgaA, 2005, p. 6).

There are some legal requirements for motor vehicles and trailers according to ECE regulation. In order to optimally equip and/or retrofit a vehicle, legal requirements must be considered. For examle, legal regulations for lights and headlights of vehicles are defined in depth and particularly their quantity and colour, their mounting height and width, their geometrical viewing angle and electric circuit detailes are described in directives (Hella KgaA, 2005). The main purpose of such kind of a obligation is to ensure that the necessary and sufficient portion of the road is illuminated and doing this, the lights do not disturb oncoming drivers' eyes during the traffic.

Furthermore, dolmuş-minibuses are designed to allow for several standing passengers since there is always more demand than the seats available. The role of design here is to provide the base equipment and to create a suitable space (Boztepe, 2008). Regulations and directives describe the minimum and maximum measurements of the space allocated for the seated and standing passengers as indicated in Figure 4.10 a, b and Figure 4.11 a, b.

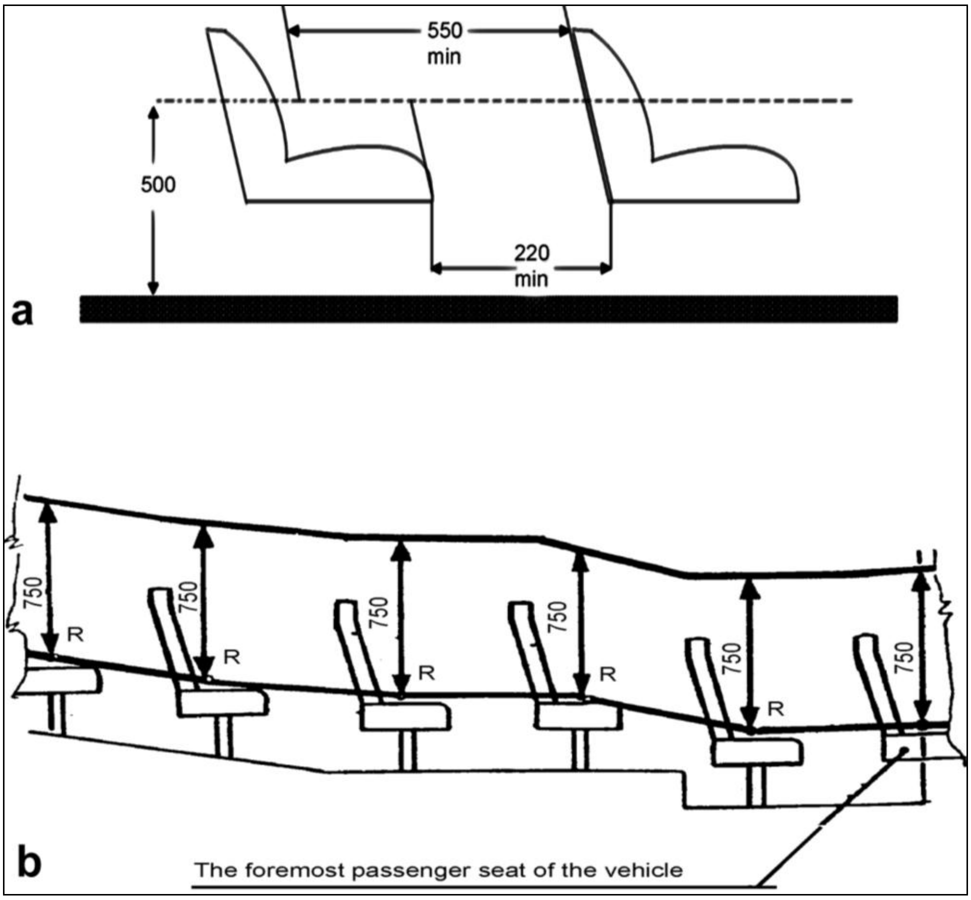


Figure 4.10 : (a,b) Regulations for passenger seats (Directive 2001/85/EC of Official Journal of the European Communities, 2002, p. 74).

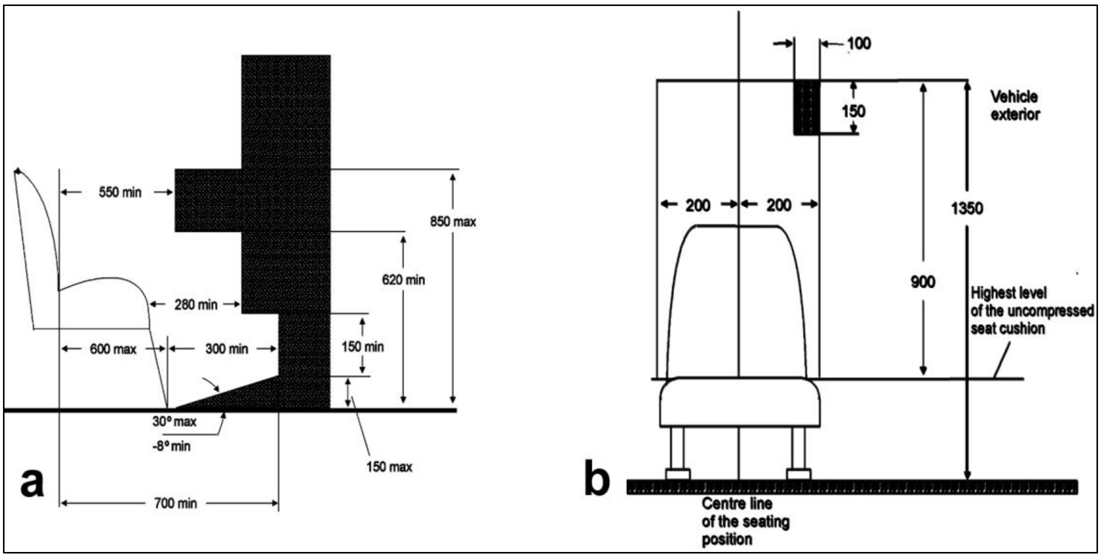


Figure 4.11 : (a,b) Detailed seating measurement of vehicle (Directive 2001/85/EC of Official Journal of the European Communities, 2002, p. 64 and p. 65).

Therefore, it is possible to say that, the design of any paratransit vehicle is highly affected by the regulations and improved directives. When the regulations are ameliorated, the vehicles may become more user-centered in the context of safety, security and durability.

4.3 Future Trends of Paratransit Vehicle Design

In course of time, dolmuş-minibus typology and design may become to present much more different and rich qualifications rather than the previous ones if considered the local and social relationships. Enhancements in manufacturing technologies, new materials usage preferences, more functional and innovative design approaches together with the improved legal regulations for human centered approaches will make dolmuş-minibuses industrially designed vehicles.

In depth field researches and their correctly analyzed results, may help to define some design criteria. Therefore understanding the admirations of the users and customer group of the dolmuş-minibus, and also thinking of the local qualifications of the society may possible affect the styling of paratransit vehicles in the very near future. Furthermore, in the design process of the paratransit vehicles, customization possibilities may be provided to the driver. So that the drivers' psychological satisfaction may be created and also some undesirable intervenes to the vehicle design coming from the drivers such as decorations and ornamentations hanged or placed somewhere around the inner side of the vehicle may be got under control (Asatekin, 2005).

In this manner, one strategy for local companies would be to target niche markets emphasizing localness, authenticity, uniqueness, and prestige as distinguishing characteristics. Such a strategy surely needs to be supported with sophisticated industrial design and marketing. Another strategy would be to look for markets with similar market characteristics and user needs such as passenger car or other commercial vehicle market. This works specifically for companies competing on the basis of solving local problems, like Otokar (Boztepe, 2008; Asatekin, 2005).

To sum up, as also Asatekin (2005) has emphasized, Turkish automotive industry, particularly paratransit sector, will maintain its existence more successfully by creating unique designs if needs are defined correctly and customer profiles analyzed attentively.

4.3.1 Leading examples throughout the world

As also mentioned in the second chapter, paratransit mode of public transport is widely used system with different vehicle and application types in almost every country. Car sharing or for some countries shared-taxi is one of the currently used paratransit application type. Recently, personal rapid transportation (PRT) system becomes to be seen as a futuristic study in some countries that will be more likely the future form of shared-taxi. Therefore, it can be said that, personal rapid transit examples would be one of the futuristic form of paratransit system.

The PRT system uses automatically driven small vehicles to carry small group of people (4-10 people) and usually operates as non-stop from the origin station to the destination station, wherever the stations lie on the network of guideways. There are no schedules or fixed routes and passengers decide when and where to go. Because vehicles can be parked off-line at stations to be immediately available when passengers arrive, or if no vehicle is at the station one can be called up automatically from nearby. Waiting times are usually very short or zero, and since all stations are off-line, there are no intermediate stops (Lowson, 2004).

PRT guideways can be built underground, over the streets supported by posts on the sidewalk, or over the rooftops (“Personal Rapid Transit: What is PRT?”, 2011).

Guideways provide a track for the vehicles and a curb for the guidance system. They are not powered and do not contribute to the operation or communication of the vehicle with the control which is done wirelessly (“Clean technica: Transportation Tech”, 2011).

In this manner, there are some approaches towards new mobility solutions in some developed countries. For instance, European project “CityMobil”, an Integrated Project, part-financed by the European Union, has been set up to build up knowledge of the issues arising from the integration of automated transport systems in the urban environment. The CityMobil project (n.d.) claims, “a shift from the private automobile to a multi-modal approach is the preferred trend objective”. The aim of the project is to create vehicles for urban transport by combining the major alternatives of other public and individual transport modes in other words, to design intelligent and effective vehicles by recognizing the needs for high speed scheduled mass transport and also for individualized on-demand short distance transport (“CityMobil: About CityMobil”, 2011).

ULTra (Urban Light Transport), a City Mobil project, is a leading example of "Personal Rapid Transportation" system which was designed for public transport between London's Heathrow Airport and the city center (Figure 4.12, Figure 4.13 and Figure 4.14). It is the first working prototype model among the other personal rapid transportation systems.

Figure 4.12 : Visualization of *ULTra* system vehicle waiting at the station (“ULTra Global PRT: Photos/Videos”, 2011).

ULTra system, whose design process began in 2005 is currently being installed and tested and in summer 2011 Heathrow became home to the first commercial ULTra pod system. ULTra now has two established systems in operation; the company's Cardiff test facility, and the newly opened system at London Heathrow airport. In addition, PRT systems are being actively considered for applications around the world, with developers, local authorities and private companies all keen to take advantage of the benefits this innovative new form of transport provides ("ULTra Global PRT: Where's it used?", 2011).

The *ULTra* system uses small four-seated electric vehicles automatically controlled on a concrete or steel guide way, with a maximum speed of 40 kilometer per hour. It is based on conventional automotive technologies and comprises rubber tired and battery powered vehicles (Lowson, 2002). The basic operation of the *ULTra* system will be explained in next chapter.

The future roles and the significance of personal rapid transportation systems might increase particularly in developed countries, even though construction of its infrastructure would be highly expensive. Actually, most researchers claim that in the near future personal rapid transit system will be very low cost, both to install and to operate, because the communication technology will be cheapened. Nevertheless, such kind of an implementation of personal rapid transportation is off chance for the very near future in most of the developing countries especially in Turkey.

Figure 4.13 : *ULTra* system vehicle departing from station ("ULTra Global PRT: Photos/Videos", 2011).

Figure 4.14 : *ULTra* system vehicles operating at Heathrow Airport ("ULTra Global PRT: Photos/Videos", 2011).

5. POSSIBLE CURRENT AND FUTURE TECHNOLOGY IMPACT ON PARATRANSIT

Today public transportation gives an honest appraisal of the pros and cons of new public transport technologies in urban areas. These technological improvements for transport sector may indicate how public transport can be made a more acceptable alternative to the private car for the near future.

Advancements in software, computers, remote communications, expert systems, digital maps, in-vehicle computers, GPS (Global Positioning System) technologies and any other technological developments have started to influence the paratransit sector as well as other transport sectors. Thus, the viability of these technologies to the commercial transport sector has become discussed in some circles.

Technology may allow operators to monitor and analyze service patterns, potentially allowing the system to evolve more effectively, and this may be the reason to adopt a high-tech approach. However, the costs of high-tech schemes are still relatively expensive to introduce, and there remain occasional problems installing and using the technological equipment. When selecting the level of technology required, the scale and complexity of the operation envisaged should determine that whether a high-tech set up is necessary or not (Enoch, et al., 2004).

Additionally, technology may also offer almost close to real-time demand responsiveness even on complex networks, to a level far in advance of manual systems. Interestingly, so far the few commercial paratransit operators have looked to low-tech solutions based on technology for conventional public transport operation, which are deliberately limited in what they can achieve (Enoch, et al., 2004).

Therefore, the objective of this chapter is to seek, analyze and explain the possible current and future technology impact on paratransit system. In order to have a comprehensive perspective and find out how technological improvements affect this system, this chapter is divided into two main parts. The first part of the chapter begins with intelligent public transport applications. There are numerous intelligent applications for transportation sector. Within the scope of this study, these applications are studied in depth under the headings of vehicle information and communication systems, automation and assistance systems, safety and security systems and electronic payment. In the second part of the chapter sustainability of paratransit systems has been investigated with usage of alternative energy sources. Thus, in this part it is quested for how ameliorated paratransit systems, incorporating new approaches to system design and new technologies can put urban transportation on a more sustainable path.

İstanbul Technical University library and Otokar Inc. databases are the most essential sources to be searched. In order to find out necessary and sufficient information about the keywords including intelligent public transport, sustainability, information and communication technology for vehicles, vehicle automation, electronic payment and fare collection, alternative energy sources, safety and security systems and so on, numerous online recourses are scanned with either direct access or through search engines like: ITU Library online search and Google Scholar in addition with the electronic databases such as IEEEXplore, EbscoHost, Ebrary, Elsevier, Science Direct, Transit Research Board, and Wiley Inter Science.

5.1 Intelligent Public Transport Applications

Intelligent transportation systems (ITS) for public transportation include a wide and growing suite of technologies and applications both in-vehicle and outside. In-vehicle ITS units are becoming more complex and multifunctional, often providing several capabilities; such as providing real-time status information, communications, computing, entertainment, safety and security systems, assisting or automating the driving and automatically fare payment and toll collection, and so on. Developing those intelligent transportation technologies can play an important role in making these systems user-friendly, easy to manage, and efficient. However, these systems will not necessarily succeed through the application of separate ITS technology bundles. There is an important need to tightly integrate the different types of technology and to develop an effective systems architecture (Barth and Todd, 2000).

There are several ITS technology bundles that can possibly be applied or planned to be used for paratransit systems, including vehicle information and communication systems together with tracking and dispatching systems to provide vehicle check-out, location and identification so that users can obtain system information and make reservations over the web, by phone, by kiosk, etc., vehicle automation and/or assistance systems, safety and security systems and electronic payment (Barth and Todd, 2000).

5.1.1 Vehicle information and communication systems

Perhaps the most familiar intelligent transportation systems are telematics-based applications such as satellite-based vehicle navigation or other services that deliver real-time traffic information to drivers either in-vehicle or outside (Ezel, 2010).

The most effective traveler information systems are able to inform drivers in real-time of their precise location, inform them of current traffic or road conditions and surrounding roadways especially making this information inside the vehicle.

Some modern and enhanced public transportation vehicles have in-vehicle digital data communication system providing traffic information to drivers through their on-board vehicle navigation system. Therefore, paratransit services can enjoy the benefits brought by the development of mobile device locating technology (Cevallos, et al., 2009).

- Geographic Information System,

A geographic information system (GIS) is a special type of computerized database management system in which databases are related to one another based on a common set of locational coordinates. This relationship allows users to make queries and selections of database records based on both geographic proximity and attribute values (Casey, et al., 1998). GIS displays and analyzes the spatial relationship of the different data such as vehicle routes, trip pick-up and drop-off points, transit stops, streets, landmarks, and terrain characteristics. GIS is often used to display Automatic Vehicle Location (AVL) data graphically.

- Automatic Vehicle Location,

Automatic vehicle location systems operate by measuring actual real-time position of each vehicle, and forwarding the information to a central location (Figure 5.1). There can also be obtained real-time freeway congestion information by interfacing with an automatic vehicle location system. Each AVL system employs one or more of the following location technologies: dead-reckoning, ground-based radio, signpost and odometer, global positioning system (GPS).

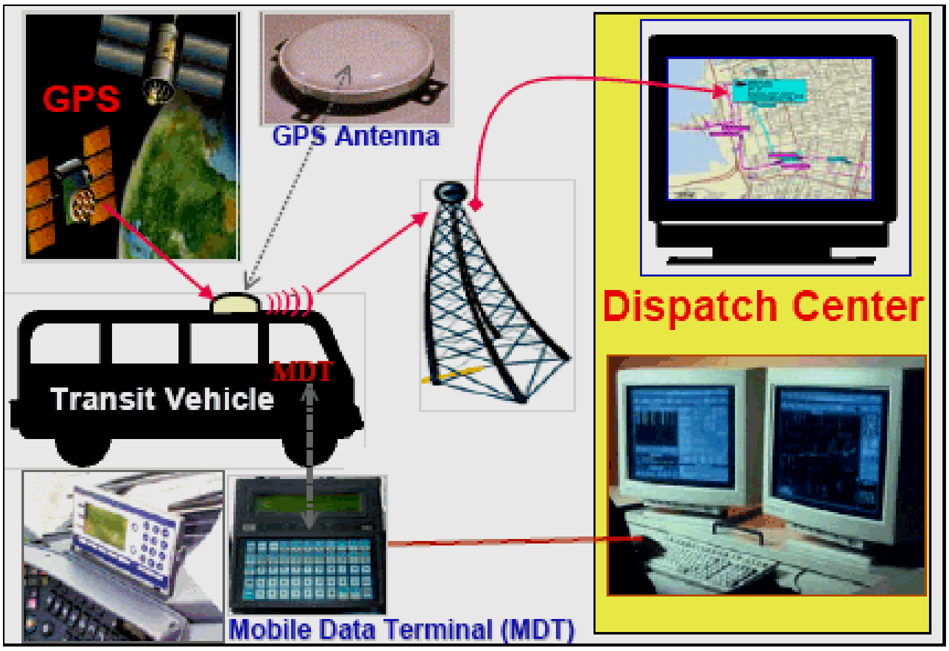


Figure 5.1 : AVL system operation ("Transit Core Technologies", 2007).

Although some paratransit operators in North America have tried using dead reckoning, which determines location by associating the odometer reading with a compass along with a few signposts to help in calibration, they could not yield for it. Because these systems report relative distance traveled but do not permit tracking enroute and they cannot easily respond to changes in routes (Kihl, 1993).

GPS is the core technology behind many vehicle navigation and route guidance systems. Embedded GPS receivers in vehicles' on-board units receive signals from several different satellites to calculate the vehicle's position (Ezel, 2010).

Furthermore, many public transit operators supply some combination of audible and visual information such as major intersection, transfer point information and next stop which is displayed to passengers as the public transport vehicle approaches the station. All these messages are automatically triggered by a global positioning system on the vehicle. Automating the provision of in-vehicle information and implementing it to paratransit vehicles allows the vehicle operator to concentrate on the task of driving and may possibly reduce potential driver distraction.

Intelligent vehicle information and communication systems have a wide range of usage area. As an example, Orange County Public Schools in Florida have become a pioneer in the field of school bus AVL applications. They made use of the GPS technology as assistant to achieve the safety and efficiency goals. The system, which they use, provides real-time location of the midibuses. In addition to an accurate snap-shot of daily operations, transportation staffs have real-world data which can be used to analyze route mileage, speed, direction, stop status, emergency status, safety policy compliance, ridership trends, and vehicle and driver deployments ("Orange Country Public Schools", 2010).

Another example is from London city. The unique feature of London Transit's in-vehicle traveler information system is bus-to-bus transfer notification capability that has being developed. When fully implemented, a passenger will be able to request from the bus driver to notify the next bus on a connecting route. Therefore, a transfer has also been requested. The bus driver does so by entering the connecting route number on the in-vehicle console. This will trigger a notification to the connecting bus operator to wait at the transfer point for a preset, limited amount of time (Casey, et al., 1998).

Recent technological developments, notably in mobile computing, wireless communication and remote sensing are now pushing intelligent transportation systems toward a major leap forward. Technology which make the vehicles sophisticated enough with several computers and sensors onboard is already exist. The new element is the addition of new wireless communication, computing and sensing capabilities. Take for instance, dolmuş drivers in İstanbul. They have contrived a way of communication between each other by using their mobile phones as a radiotelephone. Thus, they get into contact during the journey in order to learn that where the traffic congestion or accident has occurred. This is a quite primitive form of vehicle to vehicle communication whom they have established on their own. Intelligent transport applications mentioned above would be helpful in order to transmute such kind of rudimentary communication to a more advanced communication system. Thus, interconnected dolmuşes not only collect information about themselves and their environment, but they also exchange this information in real time with other nearby vehicles.

- Computer Aided Dispatching and Tracking, With vehicle tracking systems, the precise locations of transit vehicles are known at all times. As customers request service, computer-aided dispatching systems schedule, dispatch and route the appropriate vehicle. Transit providers disseminate up-to-date information to the public and also direct emergency services to the vehicle when necessary. Computer Aided Dispatching (CAD) is often integrated with AVL and GIS technologies to provide advanced real-time system capabilities (Figure 5.2). Kihl (1993) has mentioned that it has become possible to track vehicles with or without established routes with the advent of GPS. Since this system works by establishing vehicle positions vis-a-vis a triangulation information formed by satellites, it can track vehicles precisely wherever they might be.

