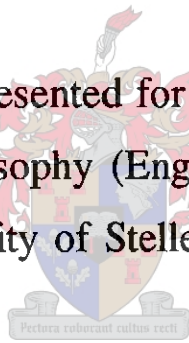


THE ECONOMIC EVALUATION OF BUS AND MINIBUS TAXI TERMINALS AND TRANSFER FACILITIES

by

WESSEL JOHANNES PIENAAR

Dissertation presented for the Degree of
Doctor of Philosophy (Engineering) at the
University of Stellenbosch




Promoter: Prof. C.J. Bester

August 1998

DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature : 
.....

Date : *18 August 1998*
.....

SUMMARY

The dissertation describes the functions of bus and minibus taxi terminals and transfer facilities. Planning, design and evaluation guidelines are proposed. These proposals are aimed at the following aspects:

- the geometric features and functional layout of facilities in order to enhance the effective usage thereof by passengers, as well as the smooth flow of vehicles;
- the location of facilities and traffic control arrangements, which take cognisance of effective traffic flow as well as acceptable walking distance by commuters; and
- an evaluation methodology which addresses allocative efficiency from an economic viewpoint, supplemented by analysis guidelines which consider distributive efficiency from a viewpoint of equitable distribution of welfare.

It is explained how benefits for travellers, the transit operator and the subsidizing authority, and the opportunity costs of supplying the facility can be determined. A model is proposed whereby the non-monetary component of generalised travel costs can be estimated.

The use of economic evaluation techniques for the selection and prioritisation of projects is detailed. This is supplemented by an example of an economic evaluation of a proposed bus/minibus taxi terminal. Subsequently it is examined how the design and effectiveness of a real world passenger transport terminal could be affected by the use of the guidelines proposed in the dissertation.

The dissertation, lastly, deals with welfare distribution and the more equitable community accessibility and mobility which can be brought about by the creation and use of passenger transport terminals and transfer facilities. Also discussed is the accommodation of welfare distribution with an economic evaluation as a means of achieving greater equity or fairness and the ways in which this can be done.

OPSOMMING

Die proefskrif beskryf die funksies van bus- en minibustaxivervoereindpunte en oorstapfasiliteite. Beplannings-, ontwerp- en evalueringsriglyne word voorgestel. Die voorstelle is gerig op die volgende aspekte:

- (1) Die geometriese en funksionele uitleg om die doeltreffende gebruik deur passasiers en vloei van voertuie te bevorder;
- (2) fasiliteitplasing en verkeersbeheermaatreëls wat vlot voertuigbeweging sowel as aanvaarbare stapafstand in ag neem; en
- (3) 'n evalueringsmetodologie wat toewysingsdoeltreffendheid vanuit 'n ekonomiese oogpunt en verdelingsdoeltreffendheid vanuit 'n billike welvaartsverdelingsoogpunt in ag neem.

Dit word verduidelik hoe voordele vir reisigers, die transit-operateur en die subsidiërende owerheid, en die geleentheidskoste van fasiliteitsvoorsiening bepaal kan word. 'n Model word voorgestel waarvolgens die nie-monetêre gedeelte van veralgemeende reiskoste beraam kan word.

Die gebruik van ekonomiese evalueringstegnieke vir die keuse en prioritisering van projekte word verskaf. Dit word aangevul met 'n voorbeeld van 'n ekonomiese evaluering van 'n voorgestelde bus/minibustaxi-eindpunt. Vervolgens word dit ondersoek hoe die ontwerp en doeltreffendheid van 'n werklike passasiersvervoereindpunt deur die gebruik van die voorgestelde riglyne beïnvloed kan word.

Ten slotte word welvaartverdeling en die groter toeganklikheid en beweeglikheid behandel wat binne 'n gemeenskap geskep kan word deur die voorsiening en gebruik van passasiersvervoereindpunte en oorstapfasiliteite. Dit word bespreek hoe 'n ekonomiese evaluering aangepas kan word as 'n maatreeël om billikheid te bevorder.

ACKNOWLEDGEMENT

I wish to express my gratitude to the following persons who made it possible for me to complete this dissertation:

Prof Christo Bester, my promoter, for his guidance and constructive criticism.

Prof Vukan R. Vuchic for his advice on my previous draft document and for many valuable suggestions relating specifically to section 1.2 and Chapters 2, 3 and 5.

Prof David A. Hensher for thought-provoking discussions on the estimation of generalised travel costs and the use of stated preference survey techniques during my two fact-finding visits to Australasia.

Marlene Mostert who typed this dissertation.

Glory be to God through whom all things are possible.

TABLE OF CONTENTS

THE ECONOMIC EVALUATION OF BUS AND MINIBUS TAXI TERMINALS AND TRANSFER FACILITIES

	page
CHAPTER 1: INTRODUCTION	1.1
1.1 Reasons for the study and research method employed	1.1
1.2 Definitions of concepts used in the dissertation	1.6
1.3 Structure of the dissertation	1.10
 CHAPTER 2: FUNCTIONS OF BUS AND MINIBUS TAXI TERMINALS AND TRANSFER FACILITIES	 2.1
2.1 Introduction	2.1
2.2 Planning and design considerations for bus and minibus taxi terminals	2.3
2.3 Planning and design considerations for transfer facilities	2.14
2.4 The placing of stops in relation to bus terminals and transfer facilities	2.24
 CHAPTER 3: DETERMINING ECONOMIC BENEFITS OF BUS AND MINIBUS TAXI TERMINALS AND TRANSFER FACILITIES	 3.1
3.1 Introduction	3.1
3.2 The transit operator(s)	3.2
3.3 Transit passengers	3.3
3.4 The users of streets adjacent to the facility	3.34
3.5 The government institution/facility developer	3.35
3.6 Non-transport economic benefits	3.36
3.7 Determining benefits for use in economic evaluation	3.37
3.8 List of terms	3.40

CHAPTER 4: DETERMINING THE COST COMPONENT OF BUS AND MINIBUS TAXI TERMINALS AND TRANSFER FACILITIES FOR USE IN ECONOMIC EVALUATION	4.1
4.1 Opportunity cost of the investment	4.1
4.2 Assessment of costs	4.3
4.2.1 Sunk costs	4.3
4.2.2 Shadow prices	4.4
4.2.3 Unforeseen expenses and inflation	4.6
4.2.4 Interest during construction period	4.7
4.2.5 Other cost considerations and concepts	4.7
CHAPTER 5: TECHNIQUES OF ECONOMIC PROJECT EVALUATION	5.1
5.1 Introduction	5.1
5.2 Economic evaluation techniques	5.3
5.2.1 Evaluation criteria	5.3
5.2.2 Present worth of costs (PWOC) technique	5.5
5.2.3 Net present value (NPV) technique	5.5
5.2.4 Benefit/cost ratio (B/C) technique	5.6
5.2.5 Internal rate of return (IRR) technique	5.7
5.2.6 Timing of project implementation and the First Year Rate of Return (FYRR)	5.8
5.3 Example of an economic evaluation of a proposed passenger transport terminal	5.9
5.4 Case study: economic evaluation of a proposed bus passenger transport terminal in Wynberg, Cape Town	5.17
CHAPTER 6: CONSIDERATION OF WELFARE DISTRIBUTION IN PROJECT EVALUATION AND SELECTION	6.1
6.1 Introduction	6.1
6.2 A fundamental point of departure in project evaluation with respect to welfare distribution	6.2

6.3	The accommodation of equity in economic evaluations	6.4
6.4	The use of weights in project evaluation to bring about equitable welfare distribution	6.6
6.5	Conclusions	6.10
6.6	Example of a prioritisation of transport projects based on welfare distribution considerations	6.11
6.7	List of terms	6.13

CHAPTER 7: CONCLUSIONS	7.1
-------------------------------	-----

REFERENCES	8.1
-------------------	-----

FIGURES

2.1	Parallel island layouts for twelve bus loading berths	2.6
2.2	Influence of layout on cost of parallel bus platform scheme	2.7
2.3	Wide oval island layout for buses	2.8
2.4	Narrow oval island layout for buses	2.8
2.5	Narrow island with shallow sawtooth berths for buses	2.9
2.6	Elements of minibus taxi facilities	2.10
2.7	Parallel and oval island minibus taxi terminal layouts	2.11
2.8	An example of a minibus taxi terminal layout	2.13
2.9	Illustration of walkway levels of service	2.17
2.10	Width of walkways, pedestrian flows and level of service	2.18
2.11	Levels of service for queuing areas.	2.20
2.12	Diagrammatic representation of the relation between density of bus stops and total travel time for the door-to-door trip.	2.28
3.1	Relationship between trip generalised cost and place utility	3.6
3.2	Potential users' benefits over a specific period in respect of a new or improved facility	3.39
5.1	Location of Wynberg Bus Terminal	5.17
6.1	Estimating the Gini coefficient	6.14

TABLES

2.1	Factors in identifying transport needs	2.2
3.1	Details of responses obtained during a survey at Mowbray Bus Terminus in 1998 aimed at estimating the disutility that male bus passengers attach to travel time while standing, relative to travel time while seated	3.19
3.2	Details of responses obtained during a survey at Mowbray Bus Terminus in 1998 aimed at estimating the disutility that female bus passengers attach to travel time while standing, relative to travel time while seated	3.20
3.3	Details of responses obtained during a survey at Bellville Bus Station in 1998 aimed at estimating the disutility that male bus passengers attach to travel time while standing, relative to travel time while seated	3.21
3.4	Details of responses obtained during a survey at Bellville Bus Station in 1998 aimed at estimating the disutility that female bus passengers attach to travel time while standing, relative to travel time while seated	3.22
3.5	Distribution of home-end walking times	3.23
3.6	Comparison of walking times from home to bus, train and minibus taxi	3.24
3.7	Distribution of work-end walking times	3.24
3.8	Comparison of walking times to work from bus, train and minibus taxi	3.25
3.9	Relationship between satisfaction and home-end walking times	3.26
3.10	Relationship between satisfaction and work-end walking times	3.26
3.11	Summary of responses obtained during a survey in 1996 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Mowbray Bus Terminus, Cape Town	3.29
3.12	Summary of responses obtained during a follow-up survey in 1998 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Mowbray Bus Terminus, Cape Town	3.30
3.13	Summary of responses obtained during a survey in 1998 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Bellville Bus Station	3.31
6.1	International comparison of Gini coefficients.	6.3

CHAPTER 1**INTRODUCTION****1.1 REASONS FOR THE STUDY AND RESEARCH METHOD EMPLOYED**

Passenger transport terminals (such as bus and minibus taxi terminals) and transfer facilities are critical components of transit systems as they represent the points of contact of these systems with the operating environment and the different modes of passenger transport such as walking, private transport and the various transit services. Well-designed terminals and transfer facilities which function effectively not only have a great influence on passenger convenience, comfort and safety, but also influence transit system capacity, operating speed and service reliability. Terminals and transfer facilities are also in interaction with the surrounding activities and the environment. To ensure the effective operation of the transport system as well as the efficient use of bus and minibus taxi terminals and transfer facilities, investment in and operation of the latter must be carefully planned, designed and evaluated.

The planning and design of transport infrastructure, including bus and minibus taxi terminals and transfer facilities, usually involve the creation and evaluation of alternatives. Although it is possible to build a successful facility without considering more than one possibility, it is always good practice to evaluate a full range of alternatives.

Investment in terminal and transfer facilities usually involves large amounts of money. These investments must therefore be very carefully evaluated. In order to ensure that the most viable project in terms of transport economics is selected, the assessment of alternatives must be undertaken on the basis of their effectiveness and efficiency. An effort must be made to attain the highest level of effectiveness (satisfying specified standards/travellers' requirements) in the most efficient way (with minimum input/ scarce resources).

1.2

Since bus and minibus taxi terminals and transfer facilities are able to increase the accessibility and mobility of transit-captive travellers (i.e. those who do not have the ability to pay for travel by means of other modes of transport), they should also be evaluated in the light of income distribution. In a paper delivered at an International Road Federation Conference and Exposition the author (Pienaar, 1994:A29) stated that with respect to accessibility and mobility there can be little doubt that any new urban transport policy in South Africa will aim at redressing the imbalances of the past. It was contented that an urban transport policy should strive towards three ultimate goals. It should:

- (1) Enhance the quality of urban life through adequate (but not wasteful), effective and safe transport.
- (2) Support and promote other urban functions and policies. (Transport is a means to an end and not an end in itself. It is a function of other human activities. Therefore it has a derived demand. It may be argued that transport is a prerequisite to create wealth.)
- (3) Contribute towards a desired mixture of equity (through a redistribution of accessibility and mobility opportunities) and efficiency (e.g reasonable costs, no unnecessary duplication of services and appropriate technology).

Kane (1998:114) argues that the existing assessment tools in place in South Africa are no longer appropriate for the prevailing political climate. In particular:

- insufficient attention is paid in assessments to public transport and non-car schemes;
- in many cases assessment procedures do not allow for the evaluation of packages of schemes (which may include, for example, information provision, or development of secure areas for public transport passengers);
- the procedures often do not allow for the comparison of private transport and public transport schemes; and
- there is no linkage between the new policy objectives in place, and the outcomes of the assessments.

1.3

The question is, how should new assessment procedures be developed in South Africa to answer these concerns? According to Kane a quantitative approach in evaluation offers many advantages. Quantification usually introduces rigorous, detailed and systematic work which is often necessary. Furthermore, an appropriately developed economic evaluation can be a very useful tool to support decision-making.

The economic evaluation of urban transport infrastructure projects, such as terminals and transfer facilities, is something practitioners often experience difficulties with. Economic evaluation requires judgement. Terminals and transfer facilities are among the most complicated of transport system components, composed of many of different design elements. An effective design must carefully balance these elements to achieve the best facility at a given cost. Hence, evaluation is not a single step but a process that starts with the design of alternatives and ends with a decision incorporating the opinions of experts, potential users, transit operators and the community at large.

The author was approached by the National Department of Transport (NDOT) early in 1993 to develop guidelines for use in the cost-benefit analysis of road passenger transport terminals and transfer facilities. The NDOT identified the need that such facilities (specifically those used by bus and minibus taxi commuters) should be evaluated from both an economic and a social viewpoint.

In its description of the research problem the NDOT stated that in its opinion practitioners in South Africa had difficulty to cope with the economic evaluation of the above-mentioned facilities. This was exacerbated by the non-availability of suitable cost-benefit guidelines in this regard. The specific research questions, or needs, which needed to be addressed, were:

- to distil from available cost-benefit analysis texts and manuals a set of systematic guidelines for the economic evaluation of the above-mentioned facilities;
- to propose assessment techniques to bridge any methodological gaps which might occur in existing literature, without detracting from economic theory;
- where necessary, to propose techniques to quantify intangibles and non-market items; and
- to propose measures which could be used in the selection of the type of projects in question from a social viewpoint in order to enhance an equitable distribution of welfare.

1.4

The project report which resulted from the research was submitted to the NDOT during 1995. After being made available for comments, as well as being subjected to formal peer-review by the NDOT, it was approved as a final research report at the end of October 1995. Since then it is being disseminated under reference and title: RR93/960; "The objectives and benefit-cost analysis of road passenger transport terminals and transfer facilities".

During the period that the report was available for comments, the Municipality of Cape Town as the Core City of the Cape Town Metropolitan Transport Area (CTMTA), requested the author to prepare three sections for inclusion in the (then forthcoming) second edition of the CTMTA Guidelines for conducting the economic evaluation of urban transport projects. The author's brief was to use the research report submitted to the NDOT as a base, and to incorporate the latest background information emanating from his ongoing research on the subject matter during this preparation.

The following three sections were prepared:

- *Basic principles and background information with respect to the economic evaluation of urban transport projects;*
- *Economic evaluation of passenger transport terminals and transfer facilities; and*
- *Consideration of income distribution in project evaluation.*

The CTMTA guideline document (Hromic, 1995) was released for dissemination early in 1996.

The following quotation, taken from page vi of the CTMTA guideline document, provides an indication of the author's contribution to engineering practice (underlinings inserted by the author):

.... In the meantime, the Technical Liaison Committee of the Cape Town Metropolitan Transport Advisory Board (MTAB) resolved to approve the Document and send it to all the local authorities and consulting engineers in the Cape Town Metropolitan Transport Area to use when preparing project economic evaluations.

This Second Edition of the document, containing a major restructuring and substantial additions to sections dealing with public transport, non-motorised transport and income distribution in project evaluation....

The whole approach in principle, and the formulation of the social evaluation procedures in particular, were accepted and approved by the Moving Ahead Steering Committee on 1995-12-06 following the positive comments in writing by members of the Moving Ahead Consultative Advisory Group and its own members.

The purpose of this dissertation is to present an economic evaluation and supplementary social evaluation methodology whereby the transport economic value, in terms of both efficiency and equity considerations, of terminals and transfer facilities used by road transit modes and passengers may be established. This is a new development as it has not been applied before. In these evaluation methods a model is presented to assist in determining the non-monetary portion of generalised travel costs with different transit modes which move through terminals and transfer facilities. This model is presented as an advance within engineering practice as the concept of generalised travel cost, which is based on disutility, has in the past only been used to model mode choice, destination choice, residential location choice, trip generation, and other travel-related choices. In addition, a method is proposed to evaluate and prioritise transportation projects from a social viewpoint to assist in the equitable distribution of welfare.

South Africa is undergoing fundamental political change and socio-economic restructuring. It is hoped that the proposed evaluation methodology will support investment decision-making objectives within the context of overall urban transport policy.

It is the author's contention that the evaluation methodology is internationally applicable. The default values proposed in the text apply in South Africa. However, procedures to assist in the calibration and validation of input values in other countries are proposed in the text.

The research methods employed in this study entailed: (1) an international literature survey, (2) an investigation into the operational aspects of public transport facilities locally and overseas, (3) interviewing transit commuters during trips to obtain their stated preferences with respect to walking, waiting, standing and transfer times during travel, and (4) the presentation of peer-reviewed papers on the subject matter of this study at international conferences, supplemented by technical panel and/or floor discussions during which the author's insights were refined (Pienaar, 1994, 1996, 1997).

The above-mentioned literature survey focussed on:

- the general principles of economic evaluation;
- procedures to evaluate public transport infrastructure projects;
- social evaluation in general; and
- the value of travel time savings.

(Only those sources from which information was used are referenced in the text.)

For the purpose of this study the author investigated operations at passenger terminals and transfer facilities in the following South African cities: Bellville, Cape Town, Johannesburg and Pretoria. The author also went on fact-finding tours to investigate the operational characteristics of public transport operations and terminal facilities in 16 cities in South America, North America, Europe, Asia and Australasia. (Transit terminals and transfer facilities in Rio de Janeiro, Buenos Aires, Los Angeles, San Diego, London, Grenoble, Paris, Essen, Rasstadt, Istanbul, Hong Kong, Tokyo, Shanghai, Beijing, Sydney and Auckland were visited.)

1.2 DEFINITIONS OF CONCEPTS USED IN THE DISSERTATION

The basic concepts and terms used in this study are defined here.

Economic evaluation: The conceptual procedure to determine the viability of investment projects by considering all benefits and costs regardless of to whom they accrue within a country. A benefit is regarded as any gain in utility emanating from the operation and use of a facility, and a cost is any loss of utility associated with the implementation of a project, where utility is measured in terms of opportunity costs. (The term "economic evaluation" is used interchangeably with benefit-cost analysis and does not include financial evaluation.)

The official definitions pertaining to urban public transport and approved by the National Transport Commission (NTC) are those in the National Institute for Transport and Road Research (NITRR) Report TPRR 2, "Definitions of Urban Transport Planning Terms" (Baxa, Ferreira, Rathbone, Royce & Van Zyl, 1979).

Definitions from the abovementioned document are quoted below, in certain cases together with the relevant definitions from the International Transit Handbook's Dictionary of Public Transit. This dictionary was endorsed by the Union Internationale des Transports Publics (UITP) and the Verband öffentlicher Verkehrsbetriebe (VöV) (N.D. Lea Transportation Research Corporation, 1981).

The definitions relating to minibus taxi transport were taken from "Guidelines for the design of combi taxi facilities". These definitions were published by the Department of Transport*, with the approval of the Committee of Urban Transport Authorities (Rontiris, 1990). (Subsequent to the publication of the latter document the Committee of Urban Transport Authorities resolved to give preference to the term "minibus" rather than the term "combi".)

a) Terminal

i) the NITRR definition is:

Terminal: A special area, including buildings, structures and equipment at the end of a transport facility, for the storage, transfer, handling and reception of vehicles, passengers and materials.

ii) the comparable International Transit Handbook (ITH) definitions are:

Terminal: The end of a transport route, regardless of whether special facilities exist for turning vehicles or handling passengers there.

Bus terminal: A location, either off-street or on-street, at the end of a route where buses can wait before starting their return trips and where they can set down and pick up passengers.

The latter definitions reflect the existing situation, where many terminals, especially at the residential ends of routes, are simply bus stops, without special facilities, where buses wait to start their next trips.

*In this dissertation "Department of Transport" means the National Department of Transport (NDOT).

b) Station

i) the NITRR definition is:

Station: An enclosed or partially covered area, the main function of which is to allow large volumes of public transport passengers to change mode or to alight or board a public transport vehicle efficiently.

ii) the ITH definition is:

Station: A point on a line, usually including an enclosed building or covered area, that serves as a collection and distribution point for passengers.

A bus station can thus be located at some point along a route, and not necessarily at the end of a route. It also implies a large volume of passengers or buses and the supply of facilities in contrast to a bus stop, which is considered to be more simple.

c) Bus stop

i) the NITRR definition is:

Bus stop: A place where passengers may board and alight from a bus.

ii) the ITH definition is:

Bus stop: A designated point, usually marked by a post, at which a bus stops for passengers boarding or alighting.

Note that the terms "bus terminal" and "bus station" tend in common usage to be used synonymously.

From the above definitions it is clear that a bus terminal could vary from a simple curbside bus stop, marked by a post and having no passenger facilities, to a major bus station, located off-street with properly designed loading berths and passenger platforms with shelters and facilities for the operators and the passengers (Jackson & Simmons, 1983:12).

d) Minibus taxi-related definitions

Minibus taxi: A passenger vehicle used to provide a transport service available to the public, distinct from conventional mass transit passenger vehicles, characterised by frequent but unscheduled operation of small vehicles designed to carry up to 15 seated passengers over generally fixed corridors with flexible routes with access by hail.

(There are two clearly defined types of operations within the minibus taxi industry in South Africa. The first type of operation provides primarily a commuter transport service. Peak periods of demand are in the early morning and late afternoon, similar to those of conventional transit modes. The second type of operation consists of long-distance minibus taxis providing an inter-urban passenger service. Long-distance minibus taxis in general operate on routes longer than 30 kilometres and their peak is not clearly defined on weekdays. Their peak periods of demand are usually on Friday and Sunday evenings. For the purpose of this dissertation the term "minibus taxi" refers to the commuter-type operation.)

Minibus taxi stop: A place usually within the road reserve at which minibus taxis are allowed to stop, but not hold, for passengers boarding or alighting.

Minibus taxi rank: A place usually within the road reserve at which a minibus taxi is allowed to wait and/or stop for passengers boarding or alighting.

Minibus taxi terminal: A location, usually off-street at the common end of one or more routes where minibus taxis can wait and passengers can transfer, alight or board efficiently.

Minibus taxi holding area: An area, usually off-street, where minibus taxis hold before proceeding to loading points and where there is generally no passenger activity. A holding area can either be included within or be separated from a terminal facility.



e) **Facility elements**

Bus and minibus taxi facilities consist of a number of elements, as shown in Figure 2.1 through 2.8, which are defined below:

Bay: A stopping space off the travelled way reserved for a public transport vehicle.

Berth: (loading, off-loading, holding, queuing) An authorized bay at a public transport facility where vehicles stop for passengers boarding or alighting and where vehicles hold or queue before proceeding to load.

Pedestrian island: An area from which vehicles are excluded for the protection of pedestrians.

Loading island: A pedestrian island especially intended for the protection of passengers from other traffic while they wait for and board or alight from public transport vehicles.

f) **Transfer facility/Transfer/Transfer time**

Transfer facility: A special area, including structures, situated at the place where different transit routes meet, branch out or cross so that travellers can transfer from one transit vehicle to another, regardless of whether the transit part of travellers' journeys also begins or ends there. (Author's definition.)

For the sake of efficiency and better service effectiveness virtually all bus termini which are being supplied by local and regional authorities lately also serve minibus taxis. Although buses and minibus taxis generally compete with one another, minibuses often supply feeder services to and distribution services from bus facilities. Passengers usually transfer from bus to bus, minibus taxi to bus, bus to minibus taxi, and sometimes from minibus taxi to minibus taxi.

Transfer

i) the NITRR definition is:

Transfer: The act of moving over from one vehicle to another.

ii) the Transportation Research Board (TRB) definition (Gray, 1989:64) is:

Transfer: A passenger's change from one transit unit (vehicle or train) or mode to another transit unit or mode.

iii) the definition offered by Vuchic (1981:651):

Transfer: The change between vehicles of the same or different modes (intra- and intermodal, respectively) in the course of passenger travel.

iv) the author's definition is:

Transfer: The passenger's act of alighting from an arrived vehicle, moving to and boarding another vehicle for onward travel, including waiting for the onward travelling vehicle to arrive, if necessary, and waiting on board for the vehicle to depart.

Transfer time

i) the TRB definition (Gray, 1989:62) is:

Transfer time: The time required to effect a change of mode or to transfer between routes or lines of the same mode.

ii) the author's definition is:

Transfer time: The total time elapsed between the arrival and departure of the vehicles between which a passenger transfers.

(The abovementioned NITRR document does not offer a definition for "transfer time".)

g) **Bus route:** A designated, specified path to which a bus or fleet of buses is assigned and which indicates stops for serving passengers.

Terminals and transfer facilities are the primary nodes of public transport systems. Because of their location and function, and their geometric and operating characteristics, they often serve as centres of activity (in addition to the transport function) where commercial and entertainment activities may be offered.

As opposed to this, bus stops play a subordinate role in that they function only as boarding and alighting points along the links between the primary nodes, and as transfer points at subordinate nodes at the meeting points of lower-demand routes.

Because of the size of the investment required for terminals and transfer facilities, it is clear that their utilisation, as well as the beneficial influence they can have on the performance of an area's public transport system, must be maximized in order to increase their justification in transport economic terms. The latter aspect means that putting such facilities into operation should go hand in hand with the optimizing of the locations for (and thus the spacing between) bus stops on the routes linked to them in order to minimize the total travel time of passengers. In the economic evaluation procedure discussed in this dissertation it is assumed that investment in terminals and transfer facilities will be co-ordinated with an optimization of bus stop locations along their feeder and distribution routes with a view to minimizing the total travel time of passengers. This aspect is discussed further in Chapter 2.

Economic terms whose meanings are not described in the text are defined in a list of terms at the end of each chapter. These terms are underlined in the text.

The following sources were consulted for the abovementioned economic definitions: *Dictionary of economics* (Rutherford, 1992), *Macmillan dictionary of modern economics* (Pearce, 1989), *The McGraw-Hill dictionary of modern economics: a handbook of terms and organisations* (McGraw-Hill, 1973), and *The new Palgrave: a dictionary of economics* (Eatwell, Milgate & Newman, 1987).

1.3 STRUCTURE OF THE DISSERTATION

This dissertation consists of seven chapters. Chapter 1 outlines the reasons for the study, the research methods employed, definitions of the main concepts dealt with in the document, and the structure of the dissertation.

Chapter 2 sets out the planning objectives (geared to meeting identified transport needs of the traveller, operator and the community) which should be taken into account in the creation of bus and minibus taxi transport terminals and transfer facilities.

In Chapter 3 the benefits of bus and minibus taxi terminals for inclusion in economic evaluation are identified. A distinction is made between, on the one hand, transport economic benefits, applicable to the transit operator, transit passengers who make use of the facilities, adjacent street users and the provider of the facility and, on the other hand, non-transport economic benefits which are to the advantage of everyone within the sphere of influence of the facility.

Chapter 4 addresses the cost component of bus and minibus taxi facilities for inclusion in economic evaluation.

In Chapter 5 the use of economic evaluation techniques for the selection and prioritisation of projects is discussed. This is supplemented by an example of an economic evaluation of a proposed bus/minibus taxi terminal.

Chapter 6 deals with welfare distribution and the more equitable community accessibility and mobility which can be brought about by the creation and use of terminals and transfer facilities. Also discussed is the accommodation of welfare distribution with an economic evaluation as a means of achieving greater equity or fairness and the ways in which this can be done.

The conclusions of the study are contained in Chapter 7.

CHAPTER 2**FUNCTIONS OF BUS AND MINIBUS TAXI TERMINALS AND
TRANSFER FACILITIES****2.1 INTRODUCTION**

Urban transport policy is, among other objectives, geared to the enhancement of accessibility, mobility and transport convenience at reasonable costs and with minimum adverse side-effects. In its proposal for a transport strategy for South Africa over the next two decades the National Department of Transport (1998:40) indeed lists *(1) affordable basic access for stranded, (2) attractive public transport system, and (3) high cost public transport system* as the foremost challenges within urban transport. These considerations should therefore be the primary aims of any investment in a public transport facility such as a bus or minibus taxi terminal or transfer facility.

