WHEELCHAIR-ACCESSIBLE TRANSPORTATION IN DARMSTADT

An Interactive Qualifying Project Report

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

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Date: 6 May, 1999

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ABSTRACT

This report, prepared for Worcester Polytechnic Institute (WPI) in conjunction with the Technische Universität Darmstadt (TUD), examines the handicapped-access technologies present on the local transportation system in Darmstadt, Germany. Also, we gauge the level of satisfaction among wheelchair-bound patrons with the current system. Through a methodology of interviews, observations, and surveys, we determine the effectiveness of the handicapped-access technology in Darmstadt and then formulate recommendations for improving the current system.

AUTHORSHIP

M. Chris Boylan, Isaac Hogate, Jim Shannon, and Stephen Nash-Webber have completed this report for Worcester Polytechnic Institute (WPI) as a partial requirement for a Bachelor of Science degree. The individual responsibilities for the creation of this document are listed below. Furthermore, note that all of the above participated in editing all sections.

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EXECUTIVE SUMMARY

This project, "Wheelchair-Accessible Transportation in Darmstadt", examines the relationship between the technology behind handicapped access and society. Specifically, the project studies wheelchair drivers and the handicapped-access technologies that allow them to use the buses and trams in Darmstadt. Handicapped-access technologies are employed in public transportation systems to allow wheelchair drivers the same access to a bus or tram that a nonwheelchair-bound patron would have. These include, but are not limited to, lifts, ramps, raised platforms, kneeling buses (buses that tilt in order to reduce the step between the street and the vehicle floor), and low-floor vehicles.

First, this project evaluates the proficiency of the current handicapped-access technologies existing in Darmstadt. Second, this project provides an appraisal of the level of wheelchair drivers' satisfaction with the employed technologies. Through an analysis of wheelchair drivers' opinions regarding the technology in place, we can formulate conclusions as to whether or not the employed technology is effective. From our conclusions, recommendations regarding methods for improving the system can be made.

In order to collect the essential data relating to handicapped-access technology, we utilized a methodology composed of three procedures. First, semi-standardized and focus group interviews are conducted with transportation organizations to learn about handicapped-access options in Germany. Via these interviews, we gain an in-depth understanding of the technology as well as develop awareness for the political structure governing handicapped access in public transportation. Furthermore, a focus group interview with a handicapped organization

in Darmstadt is conducted to learn the opinions of wheelchair-bound people. Second, we observe the technologies in place, noting how they are integrated into the transportation system. Through observations, we learn how the wheelchair-bound patrons interact with handicapped-access technology. Finally, a survey is implemented to gauge the opinions of the handicapped population regarding access to the public transportation system.

Another important aspect of this project is the comparison made between handicapped access to public transportation in Germany and the United States. Through background research on legislation governing handicapped access in the United States and in Germany, comparisons between the two regulatory systems are made. Furthermore, a discussion relating to the communication gaps existing between providers of technology and users of technology is contained within the report.

The goal of this project is to understand the relationship between handicapped-access technology and wheelchair-bound patrons in Darmstadt. Our data indicates an obvious incongruency between the handicapped-access technology in place and wheelchair drivers' wants and needs. It is our intention that the data collected in this report serves to exemplify these apparent discrepancies. Once the incongruencies are uncovered, recommendations for their elimination are presented.

The final intention of this IQP is to establish a foundation upon which a future study can be based. Even though this IQP makes recommendations for improving Darmstadt's transportation system, the system is far from perfect, and it might take years for our recommendations to be realized. For this reason, we include recommendations for future studies on this topic.

1.0 Introduction:

The subject of this Worcester Polytechnic Institute IQP is the accessibility of the transportation system in Darmstadt, Germany with respect to those patrons who are wheelchair bound (WCB[1]). We investigated the accessibility of the public buses and light rail street trams. Our goal was to evaluate the different industry-based and consumer-based perspectives on handicapped transportation found throughout the city. Dr. Stärk informed us that there was a high level of discontent among the WCB population in Darmstadt regarding the measures taken to make the transportation system accessible. The research we conducted rendered a determination of what was appropriate access technology for the bus and tram system.

We learned a great deal about the state of transportation systems in Germany with respect to handicapped access by documenting several important viewpoints. The viewpoints of engineers, scholars, WCB patrons, general patrons, drivers of the buses and trams, and administrators of the public transportation systems in Darmstadt and Mannheim were documented. Handicapped access in Mannheim was documented for comparison to Darmstadt's handicapped access. Our determination was that what is considered important to a WCB patron is perhaps not the primary consideration of a transit authority. We approached our research with the expectation that we would find problems with the system. This could have biased our results if it were not for our solid methodology.

This was the first year that WPI students had looked into the issue of handicapped transportation in Darmstadt. With this in mind, our research had two purposes. Our first purpose, as defined by WPI regarding the IQP, was to identify,

[1] WCB: wheelchair bound, this term is burdensome and commonly used. In order to avoid having to write the term continuously, we will use an acronym.

investigate, and report on a topic examining how science or technology interacts with societal structures and values (WPI, 1999). The specific relationship that we foresaw in Darmstadt is known as a top-down approach to engineered solutions. Our second purpose in Darmstadt was to provide a foundation on which future IQP work could be based.

Through our research we discovered that in the top-down approach to engineered solutions, information regarding specific problems is generally given to the engineer indirectly. For example, WCB patrons were not directly asked for input regarding the ease of entry into the buses and trams. Rather, an engineer was confronted with the task of getting a wheelchair driver onto a bus, and subsequently developed a technologically correct solution to the problem. In the minds of the WCB patrons, the technologically correct solution to the problem was viewed as an even greater hindrance to their everyday lives. As researchers, we attempted to determine exactly what was and what was not considered technologically and socially acceptable to the WCB patrons of the Darmstadt transportation system.

We felt it was necessary to identify the cultural characteristics influencing transportation in Germany. In order to understand these influences, we had to discard our American perspective of society for one that was more neutral. Having done this, we uncovered substantial differences between American and German social behavior. The differences we uncovered seemed to have a profound effect on the outcome of social initiatives that related to transportation. Our investigation of this theory should provide a basis for future project work in Germany.

The main method for the collection of data in this IQP was interviewing. Specifically, we interviewed WCB people as well as administrators at the transit agencies responsible for the system. Our interviews with members of CBF (a local

wheelchair organization) were extremely useful in providing the insight needed to develop a survey of the handicapped population in Darmstadt. The information provided during these interviews was also helpful in guiding our questioning of the transit agencies' administrators. Having developed an initial understanding of the potential handicapped-access problem in Darmstadt, we were able to question the local authorities on their approach to handicapped access.

The second data collection method we utilized was observation. First, observed local WCB patrons entering and exiting the trams. This allowed us to document the problems faced by these individuals as well as gauge the reaction to those problems by the driver and other passengers. This data helped us to better understand the technical and social implications of the access problems in Darmstadt. A second form of observation included documenting personal reactions to questions we asked during interviews. In doing so, we were often able to determine through a chuckle or a smirk what the respondent thought of the questions being asked were important.

Finally, we attempted to conduct a survey of the WCB patrons in Darmstadt. The survey was designed to collect numerical data aimed at measuring the satisfaction of the WCB population with respect to accessible transportation. The questions on the survey pertained to the existing service and the available handicapped-access technologies. Due to our inability to access a large enough portion of the WCB sample frame, our survey did not produce scientifically valid results.

We feel the research we conducted may have important ramifications for a diverse audience. Scholars, in Germany and in the United States, may find this to be an interesting glimpse into the cultural differences existing between the two countries and the subsequent effects they have on social programs. Following the presentation

of our results, we discuss the importance of legislation such as the Americans with Disabilities Act (ADA). We discuss the differences between the regulation set forth by the ADA and what could only be described as a weak German system of financial regulation. Members of the German government may be interested in knowing exactly what the handicapped population views as effective and efficient technology. The research we conducted may also influence transit agencies such as HEAG (Hessische Elektrizitäts-AG) and RMV (Rhein-Main-Verkehrsverbund) to reinvestigate their approaches for dealing with handicapped-accessible transportation.

From our research we concluded that the top-down approach to solving technological and societal problems does not work in the interest of minority groups. In the final chapter of this report, we discuss the social-cultural and governmental differences between the US and the Germany that cause a lack of communication between WCB patrons and the transit authorities. Furthermore, we discuss how this lack of communication adversely effects both the level of satisfaction of WCB patrons as well as the technology employed by the transit authorities.

2.0 Literature Review:

Before we begin to measure and analyze handicapped access to the Darmstadt system, we must first familiarize ourselves with the existing literature on this topic. It is vital to our research efforts that we understand the history of public transportation, current legislation, and employed technologies. This information also serves to introduce the issue of wheelchair accessibility to the reader.

2.1 A Brief History of Light-Rail Transit:

To begin our study, we must explore the history of light-rail public transportation systems. This familiarizes us with not only the early influences that acted on this technology but also how those influences varied between Europe and the

United States. This will prove very insightful in our conclusions when we place our findings in perspective given the societal influences in Darmstadt.

2.1.1 America: Light Rail is Born:

Following the Revolutionary War, populations in the major cities along the Atlantic coast began to increase exponentially. As the number of city dwellers increased, so did the need for more housing and more jobs. The inhabitants of the early cities of the United States lacked a motive to build their cities upward. The taller, labor-intensive stone buildings of Europe were not as popular in the US because of the abundance of land and wood building materials that existed in early America. Therefore, the early citizens of the US resorted to building their cities outward. The increasing area of these cities dictated a need for an organized form of urban mass transit, which would lead to the emergence of the light rail transportation systems in America (McKay, 1976).

Boston was one of the first cities in the world to offer its citizens public transportation, and this came in the form of horse-drawn carriages. However, these carriages had several major problems. Many of the roads in and around Boston in the late nineteenth century were unpaved and very susceptible to weather conditions. The horses used to pull these early vehicles proved to be expensive due to constant feeding and medical attention. These problems, when combined with the system's slow speed, caused this service to be unpopular (McKay, 1976).

New York City developed a regional mass transportation system shortly after the Boston system was created. In 1831 New Yorkers adopted their first bus system, but found that they ran into many of the same problems Boston had encountered. Only one year after the introduction of the bus in New York, the city had a solution to many of the problems the system had faced. It was determined that if the vehicles

were allowed to travel on tracks rather than directly on the street surface, both the speed and the overall comfort of the ride were greatly improved. The track-bound vehicles were very successful and were a major step in the development of urban light rail systems (McKay, 1976).

The next major advance in light rail technology was the innovation of electrified systems. In 1887 the first electrified rail was opened in the United States in Richmond, Virginia. Shortly after Richmond's success, Boston decided to complete a full-scale conversion from its horse-drawn system to an electrical system (McKay, 1976). The "light rail revolution" (McKay, 1976) went on to become one of the most important events in transportation history, with nearly every major metropolitan center in the United States employing such systems.

2.1.2 Europe: Light-Rail Transit Finds a New Home:

However, European countries were slower to realize the benefits of these systems. European cities experienced a constant state of population growth during the Industrial Revolution. But unlike American cities, European cities did not tend to increase much in area; rather, they simply increased in density. This was primarily due to strict land-use laws that restricted urban zoning to the confines of a city thus protecting rural areas from urban creep. Therefore, with the average city totaling less than three or four square kilometers in area, most travel could be accomplished by foot and there was little need for any other form of transportation (McKay, 1976). Consequently, train travel in Europe in the 1860s was restricted to moving people and goods between cities rather than within them. With this in mind, train travel did very little towards relieving the congestion found in European cities during the nineteenth century (McKay, 1976). However, city populations later increased to beyond the

contemporary ability to build upwards; as cities grew outward the need for public transport became apparent.

The first form of European urban mass transportation took much the same form as the bus systems in the United States. The European bus services grew despite experiencing many of the same problems that were evident in America. This was probably due to the fact that the European systems were born out of intense demand. As time went on, the bus systems' clientele began to realize that the aforementioned susceptibility to poor weather conditions often outweighed the benefits. Furthermore, "[Bus] travel had many inconveniences attached to it which limited its use by the wealthy, and it was not cheap enough to be used to even the same extent by the poorer classes"(McKay, 1976). This dictated the need for a new and improved service, which would eventually take the same form it had in America.

Toward the end of the nineteenth century, the horse-drawn and electric track-bound systems in Europe met with a great deal more societal and political scrutiny than they had in the United States. Disagreement came between the public and private sector:

> "[Evidence] suggests two institutional forces shaping European street railway development in addition to technological change and urban population growth. The first of these was the public authority, both national and local, which regulated the railways but did not operate them. The second was private enterprise, which sought the permission of public authority to build and operate tramways in the public streets for private profit." (McKay, 1976)

Where Americans had embraced the idea of free enterprise, the Europeans were more concerned with who was eventually to profit from the construction of such public works. As is suggested by McClosky and Zaller (1987), this was probably due to the fundamental difference between these cultures. Where Americans have an extremely individualistic perspective, Europeans adhere to a philosophy of communitarianism.

As a result, such disputes later led to agreements that allowed both the private enterprise and the public sector to profit. A basic system of leasing was often drafted that allowed the company to profit for a given period, with ownership of the system and subsequent profits eventually reverting to the public sector. Notice though that this system is very much based on money as opposed to service.

With the birth of light rail transportation and its early influences in mind, we can better understand what is happening in the industry today and will happen in the future. Light rail systems are now a proven concept as being economically, socially and ecologically sound. Where initial legislative efforts concentrated on the cost of subsidizing this unproven technology, current legislative efforts are focusing on improving access to these systems. Many governments have begun to pressure public transportation agencies to make their services fully accessible to all disabled people. This includes, but is not limited to, elderly, wheelchair-bound (WCB), blind or cognitively impaired people.

2.2 Handicapped-Access Technologies:

In order to understand these legislative efforts and resolutions we must first familiarize ourselves with what technologies exist and the theory behind their creation. There are three different ways to aid a person who has a mobility impairment to board a light rail train or bus. Carrying, lifts, and ramps are the primary modes of boarding for a handicapped person who uses a wheelchair or other mobile unit.

2.2.1 Carrying:

In the case of carrying, an employee has to pick up the handicapped person out of her mobility device and then carry her to her seat. Alternately, a boarding chair can be used. In this case, the handicapped person is transferred from her wheelchair into a

boarding chair, which is then wheeled into the bus or light rail car (ATBCB, 1992). The boarding chair is narrow enough to fit through the doors and corridors of the vehicle. Ideally, vehicle designs should allow any reasonably sized mobile unit through the doors and corridors. If this condition is met then it is possible for the person to be carried, wheelchair included, onto the vehicle. This task typically will require the help of more than one person. In this case other passengers must be involved. If there are not enough willing and able passengers on the vehicle this method will not work. Furthermore, carrying can result in employee or patron injury, which in turn may lead to worker's compensation payments or a lawsuit. However, carrying is the cheapest of the three methods mentioned (U.S. Congress, 1993), and is easy to implement quickly. Nevertheless, the aforementioned legal liabilities combined with a long boarding time and decreased comfort (ATBCB, 1992) make this option an inadequate engineering solution for most cases. Furthermore, Scherer (1996) illustrates how this sort of "no tech device" breeds feelings of segregation. As one of her study subjects states: "If you have to adapt yourself... ...it's like they're saying 'Well, okay, we really don't want you here, but...'"

2.2.2 Lifts:

Lifts allow people to board a bus or light rail train without having to be transferred into a boarding chair. This can be accomplished using two different types of lifts. Interior elevators are attached permanently to a vehicle while exterior lifts are moved to the entrances of a vehicle at a station. Exterior lifts are best suited for manned stations experiencing a lot of traffic but pose more of a problem for unmanned and low volume stops where there are logistical problems with storage and operation. In a typical transit system in the United States there exists a hierarchy of transit vehicles. A backbone of mass-transit (subway) and light-rail systems feeds

into a network of buses that serve the local communities surrounding each stop. Therefore, it is not reasonable to use exterior lifts for the majority of bus stops. Simply stated, elevator lifts are best suited for buses (U.S. Congress, 1993). The inverse is also true; high volume stations where many transit lines converge are ideal locations for exterior lifts where the use of such lifts is divided among multiple transit lines.

Some lifts are problematic for mobility-impaired people who do not use wheelchairs. Those passengers who stand using a cane or other such device might have to stoop low to get into the bus or train as the lift may adversely affect the available headroom. These people should not be overlooked as they may not be able climb the stairs to many forms of public transportation. Therefore, care should be taken to ensure proper headroom when the lift is fully raised (U.S. Congress, 1993).

Also, employees need to be trained in order to operate the lift. Oftentimes elevator lifts are located in a stair well of the bus and then fold out into a flat surface for the handicapped patron. Then the lift is ready to operate. At this point the lift has to be raised and lowered while the safety boards have to be articulated to keep the patron on the lift. The driver, to ensure the customer's safety and comfort, oversees this whole process.

In conclusion, lifts are the most expensive of the three methods mentioned (U.S. Congress, 1993), and typically have a relatively high boarding time. However, lifts are the most comfortable and reliable method of the three (ATBCB, 1992), making this option preferred by handicapped users (Scherer, 1996).

2.2.3 Ramps:

Ramps are another form of handicapped access that are used in public transportation systems. A ramp is an inclined plane used for access to a higher

platform or structure. Generally, ramps are classified into two different categories. These include station-based ramps and vehicle-based ramps. Both can be effective forms of handicapped access but are usually used in different applications.

Station-based ramps are inclined platforms that are integrated into the structures of stops or stations. This type of ramp allows people with mobility impairments to access a vehicle without assistance. Station-based ramps result in the fastest passenger transfer. They are also safe, and easily used. In 1993, the price of a station-based ramp ranged between $4,000 and $7,500 (U.S. Congress, 1993).

Vehicle-based ramps are affixed into a vehicle. These exist as both transferable and automatic ramps. The vehicle drivers assemble transferable ramps when they are needed. This requirement of assembly poses a problem. It takes two skilled employees five minutes to assemble a vehicle-based ramp. However, it takes one unskilled worker almost twenty minutes to assemble a ramp. Automatic ramps do not pose this problem and are more common. In fact, vehicle-based ramps are generally cheaper than station-based ramps. Even so, a vehicle based ramp costs between $3,500 and $4,500 in 1993 (U.S. Congress, 1993).

2.2.4 Restraint Systems:

Once in the tram or bus, the disabled person must be secured safely in place. According to the Architectural and Transportation Barriers Compliance Board, once secured, a wheelchair must not move more than 2 inches in any direction (U.S. Congress, 1993). Although it is unclear what the reasoning behind this specification is, one can deduce that this is intended to keep the wheelchair from gaining momentum in the event of an accident or sudden halt of the bus. There are many considerations required in developing a secure way of transporting a mobility-disabled person. The restraint system must be universal to all types of mobility aids

and must not damage them. The passenger should ideally be able to secure herself quickly and easily without abandoning safety. However, this is not always possible. Usually the longer it takes to secure someone, the safer the restraint. Likewise, the inverse is true, the shorter the time, the less safe the restraint. There should be a way for persons who cannot secure themselves to get assistance (ADA, 1992).

Belt and clamp systems are two different ways to secure a passenger. On the one hand, the belt design is very safe and has the ability to withstand most crashes. It is also compatible with most wheelchairs. On the other hand, one problem is that it might take 15 minutes for an untrained employee to strap in the commuter (U.S. Congress, 1993). The opposite is true with clamp systems; they are easy to use but not as safe. Handicapped persons could secure themselves with little effort, yet the clamp systems are less crashworthy than the belt design. Also, the clamp system is not as universally compatible as the belt system. A device must be attached to the mobile unit in order to make it compatible with the clamp design restraint system (U.S. Congress, 1993).

2.3 Legislation:

Legislation has an important role in specifying requirements for handicapped access and is a pivotal aspect of public transportation as many transit authorities rely on public funds in order to operate. In recent years the focus of legislation in the US and the UK has shifted towards civil rights and public services.

2.3.1 The Americans with Disabilities Act (ADA):

The Americans with Disabilities Act serves to protect the legal rights of physically limited individuals. The purpose of the ADA is to provide clear objectives for the purpose of eliminating discrimination against physically limited individuals, to provide a means of enforcing anti-discrimination law, and to assure the federal

government will assume an active role in protecting the rights of disabled persons (ADA, 1990). One of the specific goals of the ADA is to ensure that people with physical and mental limitations have the same ability to benefit from public services and programs as do people without these limitations.

Part of the Americans with Disabilities Act sets forth regulations for light rail transportation. The ADA sets forth a timeline for making light rail transportation accessible to those with disabilities and establishes specific guidelines for the design and construction of such systems. For the purposes of light rail transportation, it is considered discriminatory against physically limited passengers if any public transportation company purchases a light rail vehicle that is not accessible to such passengers. The "One car per train" rule specifies that all light rail trains must provide at least one accessible car as soon as possible. The ADA requires that all high-traffic stations be updated, and that all newly constructed stations be fully accessible. Finally, transit authorities must provide an appropriate paratransit service or other comparable services to individuals with disabilities who are unable to use fixed route services.

However, exceptions to the regulations set forth by the ADA can be made, and continuances can be granted in cases where sites are historic, or the financial burden of improvement is deemed too great for the transit authority to bear (ADA, 1990). This is the case with the Massachusetts Bay Transportation Agency in Boston, MA where funds are not available currently given other renovation projects.

The ADA sets forth a large number of specifications to describe the degree of handicapped accessibility of a light rail vehicle. Part 1192--Americans with Disabilities Act, Accessibility Guidelines for Transportation Vehicles, Subpart D-

Light Rail Vehicles and Systems (1992), sets forth a detailed list of these specifications. Some of these specifications are described below.

The greatest test of a transportation system's accessibility is its ability to accommodate wheelchair patrons. Accessible systems have the ability to be entered by an individual who uses a wheelchair. The system must also provide a place for the wheelchair to be secured within the vehicle and provide the option for the patron to transfer to a regular seat. Furthermore, it is specified that the train must provide accommodation for a number of wheelchairs equal to but not less than one half the number of cars in the train. Furthermore, an equal number of spaces must be provided to store empty wheelchairs. Specifically, the on-train space requirement for a wheelchair is defined as a clear floor space measuring at least 48 inches by 30 inches (ADA, 1990).

The ADA is very specific in its requirements for public transport. Of the three documents we researched, the ADA is the most specific and comprehensive federal documents on the subject of handicapped-accessible transportation. The comparable document in England is the Disabilities Discrimination Act.

2.3.2 Disabilities Discrimination Act (DDA):

The Disability Discrimination Act is an article of legislation passed in the United Kingdom to protect the rights of disabled people. The DDA is very similar to the ADA in the United States as both government documents establish guidelines that public service providers must follow to protect the rights of physically handicapped people. As a result of the DDA, physically handicapped citizens in the United Kingdom have the same access to public services as citizens who are not handicapped (DDA, 1995).

Section forty of the DDA pertains to the rights of handicapped patrons with respect to public transportation. The DDA sets forth specific requirements for the operation of a public transportation system that is handicapped accessible. It also states that all structures for the public must be accessible to all handicapped persons (DDA, 1995). For example, in the event that a feature such as a stairway is being designed, an alternate means to get to the top of the stairs such as an elevator or a lift must be incorporated into the design. Furthermore, in the United Kingdom, it is deemed discriminatory if a public service vehicle such as a public bus is used for public transportation with no access option for a handicapped person in a wheelchair. Also, the DDA specifies that disabled persons must be able to access public service vehicles, "and in the case of disabled persons in wheelchairs, do so while staying in their wheelchairs." Exceptions to the regulations set by the DDA are possible. For example, if the service providers responsible for implementing the handicapped access could prove that they exceeded the prescribed maximum expenditure, then they will not be held financially responsible (DDA, 1995).