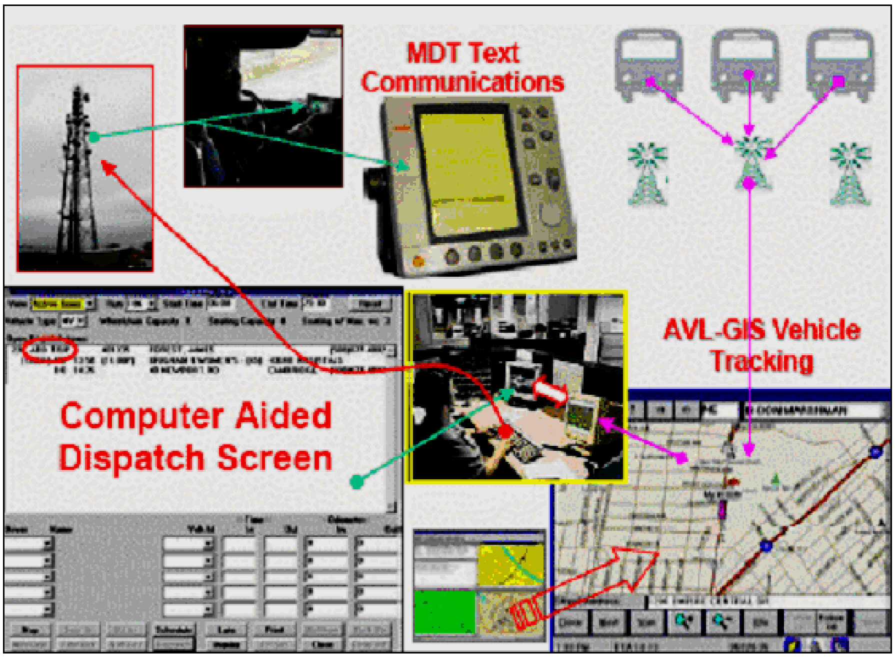


Figure 5.2 : Computer aided dispatching, scheduling and tracking ("Transit Core Technologies", 2007).

The potential for application of GPS to tracking of paratransit vehicles is apparent. When paratransit vehicles are equipped with GPS location devices, they can be tracked and routed by regional dispatching centers (Walton, et al., 2000). In fact, a real time GPS and AVL system with a map display of available vehicles would, provide a clear indication of which vehicle was closest to the call and would permit insertions into the schedule. By noting icons and depicting the real time locations of the various paratransit vehicles, the dispatcher could type in the address of a new caller and then signal the closest vehicle to stop. (Kihl, 1993). Riders can also call the dispatcher and a vehicle is routed to pick them up within a reasonable time

(Walton, et al., 2000). In Figure 5.3 there can be seen a schematic represantation of how smart paratransit works which has mentioned above.

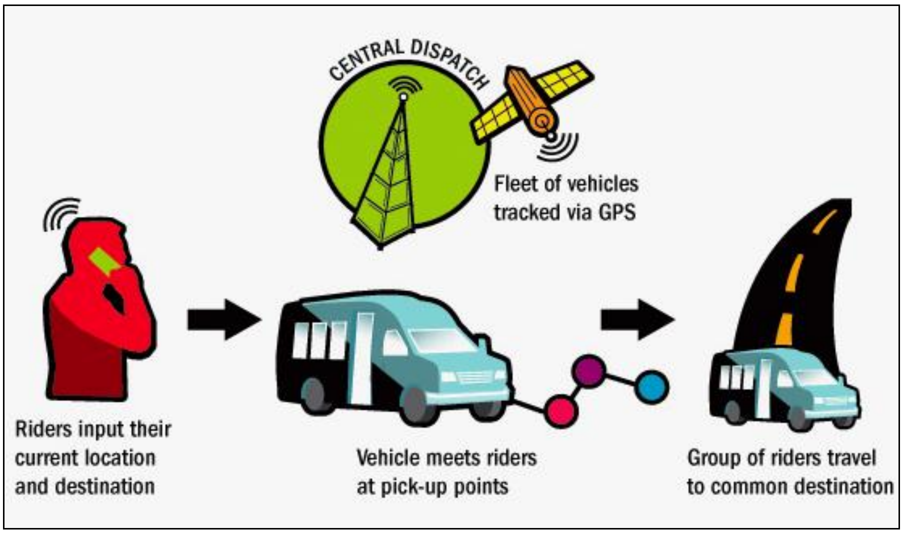


Figure 5.3 : How smart paratransit works (Newton, 2008).

The researchers from North America have showed that the benefit of vehicle tracking is most significant when one of the vehicle experiences a major delay, especially when there is a small number of connecting minibuses. Thanks to the dispatching and tracking system, transit providers are able to operate efficiently and effectively by collecting information on their fleets and passengers. On-board maintenance systems keep operators informed of the mechanical condition of the vehicles, thus allowing them to identify problems quickly and schedule maintenance as needed (Walton, et al., 2000).

In general, technology makes possible many enhancements that could improve service with lower costs (Mathias and Lave, 2000). Dailey and Haselkorn (1994) have pointed out that computer aided dispatching and tracking systems allow planners to use the real time vehicle information in positioning stops and planning routes, as well as allow systems personnel to evaluate the accuracy of the AVL information and install or reposition communications infrastructure to guarantee the desired level of accuracy. They also mentioned that as for the traveling public, dispatching and tracking have a range of possible benefits including increased productivity, public safety, ridership and mode change. For instance, if the transit riders can learn that the vehicle will be at their stop in real time, they are less likely to leave their work site earlier than necessary and allow for the perceived wait time needed to assure catching the vehicle of their choice. Additionally, if the transit user can be assured that the vehicle she/he is planning to ride has not passed their chosen stop and that it will be arriving in a timely manner, the stress level associated with the lack of information will be reduced (Dailey and Haselkorn, 1994).

The latest advances in information technology, such as automatic vehicle location, digital telecommunications, and computers, have renewed interest among public transit agencies in applying these technologies to enhance the efficiency and reliability of their paratransit systems. For instance, intelligent transportation system technologies, primarily GPS, mobile data terminals, digital mobile radios and cell phones, scheduling and dispatching and call reservation software are now in use increasingly in North America and Europe. These systems are replacing formerly manual processes with automation that is already in widespread use by the trucking industry ("Trapeze Group", 2011).

Moreover, in different part of the world there are several modes of booking paratransit. These include boarding at the terminus, 'hail-and-ride' along the route (by hand or sometimes by pressing a button at a stop so the next vehicle will deviate to pick up at that stop, as in some schemes in Italy, such as in Bologna), via the Internet and by telephone. Of these methods, the telephone and internet booking offers the most high-tech and flexible approaches to be adopted, but there is the cost of the call involved and the need for a call center, possibly routing software, and therefore additional staff. Pre-booking using a telephone has become far more viable with the widespread take up of mobile phone technology (Enoch, et al., 2004). People have already access to information and communication technologies, in particular the internet and cellular telephones, which can help them to make reservations and obtain paratransit schedule information. (Khattak and Yim, 2004). Therefore, internet booking systems and mobile phones can coordinate passengers and vehicles.

In fact, it has been noted that citizens live in developped countries today have different expectations and different travel behaviours to previous times: they have more diffuse and less predictable travel patterns and they expect that service providers will offer personalized services that match their needs, and which are adaptable and flexible. This offers great new opportunities to Flexible Transport Services (FTS). In particular FTS will need to radically reposition itself in terms of scale, so that there is mass coverage and ability to function as a full transport mode.

This will require breakthroughs in concepts, business models, organisational and operational models, and in supporting technologies. Nelson, et al (2010) have proposed a solution to this, namely Flexible Agency for Collective Mobility Services (FAMS). It provides an organisational structure and business model for FTS that incorporates the required supporting technologies as seen in Figure 5.4 (Nelson, et al., 2010).

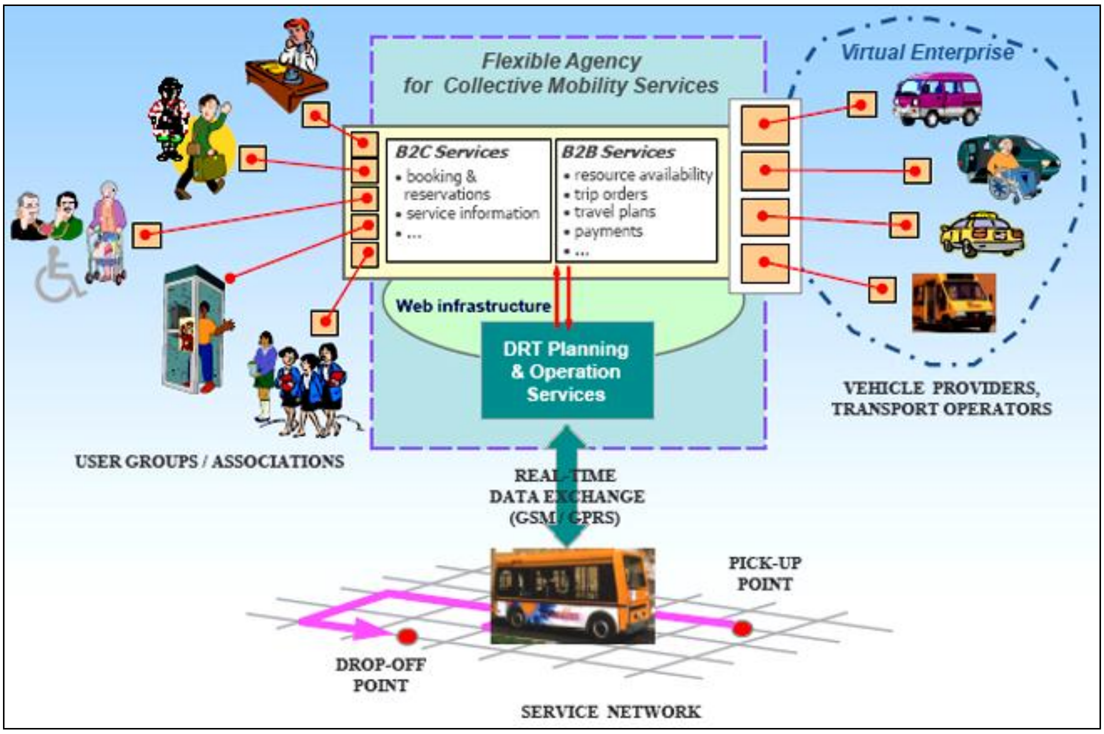


Figure 5.4 : Flexible Agency for Collective Mobility Services operational framework (Nelson, et al., 2010).

Moreover, in 2006, a new generation paratransit system has being developed in the municipality of Philippi in Northern Greece. This new paratransit system has designed so as to be assisted with intelligent transportation systems, where not only booking is done in a computerized manner, but also the vehicle routing would be supported by algorithms using recently developed methods and technologies, such as dynamic traffic assignment, real-time guidance with GPS and navigation systems, and communications systems (Mastrogiannidou, et al., 2006).

As another current example, *ULTra* (Urban Light Transport) replaces the old mass transit paradigm for transport with a new paradigm based on just-in-time transit. The basic operation of the *ULTra* system can be explained followed as:

The passengers each of whom has a smart card to be identified can choose their desired destination at the nearest stations. The passenger destination selection is passed to central control and then the central control system responds to the passenger's request by allocating a vehicle for the journey and instructing the vehicle on the required path and timing for that journey. The central control system also controls the empty vehicle management process that ensures that vehicles are sent to where they are needed. The vehicles are controlled autonomously by using embedded guide way magnets and local sensors based on ultrasonic or lasers ("*ULTra*: System, Operations", 2011).

- Advanced Passenger Counter

Advanced Passenger Counter (APC) is an on-board or in-facility data collection tool that automatically counts passenger boarding and alighting by time and location as seen in Figure 5.5. An APC system has three basic components: a method of counting passengers, a location technology and data management. APC technologies include treadle mats, horizontal or vertical infrared beams, or machine vision applications ("Transit Core Technologies", 2007). Advanced passenger counter data may be used for a number of applications such as real-time service monitoring or service planning purposes, real-time passenger information systems, dispatcher decisions on immediate corrective action, future scheduling and positioning new shelters for waiting passengers.

Moreover, Oberli, et al. (2010) has adverted that automated passenger tracking in public transportation systems can be used to estimate the short-term demand and, thereby, to optimize the fleet schedule in real time. In effect, given the tracking information and adequate datamining techniques, the historical behavior of every passenger could be synthesized and used to predict demand or enhance system performance through accurate measurement of the origin-destination matrix. Actually, maintaining statistics of each passenger's transportation habits over time enable enhancements in long-term planning. Short-term demand could adaptively be predicted and reacted to as passengers show up at expected times and expected stations for their regular daily trips, thus providing clues about their likely destinations and probable return trip times. Nonetheless, ubiquitously tracking passengers throughout a network requires the ability to recognize them at single locations in the network. Commercial off-the-shelf radio frequency identification

(RFID) technologies can effectively be used to recognize individual passengers as they board and alight buses in public transportation systems (Oberli, et al., 2010). This vision is becoming plausible as major cities in the world adopt radio frequency identification technologies.

Figure 5.5 : Advanced passenger counter and its application device on the vehicle ("Clever Devices", 2012).

It is anticipated that APCs will achieve the increased overall operating efficiency due to better service planning (Casey, et al., 1998). Therefore, authorities from cities in developed countries have started to use advanced passenger counter systems even for paratransit services. As an example, İstanbul Metropolitan Municipality is also planning to install and operate APC systems for all public transportation services including paratransit operations.

5.1.2 Vehicle automotion and assistance systems

Vehicles and mobility are changing gradually towards intelligent vehicles embedded in an integrated, intelligent transportation system. (Flemisch, et al., 2008). Bishop (2000) has pointed out that vehicles that can move autonomously and navigate in everyday traffic, on highways, and in urban and unstructured scenarios will become a reality in the next few decades. Actually, today automated control systems are becoming more common in new road vehicles.

- Vehicle automation systems

Vehicle automation systems are the applications that provide full control of a transit vehicle for an automated route or section of a route and driver is not necessarily in full control (Gross, 2010). In general, automation is designed to assist with mechanical or electrical accomplishment of tasks (Wickens and Hollands, 2000). It involves actively selecting and transforming information, making decisions, and/or controlling processes (Lee and See, 2004). The classic goal of automation is to replace human manual control, planning and problem solving by automatic devices. However, these systems still need human beings for supervision and adjustment. It has been suggested that the more advanced a control system, the more crucial is the contribution of the human operator (Bainbridge, 1983).

Vehicle automation systems include low speed automation for congested traffic, autonomous driving, close-headway platooning which provides increased roadway throughput and electronic vehicle guidance in segregated areas such as busway and freight terminals. These systems can be implemented as autonomous systems with all instrumentation and intelligence on-board the vehicle (Bishop, 2000). Additionally, as computer vision based systems like lane tracking, face tracking and obstacle detection are matured, an enhanced range of vehicle automation systems are becoming feasible. These automation systems are accomplished through the redundant fusion of various sensor technologies such as lidar, radar, ultra sound and video cameras that monitor the environment around the automobile (Kämpchen, 2011).

Furthermore, by accessing digital maps, the camera and the localization data of the extremely precise GPS, the automated vehicle can determine its location in its own lane and it can also receive exact information about the characteristics of the route ahead, including the number of lanes that section of the motorway has. This information is supplemented by data from the forward-looking camera integrated in the lane departure warning system. Objects in front of the vehicle are detected by the radar sensors of the adaptive cruise control system with stop and go function and by a laser scanner as well. The same is true for objects at the sides or rear of the vehicle (Kämpchen, 2011). However, most of the researches believe that *road following* is the most complex and challenging that paid attention in automatic vehicle guidance. Because it is based on, *lane detection*, which includes the localization of the road, the determination of the relative position between vehicle and road, and the analysis of the vehicle's heading direction and *obstacle detection* which is mainly based on localizing possible obstacles on the vehicle's path (Bishop, 2000).

Automated vehicle control systems are intended to improve safety with crash avoidance and mitigation; comfort by decreasing of driver's workload; traffic efficiency by increasing road capacity usage and reducing congestion, and the environment by decreasing the traffic noise and reducing fuel consumption (IHRA/ITS , 2010). Besides the obvious advantages of increasing road safety and improving the quality and efficiency of moving people and goods around, Bishop (2000) has mentioned, "the integration of intelligent features and autonomous functionalities in vehicles will lead to major economic benefits, including reduced fuel consumption, efficient exploitation of the road network and reduced personnel". Furthermore, the automation of basic control functions such as automatic transmission, antilock brakes and electronic stability control have proven very effective, but the safety implications of more advanced systems are uncertain such as adaptive cruise control and lane keeping assistance (IHRA/ITS , 2010).

Introduction of a fully automated highway system is technically possible now, but public introduction on a large scale is at least waiting for the safety provisions and the public acceptance, and also on proper legislation that clearly establishes responsibility and liability. Moreover, some of the technology is available on the market, or ready to be marketed, some is developed but as a prototype still under test. A prototype fully automated traffic lane exists in the USA near San Diego, including a limited number of vehicles running on the lane, for testing and demonstrating purposes (Brookhuis, et al., 2001).

- Vehicle assistance systems

Vehicle assistance systems are the applications that help the driver to maintain the control of the vehicle and so that driver is always in control (Gross, 2010). Driver assistance systems also described by the term “co-driver systems” or “driver support systems” include functions such as adaptive cruise control that automatically keep a safe distance between vehicles, lane-keeping, precision docking and precise maneuvering (“Transportation Futuristics”, 2012). These are the systems, which take partial control of the vehicle, either for steady or as an emergency intervention to avoid a collision. In addition, vehicle assistance systems can be implemented as cooperative systems, in which assistance is provided from the roadway, or other vehicles or both. Roadway assistance typically takes the form of passive reference markers in the infrastructure. Vehicle cooperation enables vehicles to operate in closer proximity to each for purposes of increased efficiency usually by transmitting key vehicle parameters and intentions to following vehicle (Bishop, 2000).

Advanced Driver Assistance Systems (ADAS) use sensors and complex signal processing to detect and evaluate the vehicle environment; this includes the collection and evaluation of infrastructure-based data. They provide active support for lateral or longitudinal control, information and warnings (RESPONSE, 2001). Tasks carried out by ADAS range from information to collision avoidance and vehicle control (IHRA/ITS, 2010).

The main purpose of vehicle assistance systems is that driver error will be reduced or even eliminated, and efficiency in traffic and transport is enhanced. There are a number of reasons why in recent years electronic driving aids are developed and implemented at an increasing rate and speed. One of the most important and foremost reason is safety (i.e. the unacceptable number of accidents), but also economic principles (time is money, among others) are a compelling drive, while bringing comfort to the driver population is obviously a good sales argument. In addition, primary functionality of vehicle assistance systems is to facilitate the task performance of drivers by providing real-time advice, instruction and warnings (Brookhuis, et al., 2001).

Advanced vehicle automation and assistance systems can be categorized based on the levels of assistance that they provide to drivers as seen in Figure 5.6. In a fundamental work by Flemisch, et al. (2008) an automation spectrum from fully manual to fully automated, with intermediate levels of "assisted" such as Lane Departure Warning Systems, "semi-automated" such as Adaptive Cruise Control or Lane Keeping Assistance Systems and "highly automated" level of automation is described. This spectrum also indicates that a human is usually actively involved in the control of the vehicle.

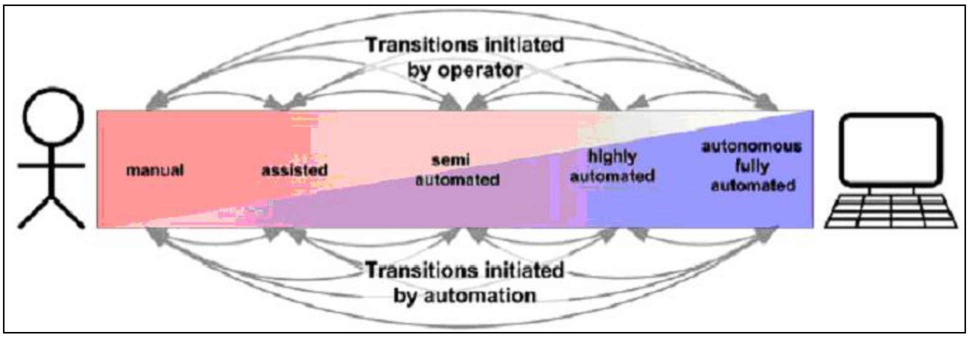


Figure 5.6 : Simplified automation spectrum, levels of automation and transitions (Flemisch, et al., 2008).

While assistance and automation systems have benefits, they can also come with downsides, especially regarding the interplay between human and technology (Bainbridge, 1983; Billings, 1997; Norman, 1990; Sarter and Woods, 1995a). In parallel to the technological progress, the science of human factors has to be continuously developed such that it can help to handle the technological complexity without adding new complexity (Hollnagel, 2007). Thus, increased complexity of the cockpit increases the likelihood of failure by the driver, and of at least one of the system's components, either by spontaneous failure or by design errors (Janssen, Wierda and Van der Horst, 1992; Brookhuis and De Waard, 1993).

In the short run, applying the automated systems to paratransit vehicles operated in Turkey do not seem feasible, due to the fact that technological infrastructure of the paratransit system is not adequate and also operators' acceptance of such kind of systems could not be possible. On the other hand, application of those vehicle assistance systems for minibuses and dolmuşes could be quite beneficial for ameliorating both the paratransit system and the vehicles.

5.1.3 Safety and security systems

Safety and security systems are current technologies that enhance the security and possibly safety of transit customers, personnel, equipment and facilities. Technologies include radio communications, silent alarms, covert microphones, closed circuit television (CCTV) cameras (also known as video surveillance) and AVL equipments assist transit agencies in monitoring and responding to situations on board vehicles along the routes and at transit facilities ("Transit Core Technologies", 2007).

Mandatory safety standards, supplemented by surveillance equipment and alarms, have helped to create a safe environment in public transportation vehicles. Most of the public transport vehicles in developed countries have some intelligent in-vehicle systems for the safety reasons;

- A two-way digital radio that allows them to connect to any emergency call services while in route.
- The "panic" button that can send a message to the dispatch center when drivers are in a situation where they cannot make a traditional phone call. In such a case, the manager can instantly locate the bus utilizing the GPS

system, and will drive up next to the bus to determine what is happening, and make the appropriate call from there ("Orange Country Public Schools", 2010).

In crowded cities like İstanbul, paratransit service providers particularly minibus and dolmuş operators should take the advantage of such kind of safety and security systems for the sake of both drivers and passengers.

5.1.4 Electronic payment

The electronic fare payment system comprises a database and technical equipment, which uses wireless technologies, is able to send and receive information from the central database. There are variety of electronic fare payment products for public transport services, which make payment much easier for both operators and passengers. Currently, transit authorities in all over the world are using three types of fare payment media: magnetic stripe cards (read-only or read-write), credit cards and smart cards. In addition, there are three types of smart cards: contact; contactless; and combi-cards (Casey, et al., 1998).