At the beginning of the planning design process it is difficult to know what the affected groups, i.e. passengers, transit operators and the community expect from the facility. Without plans and models to serve as a focus for preliminary discussions, decision-makers are unlikely to be able to give specific advice for selecting and refining the design elements. However, decision-makers should be capable of expressing a set of general goals for the facility. The statement of goals, when available, is useful in defining the breadth of alternatives and in selecting a set of more specific planning objectives.

The planning objectives for terminals and transfer facilities should be geared to identified transport needs. Needs can be identified by an assessment of the current situation, especially with respect to the needs of the passenger, operator and the community as a whole as well as the problems experienced by these groups. Table. 2.1 illustrates key factors in identifying the transport needs of the three groups mentioned above.

Table 2.1 Factors in identifying transport needs

Factors in identifying the needs of affected groups		
Passenger	Transport Operator	Community
The availability of a facility/ routes/services	The availability of a facility/ routes/passenger attraction	Less environmental impact
Walking distance and time	Reliability	Less traffic congestion
Comfort	Capacity	Economic efficiency
Convenience	Additional facilities	Social issues
Additional amenities	Safety	
Security	Lower operating cost	
Other transport modes	Control of services	

According to Hoel (1986:36) the fundamental aim of a passenger transfer facility is the transfer of passengers between the various modes of a transport network. The basic function of a transfer facility is therefore helping to ensure that the flow of passengers between modes occurs in an effective, convenient, comfortable and safe way. The extent to which terminal design and operation successfully carry out these basic functions, with consistent and continuous provision of services in an acceptable or pleasant environment, will determine the extent to which they are accepted by the travelling public.

It is crucial for the provider and/or operator of terminals and transfer facilities (whether the government or a private body) that their establishment and operation take place efficiently. For the government such efficiency will be imperative: on the one hand, because "reasonable costs" are an aim of urban transport policy and, on the other hand, because it will contribute towards the maximization of net community benefits (that is, a positive difference between output and input). Efficiency will be desirable for a private developer because, along with effective service, it is a key to the realization of profits.

To help ensure that the effectiveness needs of passengers, transport operators and the community, and the efficiency needs of the providers of the facilities are best accommodated, it is essential that

the above facilities be subject to a proper economic evaluation during the planning stage. To increase the transport economic viability of new terminals and transfer facilities, and to further stimulate the beneficial effects which such facilities can have on public transport in an area, it is imperative that the implementation of such facilities be co-ordinated with an optimization of the number and location of bus stops on the links which are focused on the facilities in order to minimize the average total travel time of users.

2.2 PLANNING AND DESIGN CONSIDERATIONS FOR BUS AND MINIBUS TAXI TERMINALS

The planning and design of a bus and/or minibus taxi terminal involves establishing three main elements:

- the geometric features and functional layout of the facility addressing the needs of facility users;
- the location of the facility in relation to street traffic flow; and
- traffic control arrangements within the immediate environment of the facility geared to minimizing traffic problems and delays in bus schedules.

The aim or objective in planning and designing these three elements must be to serve vehicles and passengers quickly and safely with the least disruption of street traffic. The aim should also be to avoid possible detrimental effects which could contribute to unsightliness. Where possible, the surrounding environment should be enhanced by the proper architectural design of the terminal as well as its equipment (signboards, telephones, shelters, etc.) (Giannopoulos, 1989:121).

There is no unique "best" terminal design as any design for a terminal is a function of specific pedestrian, bus and other transit vehicle movements, the features of the available site and the impact of the activities of the facility on the surrounding areas. Passenger and vehicle movement in particular need attention to maximize the effectiveness of the transit services and to minimize conflict between passengers and vehicles. As passengers and pedestrians by nature take the shortest possible route (often without regard to their own safety), this "natural route" should be taken into consideration in the design of any terminal. This is why safe sight distances for bus and minibus drivers as well as for passengers should also be taken fully into consideration during the design stage. (See section 3.3.3 on how conditions at terminal facilities affect user perceptions and attitudes.)

2.4

Prime influences on the layout of a bus terminal are the arrangement of the loading berths and the circulation system selected. A variety of layouts in common practice work successfully in certain circumstances.

Loading berth layouts can be classified as either drive-through or reversing. Drive-through layouts are generally preferred to reversing layouts for high-frequency urban services. Reversing layouts may be appropriate sometimes for lower-frequency services such as those associated with inter-city or long distance bus services, where headways are long and passengers can be separated from the area where buses are reversing. Generally, one-way movements within a bus station are preferred by operators (Jackson & Simmons, 1983:26).

The direction of circulation, clockwise or anti-clockwise, should be selected to minimize conflicts depending on the direction from which the buses approach, turning movements from the street into the bus terminal and the location of the loading berths.

Drive-through layouts are either parallel island or some loop arrangements where buses circulate around a central island. The central island can be in the shape of a horse-shoe, an oval or a rectangle.

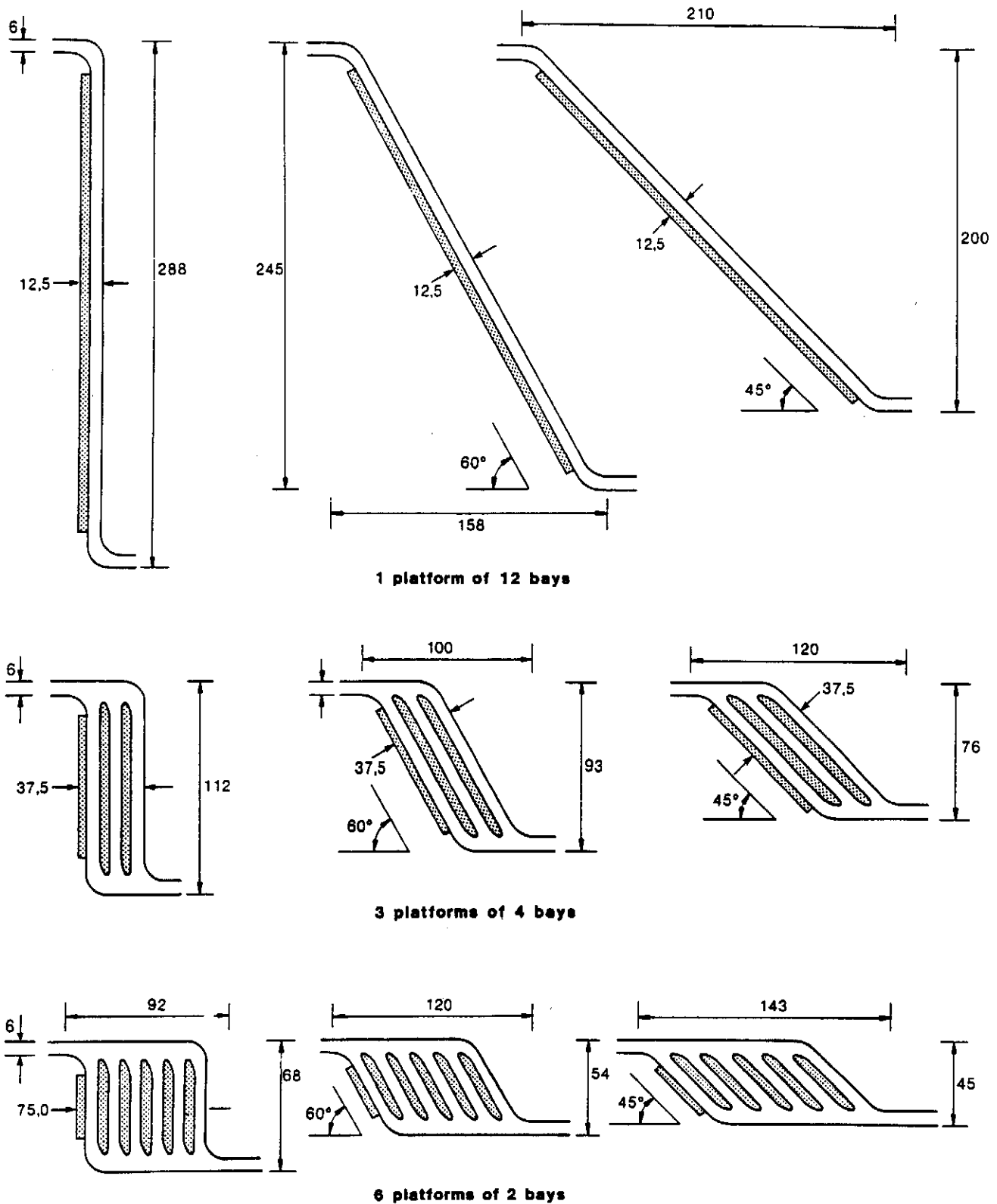
Figure 2.1 shows the dimensions required for various configurations of parallel island bus termini. Comparisons are made on different angles of layouts and different numbers of parallel islands to achieve twelve loading berths. (The dimensions in Figures 2.1 through 2.7 are in metres.)

Figure 2.2 shows the influence of the number of platforms and the angle of the platforms on the area that has to be paved to carry buses, which is a major cost factor. The cheapest layout is the single platform with twelve buses in a row. This is the most economical on space and is the type commonly encountered in on-street bus facilities. As the number of platforms increases, to carry the same number of berths, the cost also increases. Figure 2.2 shows that the most expensive layout would be for twelve platforms each with one berth, if the aisles were wide enough for passing of buses. However, if twelve platforms with one berth each are supplied with a 3,5 metre width of aisle, not permitting passing of buses (which is not really necessary for single berth platforms) then that layout becomes feasible. The angle of the platform also influences the cost as

2.5

shown in Figure 2.2. The 90-degree angle requires wider entrance and exit aisles to accommodate the turn than reduced angles do (Jackson & Simmons, 1983:28).

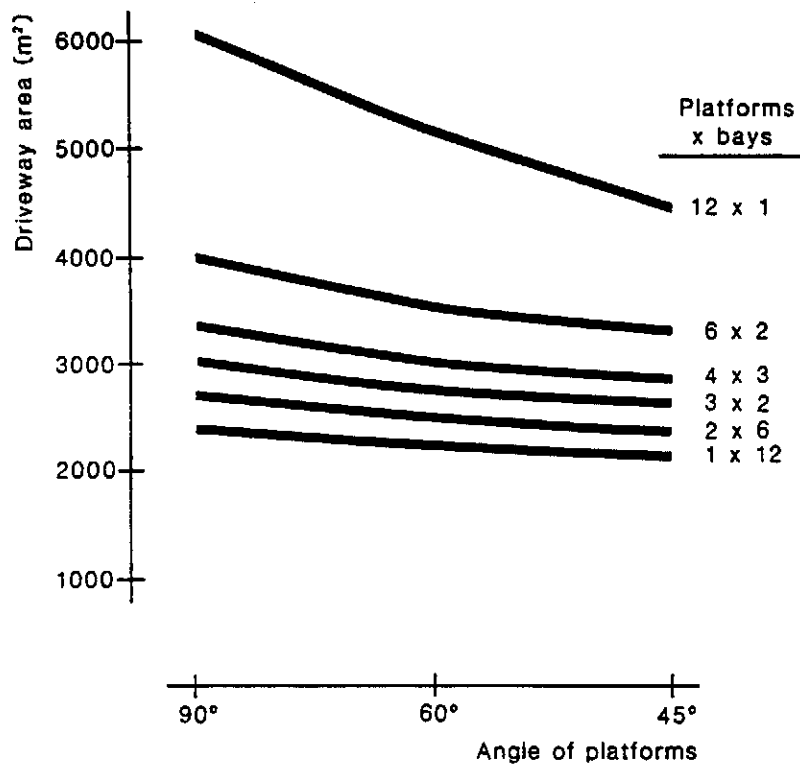
The parallel island layout becomes more convenient for bus operations the more islands there are. Obviously the more islands and the less berths per island, the less chance there is of buses being delayed. However, with more islands, there is greater risk of conflict between pedestrians and buses. A 45-degree angle to the island is much easier for bus manoeuvres than the 90-degree angle.



(Dimensions are in metres)

FIGURE 2.1 Parallel island layouts for twelve bus loading berths

(Source: Jackson & Simmons, 1983:27)

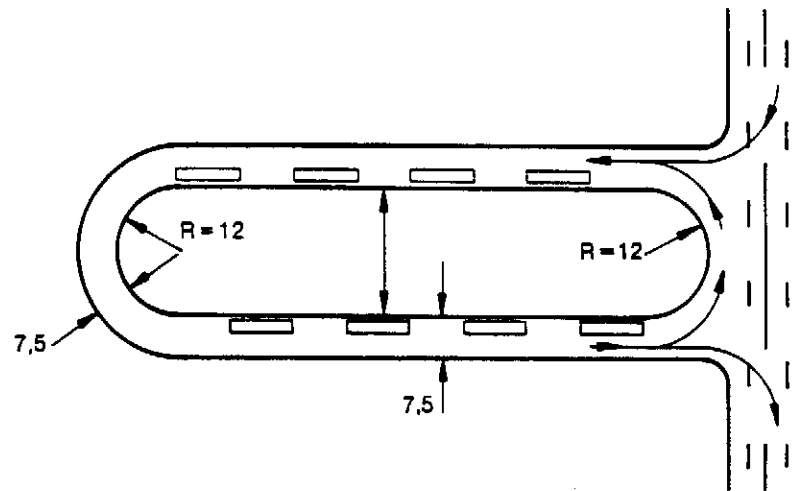


Note: Each platform layout accommodates a total of 12 buses

FIGURE 2.2 Influence of layout on cost of parallel bus platform scheme

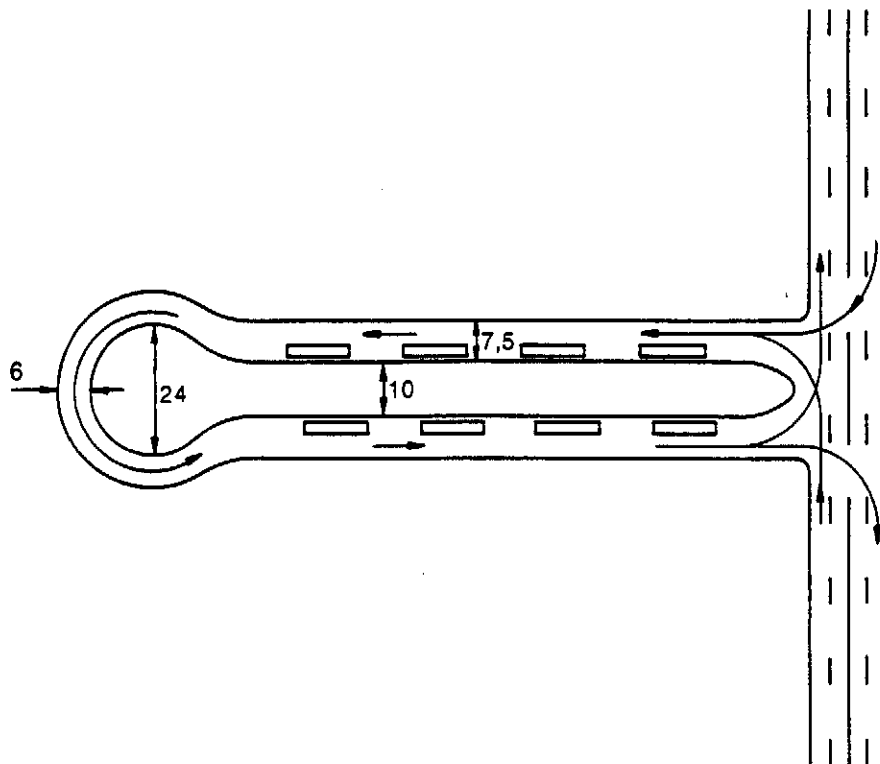
(Source: Jackson & Simmons, 1983:28)

Rectangular or oval island layouts are popular in Europe and North America. The oval island is particularly convenient for the transfer of passengers from one bus to another, as they are able to move from one loading berth to another without crossing a bus aisle. Figure 2.3 shows an oval island layout, where the island is wide enough to enable buses to turn around the island. Figure 2.4 shows the oval island layout, for a minimum width of island. This requires a turning bulb at one end of the island/platform. Figure 2.5 shows a narrow oval island, with a turning bulb at the end and laid out for shallow sawtooth berths.



(Dimensions are in metres)

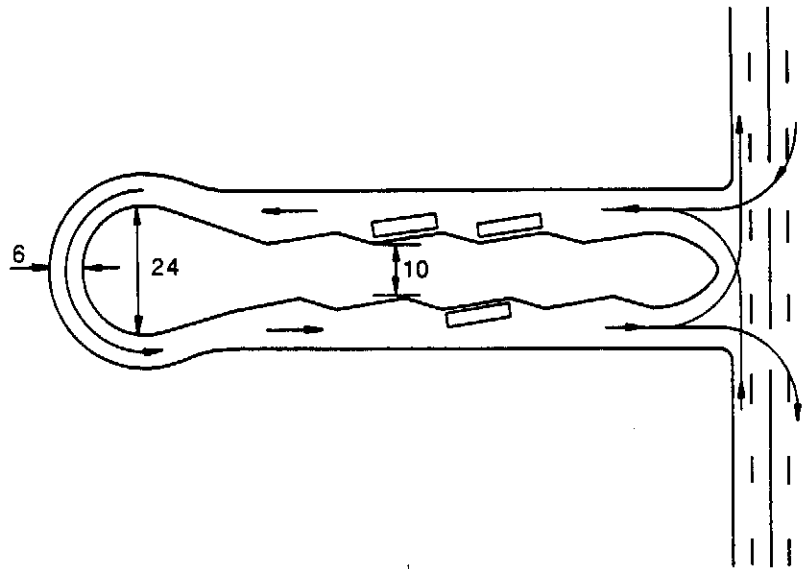
FIGURE 2.3 Wide oval island layout for buses



(Dimensions are in metres)

FIGURE 2.4 Narrow oval island layout for buses

(Source: Jackson & Simmons, 1983:29)



(Dimensions are in metres)

FIGURE 2.5 Narrow island with shallow sawtooth berths for buses

(Source: Jackson & Simmons, 1983:30)

As is the case with bus terminals, minibus taxi facilities consist of a number of elements, as shown in Figure 2.6.

Two types of minibus taxi terminal layouts occur commonly in South Africa, namely the parallel island layout and the oval island type, as shown in Figure 2.7(a) and 2.7(b) respectively. Both layouts originate from similar bus terminal layouts and are used throughout the country. The distinct and clear differences between minibus taxi and bus operations as well as between vehicle dimensions and their turning characteristics suggest that the oval type facility does not provide space-efficient layouts for minibus taxis.

In terms of space utilization Figure 2.7 shows that for a specific site, a parallel island layout can accommodate more minibus taxis than an oval island layout. Therefore the parallel island layout is more space efficient than the oval island layout and should be preferred. In addition, different routes can be accommodated on separate loading lanes and minibus taxis can be easily controlled, thereby enhancing the convenience of both passengers and operators.

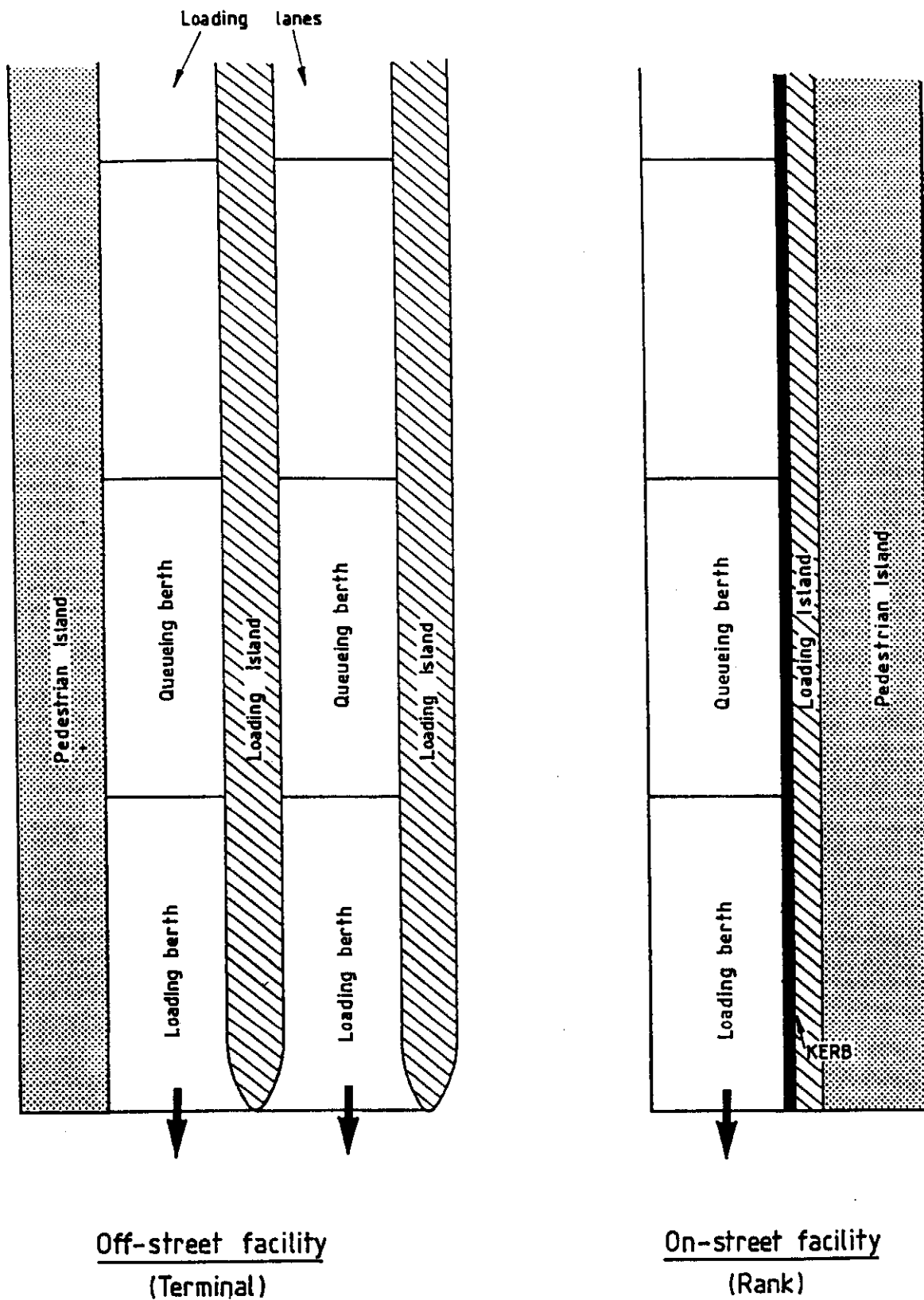
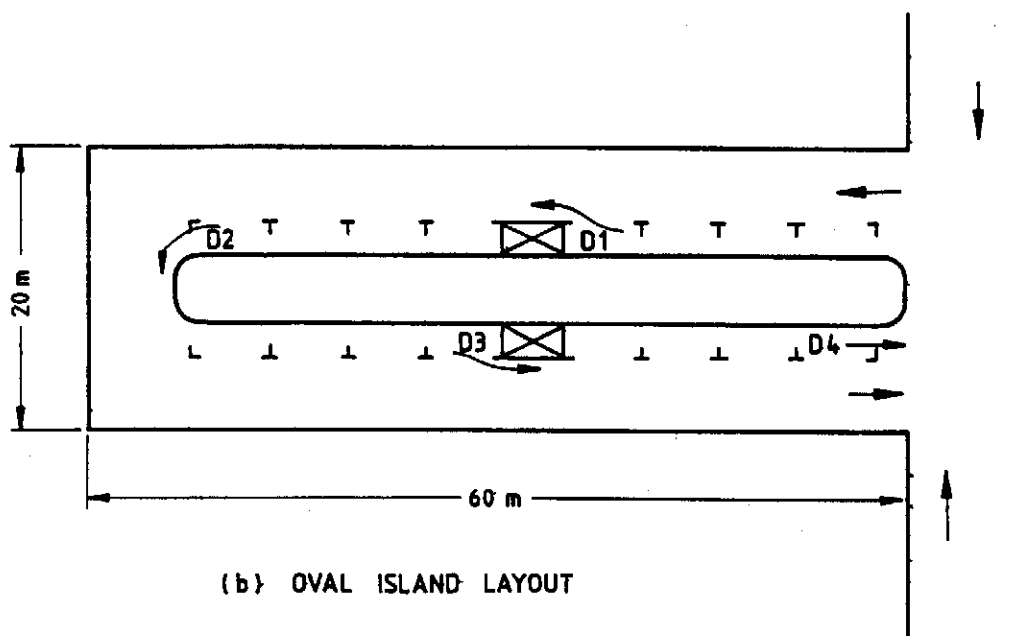
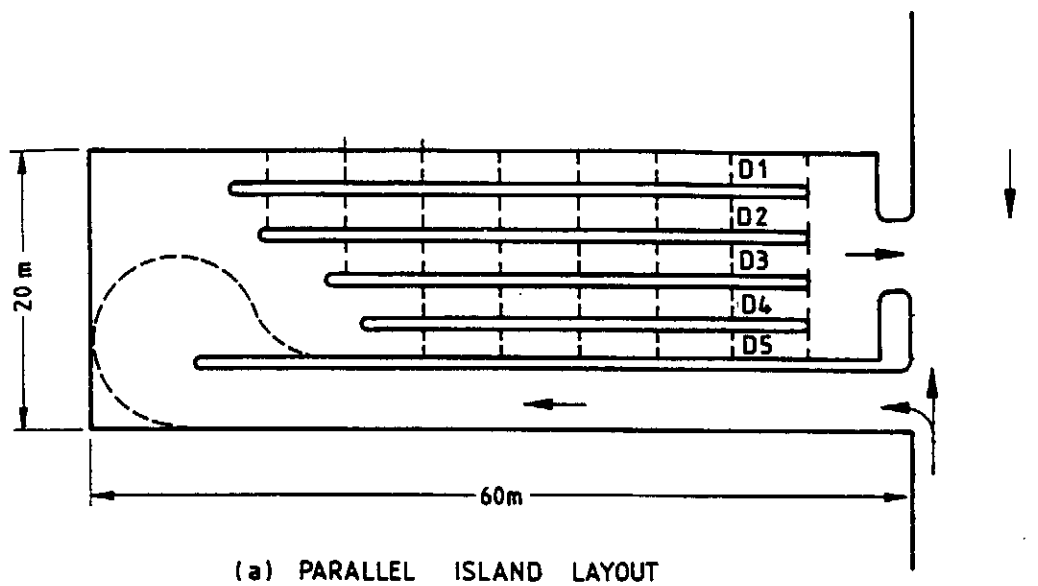


FIGURE 2.6 Elements of minibus taxi facilities

(Source: Rontiris, 1990:5.3)



D1-5: Destination 1-5

Dimensions are in metres

FIGURE 2.7 Parallel and oval island minibus taxi terminal layouts

However, there are cases where oval island layouts may be used. One advantage of the oval island is that conflicts between pedestrians and vehicles are reduced. A wide oval island can accommodate large numbers of passenger transfers more efficiently than a parallel island design can.

The layout of a minibus taxi terminal will be determined by the need for:

- separate off-loading, loading and holding areas,
- the provision of ancillary infrastructure, and
- pedestrian movements and safety.

The following guidelines of the South African Department of Transport (Rontiris, 1990:9.2) refer to Figure 2.8, which shows an example of a minibus taxi terminal layout:

- A separate off-loading area should be provided. Off-loading areas should be situated near the entrance point to the terminal or alternatively as close as possible to passengers' final destinations.
- The loading area should preferably consist of parallel loading lanes separated by passenger loading islands. Loading lanes should be parallel to the long side of the stand, provided that enough lanes can be designed to accommodate the full spectrum of destination (one destination per lane).
- Provision should be made for minibus taxi holding within loading lanes and loading lanes should be long enough to accommodate queuing and waiting minibus taxis. A holding area within a terminal facility need only make provision for secondary activities such as cleaning of vehicles, rest for drivers and long-term parking of minibus taxis. When space is restricted and holding cannot be provided for all minibus taxis within loading lanes, a separate holding area is needed to accommodate the overflow of vehicles.