The DDA not only specifies standards for handicapped access to buses but also for rail vehicles. Light rail vehicles, such as street trams, fall into this category. The DDA clearly states that disabled persons must be able to access regulated rail vehicles in safety and without unreasonable difficulty while remaining in their wheelchairs (DDA, 1995). Also, the DDA regulates how equipment must be mounted on such rail vehicles to ensure handicapped accessibility. The DDA also states that the driver of a rail vehicle who is found guilty of operating a tram that is not deemed handicapped accessible in accordance with the DDA will be held responsible and fined. One of the disadvantages of the DDA is that it is not as specific as the ADA in allotting tram or bus floor space for a certain number of wheelchairs. Indeed, the

DDA simply states that the tram or bus should have sufficient floor space for wheelchair accommodation. This may be to allow the judicial system to further specify handicapped accessibility in England.

2.3.3 German Constitution (Grundgesetz):

However, the DDA is significantly more comprehensive than the legislative support Germany has for its handicapped population. Aside from case law, the only document that protects the handicapped from discrimination is the German Constitution. In Section 3 of Article 3 of the German Constitution, the ICL (International Constitutional Law) translation states, "No one may be disadvantaged or favored because of his sex, his parentage, his race, his language, his homeland and origin, his faith, or his religious or political opinions. No one may be disadvantaged because of his handicap."

2.4 Case Studies:

In order to gain a better understanding of the role of handicapped-access in a public transportation system, several case studies have been examined. All of the case studies investigated touch upon accessibility issues, whether they were part of the initial plan for the light rail transportation system or factors considered in modifications. Two of these case studies reflect the views and usage of light rail transportation in the US and one of the case studies describes a light rail transportation system in Great Britain.

2.4.1 Portland, Oregon:

In the mid-1970s, the citizens of Portland, Oregon rejected a plan to build new urban highways. This launched the concept of a light rail transportation system for the city. Portland was growing in population and faced traffic problems on its aging urban roadway system. The city had joined many North American cities by adopting

light rail transit as an alternative to building more highways. Furthermore, Portland had some very specific goals for the success of its light rail transportation system. It was expected to alleviate traffic congestion within the city, improve air quality (which had been lowered by excessive use of automobiles in the city) and inject new life back into the deteriorating downtown Portland area. While not an original goal, making the new light rail system handicapped accessible would later prove beneficial in aiding the tram system reach the goals set by the city.

Consequently, the current light rail transit system in Portland is viewed as a success. This is not because it met all of the planners' original goals, but rather because it was the result of planning, marketing, and integrating the roles of public transportation and the private automobile in society (Middleton, 1990).

Although the Metropolitan Area Express (MAX) originated out of an aversion of the citizens of Portland to building new highways, the original 15 miles of the light rail system were built in conjunction with the widening of I-84, one of the major arteries into the city (Middleton, 1990). Despite the widened highway, the MAX posted some opening day statistics that satisfied its goals of reducing traffic congestion and the need for new highways. 250,000 people received free rides on the MAX system during its first weekend in operation in September 1986. (Middleton, 1990). The MAX continued to be a success by exceeding its projected performance. During its first year of operation, 7,230,000 people used the light rail system in Portland (Middleton 1990). This was more than double the number of riders predicted by the urban designers of the Tri-County Metropolitan Transportation District of Oregon (Tri-Met). According to Middleton (1990), the MAX light rail transit system also surprised its designers and Tri-Met by operating so efficiently. In

1989 the MAX trains posted a fairbox recovery rate of 56.2% against the original investment, approximately doubling the projected earnings (Middleton, 1990).

The MAX light rail system outperformed its designers' expectations on opening day by transporting large numbers of people. The realization of its other ambitious goal of reviving the then dormant economy of the downtown Portland area would take more strategic planning. Tri-Met's urban designers addressed the problem by instituting major transit initiatives that would help to boost the downtown economy. The construction of an 11-block Portland Transit Mall in the heart of the downtown area proved to be a vital step in returning economic stability to downtown Portland (Middleton, 1990). This Transit Mall would serve as a center for the new light rail transit and existing bus transportation. Also, limits were set by the city of Portland on the amount of parking facilities in the downtown area to encourage the use of the transit system (Middleton, 1990). Later, this Transit Mall became the centerpiece for the development of high-rise office buildings. The city center was not the only part of the city prepared for growth. Outside the downtown area, land use planning and zoning had been strategically changed to encourage high-density growth and development in areas most accessible to the MAX light rail transit (Middleton, 1990).

Contributing to the overall popularity of the MAX light rail system are the many methods by which the trams are made handicapped accessible. The stations built for Portland's MAX were all built with handicapped access in mind by utilizing ramps and ticket dispensing vending machines. Access to the trams at the stations is provided by mechanical wayside lifts powered by each train and controlled by the train operators (Middleton, 1990). Portland's MAX light rail system was the first

transportation system to utilize low-floor vehicles to accommodate handicapped passengers (Middleton, 1994)

2.4.2 Sheffield, England:

Another example of low-floor technology can be found in Sheffield, England. Not only is this a case study of a different population, but it is a study of the effect of light rail in another country with different laws than the US. After a thirty-year hiatus from public trams, Sheffield, England had decided to reintroduce tram service into its existing public transportation system. In the 1980s Sheffield was dealing with increasing traffic congestion. Sheffield's aging roadway system could not handle the increasing volumes of traffic. Therefore, in 1985, the South Yorkshire Passenger Transport Executive applied for permission from the British Parliament to begin construction of a new light rail system (Faraday, 1996). Sheffield took an unusually aggressive approach towards the construction of its new Supertram system. Sheffield's light rail system was the first to completely alter the existing traffic patterns in order to facilitate the new Supertram (Faraday, 1996).

The designers' two biggest concerns were access and safety. It was imperative to the success of the new trams that they would be accessible to all people regardless of their disabilities or handicaps (Faraday, 1996). One design feature that would increase the accessibility of the new trams is the low-floor design of the new Light Rail Vehicles (LRVs) (Faraday, 1996). With the low-floor design and level access from raised tram stops, the new Supertram is easily accessible to people with wheelchairs and strollers (Faraday, 1996). Also, ticket machines in the stations were constructed at a level that would be reached easily by all people.

Interestingly, in order to gain a perspective on the access needs of the handicapped, meetings were held with disability groups to hear their needs for access

in order for them to easily use the new Supertram system (Faraday, 1996). Hegel and other philosophers have written at great lengths as to the effect of such efforts being made to hear constituents (in this case customers). By providing a means by which individual customers can be heard, all resultant operational efforts are automatically legitimized. Scherer further states that, "One of the most common reasons for the non-use or reluctant use of an assistive technology is that it was forced upon the person..." Finally, the marketing manager for the Sheffield project stated, "if it is accessible for the disabled, then it is accessible for everyone." about the light rail system (Faraday, 1996). These are extremely important concepts that are further discussed in chapter six of this report.

citation?

Not only was the Supertram a design success, it also had similar positive effects on the economy of Sheffield that the installation of light rail had in rejuvenating the economy of downtown Portland, Oregon. The Supertram was established to alleviate traffic congestion in Sheffield, and it was coupled with an urban renewal program with positive effects. Through the urban renewal program the Supertram was routed through economically depressed areas of Sheffield. Faraday (1996) attributes the appearance of new businesses and jobs into those areas to the Supertram.

The Supertram was also a design and marketing success. The cars for the new Supertram were designed and constructed to be powerful, quiet, and attractive in an attempt to lure people away from using their own cars and use the tram service. The rail bed and tracks that the Supertram would run on were also specially designed to reduce noise and provide for a comfortable ride. Noise reduction was not the only design concern in implementing the Supertram in Sheffield. By communicating with the public throughout the design of the Supertram, designers were able to take the

majority of the public's concerns into consideration before the tram went into operation. Before construction began, pamphlets containing phone numbers where Sheffield residents could ask questions and raise complaints were distributed. Public meetings were held to hear the opinions of the residents and local businesses (Faraday, 1996). Also representatives of the new Supertram visited local schools to educate children on safety and use of the new trams. Constant communication with the public throughout the construction of the Sheffield Supertram led to its overall success.

2.4.3 Boston, Massachusetts:

Boston, Massachusetts has one of the oldest light rail systems in the United States. The system in place in Boston contains four major urban rail lines. We will only consider the green line, because that is the only line in Boston that operates at the street level. The Massachusetts Bay Transportation Authority is currently in the process of renovating its aging light rail system with new low-floor cars and handicapped-access improvements. This is in part due to the fact that in the last decade, the number of commuters using Boston's light rail system has more than doubled. (Middleton, 1991). This is likely due to increasingly congested car traffic in the city during this time. This growth in riders on the light rail system has led to some major improvements to Boston's light rail network. However, handicapped-access to the green line in Boston is currently almost non-existent. It is almost impossible to get a wheelchair to any green line stop, and access to the train cars themselves is extremely difficult.

To alleviate the major problems with handicapped access that exist on the green line, the MBTA has contracted for 100 low-floor vehicles at a cost of 245 million dollars (Railway Age, 1995). These new LRV's will allow for easier access

to wheelchairs and other disabled passengers. The new cars will also include features that aid hearing-impaired as well as mobility-impaired passengers. The new LRV's will have two wheelchair stations per car and audio announcements of station destinations and stops (Middleton, 1995). Improvements to the tram stations have also taken place to accommodate handicapped passengers. All of the stations that have been built or rebuilt since 1982 have full-length high platforms which are level with the floors of the new tramcars (Middleton, 1991).

3.0 Methodology:

The purpose of this chapter is to familiarize the reader with the techniques we employ in this IQP. These techniques fall into three categories; interviews, observations, and surveys. Within each of these categories, there are specific guidelines by which the method should be executed. To formulate conclusions, three different methods are often used to measure the same variable. This concept (known as triangulation) insures that any source of error introduced by one method can be counter-acted and cancelled by the different errors introduced from the other two methods.

3.1 Interviews:

Interviewing is a valuable tool in any research project where the objective of the project is a search for information. An interview is described as a conversation with a purpose, where the purpose of the conversation is to collect information (Berg, 1998). There are three interview types that are relevant to the successful accomplishment of the goals set forth in this IQP. The three types used throughout the research contained in this report are the semi-standardized interview, the un-standardized interview, and the focus-group interview. While the purpose of each of

these methods is the collection of information, it is fundamentally important to realize that each method produces different results.

The first method is the semi-standardized interview. The semi-standardized interview is conducted in compliance with a predetermined set of questions and has three or four participants, each having a different function. The respondent is the person being interviewed. The interviewer and her research assistant are the two other fundamental participants in this method. It is the interviewer's job to ask questions while her research assistant records the interview and notes the physical surroundings in which the interview is taking place. By describing the physical location of interview, a reference is made to the clothes worn by the respondent, the respondent's physical reaction to certain questions, and perceived attitudes of the respondent researchers gain valuable data which aids the interpretation of the respondents statements.

In a foreign culture, where the language barrier is substantial, we have difficulty preparing for and conducting an interview. Therefore, the fourth and final participant in our interviews is the culture broker. A culture broker is needed if an interviewer comes from a different culture than the respondent. In our case, it is important that the culture broker understands German culture and speaks German and English proficiently. He or she arranges the interview (e.g., time and location) and then acts as a translator during the interview period (Berg, 1998).

While a semi-standardized interview is conducted with a pre-determined set of questions, it lacks the reified structure of a standardized interview. This lack of reified structure is attributed to the allowance of probing questions designed to allow the respondent to elaborate on her answers. Berg suggests that not only is the

moderator permitted to ask probing questions, but she must also ask for elaboration in order for the method to be successful (Berg, 1998).

The second method is known as un-standardized interviewing and follows Berg's previously discussed definition of an interview: "Un-standardized interviews are sometimes used during the course of field research to augment field observations" (Berg, 1998). Therefore, our methodology uses information obtained via un-standardized interviews to test our field observations of the non-handicapped population in Darmstadt. For example, if we were to detect resentment of the WCB patrons among the non-handicapped patron (e.g., negative physical demeanor), we can test that observation via un-standardized interviews.

The difficulty in conducting un-standardized interviews is that they are often difficult or impossible to code or analyze. The obstacle arises from the fact that several people can assign different meanings to the same word, this is called inter-subjectivity. For similar reasons, it is impossible to test opinions between different frames (e.g., WCB patrons versus non-handicapped patrons) via un-standardized interviews. The term "care," when used in the context of discussing public interest in handicapped-accessible transportation, is an example of this phenomenon. Simply stated, WCB patrons may assign a stronger or different meaning to the word "care" than do non-handicapped patrons (Berg, 1998).

Focus group interviews are our third methodology for the accumulation of data through discussion. They are a quick way of recording the opinion of a group of people and an effective way of brainstorming different ideas and criticisms. The focus group interview is specifically designed for collecting data that precipitates from a small group discussion. Researchers using this method attempt to determine the opinion of a whole group of people, such as a company or a handicapped group.

Moreover, in focus groups, individual opinions are not expressed as strongly as if the interview was conducted individually. The focus group interview is very similar to the semi-standardized interview, yet the dynamics brought about by a group situation fundamentally change certain answers (Berg, 1998).

The fundamental differences between the production of answers in the focus group as opposed to the semi-standardized interviews are directly related to pressure from the group. All interviews, whether standardized, semi-standardized, un-standardized, or focus group produce biased answers. Yet, the bias produced during a focus group interview is a direct derivative of the group situation. In other words, a person tends to be less honest and direct during an interview when their answers are subject to peer evaluation. For example, an employee at company X is more likely to discuss the faults of company X when her co-workers are not present. Similarly, children are less likely to discuss delinquent activities in the presence of their parents than they are in the presence of their peers. We can overcome the bias in our interviews by triangulating our methodology. If we receive the same results with three different data collection methods (e.g., interviews, observations, and surveys), then the biases of all three methods are counteracted and the data can be considered accurate (Berg, 1998).

Focus group interviewing is also similar to semi-standardized interviewing in that the interview is conducted based on a given schedule of questions with allowed deviation. The questions administered during a focus group interview are merely subjects for discussion. Furthermore, as in other interviews, a research assistant is also necessary for recording the opinions generated by certain topics as well as the physical surroundings in which the interview takes place.

An important task to be accomplished during any interview is a successful initial social exchange. Before asking for or attending an interview, the interviewer must perform a cost-benefit analysis. Simply stated, the interviewer must determine what the costs and the potential benefits are to the respondent. In order to accomplish a successful social exchange, the interviewer must minimize the costs and maximize the benefits to the respondent. In a successful social exchange, the respondent grants the interview and is more than willing to talk (Berg, 1998).

The fundamentals of social exchange theory rest on the concept of utilitarianism. The simple definition of utilitarianism states that the aim of a person's actions should be the largest possible balance of pleasure over pain (Webster, 1999).

> "Utilitarianism posits that humans seek to balance their pleasure (i.e., rewards) over their pain (i.e., costs) as well as seek to achieve the most happiness for all (i.e., an equal balance of the most positive outcomes or rewards for both or all individuals in a relationship or group)" (Pollock, 1996).

This quote indicates that people need to be rewarded for their participation. Otherwise, they will not participate. By definition, our relationship is with the subject we intend to interview. The cost of participating in an interview for someone such as a business executive might be retribution for telling the truth. The retribution might take the form of corporate termination, or social ridicule by her peers. Rewards to an interview participant could be altruism or philanthropy, social good, and self-gratification. Generally speaking, people are more than willing to talk if the "pains" of doing so are kept to minimum. Therefore, we must attempt to lower the costs by keeping interviews concise and providing specific options for confidentiality while raising the respondent's benefits (Berg, 1998).

Interviewing a Darmstadt focus group such as an organization for wheel chair drivers, is the first step in attaining our goals. This develops our understanding of the

existing transportation problem, and allows us to develop possible survey questions. Furthermore, an interview with a focus group allows questions for public officials to be accurately developed. One of our research goals is to attempt to understand the problems WCB patrons face in everyday transport, and thus determine what is being done to rectify the situation. Cross-referencing stated problems with proposed solutions allow us to establish whether or not a communication gap exists between the handicapped population and the local transportation company in Darmstadt.

3.2 Observation:

Observation is one method of obtaining data about handicapped access to public transportation in Darmstadt. Three basic types of observation were used to obtain the data collected for our project. Naturalistic, shadowing, and participant observations provided us with knowledge of how WCB people access public transportation systems. Through observations, we further evaluated the effectiveness of current handicapped access to the transportation system in Darmstadt. The observations also serve as a tool to determine how the general public Darmstadt view people in wheelchairs.

Site research for our project involved analysis of bus and tram stops and represents one subset of our naturalistic observations. When each stop was analyzed, the types of handicapped access (e.g. ramps and raised platforms) were recorded into a spreadsheet. This spreadsheet was then used to evaluate the use of each stop compared to the type of handicapped-access technology available. Site visits to the tram and bus stops also helped us understand the extent to which the public transportation system in Darmstadt is handicapped accessible.

An observation method that was used to evaluate handicapped access at stops, as well as in buses and trams, is naturalistic observation. This type of observation is

defined as "the study of people acting in the natural courses of their daily lives" (IGSD, 1998). Naturalistic observations investigate the natural states of patrons using trams and buses without any input from the researcher. A natural view of the subject using the system is gained if the subject does not know she is being researched. Therefore, through these observations, the researcher can judge the effectiveness of handicapped access to the transportation system without biases from the subject. One difficulty in naturalistic observation is that this method requires a lot of time to implement. The researcher might spend days, weeks, or even years and never observe anyone using the system she is studying.

Shadowing observation is a more efficient method for an in-depth analysis of the effectiveness of an entire system. As defined by Berg, shadowing is following a person around during her usual routine while watching specific activities and the people she interacts with (Berg, 1998). Through shadowing observation, a researcher is capable of asking a shadowing participant to use different aspects of a transportation system. Therefore, the researcher obtains an idea of how effective an entire system really is and not just a specific stop or vehicle. Shadowing of WCB patrons gave us a better idea about how WCB patrons use public transportation in Darmstadt. Also, shadowing WCB patrons from different age groups allowed us to determine accessibility options that work for all ages. Observations taught us not only the effectiveness of the system in place, but gave us a glimpse into how the general public views WCB people. Perceiving how other passengers react to WCB people accessing buses or trams gave our group a comprehension of how tolerant or helpful the general public is toward people in wheelchairs using the public transportation system. Ideally, this gives us a better understanding of bus and tram passengers' unvoiced feelings toward WCB patrons (IGSD, 1998).

Another method we implemented in order to understand the effectiveness of handicapped access to the buses and trams in Darmstadt was to simulate a disability, thus gaining first-hand experience of using handicapped access. This method of observation is known as participant observation (IGSD, 1998). For our participant observations, we used a wheelchair to attempt to access the public transportation system in Darmstadt. In conjunction with observing WCB patrons, this method gave our group an idea of which forms of handicapped access are most effective for wheelchairs.

Factors that we consider during our participant observations included time of boarding and safety. Boarding time is important because all of the buses and trams need to maintain a strict schedule. Therefore, if a WCB person needs a substantial amount of time to enter the bus or tram, the vehicle could be late for its next stop, thus decreasing the volume of passengers transferred and making the system less profitable. Safety is also important to any passenger. In order for handicapped people to use public transportation, they must feel comfortable accessing the system. If they do not feel that accessing buses or trams is comfortable and safe, they will find an alternative means of transportation. This comfort level was also measured in our observations.

3.3 Surveys:

One goal of this IQP is to determine the level of satisfaction among WCB patrons concerning the handicapped access in the local transportation system in Darmstadt. Because it would take too much time to interview a large number of WCB people, surveys present the most logical method to determine the opinion of all WCB people in Darmstadt. To use a survey, we must be able to answer five basic questions. First, we must find out how many people are required for a valid survey.

Second, we determine what type of survey method to employ. Third, we figure out how the survey sample is selected. Fourth, we determine how high the response rate should be. Fifth, we figure out how accurate the results are (Salant and Dillman, 1994).

Creating a sample frame out of the total population to get specific opinions of certain groups was essential in this IQP. We needed to be able to quantify the WCB peoples' level of satisfaction with the transportation system in Darmstadt. There are four options that we could have chosen to determine opinions about handicapped access. First, we could have specifically targeted WCB patrons of the public transportation system in Darmstadt. Another possibility was to widen the sample frame to incorporate those WCB people who could use the local transportation system but do not, and then try to figure out why they do not. A third option was to survey all WCB people regardless of the extent of their handicap. A final option was to also survey both bus and tram drivers as well as the general public to determine how they feel about handicapped access within the system. We had less than seven weeks to perform a survey, and it was very hard to find WCB people. Therefore, our sample frame incorporated all WCB people instead of a certain group of handicapped people.

There are four main techniques of sampling that are commonly used; simple random, systemic, stratified, and purposive sampling. The type of sampling method to implement depends on many factors (e.g. resources, sample frame, and size of population). Simple random sampling is based on randomly selecting subjects from a population. Therefore, everyone in the sample frame has an equal chance of being chosen. In systemic sampling, every nth name is chosen out of a list of the sample frame. The size of the interval between each name is dependent on how many subjects are needed. In stratified sampling, subgroups are created from the sample

frame in order to represent every group in a population. In each subgroup, a sample is taken proportionally to the size of the subgroup. Purposive sampling is described as distributing surveys to people who are believed to represent a specific population. This type of sampling methodology is usually employed when the subjects in the sample frame do not appear in big enough groups and are hard to find (Berg, 1998).

Because of the small amount of WCB patrons in Germany and the difficulty of finding these people, we used purposive sampling as a sampling method. We did not have a list of the sample frame population. Therefore, we could not employ the other three sampling methods. We implemented this survey by finding different groups that handicapped people belong to and gave any WCB person a survey to complete. We also gave surveys to any WCB person we happened to meet.

A number of different survey methods could be employed in order to get the WCB community's point of view regarding handicapped access. Possible survey methods include face-to-face, mail, and telephone surveys. There were not enough time or money resources available to us in this project to employ a mail or telephone survey. Therefore, we performed face-to-face surveys. This type of survey is effective for us because it is cheap and does not require much time to get results. Our frame population was small and the monetary value of our personal time was low (Salant and Dillman, 1994).

Survey results are devalued because of different types of errors. Four errors that researchers search for are coverage, sampling, measurement, and non-response error (Salant and Dillman, 1994). These types of error should be reduced in order to get useable results.

Coverage error is directly related to the sample frame. On the one hand, if surveys are given to people who are not mentioned in the sample frame and that data

is grouped with the sample frame data, error occurs. On the other hand, if not enough people who are part of the sample frame are considered in the survey, then error is increased. Complete randomness in a survey would eliminate coverage error.

Sampling error is the most quantifiable. Usually, this is the only error mentioned when a survey is presented in non-academic reports. Sampling error occurs when the sample size is not large enough compared to the sample frame or population (Salant and Dillman, 1994). There will always be some sampling error unless everyone in the sample frame participates in the survey. It must be determined how large a sampling error is acceptable. Then, the required amount of people must be surveyed in order to achieve that level of error.

