

AN APPROPRIATE STRATEGIC MODELLING APPROACH FOR SOUTH AFRICA

A D Perold

City Council of Pretoria, PO Box 1409, PRETORIA

and

S J Andersen

Africon Transportation Division, PO Box 905, PRETORIA, 0001

1 INTRODUCTION

Urban Transportation Modelling in South Africa generally follows international trends, with an implementation lag of approximately five years. The development of software is typically done in major development organisations, with a focus on market demands in primary users countries, such as the USA, Great Britain and others.

There is a continuing local need to be in touch with “cutting edge” developments in urban transportation planning. However, it is also recognised that local needs can differ substantially from the market demands and planning requirements of countries abroad. In particular, there is a dire need for models that represent and evaluate as far as possible all the significant effects of transport policy. It is currently difficult, for example, to differentiate between the relative priorities of current and proposed Integrated Development Plan (IDP) projects from a modelling perspective – the tools are not available to adequately test policy matters related to land use/transportation planning, specifically with regard to public transport strategies.

Furthermore, an increasing number of different types of software is becoming available in order to address the more diversified needs of users. It is not always easy to judge the appropriateness of specific software for local application by initially available information. Quite often more detailed information is not available – such as the level of sophistication provided, the degree of accuracy that can be expected and the amount of data required. It is becoming increasingly important to be aware of the latest international trends in land use/transportation modelling, and have enough information on these developments to establish its use for local conditions.

In light of the above, the City Council of Pretoria with the support of the Greater Pretoria Metropolitan Council, embarked on a four stage process to position themselves with respect to an appropriate approach towards Strategic Transportation Modelling. The first phase identifies issues and options regarding strategic modelling, involving desktop research on current trends in this field. The second phase includes a closer look at feasible options as well as a study tour to familiarize oneself with the latest modelling trends. The third phase considers possible pilot projects with the final and fourth phase involving actual implementation. This paper largely reports on the first two phases of this study, and extends the results to the larger transportation modelling fraternity.

2 TRAVEL DEMAND MODELLING NEEDS AND OBJECTIVES

Since the beginning of civilization, the viability and economic success of communities have been, to a major extent, determined by the efficiency of the transportation infrastructure. To make informed transportation infrastructure planning decisions, planners and engineers have to be able to forecast the response of transportation demand to changes in the attributes of the transportation system and changes in the attributes of the people using the transportation system. Travel demand models are used for this purpose; specifically, travel demand models, after having been calibrated against the current "real world" transport and land use conditions, are used to predict travel characteristics and the usage of transport services under alternative socio-economic scenarios, and for alternative transport service and land use configurations.

Travel demand models were developed during the past forty years typically by utilizing the traditional four step approach, viz trip generation, trip distribution, modal split and trip assignment. Main frame software versions, such as BACKPAC, DELTRAN and the earlier UTPS suites, were developed in earlier years. More user-friendly desktop versions were developed in the eighties, such as TRANPLAN, and more recently the widely used Canadian software, Emme/2.

Through the years, the modelling fundamentals did not change dramatically – development of the software was a function of developments in the micro-electronic industry coupled with the specific needs of users. This has not changed. In the United States, for example, traffic and transportation engineers recently identified a number of needs in the transportation modelling field. These are summarized in Table 1.

Table 1 : Transportation Modelling Needs (Ref. 7)	
1	Interface between travel demand modelling and GIS
2	Trip chaining (e.g. the ability to not only model a trip from home to work, but also allow for dropping off kids at school)
3	Time of day modelling (e.g. not just the am peak hour)
4	Presentation of transportation plan results for meetings with officials, politicians, public and other interested parties
5	Public transport routing and scheduling
6	User-friendly simulation
7	Modal integration
8	The next generation of travel demand forecasting

Locally, we can identify with many of the needs depicted above. However, circumstances and constraints often dictate, also recognizing that our approach cannot be the same as that of a typical industrialized European or American city. Within our modelling approach we need to recognize the specific needs in our own society. With this in mind, modelling needs for the Greater Pretoria Metropolitan Area were listed as follows:

Table 2 : Transportation Modelling Needs and Objectives in the Pretoria Metropolitan area
• quantitative input need to be provided to the LDO/IDP process
• advances in public transport modelling must enable:
- optimization of public transport services
- passenger modal choice and trip composition
- vehicle scheduling
- vehicle routing
• inter-modal optimization
• a user-friendly display of results
• trip chaining
• advances in “real-time” modelling
• possible inclusion of freight transport modelling
• integration of sub-area modelling with metrowide and regional models

In summary, current development and transport needs, the high cost of public transport subsidies and infrastructure, and the manifested shortage of funds to sustain the required road infrastructure to accommodate the expected growth in private vehicles, ***makes it imperative that ways be found to plan (model) and implement an effective and efficient transport system, including the design of optimised multi-modal public transport services contracts.***

3 TRAVEL DEMAND MODELLING IN CONTEXT

In an effort to address the modelling needs as identified in the previous section, it is imperative to recognize the context of various modelling software programs and its area of application.

The ideal model would be one that could cover any area which functions as a single transport system, e.g. the Greater Pretoria Metropolitan Area. All roads of traffic significance as well as all modes of travel are included. On the supply side, it will be able to model the impact of a regional freeway (at one extreme) as well as the detailed operation of an individual signalized intersection. It would furthermore be able to model the impact on travel demand due to changes in the supply of travel – both in the short and long term. It would also be capable of estimating changes in demand due to factors not directly connected to the supply of travel e.g. changes in land-use and spatial distribution, car ownership, population, income etc. the ideal model is also capable of addressing strategic planning issues as well as an operational (often “real-time) assessment of elements of the transport system. Unfortunately, no such ideal model exists.

The existing models can be classified in a number of ways. A useful classification, from a users viewpoint, is based on the types of scheme that can be evaluated with a particular model. Under this classification, models can be differentiated by the level of detail of network coding and the maximum practicable size of the network.

This classification is summarized in **Figure 1**.