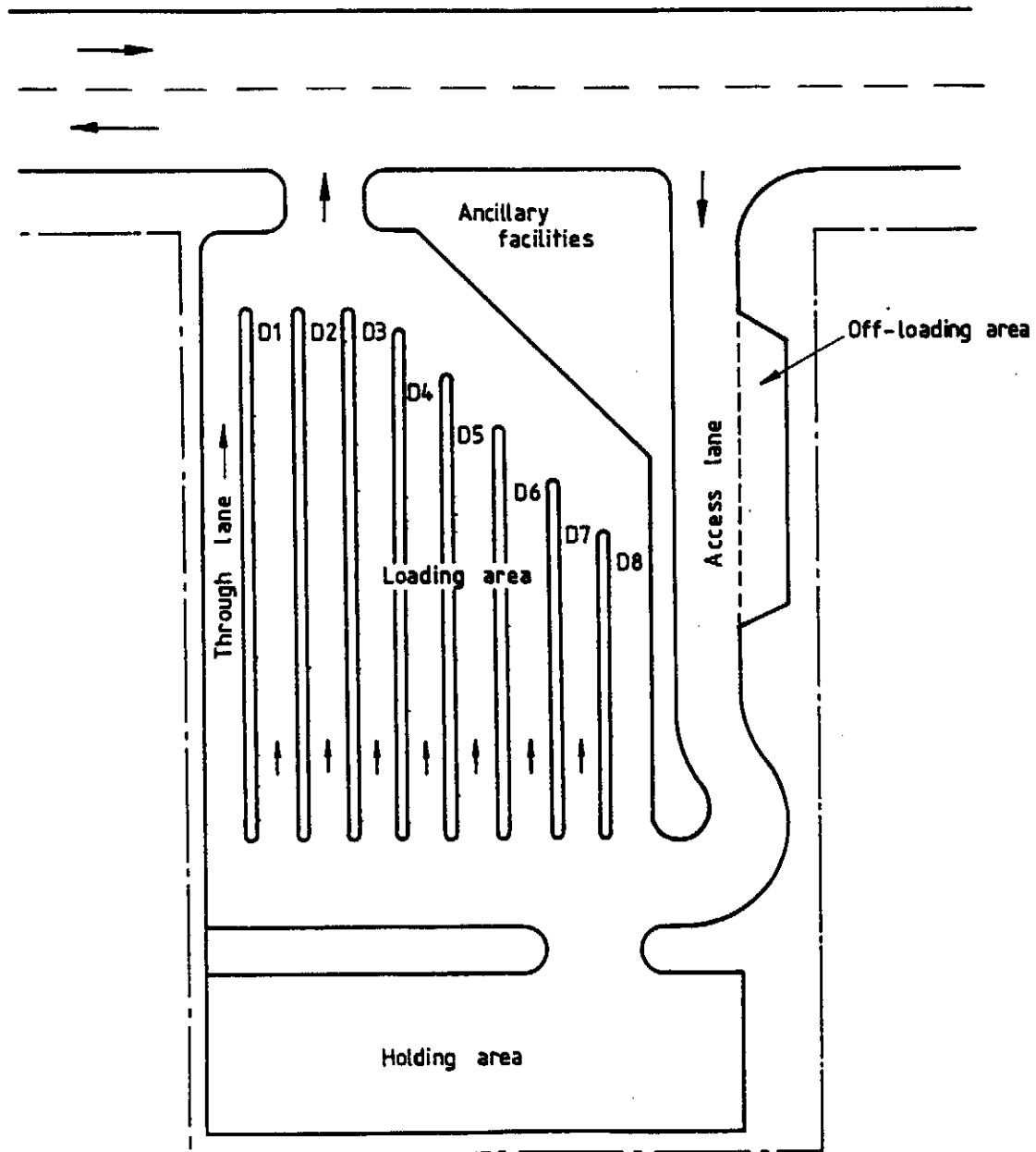


FIGURE 2.8 An example of a minibus taxi terminal layout

- In general through lanes are not required in a terminal. If sufficient space is available a through lane could be provided to allow for direct exit from the holding and off-loading areas.
- Loading lanes need not have the same length. There are usually a few dominant routes with high demand and these routes should be allocated to the longest loading lanes. Routes with low demand can be allocated to shorter loading lanes. This can result in a triangular-shaped area where ancillary infrastructure can be located.
- Minibus taxis should form queues in loading lanes and the front of the queue should be as close as possible to the passenger demand or alternatively to the exit point of the terminal. Pedestrian circulation should ensure that passengers are directed to the ends of queues on loading islands.
- Pedestrian/vehicle conflicts should be minimized.
- Pedestrian islands and paths should be located in accordance with the natural flow of pedestrians, which is normally the shortest path.
- Provision should be made for physically disabled passengers by means of ramps to raised loading and pedestrian islands.

2.3 PLANNING AND DESIGN CONSIDERATIONS FOR TRANSFER FACILITIES

Transfers are often necessary to complete trips; however, passengers perceive them as negative experiences. The stated-preference surveys conducted during the course of this study indicate that passengers dislike the time and cost required for transferring, but they also dislike the need for added trip planning, the possibility of a missed connection, the uncertainty of arrival time at their destination, exposure to inclement weather conditions, crowding, the need to find the next vehicle and waiting in unfamiliar, intimidating or hostile surroundings. (See section 3.3.3 on how transfer conditions affect user perceptions and attitudes.)

A good transfer facility can decrease the unpleasantness of the transfer by directly addressing the reasons why passengers avoid transfers (Horowitz, 1981:149).

The planning, design and evaluation of a transfer facility are dictated by the nature of the transfers occurring there. Experience has shown that where the difficulty of transferring has been reduced, user satisfaction and the amount of travel have both increased. Since transfers cannot be entirely eliminated, it is essential to make them as short and pleasant as possible.

According to Hoel (1986:36) the physical design of a transfer facility must be geared to the convenience, comfort and safety of passengers as well as the needs and interests of the operators.

Passenger convenience refers to the time and energy (effort) required to transfer. A convenient facility will minimize passenger delay and effort, reduce or eliminate passenger congestion, provide travel information, ensure reliable service and thereby provide an effective service for clients.

Terminal elements related to comfort include temperature control, restroom facilities, adequate waiting areas, cleanliness and aesthetically pleasing design. Smooth passenger flow through transfer facilities is also a major condition for comfort.

Safe conditions also need to be taken into account throughout the transfer facility. These include non-slip walking surfaces, adequate lighting and emergency exits. The security of passengers against crime could be achieved by conspicuous policing, lighting and video monitoring. In this respect it is advisable that the view of walking areas and modes of passengers not be blocked by walls or other obstructions. Passenger security can be built into terminal design by way of an "open design", sufficient lighting and direct access to the local police/security staff or to the staff of the public transport institution or facility.

From the point of view of the operator, it is desirable that a transfer facility can handle passenger flow safely and smoothly. Adequate passenger entrance and exit facilities, reliable fare collection equipment and satisfactory platform space are significant elements in this regard. Passenger entrance and exit facilities include wide doors, steps, lifts/elevators and walking areas with sufficient space for large numbers of passengers. However, according to the Transportation

Research Board (TRB), it is extravagant to design for extreme peak one-min flows which may occur only one or two percent of the time. An appropriate time period must therefore be determined through closer evaluation of the short-term fluctuations of pedestrian flow (TRB, 1985:13-10).

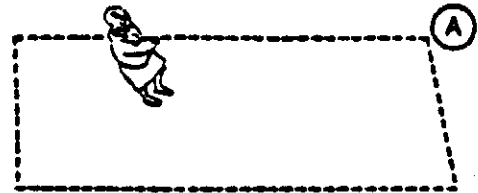
Passenger transfer facilities can create added surges in demand by releasing large groups of pedestrians in short time intervals, followed by pauses during which no flow occurs. Until they disperse, such pedestrians move together as a platoon. Platoons can also form if passing is impeded because of insufficient space, and faster pedestrians slow down behind slower walkers. In walkway sections having pronounced platooning effects, the duration and magnitude of these variations in demand should be established. This is done by timing and counting these short-term surges in demand. The magnitude and frequency of occurrence of the platoons would then be compared to the longer-term 15-min average flow to provide a more accurate view of level of service (LOS) conditions on the walkway segment (TRB, 1985:13-10). Graphic illustrations and descriptions of walkway LOSs are shown in Figure 2.9.

The TRB (1985:13-11) expresses the opinion that the selection of an appropriate design LOS to accommodate either average flows over a longer period, or the surges in demand occurring in platoons, depends on an evaluation of pedestrian convenience, available space, costs and policy considerations.

LEVEL OF SERVICE A

Pedestrian Space: ≥ 130 sq ft/ped Flow Rate: ≤ 2 ped/min/ft

At walkway LOS A, pedestrians basically move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.

**LEVEL OF SERVICE B**

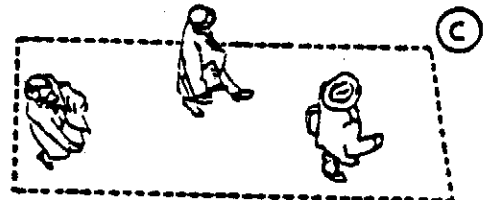
Pedestrian Space: ≥ 40 sq ft/ped Flow Rate: ≤ 7 ped/min/ft

At LOS B, sufficient area is provided to allow pedestrians to freely select walking speeds, to bypass other pedestrians, and to avoid crossing conflicts with others. At this level, pedestrians begin to be aware of other pedestrians, and to respond to their presence in the selection of walking path.

**LEVEL OF SERVICE C**

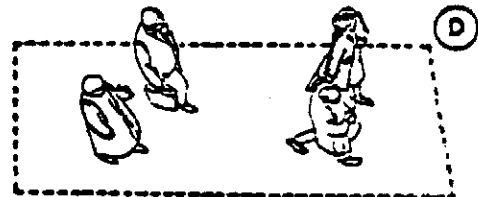
Pedestrian Space: ≥ 24 sq ft/ped Flow Rate: ≤ 10 ped/min/ft

At LOS C, sufficient space is available to select normal walking speeds, and to bypass other pedestrians in primarily unidirectional streams. Where reverse-direction or crossing movements exist, minor conflicts will occur, and speeds and volume will be somewhat lower.

**LEVEL OF SERVICE D**

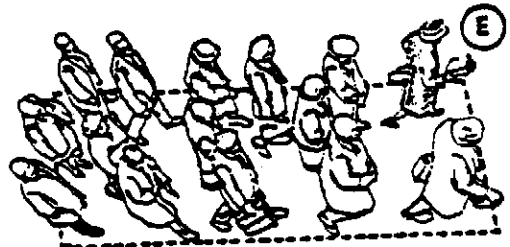
Pedestrian Space: ≥ 15 sq ft/ped Flow Rate: ≤ 15 ped/min/ft

At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Where crossing or reverse-flow movements exist, the probability of conflict is high, and its avoidance requires frequent changes in speed and position. The LOS provides reasonably fluid flow; however, considerable friction and interaction between pedestrians is likely to occur.

**LEVEL OF SERVICE E**

Pedestrian Space: ≥ 6 sq ft/ped Flow Rate: ≤ 25 ped/min/ft

At LOS E, virtually all pedestrians would have their normal walking speed restricted, requiring frequent adjustment of gait. At the lower range of this LOS, forward movement is possible only by "shuffling." Insufficient space is provided for passing of slower pedestrians. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with resulting stoppages and interruptions to flow.

**LEVEL OF SERVICE F**

Pedestrian Space: ≤ 6 sq ft/ped Flow Rate: variable

At LOS F, all walking speeds are severely restricted, and forward progress is made only by "shuffling." There is frequent, unavoidable contact with other pedestrians. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams.



FIGURE 2.9 Illustration of walkway levels of service

(Source: Fruin, 1971:74)

(Note: 1 square foot \approx 0,093 square metre)

Fare-collection systems must be capable of dealing with peak-period traffic volumes. This will obviate long queues (which could possibly obstruct passenger flow) and prevent excessive congestion. The other components of the facility must be situated in such a way that they do not hinder passenger movement. Platform space should also be able to handle peak-period traffic satisfactorily.

Level of service C is appropriate for most bus terminals in South Africa which will have severe peaking characteristics and restrictions on the space available. At this level of service freedom to pass other pedestrians is restricted and there is a high probability of conflict requiring speed and direction changes to avoid contact with cross movements and reversed flows if they exist. However, it provides reasonably fluent flow but with some friction and interaction among the pedestrians (see Figure 2.9).

The graph in Figure 2.10 has been developed to provide guidelines for the width of walkways to achieve various pedestrian flow rates at any selected level of service.

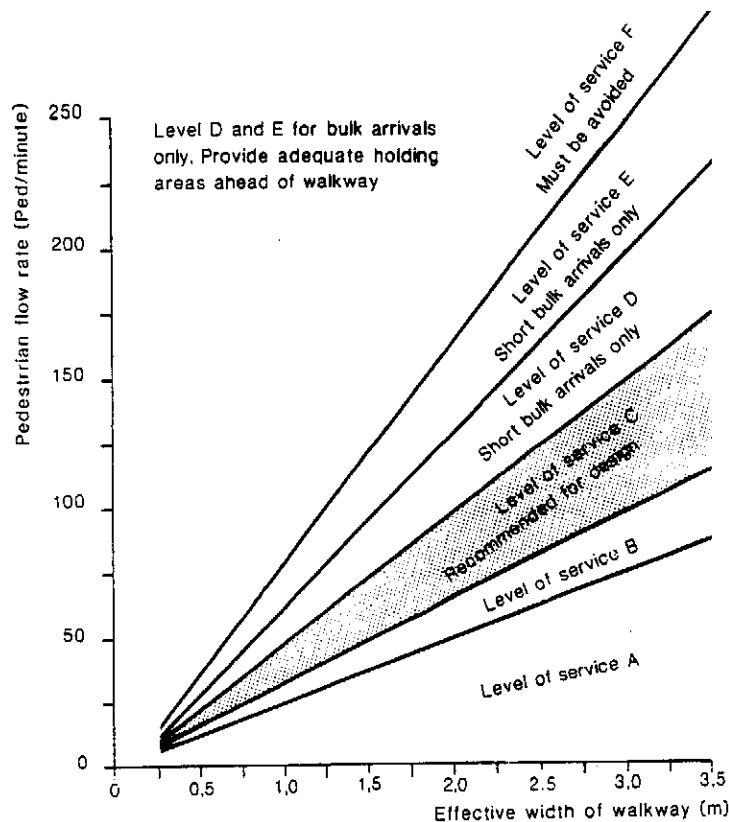


FIGURE 2.10 Width of walkways, pedestrian flows and level of service

The concept of using the average space available to pedestrians as a walkway level-of-service measure can also be applied to queuing or waiting areas, such as platforms. Level-of-service descriptions for standing spaces based on average pedestrian space, personal comfort, and degrees of internal mobility are shown in Figure 2.11.

According to the TRB (1985:13-11), standing areas in the LOS E category of 0,2 to 0,3 square metre/pedestrian are experienced only in the most crowded lifts/elevators or transit vehicles. LOS D, at 0,3 to 0,7 square metre/pedestrian more typically exists where there is crowding, but where some internal manoeuvrability is still present. This commonly occurs at sidewalk corners where a large group of pedestrians is waiting to cross. Waiting areas where more space is required for circulation, such as transit platforms, require a design LOS of D and better.

The primary transfer points within an urban area consist of combinations of bus, rail and/or minibus taxi terminals. Transfer facilities form an integral part of a public transport system. The system can extend over a vast area. When designing a transfer facility, it is imperative to assure its compatibility with the remainder of the transport system and to assure the transport system's compatibility with the transfer facility. This harmonising or integration of system components can encompass the following (Horowitz, 1981:149):

- Properly locating a facility relative to other facilities and modes.
- Relocating modes to better service the facility.
- Realigning schedules to better co-ordinate transfers at the facility and throughout the system.
- Integrating the system both physically and institutionally. (Institutional integration can lead to better overall service co-ordination and fulfilment of transit users' needs.)

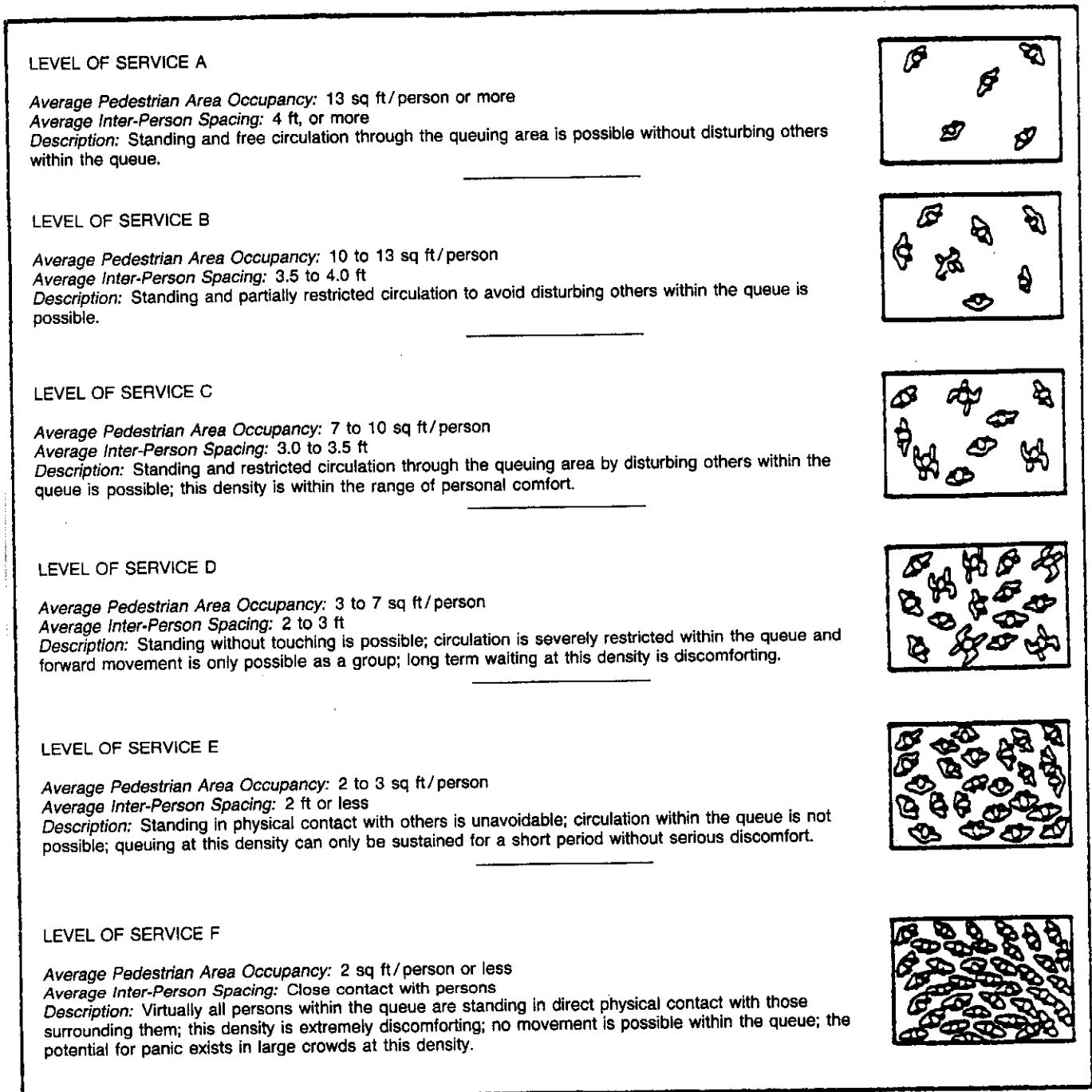


FIGURE 2.11 Levels of service for queuing areas.

(Source: Fruin, 1971)

(Note: 1 square foot \approx 0,093 square metre)

2.21

- Introducing new modes and services to capitalise on the new facility and to accommodate new demand.
- Establishing priorities of access to the facility.
- Redefining the roles of existing transfer facilities to eliminate duplication and to develop specialisation.
- Upgrading the condition of modal equipment to match the new facility.
- Respecting business and community needs and environmental concerns.

To serve public transport in central business districts efficiently, transfer facilities need to satisfy the following requirements (Stander, 1985:4.13):

- The design and construction of the facility should make provision for adequate capacity. In most cases the capacity of bus and rail terminals determines the capacity of the entire system. Critical design aspects include the rate at which passengers board and alight, the number of passengers handled, the average vehicle headway during peak periods, the way control is exercised over tickets and the average walking speed of passengers.
- The facility should be designed to provide adequate shelter from weather conditions and to combat crime as far as possible.
- It should be accessible. Seeing that the distance most commuters are prepared to walk is limited to about 500 metres, provision should be made for feeder services and park-and-ride facilities.
- Where there is a transfer from one mode of public transport to another, the fare systems of the two modes should be co-ordinated in order to make the transfer as rapid and easy as possible. The time schedules of the modes concerned should also be co-ordinated.

In cases where minibus taxis operate at bus terminals, there is often conflict between the bus and minibus taxi operators, delays in the departure of buses, an under-utilisation of available space and a gradual take-over of the terminal by the minibus taxis. These problems should be reduced as far as possible by sound planning and design of the transfer facility - specifically in that they should provide for equal opportunities for all competing modes (Rontiris, 1990:10.3).

In certain urban areas, especially in the metropolitan areas, different types of bus and minibus services as well as private access modes often make use of common facilities. These include: (1) bus commuter services, (2) long-distance bus services, (3) minibus taxi commuter services, (4) long-distance minibus taxi services, and (5) park/kiss-and-ride uses with private transport. Each type of service meets a specific transport need of the travelling public and requires conditions distinctive to that particular mode in order to operate effectively. Facility design should therefore take this into account. A careful design will improve utilisation of all modes using the facility. In the case of a transfer facility the space allocated to a specific mode must firstly satisfy its specific requirements and then be designed to accommodate the most dominant type of vehicle for the particular mode. The following should serve as guidelines in planning and designing such a facility (Rontiris, 1990:10.3):

- Special consideration should be given to passenger movements, especially if they need to cross stopping areas of different modes to gain access to platforms.
- Conflict between the vehicles of the different modes must be kept to a minimum.
- Every mode must be provided with clearly demarcated stopping areas, separated from those for the other modes.
- The vehicle movements of the various modes, as well as their entrance and exit to the facility, should be separated.

A condition for the smooth functioning of a transfer facility is effective provision of information for the transport user. The communication of information occurs primarily visually (in the form of direction boards and warning notices) and/or verbally by public address systems. Secondly, information is conveyed in the form of information sheets and newsletters aimed at keeping travellers informed about planned changes and special events. Thirdly, information can be communicated by vehicle dispatchers and marshalls at terminal and transfer facilities.

For any institution(s) establishing or investing in a transfer facility, a sound information system has the benefit of leading to greater use of the facility (Tichauer & Visser, 1991:6.11).

(See section 3.3.3 for commuters' attitudes towards transferring.)

2.4 THE PLACING OF STOPS IN RELATION TO BUS TERMINALS AND TRANSFER FACILITIES

From a planning point of view the location of and spacing between bus terminals and bus stops is of particular importance as they influence the effectiveness of public transport and traffic activities. The spacing between stops and terminals refers to the average distance between them. Spacing influences the average walking distance for passengers to the facilities and the operation of the route in that it affects travel time via the influence of stop-go cycles on bus speed. From the passengers' point of view it is desirable that stops and terminals be spaced in such a way that total travel time (the total of access, travelling, transfer and exit times) be kept to a minimum (Giannopoulos, 1989:113). For the operator, however, the key issue has to do with route location and spacing of terminals, which is a compromise between shorter walking distances (in other words, less passenger inconvenience) and a higher average bus speed (in other words, better vehicle utilisation) (Canadian Urban Transit Association, 1985:11.1).

Long walking distances create dissatisfaction in passengers (especially those with luggage) and also have a negative effect on their safety and security. Long walking distances to or from a terminal by large numbers of passengers imply more pedestrians who must cross (busy) streets, with the consequent detrimental effect on their safety as well as the flow of street traffic. In addition to this there is congestion on the sidewalks — an unpleasant situation not only for bus and minibus taxi users but also for the public in general. (Long walking distances for minibus taxi users have a further disadvantage in that this encourages minibus taxis to stop informally at unsuitable places.) In practice a walking distance of at most five minutes (400m to 500m) from the highest concentration of places of employment within a particular urban area is recommended for establishing a terminal (Rontiris, 1990:6.1). (See section 3.3.3 for commuters' attitudes towards walking times.)

According to the Department of Transport (Jackson & Simmonds, 1983:16) the appropriate location of a bus terminal gives the operator the benefit of a reduction in the number of dead and low-income bus kilometres.

According to the Canadian Urban Transit Association (1985:11.2) there are many factors associated with pedestrian access and bus stop spacing that affect the efficiency of transit and traffic operations. Adjacent streets, the intensity of land use, and the form of abutting land development all play key roles. For example, bus service on a lightly developed rural or suburban arterial road might only require one to two stops per kilometre. At the other extreme, bus routes on some central business district streets, with stops every second block, might result in more than six stops per kilometre.

Between the abovementioned extremes are cases where arterials may be intersected by residential streets at intervals of 100 metres or less. If stops are located every two blocks, approximately one-half of the population served need to walk less than a block along the bus street to reach a stop, while the other half have to walk only one block. In this case, stop density exceeds five per kilometre. If stops are located every three blocks, approximately one-third of the population served need to walk less than a block along the bus street, while two-thirds must walk only one block. Here, stop density would be about four per kilometre. This small loss in convenience to one-third of the served population may be more than balanced by potential advantages for (a) passengers, (b) transit operators and (c) the community (CUTA, 1985:11.2):

(a) Passengers:

- higher travel speed, hence, shorter journey time; and
- greater comfort (especially for standing passengers) because of the lower occurrence of stop-go cycles. (See section 3.3.3 with respect to commuters' attitudes towards riding while standing.)

(b) Operators:

- the possibility of offering the same service with fewer vehicles because of the higher average speed (or of offering more services with the same number of buses);
- reduced fuel consumption;
- reduced bus wear and tear; and
- a reduction in the number of information signs, benches and shelters as well as concomitant maintenance costs at bus stops.

(c) The community

- a lower level of air pollution and noise;
- an improvement of street capacity due to less stopping in traffic lanes; and
- less sidewalk space is allocated to bus stops which in turn means more freedom of movement for pedestrians.

According to Giannopoulos (1989:113) the criteria for the location and spacing of bus terminals are primarily related to the type and concentration of land uses along a bus route, the location of points with a concentrated demand for bus transport and the potential impact of the operation of the terminal on the flow of street traffic. General guidelines for the positioning of bus stops are as follows:

- a) The initial selection of a position for a bus stop would be near a major concentration of passenger movements, such as shopping centres, hospitals, schools, etc. Also near points where two or more lines of public transport intersect or near big parking lots.
- b) As a second consideration, the traffic effects of the proposed stop must be examined, especially if it is in a congested area.
- c) If both the previous considerations have been satisfied, one must then consider the walking distances to this particular bus stop in relation to the other stops and the overall travel times of the line (see Figure 2.12).

Concerning walking distances and with all due regard to the point (b), it might be preferable to choose a point near an intersection, so as to minimize walking for passengers who want to access the crossing street.

- d) When the basic bus stop points have been determined according to the above guidelines, it may be possible to reduce their spacing further by putting stops on request in between, i.e. stops where the bus driver stops only if there are passengers wishing to use the stop.

In some cases, certain amenities may be added to stops to reduce the apparent travel time for commuters who have to wait there (Morrall, 1970), but clearly, the network of stops should be arranged to minimize travel time for users, within the constraints of economic reality.

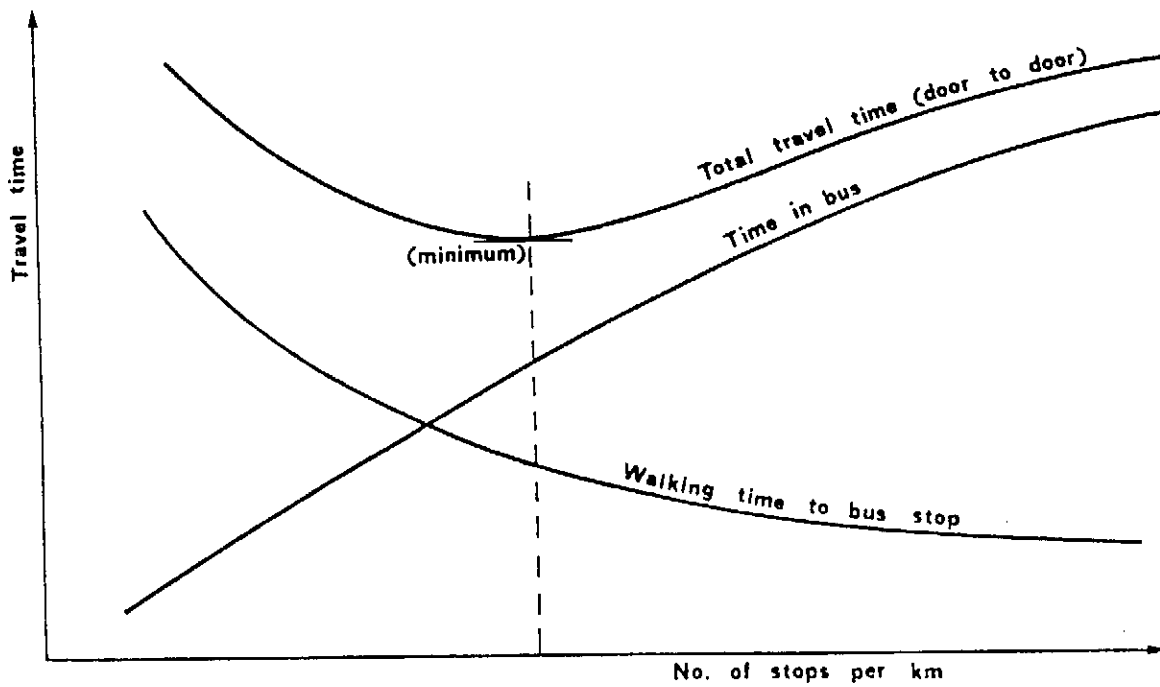


FIGURE 2.12 Diagrammatic representation of the relation between density of bus stops and total travel time for the door-to-door trip.