Non-response error is related to response rate. The higher the response rate is, the lower the non-response error. Response rate is important because people who do not respond could have an opinion that is totally different from everyone else (Salant and Dillman, 1994). For example, people who might not care about handicapped access will not bother doing our survey. Thus, we might think that a higher percentage of people care about handicapped access than is accurate.

Measurement error is the most complex error to be quantified because there are many different sources of measurement error to be considered. This type of error comes from the survey method, the questionnaire, the interviewer, and the respondent (Salant and Dillman, 1994). Different survey methods create different measurement errors, which are often impossible to quantify. Face-to-face surveys create problems for the people being surveyed because interviewers control the order in which each question is asked and how quickly the survey proceeds. The respondents cannot read ahead but must base their answers on what was said to them earlier in the survey. Latent (opinion) questions are effected more by the survey method used than manifest

(factual) questions (Salant and Dillman, 1994). The questionnaire is another source of measurement error. A question could be too vague or misunderstood and result in a totally different answer than would be given if the question were more clear and concise. Another problem could result from interviewers biasing respondents. Measurement error occurs both when respondents answer questions the way they think the interviewers want, and when interviewers lead respondents. The respondents also might not understand what the interviewers are actually saying and respond differently then they normally would. An even worse problem is that the respondents could lie, whether by pressure to be socially correct or discomfort with the question asked (Salant and Dillman, 1994).

Since our survey was conducted in German, we had to make sure that there was nothing misunderstood or lost through the translation in order to get substantive results. Therefore, we tested our survey with two German people who were proficient in English. We gave one person a copy of the survey to translate. The translated copy was then given to the other person who translated it back into English. When the survey questions returned were acceptably similar to those first-written, we administered the survey. If the translation was inaccurate, we would have had to change the questions and go through the process again until the original questions and the translated questions were the same. Cultural differences may change the meaning of some questions in a survey. Therefore, translating the survey twice allows the survey writer to rewrite any questions that did not make sense in German.

To reduce questionnaire error we had to pre-test all our questions. We created a survey and gave them out to a few of the people in the sample frame. The people in the sample frame filled out the survey. We then collected the survey and asked the people being surveyed whether they understood what was being asked. This was

done to figure out whether the questions created were clear and concise and conveyed the right meaning. The results of our pre-test survey told us that the information gained was enough to meet our project goals. After this process, a new survey was created with all the criticisms in mind. Ideally this is done until we are satisfied with the results accumulated. Unfortunately, we only had enough time to go through this process once.

4.0 Results:

The purpose of this chapter is to present the raw results that we have accumulated through our research. The information in this chapter allows us to triangulate the information we gained through different methods. Through this triangulation, we can analyze and ultimately draw conclusions. We accumulated the data contained in this chapter through interviews, observations, and a survey.

We began our data collection by holding an interview with CBF (Club für Behinderter und ihrer Fruende, club for the handicapped and their friends). Our intent in holding a focus group interview with CBF was to develop an understanding of the handicapped perspective on wheelchair accessible transportation in Darmstadt. The information that was provided during our first meeting with CBF was important in that it also gave our group a good foundation upon which to further our research.

Following our meeting with CBF, we felt it would be useful to gain an industry perspective on handicapped transportation in Darmstadt. In order to develop this perspective, we conducted an interview with Mr. Langbein, the head of technology and infrastructure at HEAG (Hessische Elektrizitäts-AG), the local transportation concessionaire. The information provided by Mr. Langbein allowed us to acquire an understanding as to which technologies have been employed in

Darmstadt as well as develop a perspective on whether or not the employed technologies have been effective.

After our interview with HEAG, we conducted an interview with RMV (Rhein-Main-Verkersverbund). The RMV is the company responsible for transportation on the regional level. The information provided to us through the RMV has allowed us to better understand the degree of regulation placed on transportation in Germany.

Our final interview was conducted with Mr. Rabe of the MVV (Mannheimer Versorgungs und Verkehrgesellshaft). We wanted to compare and contrast the information provided by Mr. Langbein of HEAG with the information provided by Mr. Rabe. Comparing the comments made by these two men was important because the two men share a similar job and knowledge of German technology. The interview also allowed our group to compare the technology employed in Darmstadt with the technology available in Mannheim.

Naturalistic observations allowed our group to develop an understanding of the technology available in Darmstadt as well as recognize the methods people employ when coping with this technology. The site analysis spreadsheet provided our group with the information needed to produce a coverage map, while documentation of incidental experiences provided descriptions of people using the handicapped technology employed in Darmstadt.

The tracking and participant observation data collection methods allowed us to gain insight into the function of the handicapped technology in place. By becoming handicapped for a day, we were able to provide first-hand documentation of the problems experienced by WCB patrons while traveling in Darmstadt. Simply stated, by becoming WCB, we were able to determine what worked and what did not work.

We have provided HEAG passenger volume and usage information for the time period between 1970 and 1997. Doing so allowed us to develop a series of curves depicting passenger trends and overall system capacity. The developed curves were produced to display a possible relationship between trends in technology and trends in system utilization.

4.1 Interview with CBF:

As the name suggests, CBF is an organization of and for handicapped people. The organization provides services such as personal assistants, as well as a place where individuals with various handicaps can meet to discuss the trials and tribulations of everyday life. The office that we went to was a relatively small, single-story building, just outside the center of Darmstadt. The building and grounds seemed well kept, and a young man was cleaning the interior of one of the Club's half dozen small red cars as we arrived. The building's offices were slightly cramped yet spacious enough to allow passage by wheelchair between the desks and other furniture. Whereas each of the various offices seemed to display this duality, the first room we entered was large and almost completely empty of furniture. It was in this room, surrounded by various poster board-visual aids, that we first met Mr. Alfred Konhäuser.

Mr. Konhäuser is a wheelchair-bound man in his early fifties. We were told he is the handicapped peoples' representative to DADINA (Darmstadt-Dieburg Nahverkehrsverbund, Darmstadt-Dieberg area transportation system). Later, he explained that he was more interested in working with CBF where he maintained a computer network as well as oversaw matters of infrastructure. Mr. Konhäuser claimed to understand English but his conversational ability was very limited. The rest of our meeting was conducted half in English and half in German where each

party essentially spoke its primary language with Dr. Gerhard Stärk translating German to English.

In our first meeting with Mr. Konhäuser, he led us into a common area with a small kitchen and two sets of tables pushed together to make two large working areas. We sat down at the closer and larger of the two tables where a young woman who was not handicapped was placing drinks. Once everybody was settled, the meeting began. Chris asked the questions as Stephen, Isaac, and Jim took notes and recorded secondary data. Mr. Konhäuser's demeanor was one of attention and interest as he leaned forward with his arms crossed on the table. In the process of our introduction, Mr. Konhäuser interrupted Chris to explain that DADINA was not his first-rank interest and that the Club was his primary focus.

It should be noted that instead of attempting to provide a direct translation, Dr. Stärk listened to Mr. Konhäuser and then explained what was said in his own words. As was often the case, Mr. Konhäuser answered our questions in five or six sentences, and Dr. Stärk paraphrased the answer in two or three sentences. Therefore, quotes could only be attributed to Dr. Stärk on behalf of Mr. Konhäuser. Furthermore, as our interview was located in a common area, there were a number of people walking about. By the time Chris presented our introduction and settled on a confidentiality agreement, we were joined by two more people: another young, non-disabled woman and a middle-aged man in a wheelchair named Mathias Vogl. Where the intention of this meeting was to conduct a semi-standardized interview with Mr. Konhäuser, the meeting quickly took the form of a focus group where other people gave their input.

One of the first topics discussed was the history of handicapped access in Darmstadt. Apparently, HEAG's first attempt to solve the problem of handicapped access was in 1979. At that time HEAG proposed what Mr. Konhäuser called a "taxi

on demand" system of special buses. This proposal was immediately rejected by CBF and deemed as segregating. According to Mr. Konhäuser, Neoplan, a German bus manufacturer, was the first to develop low-floor buses in 1980. It was not until 1990, ten years after the low-floor bus was made available, that HEAG began employing the technology. In 1986, CBF organized a demonstration at Luisenplatz, the city's central square and a major nexus point for HEAG's bus and tram system. Finally, in 1990, HEAG purchased low-floor buses and implemented the technology along only one of its fixed routes.

At this point, Mr. Konhäuser explained that the major options for bus access. In his estimation, approximately ten years ago, Mercedes-Benz (MB) developed a high-floor bus with a "big lift". At the same time, MB "became a member of the association of public transportation companies" and pushed for the acceptance of high-floor buses equipped with lifts. Shortly after that, he explained, Neoplan developed an intermediate step between the low-floor systems with ramps that we see today and the high-floor systems such as the one developed by MB. In response to MB´s action, Neoplan developed a low-floor bus with a small lift located at the vehicles front door. Mr. Konhäuser pointed out that Bremen employs this type of bus. Everyone present seemed to concur that Bremen's system was the best they had seen or heard about.

The most stressed advantage of driver operated lifts by CBF was that the driver is held responsible for the handicapped patrons' boarding. It was explained that in Darmstadt, the handicapped patron must push and hold a special button while the ramp extends. According to Mr. Vogl, "When the ramp does not work, the bus leaves." The group made it clear that they prefer a driver-controlled access system because the driver is held responsible for their boarding. It was stated that in

Darmstadt, the handicapped patron is not in contact with the driver, and the driver is not engaged by the patron.

Many of the people present expressed frustration with not being heard. Mr. Konhäuser talked about subsidies and discussed how they are not linked to handicapped usage or satisfaction. He added that one of HEAG's complaints is that the subsidies they receive are not sufficient. Furthermore, they (CBF) did not feel that the government was really supporting them. They knew of no law in Germany similar to the ADA (Americans with Disabilities Act – USA) or DDA (Disability Discrimination Act – UK). They mentioned that the German constitution (Grundgesetz) makes it illegal to discriminate against the handicapped (Article 3) but is not grounds upon which to sue HEAG. One of the group members made the point that Dr. Wolfgang Schäuble, head of the Christian Coalition, was shot and is now confined to a wheelchair. Unfortunately, they explained, he has yet to do anything on behalf of WCB people. This was especially bothersome, they explained, because there exists no lobby for handicapped people in Germany. Mr. Konhäuser and Mr. Vogl described their prospects for being heard as bleak. They supported this view by stating that the few individuals that could have taken a stand for handicapped rights had chosen not to do so.

Similarly, Mr. Konhäuser did not seem to be interested in the local system of handicapped representation. In a follow up meeting with Mr. Konhäuser and Mr. Vogl, we asked why Mr. Konhäuser was not interested in DADINA and the Fahrgastbeirat, transportation advisory councils to HEAG. He answered that it was not effective. The Fahrgastbeirat, he explained, consists of approximately thirty people who advise all aspects of the transportation system. As a result, he continued, handicapped issues are often forgotten. When we mentioned some possible technical

changes that HEAG could employ, Mr. Vogl passed our suggestions on to Mr. Konhäuser as being his responsibility. Mr. Konhäuser's response was that he could propose the ideas. Unfortunately, Mr. Konhäuser's tone did not seem to indicate that he would actually bother.

When discussing issues such as technology, the group seemed to have quite a bit to say. First, they talked about how HEAG seems to have a different understanding of what an accessible step height is than WCB people do. Mr. Konhäuser claimed that HEAG expected that an 8 cm (centimeter) step was acceptable, while he thought that a 5 cm step was acceptable and that a 3 cm step would be best. It was further stated that although younger WCB people could overcome higher step heights, it would be quite difficult for an older patron lacking strength and agility to overcome a significant level difference. Members of CBF explained yet another shortcoming with the buses: they claimed that the button used to control the bus' ramp requires a considerable amount of pressure for the complete duration that the ramp is extending. Often, they claimed, patrons are not able to keep pressure on the button for the duration and consequently the ramp retracts. Again they emphasized that this can be a problem for those patrons with weak arms such as older WCB patrons.

Overall the group seemed displeased but came to a consensus that the system was better than many. When asked to rate the tram and bus system between no access and Bremen (their estimated best), they responded by saying that Darmstadt falls right in the middle of the range. They all seemed to agree that the system was not sufficient but that it was much better than some others were.

4.2 Interview with HEAG:

On Tuesday 30 March 1999, Stephen Nash-Weber and Chris Boylan traveled to HEAG headquarters in Darmstadt, Germany to speak with Mr. Langbein, head of technology and infrastructure. The interview was focused on developing an understanding of the handicapped-access technology in place, as well as gaining an industry perspective on the state of handicapped transportation in Darmstadt. Mr. Langbein spoke limited conversational English. For that reason, Christine Lotz was present during the interview to act as a culture broker and provide the necessary translation. The questions posed in this interview focussed on factual information rather than opinions.

We began the interview in Mr. Langbein's office with a brief introduction and what would have been classified as a successful social exchange. After providing Mr. Langbein with our contact information and a description of our project goals, he gave us an unprompted lecture on the history of HEAG. The information was as follows: HEAG's parent company was initiated to provide electrical transmission in Darmstadt, Germany. The parent company ventured into the transportation business in 1868 and introduced Darmstadt's first electric streetcar in 1897. In 1912, the electrical and transportation divisions of the company were placed under the same management. In 1941, the parent company took the name HEAG, at which time the main product was still electrical transmission. In 1990, following continued growth, HEAG made the transportation division of the company a separate entity, placing it under its own management. Mr. Langbein went on to explain that the transportation division of HEAG currently employs 460 people. He said the company operates sixty-three buses and forty-four trams on a network consisting of thirty-seven kilometers of rails and 220 kilometers of bus routes.

Mr. Langbein was prompted to elaborate on the structure of the transportation division of the company. He described the structure of the company as being broken into three divisions. The primary divisions of the company were the operations and technical divisions, which shared resources that were provided by the marketing division. Mr. Langbein indicated he was in charge of the technical division. He described the technical division as being responsible for the technology related to the vehicles and the stations.

Following the discussion of background information on HEAG, Mr. Langbein was asked to discuss some of the handicapped-access technology the company had made available to the public. The information was as follows: the idea of using low-floor bus technology was introduced in Darmstadt in 1990. The low-floor system was described as being a two-component system; the two components being the low-floor vehicle and the raised-platform stop. This technology had been available from the Neoplan bus manufacturing company since 1980. The entry of Mercedes-Benz into the low-floor bus manufacturing field drove prices low enough that HEAG was financially able to introduce the technology in 1990. He indicated that seventy-five percent of the buses the system uses today are of the low-floor variety.

In 1994, three low-floor trailer trams were added to the system. Mr. Langbein said that a low-floor tram at a raised-platform stop had a maximum step height of ten centimeters and a station to platform gap of five centimeters. It was Mr. Langbein's opinion that under these circumstances a WCB patron was able to enter the vehicle without assistance. In 1998, HEAG's fleet consisted of twenty low-floor tram engines with all tram trailers (see Figure 1) being low-floor.

After the discussion on the technologies available, Mr. Langbein was asked to explain the operation of the bus ramps and doors. He was told that on numerous

occasions, members of the project group had attempted to activate the ramp. He indicated that the driver of the bus has the ability to deactivate the ramp in a case where he feels its use is not necessary. Mr. Langbein also explained that when the handicapped button is pressed the bus doors no longer close automatically, and that the driver must reactivate the doors.

Photo courtesy of HEAG

Figure 1: Woman with Stroller Entering a Low-Floor Trailer

Next, Mr. Langbein provided some information on the manufacturers of the buses and trams in use at HEAG. Before providing verbal information, he provided two brochures describing the construction of the trams. He went on to say that there were three companies, Mercedes-Benz, Neoplan, and MAN, in the business of manufacturing low-floor buses. It was stated that the MAN and Mercedes-Benz companies manufactured the buses used in Darmstadt. At this point Mr. Langbein was asked whether or not Mercedes-Benz and MAN companies were responsible for designing the ramps available on their buses. He replied by saying that third party vendors manufactured the ramps as well as the door systems. He then said that Siemens, Alsthom, Altrans, ABB, and Bombardier were several companies in the

business of manufacturing trams in Germany. He did not further elaborate on the manufacture of the Darmstadt trams. After reading the brochures, it was determined that the low-floor trailers were manufactured by Linke-Hofmann-Busch in conjunction with ABB Henschel, while Alsthom manufactured the tram engines.

The final phase of the interview involved discussing HEAG's motivations for providing handicapped transportation. Mr. Langbein first pointed out that low-floor technology and handicapped-accessibility features speed up boarding time and thus increase overall capacity. He also explained that there were considerations as to which bus and tram stops were improved. We were told that HEAG is responsible for the combined bus/tram as well as the tram-only stops and that the city of Darmstadt is responsible for improving the bus-only stops. He also added that areas such as Luisenplatz are historically protected and thus can not be improved with raised platforms. Finally, Mr. Langbein added that handicapped transportation in Germany is highly subsidized by the government. He explained that companies receive government subsidies for making improvements to handicapped access in public transportation. He said the word "improvements" was a poorly defined term. He stated that HEAG receives money from the government for purchasing products built in Germany. He also pointed out that the company is eligible for subsidy money based on what technologies they employ as opposed to the level of handicapped use or satisfaction.

In discussing HEAG's motivations for handicapped accessibility and the financing of such systems, Mr. Langbein explained HEAG's relationship with RMV and DADINA (Darmstadt-Dieburg Nahverkehrsverbund). He said that HEAG is basically a transportation concessionaire. It was explained that HEAG competes for the rights to their transportation routes that are granted by DADINA. He indicated

that DADINA awards these contracts every eight years for bus routes and every twenty-five years for tram routes. Mr. Langbein also explained that RMV is only responsible for setting fares and schedules in the Hessen area and has few significant ties to HEAG.

Following the interview portion of our visit to HEAG, Mr. Langbein offered to take us on a tour of the bus and tram garages. He began his presentation with a tram, where the subject of the presentation was the tram doors. Mr. Langbein explained that there had been a problem with the doors closing prematurely on the handicapped, the elderly, and people with strollers. The root of the problem was the location of the laser controlling the door's automation. The laser was originally placed approximately thirty centimeters above the floor of the vehicle. In order to alleviate the problem, the lasers were relocated to the floor of the vehicle. With the lasers having been moved, people's feet were no longer being pinched in the doors. The pinching brought about another interesting point. It was explained that the doors have a feature that prevents injury. The demonstration highlighted the motor's ability to measure an excess amount of current and consequently reversed the closing action when Mr. Langbein placed his fist between the doors.

After, the tour proceeded to a new garaging facility where we had the opportunity to examine some of the accessibility features available on a bus. Mr. Langbein explained that the operation of the doors on the bus was similar to the operation of the doors on the tram. He indicated that he wanted to demonstrate the leaning and the ramp features on the bus. These were our observations: a switch at the driver's seat controlled the leaning feature of the bus. The degree to which the bus leaned was proportional to the time for which the button was depressed. When questioned, Mr. Langbein confirmed our observations. Next, he demonstrated the

ramp. Stephen pressed the handicapped-accessibility button on the exterior of the bus. Our observation was that the bus sprung from its leaned position back to a level position without the ramp deploying. Stephen made Mr. Langbein aware that the ramp was not deploying and Mr. Langbein proceeded to flip a switch at the driver's console. After the switch was flipped, the ramp deployed from beneath the middle door of the bus. It appeared to be approximately one meter long and came to the height of the bus floor, a height of approximately thirty centimeters. Mr. Langbein explained that the ramps do not always work well. He indicated that the ramps were susceptible to exterior elements such as sand and salt, which often caused them to jam. Lack of use was also cited to justify the unreliable operation of the ramps.

4.3 Interview with RMV:

The RMV (Rhein-Main-Verkersverbund) is a management company that manages regional transportation in Hessen. Isaac Hogate and Jim Shannon went to the town of Hofheim to interview Frau Shrama, an RMV employee in charge of train stations. Gerhard Stärk accompanied us to act as an interpreter. Herr Vollmer, RMV public relations representative, who did most of the talking and gave two presentations, accompanied Frau Shrama. The interview with Herr Vollmer and Frau Shrama must be classified as a focus group interview since more than one person was involved in answering questions. This was slightly different from the semi-standardized interview that we planned.

Mr. Vollmer began by giving us a brief history of the RMV. The RMV was created on July 1st, 1994. Regulation of traffic by the RMV started on May 28th, 1995. Therefore, it was explained that the RMV does not have a lot of experience in the field of handicapped-accessible transportation. The RMV used their young age as a justification for the apparent lack of technology and regulation already in place.

Rather than dwell on what had not been accomplished, Mr. Vollmer seemed to be very interested in showing us their planned progress of new ramp and lift implementation into new and old trains.

Through the use of a slide show, Mr. Vollmer presented the basis for control of the transportation industry in Hessen and how their regulation is based on a three level model. The three levels discussed were the political level, the management level, and the company level. He further explained that the political level was composed of shareholders that are the state of Hessen, counties, and member cities. Local companies such as HEAG and the RMV were explained to be on the management level. Local and regional transportation companies such as Deutsche Bahn (DB) and HEAG were explained to be on the company level.

After having provided the basis for the three-tiered transportation management system, Mr. Vollmer went on to discuss the interaction between the different levels. He stated that the process begins at the political level where all decisions regarding transportation regulation are made. It was explained that once the regulations are created, it is the job of the management level to ensure that the regulations are carried out. The companies were said to be responsible for the implementation of the regulated technology.

Mr. Vollmer explained that the line between the management level and company level is very obscure when related to local transportation. HEAG is considered to be on both the management level and company level since it makes decisions concerning transportation and provides transportation vehicles. Furthermore, he said, HEAG is responsible for implementing some of its own infrastructure improvements.

The three-level model is much clearer with respect to regional transportation. The RMV is on the management level and Deutsche Bahn is on the company level. The RMV is responsible for the financial transactions between the state and the national transportation company, Deutsche Bahn. Through the RMV (regional level), the government subsidizes handicapped access in order to get transportation companies (company level) to implement handicapped technologies.

The next slide presented by Mr. Vollmer introduced the five principles RMV is based on. He described the principles as being the "communal association principle", "decentralized organization principle", "orderer principle", "performance principle", and "separate accounting principle." Through these principles, Mr. Vollmer stated the government's purpose for setting up the RMV.

As it was described, the "communal association" principle is concerned with control of transportation through a communal association. Towns, cities, counties, and the state of Hessen are equal partners in controlling the RMV. Therefore, the RMV is influenced heavily by the government. The RMV's position as a non-profit organization allows the company to operate with social and not financial aims. Mr. Vollmer stated that since handicapped people do not have to pay to use the transportation system, companies do not stand to profit directly from providing handicapped-access technologies.

The second principle explained during the interview was the "decentralized organization" principal. It was stated that the RMV is in charge of regional transportation, while the local municipalities have control of local transportation. As long as the local municipalities maintain adherence to a minimum number of regulations set forth by the RMV, they are allowed to remain in a state of self-government.

The third principle discussed was the "orderer principle." It states that the RMV looks for the best-priced offers of transportation services from companies such as Deutsche Bahn. The RMV rewards transportation companies by increasing their funding or subsidies for having exceeded a minimum set of standards. Conversely, the RMV punishes those companies who are deemed to be providing less than adequate handicapped-access services by reducing the subsidy money they receive.