Recently, in the field of public transportation, smart cards have widely used especially for registering the fare upon, entering the vehicle and charging it to the passenger's account. When entering a means of public transport, i.e. bus, trolleybus or tram, passengers will have to approach the smart card to the electronic card validator that will be located inside of the vehicle.

Smart cards are generally made to match the size of a credit card, but have an embedded microprocessor chip that allows for processing, storage and transmission of information. In addition, smart cards for fare payment, that function as an electronic ticket, allow transit systems to handle all fare categories and process different kinds of fares (single-trip fares, period passes, special fares) in an automated, user-friendly and cost efficient way. Prepaid electronic tickets remain valid even when fare increases are introduced (Sheikh, 2004).

The key benefit of the contactless smart card is the speed with which transactions can be performed, as the card only needs to be placed next to the reader to pay for the fare. This makes contactless systems very convenient and attractive to users as well as to service providers, reducing queuing and delays by allowing passengers to get on or off faster. Additionally, because the card is contactless, the card reader can be in a sealed unit, protecting it from the environment and reducing maintenance costs ("Smart Cards Canada", 2010). In some systems, like the ones used in London, passengers also have to validate their trips at alighting time. These successive “sightings” of the smart cards provide unique identifications that allow for passenger recognition, tracking, and, in general, sufficient information to estimate demand and origin-destination matrices (Starry, 2001).

Akbil, a steel button shaped electronic memory device, was the first electronic ticketing system used in major public transit systems of Istanbul. The system uses technology in which information is transferred between the passenger's "button" (similar to a smart card) and a computer unit mounted on the bus. Each transaction record contains information such as user identification, fare category, payment amount, credit left, route number, bus identification, date and time of day (Şahin, 2007). As also Kazakoğlu (2009) has mentioned that Akbil is being replaced by a contactless smart card system called *İstanbulkart*. This new system will require additional equipments, some of which will be in-vehicle equipments, such as modems, global positioning system receivers, mobile communication modules, monitors and other computers.

In Turkey case, cooperation of passengers in passing fares forward to the driver might become a history in the near future thanks to the electronic fare payment system together with contactless smart cards usage. Nonetheless, implementing an electronic payment system to whole paratransit vehicles operated in İstanbul might be a little more difficult. Because the fares paid for minibus or dolmuş are not always fixed and sometimes depend on the distance. For fully implementation of this system might be possible only with the application of multiple ITS technology bundles.

5.2 Sustainability of Paratransit Systems

Today, cities face enormous problems of transport sustainability due to rapidly increasing populations and so that rapid growth in oil use and unacceptably high levels of air pollution. Given that the term transport sustainability has many different aspects and among these different aspects the most relevant ones are distilled for this study. In 2001, ministers of transport from Council of the the European Union adopted a slightly revised version of a definition which states that a sustainable transport system is one that:

...Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of nonrenewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise (European Commission, 2001).

In addition, Black (1996, p. 151) has pointed out that sustainable transportation is characterized as "satisfying current transport and mobility needs without comprising the ability of future generations to meet these needs". In fact, with the introduction of environmental impact assessments in the eighties, ecological sustainability, economic efficiency, and competitiveness of urban transport systems came to the fore against the background of increasingly deficit-ridden budgets in the cities of the developing countries (Joewono and Kubota, 2005). Therefore, public transportation planning is seen as a promising approach for achieving urban sustainability (Newman and Kenworthy, 1999).

Typically, most studies consider the impacts of pollution caused by public transport on ecosystem and human health; the effects of various substances being released in the atmosphere vary widely depending on their nature, the duration of the emissions, timing and geographic scale. Air pollution is usually given the most attention (Rahman and Grol, 2005). There is an urgent need for paratransit solutions which are environmentally acceptable and match the public transport needs of the new structure of the cities. For this reason, this part of the study is focused on ways of improving the paratransit system in terms of sustainability.

In a wider perspective, the use of natural resources in the paratransit system would require taking the whole life cycle of different parts of the system (e.g. of vehicles or a road network) into consideration (Rahman and Grol, 2005). Actually, each technology, that would ameliorate the paratransit, includes both fuel and vehicle components, a complete inventory of characteristics must include all the characteristics of fuel and vehicle components of that technology for all the steps shown in Figure 5.7 (Weiss, et al., 2000). Life-cycle analysis (LCA) of the whole paratransit system would become, therefore, extremely complicated.

The life cycle of vehicle technology is defined here to comprise all the steps required to provide the fuel, to manufacture the vehicle and to operate and maintain the vehicle throughout its lifetime up to scrappage and recycling. The stakeholder groups of concern here include the six major groups whose buy-in is required for successful development, introduction, and penetration of a new technology. Those groups include fuel manufacturers, fuel distributors, vehicle manufacturers (materials and parts), vehicle distributors (maintenance and repairs), customers for vehicles and fuels, and governments at all levels whose cognizance covers environmental, safety, local zoning, and other aspects of new technologies including promoting their development with their tax and environmental regulations. In other words, a complete assessment should consider the impact of each characteristic of each technology on each of these groups; a change that may be trivial to one group may be critical to another group (Weiss, et al., 2000). Therefore, the economic, environmental, and other characteristics of each technology must be assessed for their potential impacts on each of the stakeholder groups. Furthermore, for the time being, LCA is a fairly new approach in transport research and much less data is available compared to measuring the outputs of transport system to environment such as pollution (Rahman and Grol, 2005).

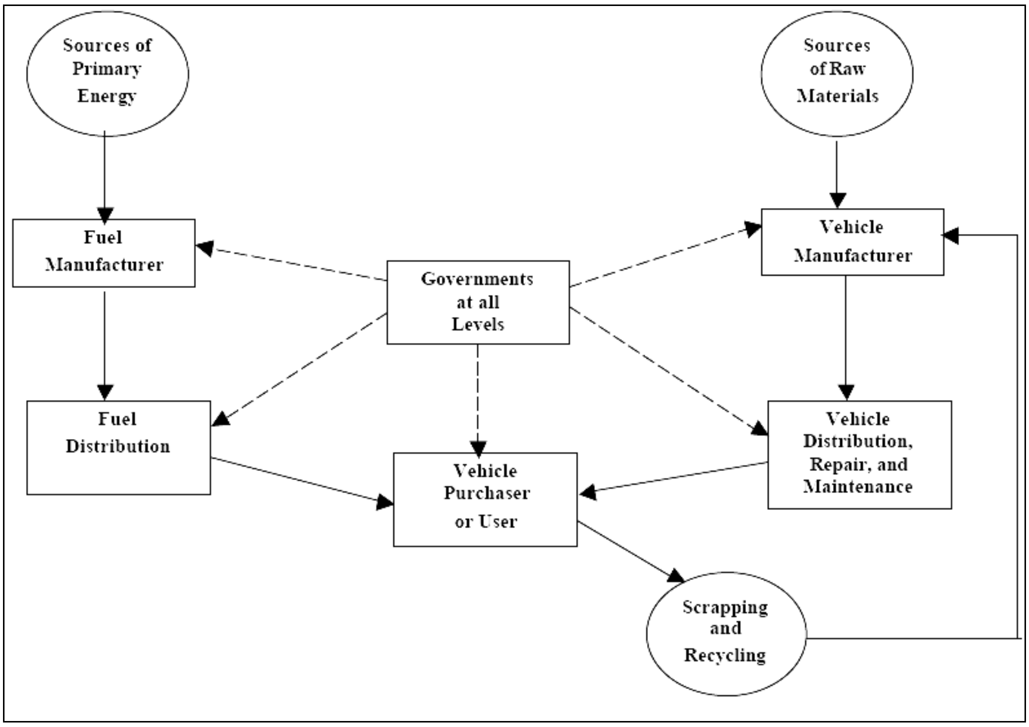


Figure 5.7 : Steps in the life cycle of vehicle technology (Weiss, et al., 2000).

Moreover, as the demand for transportation inexorably increases, one environmental consequence of public transportation takes on increasing potential importance and provides the impetus for looking at new technologies. That consequence is the emission of greenhouse gases (GHG), mostly CO_2, in huge amounts (Weiss, et al., 2000). Therefore developing countries need access to environmentally sound technologies. Because, public transport can become more sustainable only by moving people more efficiently and improving vehicle technologies and fuels. However, technology co-operation can only succeed through joint efforts by enterprises and governments, by suppliers of technology and by its recipients (IEA, 2002).

A variety of new and more advanced technologies for propulsion systems are being developed that could make important contributions to energy savings, improving air quality and reducing CO_2 emissions, as well as provide superior service to travellers. In spite of the fact that diesel engines have historically produced high levels of pollutant emissions, especially oxides of nitrogen (NO_x) and particulate matter (PM), recent improvements in engines, fuel and emissions control technology have resulted in new diesel systems for vehicles that are substantially cleaner than they were only a few years ago. That is to say, older and poorly maintained diesel engines may produce large amounts of coarse particulate emissions, including black carbon smoke, which may be coated with dangerous, unburned volatile compounds (IEA, 2002).

Furthermore, the Euro system of heavy-duty vehicle emission standards is frequently referenced around the world. The various Euro standards for public transport vehicles, their dates of application in Europe and the approximate diesel vehicle and fuel requirements to meet these standards are shown in Table 5.1. Meeting these standards also involves using the appropriate diesel fuel, and the Euro system has required fuel providers to make available lower-sulphur diesel fuels in time to assist vehicles in meeting these standards. Additionally, as a more advanced tier Euro VI is introduced and will be started to use in 2013 in Europe. In fact, a modern vehicle, driven under the right conditions, can be up to 95-99% cleaner in terms of toxic emissions than its equivalent of 40 years ago (Mondt, 2000).

Moreover, the developing countries are often the recipient of second-hand technologies. For instance, in Turkey, most minibuses and dolmuşes are older or poorly maintained and most of whom, still operating in İstanbul, have either Euro II or Euro III tier emission standards. Only the small amounts of them, which have recently placed on the market, have Euro IV stage diesel engines. Proper engine maintenance, repair and tuning for minibus and dolmuşes are probably the most important and cost-effective steps to reduce diesel emissions, especially particulates. In other words, strategies to clean up those existing paratransit vehicles quickly include better vehicle maintenance and improvements in fuel quality. Incremental improvements to the design of diesel engines, control systems and after-treatment systems (in conjunction with a shift to low-sulphur diesel fuel) can reduce diesel emissions dramatically (IEA, 2002). In the short term, this may well be a successful step towards more optimised and sustainable urban public transport delivery in Turkey. However, such steps may require strong government regulation and strict enforcement.

Table 5.1 : The Euro emission standards for diesel engines (IEA, 2002).

	Date	NO_x	PM	Emission control requirements
Euro II	1998	7.0	0.15	Minor diesel engine improvements, good maintenance, proper operating settings, and diesel fuel preferably with 500 ppm sulphur or less
Euro III	2000	5.0	0.10	Further engine improvements (e.g. closed loop system) and probably a diesel oxidation catalyst. NOx standard may require an EGR system
Euro IV	2005	3.5	0.02	Ultra-low sulphur diesel (<50 ppm) and a catalytic particulate filter, with additional NOx control such as advanced EGR
Euro V	2008	2.0	0.02	Further NO_x reduction such as NO_x adsorber or SCR technologies

Although clean diesel provides impressive emissions reductions, its contribution to sustainable paratransit is limited by the fact that it does little to reduce oil use. Researches, nevertheless, aware that powertrain improvements alone cannot totally solve the problem of sustainable mobility. Continued reliance on diesel fuel does little to prepare for the potential future switch to advanced fuels particularly to gaseous fuels like hydrogen and electric-drivetrain systems such as those used in hybrid-electric and fuel-cell vehicles (IEA, 2002).

5.2.1 Usage of alternative energy sources

Conventional transportation technologies usually involve the use of fossil fuels for vehicle propulsion. Therefore, researchers believe that transport will account for more than half the world's oil demand in 2020 as also seen in Figure 5.8. Researches believe that, besides the energy security and sustainability implications of this dependence on oil, transport will also generate roughly one-fourth of the world's energy-related CO_2 emissions (IEA, 2002). In addition, more recent concerns about

CO_2 emissions and their potential to change climate have led to a major reexamination of our extensive use of carbon-based fuels (Weiss, et al., 2000).

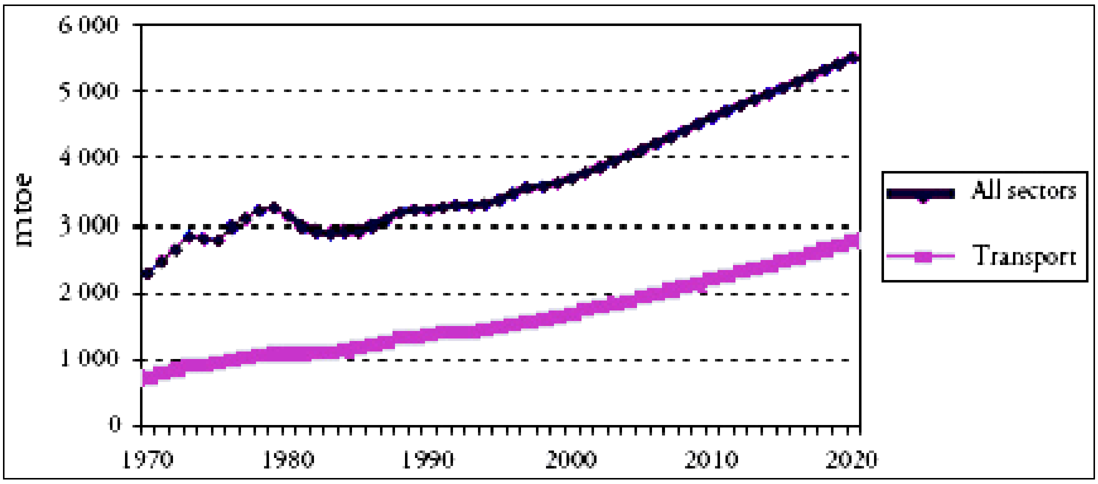


Figure 5.8 : World oil consumption: transport and total (IEA, 2000).

The evolutionary baseline vehicle system is expected to show significant improvements over the vehicle and fuel technologies employed today (Weiss, et al., 2000). Because transit agencies become under pressure to lessen the environmental impact of their vehicles. In addition, the growth in oil usage and rising fuel prices are also causing mainstream awareness and interest in alternative transportation technologies. Many vehicle manufacturers are working hard to develop more sustainable vehicles in order to combat fuel costs and the harmful environmental effects of petroleum as a fuel source. For such reasons, new road vehicle technologies for reducing carbon emissions and alternative fuels may provide attractive options for dealing with air and noise pollution. (IEA, 2002). Although alternative fuels will be facing a robust competitor in the petroleum industry, in the interim, there have been a number of small-scale experiments with a variety of alternative energy sources and with alternative vehicle systems. (Weiss, et al., 2000). In the scope of this study CNG, hybrid-electric, fuel-cell and battery powered-electric systems are reviewed which are thought to be feasible alternative technologies for the future of paratransit system vehicles. The evaluations and comparisons of these alternative technology combinations show that each has benefits and disadvantages.

- Compressed natural gas (CNG) systems

There has beeen a continuing search for viable alternative fuels and propulsion systems. Foremost among these is natural gas, which can be used today in conventional vehicles powered by slightly modified internal combustion engines (IEA, 2002). Even though its combustion does produce greenhouse gases, like clean diesel, natural gas can provide immediate air quality benefits and so it is a more environmentally clean alternative to those fuels, and it is much safer than other fuels in the event of a spill.

On the other hand, natural gas has a number of shortcomings as a vehicle fuel. Due to the very low energy density of methane, the gas must be compressed for on-board storage in large, expensive cylinders. These factors plus required engine modifications can make CNG buses significantly more expensive than even clean-diesel buses (IEA, 2002). However, there are several bus manufacturers which offer high-quality CNG buses, and many bus conversions from diesel to CNG have been performed in various cities, although with a mixed record of performance. The cost of this conversion is a barrier for CNG use as fuel and explains why public transportation vehicles are early adopters, as they can amortize quicker the money invested in the new and usually cheaper fuel (Technology Committee Bulletin, 2010).

Moreover, compressed natural gas vehicles require a greater amount of space for fuel storage than conventional gasoline powered vehicles. Since it is a compressed gas, rather than a liquid like gasoline, CNG takes up more space for each gasoline gallon equivalent. Therefore, the tanks used to store the CNG usually take up additional space in the trunk of a vehicle (Technology Committee Bulletin, 2010). Because of the reasons explained above, CNG technology application for paratransit system might only be a viable alternative when this technology is used for midibuses, which are large than minibuses.

- Hybrid-electric systems

Hybrid electric vehicles (HEVs) incorporate two propulsion systems: a smaller size combustion engine that operates nearer peak efficiency and an electric motor with a battery supply. The engine is turned off at idle and light vehicle loads, charges the batteries when needed if there is excess power, and augments its power with motor power drawn from the batteries for acceleration. Regenerative energy recovered during braking also is used to charge the batteries. Most of the HEVs' engines are designed to shut off automatically when the vehicle is braking or stopped at a red light. Despite the fact that the two separate vehicle power systems entail added costs, weight, and complexity, the efficiency benefits are significant, especially for urban driving where starts and stops are frequent. (Weiss, et al., 2000). That is to say, hybrids are a good match to urban driving cycles. Nevertheless, they are less attractive for high speed travel, carrying heavy loads, and/or over long grades, where the batteries may become drained and unavailable to supplement the lower power from the smaller engine (Weiss, et al., 2000).

Hybrid drive offers numerous operational advantages over conventional diesel paratransit vehicles, such as smoother and quicker acceleration, more efficient braking, improved fuel economy and reduced emissions. On the other hand, maintenance requirements may be higher than for conventional paratransit vehicles due to the complexity of the combined mechanical and electric-drive systems, at least until the technology matures (IEA, 2002).

- Fuel-cell systems

Fuel cell vehicles offer an alternative energy conversion system that has several advantages over internal combustion engines. In particular, polymer electrolyte membrane (PEM) fuel cells have the potential to be an excellent power source for public transportation applications, and they have emerged as a replacement for the internal-combustion engine. They also have longer driving range, high power density, and potentially short refuelling-time characteristics that makes them more attractive as a substitute for internal-combustion engines. Fuelcell systems can be powered by a variety of fuels including natural gas, alcohol, gasoline or hydrogen (IEA, 2002). Although some fuel-cell systems can run on a variety of hydrogen-rich fuels, most fuel-cell vehicle research and development programmes appear to be increasingly focussed on systems that run directly on stored hydrogen (DeCicco, 2001). However, the emissions and inefficiencies associated with the production and distribution of hydrogen are comparatively large (Weiss, et al., 2000). Because hydrogen is a lightweight gas, a relatively large volume or weight is required to contain enough energy to provide the same driving range as today’s paratransit vehicles. Currently, two methods of storing hydrogen are receiving the most investigation: compressed hydrogen gas in storage tanks at high pressure, and liquid hydrogen in insulated storage tanks at low temperature and pressure (CFCP, 2001).

The state of the art for hydrogen storage is still a limitation on this technology. Principally, on-board hydrogen storage is a major limitation on the use of fuel cells. Building a hydrogen production and storage infrastructure will take significant investment and will start to shift the paratransit mode of transportation sector from petroleum to natural gas. However, the number of paratransit vehicle companies in the developing world prepared to undertake the challenge of maintaining a fuel-cell vehicle fleet remains to be seen. Fuel cell technology is still in the prototype stage, and major improvements in cost, weight, volume, and performance will be required to compete with internal combustion engine based technology (Weiss, et al., 2000). Some experts believe that after some additional technological refinements, perhaps even after the current round of demonstrations and evaluations, the fuel-cell vehicle industry will be ready to begin production on a semi-commercial basis (IEA, 2002).

- Battery-powered electric vehicles

Battery operated electric vehicles are powered by an electric motor that draws on stored electricity from the on-board batteries. Most of the time they are referred to as *zero emission vehicles*, because there are no tailpipe and so that no tailpipe emissions, nor are there emissions associated with fuel evaporation, refining, or transport (SAIC, 2002). Under the hood, there are many differences between gasoline and electric cars. The gasoline engine is replaced by an electric motor and the electric motor gets its power from a controller. In addition, the controller gets its power from an array of rechargeable batteries (Brain, 2011).

Adding to the efficiency of electric vehicles is the technique of regenerative braking. This involves slowing and stopping a vehicle by absorbing its energy and converting it to electricity that may be returned to the vehicle’s onboard battery. In a conventional vehicle, this energy is simply wasted as heat (SAIC, 2002).

The driving ranges of battery-operated electric vehicles typically vary from 90 to 250 kilometers, depending on a vehicle’s weight, its design features, and the type of battery it uses. In fact, well-designed electric vehicles can travel at the same speeds as conventional vehicles and provide similar performance capabilities (EERE, 2003). A major limitation in performance is due to the energy storage limitations of batteries. Drivers can refuel a battery-operated vehicle by simply plugging it into a special recharging outlet at home, which is both convenient in the sense of allowing drivers to refuel overnight at home, and inconvenient, due to the fact that it can take extended periods of time to charge the vehicle (EERE, 2003). The recharging time depends on the voltage of the recharging station, the ambient air temperature, the size and type of the battery pack, and the remaining electrical energy in storage. Typically, the process takes several hours, but batteries are being developed that can be recharged more quickly (SAIC, 2002). Current electric motors generally use the lithium-ion batteries. The charging time of the lithium-ion batteries has been substantially reduced with over 80 per cent of its total capacity being reached in just over an hour. This improvement makes battery-powered electric vehicles more suitable for paratransit system operation.

Since the driving range of battery powered electric vehicles are trying to be increased and the longest minibus route in Istanbul is nearly 50 kilometers, electric minibuses-dolmuşes would be the most feasible alternative for the near future of paratransit system in Turkey. In addition, with the establishing of properly designed dolmuş or minibus stations, it might be possible that batteries would be charged while the vehicle is waiting at the main station.