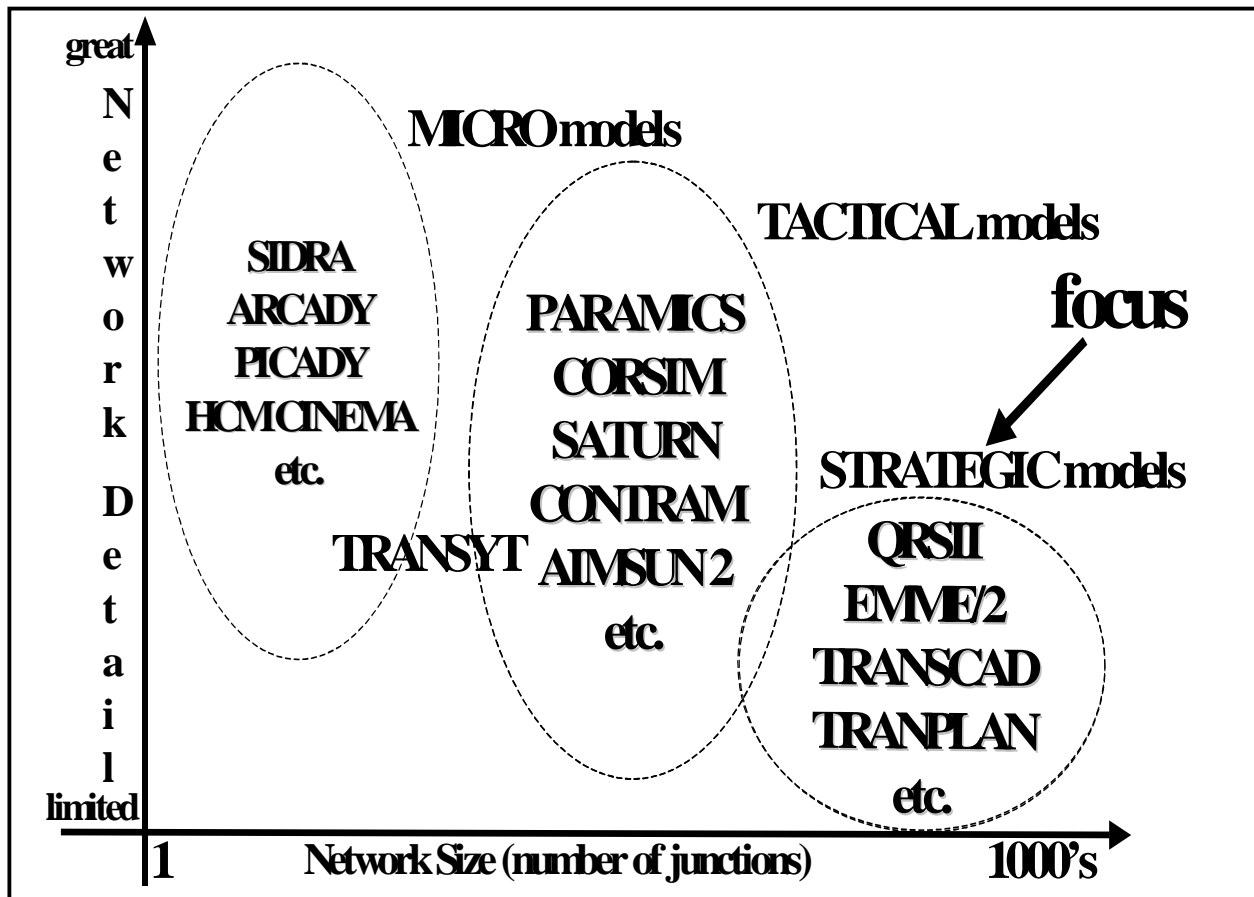


Figure 1 : Classification of Transportation Models

From the above figure, it is possible to identify three broad classes of models, as discussed hereafter.

(i) Strategic models

Strategic models focus on macro aspects, i.e. aimed at evaluating projects on metropolitan or regional level. An example of an appropriate project would be a large scale project such as the evaluation of a new freeway. These are typically kink-based models characterized by their relatively limited data requirements. Strategic models requires a substantial amount of planning data, such as future land use, population, employment, income etc. This information is typically used to develop trip matrices for various development scenarios.

(ii) Tactical models

Tactical models are much smaller in size than the strategic models, typically modelling 50 to 150 intersections. Furthermore, much more extensive network data is required, particularly for the coding of intersections. Micro behavior, including consideration of delay at intersections, is explicitly dealt with. Projects with a more localized impact, is evaluated with tactical models. It furthermore assumes a fixed trip matrix, i.e. any changes due to mode choice, land use, etc. need to be calculated extraneously to the model.

(iii) *Micro models*

Micro models simulate traffic at a very detailed level – typically an isolated intersection. This model requires a high level of detail focusing on micro behavior, and typically used for intersection design.

Within the above context, this paper focuses on strategic models and its associated applications. We recognize that within the South African context, most major Metropolitan areas have developed such models. Not all of these models are updated and used regularly, and are also used for varied purposes with varying scope of application. It often is used to provide the necessary forecast year trip matrix for input in a sub-area tactical model.

4 TRENDS IN STRATEGIC TRANSPORTATION MODELLING

Substantial development in transportation modelling has taken place in the international arena with which we have to familiarize ourselves. This section addresses three aspects, namely:

- general trends in the modelling approach
- criteria to consider in choosing appropriate modelling software
- an overview of a recent study tour specifically focussing on worldwide approaches in transportation modelling.

4.1 General Trends in the Modelling Approach

Theoretical methods applied to transport modelling make a distinction between trip-based and activity-based modelling.

Trip-based models are well known as the conventional four-step modelling or classic transportation model. They are currently the most commonly used suites of models worldwide. The trip based approach uses individual trips as the unit of analysis. Time-of-day trips is either not modelled or is modelled in a limited way often by applying time-of-day factors to 24-hour travel volumes.

Trips are the unit of analysis with separate models for home-based trips and non-home based trips – therefore not considering the dependence among such trips. The organization of trips is not considered; there is no distinction between a home-based trip made as part of a single trip between origin and destination and a home-based trip with multiple stops along the way. The impact of such multiple stops has proven to be significant in the local environment.