The fourth principle discussed was the "performance principle." The companies that make profits get to keep profits, and the companies that incur debt must pay for that debt. This was explained as being a big change from earlier times when all profits and debts were redistributed throughout a region to every transportation company.

The last principle discussed was the "Separate Accounting principle." It was explained that this principle is meant to present each individual expense associated with running a transportation company, separately. In doing so, companies are allowed to separate the expense for improved infrastructure from the costs associated with everyday operation. Furthermore, operational costs are broken down into vehicle expenses and operating costs (e.g., maintenance and payroll). It was explained that in performing the breakdown, all of the expenses associated with public transportation could be presented in a transparent manner. In doing so, vehicle expense (e.g., purchasing), and infrastructure improvements (e.g., raised platforms) are paid for by the government.

After the explanation of the final principle, Mr. Vollmer discussed the RMV's system for communicating with handicapped people. To obtain the opinion of handicapped people, Mr. Vollmer stated that the RMV utilizes two advisory boards. Handicapped representatives participate in these boards. Since there are no German

federal laws governing handicapped-accessible transportation, the larger of the RMV's two advisory boards writes regulations intended to fill all voids. The second, smaller advisory board, consisting of only handicapped representatives, was described as being far less formal than its larger counterpart. The smaller board's main duty is recommending different handicapped regulations and access technologies. According to Mr. Vollmer, the RMV's advisory board structure allows the handicapped faction to voice its opinion.

We were also told that there are two different philosophies concerning handicapped access to transportation. One philosophy is to focus on redesigning all the train stations while the other philosophy is to redesign trains to make them handicapped accessible. The RMV believes that both need to be done. However, according to Herr Vollmer, handicapped access on trains should be a greater focus than it currently is. He explained that when trains are equipped with handicapped-accessible technology, conductors are always present to provide assistance to the WCB patron. However, when improvements are focused only on stations, there is not always an employee present to help the WCB patron utilize the technology. Mr. Vollmer also explained that vehicle-based access technology is better than station-based technology because it allows access to the train at every station. Similarly, it was explained that if access technology is station based, WCB patrons are only permitted to board and deboard at improved stations.

Mr. Vollmer concluded the interview by posing the question of whether or not to employ lifts and ramps in handicapped-accessible transportation. He explained that it really depends on the station. If a station has a lot of room, station-based ramps should be implemented. Ramps do not break and are cheaper to implement than lifts.

If a station does not have a lot of room, lifts should be implemented. Lifts are more dangerous and require more maintenance than ramps.

4.4 Interview with MVV:

On April 9th, 1999, three members of our group traveled to Mannheim for a meeting with Mr. Rabe of the MVV, a company with interests similar to those of HEAG. We had an agenda for an interview with Mr. Rabe in the morning, and it was our understanding that in the afternoon he would present the handicapped-access technologies currently in place in Mannheim. As Mr. Rabe's ability to speak conversational English was limited, Gerhard Stärk accompanied our group as a culture broker and interpreter.

Before we began our formal interview we sat down with Mr. Rabe and explained our project. In the process of doing so, we learned more about his function at MVV. Mr. Rabe explained that he had been a transportation planner at MVV for twenty years before his retirement. After his retirement, MVV restructured, allowing Mr. Rabe to return and take on the sole responsibility of handicapped access. He explained to us that before the company restructured he never had sufficient time to accomplish any of his initiatives regarding handicapped access. At present, he has been in charge of improving the handicapped access to Mannheim's public transportation system for two years. Finally, as his hobby, Mr. Rabe stated that he was interested in the history of public transportation in Germany.

We conducted a semi-standardized interview in the morning. Mr. Rabe was asked factual questions about the current handicapped access to Mannheim's public transportation system. Mr. Rabe remained relaxed throughout the interview while providing us with valuable data about the MVV transportation system and the handicapped-access improvements he initiated. Some of the improvements to the

handicapped access that he initiated are the thirty-centimeter raised-platform tram stop and the purchasing of new low-floor trams with ramps. We discovered that MVV owns fifty of the newer low-floor trams, twenty three of the older trams with low-floor sections in the middle car, and sixteen old, high-floor trams. These trams cooperate to transport an average of approximately 60 million people in Mannheim per year. We discovered that the MVV is working to improve handicapped access through infrastructure changes and not vehicle technology changes. Instead of equipping all of the transportation vehicles with lifts, Mr. Rabe and the MVV are redesigning all stops implementing platforms that are level with the floors of the buses and trams. The justification behind this idea is that lifts are too specific in their function and benefit wheelchairs only. By raising the level of the platforms they are benefiting a larger number of people. Raised stops benefit the elderly, mothers with baby buggies, people with crutches and canes, as well people in wheelchairs. We discovered that the main argument used by the transportation companies to gain support for improvements to the public transportation system is "Commuting times are shorter when handicapped access exists." (personal interview (Mr. Rabe, 1999)). This justification was important to our understanding of why transportation companies spend money to improve handicapped access when they cannot profit directly from the handicapped people. Because accessible transportation in Germany is subsidized, handicapped patrons are not forced to pay to use the systems. Furthermore, Mr. Rabe was able to supply us with some valuable information regarding the number of people who use the MVV transportation in a year as well as the number of people in wheelchairs that use the trams and buses regularly. Out of the approximately sixty million people per year who use the public transportation system in Mannheim thirty regular users are in wheelchairs.

As the morning interview was drawing to a close, Mr. Rabe was asked to explain the influence handicapped people have on regulation regarding public transport. Mr. Rabe then explained that in 1992, wheelchair drivers protested the fact that they could not access the public transportation in Mannheim by obstructing tram and bus traffic across the city. This demonstration was a powerful method for the handicapped to communicate to the MVV that the public transportation system needed more handicapped access. He also stated that the handicapped have developed a strong tie with the local green party and it is through this party that they are able to voice their opinions in Mannheim.

Throughout the interview Mr. Rabe impressed us with his extensive knowledge of the history of the public transportation systems in Germany. He explained how mass transit became public in 1648 when a German noble family was given permission to oversee public transportation. He discussed the idea that government subsidies have been supporting the public transportation systems in Germany for about three hundred years. It was obvious at many different points in our interview that Herr Rabe was a historian of transportation systems. Furthermore, through the discussion about the history of public transportation in Germany we learned how many of the cities decided on the types of trams and buses they use for their transportation systems. Mr. Rabe explained to us that before the unification of Germany the cities realized that public transportation needed to be improved. It was explained that the former East Germany had more public transportation than West Germany. Based on this fact, the west thought there would be strong competition for public transportation when Germany unified in 1989. As new trams were needed throughout Germany, tram manufacturing companies designed prototype trams and proposed them to cities. Mannheim, Munich, Frankfurt, and Düsseldorf joined

together to foster this competition. New technologies emerged through the competition and the cities were able to choose which transportation technologies they wanted.

Once the interview was complete, Mr. Rabe took us on a tour of the MVV maintenance garage and the transportation system. First, we visited the MVV maintenance garages where Mr. Rabe displayed the operation of the ramps on MVV low-floor trams. It was determined that the ramps are driver controlled from a panel beside the door beneath which the ramp deploys. Mr. Rabe further explained that the ramps were only for stops that were less than eighteen centimeters in height. We were told the ramps could not function in conjunction with the thirty-centimeter raised platforms. Once we had seen the technologies in place on the tram, we ventured out on the transportation system to see the raised stops. The thirty centimeter raised stops were level with the floor in the low-floor trams and buses. The gap between the newer low-floor trams and the actual stop was about one centimeter, and it was about fifteen centimeters for the older trams. The buses had guide wheels mounted perpendicular to the front wheels that rolled against the curb as the bus pulled into a stop. The wheels regulated the distance between the bus and the platform (See Figure 2). Furthermore, the raised platforms had textured tiles to lead blind patrons along the platforms as well as warn them as to the location of the platform edge. All of the stations we visited in Mannheim, except for one in the pedestrian zone, had raised platforms and appeared they were very accessible to people in wheelchairs. Overall the interview and presentation were extremely effective in educating our group

Figure 2: MVV Guide Wheel

about the MVV, and the handicapped access to their public transportation system. The information learned from this interview allowed our group to make comparisons between the handicapped access available in Mannheim and in Darmstadt.

4.5 Interview with MVV Tram Operator:

While on our trip to MVV in Mannheim we had the opportunity to conduct a short un-standardized interview with a tram operator. We posed simple questions related to WCB patrons and their use of the trams. The operator stated that he saw, at most, one or two WCB patrons on his tram per week. When asked how often the tram's ramp was used, the operator responded by saying he deployed the ramp not more than once or twice per year. He said that WCB patrons generally entered and exited the trams via raised platforms.

4.6 Naturalistic Observations:

4.6.1 Site Analysis Spreadsheet Data:

The following section contains a spreadsheet that evaluates the handicapped accessibility of some of the tram and bus stops in Darmstadt. The criterion used to evaluate the stops was determined by reading "Forschung Stadtverkehr". This book outlines some general guidelines for making tram and bus stops accessible to

handicapped people. The book defines acceptable handicapped access as access that allows people in wheelchairs to board and de-board trams and buses as easily as people without handicaps do. From this definition, as well as information we gained from interviews with handicapped groups, we designed this spreadsheet to evaluate the handicapped accessibility of some bus and tram stops in Darmstadt.

Our original goal for naturalistic observations was to visit and evaluate all of the raised-platform stops. They are referred to in posted bus and tram schedules as NF or Niederflurhaltestellen. Through group discussions, and the fact that the high passenger volume stops did not have raised platforms, we decided to broaden the scope of our site visit observations to include some high passenger volume bus and tram stops. Finally, we evaluated bus stops near CBF where there is a concentration of wheelchair drivers.

Table 1: Naturalistic Spreadsheet Data (Inbound)

Inbound Stops	accessible without crossing traffic	accessible without crossing rails	traffic signals accessible	dropped curb at street crossing	dropped curb at station entrance	street crossings are four meters wide	lips on curbs are less than 3cm	Ramp provided	ramp less than 15 meters	ramp less than 6% grade	Signs indicating handicapped access	Ticket vending accessible	schedules readable	raised platform at stop: 19-20 cm	tactile warning at platform edge (40cm)	
Bus L Stops																
TU-Lichtwiese	X	X	NA		X		X	X	X	X	X		X	X	X	NF
Breslauer platz			NA	X	X	X	X	X	X	X	X		X	X		NF
Klinikum																
Willy-Brandt Platz																
Beckstraße	X	X	X		X	X		X	X	X	X		X	X	X	NF
Tram 9 Stops																
Steinburg/Stadion					X	X	X	X	X	X	X	X	X	X	X	NF
Jahnstraße					X	X	X	X	X	X	X	X	X	X	X	NF
Herdweg		X	NA	X	X	X	X	X	X	X	X	X	X	X	X	NF
Schulstraße			X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Rhein Neckar Straße		X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Mozartturm	X		X		X		X	X	X	X	X	X	X	X	X	NF
Waldfried-Hof	X				X		X	X	X	X	X		X	X	X	NF
Flughafen Straße	X	X	X	X	X	X	X	X	X	X	X	X	X	X		NF
St. Stephan	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Kantstraße	X		X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Wagenhalle/Griesheim	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Bus F Stops																
Alexander Straße	X		NA	X	X	X	X	X	X	X		X	X			
Hauptbahnhof	X	X	NA									X	X			
Berliner Allee	X		X	X		X						X	X			
Luisen Platz	X		NA									X	X			
Schloss	X		NA	X		X	X					X	X			
Bus R Stops																
Windmülhe	X	X	NA										X			
Trams 1,7,8 Stops																
Von-Ketter Straße			X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Bessunger Straße	X	X	X	X	X	X	X	X	X	X	X	X	X	X		NF
Prinz-Emil-Garten			X	X	X	X	X	X	X	X	X	X	X	X		NF
Eschollbrücker Straße			X	X	X	X	X	X	X	X	X	X	X	X	X	NF

Table 2:Naturalistic Spreadsheet Data (Outbound)

Outbound Stops	accessible without crossing traffic	accessible without crossing rails	traffic signals accessible	dropped curb at street crossing	dropped curb at station entrance	street crossings are four meters wide	lips on curbs are less than 3cm	ramp provided	ramp less than 15 meters	ramp less than 6% grade	Signs indicating handicapped access	Ticket vending accessible	schedules readable	raised platform at stop: 19-20 cm	tactile warning at platform edge (40cm)	
Bus L Stops																
TU-Lichtwiese	X	X	NA		X		X	X	X	X	X		X	X	X	NF
Breslauer platz			NA	X	X	X		X	X	X	X	X	X	X		NF
Klinikum				X	X	X	X	X	X	X	X		X	X	X	NF
Willy-Brandt Platz				X	X	X	X					X	X			
Beckstraße	X	X			X	X		X	X	X	X		X	X	X	NF
Tram 9 Stops																
Steinburg/Stadion	X	X	X	X	X	X	X	X	X	X	X	X	X			
Jahnstraße		X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Herdweg	X	X	NA	X	X	X	X	X	X	X	X	X	X	X	X	NF
Schulstraße	X	X		X	X	X	X	X	X	X	X	X	X	X	X	NF
Rhein Neckar Straße		X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Mozartturm	X		X		X		X	X	X	X	X	X	X	X	X	NF
Waldfried-Hof	X				X		X	X	X	X	X		X	X	X	NF
Flughafen Straße	X	X	X	X	X	X	X	X	X	X	X	X	X	X		NF
Kantstraße	X		X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Wagenhalle/Griesheim	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Bus F Stops																
Alexander Straße			NA	X	X	X	X	X	X	X		X	X			
Hauptbahnhof			NA									X	X			
Berliner Allee	X		X	X		X						X	X			
Luisen Platz	X		NA									X	X			
Schloss	X		NA	X	X	X	X	X				X	X			
Tram 1,7,8																
Von-Ketter Strasse			X	X	X	X	X	X	X	X	X	X	X	X	X	NF
Bessunger Strasse	X	X	X	X	X	X	X	X	X	X	X	X	X	X		NF
Prinz-Emil-Garten			X	X	X	X	X	X	X	X	X	X	X	X		NF
Eschollbrücker Straße			X	X	X	X	X	X	X	X	X	X	X	X	X	NF

4.6.2 Incidental Naturalistic Observations:

The observations contained in this section are the incidental observations of project group members over the course of the project. These observations occurred only by chance.

On Tuesday April 20th, 1999, a group member observed Mr. Vogl in the pedestrian zone in Darmstadt. It was a pleasant morning, sunny and fairly warm. When Mr. Vogl was approached, he appeared to be in good spirits. Through a conversation with Mr. Vogl, it was discovered that he had used a public bus to come into Luisenplatz for some shopping. He commented that the low-floor buses with ramps were not that difficult to use and that he intended to return to CBF on another public bus with a ramp. Furthermore, Mr. Vogl commented that this was only his second time using the public bus system, his first was with our project group during the tracking observations.

On Saturday April 3rd, 1999, Stephen had the opportunity to watch two unknown wheelchair drivers get on buses at Luisenplatz. The first was an older man in a power wheelchair who appeared to be alone. As the time for his bus approached, the stop he was waiting at started to back up with buses. Often in this instance, the buses that are farther back will allow passengers on and off without being the first or second in line. As a result, the older man drove his wheelchair down the queue in an attempt to find his bus. Having determined that it had not arrived yet, the man waited between the second and third buses in the line. His bus was apparently the next bus to arrive and it stopped behind the third. As the old man drove by the front door of the bus he signaled to the driver that he wanted to get on and the bus began to kneel and the doors opened. The old man held the blue button on the outside of the bus and the ramp deployed. As soon as it was deployed, the old man rolled his wheelchair about

one meter in front of the ramp and powered strait up the ramp. Unfortunately, his wheelchair nearly flipped backwards when the front wheels hit the black protective flap that sits on the ramp when it deploys. The old man reacted very quickly and grabbed the handrails on the doors. Somehow he managed to free one hand from the rails and proceeded to move his chair the rest of the way in.

The second sighting was also at Luisenplatz where a middle-aged man being pushed by a rather old man attempted to board the bus without the help of the ramp. The older man pushing the wheelchair was not even remotely able to lift the wheelchair into the bus. Three younger men, already on the bus, stepped out to help the pair onto the vehicle.

4.7 Tracking Observations:

On Thursday April 18th, 1999, all four members of the project team traveled to CBF to conduct shadowing observations of two wheelchair drivers boarding the system at various locations. The shadowing participants were Alfred Konhäuser and Mathias Vogl. The intent of our observation was to gain a first hand perspective of the problems faced by WCB patrons when attempting to use the public transportation system in Darmstadt, Germany. We documented our observations by taking video, pictures, and writing notes.

We met Mr. Konhäuser and Mr. Vogl in the large CBF conference room where we had previously conducted an interview. The two gentlemen appeared to be finishing their lunch and were in the middle of having a cup of coffee. After talking for a few minutes, Mr. Konhäuser suggested we begin our work. He wheeled to his office and picked up a small bag with a tape measure attached to it. We then traveled to the Windmühle bus station on the R route located approximately 100 meters from the club.

At the stop, Mr. Konhäuser used a tape measure to measure the height of the curb. The curb height is the measured distance from the road surface to the top of the curb at the station. He determined the curb height at the stop to be ten centimeters. While we waited for the bus to come, we had a quick conversation with our two participants. Stephen first discussed the book he had been reading titled "State of Stuck" with Mr. Konhäuser who seemed very interested in the subject matter. Next, the two gentlemen were asked to discuss the history of their mobility impairments. Mr. Vogl responded by telling us that he had been handicapped since birth. Mr. Konhäuser told us he had been handicapped since 1969, following a bad motorcycle accident. After about fifteen minutes, the bus came, and much to our surprise was not of the low-floor variety. The bus was a typical high-floor Mercedes-Benz model with doors and a handrail that would not have allowed us to carry either of the participants onto the bus. Unable to enter the bus with two wheelchair drivers, we were forced to wait fifteen minutes longer for the next bus. This prompted Jim to check the schedule. It was his observation that the schedule did not indicate which buses were high-floor and which buses were equipped with low floors. Mr. Konhäuser replied to Jim's discovery by saying that HEAG would not change the schedules due to logistical problems such as unpredictable maintenance and repair on the buses. In our discussions with Mr. Vogl, he mentioned that he had never used the transportation system in Darmstadt prior to this day. After fifteen minutes a bus with a low floor finally arrived. At this point, we had been waiting at the bus stop for close to thirty minutes.

As the bus pulled up, Jim hid behind the schedule sign as not to taint the video data we received while taping the bus. He did not want to influence the bus driver's actions by letting the driver know he was being watched. The driver of the bus did a

good job of pulling the middle door of the bus, the handicapped-accessible door, directly up in front of the two WCB patrons. Mr. Vogl pressed one of the buttons on the side of the bus in an attempt to activate the wheelchair ramp. At first, Mr. Vogl pushed the wrong button and appeared to be quite confused. Stephen attempted to tell Mr. Vogl he that was pushing the wrong button but due to the language barrier Mr. Konhäuser was required to make the point. It was our observation that the bus driver seemed well aware of the situation and took the appropriate measures to load the two gentlemen. The bus seemed to lean over farther than we had seen any other bus lean before, reinforcing the observations we made with Mr. Langbein at HEAG. After the leaning operation was complete, and the ramp deployed successfully, Mr. Vogl and Mr. Konhäuser wheeled onto the bus (see Figure 3).

Figure 3: Windmühle Stop

Based on Mr. Konhäuser's recommendation, we proceeded to the Hauptbahnhof (main train station) stop located along the R bus route. The Hauptbahnhof station is not equipped with a raised platform, nor are the curbs dropped. He explained that he wanted to show us the elevator under construction in the train station. Upon arrival to the Hauptbahnhof, Mr. Konhäuser pressed and held the wheelchair access button on the bus. We observed that the ramp on the bus did

not deploy upon the pressing of the button. It was unclear whether the non-deployment was due to malfunction in the system or lack of interest on the driver's part. Nonetheless, Mr. Konhäuser finally had to yell forward to the driver, who then deployed the ramp. As the ramp was deploying, a woman walked in front of it, causing the ramp to detract slightly. Finally, the ramp deployed fully, and both of the participants were able to successfully exit the bus.

Both Mr. Konhäuser and Mr. Vogl appeared to have no problems negotiating the high curbs at the Hauptbahnhof. It was obvious in watching the two gentlemen that they were experienced in negotiating such curbs. We followed the two gentlemen as they wheeled towards the elevator, under construction between tracks one and two, in the station. At the elevator shaft, Mr. Konhäuser explained the current system for providing wheelchair access to the regional trains. He pointed to the far end of tracks one and two, far past the platform, where there appeared to be a small path crossing the tracks. He went on to explain that a WCB train patron could access the tracks under the supervision of a Deutsche Bahn (DB) employee. He then explained that handicapped people had been waiting for the elevator to be constructed in the station for over twenty years.

After having examined the access problems at the Hauptbahnhof, we left the station and travel to Berliner Allee. Berliner Allee is a combined tram and bus stop located approximately 300 meters from the Hauptbahnhof. After we got to Berliner Allee, it was obvious that our participants were fairly fatigued. Our intent had been to travel outbound from Berliner Allee to Mozartturm aboard a tram. Unfortunately, this was not a possibility. Upon arrival to Berliner Allee, it was quite obvious by watching Mr. Konhäuser that a WCB transportation patron would have significant difficulty accessing the outbound stop. Therefore, we decided to head inbound to

Luisenplatz. The station, Berliner Allee, was located in the middle of the road, creating the need for the participants to cross traffic. The outbound side of the station had railings and high curbs preventing either of the participants from accessing the platform. That observation having been made, we proceeded to the inbound platform at Berliner Allee. We observed that the platform was not raised, but that both Mr. Konhäuser and Mr. Vogl were nevertheless able to access the stop with few difficulties.

After both of the participants accessed the station it was our intent to watch them attempt to load themselves on a low-floor tram. As the first tram pulled up, we observed it pass by both participants and then stop. There were no other vehicles in the vicinity requiring access to the station. Both Mr. Konhäuser and Mr. Vogl were forced to wheel themselves approximately thirty meters to the back door of the tram. By the time they had reached the back door of the tram, the door had already closed. Mr. Konhäuser pressed the door button to access the tram. However, it did not open. The tram began to pull away, at which time Mr. Konhäuser began yelling and banging on the doors of the trailer. After several minutes, another low-floor tram arrived, at which time Mr. Konhäuser and Mr. Vogl attempted to board the vehicle. They were unable to board the vehicle without aid. Stephen helped both gentlemen board the vehicle.

As observers, we also wanted to study how the low-floor trams functioned at raised-platform stops. In order to accomplish this, we watched Mr. Konhäuser exit and then once again enter the vehicle at the Rhein-Neckarstraße raised-platform stop. Our observation was that he was able to exit the vehicle with little effort, but had a difficult time re-boarding the vehicle. The floor of the tram vehicle was about nine centimeters above the raised-platform stop. Under these circumstances, the foot rests

on Mr. Konhäuser's wheelchair kept getting caught on the edge of the vehicle. As he attempted to board the vehicle he stated: "see...see...." (see Figure 4). He then lifted the front his wheelchair and entered the tram.