(Source: Vuchic & Newell, 1968:303)

CHAPTER 3**DETERMINING ECONOMIC BENEFITS OF BUS AND MINIBUS TAXI
TERMINALS AND TRANSFER FACILITIES****3.1 INTRODUCTION**

The use of bus and minibus terminals which have been designed in terms of the objectives set out in Chapter 2 can hold benefits for (1) bus and minibus taxi operators, (2) passengers (commuters), (3) users of streets adjacent to the facility, (4) the supplier of the facility, (5) the subsidizing government, and (6) the community/surrounding business district. The benefits to bus and minibus taxi operators, passengers, adjacent street users and the subsidizing government are mainly of a transport economic nature and mostly involve savings stemming from the greater efficiency and effectiveness of the transport process. Benefits to the community/surrounding business district and the facility developer can in some cases entail "savings" in external costs (i.e. less exposure to negative external impacts such as pollution, noise, vibration and unsightliness, and non-transport economic benefits. Non-transport economic benefits do not involve savings but represent returns (profits) brought about by increased activities stemming from the investment in and operation of such facilities.

The economic benefit from the implementation and operation of terminals and transfer facilities, which is included in a benefit-cost analysis of these facilities, is equal to the saving this brings about in recurring costs (see section 3.7 regarding the benefit accruing to generated traffic). These costs are the transit operating costs, travel costs (excluding the travel fare) of transit passengers who use the facility, the costs for road users on the roads where the traffic conditions are influenced by the facility, and the operating costs of the facility. The benefits or savings in recurring costs offered by a new facility are calculated on the basis of a "with-and-without" situation and can occur in two ways:

3.2

- If a proposed facility is going to replace an existing facility a projection is made of all recurring costs with the existing facility, as well as a projection of all recurring costs as if the new facility were functioning in place of the existing facility. Savings in recurring costs are calculated by deducting recurring costs with the new (proposed) facility from the projected recurring costs with the existing situation.
- If the new facility is an addition to the existing situation, savings in recurring costs are calculated by calculating projected recurring costs "with" the new facility and then deducting these from the projected recurring costs "without" the new facility.

3.2 THE TRANSIT OPERATOR(S)

The benefits calculated in respect of street transit operators for application in economic evaluation are based on (1) the shorter distance that has to be travelled per vehicle, (2) the more economic trip speeds attained, (3) safer vehicle movement at the facilities and (4) less dwell time at the facilities. Formulas to determine the running costs of minibus and the various bus classes (in conditions similar to those described here) have been developed by the author (Pienaar, 1985:215-229). The following variables are included in the equations: travel speed, vehicle mass, number of stops, distance and idling time. As these formulations formed the primary focus of a previous doctoral study by the author, they are not repeated here. Subsequent to completion of the aforesaid project, its results were incorporated in the benefit-cost analysis vehicle cost schedules of the National Department of Transport. Therefore, to ascertain the running costs of road vehicles, vehicle running cost data as updated from time to time on behalf of the Department of Transport (Schutte & Pienaar, 1996) may be consulted.

3.3 TRANSIT PASSENGERS

3.3.1 The concept of generalised travel cost

Recurring costs for users of buses and minibus taxis are a function of, among other things, the value of travel time and the associated monetary costs to undertake a journey. The monetary cost component includes the fare paid as well as any costs incurred to reach the destination. The latter are primarily applicable to park-and-ride facilities situated at passenger transport terminals and transfer facilities and include the running costs of the vehicle used to reach the destination.

The value of travel time is traditionally accepted as the product of the number of hours spent by the passenger in travelling from point of origin to destination (walking, waiting, travelling and walking again) and the unit value of time. (Analysts should note that according to the convention in South Africa to assess travel time savings, all time savings, regardless of how short they may be, are accumulated and treated as if they have the same value as a long uninterrupted period of the same duration.)

Since the 1970s analysts have increasingly realized that there are additional sacrifices in travelling (apart from time and money) which contribute to the opportunity costs of commuting such as, for example, discomfort and inconvenience endured. These sacrifices, which present a resistance to the occurrence of a journey or accompaniment on a journey, may be called its disutility. There is a body of literature using multivariate utility functions, containing perceptual and attitudinal explanatory variables, to model mode choice, destination choice, residential location choice, and trip generation.

At the basis of any analysis of the demand for transport services is the fact that this demand is a derived function. With the possible exception of recreational journeys, road use as such does not normally contribute to the satisfaction of any need - people travel because they wish to do something at their destination. As transport therefore does not occur for the sake of the journey itself but is only a means to an end, there are accompanying sacrifices. The higher the level of disutility the less travellers would be willing to undertake trips. The components of this disutility are the following:

3.4

1. monetary cost (usually the travel fare in the case of transit journeys);
2. travel time (usually regarded as a sacrifice, or it has a negative value attached to it); and
3. negative qualitative aspects (for example, discomfort and inconvenience endured, safety risks, exposure to frustration, unreliable service, walking times and waiting times at passenger transport terminals and transfer facilities).

The particular intensity or level of the experience of disutility is called generalised cost. The demand for transport is thus not simply dependent on travel costs or fares but in fact on the general associated opportunity costs (Button, 1993:85). Goodwin (1974:24) argues as follows: "The generalised cost of a trip is expressed as a single, usually monetary, measure combining, generally in linear form, most of the important but disparate costs which form the overall opportunity costs of the trip. On occasions a generalised time cost measure may replace the financial index." Based on this Button (1993:86) comes to the following conclusion: "The characteristic of generalised cost is, therefore, that it reduces all cost items to a single index and this index may then be used in the same way as monetary costs are in standard economic analysis."

In this study it is assumed that disutility has units of riding time. According to economic theory disutility has units of "utils" which have no special meaning.

Disutility can be rescaled without loss of generality by multiplying by a constant. Research has shown that disutility of travel is almost linearly related to a trip's duration. Thus, disutility can be converted from utils to minutes of riding time by multiplying them by an appropriate factor. It is known that the disutility of any trip can be influenced by the conditions of travel. Waiting and walking accrue greater amounts of disutility than riding the same amount of time. Poor weather, crowding and congestion, among other factors, will increase disutility or generalised cost. The choice as to whether a journey is to be undertaken or not will be determined primarily by whether the generalised cost of the journey is regarded as greater or less than the utility a person may derive from being at the destination of the journey. (This utility is known as place utility.)

3.5

If a traveller does decide to undertake a journey, he will choose that mode which has the lowest generalised cost for him. But what must be realised here is that the mode which has the lowest generalised cost in the eyes of the user does not necessarily also have the lowest perceived monetary cost. For example, a commuter may perceive that trips to work by bus or train may be considerably more advantageous financially than car trips, but his personal bias against riding by bus or train may represent such a degree of disutility that the generalised cost of a car journey may be considerably lower than that for transit journeys. It is therefore clear that well-designed terminal and transfer facilities which function effectively, and with stops on their feeder routes which are optimally placed, will reduce the generalised cost of transit trips considerably and therefore increase commuters' willingness to travel by transit.

Travellers gain utility by reaching desired places, even though they lose utility by getting there. For a trip to be worthwhile;

$$\text{place utility} > \text{trip disutility or generalised trip cost}$$

where place utility and generalised cost are expressed in units of time. Place utility varies by destination, purpose and traveller.

Figure 3.1 shows the disutility or generalised cost of a trip between its origin and destination. Two trajectories, before and after, are shown. Trip 1 (before) requires a difficult transfer at location B; consequently it incurs a substantial transfer penalty. Trip 2 (after) has a less difficult transfer at a transfer facility. Trip 1, had it been made, would have a generalised cost greater than the place utility. Trip 2, on the other hand, can be made with less generalised cost than the place utility achievable. Thus, Trip 2 would be made and Trip 1 would not be made. The net utility for Trip 2 is shown by the bracket.

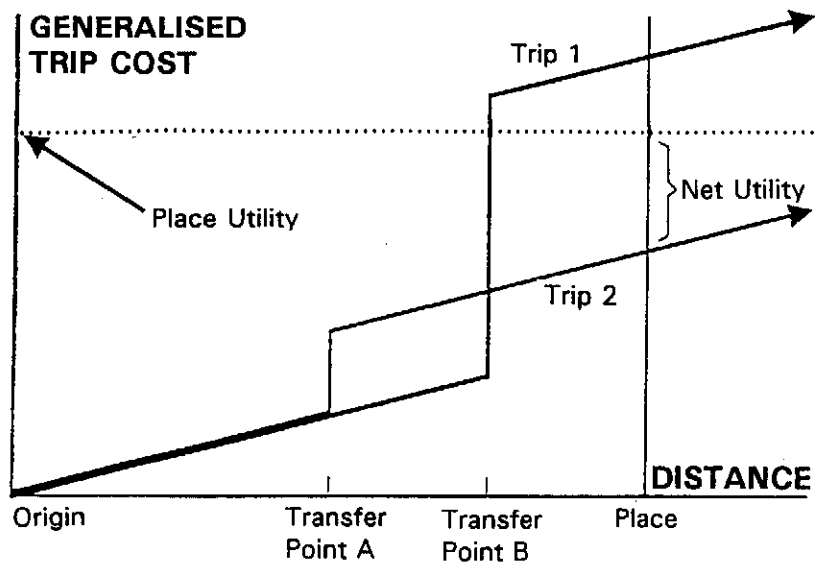


FIGURE 3.1 Relationship between trip generalised cost and place utility

To determine the total amount of utility improvement a person gets from a new facility, it is necessary to compare that person's trip-making before and after the change.

$$\text{Total net utility} = \sum (\text{place utility} - \text{trip generalised cost}) \text{ after} - \sum (\text{place utility} - \text{trip generalised cost}) \text{ before}$$

On the basis of the above points the generalised cost of a trip for a traveller can be defined as the degree of perceived disutility, based on user sacrifices, that offers resistance to the undertaking of a journey or the selection of a particular mode by a traveller.

Comfort refers to the in-vehicle quality of service of a transport service. For example, passengers desire suitable sitting and standing space, ventilation and possibly air conditioning. Congestion and an inadequate number of seats may be experienced as a disutility on longer commuter trips (when a passenger may have to stand for a long time in the vehicle). If congestion is also accompanied by a feeling of lack of safety or of personal threat, the sense of disutility may be so intense that travellers resort to alternative forms of transport or even cancel the journey.

3.7

Whereas comfort refers to in-vehicle quality of service, convenience refers to the extra-vehicular standard of service of a transport system. The need to walk from one vehicle to another may be experienced as inconvenient, especially if a passenger has to wait for a long while for the arrival of the next transit vehicle (even more so if the passenger did not expect to wait) (ECMT, 1973:65). The more a passenger has to transfer and wait during unfavourable weather conditions without adequate shelter at the point of transfer, the more drastically the sense of inconvenience, and thus of disutility, will rise. Poor off-peak period services, insufficient system information, inadequate shelter at passenger transport terminals and transfer facilities, and a lack of parking space at these facilities can all be regarded as contributors to inconvenience. Although no traveller or commuter regards transferring as convenient, it can be accepted with certainty that if transferring is unavoidable, passengers will regard it as a lower cost penalty to transfer at a well designed and sheltered facility which is functioning effectively and has relatively shorter vehicle headways than at an unsheltered and disorganised facility where the flow of vehicles is not smooth.

Convenience also has to do with the accessibility or availability of a transit system to its users. There are two facets to accessibility: in the first place it indicates the spatial proximity of a system's access points to the users' personal trip origins and destinations and, in the second place, to temporal frequency and headways between vehicles and the punctuality with which schedules are adhered to. Jointly the accessibility of transit components amounts to availability of services. The more available a service is in terms of the users' value judgements, the less it will be experienced as a disutility and the less it will contribute to generalised cost, and vice versa. A high level of accessibility or availability requires access points that are close by and adequate frequency of service. It is unfortunately true that, due to cost limitations, there have to be continual compromises between the two components of accessibility. At the one extreme, for example, there could be a dense route network with a low service frequency (that is, access points close by but long vehicle headways) necessitating a transfer facility at each node, and at the other extreme a high-frequency service on a single track or single route, probably necessitating a large passenger transport terminal at each route end.

3.3.2 Valuation of travel time savings

The latest recommendations of the World Bank (Gwilliam, 1997:4) with respect to the evaluation of travel time savings are as follows:

1. That values of time savings, both for leisure and work, should always be considered in economic evaluation of projects.
2. That for major projects demand analyses should be constructed in such a way as to make explicitly the values of time implicit in forecasts. Stated preference experimentation is an economical way of doing this, which clients' consultants should be encouraged to employ. Special attention should be given to: (a) modally specific values, (b) variation of values by journey length, (c) the relationship between the value of time and income, and (d) excess travel time (walking, waiting, transfer).
3. Where it is not possible to derive values locally the following bases should be used (note: W = wage rate per hour; H = household income per hour):

PURPOSE	VALUE	RULE
Work trip	Cost to employer	1,33W
Business	Cost of employer	1,33W
Commuting and other non-work	Empirically observed value	0,3H (adult) 0,15H (child)
Walking/waiting	Empirically observed value	1,5 x value for trip purpose
Freight/public transport	Resource cost approach	Vehicle time cost + driver wage cost + occupants' time

4. Where such "foreign" values are imported, their general plausibility should be checked by reference to local expertise and experience.

The value of travel time is linked to the purpose of the journey (such as working, leisure and commuting time), the travellers' level of income and the amount of time saved per trip. Different

units of value for time can therefore be chosen according to the type of traveller and the journey. Savings in travel time can accordingly be given a value by multiplying the selected unit value(s) of time by the amount of time saved. In the same way travel time including and not including the use of the terminal can be multiplied by the appropriate unit value(s) of time. The difference between the two products thus obtained is the value of time saved.

The conceptual model underlying the valuation of travel time savings is one of consumer welfare maximization. It postulates that each individual maximizes the satisfaction or utility he gets by consuming and by engaging in leisure activities. Consumption of goods and leisure activities is constrained in two important ways.

First, expenditure is limited by income which must be earned by devoting time to working. Second, work, leisure activities and travel compete for an amount of limited available time.

In allocating time between activities the individual must trade off the extra consumption that work earns against the foregone leisure which it requires. But he also has possibilities of extending the amount of working or leisure time available by spending extra money to save travel time. For example, this may arise (1) in the choice between fast and expensive modes or routes and cheaper, slower alternatives, or (2) in the broader context of choices of work, business and leisure activity and residential location. By analysing the relative sensitivity of such choices to variations in money and time cost, the implicit value of time of decision-makers can be identified.

These preference structures can be identified in two main ways. Revealed preference analysis estimates values of time which best explain actual observed choice behaviour (for example choice between a fast high perceived cost mode and a slow low perceived cost mode). Conceptually this would appear to be the most realistic basis for study. In practice such inquiry into revealed preferences are expensive because many people really have little effective choice of travel alternative; at best only one decision can be analysed per respondent. It is also uncertain because, even where there is a choice, direct (revealed) evidence only exists on the alternative chosen and not on the alternative rejected.

Stated preference analysis overcomes the expense and clarity problems of revealed preference by presenting hypothetical alternatives closely related to an activity currently undertaken (for example, by interviewing commuters during the course of a journey, as was done during this study). This can be done in a wide range of contexts offering alternatives designed to give numerous credible trade-off possibilities at little cost in a single experiment. This overcomes the limitation of revealed preference analysis to situations where the number of "traders" is great and the nature of the trade obvious (mostly choice of mode for the journey to work).

Revealed preference data have until fairly recently been the preferred research technique in the valuation of travel time savings. According to Hensher (1995:16) revealed preference data can be described as:

1. depicting situations as they are now;
2. having built-in relationships between attributes;
3. having only existing alternatives as observable;
4. embodying market and personal constraints on the decision-maker;
5. having high reliability and face validity; and
6. yielding one observation per respondent at each observation point.

In contrast, according to Hensher (1995:16) stated preference data can be described as:

1. depicting virtual decision contexts (flexibility);
2. having controlled relationships between attributes (permitting mapping of utility functions with technologies from existing ones);
3. including existing and/or proposed and/or generic choice alternatives;
4. having difficulty (if not impossibility) to effectively represent changes in market and personal constraints;
5. being reliable to the extent that respondents understand the task, are committed to the task, and can really respond to the task; and
6. yielding multiple observations per respondent at each observation point.

There is a view that for non-working time the behavioural value of time savings should be the same for all modes, routes and trip purposes. The resulting equity value is consistent with the position that scarce investment funds should not be directed towards projects which are more likely to benefit individual travellers with a higher willingness to pay simply because they have a greater ability to pay. This argument rests on the proposition that the value of travel time savings is a function of personal income. Although the empirical evidence on the relationship between value of travel time saved and personal income is ambiguous, despite its theoretical appeal, equity values of travel time savings can be derived from the behavioural values for non-working time. If equity values are used, then the resource value for non-working time should be derived from this equity value. (Hensher, 1995:13.)

Employers, trade unions, authorities which subsidise transit-captive commuters, and other interested parties often require information about what constitutes a 'living wage'. This is particularly relevant when a minimum wage or the remuneration of unskilled workers has to be determined. As a result there have been numerous attempts, in many countries, to define such a wage. The usual procedure is to estimate the amount of money required by an unskilled worker with an average size family to satisfy 'reasonable needs'. The problem, however, is that there is no consensus on what constitutes 'reasonable needs'. Should they be restricted to basic needs such as food, shelter, clothes, fuel and light? Or should they include some simple comforts as well?

In South Africa the authoritative work in this regard is done by the Bureau of Market Research (BMR) at the University of South Africa. In an attempt to give empirical content to the concept of a living wage, the BMR (1997) developed two measures: the minimum living level and the supplemented living level. The minimum living level (MLL) indicates the minimum financial requirements for the basic needs of a family if they are to maintain their health and have acceptable standards of hygiene and sufficient food, clothing and lodging. The supplemented living level (SLL) provides for more simple comfort items than the MLL. It is neither a subsistence nor a luxury budget. The BMR describes the SLL as an attempt at determining a modest low-level standard of living.

In the author's opinion the MLL wage approximates the equity time value of unskilled and transit captive commuters reliably enough to serve as the shadow price or surrogate value at which they will start to trade leisure time for periods of work. (This is represented by variable " U " in equation 3.1.)

3.12

The items allowed for in calculating the MLL include (i) food, (ii) clothing, (iii) compulsory payments to local authorities in respect of rent, water, electricity and miscellaneous services, (iv) domestic fuel and light, (v) washing and cleaning materials, (vi) education, (vii) transport (work, school and shopping), (viii) contributions to medical funds, other medical and dental expenses, and (ix) replacement of household equipment. In addition, the SLL allows for modest recreation and entertainment, personal care, contributions to pension, unemployment and burial funds as well as for extra items in each of the categories included in the MLL.

MLLs and SLLs are calculated in February and August of each year for 26 areas. For each area there are as many as 12 different MLLs, calculated according to household size and place of residence. The MLL and SLL data are widely used as a guide in wage negotiations and settlements.

Another source of data on minimum living levels is the Institute of Planning Research at the University of Port Elizabeth, which regularly publishes estimates of the household subsistence level (HSL) in various areas.

The total travel costs of terminal users are a function of transport system and community variables and uncertainties. This is clear from the following relationships (AASHTO, 1977:104):

- the time spent walking to and from a terminal depends on:
 - the spatial distribution of points of origin and destinations of passengers in relation to the terminal and route;
 - the number and location of passenger transport terminals; and
 - the probability that a passenger travels to a terminal by car or taxi.
- the waiting time for a bus or minibus taxi depends on:
 - the service frequency of buses on a specific route;
 - the reliability of bus schedules (not applicable to minibus taxis as they do not operate according to fixed schedules); and
 - the pattern in which travellers arrive at a terminal.

As the opportunity costs of transit operations are borne by transit operators, it should be noted that these costs and travellers' fares are not added together in determining recurring costs. To avoid double counting only the non-monetary part of travellers' generalised travel costs is added to the

opportunity costs of transit operators in determining the economic travel cost portion of recurring costs.

The calculation of quantifiable benefits for facility users entail measuring the reduction in costs incurred to undertake a particular type of journey (AASHTO, 1977:104). For the purposes of this calculation the following calculations are required for specific categories of journeys:

- the number of trips undertaken with and without the creation of the terminal; and
- the average time spent to undertake a certain class of journey. Where possible this must be differentiated according to walking, waiting, transferring, in-vehicle travel and in-vehicle standing times (individuals attach different values to different components of the journey).

In evaluating the quantifiable benefits offered to facility users, a distinction needs to be made between the savings gained by the existing bus and/or minibus taxi users, the savings gained by road users who changed to using these modes of transport after the creation of the terminal (the diverted traffic) and the benefit gained by generated users (i.e. those passengers who previously did not travel but started to travel because of the creation of the terminal). This quantification is explained in section 3.7.

3.3.3 Valuation of the non-monetary part of generalised travel costs per transit passenger making use of passenger transport terminals and transfer facilities

It is often argued that relative door-to-door travel time is a reliable substitute to represent the relative generalised cost users attach to services. Total door-to-door travel time could consist of five components: access, waiting, travelling, transfer and exit. The relative generalised cost of these periods varies as travellers experience them with different degrees of resistance or intensity of disutility (ECMT, 1973:60). A passenger is seldom able to give an exact figure for a trip's degree of disutility. It is nevertheless possible to estimate any given trip's disutility from analysing how people have behaved in the past. Assuming passengers are rational, they tend to choose modes and routes that have the lowest disutility. By looking at a large number of such choices in a great variety of situations, it is possible to infer a set of *weights* and *penalties* for each component of a trip. Psychological scaling studies have also provided help in estimating disutility. (Horowitz, 1981:149). (See the time weighting factors recommended later in this chapter.)

Many planners have adopted a rule-of-thumb that says the value of time while waiting is twice the value of time while riding. This rule-of-thumb has been reconfirmed so often that it is now accepted without much question. A transit operator can accordingly achieve the same improvement in the disutility of a trip by eliminating two minutes of riding or by eliminating one minute of waiting. Waiting can be reduced by better schedule co-ordination, better passenger information, improved punctuality and by eliminating transfers wherever possible.

Surveys conducted by Navin (1974:11) have indicated that walking and waiting are respectively approximately 2,3 and 3,0 times more disagreeable than riding.

According to AASHTO (1977:105) the value placed on walking and waiting times is usually 1,5 or 2,0 times the in-vehicle travel time per person per hour. This value can be higher in cases where the quality of extra-vehicular convenience and safety is poor.

Horowitz (1981:149) has suggested the following weights for use during fair weather conditions:

time component	weight
riding while seated	1,0
walking	1,25
walking with luggage	3,0
unproductive waiting	2,0
productive waiting	1,0
queue time	3,0
riding while standing	3,0

Horowitz also suggested that during rainy weather conditions the above-mentioned weights must be multiplied by a factor of 1,25 and when the air temperature is below freezing the weights must be multiplied by a factor of 4,25.

In a paper by the author (Pienaar, 1986) the generalised cost for users on different urban transport modes in South Africa was calculated by investigating the relative door-to-door travel times of commuters in different transit vehicle classes. Walking times at route terminals and waiting times at transfer points were both multiplied by a factor of 2,0. The assumption was that travellers' generalised cost of walking and waiting time is double that of in-vehicle travel time.

Ortúzar & Willumsen (1990:262) are of the opinion that walking and waiting time during access, transfer time and exit time must be weighted with factors which vary in value between 2,0 and 3,0.

On the basis of various studies on this, Vuchic (1992:280) recommended that multiplication factors of 2,0 be used to weight walking time and 2,5 be used to weight waiting time and in-vehicle standing times in order to arrive at a generalised travel cost.

According to the MVA Consultancy (1994:263) the British Department of Transport recommends that walking and waiting time should be valued double that of in-vehicle time.

According to the World Bank (Gwilliam, 1997:3) recent European studies show transfer times and waiting times with values between one and a third and two times those of in-vehicle times. (However, waiting in inclement conditions in Sweden predictably has a much higher value.)

A model to assist in determining the non-monetary portion of generalised travel costs with different transit modes which move through passenger transport terminals and transfer facilities can be formulated as follows (Pienaar, 1995:30):

$$\text{where } NMGC = U \left[\left(\frac{VT}{60} \right) + \left(\frac{A}{60} \right) (a-1) + \left(\frac{B}{60} \right) b + \left(\frac{C}{60} \right) c + \left(\frac{D}{60} \right) d \right] \quad (3.1)$$

NMGC = The average non-monetary part of generalised travel costs per transit passenger making use of the passenger transport terminal or transfer facility expressed in rands.

U = Average hourly rand value of time according to income group and trip purpose of travellers. (In the case of unskilled and transit-captive commuters it is recommended that the shadow price of *U* should be set equal to the minimum living level wage.)

VT = The total in-vehicle travel time per person per journey, expressed in minutes. This includes the time spent in buses and/or minibus taxis as well as time spent in vehicles used to approach and depart from the terminal.

<i>A</i>	=	The total in-vehicle standing time per person per journey, expressed in minutes.
<i>B</i>	=	The walking time per person per journey, expressed in minutes. Walking time comprises the time needed by the passenger to walk from the point of origin to the terminal and from the terminal to his destination.
<i>C</i>	=	The waiting time per person during access, expressed in minutes.
<i>D</i>	=	The total transfer time per person, expressed in minutes.
<i>a</i>	=	Time weighting factor for in-vehicle standing time. (To avoid double counting with respect to variable <i>VT</i> , the value 1,0 is subtracted from <i>a</i> .)
<i>b</i>	=	Time weighting factor for walking time.
<i>c</i>	=	Time weighting factor for waiting time.
<i>d</i>	=	Time weighting factor for transfer time.

A procedure to assist in determining the non-monetary portion of generalised travel costs with different transit modes which move through passenger transport terminals and transfer facilities will broadly include the following:

1. Estimate the average total door-to-door travel time of the expected users of a system. In this process the following variables need to be researched: the actual location of the points of origin and destinations of prospective transit travellers who will use the passenger transport terminal or modal transfer facility; their average walking time during access (this is a function of walking distance to this facility and average walking speed); average waiting and transfer times at the facilities (the latter is a function of mainly vehicle time headways); travel time of modes; average in-vehicle standing times and average walking time during exit.
2. The calibration of factor weights whereby walking, waiting, in-vehicle standing and transfer times are weighted: these values will depend on, among other things, the age, sex and income level of the passengers, and on climatic conditions. Gathering such information is done through terrain-specific investigation and questioning of potential passengers. If there

is no opportunity for terrain-specific research, default values could be used based on the regional or average national attitudes of passengers which could in turn probably be ascertained through passenger panels. If there is no opportunity to research time weighting factors in this way during the planning and evaluation of passenger transport terminals and transfer facilities, the following default values are recommended for time weighting factors:

Component of trip	Time weighting factor
Vehicle travel time (sitting) (<i>VT</i>)	1,0 (no weighting)
Vehicle travel time (standing) (<i>A</i>)	<i>a</i> : 2,0
Walking time during access and during exit (<i>B</i>)	<i>b</i> : 2,5
Waiting time during access (<i>C</i>)	
· at a well-designed and sheltered facility which functions effectively	<i>c</i> : 1,5
· at a partially sheltered facility functioning neither well nor poorly	<i>c</i> : 2,0
· at a badly designed and unsheltered facility which is relatively disorganised	<i>c</i> : 2,5
Transfer time (including waiting time) (<i>D</i>)	
· at a well-designed and sheltered facility which functions effectively	<i>d</i> : 2,0
· at a partially sheltered facility functioning neither well nor poorly	<i>d</i> : 2,5
· at a badly designed and unsheltered facility which is relatively disorganised	<i>d</i> : 3,0

The factors whereby time is weighted usually vary between 1,5 and 3,0 with increments of 0,5 or 0,25 between them. A factor of 1,0 indicates no weighting while a factor of 3,0 usually indicates the highest degree of resistance (ECMT, 1973:60; AASHTO, 1977:104; Horowitz, 1981:149; Pienaar, 1986:9; Ortúzar & Willumsen, 1990:262; Vuchic, 1992:280; MVA Consultancy, 1994:263; Gwilliam, 1997:3).

The abovementioned default values are based on suggested weights obtained through conducting an international literature search reported on earlier in this section and stated preference surveys conducted in Bellville, Cape Town, Stellenbosch and Pretoria.

Examples how to use equation 3.1 are supplied in a hypothetical case in section 5.3 and in a real world case study in section 5.4.

Estimation of the disutility that bus passengers attach to travel time while standing, relative to vehicle travel time while seated (variable A in equation 3.1)

A survey was conducted during March 1998 at Mowbray Bus Terminus in Cape Town, and at Bellville Bus Station with a view to estimating the disutility that bus passengers attach to vehicle travel time while standing, relative to vehicle travel time while seated.

Passengers who indicated that they often have to stand in a bus during travel, because of the unavailability of a vacant seat, were asked: (1) how long (in minutes) they usually have to stand, and (2) how much extra travel time (in minutes) would they tolerate should it be possible to guarantee seated travel throughout.

The details of the survey results pertaining to male and female respondents at Mowbray Bus terminus and at Bellville Bus Station appear in Tables 3.1 through 3.4.

The survey results suggest that the weighting factor for standing time should be 1,9. A rounded default weighting factor of 2,0 for both genders with respect to vehicle travel (riding) time while standing is recommended in this dissertation. This recommendation is supported by the fact that (1) both the median and mode values of the surveys are equal to 2,0, (2) the standard deviation of all the observations is only 0,36 and (3) the literature survey has shown that the factors whereby standing time is weighted usually vary between 1,5 and 3,0 with increments of 0,5 between them.