On the other hand, electric vehicles are significantly more expensive to purchase than comparable conventional vehicles. An additional expense with battery operated vehicles involves replacing the vehicles' batteries every few years. Nevertheless more routine maintenance costs are less with battery-operated vehicles than their conventional counterparts, since the vehicles have fewer moving parts to service and replace (EERE, 2003).

Furthermore, the initial introduction of electrical vehicles could pose local distribution problems if battery vehicles were used in clusters, but would not stress national generating capacity (Weiss, et al., 2000). Actually, over the past decade, a number of regulatory policies have been introduced in the U.S. to promote the use of electric vehicles (EVs). If some initiatives are introduced also in Turkey such as a tax deduction for the purchase of EVs, especially for the ones which will be used for commercial purposes, paratransit system vehicles will take advantage of battery-powered electric vehicles and so that the cities where they operated would not exposed to so much polluted air caused by excessive fuel consumption of public transport vehicles.

Additionally, there are some presented studies into the viability of a mass-market, emission-free paratransit vehicles powered by an electric motor. For instance, as also mentioned previous sections, *ULTra* offers massive reductions in energy; emissions output and resource usage compared to existing paratransit types. Because *ULTra* is electrically powered, there is zero emission in the city, but in any case overall energy and emissions are significantly reduced (Lowson, 2002). There are also numerous conceptual studies related to battery-powered electric paratransit vehicles. As an example, the Daihatsu FC ShoCase is a minibus proposal for a zero-emission next-generation mobility solution, with an advanced fuel cell power train and a boxy, high-tech design (Figure 5.9). The main technical feature of this vehicle is the rare metal-free liquid fuel cell technology suggesting new possibilities for compact, zero-emission vehicles of the future. The vehicle is based on a new platform which incorporates the cell system in the under floor space, leaving a high degree of freedom to designers ("Car Body Design", 2011).

Figure 5.9 : A battery-powered electric minibus proposal of Daihatsu FC ShoCase model ("Autoweek", 2011).

Another example of electric paratransit vehicle concept is Volkswagen Bulli minibus concept, which presented at the 2011 Geneva Motor Show (Figure 5.10). The Volkswagen Bulli concept is a modern reinterpretation of the original and the legendary 1950 Bulli, known as *microbus* in the US. The batteries of the vehicle are arranged in layers on the floor, so it can make the distance of 300 km. The concept that has a top speed of 140km/h might supplant of the vehicles used for dolmuş concept ("Car Body Design", 2011).

Figure 5.10 : Volkswagen Bulli electric vehicle concept for paratransit operations ("CARSCOOP", 2011).

Moreover, it is likely that all the advanced propulsion system designs of the future will be configured with an advanced body design which involves the substitution of lighter weight structural materials (e.g., aluminum, plastics), reductions in drag and rolling resistance (Weiss, et al., 2000). In addition, currently presented technological studies about hub motor or in-wheel engines are likely to change the body design and structure of paratransit vehicles. To explain in more detail, using four electric wheel hub motors on the front and rear axles instead of using the conventional engines and drive trains would render possible the placement of the wheels closer to the corners of the vehicle (Figure 5.11). This not only enhances the maneuverability of the vehicle but also increases the passenger carrying capacity in the same vehicles dimensions by totally changing its interior design.

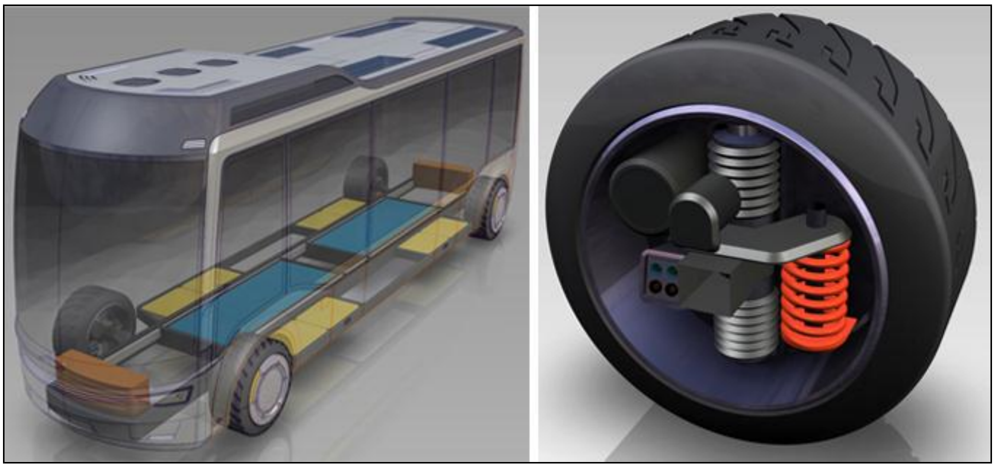


Figure 5.11 : A concept midibus with hub motors on front and rear axles (Otokar database).

6. FIELD STUDY : EXPLORING THE CUSTOMER'S AND DRIVER'S PREFERENCES OF THE VEHICLES USED FOR PARATRANSIT

It is an indisputable fact that the design research is one of the most vital phases of the vehicle design process. Most of the time, information gained from the research results define the direction of the vehicle design process. In majority of the local industries, the information required before the vehicle design process are usually supplied by the marketing or sales departments. Nonetheless, marketing research about paratransit vehicles, that have strong social origins, is sometimes inadequate to provide detailed qualitative information for the designers. This is generaly because of the fact that marketing is related with how people purchase, rather than how people use that kind of a vehicle. Additionally, marketing research is either a benchmarking process or mainly focuses on how a vehicle compares to other competitors' similar vehicles (Kotler, 2000). Therefore, in order to create better vehicles as well as the researches coming from the marketing departments, designers should conduct supplementary field researches before the design process.

The main purpose of this chapter is to manifest the intriguing results of the field study about preferences of customers and drivers for the vehicles used for paratransit system. After explaining the chosen methodology with its reasons and details at first part, findings of the field study are discussed at second part. Then, these findings are analyzed elaborately in the last part of this chapter.

6.1 The Methodology

Throughout this research study various research methods, based on the characteristics of the research topic, have been used to reach the intended goals. In each phase of the study process, different sets of research methods have required. Because, it is evident that, defining and then carrying out the appropriate searching methods construct the most essential part of the research study. In addition, the apprehensive choice of the most appropriate set of methods determines the accuracy and validity of the findings.

This study mainly comprised the literature review and the exploratory researches. To structure the theoretical basis of the study and to collect the data related to previous studies a detailed state-of-art research has been made. As with many studies, this research study also covers a level of tacit knowledge which cannot be classified. These tacit data used within the scope of this thesis are mainly originated from the working experiences of the author. Additionally, a set of empirical studies have been conducted in order to build the practical basis of the research and to validate the arguments proposed.

At the very initial part of this study a pilot survey has been conducted with dolmuş-minibus drivers in Istanbul. However, useful results could not be gained. The notable fact to be recognized here is that; the survey questions were perceived as hard to understand for drivers; because of this reason most of the answers were totally irrelevant. Therefore, considering drivers' socio-cultural situation and level of education, the research method for this study has been changed. Face to face meetings with drivers instead of conducting a survey was thought to be more useful.

As a field study the interviewing with the suitable stakeholders was preferred to define how the industrial design and technology ameliorate the paratransit system and the vehicles particularly dolmuşes and minibuses in Turkey. Actually, this empirical research was to understand the drivers' and customers' perceptions, preferences and expectations from the paratransit vehicles of both exterior and interior elements together with their design and technological features.

Popovic (1999) has mentioned that "interviewing users, as an important design evaluation tool, aims to identify users' needs and better understanding their culture and the contextual environment in which artefacts are going to be used". Therefore, interviewing is one of the most important sources that provide in-depth knowledge about both the cultural and functional needs of users.

As Yin (1989) describes there are three major sorts of interviews. The first one has an open-ended nature, through which the respondent of the interview provides with both facts of matter and individual' own insights in the research concern. Investigator asks unrestricted questions and identifies the important issues for the user. In this type of interview, Yin (1989) illustrates the respondent more as an informant. In the second one, when compared to an open-ended interview, the interviewer follows a rather systematic approach with a certain set of questions in the subject matter. This type of interview, which is described as focused interview by Yin (1989), may help the interviewer support the facts of matter that the investigator assumes to be already applicable. When executing this type of interview, the interviewer should appear naive about the subject matter and let the respondent clarify the inquired matter (Yin, 1989). The third type of interview is structured, which consists of predefined set of questions and moves forward as a formal survey (Yin, 1989; Popovic, 1999). This type of interview is usually considered as an effort to approve the facts of matter that has already been proved applicable by the research study.

The interviewing method used in this field study was both structured and semi-structured interviews and the questions have mostly open-ended nature. Because in such a study, undestanding the opinions, perceptions and real expectations of each stakeholders could only be possible with unrestricted questions.

A pre-interview was performed on selected participants with five open-ended questions. Interestingly, drivers have more tendencies to answer the questions and to declare their opinions, needs and preferences than estimated. Actually, the most important and beneficial aspect of the pre-interview was that the questions have to be short and easy as much as possible to be correctly understood by the selected stakeholders.

Moreover, in order to generalize the interview findings and to make assumptions about the population there must be adequate sample size. Nevertheless, to reach the adequate driver and/or customer from different settlements in İstanbul was quite hard. Because of this reason, the best and the practical way to learn the drivers' insights were to define the well-known routes in Istanbul. The respondents were grouped into two parts. The first interviewee group of this field study was comprised by minibus drivers from the well-known minibus route Kadıköy-Pendik, and the second group of respondents was comprised by dolmuş drivers from the Kadıköy-Taksim route, which is also well known, and one of the densest route of the city. Although these two groups were considered as paratransit operators, their insights, expectations and preferences from a paratransit vehicle design might differ from each other in some aspects. Because, as elaborately explained in the third chapter, there are some differences in the characteristics of these two paratransit implementations: dolmuş and minibus.

During the interview, total of fifteen questions which were prepared as to be similar for both two groups were asked to the respondents. In addition, the interview was conducted with a group of five participants from the selected minibus route and five participants from the selected dolmuş route. Actually, this limitation with five people stems from the fact that after gaining answers from the participants, it was seen that all the answers began to repeat each other.

According to Yin (1989), in executing all types of interview, tape-recording taken through the interview increases the accuracy of the evidences. In this respect, while interviewing process, the whole conversations were recorded.

6.2 Findings of the Field Study

Interviewing respondents in their own context enabled in depth information about drivers' preferences, expectations and purchasing decisions. When asked, most of the users gave confident and definite answers about their vehicle usage habits and continuing the interview with new questions revealed actual usage patterns. In addition, there were interesting differences between the answers of minibus and dolmuş drivers especially the ones related to technological improvements and perception of aesthetical appearance. Below are the contextual factors gained from minibus and dolmuş operators' answers.

6.2.1 Findings gained from minibus operators

At the first step, minibus drivers were questioned about their personal information such as their age, how many years they have done this job and whether the vehicles they use belong to them. In Table 6.1 there can be seen the personal information of the first respondent group.

The average age of the first respondent group was 39 and for an average of 18 years, they have been doing this job. Most of the respondents have declared that, the vehicle they use is belonging to them. Only one of the driver was using someone else's (a relative of his) vehicle. They also added that most of the drivers in this route are also the owners of the vehicle just like many other minibus routes. However, drivers usually hire the license plate of the vehicle due to their higher prices.

Table 6.1 : Personal informations of the first interviewee group.

Minibus drivers	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Age	37	38	48	44	29
Job experience (years)	15	18	29	21	8
Owner of the vehicle	x	x	x	x	-

The second question was asked in order to elicit that what would be the first feature they search if they would decide to buy a new minibus.

Almost all the minibus drivers think that, fuel economy, maintenance cost and durability are the three most important factors they looked for if they would buy a new vehicle.

As another question, participants were demanded to give information about how the external image, aesthetical appearance or styling of the vehicle effects the clients' purchasing decision.

Among acceptable answers, more than 80 % of the respondents have mentioned that the aesthetic outlook is one of the most important features for the potential minibus customers. Additionally, there are interesting highlights gained from them. Drivers are willing to buy the vehicle, which seems more attractive than the others do. In fact, drivers perceive their minibuses as their home. Therefore just like a housewife who adorns herself to rooms, furniture, etc., the drivers do not buy the vehicle if he does not admire the throughout aesthetic of the vehicle. On the other hand, only a few of the drivers, especially the older ones, thought that the aesthetical appearance of a vehicle is not very important for them, its importance comes from the passengers' preferences.

In the next enquiry, it was aimed to learn from minibus drivers that whether their passengers opt for a minibus by brand or model while they are waiting at the stop.

There is a widespread opinion among minibus drivers on this topic. That is to say, they think that the good looking of the vehicle may help to increase the total passenger amount. They gave essential examples. Some friends of those drivers have realized that the amount of passengers they carry in a month has remarkable increased when they have changed the vehicle with the newest one. Passengers are willing to get on the newest vehicles due to their comfortable features, especially if passengers' trip will be longer. Notwithstanding, passengers do not make a choice among minibuses when their trip is shorter. Actually, drivers are granting their passengers right and adding that if they were a passenger and most especially, they were an older or a disabled passenger, they would prefer a more modern vehicle.

The following two questions were aimed to have information about what kind of modifications or additions that drivers have made or preferred especially for the exterior of their vehicle and what are the reasons of those modifications.

As an answer of this question, there were numerous subject matters, but the most pronounced ones were related to the exterior image of the vehicle. Almost all the participants have mentioned that the outer rim cover of the wheels is one of the most wanted additional parts for a minibus. Furthermore, they would rather attach a long metallic-colored plastic barrier below the front bumper of the vehicle with which the minibus could appear like a low-floor vehicle. Grille is one another vehicle exterior part, which is most desired to be modified due to the fact that it is the most visible part of the vehicle being just in the middle of the exterior front face of the vehicle. In addition, a flap that made of rubber is usually preferred to hang behind the rear wheels, because it is believed that this flap can protect the vehicle against mud and dirt by functioning as a mudguard. Drivers also want the darker colored side windows in order to be protected from the sun light. Klaxons are other most preferred additional features for drivers. Because drivers demand to be easily recognizable while the vehicle is pulling into a stop. Thereupon, when asked the real reasons underlying those modifications, answers came from drivers were surprising. Especially the youngest driver has mentioned that, those modifications are availed just for to be different from the others. He believes that modifications beautify the vehicle. If a minibus has a distinctive outlook among the other vehicles waiting at the same station, it would be distinguishable and so that it may charm the passengers. Hereby, that minibus may be preferred by much more people. They also declared that, if the vehicle goes out the production line with full-accessories of which they added after purchase, then drivers do not prefer to buy that vehicle. Because, in such a case, all the minibus operators would have exactly the same vehicle and the same vehicle accessories; there would not be any difference between the minibuses waiting at the station.

One another inquiry was about the ornaments and decorations hanged, pasted or attached especially somewhere inside of the vehicle. In this part of the interview the purpose was to understand thoroughly that why drivers prefer such kind of ornamentations, do they think that those decorative stuffs yield a profit for them and do they prefer any ornaments in their personal automobiles.

In most of the minibuses in which interviewed with the drivers there were various kind of decorations and ornaments that could easily be seen. Rounded tassels ornaments and engravings which were similar to the ones situated in old seats of private homes, plastic signboards, stickers or labels which are affixed to some trims inside the vehicle, artificial flowers made from plastic or the evil eye beads which hung around the interior trimming (particularly upper side of the driver), steering wheel covering usually made of artificial leather and nickel-plating trimming parts were the most prominent examples. Most of the respondents have asserted that, some of the coverings like nickel-plating or mahogany are done in order to create the perception of luxury. However, drivers have also added that the vast majority of the ornamentations in minibuses are just for pleasure and those decorative stuffs do not have any financial return, on the contrary, they are too sumptuous for them. In fact, respondents thought that in days of yore, garnishing of the minibuses had been a trend among younger minibus drivers, but it is not so fashionable anymore. Furthermore, majority of the respondents have declared that, they do not prefer any ornaments in their personal automobiles.

In the ensuing question, the opinions of drivers were tried to be found out by asking that would it be correct if all the minibuses in İstanbul were monotype.

All the answers were surprisingly the same. They have mentioned that, none of minibus drivers would prefer such an application. In fact, there are reasons that make sense for this answer and respondents have given some examples. For instance, if a minibus route is shorter and the vehicle does not have to start and stop frequently along the route, then drivers prefer vans for this operation such as Iveco *Daily*, Mecedes *Sprinter* or Peugeot *J9* brands. On the other hand, if the minibus route is longer and the vehicles have to start and stop frequently along the route, then drivers choose minibuses such as *M-2000* or *M-2010* models due to their powerful engine.

The following two issues of the interview were about the ergonomic features of minibus interiors. Participants were asked about their opinions, complaints or recommendations related to both driver area and passenger compartment of their vehicles.

The most mentioned topic by the respondents was the interior free space allocated for standing passengers. Drivers have told that the biggest complaint heard from the passengers is usually related to the congestion inside the vehicle and so that lack of ventilation caused by the crowd. Therefore, the openable side windows instead of an air condition are thought to be necessary for good ventilation of the vehicle. Moreover, since the minibus provides a flexible public transportation opportunity, one of the most wanted vehicle feature demanded by the users is being agile, in other words the vehicle has to be quick and light in movement. Because of that reason, there have always occurred sudden acceleration and sudden stops along the route. This causes loss of balance for standing passengers during the trip. Participants have declared that properly designed handrails would be a good solution for this problem when placed them to the appropriate areas of the vehicle interior. Furthermore, drivers demand the steering wheel to have an adjustable mechanism for themselves. Thus, it would provide a more ergonomic usage for each driver even he is too short, tall, weak or fat. Participants have pointed out that even though one of the new minibus model namely *M-2010* has such an adjustable mechanism for steering wheel, drivers who have this vehicle usually do not prefer to adjust the steering wheel according to them. Because when it is adjusted according to the driver, then unfortunately, the indicator panel behind the steering wheel cannot be seen. Additionally, they have uttered that drivers always need appropriate areas around driver seat to put into their personal belongings because minibus is not only a vehicle for them, but also a place where they spend at least half of their day.

The next interrogation was related to a comparison between old and new model minibuses. The participants were wanted to give information about positive and negative features of minibuses, which are newly designed and recently released, into the market.

Majority of the interviewees have thought that, new generation minibuses are very advantageous for passengers; on the other hand, they also have some disadvantages especially for the operators. For example, one of the new minibus appeared on the market namely *M-2010* has a very attractive styling, low interior noise level, spacious interior environment so that it is comfortable enough for both passengers and the driver. In addition, *M-2010* is a low entry and low floor minibus. By means of its steeples structure, to pick up or drop off passengers is possible in a little time and getting on and off the vehicle is easy particularly for older people. On the other hand, in very old minibuses, the interior environment was not roomy enough and the interior height of the vehicles was too low, because of that, passengers who had to transport by standing were always complaining about the vehicle. In older generation minibuses, the noise level inside the vehicle was too high; therefore, most of the drivers sometimes could not hear the voice of passengers who want to get off the vehicle. Furthermore, in those new types of minibuses, mentioned above, there are not openable windows, instead, there is an air condition. Participants have believed that air condition is not a feasible feature for a minibus. Because minibus is the vehicle that frequently stops and then starts to go; that is, the doors are opened and closed frequently, in that manner, an air condition does not function effectively. Actually, as also all the minibus drivers have declared that, the major differences between the new and the older vehicles mentioned above arising from their engine technology. Interestingly, the newest model minibus in the market, *M-2010*, is not opted for purchasing by most of the drivers because of the assembly design and details of that vehicle. Especially, in the big cities there usually occurred much more small traffic accidents. Drivers have pointed out that when this vehicle is crashed, its repair time would be too long for a commercial vehicle and its labor cost to be repaired in the authorized service would be too expensive. In an older minibus, every small repairment was done by either its driver or a skilled worker who was well known among minibus drivers. Respondents have asserted an important point for a commercial vehicle; that is, the little time in the authorized service, the more time to earn money.

In one another inquiry, it was aimed to understand that what were the most appreciated and the most popular minibus model among drivers that have ever been used in İstanbul and the reasons of it.

Almost all the drivers have expressed that *M-2000* model minibus has been the most favorite vehicle among the drivers since more than ten years. After this vehicle, some facelift models of it namely "*M-2000 Sport*" and "*M-2000 Platinum*" have been introduced to the market. Both of them again have achieved a reputation among the drivers; indeed, drivers queued up to buy those vehicles. That is to say, these vehicles were sold before they got into the market and drivers have paid a remarkable amount of money for them. A few of the most important reasons for this success are that, as also respondents have spoken out, those minibuses mentioned above are durable enough, less costly, easy for maintenance and simple designed.

In the ensuing question, the participants were demanded to share their opinions about the applying of the technological improvements used in new generation automobiles to the paratransit vehicles. Meanwhile, in the question some examples of these technological improvements such as electronic payment system, parking sensor, digital indicators, on-board computer, navigation system, Automatic Braking System (ABS), automatic transmission, digital line board, security cameras, audio and light information systems, automatic vehicle location system, etc. were given.

While answering this question all of the drivers have behaved timidly. Actually, majority of the respondents know very well that, most of the new generation automobiles are equipped with the technological innovations that make the life easier. Nonetheless, minibus drivers are somehow conservative against the innovations and afraid of those technological improvements by thinking that they may cause lots of problems rather than benefits while driving. Although some of the technological innovations such as electronic fare payment system, digital line boards and Automatic Braking System (ABS) may be welcomed by the drivers, they, nevertheless, worry about the additional cost of them. Participants have mentioned that, of course, drivers and especially the passengers like technological improvements, but operators most probably would not prefer to pay much more just for these added values. Especially the older drivers have told that they are afraid of the stuffs, which are composed of any kind of electronic equipment. Because they are used to repair their own vehicles' parts, except for the electronic ones. Drivers have also pointed out that if all the controls in the vehicle become electronically equipped, then they will have to pay much more for repair and maintenance.

Approaching towards the end of interview, the respondents were requested to share their ideas about new generation and more environment friendly engines and the Euro emission standards for diesel engines such as Euro IV, V and VI.