Our next stop on the trip was Luisenplatz. We wanted to test the wheelchair accessibility of the major nexus points to Darmstadt's transportation system. Our intent was to observe Mr. Konhäuser and Mr. Vogl exit the low-floor tram. Our observations were that neither man was able to exit the tram under his own power. Both men needed significant help leaving the tram. Stephen needed to physically help

Figure 4: Footrests Bumping

Mr. Konhäuser and Mr. Vogl out of the tram, which, according to Stephen, required a lot of strength (see Figure 5).

Following our observation of the buses and trams, Mr. Konhäuser invited the group for a cup of coffee in the Luisencentre. The Luisencentre is a mall located in Luisenplatz. Rather than take the elevator to the coffee shop on the second floor of the building, Mr. Konhäuser and Mr. Vogl demonstrated their ability to ride the escalators while seated in wheelchairs. Quite impressed with their ability to deal with everyday situations, we chatted with the two gentlemen for over one hour.

Figure 5: Tram Unloading at Luisenplatz

4.8 Participant Observations:

We conducted participant observations to personally experience what handicapped people encounter when accessing the public transportation system in Darmstadt. In other words, we became WCB for a day. Through these observations, we hoped to gain two important perspectives. First, we wanted to better our understanding of the problems WCB patrons experience when accessing the transportation system in Darmstadt. Furthermore, we hoped to gauge the attitudes of the bus and tram operators as well as general passengers as we utilized the system. While in the wheelchair, we attempted to access buses from regular curb heights and trams from raised platforms. Finally, we accessed a tram and a bus from ground level at Luisenplatz.

Mr. Konhäuser and Mr. Vogl provided us with a wheelchair and accompanied us on our transportation tour of Darmstadt. We departed from the CBF building in wheelchairs, rolling to the Windmühle bus stop on the R bus Line. The first bus to stop was a low-floor bus equipped with a ramp. The bus pulled up to the stop about ten to twenty centimeters away from the curb. As the ramp deployed from beneath the middle door of the bus, the gap was easily spanned. The ramp reacted about five seconds after the button was depressed and was fully deployed in about thirty

seconds. Furthermore, when the button for the ramp was pressed, the bus continued to kneel until it was about five to ten centimeters above the curb. Because the ramp spanned the gap and the bus knelt to decrease the angle of the ramp, the bus was easy to access. The bus was nearly empty of passengers so there was sufficient room in the bus for three wheelchairs. Even though the time required for the stop was more than normal, the bus driver did not appear to be in any hurry.

We then proceeded to the Darmstadt Hauptbahnhof where we exited the bus. The people waiting to board the bus waited patiently while the ramp deployed and all three wheelchairs exited the vehicle. The combination of the normal curb height of approximately ten centimeters and the ramp made exiting the bus easy for both Mr. Könhauser and Mr. Vogl. The Hauptbahnhof stop was particularly difficult to leave because the entire stop was raised approximately ten centimeters above the road with no ramps to street level. Mr. Vogl and Mr. Konhäuser overcame the raised curbs with ease, but Isaac, with no experience in a wheelchair, needed help to get down to street level. Once all the wheelchairs were on the road we proceeded down a paved path to Mozartturm, a raised-platform stop.

The first tram to arrive at Mozarttrum was an older high-floor tram that was equipped with a low-floor trailer. Even with the low-floor, a ten-centimeter step existed between the raised platform and the floor of the vehicle. Once again, the experienced wheelchair drivers had no difficulty boarding the tram, but as an inexperienced wheelchair driver, Isaac needed assistance boarding the vehicle. There was a woman on the tram with a baby carriage who graciously moved her carriage to make room for three wheelchairs. It was Mr. Konhäuser's suggestion that Isaac try to access the tram without external help at the next raised stop. Upon our arrival to Berliner Allee, Isaac entered the tram with some difficulty. Isaac had to lift the front

wheels of the wheelchair up into the tram, and then, using the bars located beside the doors, pull himself completely into the vehicle. Following the boarding, we stayed on the number nine tram and proceeded to Luisenplatz.

There was no curb or raised platform at Luisenplatz. All of the wheelchairs needed help negotiating the thirty-two centimeter difference between the height of the low-floor tram and the ground. Our observations indicated that it was impossible to exit or enter the tram at Luisenplatz in a wheelchair without assistance. Having completed the loop to Luisenplatz, we decided to return to CBF. The first R bus to come to Luisenplatz was a low-floor bus equipped with a ramp. Because of the absence of a curb in Luisenplatz, even when the bus knelt fully and the ramp deployed the ramp was still very steep.

Figure 6: Passenger Aid

The experienced wheelchair drivers were able to get in the bus, but had difficulty doing so. As an untrained wheelchair driver, Jim attempted first to get up the steep ramp by himself, but he was unable to do so (see figure 6). As soon as Jim began to struggle, two ordinary pedestrians assisted him onto the bus. Exiting the bus at the Windmühle stop was once again easy with the kneeling bus, the ramp, and a ten-

centimeter curb height. Every time the ramp was activated on the buses, it worked and was fully deployed within a minute of pressing the button.

4.9 HEAG Ridership Data:

HEAG provided us with the following statistics regarding their transportation system. The information was provided via the marketing division of the company. The following table shows passenger numbers as well as distances traveled by buses and trams for the years 1970 to 1997 (see Table 3).

Year	Streetcars		Buses		Total Passengers°
	Km Traveled°	*Passengers°*	*Km Traveled°*	*Passengers°*	*°in thousands*
1970	3436	19487	2092	7902	27389
1971	3042	19089	2305	9761	28850
1972	3247	19426	2305	9676	29102
1973	3211	21141	2305	10307	31448
1974	3308	22162	2422	10751	32913
1975	3387	22690	3260	10876	33566
1976	3511	22873	2452	10824	33697
1977	3457	23069	2523	10970	34039
1978	3487	23128	2676	10932	34060
1979	3473	24322	2663	11379	35701
1980	3635	24341	2650	11388	35729
1981	3644	24592	2662	11553	36145
1982	3675	23573	2697	11085	34658
1983	3291	19951	2656	13002	32953
1984	3108	19976	2483	10959	30935
1985	3151	19717	2400	10817	30534
1986	3207	18642	2444	10348	28990
1987	3032	17579	2591	10248	27827
1988	2975	17704	2636	10309	28013
1989	3080	17623	2654	10260	27883
Low-Floor Technology Introduced					
1990	3089	17803	3031	10368	28171
1991	3049	18701	3376	10925	29626
1992	2993	19734	3922	11494	31228
1993	3181	20327	4684	11870	32197
1994	3359	18748	4774	12679	31427
1995	3901	17565	4853	11986	29551
1996	4274	17813	4940	12341	30154
1997	4217		4999		29149

HEAG

Table 3: HEAG Distance and Passenger Data

The following chart depicts the passenger trends for the HEAG bus and tram transportation system in Darmstadt, Germany (see Figure 7). Please note that the passenger numbers are in thousands and given by year. Please also note that low-floor vehicles were introduced to the system in 1990 and 1994.

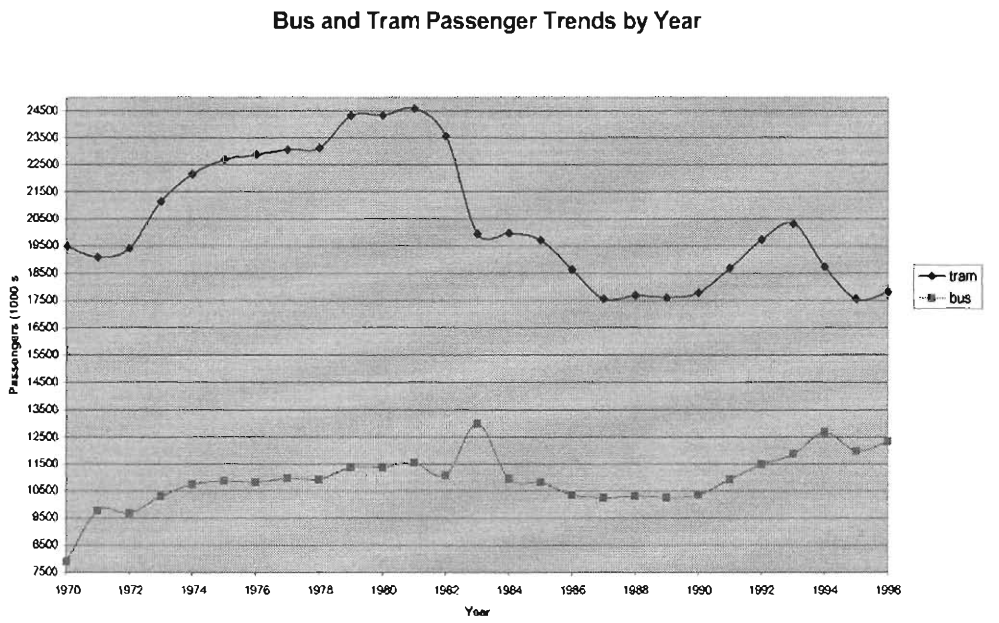


Figure 7: Individual Passenger Trends

The following chart (Figure 8) depicts the distances traveled by HEAG vehicles.

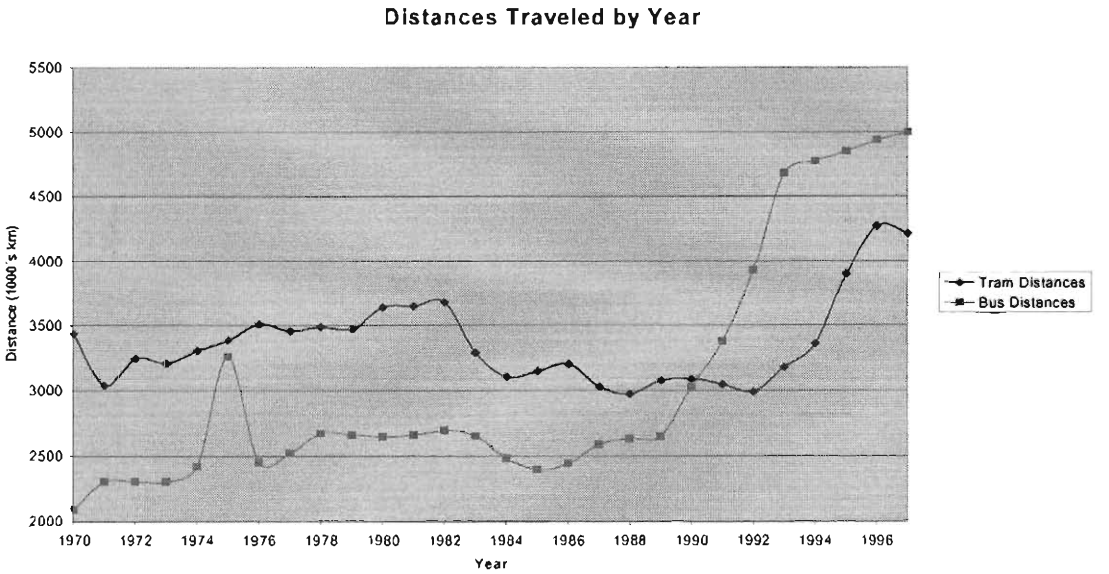


Figure 8: Bus and Tram Distances Traveled by Year

The following table (Table 4) depicts the ratio of kilometers traveled per passenger served by the HEAG streetcars.

Streetcar Ratio			
Year	Ratio (Km/Passenger)	Year	Ratio (Km/Passenger)
1970	0,176322677	1983	0,164954138
1971	0,159358793	1984	0,155586704
1972	0,167147122	1985	0,15981133
1973	0,151884963	1986	0,172030898
1974	0,149264507	1987	0,172478526
1975	0,149272807	1988	0,168041121
1976	0,15349976	1989	0,174771605
1977	0,149854783	1990	0,173510083
1978	0,15076963	1991	0,16303941
1979	0,142792534	1992	0,151667173
1980	0,14933651	1993	0,156491366
1981	0,148178269	1994	0,179165778
1982	0,155898698	1995	0,222089382
		1996	0,239937125

Table 4: Streetcar Passenger Ratio Table

The following chart (Figure 9) is a graphical representation of the data presented in Table 4.

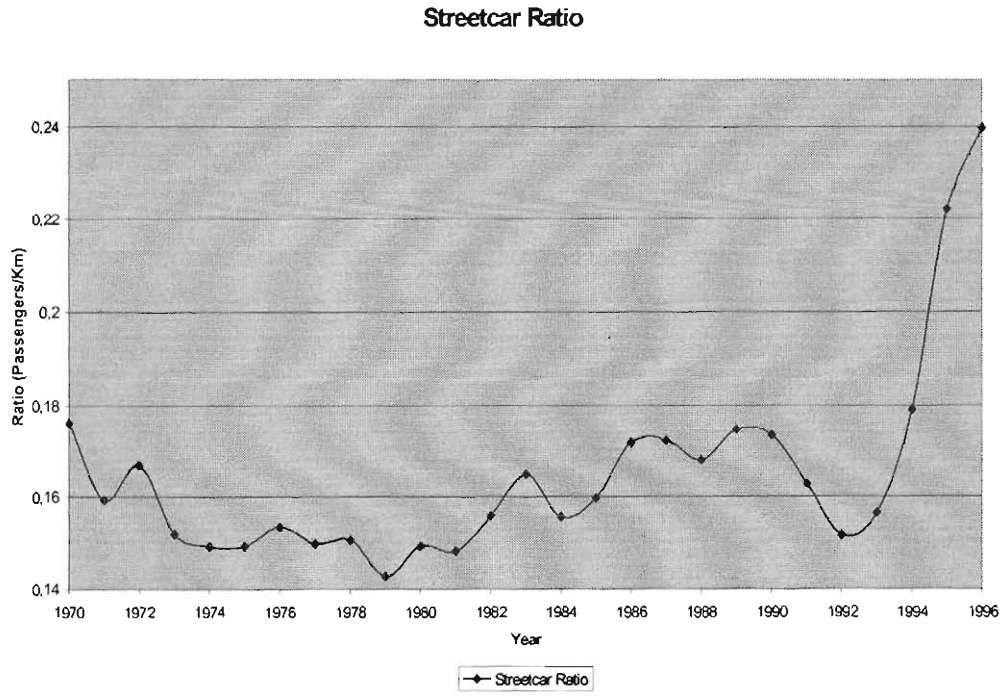


Figure 9: Streetcar Passenger Ratio Chart

The following table (Table 5) depicts the ratio of kilometers traveled per passenger served by the HEAG buses.

Bus Ratio			
Year	Ratio (Km/Passenger)	Year	Ratio (Km/Passenger)
1970	0,264743103	1983	0,204276265
1971	0,236143838	1984	0,226571767
1972	0,238218272	1985	0,221872978
1973	0,223634423	1986	0,236180905
1974	0,225281369	1987	0,25282982
1975	0,299742552	1988	0,255698904
1976	0,226533629	1989	0,258674464
1977	0,229990884	1990	0,292341821
1978	0,24478595	1991	0,309016018
1979	0,234027595	1992	0,341221507
1980	0,232701089	1993	0,394608256
1981	0,230416342	1994	0,376528117
1982	0,243301759	1995	0,404889037
		1996	0,400291711

Table 5: Bus Passenger Ratio Table

The following chart (Figure 10) is a graphical representation of the data presented in Table 5.

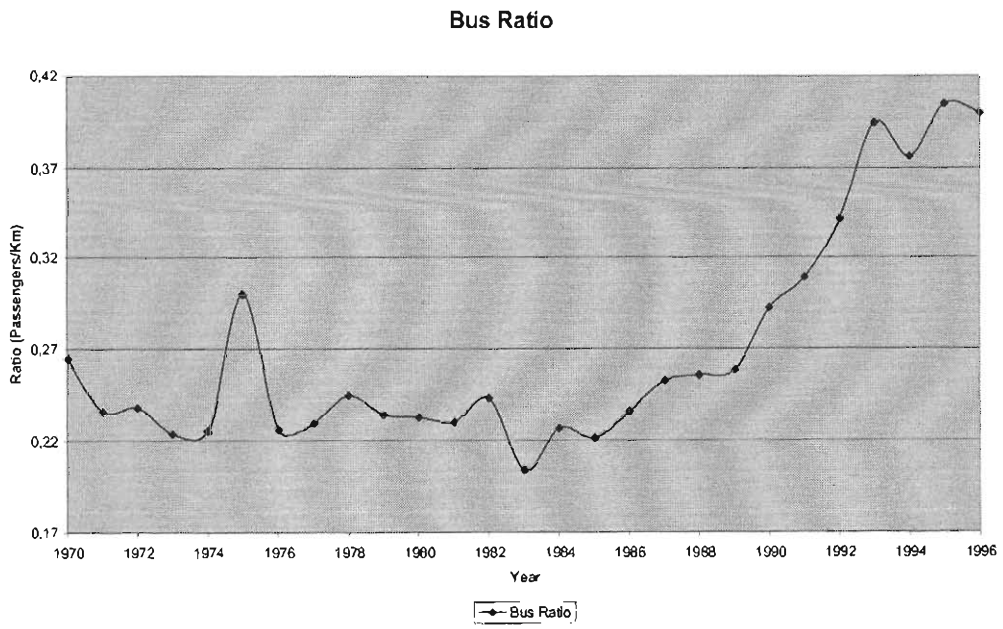


Figure 10: Bus Passenger Ratio Chart

The following chart (Figure 11) represents the overall passenger trends HEAG experienced between 1970 and 1997.

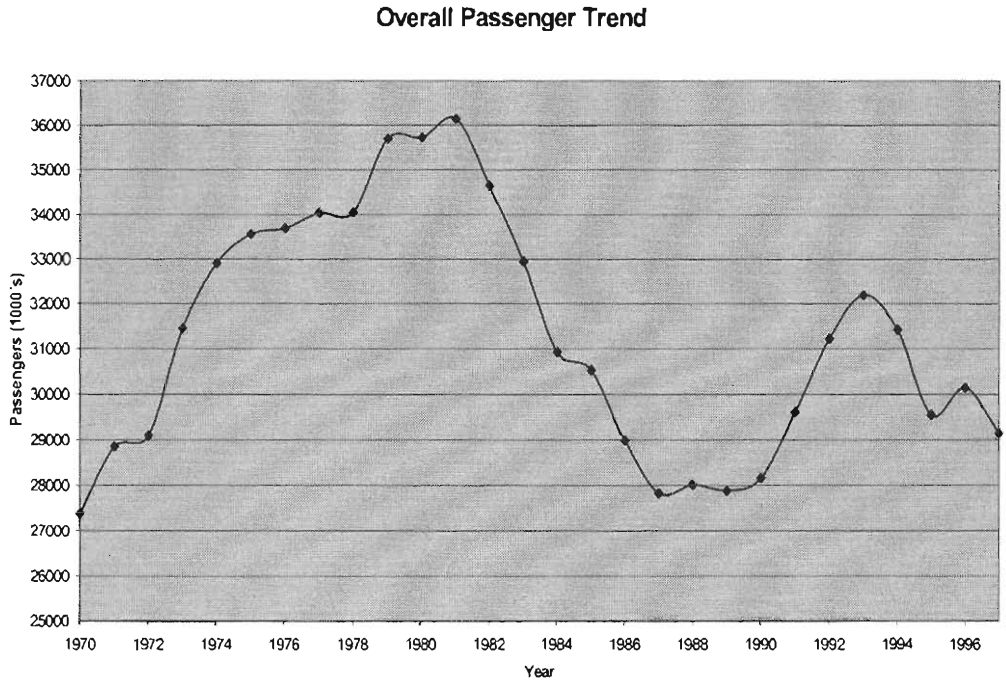


Figure 11: HEAG System-Wide Passenger Trends

Passenger Trends 1970-1997 (Numerical Analysis):

Trams:

All-time High: (1981), 24.592 million persons
All-time Low: (1995), 17.565 million persons

Busses:

All-time High: (1983), 13.002 million persons
All-time Low: (1970), 7.900 million persons

System Overall:

All-time High: (1981), 36.145 million persons
All-time Low: (1987), 27.827 million persons

Passenger Trends - Introduction of Low-Floor Technology (Numerical Analysis):

Trams (1994-1996):

(1994), 18.748 million persons
(1996), 17.813 million persons
-4.98% passenger decrease

Buses (1990-1996):

(1990), 10.368 million persons
(1996), 12.341 million persons
+19.0% passenger increase

System Overall (1990-1996):

(1990), 28.171 million persons
(1996), 29.149 million persons
+3.47% passenger increase

Distance Traveled by System Vehicles – Introduction of Low-Floor Technology:

Trams (1994-1997):

(1994), 3359 million kilometers
(1997), 4217 million kilometers
+25.5% increase in distances traveled

Buses (1990-1997):

(1990), 3031 million kilometers
(1997), 4999 million kilometers
+39.4% increase in distances traveled

4.10 Survey Data:

Our survey was conducted in order to determine the opinions of WCB people concerning handicapped access to the local transportation system in Darmstadt. Unfortunately, we were only able to survey thirteen people. Therefore, we can only say that the opinions represented in this survey were the opinions of only the WCB people who were surveyed. Out of the thirteen people, nine completed the survey. Therefore, our response rate was sixty-nine percent. Unfortunately, we surveyed only two groups out of the whole Darmstadt population. One was the CBF and the other was a wheelchair-bound basketball team.

WCB people were asked how satisfied they were with the handicapped accessibility of the local transportation system in Darmstadt. We divided this question into their satisfaction with trams and buses. Therefore, we were only able to determine what form of transportation was better suited for the WCB patrons

surveyed. From these subgroups, we made further divisions into specific handicapped-access technologies. From this data, we could determine what handicapped-access technologies were the most and least effective. The results of the satisfaction with buses and trams are shown on Figure 12.

The people surveyed were asked about their opinions on different types of stops in Darmstadt. We split this question into two parts; their satisfaction with raised-platform stops and stops without raised platforms (see Figure12). Therefore, we were able to determine how effective raised-platform stops were compared to regular stops, and determine how satisfied the WCB patrons surveyed are with raised platforms.

	Mean	***Median***	***SD***
Overall Bus Access	3.67	3.5	1.21
Kneeling Buses	2.67	2.5	0.82
Low-Floor Buses	2.67	2.5	0.82
Ramps on Buses	2.67	2.5	0.82
Overall Tram Access	3	4	0.71
Low-Floor Trams	3.75	4	0.5
Raised-Platform Stops	3.2	3	1.31
Stops without Raised Platforms	4.6	5	0.89
HEAG's Efforts	3.57	3	0.79

Figure 12 : Satisfaction of WCB People with the Local Transportation System in Darmstadt (1 =Very Satisfied, 5 = Very Unsatisfied)

We also asked WCB people how large a gap they could overcome in order to enter or exit a bus or tram (See Figure 13). We chose five different heights, which

ranged from 5 cm to 32 cm. We made 5 cm as a choice because it was the height suggested by the CBF as acceptable. The distance between the tram floor and a raised platform stop was at most 13 cm. The choice of 18 cm was determined to be the average distance between both 13 cm and 24 cm. The distance between a tram floor and the average curb was around 24 cm. Lastly, 32 cm was the largest gap that we found during our observations, determined to be the distance between the ground at Luisenplatz and a tram floor.