Table 3.1 Details of responses obtained during a survey at Mowbray Bus Terminus in 1998 aimed at estimating the disutility that male bus passengers attach to travel time while standing, relative to travel time while seated

Number of respondents	Standing time (minutes)	Additional travel time tolerated (minutes) per respondent	Implied time weighting factor
2	5	0, 5	1,50
1	6	5	1,83
2	7	7, 10	2,21
5	8	5, 5, 8, 8, 10	1,90
5	9	0, 5, 10, 10, 15	1,89
8	10	5, 5, 10, 10, 10, 10, 15, 15	2,00
4	12	10, 10, 12, 15	1,98
2	15	10, 15	1,83
1	20	15	1,75
2	25	25, 30	2,10
1	30	30	2,00
33	Weighted average = 1,9		

Table 3.2 Details of responses obtained during a survey at Mowbray Bus Terminus in 1998 aimed at estimating the disutility that female bus passengers attach to travel time while standing, relative to travel time while seated

Number of respondents	Standing time (minutes)	Additional travel time tolerated (minutes) per respondent	Implied time weighting factor
1	4	5	2,25
2	5	5, 5	2,00
1	6	5	1,83
3	7	5, 5, 10	1,95
2	8	5, 10	1,94
4	9	5, 10, 10, 15	2,11
6	10	10, 10, 10, 10, 15, 15	2,17
2	15	15, 20	2,17
1	20	30	2,50
22	Weighted average =		2,1

Table 3.3 Details of responses obtained during a survey at Bellville Bus Station in 1998 aimed at estimating the disutility that male bus passengers attach to travel time while standing, relative to travel time while seated

Number of respondents	Standing time (minutes)	Additional travel time tolerated (minutes) per respondent	Implied time weighting factor
3	3	0, 2, 3	1,56
4	4	0, 1, 4, 5	1,63
8	5	0, 0, 1, 2, 3, 3, 5, 5	1,48
3	6	0, 2, 5	1,39
6	7	2, 3, 4, 7, 7, 10	1,79
4	8	5, 5, 8, 10	1,88
7	9	5, 7, 8, 9, 9, 10, 10,	1,92
10	10	5, 5, 7, 8, 10, 10, 10, 10, 10, 15	1,90
9	12	5, 6, 7, 10, 10, 10, 12, 12, 12	1,78
8	13	8, 10, 10, 10, 10, 13, 13, 15	1,86
9	15	5, 10, 12, 13, 15, 15, 15, 17½, 20	1,91
4	20	10, 15, 15, 20	1,75
1	25	15	1,60
76	Weighted average = 1,8		

Table 3.4 Details of responses obtained during a survey at Bellville Bus Station in 1998 aimed at estimating the disutility that female bus passengers attach to travel time while standing, relative to travel time while seated

Number of respondents	Standing time (minutes)	Additional travel time tolerated (minutes) per respondent	Implied time weighting factor
3	4	0, 3, 5	1,67
5	5	0, 1, 3, 5, 5	1,56
2	6	5, 5	1,83
4	7	5, 7, 7, 10	2,04
2	8	8, 10	2,13
4	9	5, 9, 9, 10	1,92
7	10	5, 10, 10, 10, 12½, 15, 15	2,11
6	12	10, 10, 10, 15, 15, 15	2,04
5	13	10, 13, 13, 15, 15	2,02
4	14	10, 15, 15, 20	2,07
5	15	10, 15, 15, 15, 20	2,00
1	18	25	2,39
1	20	30	2,50
49	Weighted average =		2,0

Commuters' attitudes towards walking times (variable *B* in equation 3.1)

During the 1980s the National Institute for Transport and Road Research (of which the author was a member) undertook a study of 1 045 Black commuters living and working throughout the Pretoria area. This was the Pretoria Black Commuting Study (Morris, 1983).

The commuters interviewed were selected to be representative of the great variety of journeys (long, medium, short, bus, train, minibus taxi, mixed mode, with and without transfers, etc.)

undertaken by public transport in the Pretoria area. Among the 1 045 commuters interviewed, there were 497 bus-only commuters, 184 train-only commuters and 55 minibus taxi-only commuters. The remaining 309 commuters used two or more modes during journeys.

The objective of the Pretoria Black Commuting Study were threefold:

- (a) to establish the facts and reality of Black commuting (how do commuters reach their places of employment in Pretoria, what modes do they use, how long does the journey take, etc.);
- (b) to establish the levels of service considered satisfactory and unsatisfactory by Black commuters; and
- (c) to investigate in detail the key operational aspects of the public transport system which cause dissatisfaction and to identify the reasons why these problems exist.

Walking times at both the home-end and the work-end of the journey were obtained. Both times were calculated as the difference between the time of leaving home and the time of arriving at the bus stop or station (home-end) and the difference between the time of arriving at the final bus stop or station and the time of arriving at the place of work (work-end). All these times were sufficiently well known to the commuters to produce adequate reported walking times.

The average home-end walking time was 13 minutes. As only 22 percent of the commuters walked for more than 15 minutes, it is clear that most lived within about a kilometre's walk of their first mode of transport. Details of these walking times are shown in Table 3.5.

Table 3.5 Distribution of home-end walking times

Home-end walking time (minutes)	Respondents	
	Number	Percentage
0 < 5	305	29
5 < 10	261	25
10 < 15	246	24
15 <	224	22
Total	1 036	100

The first mode for most commuters (76%) was the bus. Twenty-two percent walked to a railway station and two percent walked to a minibus taxi. Walking times to railway stations averaged 18 minutes compared with twelve minutes to the bus and nine minutes to the minibus taxi. A detailed break-down is given in Table 3.6.

Table 3.6 Comparison of walking times from home to bus, train and minibus taxi

Home-end walking time (minutes)	Percentage of respondents		
	to bus (N=773)	to train (N=227)	to minibus taxi (N=17)
0 < 5	34	7	64
5 < 10	27	20	24
10 < 15	23	30	0
15 <	16	43	12
Total	100	100	100

The average work-end walking time was 11 minutes.

As shown in Table 3.7, most commuters worked within about a kilometre's walk of their final mode of transport.

Table 3.7 Distribution of work-end walking times

Work-end walking time (minutes)	Respondents	
	Number	Percentage
0 < 5	337	34
5 < 10	333	33
10 < 15	162	16
15 <	166	17
Total	998	100

Most commuters walked to their place of work from a bus stop (59%), while 39 percent walked from a railway station and two percent walked from a minibus taxi. Train passengers had the longest average walk (13 minutes). Bus passengers walked an average of 10 minutes and minibus taxi passengers an average of 8 minutes. Table 3.8 gives a detailed comparison of these walking times.

Table 3.8 Comparison of walking times to work from bus, train and minibus taxi

Work-end walking time (minutes)	Percentage of respondents		
	from bus (N=607)	from train (N=409)	from minibus taxi (N=24)
0 < 5	43	18	58
5 < 10	29	41	21
10 < 15	15	19	16
15 <	13	22	5
Total	100	100	100

Walking time at the work-end was viewed as more unsatisfactory than at the home-end: 42 percent of the commuters were dissatisfied at the work-end. Walking time at the home-end was the source of less dissatisfaction, with only 26 percent of the commuters dissatisfied. Train-only commuters were slightly more dissatisfied than bus-only commuters with each walking time.

The dissatisfaction expressed was not great considering that the average walking times were long by Western standards. Lam and Morrall's study (1982) in Calgary, Canada, for example, showed that the average walking time in suburban residential areas was only four to five minutes. In the central business district and industrial areas of Calgary, average walking times were only two to four minutes.

Table 3.9 shows how satisfaction decreased and dissatisfaction increased as home-end walking time increased. Walks of up to ten minutes were largely satisfactory, but there was substantial

dissatisfaction with walks of 10 - 15 minutes. Most commuters were dissatisfied with walks which exceeded 15 minutes.

Table 3.9 Relationship between satisfaction and home-end walking times

Home-end walking time (minutes)	Number of respondents			
	Satisfied	Mixed feelings	Dissatisfied	Total
0 < 5	204	7	124	335
5 < 10	193	23	116	332
10 < 15	73	19	70	162
15 <	43	10	113	166

The relationship between satisfaction and work-end walking time (see Table 3.10) was anomalous in that dissatisfaction with walks of only up to five minutes was surprisingly high.

Table 3.10 Relationship between satisfaction and work-end walking times

Work-end walking time (minutes)	Number of respondents			
	Satisfied	Mixed feelings	Dissatisfied	Total
0 < 5	274	9	22	305
5 < 10	196	18	47	261
10 < 15	147	19	79	245
15 <	86	15	120	221

Two interesting observations can, however, be made from examining Table 3.10 and comparing it with Table 3.9. Firstly, the broad pattern of satisfaction and dissatisfaction is similar: most commuters were satisfied with walks of up to ten minutes; feelings were mixed for walks of 10 - 15 minutes, and most commuters were dissatisfied with walks exceeding 15 minutes.

Secondly, dissatisfaction was greater with the work-end walk than with the home-end walk for each time band. This finding suggests that fatigue at the end of the journey and possible anxiety about arriving at work on time combine to make walking time at the work-end more crucial and more unsatisfactory than walking time at the home-end (Morris, 1983:12).

According to Morris (1985) commuters who expressed their "satisfaction" with walking times indicated that they regarded walking time minutes (on average) as twice as costly as riding time minutes, and that commuters who were "dissatisfied" with walking times regarded walking time minutes (on average) as three times more costly than riding time minutes. In this study the "mixed feelings" assessment is assumed to indicate a relative disutility rating of 2,5 (i.e. the average disutility of "satisfactory" and "dissatisfactory" walking times). Based on these relative cost assessments, the weighted average disutility factor for home-end walking minutes relative to riding minutes, using Table 3.9 is 2,3. The similar disutility factor for work-end walking time, based on Table 3.10, is 2,5. A default weighting factor of 2,5 with respect to walking during access and egress is recommended in this dissertation.

Estimation of the disutility that bus passengers attach to transfer time relative to seated vehicle travel time (variable D in equation 3.1)

A survey was conducted during 1996 at Mowbray Bus Terminus (next to Mowbray Railway Station) in Cape Town with a view to estimating the relative disutility that bus passengers attach to transfer time at the terminus/transfer facility. (This is a partially sheltered facility functioning neither well nor poorly.)

Transferring passengers were asked: (1) how long (to the nearest five minutes) their total journey time from boarding the first bus to alighting from the last bus usually lasts; (2) how long (to the closest 2,5 minutes) their transfer time usually lasts; and (3) if it were possible to catch a bus on which a seat is guaranteed and **on which no transferring takes place**, but the total travel time increases due to the circuitous nature of the route followed, how much extra travel time they would tolerate (to the closest 2,5 minutes), taking all-year-round weather conditions into consideration.

Of the approximately 80 passengers approached during the survey, 27 usable responses were obtained. These responses are summarised in Table 3.11.

In an attempt to increase the reliability of the abovementioned results obtained during 1996 at Mowbray Bus Terminus, the facility was again visited during the last week of February 1998. Exactly the same questions asked during the 1996 survey were again posed to transferring passengers. Of the 38 passengers approached during the survey, 14 usable responses were obtained. These responses are summarised in Table 3.12

The survey results suggest that the appropriate weighting factor for transfer time at Mowbray Bus Terminus should be 2,4. The results obtained during the two surveys do not differ significantly. However, **a default weighting factor of 2,5 with respect to transfer time at partially sheltered facilities which function neither well nor poorly is recommended** in this dissertation. This is done because the literature survey has shown that the factors whereby time is weighted usually vary between 1,5 and 3,0 with increments of 0,5 or 0,25 between them (ECMT, 1973:60; AASHTO, 1977:104; Horowitz, 1981:149; Pienaar, 1986:9; Ortúzar & Willumsen, 1990:262; Vuchic, 1992:280; MVA Consultancy, 1994:263; Gwilliam, 1997:3).

A similar type of survey was conducted at Bellville Bus Station (next to Bellville Railway Station) during the first week of March 1998. Bellville Bus Station is a sheltered facility which functions effectively.

Of the 106 passengers approached during this survey, 43 usable responses were obtained. These responses are summarised in Table 3.13.

An average implied time weighting factor of 1,91 was obtained from the Bellville Bus Station data. However, **a rounded default weighting factor of 2,0 with respect to transfer time at sheltered facilities which function effectively is recommended** in this dissertation. A different default value as the value recommended for transfer time at facilities which function neither well nor poorly is supported by the fact that a one-directional variance analysis indicated that the averages obtained during the Mowbray and Bellville surveys differ significantly.

Table 3.11 Summary of responses obtained during a survey in 1996 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Mowbray Bus Terminus, Cape Town

Total travel time (minutes)	Duration of transfer (minutes)	Additional travel time tolerated (minutes)	Implied time weighting factor
25	10	10	2
30	5	10	3
30	7,5	10	2,33
30	10	10	2
30	10	12,5	2,25
35	5	5	2
35	5	10	3
35	10	10	2
40	7,5	10	2,33
40	10	10	2
40	10	15	2,5
45	5	7,5	2,5
45	7,5	10	2,33
45	7,5	12,5	2,67
45	10	15	2,5
50	5	10	3
50	10	10	2
50	10	15	2,5
55	7,5	10	2,33
55	10	15	2,5
60	5	10	3
60	7,5	10	2,33
60	10	15	2,5
60	12,5	15	2,2
75	10	10	2
75	10	15	2,5
90	10	15	2,5
Average			2,4

Table 3.12 Summary of responses obtained during a follow-up survey in 1998 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Mowbray Bus Terminus, Cape Town

Total travel time (minutes)	Duration of transfer (minutes)	Additional travel time tolerated (minutes)	Implied time weighting factor
30	5	10	3
30	10	15	2,5
30	10	20	3
35	5	5	2
35	7,5	10	2,33
40	5	7,5	2,5
40	10	10	2
45	10	12,5	2,25
50	5	5	2
50	10	10	2
50	15	20	2,33
60	10	10	2
60	10	15	2,5
70	10	15	2,5
Average			2,35

Table 3.13 Summary of responses obtained during a survey in 1998 aimed at estimating the disutility that bus passengers attach to transfer time relative to seated travel time at Bellville Bus Station

Total travel time (minutes)	Duration of transfer (minutes)	Additional travel time tolerated (minutes)	Implied time weighting factor
20	5	2,5	1,5
20	7,5	5	1,67
25	5	5	2
25	10	7,5	1,75
30	5	5	2
30	5	5	2
30	7,5	5	1,67
30	7,5	5	1,67
30	10	7,5	1,75
30	10	10	2
35	5	5	2
35	10	10	2
35	12,5	10	1,8
35	15	10	1,67
40	5	2,5	1,5
40	5	5	2
40	5	5	2
40	7,5	5	1,67
40	10	5	1,5
40	10	7,5	1,75
40	10	7,5	1,75
40	10	10	2
40	10	10	2
40	10	10	2
40	12,5	10	1,8
40	12,5	15	2,2
45	5	5	2
45	5	5	2
45	7,5	10	2,33
45	10	5	1,5
45	10	10	2
45	12,5	10	1,8
50	5	5	2
50	5	7,5	2,5
50	7,5	7,5	2
50	10	10	2
50	10	10	2
60	7,5	10	2,33
60	7,5	7,5	2
60	10	10	2
75	10	10	2
75	10	10	2
75	12,5	15	2,2
Average			1,91

A similar survey was conducted at Pniel (near Stellenbosch) where bus passengers who commute between Stellenbosch and Paarl have to transfer. The transfer location is not sheltered and no seating and ablution facilities exist. The transfer area is not paved: during windy conditions the air is dusty and during periods of rain the waiting area becomes muddy. Overall judged the transfer conditions are poor.

Of the 16 passengers who transferred there during the surveyed journey eleven usable responses were obtained. An average implied time weighting factor of 3,09 was obtained (3 statements implied a weighting of 2,0; 4 statements implied a weighting of 3,0; and 4 statements implied a weighting of 4,0).

A default weighting factor of 3,0 with respect to transfer time at unsheltered and disorganised transfer locations is recommended in this dissertation. A different default value as the value recommended for transfer time at transfer facilities which function neither well nor poorly is supported by the fact that a one-directional variance analysis showed that the averages obtained during the Mowbray and the Stellenbosch-Pniel surveys differ significantly.

Estimation of the disutility that transit passengers attach to waiting time during access (variable C in equation 3.1)

Approximately 95 percent of the respondents in the Pretoria Black Community Study stated less dissatisfaction with waiting times at a facility (i.e. after arriving at a facility but before departure) than with walking times. The remaining five percent of commuters indicated that they felt uneasy while waiting at over-crowded facilities. The latter group stated an indifference (in terms of disutility) between walking to terminals and waiting at terminals. None of the commuters were more dissatisfied with waiting times than with walking times.

During the surveys at Mowbray Bus Terminus, Bellville Bus Station, and Stellenbosch-Pniel approximately ten percent of the commuters who stated the measure of disutility that they attach to transferring also expressed an opinion on waiting times during access. In the rule these commuters stated that they regard transferring as a greater nuisance than waiting during access.

Based upon the above reactions the following **default weighting factors are suggested with respect to waiting time during access:**

- at a well-designed and sheltered facility which functions effectively $c : 1,5$
- at a partially sheltered facility functioning neither well nor poorly $c : 2,0$
- at a badly designed and unsheltered facility which is relatively disorganised $c : 2,5$

Converting disutility to monetary units requires an assumption about the value of time of each individual. Indigent people have lower values of time than affluent people. Consequently, alternatives that principally serve the affluent tend to have greater user benefits than alternatives that serve the indigent. Such a bias may be inequitable and unacceptable for transit projects whose principal purpose is to provide transportation for the mobility of lower-income groups. The

supplementation of economic evaluation by social evaluation to accommodate a higher degree of equitable welfare distribution in project selection is detailed in Chapter 6.

3.4 THE USERS OF STREETS ADJACENT TO THE FACILITY

The creation of an off-street passenger transport terminal will lead to an increase in the normally limited availability of street space. This could result in freer traffic flow, especially if there are also sound traffic control arrangements in the immediate vicinity of the facility. Improved traffic flow offers motorists the benefit of savings in travel time and vehicle running costs. The freer traffic flow could also lead to a reduction in the risk and costs of accidents.

Savings in vehicle running costs as a consequence of a new or improved passenger transport terminal can usually be calculated fairly accurately by working out the difference in running costs with and without the new or improved terminal. This is done by taking into account (1) the distance savings (if any) by vehicles using such new facilities and (2) the shorter average vehicle travel time per kilometre (including shorter vehicle idling times). This calculation procedure is detailed in Pienaar (1985:215-229). To avoid double counting with respect to the costs calculated in 3.3 above, in evaluating time savings a distinction must be made between such savings for transit vehicles and for other vehicles. As far as vehicle users are concerned, time savings are manifested in terms of working and leisure time. The use of the abovementioned units of time updated from time to time on behalf of the Department of Transport (Naude, 1992) is also recommended in this instance.

Determining the benefit of accident prevention quantitatively requires an estimation of the number of potential accidents and their degree of seriousness (based on similar traffic conditions and terminal situation). The saving in accident costs may be obtained by deducting the expected accident costs of the new or improved terminal from the accident costs of the current situation. The accident cost data updated from time to time on behalf of the Department of Transport (Naude, 1992) can be used in this instance.

An example of how an economic evaluation of a road improvement can be conducted, can be followed along the lines described by Schutte (1984) and involves the determination by means of traffic models of vehicle travel speeds with and without the supply or improvement of a transfer facility. The proposed information which can be used to model the vehicle running costs for use in such an evaluation is given in Schutte & Pienaar (1996). The aforementioned example and vehicle running cost models are based on previous academic research conducted by the author (Pienaar, 1985:chapter 7) and they are therefore not repeated here.

3.5 THE GOVERNMENT INSTITUTION/FACILITY DEVELOPER

In cases where the transport authority or other property developer involved in the operation of a terminal also makes the property available for commercial activities, income from rent is derived as a financial benefit. According to Hoel (1986:37) an operating body should not depend too heavily on income derived from commercial activities. Large passenger numbers are no guarantee of commercial success as travellers who use terminal facilities are not captive buyers. Furthermore, in South Africa a large proportion of transit users earn relatively low incomes.

Yet it should be borne in mind that the possible financial returns from business activities at a terminal or transfer facility should not be included as an economic benefit in a transport economic benefit-cost analysis of these facilities. The rental from businesses and the returns realised by traders at such facilities have nothing to do with the economic sources sacrificed in the transport process. In the first place, these financial returns do not reduce the opportunity costs of the public transport process. In the second place, it can be accepted that the business activities at such facilities would in any event occur elsewhere because the travellers are not captive buyers (and thus make their purchases voluntarily) and therefore do not enhance the economic welfare of the community. However, passengers can save time and possibly a trip if shopping is done at the terminal or transfer facility. In cases where such savings are expected to materialise, their value must be included in the analysis.

Transit operators who use effective terminal facilities can bring about savings in vehicle operating costs. Such savings can be expressed as lower fares and/or savings in the subsidy expenditure of the regulating transport authority (i.e. government institution). But it must be remembered that the latter savings must not be included as an additional economic benefit in the benefit-cost analysis of the facilities. The reason for this is that the saving in transit operating cost has already been included as an opportunity cost saving in the calculation in benefit-cost analyses (see section 3.2) and benefits will be counted twice if a reduction in subsidy obligations is also counted.

3.6 NON-TRANSPORT ECONOMIC BENEFITS

Non-transport economic benefits do not really involve savings but represent a group of plus factors or returns which are partly the consequence of incentives and investments in other sectors of the economy. They can be seen as general economic benefits, above and beyond the direct transport benefits, which contribute to the welfare of everyone within the geographical sphere of influence of the facility. It is critical to note the qualification: "within the geographical sphere of influence of the facility". The non-transport economic "benefits" of a transport facility usually amount to a transfer of economic activities (which would have taken place elsewhere anyway) to the location or vicinity of the transport facility. The extent to which general economic (non-transport economic) benefits can be ascribed to the provision and operation of a new transport facility is determined by the extent to which accessibility and mobility are increased and facilitated. The latter are directly expressed in transport cost savings - that is, those savings discussed in section 3.2 to 3.4.

Seeing that an increase in non-transport economic benefits is nothing more than a spatial transfer of returns which would in any event have been realised elsewhere, these apparent benefits are not credited to a transport facility in benefit-cost analyses. It must be remembered that additional investment (above and beyond that necessary for the terminal or transfer facility) is a prerequisite for the realisation of non-transport economic benefits.

A road which opens up a fertile area for agricultural development, for example, will not be credited in terms of the economic benefit of the agricultural returns in a transport economic benefit-cost

analysis - it will be regarded as a benefit of the agricultural investment whereby it came into being (above and beyond the investment in the road). Similarly the additional investment in the non-transport-related sections of a terminal (such as commercial areas where goods and services not related to passenger transport are traded) will receive the credit for returns from commercial activities which might occur there and not the investment in the terminal facility itself.

The additional income stemming from the multiplying effects of investment in a terminal, and any increase in commercial activities stemming from the later operation of such a facility, is therefore not taken into account in an economic evaluation.

3.7 DETERMINING BENEFITS FOR USE IN ECONOMIC EVALUATION

The economic benefit from the implementation and operation of passenger transport terminals and transfer facilities is equal to the saving it brings about in recurring costs. These costs are the travel costs (excluding the financial expenses) of those who use the facility, transit operating costs, the costs for road users on the roads where the traffic conditions are influenced by the facility, and the operating costs of the facility. The expected saving is calculated by using the with-and-without method described in section 3.1. However in section 3.1 the benefit accruing to additional or generated traffic is not considered. On the assumption that demand for a transport facility is represented by a linear demand schedule, half of the benefit accruing to each existing journey is added to the project benefits for each generated trip. This is based on the additional consumer surplus accruing to existing and diverted users and the new consumer surplus created with respect to generated traffic.

The consumer surplus is the difference between the price a consumer or user actually pays for a product (i.e. a good or a service) and the amount that he would be willing to pay for the product. (A user's willingness to pay for a good or service is reflected by the satisfaction or utility he or she derives from the product, which is taken to be greater than the price actually paid.) In Figure 3.2 the willingness of users to make use of a transport facility at different prices is represented by demand curve D. The area below the market demand curve (schedule) represents users' total utility

that they will derive from consuming or using a product. In the case of transport the area below the demand curve is represented by the total of place utility and time utility. At traffic volume T_0 the user cost per journey (the price paid) is equal to U_0 , with a resultant consumers' surplus represented by area UAU_0 .

If, for example, the facility referred to above is improved so that the user cost for existing traffic is reduced to U_1 and the existing traffic volume is T_0 , the savings for existing users is represented by rectangle U_0ACU_1 in Figure 3.2. This rectangle is the area by which the consumers' surplus or net utility of the existing users increases. If $T_1 - T_0$ represents the generated traffic volume, the benefit achieved by generated traffic is not represented by rectangle $AA'BC$; instead, the demand curve halves the "savings" to the area of triangle ABC , which represents the consumers' surplus of the generated traffic.

The benefits achieved by each individual traffic component is calculated thus:

- (1) The savings accruing to existing traffic and normal growth traffic (i.e. that traffic growth which would have taken place anyway, even if the facility was not improved) are computed by subtracting each group's user cost between origin and destination with the new facility from what it would have been without the new facility.
- (2) The benefit of traffic diverted from other routes and transport modes is calculated by subtracting the cost of diverted journeys from the cost saving affected on those routes and by those transport modes from which traffic has been diverted.
- (3) The benefit accruing to generated traffic is equal to the consumers' surplus created with respect to this traffic component (see Figure 3.2).

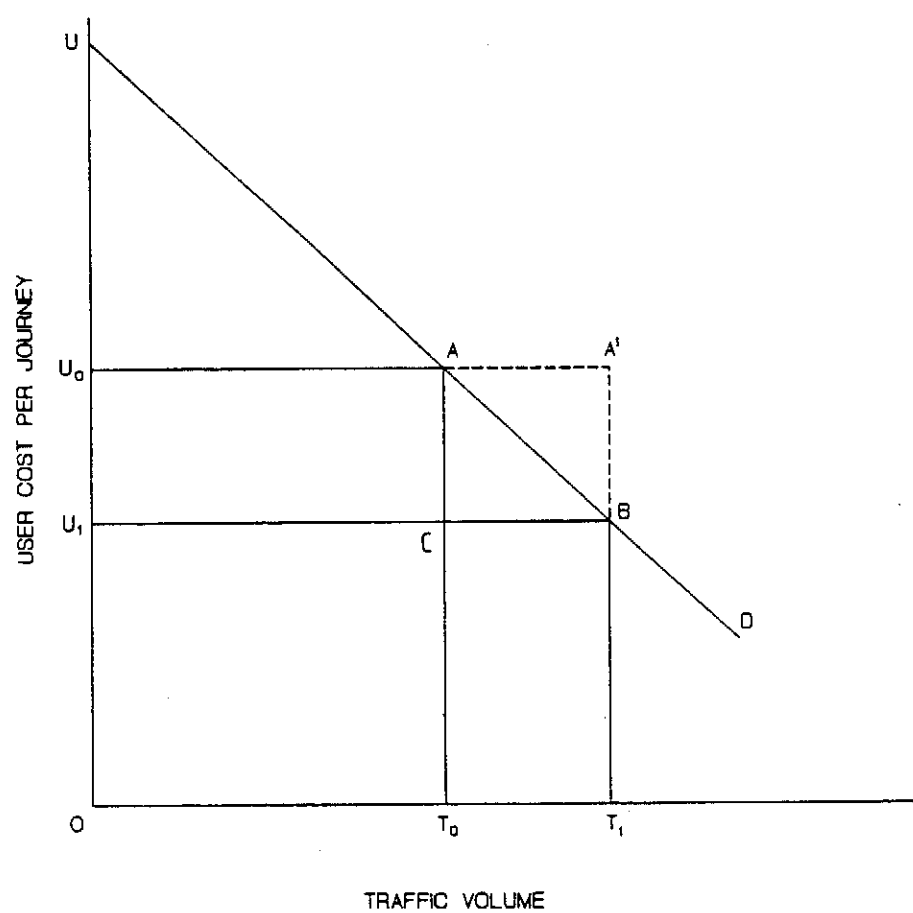


FIGURE 3.2 Potential users' benefits over a specific period in respect of a new or improved facility

3.8 LIST OF TERMS

Disutility: A negative satisfaction, e.g. discomfort, frustration, inconvenience, irritation, pain, tiredness.

Generalised trip cost: The degree of perceived disutility, based on user sacrifice, that leads to resisting the undertaking of or participation in a trip.

Perceived monetary trip cost: The amount of money which the vehicle user believes he sacrifices for a trip, as based on his awareness of the monetary input required to bring about the trip or participate in it.

Place utility: The value derived by a person from being at a specific location or by reaching a destination.

Time utility: The value derived by a person from arriving at a destination at the desired or intended time.

Util: One unit of satisfaction.

Utility: The satisfaction derived from an activity, particularly consumption.

CHAPTER 4**DETERMINING THE COST COMPONENT OF BUS AND MINIBUS TAXI
TERMINALS AND TRANSFER FACILITIES FOR USE IN
ECONOMIC EVALUATION****4.1 OPPORTUNITY COST OF THE INVESTMENT**

It was indicated in Chapter 3 that, in economic evaluation, recurring costs form the basis for calculating benefits. As opposed to this the opportunity cost of the investment or construction (the so-called one-off cost) is the cost component in economic evaluation. (See definition of "economic evaluation" in section 1.2.)