Minibus drivers have uttered that, they realize the fact that the black smoke released from the vehicles' exhaust pipes have become decreased of late years, thanks to the new engine technologies. Drivers have thought that even though this situation is less harmful for the environment, unfortunately, the newest engines are perishable compared to the older ones and the traction of them are lower. In addition, participants have believe that, emission standards for diesel engines become rise, that usually begin obligatory by laws, then they have to use higher quality and more expensive fuels. Because new engines may break down when used cheap and poor quality fuel. Of course, they do not prefer such a reduction in profit arisen from the engine and emission standards.

In the last part of the interview, minibus drivers were questioned about the electric and hybrid vehicle technologies.

Although most of the respondents have heard about electric and hybrid vehicle technologies, only a few of them have informed about those technologies. Due to the lack of knowledge, they do not believe that these alternative technologies would be appropriate for such kind of paratransit vehicles.

6.2.1 Findings gained from dolmuş operators

At the beginning of the interview with dolmuş drivers, the participants were asked about their personal information such as their age, how many years they have been doing this job and the vehicle was belong to them or not. Table 6.2 indicates the dolmuş drivers' personal information.

Table 6.2 : Personal informations of the second interviewee group.

Dolmuş drivers	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Age	47	42	51	39	43
Job experience (years)	24	21	27	13	23
Owner of the vehicle	x	x	x	x	x

As demonstrated in the table above, the average age of the respondents was 44 and an average of 21 years they have been doing this job. All of the interviewees have declared that, just like in many other dolmuş routes, drivers working in this route were also the owner of the vehicles. In addition, there are also some situations such that an older and retired person could rent his own vehicle to someone else. Most of the drivers do not want their children to do this job. Therefore, they are also planning to rent their vehicle after their retirement. On the other hand, almost all the license plates of the vehicles were hired for this operation hence the average price of the license plates are at least ten times more than the price of the vehicle.

For years, majority of the yellow vehicles operated as dolmuş in İstanbul were the monotype vehicles with Ford *Transit* brands. The drivers were asked the reasons of this situation; whether it was a compulsory or not. Additionally, it was asked that what the most suitable vehicle for dolmuş operation be.

Respondents have clarified that, actually, many years ago, there were only American cars on the market to be used for dolmuş operation. In 1994, Ford brand vehicles namely "*Transit*" came onto the market. Majority of dolmuş drivers who preferred those vehicles were satisfied enough. Then, almost all the dolmuş operation in İstanbul had been done with these vehicles. In fact, this was not a legal obligation, but there were not any other suitable vehicle for this operation. Dolmuş drivers have uttered that, due to this reason, yellow colored *Transit* minivans were the only option for their colleagues. After a period, these vehicles became to wear out and also it have been legislated that dolmuş operators could not use any commercial vehicle which was older than eight years. Afterwards, new model Ford *Transit* vehicles have been launched. However, those newest vehicles, unfortunately, could not substitute for the older ones due to the fact that they were front-wheel drive vehicles which made their mechanical parts too complex for maintenance. Additionally, drivers suffered from new vehicles' failures especially during the frequent start-stop operation; therefore, it was thought that these new vehicles were not suitable for inner city dolmuş usage. Citroen and Volkswagen brand minivans were also tried to be used for dolmuş operation for a short time, but drivers still have experienced the same operational problems with these vehicles. Finally, Renault brand minivans namely *Trafic* get into the market. Despite the fact that it is a front-wheel drive vehicle, nowadays, it is thought to be the most convenient vehicle for this operation.

Because, respondents have mentioned that, those Renault brand minivans were bought and tested by many dolmuş operators in İstanbul and they have not heard any major complaints until today compared to other counterparts vehicles. One important fact adverted during interview was that if a new model Ford *Transit* minivan would be manufactured which have the similar features with the older ones; almost every drivers would purchase it.

The purpose of the next question asked to the dolmuş drivers was to find out their ideas about the operational differences between the two of paratransit operations in İstanbul: minibus and dolmuş.

Respondents have asserted that, there are many differences between these two paratransit operations. The major differences between minibus and dolmuş arise from the passenger transportation format and total passenger-carrying amount. They have also added that dolmuş offers a more comfortable and speedy transportation opportunity with eight people in total, which is closer to the taxi operation. In fact, the license plates used for dolmuşes are at the same time valid in taxi operation. Time out of mind, dolmuşes provide a transportation mode that is in between of minibus and taxi operations. Interviewees have specified that inner city transport with dolmuş is more expensive than the ones with minibus for such kind of reasons. Drivers gave an example for prices such as; if a passenger wants a trip from Kartal to Kadıköy, he/she has to pay at least 35 TL for taxi, 3 TL for minibus, on the other hand 6,25 TL for dolmuş. Maybe because of the reasons mentioned above, respondents have believed that passengers who prefer dolmuş to the other paratransit modes are those creams of society in means of socio-economic level.

In the ensuing inquiry, the respondents were wanted to give explanations about the prospective modifications on vehicles such as seating units and doors after purchase, and what might be the reasons of those modifications were quested.

Dolmuş drivers have thought that although new generation vehicles used for this operation are entailed less modification compared to the older ones, they still have believed that there is not any vehicle, which is totally designed for dolmuş operation. Therefore, most of the vehicles, even Renault brand minivans namely *Trafic*, that recently became the most commonly used vehicle as dolmuş, require some modifications. For instance, seating units and the doors of these vehicles are usually modified in order to optimize for public transport. Their doors are engineered to be controlled manually and this is not a preferred feature for dolmuş operation. Because of that, they used to take the vehicle to any small industry and automate its doors after purchase. In addition to this, most of the vehicles, which will be used as dolmuş, require some handrails for passengers to get on and off the vehicle easily. The engine power of those vehicles also was not enough for frequent start-stop in the city. Actually, respondents have declared that, they have tried to inform the manufacturer company about their complaints and recommendations. Drivers had the return from the company; that is, the seating units became manufactured, as they do not require any change for dolmuş operation. However, the doors are still as manually controlled. Additionally, the engine power of those vehicles is now 115 hp (horsepower) while the previous ones are 100 hp.

The following step of the interview was to understand whether the vehicles seen on the market are comfortable for both dolmuş drivers and passengers and what were their recommendations to ameliorate the ergonomic features of those vehicles.

Participants have said that, surely, the new manufactured vehicles are more comfortable than the old ones. Nevertheless, there are still some structural problems, which cause difficulties especially for passengers. One of the major ergonomic defect about which passengers have too many complaints is that getting on and off the vehicle is not easy especially for the older, disabled or pregnant passengers. Drivers have recommended that entrance of the vehicles would have a stepless structure; just like the ones, those new minibuses have, in order to ameliorate the ergonomic features of the vehicles. In addition, minivans operated as dolmuş in İstanbul have not any convenient space for coins. All of the drivers have told that they have to solve this problem with their own methods such as by putting a console next to the driver seat for cash and coins.

After gaining answers about the comfort of the vehicles, the next issue was to comprehend the appropriateness of the vehicle dimensions and passenger carrying capacities.

As also indicated in Table 3.1 (in the third chapter), minivans operated as dolmuş in Istanbul are the vehicles in regulation class of M1. Therefore, all of the respondents have agreed that carrying eight people in total is the most suitable capacity for such kind of a public transportation. As a matter of fact, the trip with these vehicles does not take very long and there is usually not a need for the luggage, so that the length of the vehicle is also suitable. Furthermore, dolmuş drivers have also uttered that these vehicles do not carry any standing passengers, thus the height of vehicles is also convenient.

In one another inquiry, it was questioned that what are the pros and cons of new generation vehicles compared to the old versions.

Majority of respondents have recognized the advantages of the newest vehicles, although they have thought that there are some other pros of the older ones. Drivers have explained some pros and cons of new generation dolmuşes with examples. This is an indisputable fact that the vehicle noise is one of the most important factors, which affects the comfort of the vehicle. Unlike new vehicles, old dolmuşes have too much noise arising from the engine and the lack of insulation materials. Moreover, air conditioned interior space together with darker colored side windows are another essential factor which make the newest vehicles more comfortable especially in summers. On the other hand, when a minor repair work was needed for old version vehicles, then, either drivers was mending the vehicle part on their own efforts or they were taking the vehicle to a skilled worker from any small industry, due to the fact that the mechanical and structural features of those old vehicles was too simple for them. Respondents have emphasized that for the newest vehicles the process is totally different and time-consuming. For instance, in case of any small traffic accident, no longer they have to make a report for automobile insurance. Additionally, if they confront any problem, they have to take the vehicle to the authorized service because those new vehicles have too complex mechanical and structural features. This means that the vehicle does not work for some time and so that they cannot earn money during this time.

In the next question, drivers were requested to explain the reasons of the lack of decorations and ornamentations in dolmuşes compared to minibuses.

Participants have attributed the causes of lack of decorations and ornamentations in dolmuşes to their passenger profile. In fact, they believed that dolmuş have been a continuation of the taxi operation and, as also mentioned before, people who prefer dolmuş are the ones whose socio-economic and even socio-cultural level is higher than the minibus passengers. Therefore, dolmuş users do not like such ornamentations in the vehicles. On the other hand, only a few of dolmuş operators, especially the youngest ones who have started this job a little while ago, may prefer some mahogany coverings or nickel platings for dashboards of the vehicle, by thinking in mind that those platings may increase the perception of luxury. Respondents have added that, already any kind of accessories is now prohibited.

Rail transport network such as trams and subway trains has increasingly pervaded throughout the city. The next step of the interview was to learn drivers' comments about the future of dolmuş by looking at this situation.

Almost all of the dolmuş drivers are looking at the future optimistically. They have believed that, dolmuş routes would be the least influenced paratransit route of the city by rail transport network. Because, as also mentioned before, most of the passengers who prefer dolmuş are the ones who look for a public transport choice as comfortable as a taxi; but cheaper than it does. Drivers have also mentioned that intercontinental dolmuş routes lying between the Anatolian side and the European side of the city, in fact, would be the ones who suffer the most by the tube project namely Marmaray. Nevertheless, participants have relied on their license plate, which can also be used for taxi operation by merely changing the vehicle; therefore, they believe that they do not stay open.

İstanbul is a growing city by formation of new settlement areas and satellite towns. Dolmuş operators were requested to explain by giving examples that whether dolmuş routes are also increasing parallel to this growth.

Respondents have affirmed that there can be seen a certainly parallel growth in dolmuş routes by formation of new settlement areas or satellite towns. For instance, Ataşehir-Bostancı and Üsküdar- Çekmeköy are the newest dolmuş route examples. Nonetheless, opening of a new route between the two main stops in the city solely be possible with too much procedural operations. Drivers have informed that they are connected to the chamber of cabbies. This chamber has to make an application to İBB for a new dolmuş route. In addition to this, emergence of a new dolmuş route needs to get permissions from approximately sixteen different foundations and institutions such as chamber of craftsmen and artisans, ministry of forestry, fire department, police and law enforcement organization and etc.

By approaching the end of the interview, dolmuş drivers were enquired about the kind of fuel that they prefer to use for their vehicle. In addition, this question was supported with a following inquire which intend to comprehend drivers' ideas about new generation and more environment friendly engines and the Euro emission standards for diesel engines such as Euro IV, V and VI.

Participants have asserted that, if a driver uses his own vehicle and the vehicle is a new generation one that has the engine with Euro IV or Euro V exhaust emission level, and then he usually has to prefer a high-quality fuel. Because the components of the engine block in new generation vehicles, particularly injector and pump would either go out of order or at least easily fail when used low-quality fuels. Thus, the expense of the operator become approximately 3000-4000 TL. On the other hand, drivers who use rental vehicles and drivers who have old generation vehicles prefer low quality and cheaper fuel in most cases; even though they know, it is harmful to the environment.

The next interrogation was associated with the technological improvements, which have started to be widely used in automobiles. It was intended to learn that would dolmuş drivers expect the technological applications like electronic payment system, parking sensor, digital indicators, on-board computer, navigation system, Automatic Braking System (ABS), automatic transmission, digital line board, security cameras, audio and light information systems, automatic vehicle location system, etc. for their own commercial vehicle.

There is a common opinion among the dolmuş operators: the more a vehicle has technological or electronic components, the more it breaks down frequently. Nonetheless, when the conversation progressed and those technologies were better explained, it became clear that most of the dolmuş operators have a positive attitude towards the technological applications that can possible be used in their vehicle. For instance, automatic transmission if only gear changes would be faster enough, automatic vehicle location system together with on-board computer, digital line board together with audio and/or light information systems which can inform the passengers about the route or stops of the vehicle and security cameras which may make the passengers feel secure for situations such as theft would make operators life easier. In fact, some of the drivers have declared that in order to indicate the route of the dolmuş, they have made a primitive form of digital line board instead of hanging a signboard to the vehicle's windshield. That is to say, drivers prefer such kind of additional features being on the vehicle while they are purchasing it. On the other hand, participants still worry about the maintenance cost of any additional electronic and technological equipment in the vehicle.

The last question asked to dolmuş drivers was about electric and hybrid vehicles. It is intended to learn whether they have any idea about those new generation alternative fuel and engine technologies.

Interestingly, almost all of the dolmuş operators have the knowledge of electric and/or hybrid vehicles. They have learned the technological features of those alternative fuels and engines by watching news or from the hearsay information. Therefore, they believe that, if a battery powered electric vehicle has the driving range of aproximately 300-400 kilometers, then it would be appropriate for dolmuş operation in Istanbul.

6.3 Analysis of the Findings

Interview with one of the major stakeholders of paratransit system in Turkey had the strength of providing indepth information. Maybe because of the fact that the interview was conversational tone with an informal approach, it gave the opportunity to discuss with drivers of paratransit vehicles, learn their actual behaviors, needs, recommendations and preferences and reveal many factors related with context. In addition, the research in the field showed quite notable and interesting findings regarding the perception of operators for dolmuş-minibus system in İstanbul. Hence, in this part, conversation results together with their analysis are presented and evaluated subsequently. Table 6.3, which is created with the data gained from drivers' answers, represents the perceptions of the two participant groups. It can be seen from this table that, there are many differences and also many similarities in the preferences and opinions of the minibus and dolmuş operators against the design and technology whose contributions to ameliorate the paratransit system are discussed in the previous chapters.

To begin with, it is possible to say that, comfort and ergonomic features of both minibuses and dolmuşes need to be developed in order to make them much more human centered for both drivers and passengers. For instance, minibus drivers have complaints about the steering wheel and its existing adjustment mechanism due to the inefficiency to meet the ergonomic criteria. Therefore, if the steering wheel is designed as being connected to the indicator panel; then it would be suitable for each driver regardless of the weight or size. Thus, when the steering wheel's height is adjusted according to the driver, the indicator panel can still be seen.

Table 6.3 : Preferences and opinions of minibus and dolmuş drivers agains the design and technology.

		DOLMUŞ	MINIBUS
DESIGN	Comfort and ergonomic features	needs to be additional improvements for both passengers and drivers	needs to be additional improvements for both passengers and drivers
DESIGN	Styling and/or aesthetics values	important, but not so much in purchasing decision	one of the most important factor in purchasing decision needs to be designed to give the opportunity of customization
DESIGN	Modifications on vehicles (interior and exterior)	interior functional modifications negative attitude towards the ornamentations	interior functional modifications and exterior modifications just for fond of show or to be different from the others positive attitude towards the ornamentations
TECHNOLOGY	Intelligent, improved transport applications	positive or at least impartial attitude towards most of the intelligent or any improved technological equipments in the vehicle.	negative attitude towards most of the intelligent or any improved technological equipments in the vehicle due to the lack of knowledge
TECHNOLOGY	Sustainability (fuel, emissions, alternative energies)	positive or at least impartial attitude towards the clean diesel and upgraded Euro emission standards despite the cost positive attitude towards the hybrid or electrical vehicles	negative attitude towards the clean diesel and upgraded Euro emission standards due to the cost negative attitude towards the hybrid or electrical vehicles due to the lack of knowledge

Additionally, it is an indisputable fact that paratransit vehicle drivers spend a very long time inside the vehicle. That is why, vehicle designers should regard that drivers need locked luggage locker and/or additional spaces for the personal stuffs. As another example, access and egress of the vehicles should be designed as to be easy for each passenger particularly old, disabled and pregnant ones.

Furthermore, even though majority of the participants have mentioned that throughout aesthetical appearance of the vehicle is one of the most important factor in the purchasing decision, most of the minibus operators are willing to make exterior modifications on the vehicle after bought it, whereas dolmuş drivers do not make any exterior styling change on their own efforts. This may indicate that minibus drivers want to be different among the other counterparts. In addition, although it is not a functional modification, interestingly, almost all the drivers prefer some of the coatings like nickel-plating or mahogany for the interior trims or dashboard of their vehicles in order to create the perception of luxury. This may be interpreted that, the drivers willing to give their vehicles a sportive outlook that may be perceived as an expensive vehicle. Because those coatings are just a simple imitation of the trims, which is widely used in those luxury sports cars.

As also mentioned in the fourth chapter, there is a strict relationship between the aesthetic perception of individuals and socially admitted aesthetic values, which definitely affect the vehicle design in that culture (Asatekin, 2005). This may explain why paratransit vehicle drivers prefer a robust outlook with pure design understanding for the vehicle. In fact, the important point is that of customization. In the development process of the paratransit vehicles, designing modular and/or interchangeable parts both for interior and the exterior of the vehicle that provide the customization possibilities to the drivers seems necessary. Thus, as also emphasized in the fourth chapter, some undesirable intervenes to the vehicle design coming from the drivers may be got under control. Actually, designing optional parts might also be beneficial for the companies in order to sale them as spare parts.

After all, it is possible to say that as well as aesthetic outlook, the demountable parts is essential for a commercial paratransit vehicle to lessen the repair cost and time, which means, it is an important point that while designing a paratransit vehicle, not only a good styling but also a totally successful industrial design is needed.

Moreover, there are dissidence between the two participant groups about the application of the new technological improvements and promising innovations. Even though vehicles equipped with intelligent technological improvements will make their life easier, particularly minibus drivers avoid and even afraid of the usage of these improvements in their vehicle due to their additional cost. In fact, this may stem from the lack of education and so lack of confidence to the technology; that is, technology is not commonly accepted among these people yet.

In addition, most of the paratransit operators in İstanbul realize the fact that Euro emission standards upgraded with regulations and new clean diesel engine technologies start to force them to use high-quality and so that expensive fuels which make this system less cost-effective compared to the old times. In fact, this situation have arisen from the fact that there are many differences between old air-cooled engines which had widely used in the paratransit vehicles manufactured till the last decade and new water-cooled types of diesel engines which have started to be used in the paratransit vehicles manufactured in the last decade and even battery-powered electric motors which might probably be the promising vehicle technology for the next decades of paratransit system. In Table 6.4 there can be seen a detailed comparison of those engine technologies. This table is prepared based on the data gained from the field study and the information given in the fifth chapter. Green colored boxes, particularly dark greens represent the positive aspects of aforementioned engine technologies, while pink colored ones representing the negative aspects. Therefore, by looking at this table, it is possible to say that battery-powered electric vehicles would be the most suitable alternative for the near future of paratransit system although their initial cost are higher than the others.

To sum up, technology and industrial design cannot be thought as the separate components for amelioration of the paratransit system. Design revisions for the vehicles are the ones that could be applied in short time, on the other hand, technological amendments for both vehicles and the whole system are the ones, which require more cost and could be applied in long time. In addition, it is true that the paratransit operation in Turkey, as with many countries is a highly cost-oriented system. The maintainability of this system is mostly depended on the total cost and therefore profitability of the operations. Today, this system is in a transition phase. Because regulations governed by the authorities make the operators go into trouble in the aspect of profit. That is why; it is an indisputable fact that, more cost-effective solutions are needed for the maintainability of the paratransit system in Turkey.

Table 6.4 : Comparison between old and new types of diesel engines with electric motors for paratransit vehicles.

	AIR-COOLED DIESEL ENGINE	**WATER-COOLED DIESEL ENGINE**	**ELECTRIC MOTOR**
COST (affects the total price of the vehicle)	LOW (old and simple technology)	HIGH (needs additional cooling components)	HIGHEST (not engine, but the batteries are expensive for today)
DURABILITY	HIGH (especially in hard inner city traffic conditions)	LOW (especially in hard inner city traffic conditions)	HIGHEST (in every traffic conditions)
MAINTENANCE COST	HIGH (simple structure, so easy to disassemble; parts are cheaper)	HIGHEST (more complex than others, so maintenance is expensive)	LOW (no maintenance is predicted; changing the failed parts is easy and fast way)
FUEL EFFICIENCY	HIGH (relevant for poor quality cheap fuel)	LOW (injectors and pumps are sensible for fuel quality)	HIGHEST (needs % 90 less energy to do the same job)
TOTAL LIFETIME	LOW (high temperature shortens the life of metals)	HIGH (water extends the life of metals)	HIGHEST (only tires are rotating not any other moving parts and so that less friction)
FUTURE CHOICE	LOW (no research facilities for development)	HIGH (still could be a choice for near future)	HIGHEST (future seems to be electrical solutions)
ENVIROMENT FRIENDLY	LOW (CO_2 emissions are too high for today's Euro standards)	HIGH (Euro standards force to produce more clean engines)	HIGHEST (zero emission)
NOISE	HIGHEST (cooler-fan noise is terribly high)	HIGH (tolerable)	LOW (difficult to hear any noise)
UPGRADE CAPABILITY	LOW (not suitable for improvements)	HIGH (hybrid variations are the alternatives for today and near future)	HIGHEST (different energy sources like fuel cells can be used with electric motors)

7. CONCLUSION

Within the public transportation matters, the focus of this thesis is the topic of paratransit. As stated in the first chapter, this thesis aims to answer the following two main questions:

- What might be the role of industrial design to ameliorate the paratransit system vehicles?
- How can current and future technology be used to improve the paratransit vehicles and operations?

A brief overview of the topics discussed throughout the research study is represented in this chapter, by summarizing and evaluating the findings of the field study within the framework of these research questions. Furthermore, this chapter is reviewed in three main parts. After presented the concluding remarks and discussions related to the context at the first part, limitations of this study are stated at the second part. At last part of this chapter, further research possibilities are discussed.

7.1 Concluding Remarks

As conclusion, there a number of key themes, which emerge from the cases, examined. The following concluding remarks rely upon both the literature review given in the second, third, fourth and the fifth chapters and the field study presented and discussed in the sixth chapter.