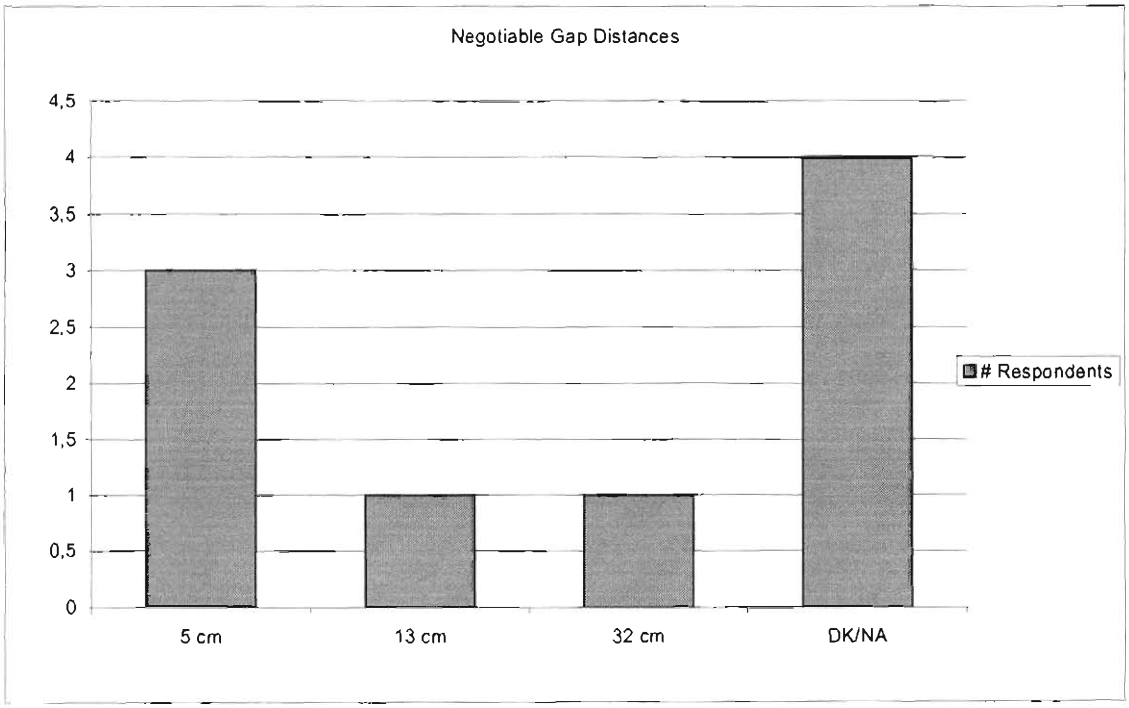


Figure 13: Acceptable Gap Distances

5.0 Analysis of Results:

The purpose of this chapter is to interpret the accumulated data regarding handicapped-accessible transportation in Darmstadt. The intent, in the following chapter, titled Conclusion and Recommendations, is to triangulate all of our interpretations in order to make coherent assertions.

5.1 Analysis of the CBF Interview:

From our interaction with the people at CBF, it seems clear that they are not entirely satisfied with the transportation service HEAG provides. The primary source of dissatisfaction appears to be a lack of proper communication and representation between the handicapped and the transportation system administrators. The second source of dissatisfaction stems from the technical issues that do not seem to meet their wants and needs. Alone, these indications do not stand the test of objectivity, but when reinforced by other information sources appear to be accurate.

From our interview with CBF, we received a strong message: They do not feel that the transportation company (HEAG) hears their views. The demonstration held at Luisenplatz in 1986 is a good example of this. It would seem as though demonstrations rarely occur when the party demonstrating is content and is acknowledged by its intended audience. This refers back to the concept of legitimacy as defined by Hegel. Again, they made it clear that their primary objective and wish was to be heard. Despite this wish, Mr. Konhäuser seems to have lost faith in the local representation system of the Fahrgastbeirat. It appears that either the representation committees presented to the handicapped are simply not open to handicapped patron input and never will be, or that CBF has not made quite enough effort to pressure the Fahrgastbeirat. A second, but equally important observation, is that HEAG may be unwilling to listen to CBF activists. With respect to the

Fahrgastbeirat, such organizations seem to typically have commercial influence. For example, Mr. Konhäuser explained that Mercedes-Benz joined one such organization approximately ten years ago and attempted to influence the use of high-floor big-lift buses. This lack of separation between the voices of the consumer and the service providers seems to indicate an environment where the top-down approach would succeed. Unfortunately, the top-down system does not appear to work if people like Dr. Schäuble are not working towards bettering handicapped access. Nonetheless, CBF seems to have been heard regarding the "taxi on demand" issue. They were able to stop HEAG from building a system that they deemed segregating and unacceptable.

The second issue discussed in the meeting was CBF's esteem of the system in place. Some of the preferences of the people at CBF surprised us. Their preference for having the access system under driver control, instead of patron control conflicted with our concept of a need among WCB patrons for independence. This may be due to the fact that corporate perspectives, as opposed to handicapped perspectives, influenced much of the published material we referenced (e.g., Forschung Stadtverkehr). As our data suggests, corporate perspectives often do not accurately portray the handicapped perspective. However, most of the preferences of the people at CBF could be expected. They prefer lifts to ramps because there is no step or gradient to physically overcome. Based on the consensus of the participants of our focus group interview, it was clear that our participants were far more concerned about boarding the vehicles without incident, and far less concerned with how they went about doing so. Interestingly, the difference in step height specification was remarkable. HEAG uses an 8 centimeter step, CBF believes the standard maximum is 5 centimeters, and they would really feel much better with a 3 centimeter maximum step. The differences in height indicate a significant lack of communication between

HEAG and CBF. Furthermore, since the government gives little input regarding handicapped transportation, it is unclear who is responsible for determining what an acceptable step height is. Based on a consensus during our focus group interview, CBF seemed to think that attempting to overcome an eight-centimeter step requires an excessive amount of effort and strength.

However, before we accept the opinions of CBF as accurate, we must realize that this data comes with a considerable amount of bias and error. The most obvious bias is that CBF is a group of activists. Mr. Konhäuser is the most powerful man in the group followed by Mr. Vogl. It is important to realize that their perspectives cannot automatically be extrapolated to all handicapped people. The second most important bias that occurred in this meeting was peer bias. Because we conducted a focus group interview, many of the feelings common among the members of the group were amplified, whereas individual perspectives that were less common or popular were suppressed (Berg, 1998). Therefore, it is hard to say how Mr. Konhäuser really feels about the situation. It is equally difficult to know what the rest of the group members think of the system solely based on the fact that they may have not wanted to step on Mr. Konhäuser's toes. That said, we can not extrapolate data collected from either Mr. Konhäuser or Mr. Vogl as being the collective view of the CBF organization. Finally, it should once again be noted that Dr. Stärk was interpreting most of what the group members said. He often summarized the information (e.g., he translated six German sentences into two English sentences). Though it is likely that the essential ideas were conveyed, it is not possible to know exactly what was said in German. Furthermore, the recording device used to record the conversation was not functioning properly, so triangulation of the translations by a second translator was not possible.

We believe it is clear that communication between the transit authority and the people of CBF is less than ideal. The same can be said for the technology being implemented by HEAG. The members of CBF seem to be unhappy with the system, yet realize that it is better than having nothing.

5.2 Analysis of the HEAG Interview:

Our analysis of the data collected during the HEAG interview is meant to expose some of the corporate motivations for providing transportation that is accessible to those in wheelchairs. The interview provided us with data relating to the financial and technical aspects of handicapped-accessible transportation as well as exposed several supposed incongruencies between HEAG and its customers.

The theme of money and finance reoccurs throughout the data collected during the interview with Mr. Langbein. One of the main points he emphasized was the fact that a side effect of handicapped-access technology was reduced loading time and increased capacity. Since Mr. Langbein did not explain how handicapped-access technology increases system capacity, we believe the following explanation to be reasonable. The absence of a stairwell in the bus increases the overall floor area. Increased floor area in the bus increases passenger standing room, and thus increases the physical capacity of the bus. Common sense would indicate that regardless of a patron's physical condition, age, or mobility status, they are able to board and de-board a bus faster, if they do not have to overcome a level difference (e.g., stairs or a step). A decrease in boarding time increases the dynamic or moving capacity of the bus. Simply stated, if the bus or tram requires less loading time per stop, the bus can make more stops per hour. In a system where the vehicles have higher physical and dynamic capacities, the overall capacity of the system is increased. That having been said, increased capacity should mean increased revenue for HEAG.

Furthermore, the company receives subsidies for improving and providing handicapped-access technology. According to Mr. Langbein, the difficulty with these subsidies is that the word "improvement" is wide and not clearly defined. One interpretation based on Mr. Langbein´s chuckle when describing the issue is that he does not take the concept of spending government money directed toward aiding handicapped people very seriously. Another interpretation of Mr. Langbein's chuckle may be that the government does not give HEAG enough subsidies to make the local transportation system handicapped accessible. Finally, the entire concept of HEAG being a transportation concessionaire raises some doubt as to their objectives. As a concessionaire, they are forced to bid for the rights to their transportation routes. In doing so they must bid the lowest price while providing acceptable transportation and turning an acceptable profit. An important question to ask HEAG is whether their main concerns are with making money or providing suitable transportation for all types of patrons.

Our data suggests that Mr. Langbein was quite satisfied with the technology in place. It indicates that Mr. Langbein is a firm believer in the idea that a bus with a ramp is wheelchair accessible at Luisenplatz. However, as the interview proceeded, it seemed as though Mr. Langbein began to divulge information supporting some of the faults associated with the system. Our data indicates that the ramp feature on the buses does not always function properly. Furthermore, our data indicates that the passively controlled leaning and ramp systems are usually de-activated.

The third and final theme we detect from our interview is that several important incongruencies exist between HEAG and society. The first incongruency appears to exist between HEAG, RMV and DADINA. Mr. Langbein had very little information to provide regarding either of these two organizations. From the

information provided, we detect another disconnect as emphasized in the shift of responsibility when discussing improvements to stations. Finally, there seems to be a large incongruency regarding the idea of what is considered historically protected. Mr. Langbein explained that the company's inability to improve Luisenplatz was because the area is historically protected (see Figure 14). Our observations indicate that many of the structures in Luisenplatz (e.g., cafe and magazine kiosks)

Photo courtesy of Verkehrsamt Darmstadt

Figure 14: Luisenplatz Transportation Nexus

have little if any historical significance.

In analyzing the data provided by Mr. Langbein, we must pay attention to the biasing factors present. The presence of Mr. Langbein's personal public relations representative may have had an impact on the outcome of his statements. The possibility exists that she prepared him for our interview. She may or may not have provided Mr. Langbein with an indication of what information not to divulge. It was clear during the interview that Mr. Langbein became more sincere when not in the presence of the public relations representative. Furthermore, Mr. Langbein could have been exposing himself to considerable risk by answering our questions. This theory directly relates back to the discussion of cost-benefit analysis. Finally, it should be noted that even though Mr. Langbein is a high ranking HEAG official, his

comments can not be extrapolated to the company's stance or opinion on any one given issue.

5.3 Analysis of the RMV Interview:

Our interview with the RMV provided some important information concerning handicapped access and transportation. The RMV controls regional transportation only and has minimal involvement with handicapped access in buses and trams in Darmstadt. Therefore, not much data collected from the RMV is ancillary with respect to our IQP. What is essential is the RMV's approach to handicapped-access technologies and its methods for deciding which technologies to implement.

The RMV controls regional transportation through subsidies. This type of control may be too dependent on a company's cost-benefit analysis associated with implementing the technology. Simply stated, if a company feels as though they do not need to provide handicapped access, they only suffer the fate of reduced government subsidies. A complete lack of federal regulation and legislation makes it difficult or impossible for interest groups to seek retribution against transport companies for assumed discrimination. American transportation companies avoid providing inadequate handicapped accessibility due to legislation preventing discrimination. The Americans with Disabilities Act provides grounds upon which to file criminal and civil suits. Our analysis of the data suggests the financial-based system of regulation supported by the RMV is inadequate. The RMV can only make suggestions to transportation companies as to what handicapped-access technologies to implement. It is possible that if the government took an active role in the regulation of handicapped-accessible transportation in Germany, that accessibility gaps such as Luisenplatz would cease to exist.

The data concerning the RMV's advisory committee is rather interesting. The data allow us to further develop the concept of representation in handicapped transportation. The data indicate that the RMV has a main advisory board for all decisions regarding transportation technology and a smaller, sub-advisory board responsible for promoting handicapped-access technology. What is not clear is exactly what degree of power the sub-advisory board has. Furthermore, it is not clear how much influence the sub-advisory board has on the main advisory board. The sub-advisory board provides only suggestions and has no real power. Therefore, it is a possibility, as Mr. Konhäuser of CBF suggested, that handicapped issues are often not addressed at RMV.

There were many biases present in our RMV data. As Mr. Vollmer is a public relations officer at the RMV, the first and most obvious flaw in our data is job bias. By definition, his job is to present the company to the public in a positive light. Chances are very small that Mr. Vollmer would present the RMV's regulatory ability (or any other ability for that matter) in an unflattering light. Furthermore, the premeditated fashion in which the interview was given suggests a well-polished approach to information delivery. As the theory of cost benefit analysis suggests, Mr. Vollmer has the ability to reduce the risks associated in providing us with information by filtering out data that might incriminate the RMV. It should be noted that problems with filtering can be expected in many corporate interviews.

5.4 Analysis of the MVV Interview:

From the interview with MVV and their presentation, we determined that the handicapped access to the public transportation in Mannheim is superior to the system existing in Darmstadt. Furthermore, the views of handicapped people in Mannheim are better represented in local government.

In analyzing our data, it was important to develop criteria through which we could determine which city's handicapped access to the transportation system was better. As engineers, our analysis of this data is clearly biased and may not pertain to the actual perception of a WCB patron. Nonetheless, the theories associated with technology in Mannheim and Darmstadt are fundamentally identical in nature. However, from an engineer's perspective, MVV has done a better job implementing the theories than has HEAG. On the one hand, Darmstadt has implemented raised-platform technology that does not completely eliminate level differences between stations and vehicles. On the other hand, through a well-planned design process, MVV has eliminated level changes at their raised stops (see Figure 15). The stops are thirty centimeters high rather than the twenty-centimeter height found in Darmstadt. Furthermore, while our data suggests the technology is not completely effective,

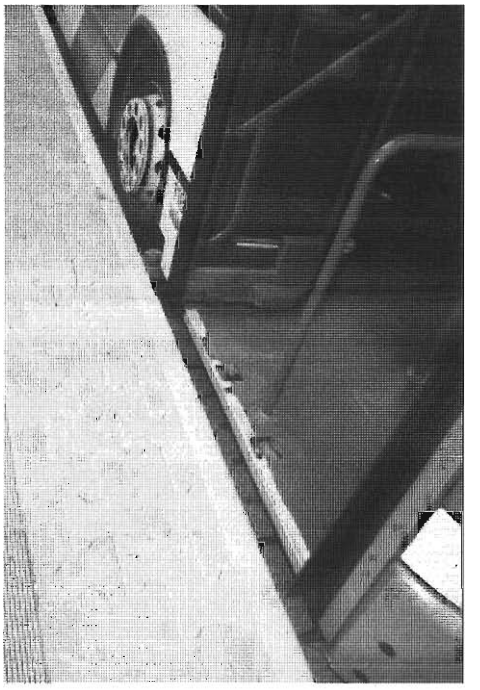


Figure 15: MVV Level Grade Bus Stop

the ramps implemented on the MVV trams have the ability to alleviate some of the problems experienced at stops with no curbs at all. The trams at Luisenplatz in

Darmstadt are completely inaccessible to WCB patrons. Implementing of tram ramps would at least allow for physically fit WCB patrons to enter at Luisenplatz.

Another interesting focus of our analysis of the data was the connection between passenger numbers and handicapped representation. Mannheim is a city with a population nearly twice as large as that found in Darmstadt. Similarly, MVV transports nearly twice as many passengers per year than does HEAG. What is not clear is why MVV transports only thirty WCB patrons on a regular basis while HEAG transports as many as fifty. Mr. Rabe suggested the Mannheim handicapped are well represented, while our analysis suggests that the implementation of technology in Mannheim is far superior to that in Darmstadt. It is unclear as to why there are not more WCB patrons using the transportation system in Mannheim than in Darmstadt. Perhaps, the Mannheim handicapped people are not informed regarding existing technology, or the MVV's passenger estimates are simply not accurate.

Final analysis of the data provided by Mr. Rabe further supports the concept that implementation of technology in Germany is competition driven and not socially driven. The completely de-regulated state of the transportation industry in Germany leads to intense competition between both the developers of technology and the providers of technology. What is clear is that technological competition exists between companies such as Mercedes-Benz ™, MAN ™, and Neoplan ™. What remains unclear is whether the developed technology is technically or socially correct for the WCB population. Regardless, it seems as though companies like MVV and HEAG constantly strive to provide the most advanced technology. In the pursuit to provide the newest and best technology, it is possible that the views of the WCB population are being overlooked.

We identify one bias in our analysis of the data provided by Mr. Rabe. There was a translation bias that was present in all of our interviews. Due to the translations that were provided, the possibility exists that we were not receiving the true meaning of our respondent's answers. We do not view job bias as a problem with the data collected at MVV. Mr. Rabe is in semi-retirement and could fully retire if he wanted to. Therefore, he had little to lose by telling us the truth.

5.5 Analysis of the Tram Operator Interview:

The tram operator informed us about the effectiveness of handicapped-access technologies in Mannheim and about the frequency of technology utilization. He told us that WCB patrons rarely use the trams and that when they do they almost always use the raised platforms instead of ramps. Our conclusion indicated that since the raised platforms are thirty centimeters high, WCB patrons could roll directly into a tram quickly and effortlessly. The ramps are probably not used as much because using the platforms is more efficient.

The tram operator's biases mostly stem from Mr. Rabe being present. Even though the interview was very short and manifest questions were asked, the tram driver was most likely affected by Mr. Rabe's presence. The tram operator could have possibly feared losing his job for divulging information that was unflattering. Although very unlikely, some information provided could be biased or false.

5.6 Analysis of Naturalistic Observations:

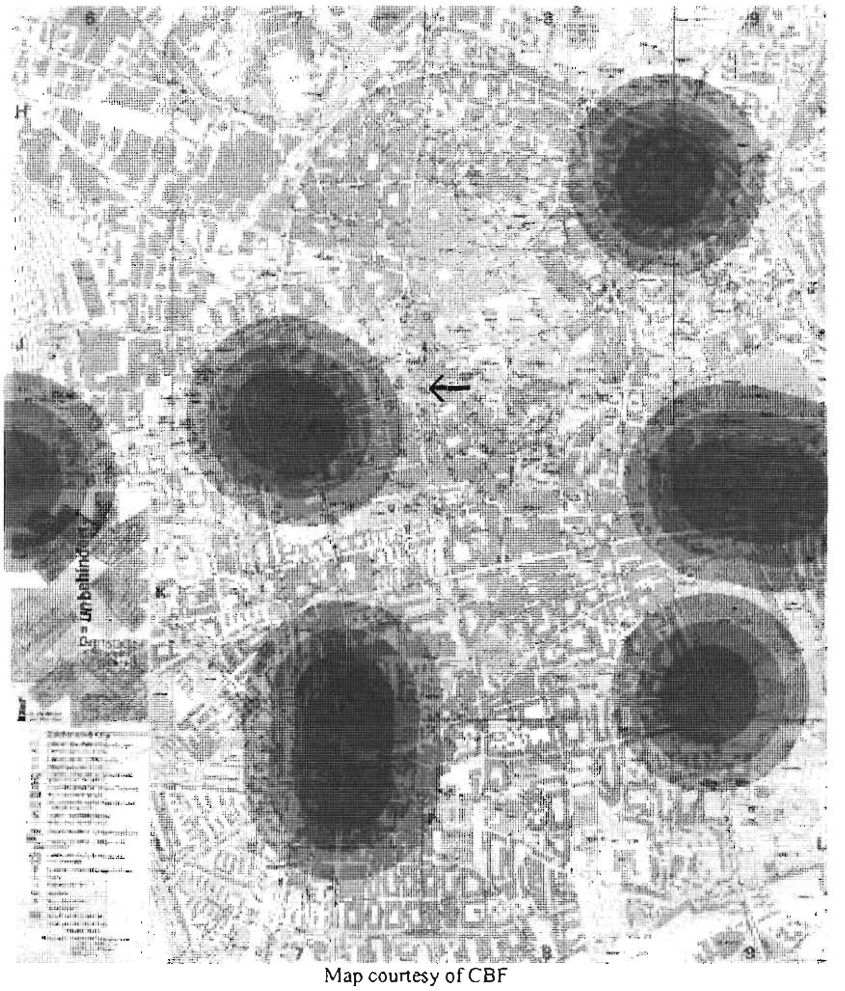
5.6.1 Analysis of Site Analysis Data:

Many interesting aspects of this project are revealed when we begin to analyze our observations of the system in its natural state. Measuring the physical parameters revealed important issues of coverage and selection as well as design questions. Next,

our incidental observations of the system revealed more information about the interaction of technology with handicapped people.

The spreadsheet presented in the previous chapter displays the information gathered from selected stops in the system (see Figure 16). This spreadsheet indicates that the new raised-platform stops meet the minimum requirements set forth by the "Forschung Stadtverkehr" publication. However, it is unclear from examining these stops why the height of the platforms is not level with the low-floor trams. Furthermore, it is unclear why most of the raised-platform stops are located on the number-nine tram route. See Figure 16 for a coverage map showing Luisenplatz with an arrow and the handicapped-accessible stops indicated by shaded areas in the vicinity.

Figure 16: HEAG Coverage Map



Map courtesy of CBF

Similarly, measurements seem to indicate that the improved stops tend to be located away from the center of the city and in especially low traffic areas. Of the six major nexus points in the system (Berliner Allee, Rhein-Neckarstraße, Luisenplatz, Willy-Brandt Platz, Hauptbahnhof and Shloß) only one (Rhein-Neckarstraße) is equipped with a raised platform. Furthermore, Rhein-Neckarstraße stop is the closest raised-platform stop to the center of town, located at approximately a three-block distance.

Likewise, the R bus line that serves CBF has only one raised-platform stop. This stop is not located near CBF. Indeed, this seems to indicate that despite CBF's presence as an advocating force for improved handicapped access, they are not given access to a raised platform near their headquarters. Furthermore, HEAG's own headquarters does not have a raised platform anywhere nearby. Incidentally, the stop nearest HEAG is on the number-nine tram route, the city's most improved tram route.

5.6.2 Analysis of Incidental Observations:

Our incidental observations are especially valuable to our research. Being able to witness the system in use without having to initiate the action reveals much about the way the system is used. This data also reveals the customers' interaction with the system and whether or not they know how to utilize the technology properly. For example, Mr. Vogl claimed he would use the bus system more often after he had participated in our tracking research. Mr. Vogl's willingness to use the bus system after he finally learned how to operate the ramp indicates a lack of communication between HEAG and handicapped passengers. For example, seminars conducted by HEAG aimed at informing and training WCB patrons would be extremely beneficial for handicapped people and HEAG's public image. Unfortunately, improved communication regarding technology would not serve to help the old man in his

powered wheelchair at Luisenplatz. Clearly, a technological change has to be made to properly accommodate such people.

5.7 Analysis of Tracking Observations:

Our analysis of the data collected during our shadowing session with Mr. Konhäuser and Mr. Vogl of CBF is meant to illuminate some of the technical considerations of handicapped-access technology as well as increase our understanding of the problems in the system.