The opportunity costs of construction include the costs incurred in direct planning (traffic surveys, studies of bus use and establishing a facility, environmental impact studies, etc.), the direct costs of designing the terminal, the acquisition and development of the site (demolishing, levelling, reinforcement, etc.) and the construction of the terminal (including the construction of access roads). Each item includes the opportunity costs for materials used, wages paid and operating and overhead equipment bought (AASHTO, 1977:37) - in fact the actual scarcity value of all inputs which are inevitably needed to create the facility (that is, to supply it complete and ready for transit operation).

Care must be taken to include in the analysis only the costs of that part of the facility which is necessary for the functioning of the terminal and the transfer facility for transit purposes. Spaces which are used for commercial activities and entertainment, for example, are non-transport economic considerations and the costs associated with them are left out of the evaluation. It is recommended that the evaluator makes use of the services of a quantity surveyor to compile a complete quantity survey for the construction of the facility to determine the additional costs caused by the non-transport related amenities. In this way it can be ascertained whether the initial cost estimates must be adapted to reflect the opportunity cost more accurately.

The economic costs associated with creating an asset are reflected in the opportunity costs of the initial investment minus the discounted end value of the asset at the end of its service life. Naturally the facility will have an economic end value only if its remnants (at the end of the service life of the facility) have an opportunity cost - in other words if it can be used for alternative purposes.

4.2

If the site upon which a terminal facility is to be erected will be made available again for an alternative use, the cost component of such a facility could be calculated in two ways for use in an economic evaluation. In the first instance, it is the sum of the discounted opportunity cost of facility development (direct costs of facility planning, design and construction) and the discounted annual benefit which is sacrificed or forfeited by not using the site of the facility for its most likely alternative use. In the second instance, the investment amount can be calculated by adding the discounted cost of facility development to the market price of the needed site (discounted from the moment that it is withheld from the alternative use and not necessarily from the moment of purchase). From this total the realisable value of the site at the end of the facility's service life is deducted, discounted from the moment it is foreseen that the site could be used again in an alternative way, regardless of whether the land is sold or not.

If it is foreseen during the planning of a facility that the site on which it is to be erected will be permanently allocated to accommodating a passenger transport terminal, the site naturally has no end value which can be discounted and deducted from the initial cost of investment. This is so because the site will be kept from being used for an alternative application and thus will have no opportunity cost at the end of the facility's service life.

As the service periods of passenger transport terminals and transfer facilities are usually 30 years and longer, it is unlikely that one could establish with certainty during an economic evaluation what a facility's site will be used for after its service period has come to an end. For this reason it is recommended that, in dealing with end value in an economic evaluation, sensitivity analyses be executed: one in which the end value is equal to the current opportunity cost of the land and one in which the end value is equal to nil (i.e. there is no opportunity cost).

It could be the case that there is no clear indication as to what the site will be used for after termination of the service life of the facility and that the decision-maker indicates that sensitivity analyses in a specific economic evaluation must be kept to the minimum. In such cases it is recommended that the end value of the site (i.e. the land) be regarded as 50 per cent of the land value at the time of the evaluation. The latter is equal to the arithmetical average of the opportunity cost of the land when available for alternative use and when not available for alternative use.

The end value of other facility remnants on the site is nil in all cases because they have no alternative application possibilities: on the one hand, the structure is a specialised transport facility which

eliminates alternative use and, on the other hand, at the end of its service life it is functionally completely obsolete which makes re-use of structural components impractical.

4.2 ASSESSMENT OF COSTS

4.2.1 Sunk costs

The economic evaluation of projects is future-oriented. All costs incurred before an evaluation with respect to items that have no alternative use (for example, planning, design and development costs) are regarded as sunk costs and are therefore excluded from an economic evaluation as their dedication to the project is irreversible - they cannot be avoided or salvaged by trading them or using them somewhere else.

4.2.2 Shadow prices

Economic evaluation is based on a consideration of opportunity costs and involves determining the scarcity value of inputs in a project and of the outputs produced as a consequence. The opportunity cost is the value of the best alternative application of an input or an output of a project and therefore represents prices which can be used in an economic analysis - actual economic values. In order to assess the economic efficiency of the application of resources in projects, it is essential that the prices of the inputs and the outputs reflect their scarcity value.

If transaction prices do not reflect the relative scarcity value of resources, such costs should be expressed as shadow prices for the economic evaluation of government and community projects. The use of shadow prices provides for subtracting taxes from and adding subsidies to the prices/costs of project inputs and outputs for the purpose of an economic analysis. Taxes and subsidies do not represent economic resources but simply involve transfers of funds between the public and private sectors. Benefits and/or costs may be under- or over-emphasised if taxes and subsidies are not excluded from an analysis of community projects. A shadow price can therefore be described as a transaction price (which includes the normal profit that will be realised in a competitive market) minus taxes and plus subsidies, along with other refinements which take into account the effect of statutory price fixing and other price distortions. Economic evaluation must be based on shadow prices as:

4.4

- there will be double counting if government levies on vehicle operating input (utilised for the provision, maintenance and control of transport facilities and services) are included with road user costs;
- there will be cost exaggeration if indirect taxation, which serves as general state income, is included in the costs of a transport project; and
- the inclusion of indirect taxation will lead to distorted cost comparisons in cases where projects are compared and their inputs are taxed disproportionately or not at all.

The Central Economic Advisory Service (CEAS, 1989:18) recommends that the shadow price of existing buildings is calculated on the opportunity-cost basis and that of new buildings on the basis of building costs. Where building costs serve as a basis for these calculations, adjustments have to be made for possible distorted labour prices which serve as an input.

The following approach to determine the shadow price of labour is proposed by the CEAS (1989:19):

- "Where unemployment does not exist, the market price of labour is used for all labourers. If the quality of a specific category of labour within a sector is homogeneous and the market operates fairly freely, then the average wage of the category concerned in that sector can be accepted as reflecting the market price in the sector. Under conditions of full employment and especially where skilled labour is particularly scarce, this estimate will probably underestimate the opportunity cost of labour, but in the absence of specific information it is not normally possible to calculate it more accurately."*
- "Where unemployment exists the shadow wage of semi-skilled and skilled workers (excluding professionals and managers) is based on the average minimum wage set for the lowest paid workers in the industry concerned. In general it is unlikely that a lower shadow wage will apply, so that the possibility of over-estimating the opportunity cost of the labour involved is small. Even under conditions of unemployment the labour of professionals and managers must still be valued at market prices."*

The shadow prices to be used in the economic evaluation with respect to vehicle classes which make use of passenger transport terminals and transfer facilities are those updated from time to time on behalf of the Department of Transport (Schutte & Pienaar, 1996) and are obtainable from that Department on request.

In addition to the use of shadow prices, certain adaptations are also required for an economic evaluation. These adaptations are described in the following sections.

4.2.3 Unforeseen expenses and inflation

In calculating the costs of a project provision is often made for unforeseen and contingency expenses. There are two instances of possible higher costs:

- costs may be higher than expected because the work is more complicated or comprehensive; and
- costs may be higher as a result of inflation which leads to higher prices for labour and other production factors.

For the purpose of an economic evaluation it is incorrect to include in costs a contingency allowance for general price increases. Tender prices (even those of the successful tenderer) seldom represent the opportunity costs of an investment in a project. It is therefore recommended that the evaluator makes use of the services of a quantity surveyor to compile a complete quantity survey for the construction of the facility (this relates to physical quantities plus labour needed) (TRRL, 1988:20). In this way it can be ascertained whether the initial cost estimates must be adapted to reflect the opportunity cost more accurately. A detailed routine that can be followed to determine construction costs of transportation projects for use in economic evaluation has been provided by the TRRL, Chapter 4 (1988:17-25).

General price increases do not influence the economic value of resources used or saved. Costs and benefits should be expressed in terms of real/deflated prices (Adler, 1987:15). It is also common practice to assume that prices will not increase differentially and therefore all costs in an economic evaluation are expressed in the real values of a particular base year (preferably close to the time of the evaluation).

4.2.4 Interest during the construction period

Interest during the construction period should not be included in the economic cost of a project. It is often included when the project is financed by loans but is excluded when the project is financed from allocations from general state income. But it has no meaning in relation to the economic cost of a project as the resources actually used are the same regardless of the method of finance (Adler, 1987:16).

4.2.5 Other cost considerations and concepts

The specific economic evaluation techniques within which the benefits and costs (as identified in this chapter) are applied are discussed in Chapter 5. As this dissertation deals with the economic evaluation of specific passenger transport terminals and transfer facilities, and not primarily with the general principles of economic evaluation or benefit-cost analysis, the reader who requires basic guidance with such an analysis in general is referred to the following four reference works:

- (1) *Manual for cost-benefit analysis in South Africa* (CEAS, 1989);
- (2) *Guidelines for conducting the economic evaluation of urban transport projects* (Hromic, 1995);
- (3) *Manual on the economic evaluation of transportation projects* (Schutte, 1984); and
- (4) *Overseas Road Note 5, A guide to road project appraisal* (TRRL, 1988).

CHAPTER 5**TECHNIQUES OF ECONOMIC
PROJECT EVALUATION****5.1 INTRODUCTION**

The purpose of this chapter is to discuss the use of economic evaluation techniques for the selection and prioritisation of projects. This is supplemented in section 5.3 by an economic evaluation of a hypothetical bus/minibus taxi terminal. Section 5.4 examines how the design and effectiveness of a real world passenger transport terminal (the Wynberg Bus Terminal in Cape Town) is affected by the use of the economic evaluation procedure proposed in the dissertation.

The economic problem of scarcity of resources leads to budget limitations at all levels of decision-making. This, along with the fact that the community's needs for transport are virtually unlimited, means that one has to be certain that the benefits offered by transport projects exceed the opportunity costs related to the project. This is why potential transport projects must not only be evaluated economically, but projects chosen for implementation need to be selected with circumspection.

The selection of projects on an economic basis usually takes place with reference to the following criteria:

- (1) the economic principles must be strictly observed;
- (2) all alternatives, i.e. the whole range of technically feasible alternatives, should be evaluated;
- (3) all projects must be evaluated in the same manner;
- (4) the cost of any chosen project must be within the scope of the budget; and
- (5) the benefits of a project must exceed its investment cost.

5.2

There are two aspects to the economic choice of projects for implementation, namely project selection and project prioritisation. Project selection involves the selection of the best (in economic terms) mutually exclusive project, or in other words, the most advantageous way of solving a specific transport problem. Mutually exclusive projects are projects which have precisely the same purpose/objective, i.e. they are alternatives for one another. Project prioritisation places all functionally independent projects on a priority list of economic viability. Functionally independent projects are projects which have different purposes/objectives. The selection of an independent project can at most postpone the selection of another, but cannot exclude it.

From an economic viewpoint projects are selected in a descending order of relative viability up to the point where the capital budget has been exhausted. Each independent project competing for selection on economic grounds is naturally already a "winner" in the groups of mutually exclusive projects.

In order to compare alternative transport projects on an economic basis, it is necessary that benefits and costs be assessed on a common time basis. As transport infrastructure projects usually remain serviceable for several years and even decades, the period taken into consideration in the transport economic analysis of such projects is usually twenty years and even longer. Because of the time preference of money, the maintenance and users' costs incurred over the course of time become increasingly irrelevant as the evaluation process incorporates values which lie further and further in the future. The rate at which costs are discounted to current values or, to put it in another way, the rate which represents the continuous value that a community places on a benefit or a cost, is called the social discount rate.

There are various points of departure in economics literature regarding the choice of an appropriate social discount rate. These viewpoints could broadly be separated into three schools of thought, namely those which argue that the discount rate must be equal to the marginal returns on capital (the opportunity costs of capital), those whose arguments depend on long-term real interest rates (the costs of funding for the state) and those that advocate a social time preference rate. The first two schools of thought adopt an economic point of view, while the third has multiple purposes which

5.3

include social objectives. There is no general agreement on the methods to be adopted in establishing a social discount rate. The Central Economic Advisory Service (CEAS) (1989:24) suggests a pragmatic approach which takes the following into account:

- The discount rate used should not be influenced by conjunctural circumstances and policies as the preferences expressed by this rate are geared to the development of the long-term welfare structure.
- A low discount rate in general favours projects which have a high initial capital cost but low recurring costs, while the opposite applies in the case of a high discount rate.
- If the real social discount rate is lower than the implicit monetary or financial discount rate in the private sector, investment by the public authorities will be encouraged at the expense of investment by the private sector. The greater the gap between these two rates, the more strongly this effect manifests itself.
- Development agencies, such as the World Bank, usually use the opportunity costs of capital as the theoretical basis for the choice of a discount rate. Although it is virtually impossible to determine this rate precisely, it is usually accepted that the rate for a developing country is between eight and fifteen percent.

Taking into account the need for employment creation and the development of the private sector, the CEAS (1997) proposed that a real social discount rate of ten percent per year be accepted for South African public investment projects.

5.2 ECONOMIC EVALUATION TECHNIQUES

5.2.1 Evaluation criteria

The individual economic evaluation techniques ascertain the economic viability of prospective projects on the basis of either (Pienaar, 1995a:2.2):

- a. minimum total transport costs which can be determined through the present worth of cost (PWOC) technique; or

5.4

- b. net benefit which is determined by the net present value (NPV) technique; or
- c. relative benefit which is usually determined either by the benefit/cost ratio (B/C) technique or the internal rate of return (IRR) technique.

In terms of their underlying philosophy, these techniques can be classified into two groups. For the first group, only the cost of each alternative is calculated, the argument being that the alternative with the least cost would be superior. The PWOC technique falls in this group. In working with the second group of techniques, both benefits and costs of alternatives are calculated.

Benefits are defined as savings in user costs of existing and normal growth traffic and maintenance costs relative to the null alternative (i.e. the existing situation or present facility whose improvement or replacement is being investigated), plus the consumers' surplus gained through additional usage generated by the proposed facility. The underlying philosophy of techniques falling into this group is that an alternative will be economically viable if benefits exceed costs.

The cost of a project can be defined as the opportunity cost of economic resources sacrificed in implementing (providing) the project (see Chapter 4). The method of identifying the best alternative depends on the specific technique. Three techniques fall into this group: the NPV, the B/C ratio and the IRR technique.

Provided the initial costs of projects do not differ, any one of the abovementioned four evaluation techniques may be used to select the best alternative among a number of mutually exclusive projects. The alternative with the smallest PWOC will have the highest B/C ratio and highest IRR, and will also have the highest NPV. If the initial costs differ significantly (this is generally the case), incremental analysis should be used to identify the most economical alternative.

The PWOC and NPV techniques cannot be used to prioritise independent projects. The absolute value of a project's benefits depends on its scope. The benefits of a large project may, for instance, have a larger net value than the benefits of a smaller project, whereas the relative return of the larger project may be considerably lower than that of the small project. Hence it is better to use either of

the IRR technique or B/C ratio technique for the prioritisation of independent projects, also taking into account the results of the investment timing analyses.

5.2.2 Present worth of cost (PWOC) technique

This technique selects the minimum cost alternative from mutually exclusive projects. For each possible alternative facility, all economic costs (i.e. the opportunity costs) incurred with respect to the provision, maintenance and usage by existing and normal growth traffic are discounted to current values and summed per alternative, minus the consumers' surplus gained through additional usage generated by the proposed alternative. Given the objective of economic efficiency the alternative which yields the smallest PWOC is regarded as the most cost-effective (beneficial) proposal.

The technique can be expressed as follows:

$$PWOC = C_A + PW(M + U) \quad (5.1)$$

where:

$PWOC$ = present worth of cost

C_A = all costs incurred in establishing the facility (i.e. the opportunity cost of the investment), minus the discounted residual value at the end of the analysis period (see section 4.1).

$PW(M + U)$ = present worth of all facility maintenance costs, external costs, and user costs during the period under review. [Note that in the case of the null alternative (i.e. the existing facility whose possible replacement or upgrading is being investigated, and against which the other mutually exclusive alternatives are measured), $PWOC = PW(M + U)$].

When a proposed project will, due to lower user cost, generate and/or develop additional traffic over and above normal-growth traffic, the above-mentioned criterion of lowest total transport cost presents a contradiction in terms and the PWOC can then be reformulated as follows:

$$PWOC = C_A + PW(M + U_N) - PW(CS_A) \quad (5.2)$$

$PW(M + U_N)$ = the present worth of all facility maintenance costs, external costs, and existing and normal-growth user costs during the analysis period; and

$PW(CS_A)$ = consumers' surplus gained through additional usage generated/ developed by the proposed alternative. (A gain in consumers' surplus may be regarded as negative recurring cost which the proposed alternative offers in relation to the null alternative.)

5.2.3 Net present value (NPV) technique

This technique selects the alternative which has the greatest net present value of benefits. The discounted initial costs of an alternative are deducted from the sum of all discounted annual benefits which the alternative offers compared to the existing facility. All alternatives which show a positive net present value of benefits offer transport economic viability, while the one with the highest such value is most suitable for implementation.

This technique can be expressed as follows:

$$NPV = PW(M_O + U_O) - PW(M_A + U_A) + PW(CS_A) - C_A \quad (5.3)$$

where

NPV = the net present value of benefits;

$PW(M_O + U_O)$ = the present value of maintenance costs, external costs, and user costs for the existing situation without the improvement (the so-called null alternative); and

$PW(M_A + U_A)$ = the present value of the maintenance costs, external costs, and user costs for the proposed alternative.

Where a choice has to be made between mutually exclusive projects, the project with the greatest NPV will be selected as this will maximize the net benefit for the community.

5.2.4 Benefit/cost ratio (B/C) technique

This technique selects the most beneficial alternative by placing project benefits in relation to initial project costs. The sum of the discounted benefits are brought into relation with the sum of the projected initial costs by dividing the former by the latter. All proposals with a ratio value greater than one are viable. When mutually exclusive alternatives are compared, incremental analysis must be used to identify the best alternative (i.e. that alternative with the largest net benefit).

This technique can be expressed as follows:

$$B/C = \frac{PW(M_O + U_O) - PW(M_A + U_A) + PW(CS_A)}{C_A} \quad (5.4)$$

5.2.5 Internal rate of return (IRR) technique

This technique calculates the anticipated internal rate of return of each alternative relative to the null alternative. The distinctive feature of this technique is that its application does not entail a singular discounting procedure with one prescribed rate only. Annual benefits for the period under review are discounted to the beginning of the period. The sum of these discounted amounts is compared with the discounted initial cost. Different rates of return are selected iteratively and applied until at a certain rate the sum of the annual discounted returns equals initial costs. This is then referred to as the internal rate of return. If the internal rate of return exceeds the prevailing discount rate, the project is economically viable. However, when mutually exclusive alternatives are compared, incremental analysis must be used to identify the best alternative.

The technique can be expressed as follows:

$$IRR = r$$

when $PW(M_O + U_O) - PW(M_A + U_A) + PW(CS_A) = C_A$ (5.5)

where

r = represents the rate at which the two sides of the equation are equal.

5.2.6 Timing of project implementation and the first year rate of return (FYRR)

Project viability itself, unfortunately, does not indicate the best timing of project implementation. For the timing of project implementation, the project should be analysed with a range of investment timings to see which one would yield maximum viability. When benefits are expected to grow continuously in the future, the First Year Rate of Return (FYRR) can be applied as an investment timing criterion. The FYRR is calculated by dividing the present worth of the benefits accruing in the first year of operation (i.e. the year subsequent to project completion) by the present worth of the capital cost involved, and expressed as a percentage. If the FYRR is higher than the prescribed rate, then the project is timely and should go ahead right away. If the FYRR is lower than the prescribed discount rate, but the NPV is positive, commencement with project implementation should be postponed. In the situation where budgetary constraints limit the construction programme, the FYRR can be used as an aid to prioritise the projects showing similar degrees of economic viability. (TRRL, 1988:70.)

5.3 EXAMPLE OF AN ECONOMIC EVALUATION OF A PROPOSED PASSENGER TRANSPORT TERMINAL

PROPOSED PROJECT

A badly designed and unsheltered passenger transport terminal is to be replaced by a well designed and sheltered terminal facility. The old (existing) terminal facility is located partially on-street and this disrupts passing traffic, while its poor layout leads to delays of buses and minibus taxis making use of it. The planned facility will be located off-street, which will lead to smoother flow of traffic on the adjacent street, while the dwell time of buses and minibus taxis at the new facility will decrease. The terminal is at the end of all bus and minibus taxi routes, which implies that all passengers transfer, end or start their transit journeys there. (There are no through-travelling passengers who remain on board vehicles.)

An economic evaluation of the proposed terminal needs to be performed by calculating the present worth of costs of the existing and proposed facility, and the net present value, the benefit/cost ratio and the internal rate of return of the proposed facility. The following input values and assumptions are supplied:

1. Should the project go ahead, the site on which the facility is to be erected will be withdrawn from alternative use at the end of year 1. (At the moment it is year nil.) The local transport authority, which will own and operate the facility, has the option to purchase the site for R3 000 000. The authority's land assessors judge that this amount reflects the site's opportunity costs.
2. All the needed planning and design of the facility will take place throughout year 1 and the costs of this will amount to R1 200 000 in economic terms.
3. The facility will be erected during year 2 at a fully competitive market price of R43 150 000. This amount includes value added tax of R3 150 000.

4. The facility will have an expected service life of 25 years and it must be evaluated over its entire expected service life. This period commences at the beginning of year 3. At the end of the service life the facility will be completely obsolete. The site is being paid for with Reconstruction and Development Programme funds and therefore the transport authority has pledged to the community that the site will always be used as an access node to public transport.
5. The estimated direct recurring costs (i.e. operating, maintenance and policing costs) of the proposed facility will remain constant at R700 000 per annum. The direct recurring costs of the existing facility amount to R100 000 per annum. Both these costs are in economic terms.
6. The total economic costs of traffic disruption and congestion imposed on adjacent street traffic by the presence of the existing facility amount to R375 000 per annum; these costs will be eliminated if the proposed facility is built and may be regarded as an indirect recurring opportunity cost of the existing facility.
7. Due to the expected improved traffic flow on the adjacent street and the opportunity for freer and orderly vehicle and passenger movement within the new facility, the arrival and departure times of buses and minibus taxis will be more punctual. The improved punctuality, shorter dwell times and shorter travel times will result in an average time saving of five minutes per trip for each bus and minibus which uses the facility. Fifty percent of the buses and minibuses which make use of the existing facility serve routes of which the round-trip cycle times are 40 minutes or less. On average these vehicles will each complete one additional return trip per day if the proposed facility is built, thereby also reducing the average time headway between vehicles. This will not only reduce waiting and transfer times of passengers, but also enable the transit services to carry more passengers, while still reducing the need for some of them to stand in the buses. Regardless of the fact that 50 percent of the transit vehicles will complete one extra trip per day, the total opportunity costs of the bus and minibus operators will, because of increased efficiencies created by the new facility, decline by R25 000 per annum. (These savings are the result of less engine idling and more economic vehicle travel speeds. The savings may be regarded as recurring additional transit operating costs associated with the existing facility.)

8. Owing to the improved quality of service and greater safety/security that will emanate from usage of the proposed facility, the existing average annual patronage of the transit services is expected to increase from 2 500 000 passengers to 2 625 000 passengers with the proposed facility. The additional 125 000 annual passenger trips all represent generated ridership.
9. At present the average travel fare by bus and minibus taxi amounts to R1,50 per single trip (which is the price of the travel ticket to the user). To this amount a central government subsidy of R0,50 (per single trip) is added so that the bus and minibus taxi operators receive R2,00 per single passenger journey. The market is split evenly between the bus and the minibus taxi operators, and the total revenue that they receive exactly covers their opportunity costs.
10. In order to calculate the average non-monetary part of generalised travel costs of the transit passengers (NMGC), equation 3.1 and time weighting factors supplied with this formula are used. (Due to the fact that site-specific time weighting factors were not determined by the local authority, the default values given in the text are to be used as average time weighting factors.) With respect to the other variables in the NMGC formula, the following values apply:

Variable	Existing facility	Proposed facility
<i>U</i>	R5,00	R5,00
<i>VT</i>	25 minutes	21 minutes
<i>A</i>	4 minutes	2 minutes
<i>B</i>	15 minutes	15 minutes
<i>C</i>	10 minutes	6 minutes
<i>D</i>	10 minutes	6 minutes

(Over and above the non-monetary generalised travel cost of the existing users, the consumer surplus or benefit that will accrue to the generated ridership may be regarded as an opportunity cost caused by the ineffectiveness of the existing facility which is eliminated by the effectiveness of the alternative or proposed facility.)

ANALYSIS

Calculation of investment or capital costs (the one-off costs) in year nil values

To obtain the present worth (PW) of the investment costs, the value of the site, and planning and design costs need to be discounted for one year (i.e. be divided by 1,08), while the construction costs need to be discounted for two years (i.e. be divided by 1,08²).

1. PW of site value: $R3\ 000\ 000/1,08$ = R 2 777 778
2. PW of planning and design costs: $R1\ 200\ 000/1,08$ = R 1 111 111
3. PW of construction costs: $(R43\ 150\ 000 - R3\ 150\ 000)/1,08^2$ = R34 293 553
(value added tax is deducted to arrive at the shadow price of construction)*
4. Due to the fact that the facility is expected to be completely obsolete at the end of its service life and that it is not foreseen that the site will be made available for alternative use, no terminal value is assigned to the proposed project.

PW of capital costs is therefore the sum of the above values = R38 182 442

Calculation of benefits in year nil values

To obtain the PW of the benefits of the proposed project, the recurring costs of the two alternative facilities during the service life of the proposed facility (i.e. beginning year 3 to end of year 27) must be discounted to year nil. The PW of the recurring costs of the proposed facility is then deducted from the PW of the recurring costs of the existing facility.

* See section 4.2.2 for a discussion on shadow pricing.

It is given that all the recurring costs of both alternatives will remain constant (i.e. uniform) per annum throughout the service life of the proposed facility. To discount the two series of annual amounts which occur from the beginning year 3 to the end of year 27, the annual costs of each alternative need to be multiplied by the uniform series present worth factor. The uniform series present worth factor at an annual discount rate of eight percent over 25 years = 10,674 776. The two single amounts thus obtained represent beginning year 3 (= end year 2) values and must still be discounted for two years, i.e. divided by $1,08^2$ to obtain their year nil values.

5. PW of direct recurring costs of the existing facility:

$$= R100\ 000 \times 10,674\ 776 / 1,08^2 = R915\ 190$$

PW of direct recurring costs of the proposed facility:

$$= R700\ 000 \times 10,674\ 776 / 1,08^2 = R6\ 406\ 330$$

Saving of direct recurring costs with the existing facility:

$$= R915\ 190 - R6\ 406\ 330 = -R5\ 491\ 140$$

6. PW of indirect recurring costs of the existing facility (traffic congestion on the adjacent street):

$$= R375\ 000 \times 10,674\ 776 / 1,08^2 = R3\ 431\ 962 \text{ (This amount is automatically a benefit (saving) with respect to the proposed facility.)}$$

7. PW of additional user costs resulting from the inefficiency of the existing facility:

$$= R25\ 000 \times 10,674\ 776 / 1,08^2 = R228\ 797 \text{ (This amount is automatically a benefit (saving) with respect to the proposed facility.)}$$

8. There are 2 500 000 existing transit users for whom the annual non-monetary savings in generalised costs are determined by using the "NMGC" formula (equation 3.1). There are 125 000 generated transit trips of which the benefit per passenger is represented by their generated consumer surplus.

On the assumption that the demand schedule of the transit users is represented by a linear function between generalised cost and number of trips, the average benefit (i.e. consumer

surplus) obtained per generated transit passenger trip is equal to 0,5 of the saving per existing transit passenger trip.

9. The passenger travel fare and subsidy granted are not taken into account in the economic evaluation as this will amount to double counting them with the vehicle operating costs of the transit operators.
10. The annual non-monetary component of the existing 2 500 000 passengers' generalised cost with the existing facility:

$$\begin{aligned}
 &= 2\,500\,000 \times R5 \left[\left(\frac{25}{60} \right) + \left(\frac{4}{60} \right) (2-1) + \left(\frac{15}{60} \right) 2,5 + \left(\frac{10}{60} \right) 2,5 + \left(\frac{10}{60} \right) 3,0 \right] \\
 &= R25\,312\,500
 \end{aligned}$$

$$(\text{PW of } R25\,312\,500 = R25\,312\,500 \times 10,674\,776/1,08^2 = R231\,657\,465)$$

The annual non-monetary component of the existing 2 500 000 passengers' generalised cost with the proposed facility:

$$\begin{aligned}
 &= 2\,500\,000 \times R5 \left[\left(\frac{21}{60} \right) + \left(\frac{2}{60} \right) (2-1) + \left(\frac{15}{60} \right) 2,5 + \left(\frac{6}{60} \right) 1,5 + \left(\frac{6}{60} \right) 2,0 \right] \\
 &= R16\,979\,167
 \end{aligned}$$

$$(\text{PW of } R16\,979\,167 = R16\,979\,167 \times 10,674\,776/1,08^2 = R155\,391\,636)$$

The annual saving of non-monetary generalised trip costs of the existing passengers:

$$= R25\,312\,500 - R16\,979\,167 = R8\,333\,333$$

Therefore the annual benefit for the generated passengers:

$$= 0,5 (R8\,333\,333/2\,500\,000) 125\,000 = R208\,333$$

$$(\text{PW of } R208\,333 = R208\,333 \times 10,674\,776/1,08^2 = R1\,906\,643)$$

5.15

PW of the annual benefits as a result of the decrease of non-monetary generalised cost:

$$= (R8\,333\,333 + R208\,333) 10,674\,776/1,08^2 = R78\,172\,472$$

The total benefit of the proposed facility expressed as a year nil value:

$$= -R5\,491\,140 + R3\,431\,962 + R228\,797 + R78\,172\,472 = R76\,342\,091$$

Application of evaluation techniques

- (i) PWOC existing facility = $R915\,190 + R3\,431\,962 + R228\,797 + R231\,657\,465 + R1\,906\,643$ = $R238\,140\,057$
(The PWOC of the existing facility is the sum of the costs under items 5, 6, 7 and 10.)