In the beginning of the study, historical origins, evolutions and organizational characteristics of paratransit system is evaluated. Briefly, conventional public transport models had become failing to meet the demands of the market, because they had deficiencies in operational issues such as inflexibility and inconvenience of the services; dissatisfaction of passengers due to the unreliability and insecurity. This situation gave rise to the birth of paratransit services all around the world four or five decades ago (Iles, 2005, p.8). Therefore, small-scale operators, legally or illegally entered to the market in order to fill those gaps. In fact, paratransit had a number of reasons to be flourished and many advantages for its stakeholders. In the literature lots of author has made a definition of paratransit so as to explain its basic characteristics. Overall, paratransit is a flexible, demand responsive public transport system which is somewhere in between the public bus and the taxi therefore, it provides almost a taxi-level of service but for almost a bus level of fare (Enoch, 2005). In general manner, alternatives of those operational characteristics include the type and size of the vehicle used for paratransit; degree of route flexibility which influenced by the level of demand; degree of timetable flexibility (interchange or not); level of technology and mode of booking. Vehicles used for paratransit could be different size and type, which depends on operation conditions, and demand levels of operating area. Most of the time, light commercial vehicles that refer to midsize 8 to 20 passenger capacity vehicles such as minibuses, microbuses, vans and minivans are preferred. These vehicles use their small size than the buses to give a more individually tailored journey and to give a faster trip for passengers with the advantage of being able to penetrate the labyrinth of narrow streets (Adam Smith Institute, 1980).

Furthermore, almost every part of the world there are many examples of paratransit implementations that have been elaborately examined in the second chapter by giving detailed examples such as the ones seen in Africa, South Asia, North America, South America and Europe. In fact, although there seems to be an enormous variety of different types of paratransit services throughout the world, the reality is that the paratransit has many similar operating characteristics wherever it is found. The apparent differences stem from the vehicles and their exotic names; the principles behind the service remain surprisingly constant. The design and technological properties of vehicles used for paratransit system differ from country to country where they operated. European paratransit vehicles have more user-oriented design features than the others, which operate in developing countries.

The first part of this study was concluded by putting forward the drawbacks of paratransit system such as unfair competition to other forms of public transport; lack of regularity and reliability of the operations; low driving quality and jeopardy of the vehicles.

In the third chapter of this study, paratransit implementations in Turkey particularly in İstanbul are elaborately studied. Briefly, paratransit in Turkey is known and operated as two different systems: dolmuş and minibus. The system is implemented with various types of organization modes and vehicles such as midibus, minibus, van, minivan and even the passenger cars (as taxi-dolmuş operation). In general manner, vehicles are licensed to run on widely defined specific routes and typically operate on an owner-driver model. There are some resemblances and also many differences between the dolmuş and minibus system in the operational aspects, economics of operation, as well as the characteristics of the vehicles used in the operation. Minibuses, having a seating capacity for 14-20 people, and standing capacity depending on the operating condition, are more common and much cheaper. On the other hand, dolmuşes, having 6-8 seating passenger capacity, provide relatively comfortable transportation with higher fares.

In fact, dolmuş-minibus operation is a locally generated system as being the citizens' solution for people's need for movement. Hence, this system is in debt its appearance and development to the inadequate and un-served public mass transportation alternatives. Over time, paratransit system in Turkey has evolved and while evolving nourished from numerous resources and events such as the changes or improvements in the city structure, social and economic situations related with whole stakeholders of the system, legal, regulatory and the governmental issues in the country. While examining the evolution of dolmuşes and minibuses, it is possible to say that, changes on vehicle features and types seen over the decades were spontaneous modifications usually arisen from drivers own efforts collaborating with workers from small industries by beholding the habits and behaviors of passengers. Vehicle companies started to manufacture vehicles, which were thought to be more convenient than the previous ones, only after they had realized those small-scale efforts.

Furthermore, land usage patterns of the city and its structural evolution have a close relationship with the evolution of paratransit system operated in that city. In İstanbul case, the city has divided into major sections by the two Bosporus channels and the Golden Horn that caused the development of sub-centers in all sections of the city. Therefore, majority of minibus routes become operate especially outlying areas, which also provide service to the new growth, and squatter areas for relatively lower income groups, whereas dolmuş routes operate within the densely built-up, central sections and around the core of the city (Şanlı, 1981).

Moreover, dolmuş-minibus system is an active element of urban living in İstanbul, both as a means of transport and as a socio-economic phenomenon. There is a close relationship between the evolution dolmuş-minibus system and the financial aspect of its stakeholders. Obviously, the main objective of the operator is to ensure the financial viability of the system and also to increase profit or social benefit. In addition, the evolution in the dimensions of paratransit system in İstanbul such as service level, service quality, organizational possibility as well as the its general prospects are highly affected by the driver profile. The causes lying beneath many of the visible problems of this system and especially encountered by minibus operation such as reckless driving, impolite or nervous behaviors are of those driver/operator profiles (Şanlı, 1981).

The intensely competitive and fragmented nature of the paratransit industry makes government regulation and control much harder than traditional public transport modes. For the legal environment of the paratransit system in İstanbul, there are two main organizational authorities and regulatory powers: İETT and UKOME who have the mission of accreditation and certification of those vehicles; together with planning, determination and evaluation of routes, stations and stops ("IMM: Organizations", 2011).

Consequently, dolmuş-minibus system should be improved as a versatile. Therefore, in the scope of this thesis, the issue was discussed under two headings: industrial design and current and future technology that are two of the most influential factors, which may help to ameliorate the dolmuş-minibus system.

In the fourth chapter of this study, in what way industrial design possible influences the paratransit is searched and clarified. To explain briefly, in order to create an approach for analyzing, designing and developing the paratransit vehicles for Turkey, it is clear that a better understanding of the culture, local problems, the potential stakeholders and their behaviors together with comprising critical elements and parameters in the operating phases should be elaborately identified. Only in this way, creating paratransit vehicles that communicate to the majority of public would be possible. Minibuses and dolmuşes have unique operational characteristics accordingly that may necessitate special treatments considering a variety of issues.

The ideal vehicle design and development process, as comprehensively explained in the fourth chapter, unfortunately, has not being applied exactly such a professional manner in most of the local companies. That is why, paratransit vehicles with pleasing features usually could not be seen in the market. However, industrial design, may contribute the overall quality of the vehicle by creating an aesthetic value, providing human centered approach and possibly minimizing the total cost of vehicle.

In particular, the 'form' properties of a vehicle, usually formalized by the aesthetic properties, are the most dominant signs and information for initial interaction, evaluation and perception of the users. Therefore, the physical form or appearance of a vehicle, that may easily create an impression of quality and prestige, is an unquestioned determinant of its marketplace success. Because the aesthetic formation is one of the most distinct socio-cultural qualities of a population, it is clear that, the interior and exterior appearance of dolmuş and/or minibus influences the perception and satisfaction of the customers. Therefore, the designer's job should be imagining the style that drivers will want in future vehicles.

Indeed, pleasing designs are made possible with improved manufacturing technology and today availability of new materials and production tools provide a greater creative freedom to the designers. One of the essential design priority for minibus and dolmuş should be to make a durable vehicle with low-purchase, low operation, and low-maintenance costs by choosing the materials that resist vandalism, fading, tearing or soiling and permit recycling (Boztepe, 2008).

Furthermore, one another primary requirement of the paratransit vehicle design is to create an ergonomic quality, which possible refers to the interaction between the ergonomic characteristics of functional elements and the users. Since the principal goal of the designer should be the “mobility for all” approach, safety, ease of use, accessibility, reach ability, visibility and posture angles for both driver and passengers are important determinants in the design of paratransit vehicles.

In course of time, analyzing driver/operator profiles attentively and defining their real needs; enhancements in manufacturing technologies and new materials usage preferences; more functional and innovative design approaches together with the well-designed legal regulations for human centered approaches will possible make dolmuş/minibuses successfully designed vehicles.

Today, personal rapid transportation (PRT) systems which use automatically-driven small vehicles carrying small group of people and usually operate as non-stop from the origin station to the destination station, becomes to be seen as a future direction of paratransit system in some developed countries (Lowson, 2004). However, in the short run, implementation of PRT would be off chance in Turkey because of the fact that construction of its infrastructure is highly expensive.

Because the impacts of industrial design on amelioration of the paratransit cannot be thought as separated from the technological improvements, in the fifth chapter of this study, possible current and future technology impact on paratransit system is sought and explained. Briefly, in order to make paratransit system easy to manage and efficient, there are several intelligent transport system (ITS) technology bundles most of whom can possibly be applied to dolmuş-minibus system and provide several capabilities; such as real-time vehicle status information and communication together with tracking and dispatching, assisting or automating the driving, enhancing safety and security and automatically fare payment and toll collection.

Most of the effective traveler information systems, which are the telematics-based applications, have the ability to inform drivers in real-time of their precise location and also inform them of current traffic or road conditions and surrounding roadways. Therefore, automating the provision of in-vehicle information for minibuses and/or dolmuşes allows the driver to concentrate on the task of driving, possibly reduces potential driver distraction, appropriately warn the driver and either prevent accidents or at least reduce their effects and protect the passengers and the vehicle against adverse driving conditions.

In addition, thanks to the advanced passenger counter technology whose application to paratransit seems possible, the historical behavior of every passenger could be synthesized and used for service planning purposes, future scheduling and positioning new shelters. Actually, maintaining statistics of each passenger's transportation habits over time enable enhancements in long-term planning.

Furthermore, there are some other technically feasible technological innovations such as the vehicle automation systems which provide the full control of a vehicle by replacing human manual control and the vehicle assistance systems which take partial control of the vehicle, either for steady or as an emergency intervention to avoid a collision. The main purposes of those systems are reducing the driver error, enhancing the transport efficiency and improving safety and comfort by decreasing of driver’s workload. Although, automated systems for paratransit vehicles operated in Turkey do not seem feasible in the short run, application of assistance systems for minibuses and dolmuşes could be quite beneficial in the amelioration of paratransit system.

Additionally, in order to enhance the security and safety of transit customers, personnel, equipment and facilities there are some technologies that should be applied to the paratransit system such as radio communications, silent alarms, covert microphones, closed circuit television cameras and so on ("Transit Core Technologies", 2007).

In the near future, cooperation of passengers in passing fares forward to the driver for minibuses and dolmuşes might become a history thanks to the electronic fare payment system together with contactless smart cards usage. Thus, queuing and delays to pay the transport fare could be reduced by allowing passengers to get on or off faster and the service speed could be increased.

By looking from a wider perspective, it is possible to say that when the paratransit vehicles will be equipped with novel computing, communication, sensing capabilities with technology bundles mentioned above and user interfaces, their interior design would become totally change in the future. For instance, the dashboard becomes less of a block, in fact, not only areas of buttons, controls and displays on the dashboard would change, but also the way driver operate them would change. Here, ease of learning, ease of use and ease of adaptation to the new novelty is important so as to be accepted them by drivers.

At the last part of the fifth chapter, it is quested that how dolmuş-minibus system ameliorated, incorporating new approaches to vehicle power train design and new alternative fuel technologies, which can put paratransit on a more sustainable path. A wide range of new and more advanced technologies for propulsion systems have still been developing that could make important contributions to energy savings, improving air quality and reducing CO_2 emissions by considering the impacts of pollution caused by public transport on ecosystem and human health. Although clean diesel with upgraded Euro emission levels provides impressive emissions reductions, its contribution to sustainable paratransit is limited due to continued reliance on fossil fuels for vehicle propulsion (IEA, 2002). As technology develops, and costs come down, the benefits and cost-effectiveness of clean and low-carbon technologies change. As an alternative of those diesel technologies, compressed natural gas (CNG) systems, hybrid-electric systems, fuel-cell systems and battery-powered electric vehicles are studied in depth in the fifth chapter. Hence, new clean vehicle technologies will soon be in a position to play a major role in reducing emissions, in particular for paratransit systems. Currently, electric propulsion appears to be the best option to mitigate air and noise pollution. Over the next decade, two technologies -hybrid and/or battery powered electric vehicles- appear likely to move towards commercial viability and start entering the minibus and dolmuş market. Although there may also be other external costs associated with selection of technology bundle, differential tax policy as enforced in some countries might result in greater use of hybrid and electric vehicles or at least clean diesel technology for paratransit system in Turkey.

Briefly, it is an indisputable fact that successful development and penetration of new technologies into the paratransit market requires acceptance by all major stakeholder groups: government bodies at many levels, transportation providers, vehicle manufacturers, ultimate customers for the vehicles, private sector for fuel suppliers and services.

At the last part of this thesis, a field study is designed in order to examine the subjects, discussed in the previous chapters, in real world. Regarding the problem formulation and the research questions set at the beginning of the study, some evaluations can be made. Industrial design could certainly contribute to the amelioration of the vehicles used for paratransit system, while the contribution of current and future technology could be in the field of both paratransit system itself and also the vehicle types and operation modes.

Considering the inquiries and the responses of the operators, the reflections of the theoretical arguments especially given in the fourth and fifth chapters may clearly be observed in the outcomes of the field study. Therefore, it is possible to say that there is compatibility between the literature researches and the empirical research findings. Actually, although there seems an incompatibility only between the operators opinion and application of some technological improvements especially the ones related to the power train design of the dolmuşes and minibuses, nothing to do for the vehicle manufacturers against the regulations. Today, companies have to comply with the regulations to manufacture the vehicles willy-nilly operators.

7.1.1 Discussions and estimations

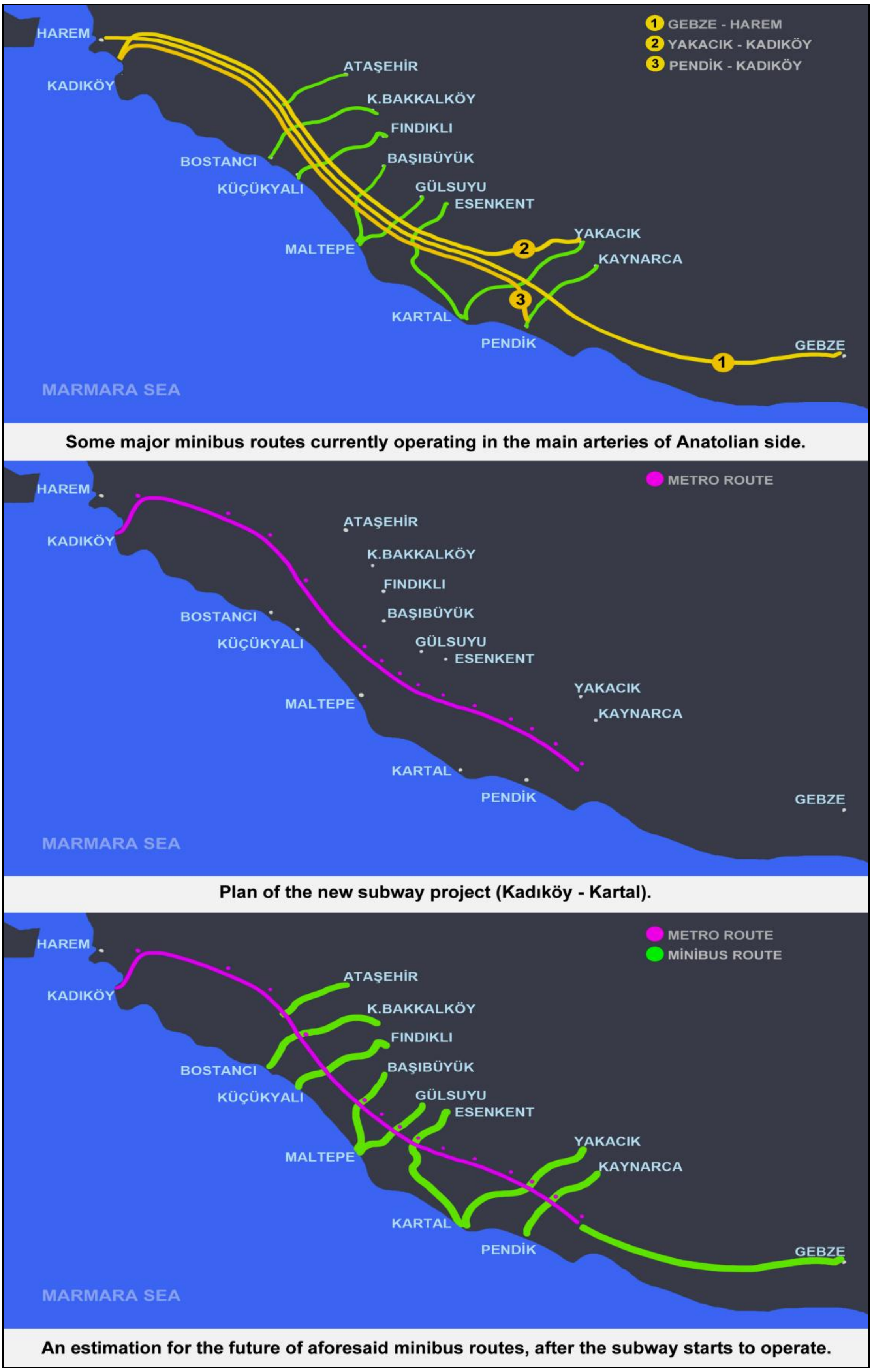
As the dolmuş-minibus system is highly inclusive issue to be studied and this thesis intends to provide a relatively broader perspective of paratransit system, the possible discussions and estimations on the subject matter may be varied.

Speaking of the future chance to the dolmuş-minibus system in Istanbul, there have been still many discussions about whether its elimination or not. It is the author's estimation that the system will survive and continue its operation one way or another. Actually, in the short run, totally elimination of dolmuş-minibus system seems impossible considering its benefits to the inner city transportation. As also Şanlı (1981) has mentioned that, there are some reasons for the survival of this system:

- Infrastructure enhancements of the metropolitans could be a clue the future public transportation trends. However, in İstanbul, the investments for the infrastructure enhancements in the foreseeable future would be too costly for the possible new alternative mass transport systems which could fully substitute for dolmuş and minibus system (such as PRT).
- Additionally this dynamic and flexible system has taken deep roots in the society and provided gainful employment for a very essential part of the population. Livelihood of that much stakeholders like the owners, drivers, helpers, as well as those employed in the spare parts, repair, service and other related sectors of the automotive industry could not be possible in a different way for the very near future.

Furthermore, the restrictions on the number of license plates, that tended to increase the price of it, made entrance into the paratransit sector more difficult. On the one hand, in the past, paratransit operation in Istanbul was transferred from one generation to the newest one; in other words, it was transferred from father to son in advance. As also mentioned in the field study chapter, today, almost all of the dolmuş and minibus operators do not prefer that their children would do this job and drivers are planning either to hire their vehicles to someone else or to sell them after retirement. One another important point is that the profitability of the paratransit operation in İstanbul has been dwindling. That is to say, minibus/dolmuş operation is no longer as cost-effective as the previous years. Because of those reasons mentioned, it may be claimed that, in the near future, there might be a diminution in the number of paratransit owner operators in İstanbul. There are some reasons, which make this system less cost-effective. The regulations and their forms of the implementations are one of the most essential factors that affects the vehicle features and so that profitability of the operation. As also mentioned in the table 6.4 (in the previous chapter), the usage of water-cooled diesel engine in new vehicles is a good example of the changes in properties of the vehicle that lessen the profitability of the operation. On the other hand, changes in the vehicle features, which are forced by the new and improved regulations, have many benefits to the passengers. Because when the paratransit vehicles become newer, drivers have to avoid the rough or adverse driving conditions. This might help to break the negative perception of the public against the dolmuş-minibus system and also this might help to prevent possible accidents.

Furthermore, decisions of the rule-makers who are, in general, municipality and local authorities on the infrastructure of the city and other modes of public transport highly affect the features and destiny of the minibus-dolmuş routes and operations. Today, the municipality has been planning to lessen the minibus operations in İstanbul. In fact, moving the minibus routes from the central sections to the outlying areas of the city is also another pillar of this plan. To give an example, nowadays, Gebze-Harem, Yakacık-Kadıköy and Pendik-Kadıköy, which are three of the longest minibus routes operating in the main arteries of Anatolian side in İstanbul, are becoming the verge of closure. The new subway project namely Kadıköy-Kartal, would badly affect the future of these minibus routes and their operators. Because, the route of this new subway will be on the parallel line with the routes of those minibuses. Figure 7.1 indicates the current situations of the major and some minor minibus routes operating in the Anatolian side; intended subway line and its stops; and also the author's estimation for the future of aforesaid minibus routes.



Some major minibus routes currently operating in the main arteries of Anatolian side.

Plan of the new subway project (Kadıköy - Kartal).

An estimation for the future of aforesaid minibus routes, after the subway starts to operate.

Figure 7.1 : Current situation and future estimation of the three minibus routes of Anatolian side.

This figure is prepared with the information gained from the minibus operators and the well known plans of İBB. Therefore, it can be estimated that paratransit system vehicles in İstanbul in particular the number of minibuses would gradually lessen, but; not eliminated. Some of them might start to operate in another format (such as public bus operation) while a small amount of them start to operate on the other shortened routes. Actually, in the the last part of Figure 7.1, existing green lines are thickened in order to represent that some of the minibuses, which are currently operating on the main arteries, might start to work on these short routes carrying the passengers to the subway stations in the very near future.

To sum up, based on the general analysis of the study, it is better to underline that industrial design is only the starting point for the amelioration of paratransit. In fact, for this comprehensive system neither industrial design, nor current and future technology contribution alone is sufficient unless there is a breakthrough in the decisions of local authorities. Because as also mentioned before, dolmuş-minibus system has numerous problems in itself that could stem from its operation, stakeholders and vehicle types and features. In addition, dolmuş and/or minibus operators are only one stakeholder of this system. Therefore, amelioration of the paratransit system requires the contribution of different areas, disciplines and all of the stakeholders such as, government at first side, local municipalities, industrial designers and engineers from different companies, investors, city planners, sociologists, economists and related foundations and instutions.

7.2 Limitations of the Study

There have been certain limitations encountered throughout the research study. Although it is needed enough written sources for a comprehensive exploration of the subjects, one of the essencial constraint was lack of literature about the paratransit system in Turkey. Actually, studies about dolmuş-minibus system are of long standing, but most of the existing academic publications are too old or out-of-date.