One of the major themes our data seems to emphasize is the idea that the driver has little connection with his passengers. This theory not only applies to WCB patrons, but also applies to walking patrons in Darmstadt. First, it is apparent that the drivers of the buses and trams are unable to see, or simply not interested in, passengers attempting to board the vehicles from the rear doors. This is reinforced by the fact that a tram pulled away from Mr. Konhäuser as he attempted to load the vehicle at the Berliner Allee platform. An experience such as this is frustrating for a walking customer, and surely the dissatisfaction is even greater for a WCB patron. Furthermore, it seems as though the system that is designed to alert the driver when a WCB patron needs to exit a bus is insufficient. Our evidence suggests that the driver of an R route bus was unaware that two handicapped patrons were attempting to leave the bus as we arrived at Darmstadt Hauptbahnhof. It is possible that the system was malfunctioning, nevertheless, the problem remains the same and should be corrected. Both events support the theory that a breakdown of communication exists in Darmstadt.

Our data indicate that the need exists for a review of the handicapped-accessibility features on the buses. It is our understanding that a master switch controls the ramp feature of the bus. The driver of the bus has the ability to de-

activate the feature. In doing so, it seems as though the driver often forgets to reengage the system. Another driver-controlled feature of the buses that needs further evaluation is the leaning feature. Our observations indicate that the buses sometimes lean fully, sometimes lean partially, and sometimes do not lean at all. There is no circumstance under which a full lean of the bus would hinder a passenger's ability to enter or exit the bus. These points support the theory that both drivers and passengers need to be thoroughly educated on the availability and the function of the technology in place.

Our initial contact with Mr. Vogl led us to believe he was thoroughly educated on the public transportation system in Darmstadt. Early during our observation day, he made it clear to us that he had never actually used public transportation in Darmstadt. Upon attempting to board the bus, Mr. Vogl had little idea which of the two buttons on the side of the bus to press. Once aboard the bus, he contradicted some of his negative comments by saying the bus was actually easy to board. This data further supports the theory that the WCB population is not thoroughly educated on the availability of accessible transportation in Darmstadt. By making the handicapped population aware of the services available, the company (HEAG) has the ability to promote a more positive image among a greater number of WCB patrons. It is possible that HEAG does not view the handicapped population's education as important because they do not pay fares and are not considered a source of revenue.

In contrast to some other cities, the engineering and planning that goes into handicapped-access technology seems to be lacking in Darmstadt. From a planner's perspective, it makes sense to place a handicapped-accessible raised-platform stop near a club for handicapped people. Unfortunately, our data suggests that no such technology exists anywhere in the neighborhood of CBF. Our observations of the

raised platforms in Darmstadt indicate that even in the best possible scenario, a WCB patron must negotiate an eight to ten centimeter level change when boarding bus or light-rail vehicles. Based on our visit to Mannheim, such level differences are not impossible to overcome through better engineering. Furthermore, the gap between the vehicles and the platforms tends to fluctuate significantly between stops. Current advances in engineered vehicle technology alleviate this problem.

Finally, we conclude that individuals in wheelchairs are by no means helpless. Our observation of Mr. Konhäuser and Mr. Vogl using the escalator in the Luisencentre supports this theory. Even in the face of adversity, handicapped people find a way to succeed, and sometimes shock people when doing so. HEAG should be providing access to WCB patrons equal to that experienced by walking patrons.

Importantly, Mr. Konhäuser and Mr. Vogl were a great help; nevertheless, it is important to remember that they are activists. It is possible that they exaggerate problems to gain attention. Secondly, videotaping has an effect on the driver of the bus. A driver's actions can be altered when he or she is being watched. If a driver suspects he or she is under surveillance, they are more likely to do their job properly. Finally, due to time restrictions, we were not able to completely randomize the stops we used while observing Mr. Konhäuser and Mr. Vogl.

5.8 Analysis of Participant Observations:

By experiencing handicapped access on buses and trams from the point of view of a wheelchair driver, we gained a first hand understanding of the difficulties faced daily by the handicapped. Also, from participant observation, we are able to prove theories learned from interviews with handicapped groups and tracking observations.

The first lesson learned from the participant observation is that a wheelchair driver requires a great amount of upper body strength and experience to access a bus or tram in Darmstadt. Regardless of the curb height at a bus stop, ascending the short ramp into the bus with a wheelchair is requires strength.

Furthermore, the absence of any raised tram stop makes it impossible to access a low-floor tram in a wheelchair. The new twenty-centimeter raised-platform stops make it possible to access the trams in a wheelchair without external assistance. However, this is not accomplished without executing a difficult balancing maneuver whereby the patron raises the front wheels of the wheelchair the ten centimeters onto the tram floor. Then, using handrails in the tram, the wheelchair driver must pull herself into the tram.

Finally, throughout our participant observations, we noticed the reaction of the general public towards wheelchair drivers. Overall, people seemed extremely helpful and considerate towards WCB patrons. For example, two pedestrians helped Jim up the steep ramp in Luisenplatz. This made it apparent to us that despite the handicapped-access technology in place, the citizens of Darmstadt are willing to help WCB patrons use the public transportation system.

5.9 Analysis of HEAG Data:

Our analysis of the data relating to passenger volume and cumulative system distance is meant to emphasize the possible relationship between trends in technology and trends in system utilization. During our interview with HEAG, Mr. Langbein commented that providing technology such as low-floor buses and raised-platform stops decreases alighting time on vehicles, hence making them more efficient and allowing for higher passenger volumes. This theory was analyzed in depth in the MVV interview analysis.

By looking at Figure 8, it is clear that HEAG experienced some of its lowest passenger volumes in the years from 1987 to 1990. The data shows that HEAG experienced declines in passenger numbers between 1981 and 1990. The underlying reasons for the nine-year decline in passenger volume remain unclear. Following the introduction of the new technology, HEAG posted a 14.3 percent gain in passengers between 1990 and 1993. The curve on Figure 11 between 1990 and 1993 suggests that if HEAG's motivation was to increase passenger numbers, rather than aid the WCB population, then the introduction of low-floor buses was justified. Based on previous performance, the numbers suggest that the introduction of low-floor trams may have possibly produced yet another increase in overall passenger numbers. Yet, the data indicate that between the years of 1993 and 1997, following the complete introduction of low-floor technology, the company experienced a 9.5 percent decline in overall passenger volume. Unfortunately, there exists no solid evidence attributing the decline in passenger volume to the introduction of new technology. For the time period spanning from 1990 to 1997, the company has only experienced a 3.5 percent increase in overall passenger volume.

Furthermore, the data provided to us by HEAG indicate that the company has begun to overextend itself. The data shows that since the introduction of low-floor technology, the trams are traveling 25.5 percent farther while the buses are traveling an average of 39.4 percent farther. They are traveling greater distances for a small passenger increase of only 3.5 percent. Figures 9 and 10 indicate the number of kilometers traveled per passenger transported. This hardly seems financially justifiable. What is not clear is whether the increase in distances traveled is as a result of a larger transportation network or increased service. It is our suggestion that the company has been concentrating more on the quantity rather than the quality of the

service provided. Our theory of HEAG's over extension is supported by the fact that the buses and trams are traveling farther per passenger. By traveling farther per passenger, it is possible that HEAG is spending additional funds on increased service that may have been better spent on improving infrastructure such as raised stops.

Based on Figure 7, it seems as though passenger numbers on buses have been increasing since the inception of low-floor vehicles, whereas the data suggest that passenger use on trams has been declining. There are several possible reasons for the constant increase in passenger numbers on the buses. The reasons may be either that passengers feel buses provide the most convenient form of travel, or that HEAG has increased bus service while decreasing tram service. The latter does not seem likely. Based on passenger trends and accessibility features, there exists the possibility that HEAG may be using trams where buses would be more profitable and convenient. Furthermore, as our participant and shadowing data analysis suggest, buses are far more accessible to those with mobility handicaps than are trams.

There are several biases that play into our analysis of the data provided by HEAG. The company's public relations department provided the information, which by definition is present to connote a positive image to the general public. It is very unlikely that such a department would provide information that may be condemning. Furthermore, the method of data collection at HEAG is unknown. There exists the chance that the passenger numbers provided are based solely on a daily passenger average, possibly rendering the data inaccurate. Finally, as researchers, we are biased by the fact that we assume there to be a handicapped-access problem in Darmstadt.

5.10 Analysis of Survey Data:

We surveyed WCB people from two different organizations, CBF and a WCB basketball club. Since these were the only two groups to be surveyed and we used

purposive sampling to choose those organizations, our coverage error is so great that we must disregard this survey as a true measure of the opinions of WCB people in Darmstadt. We surveyed thirteen people. Of these thirteen people, nine people completely filled out the survey thus giving us a sixty-nine percent response rate. This is a good response rate, but the amount of people surveyed was so small that sampling error destroys any possibility of using the results. Even though our survey data is unusable, we can still discuss the data that we accumulated with the survey as long as we do not state that the results represent every WCB person's opinion.

By finding the mean, median, and standard deviation of the responses, we can generalize the opinions of the WCB people who took the survey. Most of the people surveyed used the buses and trams less than once a month or not at all. However, when asked how often they needed help when they used the system, the mean of the responses to the survey was in between seldom and sometimes. Most of the people surveyed stated that they can only traverse a 5-cm gap between the vehicle floor and the street. This is much smaller than the actual gap between the tram floors and the street, where at best, the gap is ten centimeters. It should be noted that the ten-centimeter gap is only at raised-platform stops, which constitute 16.7% of all stops. The WCB patrons were indifferent to raised-platform stops but were very unsatisfied with stops that did not have raised platforms. Again this is unacceptable since most stops do not have a raised platform. The WCB patrons who were surveyed were slightly unsatisfied with the overall handicapped access to buses. They were slightly satisfied with the tilting buses, low-floor buses, and ramps. Conversely, they were unsatisfied with the overall handicapped access to trams as well as the low-floor trams. This indicates that the people surveyed believed that the buses are much more handicapped accessible than the trams in Darmstadt. According to the WCB people,

HEAG's efforts to make the local transportation system handicapped accessible were neither satisfactory nor unsatisfactory they remained indifferent.

When asked whether they wanted driver-operated ramps or patron-operated ramps on buses, four out of five WCB people preferred driver-operated ramps. Since this was an open-ended question, a few reasons were given as to why they chose this answer. This was a shock to us because we assumed that most WCB people would want to be independent and therefore, would prefer patron-operated ramps. One person stated that driver-operated ramps were better because it held the bus driver responsible. Another person said that it would be safer for the WCB patron if the driver operated the ramp. Another person responded that some WCB people are not capable of operating the ramp, regardless of the physical or mental ability to do so. The only antagonist stated that it allowed WCB patrons to exit the vehicle whenever they wanted to.

The WCB people surveyed were asked what could be done to improve handicapped access to the local transportation system in Darmstadt. Reducing the gap between the vehicle and the street was the biggest complaint stated in the survey. Building higher, as well as more raised-platform stops could do this. Others suggested improved safety measures, better schedules allowing WCB patrons to see what time a low floor bus or tram arrives, lifts on vehicles, better-paved stops, and assistance from people at each stop. These suggestions seem easy enough to implement. If the ramps were driver controlled, the driver could ensure that the WCB person made it safely onto and off of the bus.

6.0 Conclusions, Discussion and Recommendations:

Each of these initial indications builds upon previous conclusions. We triangulate these results into conclusions about the state of communication and technology in the public transportation system in Darmstadt. These conclusions provide the basis for our discussion of the central theme of this project. Furthermore, our conclusions combined with our knowledge of the literature allow us to make sound recommendations for improvements to the system.

6.1 Conclusions:

As was found in our analysis, many of our data collection methods had considerable errors and biases associated with them. Nevertheless, by triangulating the stories of the various people we talked to, as well as our own observations, we are able to counter-act the errors introduced by each individual method. This then yielded reinforced conclusions that helped us in our recommendations.

These conclusions can be divided into two principal categories. First, we will discuss the influences and methods of communication that are affecting this system. Second, the technical aspects will be discussed.

6.1.1 Influences:

The primary problem that seems to be occurring in Darmstadt is a lack of clear and habitual communication between the various effected parties. First, there is an apparent lack of communication between the WCB patrons and the transit authorities that serve them in Darmstadt. Clearly CBF does not feel heard. This was strongly emphasized by everyone we talked to at CBF. However, HEAG and RMV insist that they are listening to WCB patrons through the Fahrgastbeirat and two advisory boards respectively. Nevertheless, Mr. Konhäuser presents a valid argument. If the interests of handicapped patrons have to contend with the demands and requests of the

community as a whole, it is clear that the wishes of the few will be sacrificed in favor of the majority. This is especially true when these interests are competing for a resource that is in short supply. In the Fahrgastbeirat, it would seem that both money and the time of the members are in short supply.

Attention must also be paid to the individual when implementing whatever system is finally chosen. From the observation of Mr. Vogl's newfound interest in the bus system, it is apparent that HEAG may not be educating its WCB customers. WCB customers should not only be informed on how to use the system, but also encouraged to use the system. If the system is acceptable and is well advertised, the final cost of providing transportation to handicapped patrons is reduced for the taxpayer. As Mr. Konhäuser pointed out, WCB people receive direct subsidies for taxi rides, paratransit as well as automotive assistive technologies. As all of these funds are derived from the public purse, each time a WCB person uses the bus instead of a taxi, it represents a significant saving for the taxpayer. For example, a five-minute taxi ride from the train station to our offices costs approximately seven dollars. If a considerable amount of money is being spent to make changes in the accessibility of the system, the small incremental cost of advertising should be invested to help gain a return on that investment.

This apparent lack of communication hints that the subsidies and incentives that are handed down to HEAG are poorly specified. Furthermore, they are being redefined at each link in the chain of command from the European Union down to HEAG. The lack of unified policy indicates a lack of clear and habitual communication between these links. In the presence of clear and habitual communication between groups, their beliefs and behaviors tend to converge. The RMV confirms that each level is responsible for redefining these policies.

Furthermore, the RMV admits to having no real jurisdiction over HEAG despite its responsibility to collect and redistribute HEAG's fare earning capability.

This leads us to the second major problem that seems to be influencing the situation in Darmstadt. It appears that subsidies may not be working.
The final result of this hierarchical subsidy distribution method allows for poorly specified and implemented subsides at the bottom levels of the system (e.g., the HEAG level). The meeting at CBF indicated that subsidies are not linked to either handicapped patron satisfaction or ridership. Likewise, HEAG acknowledges that the requirements set forth by DADINA for technical "improvements" are significantly vague. This may be the result of poor communication, lack of unified vision, and disinterest of the greater community.

However, even if these factors are minimized in impact, the basic concept of subsidies allows that the receiver of the subsidies has a choice in that these recipients are free to make their own cost-benefit analysis to determine if the programs encouraged by the subsidies are worth the resources offered. Furthermore, if a company controls its costs and is pressured to give the lowest bid for a contract, the company's primary focus will be to reduce costs. The meeting with CBF implied that HEAG complained that the subsidies associated with handicapped access are not sufficient. This may be why HEAG has deferred responsibility for bus stop improvements to the town. All of the transit authorities consistently emphasized the cost-benefit analysis of their solutions.

In order to counter-act this emphasis on money and cost-benefit analyses, a unified vision at the federal level must be initiated. This vision must take the form of criminalizing discriminatory actions by public service providers. Despite the lack of German legislation found in our literature search, we can not rely on our indexing

methods alone to show this void. However, RMV conceded that there is no federal control over handicapped access. Furthermore, Mr. Konhäuser pointed out that the German constitution does specifically protect the handicapped from discrimination, and conceded that this fact does not provide enough grounds for legal action against HEAG, indicating a further void in support documentation. These three points triangulated; there exists a void in the German legislation regarding handicapped peoples' rights.

6.1.2 Technologies

Aside from the influences that effect this transit system, further synthesis of our data can be made on the technologies involved. With this data and its subsequent analysis, we are ready to examine the choices between lifts vs. ramps, driver vs. patron control, and buses vs. trams. Further conclusions can be made with respect to the choice of various step heights chosen and how they are addressed. These conclusions allow us to give specific technical recommendations on how to improve the level of service in Darmstadt.

The first choice one must make in determining the final form of handicapped access to any bus and tram system is whether to use lifts or ramps to aid handicapped people while they board the system. It has already been pointed out by both MVV and RMV representatives that either ramps or lifts should be integrated into a program of accessibility enhanced stations. Nonetheless, as Mr. Vollmer pointed out, the priority should be to focus on changing the vehicle before the station. We would further argue that the choice of which type of vehicle based aids to use, should be directly linked to what changes can be made to the stations served by that vehicle. In other words, lifts must be considered if, when all possible station modifications are made, there still exist stations at which ramps will have an excessive pitch. Mr.

Konhäuser made the argument that lifts can work everywhere and require no physical effort on the part of the WCB patron. This is the key to including elderly WCB patrons. Our participant observations reinforce this concept in that we needed assistance to board the buses at Luisenplatz. Our incidental naturalistic observations also indicate that ramps at this slope may even be unsafe in the case of the man with his electric wheelchair. If it were not for his quick reflexes, he would probably have fallen backwards. However, the transportation companies are not focusing on the fundamental accessibility of their vehicles by all disabled people. Rather, they focus on the fact that their ramps are cheaper, faster and more reliable. This brings us back to the cost-benefit analyses discussed in the previous sub-section. As transportation companies attempt to rationalize the cost of handicapped access, they emphasize improved service to all customers. Ramps allow for this to remain true more so than lifts do. Ramps are deployed faster and used more frequently than lifts.

Further evidence of the transportation companies' lack of investment in the specific wishes of their WCB patrons is indicated in the question of whether to employ driver-controlled technologies or hand over control to the WCB patron. The literature suggests that the independence of the person with a disability (PWD) is very important to their concept of self-worth (Scherer, 1996). However, at the moment it would seem that this need is secondary to simply being able to access the vehicle at all. Furthermore, it does seem that there may be another compounding factor involved: the social interactions of German citizens. Our cultural observations indicate that the Darmstadt transit patrons tend to have a withdrawn social postuture. It is obvious that a system of driver responsibility for WCB access helps to insure that the WCB patron will be able to board the vehicle. However, it is also possible that the need for driver control could be eliminated with a 100% accessible solution.

In order to implement such a solution, it is vital that raised-platform stations exist throughout the system. Furthermore, these platforms must be very near to level with the floor of the vehicle being boarded, thus insuring that all WCB patrons be able to board the system unassisted. This concept is as fundamental as the definition of handicapped access provided by the "Forschung Stadtverkehr." So in fact, patron control is not even an issue and should not be considered. In this context, the issue is whether to provide 100% access or to have the driver be responsible for the boarding, safety and comfort of WCB patrons.

However, simply providing a level platform does not ensure 100% accessibility. A level platform must in turn be accessible to WCB patrons from the street. Logically, to omit this defeats the purpose of building a level platform. Furthermore, proper design considerations have to be made to insure that the vehicles are able to safely approach the platform while attempting to eliminate the gap between the vehicle and the platform. MVV has demonstrated what seems to be a good solution to this problem for buses. Trams do not have the problem of safety in approaching the station that buses do. However, it is important that the tracks be built in a fashion that allows for a minimal gap.

Finally, all of the above considerations pivot on the determination of the authority responsible for handicapped access. If the authority considering these options is not fully determined to make its service accessible, then these considerations will be influenced by other factors that do not concern the individual WCB patron.

6.2 Discussion:

The central theme is that we are investigating a system that is fundamentally communitarian in structure and policy. This can be compared to the system in the United States, which is fundamentally individualistic in nature. Such a system is necessary to employ handicapped-accessibility options that are especially useful because handicapped accessibility only affects a small subset of the population. Indeed, all of our research supports this concept.

Communitarian social systems have many strengths. Foremost among these is their ability to serve the greatest possible population with the least available resources. The focus of such systems is decidedly based on the concept of "the greater good." Conversely, the individualistic approach sets the freedoms and needs of the individual within a society as the priority. All of our interviews suggest that there exists a powerful hierarchical power structure that controls public transportation. However, both HEAG and RMV claim that they provide an access point to the system at their level though advisory boards. However, even in these access points, handicapped patrons have their voices go through a sort of filtering process. At HEAG the Fahrgastbeirat hears the views of the handicapped but these have to contend with the concerns of the majority. Similarly, the two advisory boards assembled by RMV have a hierarchy that can filter the views of the handicapped. This places the handicapped population at a disadvantage where those of the non-disabled majority drown out their voices.

However, there appears to be a solution that can achieve positive results within this framework. MVV has achieved such results. The two key elements that lead the Mannheim system to its success were a dedicated individual within the bureaucracy as well as strong alliances between the Green Party and the disabled community. Mr.

Rabe provided an access point for the voice of WCB patrons precisely at the point where it was needed: at the last link of the chain of command. Furthermore, Mr. Rabe was likely one of the most senior employees of MVV as he was officially retired. His seniority allowed him to have a great deal of power in convincing his company to provide wheelchair access that meets the statues provided by the "Forschung Stadtverkehr." The situation in Mannheim is further aided by a strong alliance with a political party that is currently in power. This insures that Mr. Rabe has support at the level of resource allocation.

6.3 Recommendations:

If there is but one wish the WCB community could have granted, it should be to have another Mr. Rabe at HEAG working on the inside for them. However, enforcing that semi-retired management-level engineers, who really want to be there, fill such a position in all transit authorities, is a bureaucratic nightmare. But, the list of things that can be done is extensive. From this extensive list we have found five specific technical changes that range from necessary to simple good sense. Furthermore, we have one very solid proposal for organizational change.

6.3.1 Technical Recommendations:

The first priority that must be addressed is the situation in the center of the city. The curb-free Luisenplatz and Schloß stations, although historically protected, must be improved since they represent the most central and populated stations of the city's system. While the specifications of the ideal level-floor platform have been discussed and this is certainly the best solution to ensure 100% handicapped accessibility, a thirty-centimeter drop in what is essentially a level pedestrian area is probably not an aesthetically pleasant addition. Therefore, we suggest that a mobile lift be employed at Luisenplatz. A small kiosk type building currently exists on the

pedestrian area that is reserved for HEAG drivers who are between shifts. A mobile lift could be stored there and the off-duty drivers could ensure that WCB patrons would be able to use the lift when their bus or tram arrives.

Secondly, all trams should be equipped with ramps so that WCB patrons can access non raised-floor stations as well as raised floor stations. Here, it is possible that a problem may occur. With the current raised-platform level being between nineteen and twenty centimeters above the tracks, and only ten to thirteen centimeters from the floor of the tram, it may not be possible to extend such a ramp on raised platform.

This brings us to the third technical recommendation. Throughout the last three chapters we have suggested that the current raised platforms are inadequate. We believe that all further platform projects should be designed with a maximum step height of two to three centimeters. We further suggest that the current "raised" platforms be razed to build level-floor platforms. Though this may prove an expensive investment, the return is not only beneficial to the taxpayer who may be spending less in taxi and paratransit subsidies, but also to the everyday commuter as she experiences faster service. As Mr. Langbein said, "handicapped access is good for everyone." We deem these three recommendations to be of a high priority with respect to making this system truly handicapped accessible.