PWOC proposed facility = $R38\,182\,442 + R6\,406\,330 + R155\,391\,636$ = $R199\,980\,408$
(The PWOC of the proposed facility is the sum of the costs under items 1, 2, 3, 5 and 10.)

- (ii) NPV = $R76\,342\,091 - R38\,182\,442 = R38\,159\,649$
(The NPV of the proposed facility is equal to its total benefit minus its investment or capital cost. Alternatively stated the NPV = PWOC existing facility - PWOC proposed facility.)

- (iii) B/C Ratio = $R76\,342\,091/R38\,182\,442 = 2,0$
(The B/C Ratio of the proposed facility is equal to its total benefit divided by its investment cost.)

(iv) IRR = 18%

Discount rate per annum	Year nil values with selected discount rates		
	Investment cost	Returns	Difference or "NPV"
17	R32 810 286	R35 137 700	R2 327 414
18	R32 286 699	R32 751 438	R 464 739
19	R31 776 005	R30 602 492	-R1 173 513

(The IRR is that discount rate at which the returns or benefits equal the investment amount. Alternatively stated it is that discount rate at which NPV = 0)

A discount rate of 18 percent is the full percentage that comes closest to equalising the two quantities.

Due to the fact that the NPV > 0, the B/C Ratio > 1,0, the IRR > official discount rate and that PWOC proposed facility < PWOC existing facility, the proposed facility is economically justified, i.e. it improves economic efficiency. (As is mentioned in section 5.1 it is not necessary to perform all four described benefit-cost techniques, however, for the sake of illustration the four techniques are all demonstrated here.)

The objective of economic evaluation is the pursuit of economic efficiency, and therefore benefits and costs related to a project are assessed in terms of their scarcity value regardless of the income levels of the groups affected by the project. Indigent people have lower incomes and lower values of time than affluent people. Consequently, alternatives that principally serve the affluent tend to have greater user benefits than alternatives that serve the indigent. Such a bias may be inequitable and unacceptable for transit projects whose principal purpose is to provide transportation for the mobility of lower-income groups. The supplementation of economic evaluation by social evaluation to accommodate a higher degree of equitable welfare distribution in project selection is proposed and detailed in the next chapter. A case study detailing an economic evaluation of a proposed bus passenger transport terminal in Wynberg, Cape Town, is presented in section 5.4.

5.4 CASE STUDY: ECONOMIC EVALUATION OF A PROPOSED BUS PASSENGER TRANSPORT TERMINAL IN WYNBERG, CAPE TOWN

EXISTING SITUATION

All facilities at Wynberg Bus Terminal are located on-street along the sides of the triangle bounded by Brisbane, Broad and Ottery Roads (see Figure 5.1). At present there is inadequate capacity, characterised by long queues and delay in the peak hour. This is due mainly to the lack of space for extra loading berths which is compounded by the lack of free access to and from the terminal for buses. Extra delay is caused by the congested conditions presented by the mixing of buses, through-traffic and pedestrians.

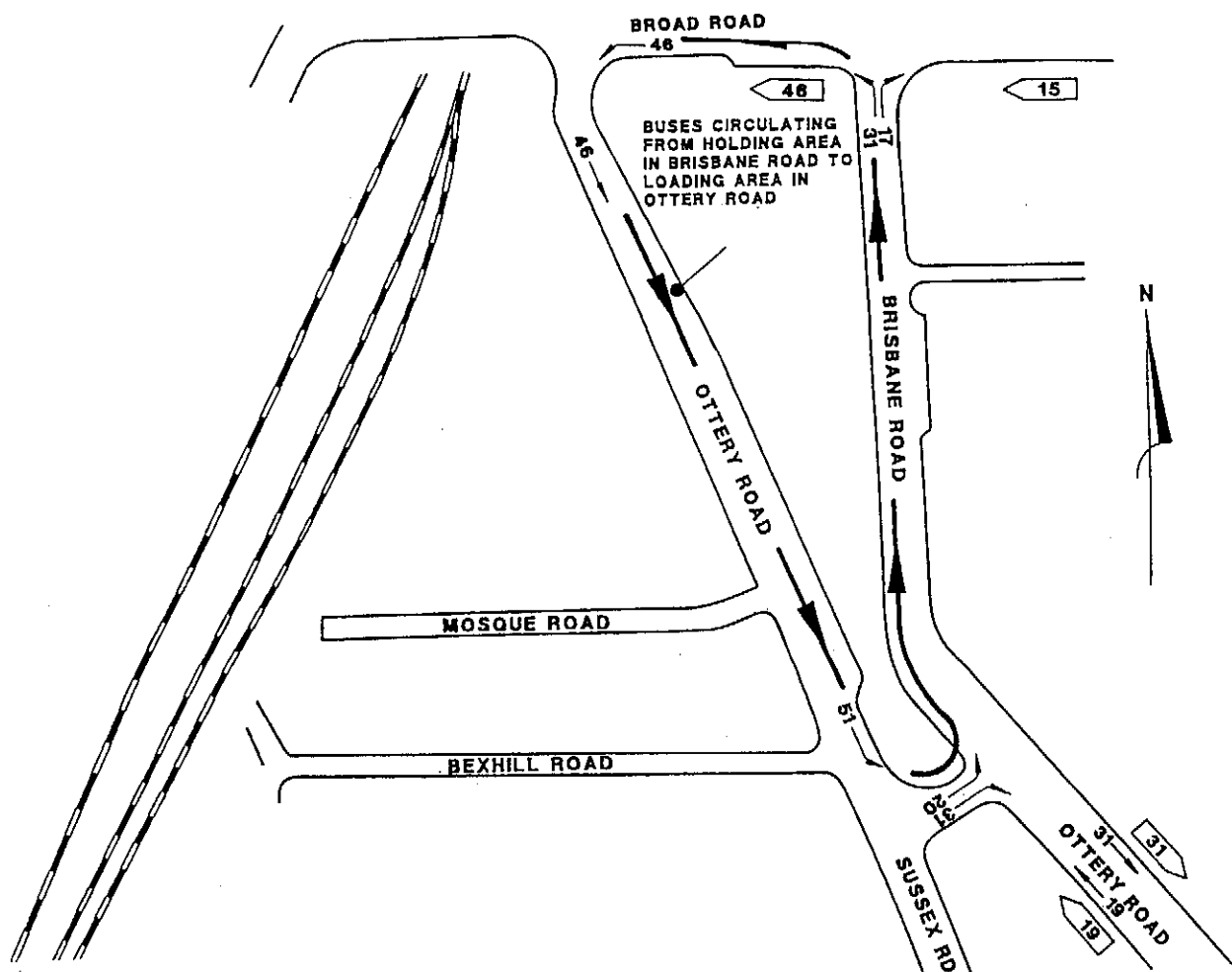


FIGURE 5.1 Location of Wynberg Bus Terminal

(Bus flows indicate the present situation during the afternoon peak hour from 17:00 to 18:00.)

Approximately one-third of all passengers using the terminal transfer between buses within the facility, while the other passengers walk to/from the nearby Wynberg Railway Station and minibus taxi stops. At present just over 4,8 million passengers move through the terminal annually, while just over 2 200 passengers use the terminal during each of the two daily peak hours.

Accessibility of the bus terminal from the railway station is very poor with commuters having to cross unmade dirt surfaces. Shelters are almost non-existent and facilities for bus company personnel are poor. Certain places are well lit but there is a need to provide consistent lighting of the correct standard throughout the terminal to enhance commuter safety. Toilets exist at a reasonable distance from loading and off-loading points but are locked in the evenings.

The existing bus terminus consists of six loading bays (five in Ottery Road on the east side adjacent to the triangle and one in Brisbane Road), and three holding berths in Brisbane Road. Three temporary holding berths are located in Ottery Road on the west side of the triangle.

Based on the DOT Guidelines for the planning and design of bus facilities (Jackson & Simmons, 1983), the minimum number of loading berths required to satisfy present demand is calculated by dividing the demand (50 buses/hour) by the berth capacity (6 buses/bay/hour) i.e. nine loading berths are required to accommodate present demand at a satisfactory level of service.

PROPOSED PROJECT

To alleviate the prevailing problems at Wynberg Bus Terminal it is proposed that the triangular site bounded by Brisbane, Broad and Ottery Roads be acquired and that a fully sheltered bus terminal be erected on it.

With a passenger growth rate of 2,5 percent per annum, a service life of 25 years, pre-cancelling of tickets allowing for an average boarding time of 4 seconds per passenger, and all other operational conditions conforming to level of service C during the design hour, the DOT Guideline document (Jackson & Simmons, 1983) indicates that 14 loading berths will have to be provided for.

ANALYSIS

Overview

An economic evaluation of the proposed new Wynberg Bus Terminal needs to be performed by determining its net present value (NPV) and the benefit/cost (B/C) ratio.

At present (mid-1998) it is year nil. The construction period of the terminal will last two years and it will be opened at the beginning of year 3 (i.e. mid-2000). The facility will have a service life of 25 years and it must be evaluated over this period. At the end of the service life the facility will have no terminal value. (It is expected that the site will always be used as an access node to public transport, and will therefore have no alternative value.)

The expected traffic growth rate is equal to 2,5 percent per annum, and the real discount rate is 10 percent per annum. (Note that with $g = 2,5\%$, $i = 10\%$, and $n = 25$, the geometric series present worth factor = 11,32814, and that with $i = 10\%$, and $n = 25$, the uniform series present worth factor = 9,07704.)

Initial cost

The initial cost of the proposed Wynberg Bus Terminal is shown in Table 5.1

Table 5.1 Wynberg Bus Terminal summary schedule of costs

ITEM	AMOUNT
Office and quarters	R 52 000
Accommodation of traffic during construction	26 000
Clearing of site/demolition of building	83 000
Relocation of services	468 000
Stormwater drainage	234 000
Construction of subgrade	182 000
Pavement layers	1 040 000
Kerbs, edging and channels	156 000
Retaining walls and housing	1 456 000
Subway and ramps	1 690 000
Traffic signals, road markings and signals	182 000
Main structure	6 590 000
Project management	608 000
Land	983 000
Total	R13 750 000

5.20

The cost of the land, R983 000, may be regarded as a present worth (PW) as the withdrawal of the site from its alternative use is imminent.

The remainder of the initial cost of R12 767 000 (=R13 750 000 - R983 000) will be invested evenly over the next two years (i.e. R6 383 500 during year 1 and year 2 respectively).

$$\begin{aligned}\text{PW of the investment amount} &= \text{R983 000} + (\text{R6 383 500}/1,1) + (\text{R6 383 500}/1,1^2) \\ &= \text{R12 061 802}.\end{aligned}$$

Operating cost of buses at the terminal

The on-street circulation of buses at the existing bus terminal affects bus approach and departure movements for a distance of 250 metres in each direction, i.e. 500 metres per visit at the terminal. The present average travel speed of buses within this affected area is 10 km/h (= 360 s/km). An off-street terminal location with bus paths running through the facility will reduce the terminal-end distance traversed by buses by 70 metres per visit, while the expected average travel speed of buses (on the remaining 430 metres within the affected area) will be 15 km/h (=240 s/km).

At present 50 660 single-deck buses and 25 330 double-deck buses (i.e. 75 990 buses in total) use the terminal per annum. The ratio between boarding and alighting passengers is 50:50. On average 30 passengers alight from and 30 passengers board a single-deck bus, while on average 35 passengers alight from and 35 passengers board a double-deck bus. Buses depart whenever all seats have been taken (no one has to stand while travelling).

At present the average alighting time is two seconds per person and the average boarding time is six seconds per person. With the proposed facility all tickets will be pre-cancelled, reducing the average boarding time to four seconds per person. This implies that with the existing facility the average idling times (i.e. the period during which a bus is stationary but its engine is running) for single-deck and double-deck buses in a loading berth is 240 seconds and 280 seconds respectively, and that with the proposed facility these idling times will decrease to 180 seconds and 210 seconds respectively.

5.21

The relevant running costs of representative vehicle classes in urban traffic conditions needed in this evaluation were taken from Pienaar (1985:225) and adjusted to mid-1998 values. These costs appear in Table 5.2.

Table 5.2 Running costs of vehicle classes in urban traffic conditions in R/1 000 km at mid-1998 values.

Travel speed per km (km/h)	Cars	Minibuses	Single-deck buses	Double-deck buses	LGVs	MGVs
10	NN	NN	8 526	8 748	NN	NN
15	2 108	2 518	6 563	6 902	2 290	4 952
20	1 551	1 855	NN	NN	1 728	3 841

NN = not needed for this evaluation.

The average cost of idling per bus in cents per minute, adjusted to mid-1998 values, are as follows (Pienaar, 1985:229):

single-deck buses : 36,4

double-deck buses : 42,5

The abovementioned information shows that under existing conditions the annual running costs of buses within the affected area at the terminal are equal to R450 756, and that with the proposed facility it would be reduced to R311 142. At a future growth rate of 2,5 percent per annum and a discount rate of 10 percent per annum, the PW for the period beginning year 3 through end year 27 would be R4 433 661 and R3 060 410 respectively for these amounts.

∴ PW savings of bus operating costs in the affected terminal area = R1 373 251.

Accidents at the terminal involving buses

From the beginning of 1992 until the end of 1997 nine accidents per annum occurred on the streets adjacent to the terminal (specifically where terminal bus movements take place). Of these 54 accidents one was fatal, three were serious, 18 were slight and 32 were damage-only accidents. The updated mid-1998 cost per accident, as furnished by the Department of Transport (Naude, 1992), is as follows: Fatal R647 685, serious R125 905, slight R27 610, and damage-only accidents R11 595. Based on this information it is estimated that the present annual accident cost at the terminal equals R315 570.

To forecast the annual accident rate with the proposed facility, the following assumptions apply:

- a) due to the expected traffic growth rate of only 2,5 percent per annum, the number of accidents will not increase;
- b) the proposed facility will have 14 loading berths;
- c) the average annual accident rate at off-street bus termini is as follows (Southern African Bus Operators Association):

functioning effectively	-	0,22 per annum per berth
functioning neither well nor poorly	-	0,44 per annum per berth
functioning poorly	-	0,66 per annum per berth*

*(Accident rates are usually expressed in accidents per 100 000 000 vehicles, however, within relatively confined off-street areas where a high amount of vehicle manoeuvring/circulation takes place, facility size and operating conditions were judged to be more useful measures of estimate.);

- d) the present composition of severity of accidents will not change in the future; and
- e) the proposed terminal will function effectively.

Based on the abovementioned information and assumptions the cost of accidents with the proposed facility will amount to R107 995.

The PW of the expected accident cost savings with the proposed facility =

$$(R315\,570 - R107\,995) 9,077040/1,10^2 = R1\,557\,162.$$

Non-monetary part of passenger generalised travel cost (NMGC)

For the calculation of NMGC, equation 3.1 and the following input values apply:

- (1) The minimum living level wage of unskilled and transit-captive passengers in the study area is R8,58 per person per hour (mid-1998 value). ($\therefore U = R8,58$)
- (2) Average bus travel time in the affected area without the proposed facility is 90 seconds (=0,25 km at 10 km/h). The comparative travel time with the proposed facility is 52 seconds (= 0,215 km at 15 km/h).
 \therefore VT (existing facility) = 1,5 minute; and
 VT (proposed facility) = 0,86 minute.
- (3) Buses do not depart from the terminal with any standing passengers and an insignificant number arrive while standing. ($\therefore A = 0$)
- (4) Two-thirds of all passengers walk to or from the nearby railway station and minibus taxi facilities. Their average walking time is 3 minutes. ($\therefore B = \frac{2}{3} \times 3 = 2$ min.)
 (One-third of all passengers transfer between buses.)
- (5) According to the CMC the average waiting times during access and during transfer are both 9,8 minutes. These values are expected to drop to 8,8 minutes with the proposed facility.
 \therefore C (existing facility) = 6,5 minutes ($=\frac{2}{3} \times 9,8$ minutes); and
 C (proposed facility) = 5,9 minutes ($=\frac{2}{3} \times 8,8$ minutes).
 \therefore D (existing facility) = 3,3 minutes ($=\frac{1}{3} \times 9,8$ minutes); and
 D (proposed facility) = 2,9 minutes ($=\frac{1}{3} \times 8,8$ minutes).

Through the use of equation 3.1 and the recommended default time weighting factors recommended in this dissertation, the present annual NMGC of the 4 812 700 passengers who make use of the existing facility is equal to R22 470 000, while the present annual NMGC with the proposed facility would have been R14 115 200.

PW of NMGC saving with the new facility:

$$\begin{aligned}
 &= 1,025^2(R22\,470\,000 - R14\,115\,200)11,32814/1,10^2 \\
 &= R82\,178\,276.
 \end{aligned}$$

Road-user cost of passing traffic

The total length of the sections on Brisbane, Broad and Ottery Roads on which traffic is affected by bus movement at the terminal equals 0,5 kilometre. The present annual average daily traffic (AADT) on these three street sections (excluding buses) is 4 485 vehicles. The expected future traffic growth is 2,5 percent per annum. The traffic composition is as follows: cars 75 percent, minibuses 10 percent, light goods vehicles (LGVs) 10 percent and medium size goods vehicles (MGVs) 5 percent.

The annual average daily travel speed of passing traffic on adjacent streets with the present situation is 15 km/h (= 240 s/km).

The expected annual average daily travel speed with the new facility is 25 km/h (= 144 s/km).

Based on the abovementioned information and those supplied in Table 5.2 it is estimated that the present annual vehicle running cost saving of passing traffic will equal R487 655.

The observed average occupancy of passing vehicles is as follows: cars 2 persons, minibuses 7 persons, LGVs 2 persons and MGVs 2 persons. The average hourly value of time for all vehicle users throughout a day in the study area is R8,58 per person (mid-1998). Based on the average travel time saving of 48 seconds per passing vehicle with the new facility, the present annual travel time saving will equal R468 294.

Virtually all present vehicle accidents on the streets adjacent to the terminal involve buses. Savings in accident costs involving passing traffic are therefore regarded as negligible.

PW of user cost savings of passing traffic on adjacent streets with the new facility:

$$= 1,025^2(R487\,655 + R468\,294) 11,32814/1,10^2 = R9\,402\,767.$$

Recurring costs of the proposed facility

The estimated direct recurring costs within the proposed terminal (i.e. operating, maintenance and security costs) will remain constant at R1 092 000 per annum. This amount is made up of the employment cost of ten permanent employees: 2x ticketing and information personnel, 2x marshalls/dispatchers, 2x cleaners/maintenance assistants, 1x artisan (millwright), 2x security officers and 1x administrator/manager totalling R960 000, plus R120 000 for electricity, water, other services, toilets, stationery, computer expenses and technical/mechanical aids, plus R12 000 for maintenance material.

PW of direct recurring costs of the proposed facility:

$$= R1\,092\,000 \times 9,07704/1,10^2 = R8\,191\,841$$

This amount represents a negative saving with respect to the proposed facility as no maintenance and security expenses are incurred with the present on-street situation.

Result

PW of the investment amount = R12 061 802

PW of the benefits	=	PW of bus operating cost savings:	R 1 373 251
		PW of bus accident cost savings:	1 557 162
		PW of NMGC savings:	82 178 276
		PW of road-user cost savings of	
		passing traffic:	9 402 767
		PW of recurring cost saving of	
		proposed facility:	-8 191 841
		<u>PW of total benefits</u>	<u>R86 319 615</u>

5.26

$$\begin{aligned}\text{NPV of proposed facility} &= \text{R}86\,319\,615 - \text{R}12\,061\,802 \\ &= \text{R}74\,257\,813\end{aligned}$$

$$\begin{aligned}\text{B/C ratio of proposed facility} &= 86\,319\,615 / 12\,061\,802 \\ &= 7,2\end{aligned}$$

The proposed Wynberg Bus Terminal is economically viable. (A cursory analysis by the author, using unverified assumptions, showed that a terminal with 13 loading berths and one with 15 loading berths would be less viable than the proposed facility with its 14 loading berths.)

Acknowledgement

The information used in this case study was supplied by the Southern African Bus Operators Association, the Transport Directorate of the Cape Metropolitan Council, Golden Arrow Bus Services, and Hawkins, Hawkins and Osborn Consulting Engineers.

CHAPTER 6**CONSIDERATION OF WELFARE DISTRIBUTION IN PROJECT
EVALUATION AND SELECTION****6.1 INTRODUCTION**

The purpose of this chapter is to illustrate how the economic evaluation of transport infrastructure projects can be supplemented by social evaluation to accommodate a higher degree of equitable welfare distribution in project selection.

Transport plays a significant role in the social and economic development of any country. The Government of National Unity has recognised transport as one of its five major priority areas for socio-economic development - in fact, after education it is regarded as the most significant catalyst for development (Department of Transport, 1996:1). Unfortunately the provision of transport infrastructure, especially road transport facilities, is being hampered severely in South Africa by inadequate funding. In turn, this hampers economic growth (Maharaj, 1995:1).

According to the World Bank (1994:3) infrastructure can deliver major benefits in economic growth, poverty alleviation and environmental sustainability - but only when it provides services that respond to effective demand and does so efficiently. Given the fact that one of the priorities of the Reconstruction and Development Programme is to address economic development, economic growth and welfare inequality through investment in infrastructure, the social evaluation approach set out below assumes that redistribution of welfare can be more efficiently done through investment in transport infrastructure than through direct transfer payments, such as subsidies (Botes & Pienaar, 1995:A.2).

6.2 A FUNDAMENTAL POINT OF DEPARTURE IN PROJECT EVALUATION WITH RESPECT TO WELFARE DISTRIBUTION

The Gini coefficient is a popular indication of income inequality, which varies in value from one in the case of total inequality and zero in the case of total equality. (The terms which are underlined in the text are defined in the list of terms at the end of the chapter.) Making international comparisons of income inequality is always fraught with the danger of non-comparability. Data sources are often very different and definitions of incomes differ. It is nevertheless interesting to make such comparisons and the fact that South Africa frequently has the highest Gini coefficients is evidence of the highly inegalitarian income distribution that characterises the South African economy (Whiteford & McGrath, 1995:12).

Table 6.1 shows a list of Gini coefficients calculated according to individual income where each individual is assumed to earn the household per capita income of his or her household. The list is not comprehensive but the presence of Brazil on the list is significant as that country is often considered to have one of the most uneven distributions of income in the world. That the Gini coefficient for South Africa is substantially higher than Brazil's again confirms the high ranking of South Africa on the world inequality list.

The World Bank (Deininger & Squire, 1996:574-577) in a later study than that of Whiteford & McGrath estimated the Gini coefficient for four countries in sub-Saharan Africa. Although the World Bank study indicated that the Gini coefficient for South Africa had between 1993 and 1996 come down from 0,69 to 0,62, it still ranked highest among the countries analysed. The Gini coefficients were as follows: Ghana 0,35; Kenya 0,54; South Africa 0,62; and Zimbabwe 0,59.

6.3

Table 6.1: International comparison of Gini coefficients.

Country	Survey Year	Gini Coefficient
Hungary	1989	0,23
Poland	1989	0,27
Nepal	1984	0,30
China	1990	0,36
Yugoslavia	1989	0,39
Venezuela	1989	0,44
Costa Rica	1989	0,46
Malaysia	1989	0,48
Dominican Republic	1989	0,50
Mexico	1984	0,51
Columbia	1991	0,51
Panama	1989	0,57
Chile	1989	0,58
Honduras	1989	0,59
Guatemala	1989	0,60
Brazil	1989	0,63
South Africa	1993	0,69

(Source: Whiteford & McGrath, 1995:12)

The creation and use of transport facilities and services, such as passenger transport terminals and transfer facilities, especially in lower-income areas, can lead to a more equitable distribution of welfare and income. The fundamental point of departure is that additional income is relatively more valuable to lower-income groups than to higher-income groups. The users of public commuter transport facilities and services, for example, are mostly transit-captive travellers as they more often than not do not have the ability to pay for travel by alternative modes of transport and they are, by implication, the more needy component of the community.

6.4

Seeing that the appreciation of lower-income groups of the marginal utility of their income (i.e. the additional utility acquired from one additional unit of income) is considerably higher than that of more prosperous individuals, the net economic benefits that a transport project has for them should be weighted accordingly to reflect the true social benefit of the project. From a distributive efficiency viewpoint this will ensure that in selecting a project, that project which can make the greatest net contribution to welfare distribution is selected for implementation. It is therefore necessary that all transport infrastructure projects should also be evaluated on the basis of a social analysis in order to reveal the effect of the implementation of such projects on a region within the country or a province, such as a metropolitan area or within sub-regions of the latter (Pienaar, 1997:26).

6.3 THE ACCOMMODATION OF EQUITY IN ECONOMIC EVALUATIONS

The purpose of any economic evaluation (of transport projects) should be, through the transport planning process:

- a. to ensure the optimal allocation of scarce resources (economic or allocative efficiency through a potential Pareto improvement in social welfare); or
- b. to bring about the achievement of the maximum possible equality of welfare benefits (distributive efficiency or equity).

Economic evaluation (as in a. above) has traditionally focused on the maximizing of economic efficiency by the minimizing of consumption. The discounting process was used to determine the net impact on consumption, after which economic efficiency was used as the only criterion in project selection. Based on the assumption that income distribution was optimal within the community, in other words that the marginal utility of the income of all individuals is equal, the striving for equity was automatically left out of consideration. Traditional economic evaluation practice has thus traditionally proceeded from the point of view that all benefits and costs related to a project carry the same weight, regardless of the level of income and consumption of groups affected by it.

6.5

A familiar critique of cost-benefit analysis is that its reliance on willingness to pay biases the method in favour of the existing distribution of income (Waters, 1994:249). Cost-benefit analysis is calculated on the basis of *potential* compensation, i.e., those who gain can, in principle, compensate those who suffer, so that everybody can be better off. But compensation normally is not paid. Therefore, a government following cost-benefit analysis allocative efficiency criteria could carry out a sequence of projects which benefited high-income groups at the expense of low-income groups, but because compensation was never paid, the net result would be to aggravate the distribution of income.

If income-related differences are reflected in the evaluation of investments, for which users do not pay directly, a vicious circle is created. High-income areas usually yield high project returns, which attract investment, which further increase income in the affluent areas at the cost of disadvantaged areas. With respect to the propagation of such disparities, the World Bank comments as follows on the valuation of time savings (Gwilliam, 1997:4): *"This can be avoided by using national average wage rates for major categories of labour and applying national average income in valuing leisure time savings. It is recommended that such an 'equity value of time' be used, especially where poverty alleviation or regional redistribution of income is a national objective."*

Poverty relief - this is the attempt to achieve an equitable distribution of consumption among contemporaries - is one of the country's most important economic development objectives. Channelling investments in transport infrastructure in such a way as to lead to an increase in the consumption expenditure of lower-income population groups and the indigent, or which will at least not affect this negatively, is one of the ways in which this objective may be achieved to a degree. Accommodating welfare distribution through socio-economic or social evaluation (as in b. above) as a means of striving for equity can be done by (1) using an adapted social discounting rate in evaluation techniques, or (2) by adjusting the benefits of projects according to weights calculated for specific income groups.

Social evaluation (based on equity or distributive efficiency) may be performed parallel to economic evaluation (based on economic or allocative efficiency), complementing it - not replacing it. Seen in transport economic terms, the inclusion of equity in the evaluation process is geared to creating

equal accessibility and increased mobility for lower-income groups in terms of marginal utility. From a non-transport or general economic point of view, it is geared towards allotting potential economic activity and its returns to lower-income communities. (Although investment in transport infrastructure will not always directly or automatically raise the disposable income of low-income groups, such investment usually results in time savings, greater convenience and safety, improvement in the quality of transport services and possibly also lower travel expenditure.)

6.4 THE USE OF WEIGHTS IN PROJECT EVALUATION TO BRING ABOUT EQUITABLE WELFARE DISTRIBUTION

Social and economic evaluation can be regarded as sensitivity analyses complementary to one another. Therefore, if the decision-maker is intent on paying due regard to both types of analysis, a project should go ahead if it is shown to be viable both with and without the application of equity weights. Although such weighting usually depends largely on political decision-making, it should nevertheless be related to the marginal utility that additional income has for each of the groups (CEAS, 1989:28). From an economic viewpoint it would, however, not be prudent if an inefficient project, despite its potentially positive effects on income distribution, is implemented if the redistribution effect can be achieved at lower cost by making use of another form of income transfer, such as direct subsidies (Georgi, 1973:50).