Another limitation of this study was about the time constraints. Total time particularly allocated for the empirical studies confined the assessments obtained for the whole paratransit system. Because, in order to gain comrehensive knowledge about dolmuş-minibus system and its operation modes, not only in İstanbul but also everywhere in the country was not possible in such a limited time.

The last limitation in this thesis was related to the generalizability of the results of conducted empirical studies. All the samples, which the enquiries were administered, consist of paratransit vehicle drivers and/or operators. Although the minibus and dolmuş operators are one of the major stakeholders of paratransit system in İstanbul, conversation with other essential stakeholders would be beneficial for this study. However, it was not possible due to lack of research funding and also research time.

7.3 Further Studies

In this thesis, a wide range of subjects are explored around a central topic and major research questions. Most of the research findings are essencial to the field of paratransit vehicle and system design. That is why, some questions are raised throughout the progress of the study. Those questions can be considered as suggestions for further studies and they might require further implications.

Firstly, in depth field researches conducting with a large sample and cooperation with the industry particularly vehicle manufacturers, designers, city planers and engineers can be promising. Large-scale researches and their correctly analyzed results may help to define some vehicle design criteria for the future attempts.

Secondly, as new technologies emerge, ongoing study will help provide a sense of their performance and suitability for the paratransit environment. Considering the innovative improvements in information and communication technologies with their increasing domination in social practices and alternative vehicle propulsion technologies, the subject matter offers a wide range of promising areas for further research.

Finally, this research study might sheds lights on the future paratransit studies for the Turkish and global academic environments.

REFERENCES

Adam Smith Institute. (1980). *The Paratransit Light Vehicle.* Date retrieved: 12.12.2010, address: http://www.adamsmith.org/research/reports/the-paratransit-light-vehicle**.**

Asatekin, M. (1997). *Endüstri Tasarımında Ürün-Kulanıcı İlişkileri.* Ankara: ODTU Mimarlık Fakültesi Yayınları.

Asatekin, M. (2005). Otomotiv Sanayiinde Endüstriyel Tasarım: Artı Değerden Öte. TMMOB Makine Mühendisleri Odası, *IX. Otomotiv ve Yan Sani Sempozyumu*, Ankara, 27-28 Mayıs.

Autoweek. (December, 2011). Tokyo Auto Show. Daihatsu FC Sho Case**.** Date retrieved: 07.03.2012, address: http://www.autoweek.com/article/20111130/TOKYO/111139977.

Bakker, P. (1999). Large Scale Demand Responsive Transit Systems: A Local Suburban Transport Solution for the Next Millennium? *Proceedings of European Transport Conference, Stream: Public Transport Planning and Manegement*, pp. 109-126.

Bainbridge, L. (1983). Ironies of Automation. *Automatica,* Vol. 19. pp. 775-779.

Balassiano, R. (1998). Van transportation-what should be considered during the process of regulation. (Transporte Por Vans-O Que Considerar No Processo De Regulamentaça˜o?). Transportes Vol. 4, pp. 87-105.

Barrett, J. (2003). Organizing in the Informal Economy: A case study of minibus taxi industry in South Africa. SEED Working paper, No. 39. *International Labour Office,* Geneva.

Barth, M., and Todd, M. (2000). Intelligent Transportation System Architecture for a Multi-Station Shared Vehicle System. *2000 IEEE Intelligent Transportation Systems Conference Proceedings.* Dearborn (MI), USA. October 1-3.

Bellotti, F., Berta, R., De Gloria, A., and Margarone, M. (2005). Human Factors and Ergonomics in Manufacturing and Service Industries, *Special Issue: Advances in Agile Manufacturing,* Vol. 15, Issue 4, Autumn, pp. 461-476.

Billings, C. E. (1997). *Aviation automation: The search for a human-centered approach*. Mahwah: Lawrence Erlbaum Associates.

Bishop, R. (Jan/Feb 2000). Intelligent Systems and Their Applications. *IEEE Journals & Magazines.* Richard Bishop Consulting, Granite, MD. 15, Issue 1, pp. 78 - 81.

Bishop, R. (October, 2000). A Survey of Intelligent Vehicle Applications Worlwide. *Proceedings of the IEEE Intelligent Vehicles Symposium 2000.* Dearborn (MI), USA. pp. 25-30.

Black, W. R. (1996). *Sustainable Transportation: A US Perspective.* Journal of Transport Geography, Vol. 3., Issue. 4. September, 1996. pp. 151.

Bloch, P. H. (1995). Seeking an Ideal Form: Product Design and Consumer Response. *Journal of Marketing*, Vol. 59(3), pp. 29-16. Americam Marketing Association Press. Date retrieved: 07.12.2011, address: http://www.jstor.org/stable/1252116.

Boztepe, S. (2008). Competing With Global Players, *International DMI Education Conference.* Design Thinking: New Challenges for Designers, Managers and Organizations ESSEC Business School, Cergy-Pointoise, France.

Brain, M. (2011). How Electric Cars Work. *How Stuff Works.* Date retrieved: 05.04.2012, address: http://www.howstuffworks.com/electric-car.htm.

Brake, J., Nelson, J.D., and Wright, S. (2006). Demand Responsive Transport: Towards the emergence of a new market segment, *Journal of Transport Geography*, Vol. 12, pp. 323- 337.

Brookhuis, K. A., De Waard, D., and Janssen, W. H. (2001). Behavioural impacts of Advanced Driver Assistance Systems*–an overview*. EJTIR, Vol. 1, no. 3 (2001), Groningen, The Netherlands. pp. 245-253.

Brookhuis, K. A., and De Waard, D. (1993). The use of psychophysiology to assess driver status. *Ergonomics, 36*, pp.1099-1110.

Buonocunto, M. (2000). How A Prototypes is Born. Date retrieved: 07.07.2010, address: http://www.geocities.com/buonocunto/info/ukhow1.html.

Buti, B. L. (1995). *L'industrial design ergonomico in Ergonomia*, ed. 5, Moretti & Vitali Editori, Bergamo.

Buti, B. L. (1998). Ergonomics Between Research and Application, SAE 95 A1025.

Button, K. J., and Gillingwate, D. (1986). *Future Transport Policy.* Croom Helm, Australia, pp. 85-88.

Caputo, F., Di Gironimo, G., Monacelli, G., and Sessa, F. (2001). The Design of a Vitual Environment for Ergonomic Studies, *XII ADM International Conference*, Rimini, Italy, September 5-7.

Car Body Design. (March, 2011). Volkswagen Bulli Concept. Date retrieved: 05.03.2012, address: http://www.carbodydesign.com/2011/03/volkswagen-bulli-concept/.

Car Body Design. (November, 2011). Daihatsu FC Sho Case Concept. Date retrieved: 05.03.2012, address: http://www.carbodydesign.com/2011/11/daihatsu-fc-sho-case-concept/.

CARSCOOP. (March, 2011). Geneva 2011: Volkswagen's Bulli Microbus Concept in the Flesh. Date retrieved: 06.03.2012, address: http://busnews.blogspot.com/2011/03/busmakers-news-germany-volkswagens.html.

Caruso, G., Polistina, S., Bordegoni, M., and Aliverti, M. (2011). Collaborative Mixed-Reality Platform for the Design Assessment of Cars Interior, Part 2, *HCII 2011, LNCS 6774*, pp. 299-308.

Casey, R.F., Labell, L.N., LoVecchio, J.A., Ow, R.S., Royal, J.W., Schwenk, J.C., Carpenter, E. J., Moniz, L., Schweiger, C.L., and Marks, B. (January, 1998). *Advanced Public Transportation Systems: The State of the Art Update '98.* Volpe National Transportation Systems Center. FTA-MA-26-7007-98-1, pp .13- 164.

Cervero, R. (1985). Examining Recent Transit Fare Innovations in the U.S. *Transportation Policy and Decision Making.* Vol. 3, pp. 23-41.

Cervero, R. (1992). Paratransit in Southeast Asia: A Market Response to Poor Roads? Reprint No. 90, *Review of Urban and Regional Development Studies,* Vol. 3, pp. 3-27.

Cervero, R. (1997). *Paratransit in America.* Praeger, Westport, CT.

Cervero, R. (1998). *The Transit Metropolis: A Global Inquiry.* Island Press, Washington, DC.

Cervero, R. (2000). *Informal Transport in the Developing World.* United Nations Commission on Human Settlements (Habitat), Nairobi, Kenya.

Cervero, R., and Golub, A. (2007). Informal Transport: A Global Perspective, *Transport Policy 14:* pp. 445-457, USA, July. Date retrieved: 2.10.2011, adress: www.elsevier.com/locate/transpol.

Cevallos, F., Yuan, Q., Wang, X., and Gan, A. (July, 2009). Using personal global positioning system devices in paratransit. *Lehman Center for Transportation Research.* doi: 10.1049/iet-its.2008.0078, selected papers from AATT 2008. Vol. 3, Issue. 3, pp. 282–288.

CFCP (California Fuel Cell Partnership). (2001). “Bringing Fuel Cells To Market, Scenarios and Challenges with Fuel Alternatives”.

CityMobil. (2011). *About CityMobil.* Date retrieved: 05.12.2011, address: http://www.citymobil-project.eu.

Clean Technica. (2011). Transportation Tech, Automated Battery Cars Replace Buses at Heathrow Airport. *Archives for Breath on the Wind.* Date retrieved: 02.12.2011, address: http://cleantechnica.com/?s=personal+rapid+transit.

Clever Devices. (2012). Automatic Passenger Counting. Date retrieved: 13.03.2012, address:http://www.cleverdevices.com/automatic_passenger_counting _technology _APC.html.

Cripps, D. (2009). Gulf Composites, Published courtesy of Gurit, Date retrieved: 20.11.2011, address: http://www.gulfcomposite.com/pdf/frp_composites-processing_april 2009.pdf.

Dailey, D. J., and Haselkorn, M. P. (1994). Demonstration of an Advanced Public Transportation System in the Context of an IVHS Regional Architecture. *Applications of Transport Telematics and Intelligent*

Vehicle-Highway Systems. First World Congress. Washington, 3 December.

DeCicco, J. (2001). *Technology Status and Commercialisation Prospects of Fuel Cells for Highway Vehicles*, American Council for an Energy Efficient Economy.

DETR (Department of the Environment Transport and the Regions). (2000a). *Transport 2010: the 10 Year Plan*. DETR, London.

Desmarteau, K. and Meadows, S. (2004, February). Facing chance, customization: Auto Interiors Firms Seek Flexibility. *Bobbin Magazine*, Vol.41, (6), p.41.

Directive, 2001/85 EC. (2002). The European Parliament and of The Council directives. *Official Journal of the European Communities,* pp. 3-74, 20 November.

DLLAJ (Traffic and Road Transport Agency). (2001). The Guide of Passenger Public Transportation Price Calculation with Fixed Road in urban Area, West Jawa, Bandung (in Indonesian).

Dormer, P. (1990). *The Meanings of modern Design: Towards the 21st Century.* London: Thames and Hudson Ltd.

Dos Santos, E., and Brasileiro, A. (1999). Concentration Rates in Brazilian Bus Markets, *Working Paper,* Department of Civil Engineering, Universidade Federal do Rio Grande do Norte.

Dourado, A. B. F. (1994). Evolution of the Relations Between Private and Public Sector Concerning the Finance of Public Transit in Brazil. Revista de Transporte e Technologia Vol. 6 (12), pp. 38-61.

Dönmezler, S., et al., (1973). *Cumhuriyetin Ellinci Yılında Türkiye'de Taşıtlar ve Şoförler,* Istanbul: Türkiye Şoförler ve Otomobilciler Federasyonu.

Dumenjo, M.M., and Brunet, P. (1998). *Dictionary of Terms.* FIORES Technical Report.

EERE (Energy Efficiency and Renewable Energy). (August, 2003). U.S. Department of Energy. *Just the Basics: Electric Vehicles, Transportation for the 21st Century.* Date retrieved: 07.04.2012, address: www.eere.energy.gov/vehiclesandfuels.

Electronic Fare Payment. (21 December, 2010). Transit Core Technologies. Date retrieved: 10.03.2012, address: http://www.pcb.its.dot.gov/factsheets/core.asp

Enoch, M. P. (2005). Demand Responsive Transport: lessons to be learnt from Less Developed Countries, *Loughborough University Institutional Repository.* Date retrieved: 15.10.2011, address: http://www.dspace.Iboro.ac.uk.

Enoch, M. P., Potter, S., Parkhurst, G. and Smith, M. T. (2004). Exploratory Assessment of and Innovations in Demand Responsive Transport Services - *Intermode, Final Report*, Department for Transport and Greater Manchester Passenger Transport Executive, London, August. Date retrieved: 12.10.2011, address: http://www.dft.gov.uk.

Er, A. H. (1993). Industrial Design in Newly Industrialized Countries: An Exploratory Study of the Factors Influencing the Development of Local Design Capabilities, Institute of Advance Studies The Manchester Metropolitan University: Manchester.

European Commission. (2001). *European Transport Policy for 2010: time to decide*. COM (2001) 370. White Paper of the Commission of the European Communities, Brussels, 2001.

Ezell, S. (January, 2010). Explaining International IT Application Leadership: Intelligent Transportation Systems. *The Information Technology & Innovation Foundation.*

Finn, B. (2008). Market Role and Regulation of Extensive Urban Minibus Services as Large Bus Service Capacity is Restored-Case Studies from Ghana, Georgia and Kazakhstan, *Research in Transportation Economics*, Vol. 22, Dublin, Ireland, pp.118-125. Date retrieved: 15.10.2011, address: www.elsevier.com/locate/retrec.

Flemisch, F., Kelsch, J., Löper. C., Schieben, A., and Schindler, J. (2008). Automation spectrum, inner / outer compatibility and other potentially useful human factors concepts for assistance and automation. *Human Factors for assistance and automation.* Maastricht, the Netherlands: Shaker Publishing. pp. 1-16.

Fontana, M., Giannini, F., and Meirana, M. (1999). A Free Form Features Taxonomy, *Computer Graphics Forum and Eurographics'99,* Vol. 18, No. 3. pp. 107-118.

Fontana, M., Giannini, F., and Meirana, M. (2000). A Free Form Features for Aesthetic Design. *International Journal of Shape Modeling,* Vol. 0, No. 0 (2000) 000-000 World Scientific Publishing Company, Genova, Italy.

Frankena, M., and Paulter, P. (1984). *An Economic Analysis of Taxicap Regulation.* Washington, D.C.: Burreau of Economics, Federal Trade Commission.

Greater İstanbul Master Plan Bureau, (1975). Jamieson and Mackay and Partners, İstanbul Urban Development Project: Traffic Engineering and Control Study, *Draft Final Report,* İstanbul: G.I.M.P.B. p. 55.

Griffiths, A., and Lewis, G. (2001). The Irizar Couch, *The Arup Journal*, 2/2001, pp.1-5.

Gross, Y. (2010). *Vehicle Assist and Automation Systems for BRT.* Intelligent Transport Systems, ITS Joint Program Office, RITA. U.S. Department of Transportation. Washington, D.C.

Grosso, S., Higging, J., Mageean, J., and Nelson, J. (2002). Demand Responsive Transport: Towards Best Practice in Rural Applications, *European Transport Conference,* Homerton College, Cambridge, 9-11 September.

Gunnarsson, A., and Shishoo, R. (2002). International Newsletter, *Technical Textiles*, pp. 31-32.

Gürdoğan, S., Thomsen, G. T., Eyler, İ., Gürdoğan, B., Marszal, M., Özkanlı, K., and Yürdaun, E. (2007). Dolmuş & Minibüs Map of Istanbul. *Superpool.* Bought the map online. Date retrieved: 02.02.2012, address: www.takeaway-istanbul.com.

Han, S. H., Myung, Y., Hwan, K., Kwang, J., and Jiyoung, K. (2000). Evaluation of Product Usability: Development and Validation of Usability Dimensions and Design Elements Based on Empirical Models. *International Journal of Industrial Ergonomics,* Vol. 26, pp. 477-488.

Happian-Smith, J. (2001). *An Introduction to Modern Vehicle Design,* Oxford: Butterworth Heinemann.

Hella, KgaA, (2005). Legal Requirements for Motor Vehicles and Trailers According to ECE Regulation 48. Company Catalogue, Germany, pp. 5-6. Date retrieved: 12.05.2011, address: http://www.hella.com.

Heskett, J. (13 November 2002). Past, Present, and Future in Design for Industry *Design Issues,* Vol. 17:1 (Winter 2001), pp. 18-26. Online. EBSCO.

Hollnagel, E. (2007). *Modelling human-system interaction: From input-output to coping with complexity.* Paper presented at the 7. Berliner Werkstatt Mensch- Maschine-Systeme, Berlin.

Hürriyet, (9 February, 1974). Dolmuş Nasıl Doğdu..., İstanbul: 09.02.1974.

ICSID, (2010). *Definition of Industrial Design,* International Council of Societies of Industrial Design. Date retrieved: 13.09.2011, address: http://www.icsid.org.

IEA (International Energy Agency), (2000). *World Energy Outlook 2000,* International Energy Agency, Paris.

IEA (International Energy Agency), (2002). *Bus Systems For The Future.* Achieving Sustainable Transport Worldwide, International Energy Agency, Paris.

IHRA/ITS, (2010). Design Principles for Advanced Driver Assistance Systems: Keeping Drivers In-the-Loop. *International Harmonized Research Activities (IHRA) Working Group on ITS.* Informal document No. ITS-19-07. DRAFT Nov 22, 2010.

Illes, R. (2005). *Public Transport in Developing Countries.*(First ed.). Netherlands: Elsevier Publishing Ltd., pp. 7-133.

IMM, (2011). İstanbul Metropolitan Municipality, Organizations. Date retrieved: 6.10.2011, address: http://www.ibb.gov.tr/en-US/Organization/Pages/OrganizationalChart.aspx.

Ishihara, S., Ishihara, K., Nagamachi, M., and Matsubara, Y. (1997). An Analysis of Kansei Structure on Shoes Using Self-Organizing Neural Networks. *International Journal of Industrial Ergonomics,* Kansei Engineering and Comfort, Vol. 19 (2), 93-104.

Janes Information Group, (2004). Janes Urban Transport Systems 2004-2005, *Transport Library,* Janes Information Group, Coulsdon, Surrey, (CD-ROM).

Janssen, W. H., Wierda, M., and Van der Horst, A. R. A. (1992). *Automatisering van de rijtaak en gebruikersgedrag: een inventarisatie en research agenda (Automation of driving and user behaviour)*. Report TNO-IZF 1992 C-16. Soesterberg, The Netherlands: TNO-TM.

Joewono, T. B., and Kubota, H. (2005). The Characteristics of Paratransit and Non-Motorized Transport in Bandung, Indonesia, *Journal of Eastern Asia Society for Transportation Studies*, Vol. 6, pp. 262-277.

Jordan, P. W. (1998). Human Factors for Pleasure in Product Use. *Applied Ergonomics*, Vol. 29 (1), pp. 33-25.

Kazokoglu, A. R. (July, 2009). Public Transport International Vol. 58. (4). *International Union of Public Transport ISSN*. 1016-796X. pp. 40-41.

Kämpchen, N. (September, 2011). Green Car Congress. *BMW developing advanced automated driver assistance systems.* Date retrieved: 02.02.2012, address: http://www.greencarcongress.com/2011/09/bmw-developing-advanced-automated-driver-assistance-systems.html#more.

Khattak, A. J., and Yim, Y. (2004). *Traveler Response to Innovative Personalized Demand-Responsive Transit in the San Francisco Bay Area.* Doi: 10.1061/(ASCE)0733-9488(2004)130:1(42). J. Urban Planning & Development. March, 2004.

Khalid, H. M., and Helander, M. G. (2004). A framework for affective customer needs in product design, *Theoretical Issues in Ergonomics Science*, Vol. 5 (1), pp. 27–42.

Khosa, M. M. (1992a). *Changing State Policy and the Black Taxi Industry in Soweto*, in DM Smith (Ed) – The Apartheid City and Beyond: urbanization and social change in South Africa (London: Routledge).

Kihl, M. (1993). Advanced Vehicle Location System for Paratransit in Lowa. IEEE-IEE *Vehicle Navigation & Information Systems Conference*, Ottawa-VNIS '93.

Kirby, R., and Bhatt, K. (1974). *Para-transit: Neglected options for urban mobility*, Urban Institute, 0877661219, Washington DC. Date retrieved: 10.12.2011, address: http://www.ecoplan.org/general/xtransit.htm.

Kotler, P. (2000). *Marketing management* (Int. ed). New Jersey: Prentice Hall.

Koutsopoulos, K. C., and Schmidt, C. G. (1986). Mobility Constraints of the Carless, Transport Sociology: Social Aspects of Transport Planning, E. de Boer (ed.), *Urban and Regional Planning Series*, Vol. 36, Oxford, England: Pergamon Press.

Kromer, K. H. E. (1993). Modeling the human-equipment interface, *in Automotive ergonomics* edited by B. Peacock and W. Karwowski, Taylor & Francis.

Lave, R., and Mathias, R. (2000). State of the Art of Paratransit, *A1E10: Committee on Paratransit*, Transportation on new Millennium. Date retrieved: 5.11.2010, address: http://www.trb.org/publications/.

Lee, E. S. W. (1990). Formalizing Informal Transport: Paratransit in Hong Kong. In: Developing World Transport. Grovenor Press, Intl. London.

Lee, J. D., and See, K. A. (2004). Trust in automation: designing for appropriate reliance. *Human Factors.* Vol. 46, Issue.1. pp. 50-80.

Lomme, R. (2009). Should South African Minibus Taxis Be Scrapped? Formalizing Informal Urban Transport in Developing Country. CNAM, Department of Transport & Logistics, Paris, pp.1-18.

Lowson, M. V. (2002). The ULTra Personal Rapid Transit System. Paper 2002-01-0174, SAE *International Congress Detroit,* March 2002. Selected for SAE 2002 Transactions, *Journal of Passenger Cars; Mechanical Systems.*

Lowson, M. V. (2002). Sustainable Personal Transport. *Proceedings of the Institution of Civil Engineers.* Municipal Engineer 151. Paper 12778. Issue 1. March 2002. pp. 73-82.