It has been indicated to us that driver control and responsibility for handicapped-access technologies is deemed important to the constituents at CBF. Furthermore, and as was illustrated in Figure 1, a guide wheel to ensure the safety of the bus as it attempts to minimize the gap between itself and the platform would be a reassuring addition to the current technologies. Though we do not deem these last

two recommendations to be of high priority, they do seem to be rather simple changes.

6.3.2 Organizational Recommendation

Finally, it has been made clear in this report that there is a distinct lack of communication between the handicapped patrons and their transit authority, HEAG. We feel that the state of handicapped access would be greatly improved if disabled patrons were better included in the design process. The case of the Sheffield Supertram is a perfect example of this concept. The efforts made there to include all citizens into the design process resulted in a very successful system. For example, when the mobile lift that has been recommended above is being considered, we suggest that all handicapped individuals be invited to come and test out the system and voice their opinions. This simple mechanism resolves three very important problems. First, WCB patrons have the chance to explain what they would like. The constituents at CBF have heavily stressed the importance of this point. Second, in the process of giving their input WCB patrons are informed about the technology being made available. This helps counteract situations such as the one discovered with Mr. Vogl, who now enjoys the convenience of the system because he knows how it works. Finally if this process is adopted, the outcome is automatically legitimized simply by the fact that those who are affected had a chance to be heard.

6.4 Recommendations for Future Study:

Our survey had so much error that we can only consider it the opinion of the people who were surveyed. We cannot say that the data from the survey represents the whole WCB population in Darmstadt. We can consider this survey a pretest for future surveys done in this field. Future IQP groups can learn from this survey by not making the same mistakes we did and not having to go through the process of making

a survey from the beginning. Instead, they can build off this survey and make any changes they need to make.

There are many changes a future IQP group can make in order to improve this survey and get tangible results. Using purposive sampling as a method does not result in useable data. Therefore a different method must be used. No matter what other type of sampling a future IQP group does, they must find a list of all the WCB people in Darmstadt and then randomly select people from that list. Doing this reduces coverage error.

We determined through the implementation of our survey that a few questions could be changed and added in order to receive better results. First, if a person does not use the transportation system at all, they should be asked why they do not. Second, the choices to the question concerning how often a WCB person uses the transportation system should be clarified. The choices should range from always to never instead of daily to never. Mr. Vogl answered the question incorrectly, stating that he used it weekly since he used it twice in one week but never used it before.

Another way to counteract the language barrier is through triangulated translations. Contacting a local university or high school English professor to use her class as a translation tool is helpful. We suggest that half a class be assigned to translate a questionnaire into German and the other half translate it back to English. This attempts to solve the triangulation problem at the same time. The professor benefits from being able to give her students exercise translating English. Also, the team can get the best possible product from a single iteration. We have already made the first step towards this possibility. Stephen Nash-Webber has contacted Dr. Deborah Vietor-Engländer of the Technische Universität Darmstadt in the English

Department. She has indicated that she would be willing to try and help "convince the students" to help out.

A few more suggestions to a future IQP group are that other groups could be surveyed in order to get a better idea of what the local transportation system is like in Darmstadt. Bus and tram operators could be interviewed in order to get the operators' perspectives. The general public also could be surveyed to determine their opinion of WCB people using the system. The public might want the government to spend more on handicapped access or they might believe it is a waste of their money. These surveys would be easier to implement because drivers and the general public are easier to contact then WCB people.

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GLOSSARY OF TERMS:

ADA: Americans with Disabilities Act U.S.A

ATBCB: Architectural & Transportation Barriers Compliance Board

CBF: Club Behinderter und ihrer Freunde, Club for the handicapped and their friends.

DDA: Disability Discrimination Act, United Kingdom

ECMT: European Conference of Ministers of Transport

Factor of safety: The safety factor is a multiplier used in mechanical design. For Example, a specification for a minimum load bearing ability of 600 pounds and a safety factor of 3 the product of these two numbers is 1800 pounds. This represents the load above which the ramp can be expected to perform without breaking given experimental data.

FTA: Federal Transit Administration

Paratransit: Bus system that serves handicapped patrons directly from their homes

Grundgesetz: The German Constitution

HEAG: Hessische Elektrizitäts-AG, Local transit authority for Darmstadt and adjacent towns.

IQP: Interactive Qualifying Project: a project WPI students must complete that integrates engineering technology with society.

Latent: (opinion) Latent questions produce opinionated answers that may not be entirely true.

LRV: Light-Rail Vehicle

MAX:	Metropolitan Area Express: light rail system in Portland, Oregon
Manifest:	Factual: Manifest questions are structured questions that produce only facts and do not allow for opinion.
MBTA:	Massachusetts Bay Transportation Authority
MVV:	Mannheimer Versorgungs und Verkehrsgesellschaft, The local public transportation authority in Mannheim
PQP:	Pre-Qualifying Project, the part of the IQP done at WPI during the term before the students completed prior to their arrival in Darmstadt
RMV:	Rhein-Main-Verkehrsverbund, Rhein-Main regional transportation association
WCB:	Wheelchair-Bound

APPENDIX A: Goal Statement

We wish to assess the level of handicapped access to the public transportation system in Darmstadt, as well as the level of satisfaction among handicapped patrons.

APPENDIX B: Satisfaction Survey
(German Version)

Technische Universität Darmstadt

Zentrum für Interdisziplinäre Technikforschung

WPI
Worcester Polytechnic Institute
Interdisciplinary and Global Studies Division

Wir erstellen eine Studie über Technologien, die behinderten Menschen den Zugang zu Bussen und Straßenbahnen in Darmstadt ermöglichen. Wir möchten Sie bitten, diesen Fragebogen auszufüllen, damit wir herausfinden können, wie zufrieden behinderte Menschen mit der Zugänglichkeit von Bussen und Straßenbahnen sind. Lesen Sie bitte alle Fragen gut durch und beantworten sie gewissenhaft!

1. **Wegen welcher Beeinträchtigung sitzen Sie im Rollstuhl? Die am ehesten zutreffende Nummer bitte markieren.**

Ich kann Arme und Beine nicht bewegen	Ich kann die Arme bewegen, Beine aber nicht	Ich bin halbseitig gelähmt	Ich habe Muskelschwäche	Anderes	Weiß nicht Keine Antwort
1	2	3	4	5	6

2. **Wie oft benutzen Sie Busse und Straßenbahnen in Darmstadt? Die am ehesten zutreffende Nummer bitte markieren.**

Täglich	Wöchentlich	Monatlich	Weniger als 1* im Monat	Nie	Weiß nicht Keine Antwort
1	2	3	4	5	6

3. **Wie oft ist dabei Hilfe nötig? Die am ehesten zutreffende Nummer bitte markieren.**

Immer	Oft	Manchmal	Selten	Nie	Weiß nicht Keine Antwort
1	2	3	4	5	6

4. **Wie groß darf der Abstand zwischen Haltestelle und Bus-/Straßenbahnboden für Sie maximal sein? Die am ehesten zutreffende Nummer bitte markieren.**

bis 5 cm	bis 13cm	bis 18 cm	bis 24 cm	bis 32 cm	Weiß nicht Keine Antwort
1	2	3	4	5	6

5. **Jetzt geht es um Busse. Auf einer Skala von 1 bis 5, wobei 1 für sehr zufrieden steht und 5 für sehr unzufrieden, markieren Sie bitte, wie sehr Sie mit dem Zugang behinderter Menschen zu Bussen zufrieden sind.**

	Sehr Zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Unzufrieden	Sehr unzufrieden	Weiß nicht keine Anwort
a. **Allgemeine Zugänglichkeit der Busse in Darmstadt für Behinderte**	1	2	3	4	5	6
b. **Absenkbare Busse**	1	2	3	4	5	6
c. **Niederflurbusse**	1	2	3	4	5	6
d. **Rampen an Bussen**	1	2	3	4	5	6

6. **Jetzt geht es um Straßenbahnen. Auf einer Skala von 1 bis 5, wobei 1 für sehr zufrieden steht und 5 für sehr unzufrieden, markieren Sie bitte, wie sehr Sie mit dem Zugang behinderter Menschen zu Straßenbahnen zufrieden sind.**

	Sehr Zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Unzufrieden	Sehr unzufrieden	Weiß nicht keine Anwort
a. **Allgemeine Zugänglichkeit der Straßenbahn in Darmstadt für Behinderte**	1	2	3	4	5	6
b. **Niederflurstraßenbahn**	1	2	3	4	5	6

7. **Jetzt geht es um angehobene Haltestellen. Auf einer Skala von 1 bis 5, wobei 1 für sehr zufrieden steht und 5 für sehr unzufrieden, markieren Sie bitte, wie sehr Sie mit angehobenen Haltestellen zufrieden sind.**

Sehr Zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Unzufrieden	Sehr unzufrieden	Weiß nicht keine Anwort
1	2	3	4	5	6

8. **Und jetzt geht es um NICHT angehobene Haltestellen. Auf einer Skala von 1 bis 5, wobei 1 für sehr zufrieden steht und 5 für sehr unzufrieden, markieren Sie bitte, wie sehr Sie mit NICHT angehobenen Haltestellen zufrieden sind.**

Sehr Zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Unzufrieden	Sehr unzufrieden	Weiß nicht keine Anwort
1	2	3	4	5	6

9. **HEAG ist in Darmstadt der Betreiber der Straßenbahnen und Busse. Auf einer Skala von 1 bis 5, wobei 1 für sehr zufrieden steht und 5 für sehr unzufrieden, markieren Sie bitte, wie sehr Sie mit den Bemühungen der HEAG zufrieden sind, Busse und Straßenbahnen für Behinderte zugänglich zu machen.**

Sehr Zufrieden	Zufrieden	Weder zufrieden noch unzufrieden	Unzufrieden	Sehr unzufrieden	Weiß nicht keine Anwort
1	2	3	4	5	6

10. **Bevorzugen Sie Rampen, die vom Behinderten bedient werden oder solche, die vom Bus-/Straßenbahnfahrer bedient werden? Warum?**

11. **Jedes System läßt sich verbessern. Was würden Sie zur Verbesserung der Zugänglichkeit von Bussen und Straßenbahnen vorschlagen?**

Vielen Dank für`s Ausfüllen!

(English Version)

Technische Universität Darmstadt

Zentrum für Interdisziplinäre Technikforschung ZIT

WPI
Worcester Polytechnic Institute
Interdisciplinary and Global Studies Division

We are doing research on technologies that assist handicapped people onto buses and trams in Darmstadt. We would like to ask you to fill out this survey so we can determine the level of satisfaction among handicapped people with the access to buses and trams. Please read each question and follow the directions given.

1. **What type of impairment do you have that requires you to use a wheelchair? Circle the number that best describes your impairment.**

I Can't Move Arms Or Legs	I Can Move Arms But Not Legs	I Can Use Only One Side Of Body	I Have General Loss of Strength	Other	Don't Know No Answer
1	2	3	4	5	6

2. **Please circle the number that best describes how often you ride the trams and buses in Darmstadt?**

Daily	Weekly	Monthly	Less Than Monthly	Never	Don't Know No Answer
1	2	3	4	5	6

3. **Please circle the number which best describes how often you need help when riding the trams and buses in Darmstadt?**

Usually	Often	Sometimes	Seldom	Never	Don't Know No Answer
1	2	3	4	5	6

4. **What is the maximum space between the stop and bus/tram floor that you can cross over. Circle the number which best describes the space that you can traverse.**

to 5 cm	to 13cm	to 18 cm	to 24 cm	to 32 cm	Don't Know No Answer
1	2	3	4	5	6

5. **We would now like to ask you about buses. On a scale from 1 to 5 where 1 means very satisfied and 5 means very unsatisfied, please circle the number which best describes your level of satisfaction with handicapped access in buses.**

	Very Satisfied	Satisfied	Neither Satisfied Nor Unsatisfied	Unsatisfied	Very Unsatisfied	Don't Know No Answer
a. **General handicapped accessibility of buses in Darmstadt**	1	2	3	4	5	6
b. **Kneeling buses**	1	2	3	4	5	6
c. **Low-floor buses**	1	2	3	4	5	6
d. **Ramps on buses**	1	2	3	4	5	6

6. **Now we are talking about trams. On a scale from 1 to 5 where 1 means very satisfied and 5 means very unsatisfied, please circle the number which best describes your level of satisfaction with handicapped access in trams.**

	Very Satisfied	Satisfied	Neither Satisfied Nor Unsatisfied	Unsatisfied	Very Unsatisfied	Don't Know No Answer
a. **General handicapped accessibility of trams in Darmstadt**	1	2	3	4	5	6
b. **Low-floor trams**	1	2	3	4	5	6

7. **We would like to ask you about stops that have raised platforms. On a scale from 1 to 5 where 1 means very satisfied and 5 means very unsatisfied, please circle the number which best describes your level of satisfaction with raised platforms.**

Very Satisfied	Satisfied	Neither Satisfied Nor Unsatisfied	Unsatisfied	Very Unsatisfied	Don't Know No Answer
1	2	3	4	5	6

8. **Unlike question #7, we are now talking about stops that do not have raised platforms. On a scale from 1 to 5 where 1 means very satisfied and 5 means very unsatisfied, please rate circle the number which best describes your level of satisfaction with the stops that do not have raised platforms.**

Very Satisfied	Satisfied	Neither Satisfied Nor Unsatisfied	Unsatisfied	Very Unsatisfied	Don't Know No Answer
1	2	3	4	5	6

9. **HEAG is the transportation company that runs the buses and trams in Darmstadt. On a scale from 1 to 5 where 1 means very satisfied and 5 means very unsatisfied, circle the number which best describes how satisfied you are with HEAG's efforts to make buses and trams handicapped accessible.**

Very Satisfied	Satisfied	Neither Satisfied Nor Unsatisfied	Unsatisfied	Very Unsatisfied	Don't Know No Answer
1	2	3	4	5	6

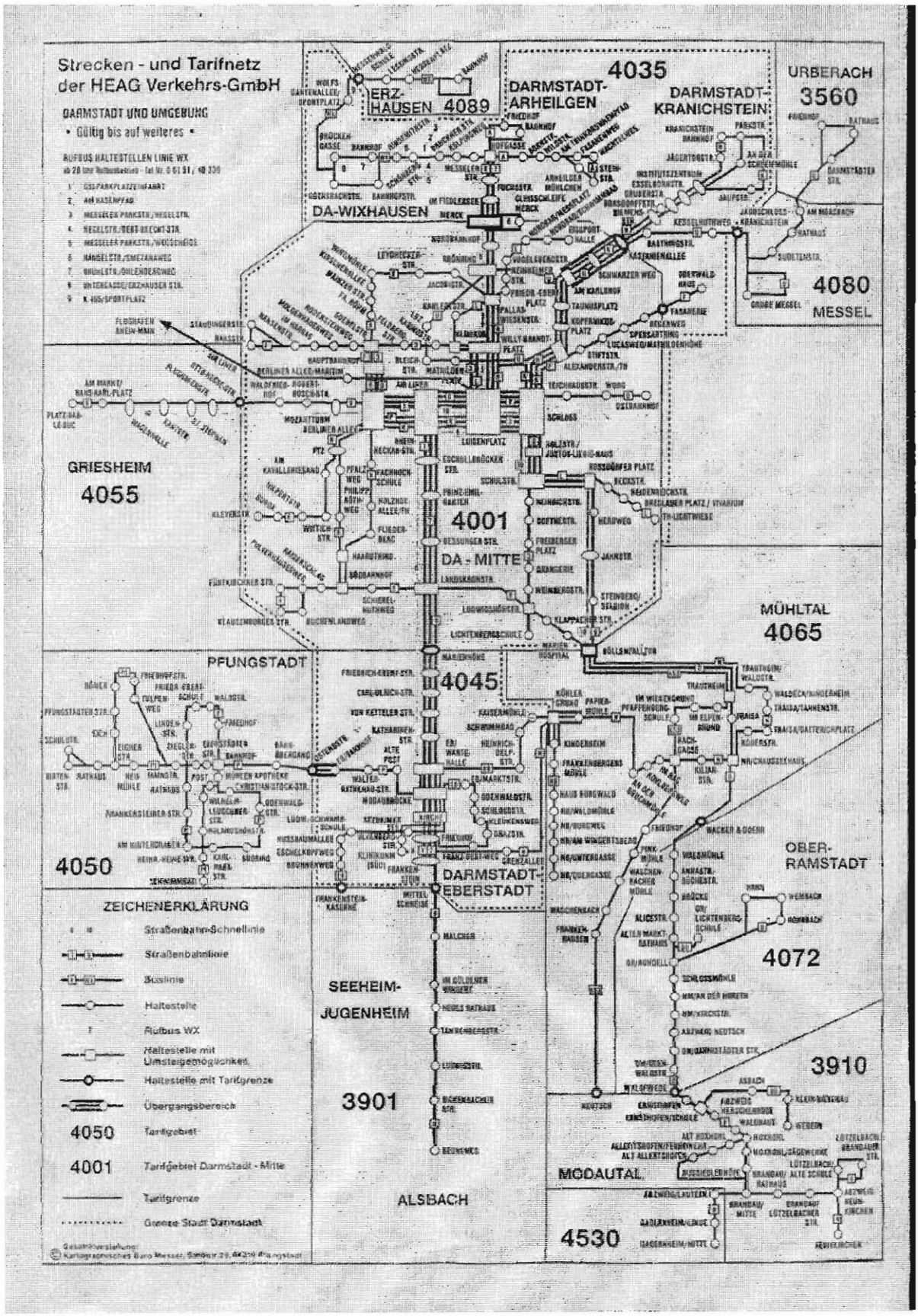
10. **Do you prefer driver operated or handicapped patron operated ramps? Why?**

11. **For any system created, there is always room for improvement. What suggestions can you give on making access to the buses and trams more handicapped accessible?**

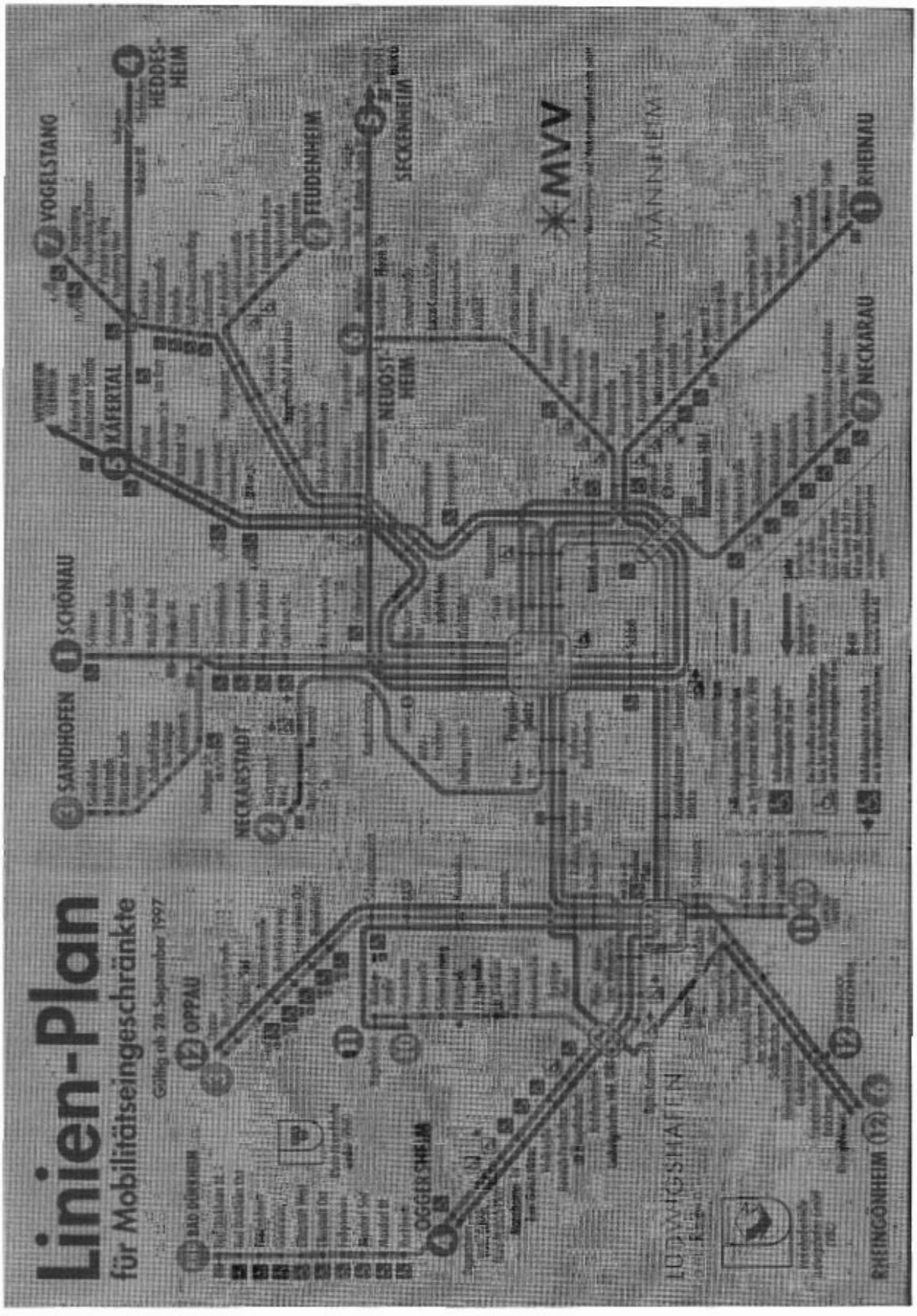
Thank you for completing this survey.

APPENDIX C Transportation Maps:

HEAG:



MVV:


Linien-Plan
für Mobilitätseingeschränkte
Gültig ab 28. September 1997
MVV
MANNHEIM
LUDWIGSHAFEN
SANDHOFEN
SCHÖNAU
VOGELSTANG
HEDDES-HEIM
KÄFERTAL
FEUDENHEIM
SECKENHEIM
NEUOST-HEIM
NECKARSTADT
OPPAU
BAD DÜRKHEIM
OGGERSHEIM
RHEINGÖNHEIM
NECKARAU
RHEINAU

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APPENDIX E: Acknowledgements

The authors would like to thank the following people:

Mr. Langbein from HEAG: Thank you for the information about the handicapped-access technologies in Darmstadt you provided.

Mr. Vollmer and Mrs. Schrama from RMV: Thank you for increasing our understanding of the structure regulating transportation in Germany.

Mr. Rabe from MVV: Thank you for providing us with information about the public transportation system in Mannheim, and for our tour of the MVV system.

Mr. Konhäuser and the CBF: Thank you for the information you provided our project with regarding wheelchair patron's views of handicapped access in Darmstadt. Furthermore, we would like to thank Mr. Konhäuser and Mr. Vogl for participating in our shadowing observations and providing us with a wheelchair for our participant observations.

Bette Koch: Thank you for providing our group access to your office and supplies as well as any help that we required.

Gerhard Stärk: Thank you for the interview contacts you established for our group. We appreciate you providing us with transportation to our interview sites and translating during our interviews. Furthermore, we would like to thank Gerhard for orientating us in German society.

Mathias Richter: Thank you for your help with translation and pleasant conversations.

Wes Jamison: Thank you for helping us with our reports and advising us on different types of methodology to use. Also, we thank you and your family for the dinners at your house and for the hospitality we received while we were there.