In practice redistribution cannot be effected by lump-sum transfers. It normally requires taxation which imposes a burden upon those taxed, representing a loss of efficiency in the economy (Layard & Glaister, 1994:47). Moreover, there may be political objections to cash redistribution, and it is often administratively difficult to devise a tax which falls specifically on the beneficiaries of a project and a transfer which goes specifically to the losers. If redistribution to offset the losses due to the project is not implemented, then the project cannot be justified on the grounds that it is a Pareto-improvement, since at least some people are worse off. Then a wider criterion has to be introduced to decide whether or not the project increases social welfare - a criterion in which the changes of income to each of the parties affected are weighted by the marginal social values attaching to the income of each group. The criterion is thus that the project should be undertaken if $\sum a_i \Delta Y_i$ is positive, where ΔY_i is the present value of the project to the i th person and a_i is the marginal social value of the i th person's wealth.

If social welfare (W) is the sum of individual utilities, and the i th individual's utility depends on his income Y_i then $W = \sum U(Y_i)$ and $\partial W / \partial Y_i = U'(Y_i)$. In fact it is much more satisfactory to assume that $W = W[U_1(Y_1), \dots, U_n(Y_n)]$, in which case $\partial W / \partial Y_i = (\partial W / \partial U_i) U_i'(Y_i)$. This satisfies the notion of fairness, that additional happiness for an indigent person is more desirable than additional happiness for someone who is already happy. However, it renders the problem of quantification even more intractable, even if it is assumed that all individuals have the same utility-of-income function. So the appropriate weight (a_i) is $U'(Y_i)$ and the project should be undertaken if $\sum U'(Y_i) \Delta Y_i$ is positive.

A simple assumption would be that $U'(Y_i) = Y_i^{-\epsilon}$. However, the problem is in determining ϵ . Eckstein (1961) argued that the government's estimate of ϵ should be implicit in the structure of marginal income tax rates. However, this is not the case if the government seeks to maximize the sum of individual utilities. To do this a government with a given national income to distribute would need to equalize the marginal utility of income of all individuals, i.e., it would aim at complete income equality, by setting taxes equal to $y - \bar{y}$, where y is individual income and \bar{y} is average income.

Weisbrod (1968) has subsequently suggested that the government's weights for different income groups should be inferred from its previous decisions on whether or not to adopt the various projects open to it. This involves the solution of a set of simultaneous equations. There is an obvious logical objection to this approach: either the government's decisions so far have been consistent; in which case why bother about helping it continue to be consistent, or they have been inconsistent, in which case why pretend they were consistent. There is much force in this criticism, especially when it is linked to the difficulties of estimation that arise (Layard & Glaister, 1994:48).

A third, but more limited, approach has been suggested by Marglin (1967). In this, total consumption is maximized subject to some minimum consumption being secured to a given indigent group or region. Alternatively, the consumption of the indigent may be maximized subject to some minimum total consumption. Any constrained maximization of this kind implies in its solution a relative weight attaching to consumption of the indigent as against consumption in general. This is measured by the shadow price on the constraint. However, this value is determined *ex post*. It is a less general approach to the income distribution problem, but, if no other is available, it is one way of allowing for an important objective of public policy.

The question of the criteria for a welfare improvement is discussed in detail by Layard and Walters (1994:179-198). They show how welfare changes for individuals can be estimated, but that the question of whether a social gain has occurred cannot be separated for the issue of the social valuation of benefits to the affluent compared with benefits to the disadvantaged.

The ethical principle on the basis of which the use of weights in project selection can be justified is utility. The user acquires utility from the application of his disposable income. Additional income brought about by a project creates opportunities for increased consumer spending from which the user derives additional utility. Additional income thus has greater marginal utility for the user. If a project holds monetary benefits, expressed as dy_1, dy_2, \dots, dy_n , for individuals 1, 2, ..., n , respectively, and the marginal utility which these individuals attach to the additional income is equal to MU_1, MU_2, \dots, MU_n , respectively, then the net change in total utility or social welfare (dU) brought about by the project can be expressed as follows:

$$dU = MU_1 dy_1 + MU_2 dy_2 + \dots + MU_n dy_n$$

The net change in total utility or social welfare is thus equal to the weighted sum of the changes in individual income, where the weight allocated to each individual is equal to the marginal utility of his income (Sugden & Williams, 1987:205).

The traditional economic evaluation treats increases in consumption directly caused by a project as cost and/or disbenefits, regardless of the income status of the spender. Changes in consumer spending may be the consequence (1) if providers of project inputs such as labour, for example, are paid for at a higher rate by the project than at any other place, and/or (2) by changes in the consumer surplus caused by the lower prices of output with the project than without the project.

In cases where the recipients of the benefit of higher consumption live in almost absolute poverty, it can be argued that their additional consumer benefits represent net social benefits rather than net social costs. This argument forms the basis for the use of weighting whereby the benefits related to a project, according to the higher marginal utility of those to whom they accrue, are weighted. The break-even point above which the benefit of higher consumption represents a net social cost and below which it represents a net social benefit is known as the "critical level of consumption". This

level is generally regarded as situated at the income level at which the payment of income tax becomes compulsory (Ray, 1984:17).

Welfare distribution weighting can be calculated on the basis of income or consumption. According to Floor, Pienaar and Botes (1993) the calculation of welfare distribution weights should ideally be based on per capita consumer spending rather than income for the following reasons:

- the relationship between income and welfare is not very clear, while per capita consumption provides a relatively good indication of welfare;
- it will take a considerable amount of calculation to deduce disposable income from total income as all transfer payments to and from individuals are not reported in total income statistics; and
- it is difficult to determine the percentage of income transferred to and from the specific area being studied.

Unfortunately up-to-date official data on consumer spending may not be readily available in South Africa. The deficiencies of the official data on wages, salaries and consumer spending, and the need for comprehensive, up-to-date information (e.g., for wage bargaining purposes) created scope for private enterprise to collect and disseminate such data. Nowadays most employers and employee organisations (e.g. trade unions) subscribe to the information of a variety of private firms which specialise in this field (Mohr, 1998:164). For this purpose it is necessary to note that consumption expenditure is a function of disposable income, which in turn is a function of total income, albeit in varying proportions.

The welfare distribution weighting can be expressed as follows (Pienaar, 1997a:26):

$$Y_w = \frac{C_p}{C_u} \quad (6.1)$$

where

Y_w = the welfare distribution weight;

C_p = the average per capita consumer spending of the population; and

C_u = the average per capita consumer spending of those whom the project benefits.

It is clear that the calculated weight will be consistently progressive - the lower the level of consumption spending, the greater the weight. The social benefit of a transport facility or service can then be determined by multiplying the calculated weight with the economic benefits offered by the facility or service. An example of how this can be calculated is shown in section 6.6.

An alternative method whereby the real social benefit of a project can be reflected includes the use of differential or variable discount rates (specific discounting rates according to specific levels of income) in the economic evaluation techniques. By applying a decreased "welfare rate" to lower-income groups, the net benefits attained may be represented as greater. This will ensure that in project selection the project which makes the greatest real contribution to social welfare (in terms of marginal utility) will be chosen for implementation.

6.5 CONCLUSIONS

According to the traditional economic evaluation approach all benefits and costs related to a project are evaluated in terms of their economic scarcity value. The traditional approach can be supplemented to accommodate a striving for equity. This can be done by weighting the benefits of a project according to weights calculated for specific consumer expenditure groups. In transport economic terms the inclusion of equity in economic evaluation is geared towards creating, in terms of marginal utility, equal accessibility and increased mobility for lower-income groups. In general economic terms it is geared towards allocating potential economic activities and returns to lower-income communities. The social analysis must be carried out separately from the economic analysis, and the findings and recommendations with respect to both the analyses must be represented in the project evaluation report.

If the decision-maker is intent on paying due regard to both economic and social analysis in investment decisions, all independent projects within the limits of the total available budget limitations should go ahead if they are shown to be viable both with and without the application of equity weights. Although such weighting usually depends on political decision-making, economically inefficient projects should go ahead only if their positive effects on welfare distribution are regarded as essential and cannot be achieved at lower cost through alternative forms of transfer.

6.6 EXAMPLE OF A PRIORITISATION OF TRANSPORT PROJECTS BASED ON WELFARE DISTRIBUTION CONSIDERATIONS

A metropolitan transport authority has obtained a loan of R100 000 000 from a development institution to implement a number of transport infrastructure projects. The conditions under which the loan is granted are that the selected projects should maximally improve the accessibility of lower-income groups, given that all the projects are efficient.

For economic development purposes the metropole is divided into five socio-economic regions. The population and total annual household consumption within the regions are as follows:

Region	Total household expenditure (xR10 ⁹)	Population (x 10 ⁶)	Expenditure per capita (xR10 ³)	Equity weight
1	0,825	0,275	3,0	8/3
2	1,5	0,375	4,0	8/4
3	2,6	0,325	8,0	8/8
4	5,0	0,500	10,0	8/10
5	6,875	0,625	11,0	8/11
	16,8	2,100	8,0	8/8

6.12

Sixteen functionally independent projects which are all economically viable (i.e. efficient) have been identified and their details are given below:

Region	Project	Present worth of initial cost (xR10 ⁶)	Present worth of benefits (xR10 ⁶)	Efficiency B/C ratio	Equity weights	Weighted equity benefits	Equity B/C ratio
1	A	15,0	15,75	1,05	8/3	42,0	2,8
1	B	8,0	8,8	1,1	8/3	23,467	2,93
1	C	10,0	12,0	1,2	8/3	32,0	3,2
1	D	7,5	10,5	1,4	8/3	28,0	3,73
2	A	12,0	15,0	1,25	8/4	30,0	2,5
2	B	13,0	15,6	1,2	8/4	31,2	2,4
2	C	9,5	12,825	1,35	8/4	25,65	2,7
2	D	10,0	11,0	1,1	8/4	22,0	2,2
3	A	20,0	60,0	3,0	8/8	60,0	3,0
3	B	18,0	55,8	3,1	8/8	55,8	3,1
4	A	22,0	55,0	2,5	8/10	44,0	2,0
4	B	25,0	65,0	2,6	8/10	52,0	2,08
5	A	30,0	81,0	2,7	8/11	58,909	1,96
5	B	35,0	98,0	2,8	8/11	71,273	2,04
5	C	32,0	92,8	2,9	8/11	67,491	2,11
5	D	30,0	90,0	3,0	8/11	65,455	2,18

Had efficiency been the sole project selection norm, projects 3B, 5D, 3A and 5C ought to have been chosen. (Projects are chosen in descending order of efficiency benefit/cost (B/C) ratios up to the point where the sum of the present worth (PW) of their initial costs utilises the whole capital loan amount.) In this case the total efficiency net present value (NPV) of the four projects is given by:

$$\begin{aligned}
 \text{NPV(four projects)} &= \text{PW benefits} - \text{PW initial costs} \\
 &= \text{R298,6m} - \text{R100m} \\
 &= \text{R198,6m.}
 \end{aligned}$$

With distribution also a project selection norm, projects 1D, 1C, 3B, 3A, 1B, 1A, 2C and 2A are chosen. (Projects are chosen in descending order of equity B/C ratios.) In this case the total equity NPV of the eight selected projects is given by:

$$\begin{aligned}\text{NPV}(\text{eight selected projects}) &= \text{R}296,917\text{m} - \text{R}100\text{m} \\ &= \text{R}196,917\text{m}.\end{aligned}$$

With efficiency and the limit on investment expenditure as the only norms, no transport infrastructure investment would have taken place in regions with below-average consumption. With a combination of efficiency and equity norms, six projects (1D, 1C, 1B, 1A, 2C and 2A) which are situated in regions with below-average consumption are selected. This implies a reallocation of an investment amount totalling R62m from average and above-average consumption regions to below-average consumption regions.

6.7 LIST OF TERMS

Allocative efficiency: A measure of how the selection of inputs minimizes the cost of producing products (i.e. goods and services) to satisfy given wants. (This kind of efficiency is synonymous with "economic efficiency" or simply "efficiency".)

Benefit/cost ratio: The ratio between the sum of the discounted benefits and the sum of the discounted initial (i.e. capital) costs of a project, where the value of the benefits forms the numerator and the worth of the costs forms the denominator. All proposals with a ratio value greater than one are viable.

Consumer's surplus: The difference between what a consumer is willing to pay and what he or she actually pays for a product (i.e. a good or a service). The maximum amount that a consumer is willing to pay is reflected by the utility that a product is expected to offer the consumer. If a consumer acts rationally, the actual amount paid is less than the total utility that the product is expected to offer - hence a surplus is gained.

Disposable income: Personal income plus transfer income (e.g. dividends) net of all taxes levied on incomes available for expenditure and saving.

Distributive efficiency: A measure of how the allocation of economic resources among groups or individuals within a country (or community) contribute to an equitable or a socially desirable distribution of welfare. (Distributive efficiency is usually used synonymously with "equity".)

Gini coefficient: The Gini coefficient is the ratio of the area between the diagonal and the Lorenz curve divided by the total area of the triangle in which the curve lies (see Figure 6.1 below). The Lorenz curve is constructed by plotting the numbers of income recipients, starting with the poorest, on the horizontal axis in cumulative percentages and with cumulative personal income percentages on the vertical axis. The lower the Gini coefficient, the better (closer to equity) the income distribution.

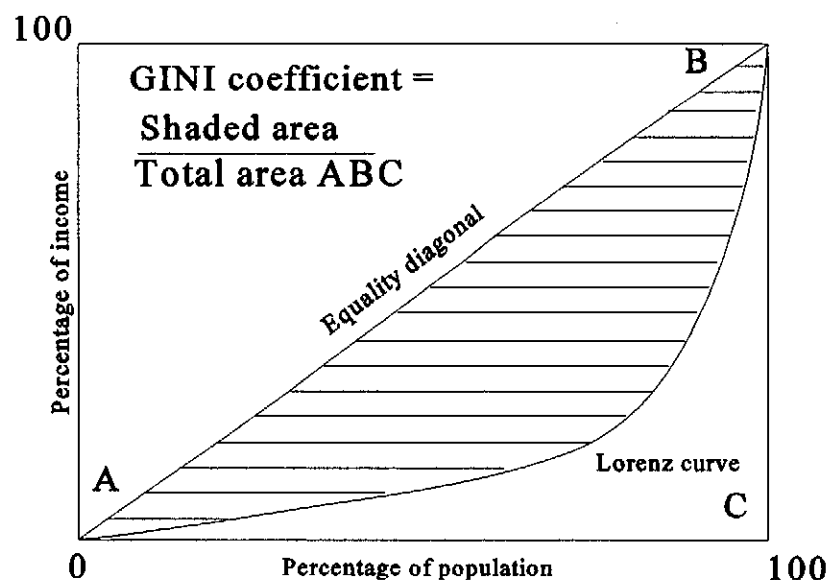


FIGURE 6.1 Estimating the Gini coefficient

Independent projects: Independent projects are projects which fulfil different functions. They do not form alternatives for one another and are therefore not mutually exclusive. The selection of a certain (functionally) independent project can at the most postpone, but not exclude, the selection of another (functionally) independent project.

Net present value: The net present value of a project is obtained by subtracting the sum of its discounted initial (i.e. capital) costs from the sum of the discounted benefits it will achieve. If a project's discounted future benefits exceed its discounted initial cost, it has a positive net present value and is therefore regarded as viable.

Pareto improvement: Making at least one person in a community better off without anyone else being made worse off.

Utility: The satisfaction derived from an activity, particularly consumption.

CHAPTER 7**CONCLUSIONS**

- 7.1 The economic benefit stemming from the construction and operation of passenger transport terminals and transfer facilities is equal to the savings it brings about in recurring costs, plus the consumers' surplus gained through usage generated by the new facility. The recurring costs are (1) transit operating costs, (2) the travel costs of those who use the facility, (3) the costs of road users on the roads upon which traffic conditions are influenced by the facility and (4) the facility operating costs. The expected saving is calculated by making use of a with-and-without calculation, but not taking the cost of generated usage into consideration.
- 7.2 Appropriate placing of a terminal or transfer facility offers the transport operator the benefit of a reduction in the number of dead or low-income vehicle kilometres. This implies better vehicle utilisation and lower vehicle operating costs. The benefits calculated with respect to transit operators in benefit-cost analyses are thus based on (1) the shorter distance travelled per vehicle, (2) the more economical speeds per journey attained, (3) safer vehicle movement at the facilities and (4) less dwell time at the facilities.
- 7.3 Benefits for facility users (transit passengers) involve savings in generalised travel costs, which include:
- monetary costs;
 - travel time; and
 - negative quality aspects (discomfort and inconvenience endured, safety risks, exposure to frustration, service unreliability, and walking and waiting times at terminals and transfer facilities).
- 7.4 As the opportunity cost of a transit service's vehicle operating costs is a transport operator's cost, it must not be added to passengers' fares in determining facility user costs. Only the non-monetary part of passengers' generalised travelling cost is added to the transit operator's

opportunity cost in determining the travel cost portion of the recurring costs of facility users.

A formula to determine the abovementioned cost is supplied in the text.

7.5 For the users of adjacent streets, the creation of an off-street passenger transport terminal or transfer facility can result in an increase in the normally limited amount of street space. This can lead to a smoother traffic flow if it is accompanied with sound traffic control arrangements in the immediate vicinity of the facility. Improved traffic flow offers road users the benefit of savings in travel time and vehicle running costs. This can also lead to a reduction of accident risks and costs.

7.6 In cases where the property developer involved in operating a terminal makes the property available for commercial activities, income from rent is a financial benefit. Yet in the economic evaluation this must not be included as an economic benefit as it has nothing to do with the economic resources sacrificed in the transport process.

7.7 The traditional economic evaluation approach can be supplemented to accommodate a striving for equity. This can be done by using an adjusted social discount rate in evaluation techniques or by weighting the benefits of a project according to weights calculated for specific income groups. An income distribution weighting formula is supplied in the text.

7.8 The dissertation's contribution to engineering practice is threefold:

- i) A methodology has been proposed to assess the economic worth of bus and minibus taxi terminals and transfer facilities. (This is a new development as such research has not been done at this level of detail before.)
- ii) A methodology has been proposed to evaluate and prioritise transportation projects from a social viewpoint to assist in the equitable distribution of welfare.

(This is a new development as such a methodology with respect to the assessment of benefits in the economic evaluation of transport projects has not been applied before.)

7.3

- iii) A model is presented to assist in determining the opportunity cost of transit travel time.

(This model is presented as an advance within engineering practice as the concept of generalised travel cost, which is based on personal perception and disutility, has in the past only been used to model mode choice, destination choice, residential location choice, trip generation, and other travel-related choices. A method to determine the shadow price of the "equity time value" of unskilled and transit-captive commuters has also been proposed.)

REFERENCES

- Adler, H.A. 1987. *Economic appraisal of transport projects*. Baltimore: Johns Hopkins University Press. (EDI Series in Economic Development.)
- American Association of State Highway and Transportation Officials (AASHTO). 1977. *A manual on user benefit analysis of highway and bus transit improvements*. Washington, D.C.
- Baxa, J.V., Ferreira, L.J., Rathbone, D.B., Royce, N.J. & Van Zyl, N.J.W. 1979. *Definitions of urban transport planning terms*. Pretoria: National Institute for Transport and Road Research, CSIR. (NITRR Report TPRR 2.)
- Botes, F.J. & Pienaar, W.J. 1995. Consideration of income distribution in project evaluation. In: Hromic, M.(Ed). *Guidelines for conducting the economic evaluation of urban transport projects*. Second edition. Municipality of Cape Town.
- Bureau of Market Research. 1997. *Minimum and supplemented living levels in the main and other selected urban areas of the Republic of South Africa, February 1997*. Research Report 242. Pretoria: University of South Africa.
- Button, K.J. 1993. *Transport economics*. Second edition. Hants, England: Edward Elgar.
- Canadian Urban Transit Association (CUTA). 1985. *Canadian Transit Handbook*. Second edition. Toronto.
- Central Economic Advisory Service (CEAS). 1989. *Manual for cost-benefit analysis in South Africa*. Pretoria.
- Central Economic Advisory Service (CEAS). 1997. *Currently valid social time-preference rate of discount*. Pretoria. (Letter FJ/1/B signed by the Director: Local Government Budgets on 10.10.1997.)

- Deininger, K. & Squire, L. 1996. *A New data set measuring inequality*. The World Bank Economic Review 10(3). Washington.
- Eatwell, J., Milgate, M. & Newman, P. 1987. *The new Palgrave: a dictionary of economics*. Macmillan: London.
- Eckstein, O. 1961. A survey of the theory of public expenditure. In: Houghton, R.W. (ed.). *Public Finance*. New York: Penguin.
- European Conference of Ministers of Transport (ECMT). 1973. *Influence of cost, quality and organisation of terminal transport and interchanges: on the choice of passenger transport mode*. Paris.
- Floor, B.C., Pienaar, W.J. & Botes, F.J. 1993. *Basis of calculation of equity weights for use in the benefit-cost analysis of transport projects*. Recommendation addressed to the Cape Town Metropolitan Transport Planning Branch.
- Fruin, J.J. 1971. *Pedestrian planning and design*. New York: Metropolitan Association of Urban Designers and Environmental Planners.
- Georgi, H. 1973. *Cost-benefit analysis and public investment in transport: a survey*. London: Butterworths.
- Giannopoulos, G.A. 1989. *Bus planning and operation in urban areas: a practical guide*. London: Gower Publishing Company Ltd.
- Goodwin, P.B. 1974. Generalised time and the problem of equity in transport studies. *Transportation*, 3, 1 - 24.
- Gray, B.H. (Ed). 1981. *Urban public transportation glossary*. Washington, D.C.: Transportation Research Board, National Research Council.

- Gwilliam, K.M. 1997. *The value of time in economic evaluation of transport projects: lessons from recent research*. (TWUTD webpage: <http://www-esd.worldbank.org/html/esd/twu/twutd/index.htm>) Washington: World Bank.
- Hensher, D.A. 1995. *Value of travel time savings in personal and commercial automobile travel*. Report ITS-WP-95-4. Institute of Transport Studies, University of Sydney.
- Hoel, L.A. 1986. *Guidelines for planning public transportation terminals*. Washington, D.C.: Transportation Research Board, National Research Council. (Transportation Research Record 817.)
- Horowitz, A.J. 1981. Subjective value of time in bus transit travel. *Transportation* 10(2):149-164.
- Hromic, M. (Ed). 1995. *Guidelines for conducting the economic evaluation of urban transport projects*. Second edition. Municipality of Cape Town.
- Jackson, R.I. & Simmons, J.B. 1983. *Bus terminals and bus stations planning and design guidelines*. Pretoria: Department of Transport. (Report U 12/7/4/52.)
- Kane, L.A. 1998. Defining a new approach for urban transport assessment in the New South Africa, 111-115. In: Freeman, P.N.W. & Jamet, C. (eds.) *Urban transport policy: a sustainable development tool*. Proceedings of the International Conference CODATO VIII. Cape Town.
- Lam, W. & Morrall, J. 1982. Bus passenger walking distances and waiting times: a summer-winter comparison. *Transportation Quarterly* (36)3:407-421.
- Layard, R. & Glaister, S. 1994. *Cost-benefit analysis*. Second edition. Cambridge University Press.

- Layard, L. & Walters, A.A. 1994. Allowing for income distribution, 179-198. In: Layard, R. & Glaister, S. *Cost-benefit analysis*. Second edition. Cambridge University Press.
- Maharaj, M. 1995. Opening address by the Minister of Transport. *Proceedings, Annual Transport Convention*, Pretoria.
- Marglin, S.A. 1967. *Public Investment Criteria*. London: Allen & Unwin.
- McGraw-Hill. 1973. *The McGraw-Hill dictionary of modern economics: a handbook of terms and organizations*. Second edition. New York.
- Mohr, P. 1998. *Economic indicators*. Pretoria: University of South Africa Press.
- Morrall, J. 1970. Traffic prediction models for central business district planning, Vol. 4, No. 1. In: *Australian Road Research Board Conference*. Melbourne.
- Morris, N. 1983. *Black commuting in Pretoria: attitude towards walking times*. Pretoria: CSIR. (NITRR Special Report BCP13.)
- Morris, N. 1985. Personal communication, March. Pretoria: NITRR, CSIR.
- National Department of Transport. 1996. *White paper on national transport policy*. Pretoria.
- National Department of Transport. 1998. *Moving South Africa: towards a transport strategy for 2020*. Pretoria.
- Naudé, C.M. 1992. *Revised unit prices for Program CB-Roads*. Pretoria: Division of Roads and Transport Technology, CSIR. (Report IR 91/024/2.)

- Navin, F. 1974. *Optimal transit fleet size*. Minneapolis: University of Minnesota Press.
- Ortúzar, J. de D. & Willumsen, L.G. 1990. *Modelling transport*. London: John Wiley & Sons Ltd.
- Pearce, D.W. (Ed). 1989. *Macmillan dictionary of modern economics*. Third edition. New York: Macmillan.
- Pearce, D.W. & Nash, C.A. 1981. *The social appraisal of projects: a text in cost-benefit analysis*. London: Macmillan.
- Pienaar, W.J. 1985. *Vervoerekonomiese bepaling van voertuigloopkoste vir aanwending in die evaluering van pad- en verkeersingenieursprojekte*. D.Comm. dissertation. Pretoria: University of South Africa.
- Pienaar, W.J. 1986. Right of way demands and effectiveness of possible solutions to the urban transportation problem in Southern Africa, II254 - II273. In: Wang, C.F. (ed.). *Symposium on strategies for urban transportation in developing countries*. Taipei, Taiwan R.O.C.: International Road Federation.
- Pienaar, W.J. 1994. Resolving urban transport problems and conflicts in South Africa, A23-33. In: *Proceedings of the International Road Federation Conference and Exposition. Roads to the 21st century: a key to competitiveness*. Calgary, Canada.
- Pienaar, W.J. 1995. The determination of economic benefits and cost of passenger transport terminals and transfer facilities. *Studies in Economics and Econometrics* 19(2):23-41.
- Pienaar, W.J. 1995a. Basic principles and background information with respect to the cost-benefit analysis of urban transport projects, 2.1 - 2.23. In: Hromic, M. (Ed). *Guidelines for conducting the economic evaluation of urban transport projects*. Second edition. Municipality of Cape Town.

- Pienaar, W.J. 1996. Economic evaluation of passenger transport terminals and transfer facilities, 2.1-2.20. *Proceedings of the Australasian Transport research Forum Conference*. Auckland, New Zealand.
- Pienaar, W.J. 1997. Modelling generalised transit commuter costs for use in urban transport planning, 307-315. *Planning of the Third International Conference on Urban Transport and the Environment for the 21st Century*. Acquasparta, Italy.
- Pienaar, W.J. 1997a. Consideration of welfare distribution in project evaluation and selection. *Journal of The South African Institute of Civil Engineering* 39(1):25-28.
- Ray, A. 1984. *Cost-benefit analysis*. Baltimore: Johns Hopkins University Press.
- Rutherford, R. 1992. *Dictionary of economics*. London: Routledge.
- Rontiris, K. 1990. *Guidelines for the design of combi taxi facilities*. Pretoria: Department of Transport. (Report 88/140/1.)
- Schutte, I.C. 1984. *Manual on the economic evaluation of transportation projects*. Draft Manual K 64. Pretoria: CSIR.
- Schutte, I.C. & Pienaar, W.J. 1996. *Characteristics and operating cost of South African vehicles*. Pretoria: Department of Transport. (Project report CR-96/038.)
- Stander, H.J. 1985. *Transporting people to central business districts and surrounding work complexes*. Pretoria: Department of Transport. (Report PG 2/84.)
- Sugden, R. & Williams, A. 1978. *The principles of practical cost-benefit analysis*. Oxford: Oxford University Press.

- The MVA Consultancy, Institute for Transport Studies at Leeds University, Transport Studies Unit at Oxford University. 1994. Time savings: research into the value of time, 235-271. In: Layard, R. & Glaister, S. (eds.) *Cost-benefit analysis*. Second edition. Cambridge: Cambridge University Press.
- Tichauer, C.R. & Visser, D.P. 1991. Information systems at modal transfer facilities, 6.1 - 6.11, 4A. In: *Jaarlikse Vervoerwesekonvensie*. Pretoria.
- Transport and Road Research Laboratory (TRRL). 1988. *A guide to road project appraisal*. Crowthorne, Berkshire, United Kingdom. (Overseas Road Note 5.)
- Transportation Research Board (TRB). 1985. *Highway Capacity Manual*. Washington, D.C.
- Vuchic, V.R. 1981. *Urban public transportation: systems and technology*. Englewood Cliffs, New Jersey: Prentice Hall.
- Vuchic, V.R. 1992. Comparative analysis, 272 - 292. In: Gray, G.E. & Hoel, L.A. (eds.) *Public transportation*. Englewood Cliffs, New Jersey: Prentice-Hall.
- Vuchic, V.R. & Newell, G.F. 1968. Rapid transit interstation spacing for minimum travel time. *Transportation Science* 2(4):303-339.
- Waters, W.G. 1994. The value of travel time savings and the link with income: implications for public project evaluation. *International Journal of Transport Economics* XXI(3):243-254.
- Weisbrod, B.A. 1968. Income redistribution effects and benefit-cost analysis, 177-209. In: Chase, S.B. (ed.) *Problems in public expenditure analysis*. Washington: Brookings Institution.

Whiteford, A.C. and McGrath, M.D. 1995. *Income distribution, inequality and poverty in South Africa*. Paper presented at the EBM Research Conference. Stellenbosch.

World Bank. 1994. *World development report*. Washington, D.C.