Lowson, M. V. (2004). The ULTra project. Paper at *EDICT Conference Cardiff,* October 2004 Bly P H., Teychenne, R.T., Three Financial And Socio-Economic Assessments of a Personal Rapid Transit System. *European Transport Conference,* October 2004.

Manish Resins and Polymers, (2008). Technical Info, Date retrieved: 5.12.2011, address: http://www.gurit.com.

Mastrogiannidou, C., Lois, A., and Ziliaskopoulos, A. (2006). Design of a Paratransit System for Rural Areas, *Journal of Transportation Research Board*, 86, August, Pedion Areos, Greece.

Mata Dumenjo, M., and Brunet, P. (1998). Dictionary of terms, *FIORES technical report.*

Michellone, G., and Levizzari, G. (1999). *L'evoluzione veicolo guidatore*, in IF, Gennaio.

Mondt, R. (2000). Cleaner Cars: The History and Technology of Emission Control Since the 1960s (Warrendale, PA: Society of Automotive Engineers). p.213.

Murray, A. T., Davis, R., Stimson, R. J., and Ferreira, L. (1998). Public transportation access. *Transportation Research D* 3 pp. 319-328.

Nagamachi, M. (2002). Kansei as powerful consumer-oriented technology for product development. *International Journal of Industrial Ergonomics*, Vol. 33, pp. 289-294.

Nagel, K. (1999). *Comfort evaluation as ergonomic tool with application to interior concepts of vehicles,* SAE 1999-01-1921.

Nelson, J. D., Wright, S., Masson, B., Ambrosino, G., and Naniopoulos, A. (2010). Recent Developments in Flexible Transport Services. *Research in Transportation Economics.* Vol. 29, Issue.1. pp. 243-248.

Nemeth, C. (2005). *Human Factors Methods for Design.* Taylor and Francis e-Library Press, U.S, pp. 10-17.

Newman, P., and Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence.* Washington, DC: Island Press. pp. 1-18.

Newton, M. (August, 2008). Could Para-Transit Work in Los Angeles?. Date retrieved: 29.02.2011, address: http://la.streetsblog.org/2008/08/29/could-para-transit-work-in-los-angeles/.

Nieuwenhuis, P., Wells, P., and Vergragt, P. J. (2006). The Business of Sustainable Mobility. Greenleaf Publishing, UK.

Norman, D. A. (1990). The ‘problem’ with automation: Inappropriate feedback and interaction not ‘over-automation’. In D.E. Broadbent, J. Reason, and A. Baddeley (Eds.), *Human Factors in Hazardous Situations.* Oxford: Clarendon Press. pp. 137-145.

Oberli, **C., Torriti, M. T., and Landau, D.** (2010). Performance Evaluation of UHF RFID Technologies for Real-Time Passenger Recognition in Intelligent Public Transportation Systems. Short Papers. IEEE Transactions on Intelligent Transportation Systems, Vol. 11, No. 3, September, 2010.

Orange Country Public Schools. (18 December, 2010). Date retrieved: 21.02.2012, address: https://www.ocps.net/op/tran/Pages/GPSTechnology.aspx.

Otobil. (12 May, 2011). Araçlarda Kullanılan Yaylar. Date retrieved: 28.03.2012, address: http://www.otobil.net/blog/wp-content/uploads/2011/05/yay1.jpg.

Personal Rapid Transit, (2011). *What is PRT?.* Date retrieved: 11.12.2010, address: http://www.personalrapidtransit.com/.

Popovic, V. (1999). Product Evaluation Methods and Their Importance in Designing Interactive Artifacts in *Human Factors in Product Design: Current Practice and Future Trends,* pp. 26-35, Eds. Green, W. S. and Jordan, W. P., Taylor & Francis, London.

Powell, N. B. (2004). Design Driven: The Development of New Materials in Automotive Interiors. *Journal of Textile and Apparel,* Technology and Management: Vol. 3, Issue 4. pp. 1-19. NC State University, USA, Winter 2004.

Rahman, A., and Grol, R. V. (2005). SUMMA (SUstainable Mobility, policy Measures and Assessment). *Final Publishable Report*. *WP1.* European Commission-Directorate General for Energy and Transport. Issue 2. GMA2/2000/32061-S07.14497, July 14.

RESPONSE (September, 2001). The Integrated Approach of User, System and Legal Perspective: Final Report on Recommendations for Testing and Market Introduction. *Project TR4022, Deliverable no. 2.2*.

Rimmer, P, J. (1980). Paratransit: A Commentary. *Environment and Planning,* Vol. 12A (8), pp. 937-944.

Rizzo, R. (1998). *La sicurezza degli impianti industriali*, Edizioni Scientifiche Italiane.

Rohmert, W. (1987). Physiological and psychological work load measurement and analysis, in *Handbook of Human Factors*, Wiley & Sons.

Roschlau, M. W. (1981). Urban Transport in Developing Countries: The Peseros of Mexico City. *Master's Thesis Series,* Center for Transportation Studies, University of British Colombia.

SAIC (Science Applications International Corporation). (July, 2002). Battery-Powered Electric and Hybrid Electric Vehicle Projects to Reduce Greenhouse Gas Emissions: A Resource Guide for Project Development. *National Energy Technology Laboratory (NETL).* Climate Change Services. Virginia.

Sarter, N. B., and Woods, D. D. (1995a). *Strong, Silent and Out of the Loop: Properties of Advanced (Cockpit) Automation and their Impact on Human- Automation Interaction* (Tech. Rep. CSEL 95-TR-01). Columbus: Cognitive Systems Engineering Laboratory, Ohio State University.

Schalekamp, H., and Behrens, R. (2010). Engaging Paratransit on Public Transport Reform Initiatives in South Africa: A Critique of Policy and an Investigation of Appropriate Engagement Approaches, *Research in Transportation Economics 29*, University of Cape Town, South Africa, pp. 371-378. Date retrieved: 15.10.2011, address: www.elsevier.com/locate/retrec.

Schalekamp, H., Behrens, R., and Wilkinson, P. (2010). Regulating Minibus-Taxis: A Critical Review of Progress and Possible Way Forward, Centre for Transport Studies, Proceedings of the 29th Southern African Transport Conference (SATC 2010), 978-1-920017-47-7, pp. 782-792, 16-19 August, Pretoria, South Africa.

Schalekamp, H., Mfinanga, D., Wilkinson, P., and Behrens, R. (2009). An International Review of Paratransit Regulation and Integration Experiences: African Centre of Excellence for Studies in Public and Non-Motorised Transport, *Proceedings of the 28th Southern African Transport.* Date retrieved: 27.1.2010, address: http://www.cfts.uct.ac.za.

Sevener, Z., and Asatekin, M. (n.d.). Influence of Aesthetic Properties on Stimulating Emotional Responses. Date retrieved: 21.11.2011, address: http://www.zstdesign.com/PDFs/D%26E_sevener2004.pdf.

Sezer, D. B. (1976). Trafik Bunalımı, Milliyet, İstanbul: 5.8.1976.

Sheikh, F. (November, 2004). Canada to hop aboard smart transit bandwagon. Date retrieved: 22.12.2010, address: http://www.smartcardscanada.com/applications/public_transport.htm.

Shirkie, R. (1979). Paving the way for low-cost transportation, *IDRC reports,* Vol. 8, No. 3, Ottawa, ON, CA, pp. 15-16. Date retrieved: 28.7.2011, address: http://hdl.handle.net/10625/25051.

Smart Cards Canada, (2010). Applications. Date retrieved: 21.09.2011, address: http://www.smartcardscanada.com/index.htm.

Smyth, S. N., and Wallace, D. R. (2000). Towards the Synthesis of Aesthetic Product Form, Proceedings of DETC'00, *ASME 2000 Design Engineering Technical Conferences and Computers and Information in Engineering Conference,* Baltimore, Maryland, September 10-13.

Starry, C. (April, 2001). The Emerging In Vehicle Intelligent Transportation Systems Market. *Business economics.* Vol. 36, No. 2. Path Record Number 24568.

Şahin, İ. A. Y. (2007). Potential Uses of Electronic Fare Payment Records for Public Transit Agencies. *ITE Journal*, Vol. 77, Issue 12, pp. 22-27.

Şanlı, H. İ. (1981). *Dolmuş-Minibus System in İstanbul*. A Case Study in Low-Cost Transportation. Gümüşsuyu: Istanbul Technical University Press, pp. 1-152.

Takala, T., and Woodward, C. D. (1988). Industrial Design based on Geometric Intentions, *Theorical Foundations of Computer Graphics and CAD,* R.A. Earnshaw Ed., Springer-Verlag Berlin Heidelberg.

Tanoue, C., Ishizaka, K., and Nagamachi, M. (1997). Kansei Engineering: A study on perception of Vehicle Interior Image. *International Journal of Industrial Ergonomics,* Vol. 19, pp. 115-128.

Tayki, I. (1990). Evaluation of Jitney Systems in Developing Countries. *Transportation Quarterly* 44 (1), pp. 163-177.

Taylor, A. J., Roberts, P.H., and Hall, M.J.D. (1999). Understanding Person Product Relationships: A Design Perspective. in *Human Factors in Product Design: Current Practice and Future Trends*, edited by William S. Green and Patrick W. Jordan. London: Taylor & Francis, pp. 228-218.

Technology Committee Bulletin (2010). How Safe are Natural Gas Vehicles?. Clean Vehicle Education Foundation. September, 17.

Tekeli, I., Gülöksüz, Y., and Oktay, I. (1976). *Gecekondulu, Dolmuşlu ve İşportacılı Şehir.* İstanbul: Yelken Press.

Tekeli, İ., and Okyay, T. (1981). *Dolmuşun Öyküsü.* First Edition, Ankara: Middle East Technical University, Department of Architecture Press, pp. 1-72.

Torres, A. (1998). Policies to Control Informal Transport—the Rio de Janeiro case. In: Freeman, P., Jamet, C. (Eds.), Urban Transport Policy: *A Sustainable Development Tool. Proceedings of the International Conference CODATU VIII*, Cape Town, South Africa, Balkema, Rotterdam.

Tracktinsky, N. (1997). Aesthetics and Apparent Usability: Empirically Assessing Cultural and Methodological Issues. *In Proceedings of CHI'97*, pp. 129-115.

Tracktinsky, N., Shoval-Katz, A., and Ikar, D. (2000). *What is Beautiful is Usable.* Interacting with Computers, Vol. 13, pp. 145-127.

Transit Core Technologies. (September, 2007). *Transit Technology Fact Sheets Overview.* U.S. Department of Transportation Federal Transit

Administration. Date retrieved: 10.12.2010, address: http://www.pcb.its.dot.gov/factsheets/core.asp.

Transportation Futuristics. (2012). The Regents of the University of California. Date retrieved: 11.03.2012, address: http://www.lib.berkeley.edu/news_events/futuristics/its/.

Trapeze Group. (2011). Intelligent Transportation Systems. Date retrieved: 13.09.2011, address: http://www.trapezegroup.com/PDFs/Trends%20in20Paratransit%20Technologies%20May-04.pdf.

TSOF, (2011). History and Aims, *Türkiye Şoförler ve Otomobilciler Federasyonu,* Date retrieved: 2.12.2011, address: http://tsof.org.tr.

Tüydeş, H., and Özen, M. (2008). A Scenario-Based Semi-Disaggregate Market Share Estimation for a Proposed Paratransit System for Philippi Region, Greece, *Journal of Transportation Research Board*, November, (CD-ROM).

Ultra Global PRT. (2011). *Where's it used?,* Date retrieved: 11.12.2010, address: http://www.ultraglobalprt.com/wheres-it-used/.

Ultra Personal Rapid Transit System, (2011). System: Operations. Date retrieved: 01.12.2011, address: http://www.ultraprt.com/prt/.

Url-1 <*http://www.wowturkey.com*>, date retrieved 29.04.2010.

Url-2 <*http://www.gurit.com*>, date retrieved 13.10.2011.

Wallace, D. R. (1991). A Computer Model of Aesthetic Industrial Design, *Master of Science Thesis,* Massachusetts Institute of Technology, Cambridge Massachusetts.

Walton, J. R., Crabtree, J. D., Osborne, M. L., Pigman, J. G., Weber, J. M., Grossardt, T. H., and Hartman, D. G. (June, 2000). Intelligent Transportation Systems: *Strategic Plan*. Research Report, KTC-00-5F. Kentucky Transportation Center, Lexington.

Weiss, M. A., Heywood, J. B., Drake, E. M., Schafer, A., and AuYeung, F. F. (October, 2000). On the Road in 2020. *A life-cycle analysis of new automobile technologies.* Energy Laboratory Report # MIT EL 00-003. Date retrieved: 05.03.2012, address: http://web.mit.edu/energylab/www/.

Wickens, C. D., and Hollands, J. G. (2000). *Engineering Psychology and Human Performance* (3rd Ed). Upper Saddle River, NJ: Prentice-Hall Inc.

Wickens, C. D., Mavor, A. S., and McGee, J. P. (Eds.). (1997). Flight to the future: Human factors in air traffic control. Washington D.C.: National Academy Press.

Wirth, C. (1997). Transportation Policy in Mexico City: Politics and Impacts of Privatization. *Urban Affairs Quarterly* Vol. 33, No. 2, pp. 155-81.

World Bank, (1996). Sustainable Transport – Priorities for Policy Reform. Washington, D.C.

Wright, A. A. (1986). Urban Transport Systems, Guidelines for Examining Options, *World Bank Technical Paper* Number, 52, The World Bank, Washington, D.C., U.S.A.

Van Dick, C. G. C., and Mayer, A. A. C. (1997). Sketch Input for Conceptual Design, *Computers in Industry*, N. 34, pp. 125-137.

Vijayakumar, S. (1986). Optimal Vehicle Size for Road-Based Urban Public Transport in Developing Countries. *Transport Reviews,* Vol. 6 (2), pp. 193-212.

VIRGIL. (2000). Verifying and strengthening rural access to transport services. Ringbuss, Sweden. *Rural Transport in Europe: Good Practice Guide.* Date retrieved: 28.04.2011, address: http://www.bealtaine.ie/virgil/.

VIRGIL. (2000). Verifying and strengthening rural access to transport services. Videobus. Rural Transport in Europe: Good Practice Guide. Date retrieved: 28.04.2011, address: http://www.bealtaine.ie/virgil.

Yin, R. K. (1989). *Case Study Research: Design and Methods,* Newbury Park: Sage Publications.

Yoshimura, M., and Yanagit, H. (2001). Strategies for Implementing Aesthetic Factors in Product Designs. *International Journal of Production Research*, Vol. 39(5), pp. 1049-1031.

APPENDICES

APPENDIX A.1 : First interview questions with minibus drivers and/or operators.

APPENDIX A.2 : Second interview questions with dolmuş drivers and/or operators.

APPENDIX A.1

Below are the questions asked to the first interviewee group, minibus drivers from Kadıköy-Pendik route.

Merhaba,

İstanbul Teknik Üniversitesi Endüstri Ürünleri Tasarımı Bölümünde yürüttüğüm Yüksek Lisans tezimde kullanmak için aşağıda 15 adet soru yer almaktadır. Bu sorulara mümkün olduğunca detaylı yanıt vermeniz beklenmekte ve vereceğiniz yanıtlar yalnızca bir tez çalışması kapsamında kullanılacak ve gizli tutulacaktır.

ARZU TOKER ÖZKURT

Soru 1.

a. Kaç yaşındasınız?

b. Kaç yıldır minibüsçülük yapıyorsunuz?

c. Kullandığınız minibüs size mi ait?

Soru 2.

Yeni bir minibüs satın alacak olsanız ilk aradığınız özellik ne olur, kısaca bilgi verebilir misiniz?

Soru 3.

Minibüsü satın alırken aracın dış görüntüsü ve estetiği sizin için ne kadar önemlidir, açıklayabilir misiniz?

Soru 4.

Yolcularınız durakta minibüs beklerken marka ya da modeline göre tercih yapıyor mu? Neden?

Soru 5.

Minibüslerin en çok hangi parçaları ya da bölgeleri modifiye edilir açıklayabilir misiniz?

Soru 6.

Sizce minibüslerde bu değişiklikler neden yapılıyor?

Soru 7.

a. Minibüslerde gördüğümüz, özellikle sürücü mahalindeki süslemeler, kaplamalar, aksesuarlar sizce neden yapılmaktadır?

b. Kendi özel otomobilinizde de aynı süsleme ve aksesuarları kullanır mıydınız?

c. Bu süsleme ve aksesuarların işinize maddi bir getirisi olduğunu düşünüyor musunuz?

Soru 8.

Bütün minibüslerin tek tip olması sizce doğru olur muydu?

Soru 9.

a. Piyasadaki minibüsler yolcular için konforlu mu?

b. Bu konuda ne tür şikayetler alıyorsunuz?

Soru 10.

a. Piyasadaki minibüslerin sürücü mahalinin konforunu ve rahatlığını nasıl buluyorsunuz?

b. Daha rahat olması için sizce neler yapılabilir?

Soru 11.

Yeni minibüsleri (mesela M 2010), eski nesil minibüslerle kıyasladığınızda artıları ve eksileri nelerdir?

Soru 12.

İstanbul genelinde en çok tutulan minibüs modeli hangisidir? Sizce neden?

Soru 13.

Minibüs sürücülerinin yeni nesil otomobillerde kullanılan bir teknolojinin kendi aracında da kullanılması yönünde beklentileri olur mu?

Örneğin bir minibüse elektronik ödeme sistemi, park sensörü, dijital gösterge, yol bilgisayarı, navigasyon cihazı, otomatik vites, dijital hat levhası, güvenlik kameraları, sesli ve ışıklı bilgilendirmeler vs. gibi teknolojik yeniliklere minibüslerde de ihtiyaç var mı? Sizin bu konudaki yorumlarınız nelerdir?

Soru 14.

Daha çevreci olan yeni nesil motorlar ve Euro emisyon standartları (Euro IV, V, ve yakın zamanda kullanılması zorunlu olacak Euro VI) hakkında ne düşünüyorsunuz?

Soru 15.

Elektrikli ya da Hibrit araç konusunda bilginiz var mıdır?

APPENDIX A.2

Below are the questions asked to the second interviewee group, dolmuş drivers from Taksim-Kadıköy route.

Merhaba,

İstanbul Teknik Üniversitesi Endüstri Ürünleri Tasarımı Bölümünde yürüttüğüm Yüksek Lisans tezimde kullanmak için aşağıda 15 adet soru yer almaktadır. Bu sorulara mümkün olduğunca detaylı yanıt vermeniz beklenmekte ve vereceğiniz yanıtlar yalnızca bir tez çalışması kapsamında kullanılacak ve gizli tutulacaktır.

ARZU TOKER ÖZKURT

Soru 1.

a. Kaç yaşındasınız?

b. Kaç yıldır dolmuşçuluk yapıyorsunuz?

c. Kullandığınız dolmuş size mi ait?

Soru 2.

Istanbul genelinde gördüğümüz dolmuşlar istisnalar dışında, yıllardır tek tip Ford Transit araçlar.

a. Bu bir zorunluluk mu yoksa tercih mi?

b. Size göre bu iş için en uygun araç hangisidir? Neden?

Soru 3.

Kullanılan araçlar dışında dolmuşçuluk ile minibüsçülük arasındaki farklar nelerdir? Açıklayabilir misiniz?

Soru 4.

Satın alındıktan sonra, dolmuşların üzerinde (koltuk, kapı, vs gibi) herhangi bir modifiye işlemi yapılıyor mu? Neden?

Soru 5.

a. Piyasadaki dolmuşlar yolcular için konforlu mu?

b. Bu konuda ne tür şikayetler alıyorsunuz?

Soru 6.

a. Piyasadaki dolmuşların sürücü mahalinin konforunu ve rahatlığını nasıl buluyorsunuz?

b. Daha rahat olması için sizce neler yapılabilir?

Soru 7.

Sizce dolmuşların boyutları ve yolcu kapasiteleri uygun mu ya da daha farklı kapasitede olmalı mı?

Soru 8.

Yeni dolmuşları, eski nesil dolmuşlarla kıyasladığınızda artıları ve eksileri nelerdir?

Soru 9.

Minibüslerdeki gibi süsleme ve aksesuarlara dolmuşlarda neden pek rastlayamıyoruz?

Soru 10.

İstanbul genelinde raylı ulaşım (metro, tramway gibi) ağı giderek yaygınlaşmakta. Yeni toplu taşıma türleri geliştirilmekte.

Bunlara baktığımızda dolmuşçuluğun geleceğini nasıl görüyorsunuz?

Soru 11.

Istanbul, uydu kentlerle, yeni yerleşim alanlarının oluşmasıyla sürekli genişliyor, buna paralel olarak, dolmuş hattı sayısında artış var mı? Örnekler verebilir misiniz?

Soru 12.

Ne tür yakıt kullanıyorsunuz?

Soru 13.

Daha çevreci olan yeni nesil motorlar ve Euro emisyon standartları (Euro IV, V, ve yakın zamanda kullanılması zorunlu olacak Euro VI) hakkında ne düşünüyorsunuz?

Soru 14.

Dolmuş sürücülerinin yeni nesil otomobillerde kullanılan bir teknolojinin kendi aracında da kullanılması yönünde beklentileri olur mu?

Örneğin bir dolmuşta elektronik ödeme sistemi, park sensörü, dijital gösterge, yol bilgisayarı, navigasyon cihazı, otomatik vites, dijital hat levhası, güvenlik kameraları, sesli ve ışıklı bilgilendirmeler vs. gibi teknolojik yeniliklere dolmuşlarda da ihtiyaç var mı? Sizin bu konudaki yorumlarınız nelerdir?

Soru 15.

Elektrikli ya da Hibrit araç konusunda bilginiz var mıdır?

CURRICULUM VITAE

Name Surname: Arzu Hüsniye TOKER ÖZKURT

Place and Date of Birth: Mucur, 12.02.1985

Address: İzmit/Kocaeli

E-Mail: arzuhusniye40@yahoo.com

B.Sc.: Middle East Technical University Industrial Design Department

Professional Experience and Rewards: Industrial Designer at Otokar Otomotiv ve Savunma Sanayii A.Ş. R&D Department since five years.