Lately, development with respect to trip-based models has focused on improving the visual presentation of results as well as integration with a Geographic Information System (GIS) platform. The theoretical challenges of these models (such as developing the algorithm for the user equilibrium approach) have largely been solved by the early 1980's.

During the eighties much work was done in Britain, as well as in many cities around the world (including in South Africa), in aggregate and disaggregate modelling. In these cases as much trip related data as possible were collected, categorized and averaged in terms of common characteristics. In aggregate modelling the averaging is undertaken per area or zone, whereas in disaggregate modelling households are the basis for averaging. This era also saw the use of advanced regression models to identify appropriate and interdependent trip making parameters.

Activity-based models have developed partially as a response to a shift in emphasis from the evaluation of long-term-investment-based capital improvement strategies, to understanding travel behavior responses to shorter-term congestion management policies. These models attempt to model a comprehensive daily activity-travel pattern for individuals, focusing on a set of activity patterns rather than an aggregated trip rate per household. This enables the individual to adjust plans in response to temporal and spatial constraints, also allowing for trip chaining, activity re-scheduling and destination substitution. A micro-simulation model replaces the generation, distribution and mode choice components and produces dynamically specified trip tables – serving as input into a dynamic assignment model.

Several practical aspects of activity-based modelling need to be considered. It does require time-use survey data and decision making criteria for analysis and forecasting, thus requiring the collection of data regarding all activities pursued by individuals over the course of the day. Although it is similar to administering household surveys, one need to collect in-home as well as out-of-home activities. Information required is a little more extensive, but experience suggests that the respondent burden or response rates are not significantly different between time-use and travel surveys, while at the same time, providing a much more comprehensive understanding of travel patterns and trip making.

Activity based models have shown that it can provide a better reflection of changes in society and the organization of travel. It is an extremely helpful tool for prediction of policy measures such as activity participation, scheduling, mode of transport as well as the destination and route choice of transport users. The activity perspective of travel provides a clear picture of the functioning of urban areas and has the potential to identify the differential quality of life associated with different segments of the population.

Locally, the need for activity based modelling has been under discussion – specifically with respect to the appropriate application thereof. On specific relevance are three need-related aspects, namely:

- time-based trip making
- trip chaining abilities
- the development of discrete choice parameters.

These needs should be explored further and its appropriateness considered in relation to the general travel demand modelling needs.

4.2 Software Selection Criteria

In considering the various developments in transportation modelling software, a large selection of applicable software was listed. It was considered not appropriate for purposes of this paper to make any selection or rank such software. Rather, it is more important to develop criteria according to your specific needs that will enable you to choose the most appropriate software. Four groups of criteria were developed and are discussed below:

One could consider **technical** criteria such as trip generation-, trip distribution, -model split- and trip assignment options; trip ability to be integrated with a GIS system; the analysis of non-motorized travel; its compatibility with land use allocation models; dynamic assignment capabilities; modelling of trip-chaining behavior; trip table estimation procedures; the ability to analyze tolling strategies; freight modelling procedures; public transport modelling; and the way it models and simulates intersections.

General characteristics of the software also need to be considered, which can include its price and price options; the annual cost of support; inclusions in the support contract' size limitations; and application in major projects.

The **track record** of software can also be an indication of its usefulness by considering the number of worldwide users as well as examples of its successful application in major projects.

Lastly, the **vision** of the software developers might give one assurance of the sustainability of particular software and can be obtained by answering questions such as “what are the main advantages of particular software?” and “which are the major software improvements foreseen in the near future?”.

These criteria can be ranked, weighed, listed or used in a multi-criteria decision making environment to assist in choosing the software most appropriate for your needs.

4.3 Transportation Planning Needs in Pretoria within the context of International Development

4.3.1 Background

The Department of Transportation Engineering and Roads of the Pretoria City Council and the Land Use and Planning Department of the Greater Pretoria Metropolitan Council, base their road construction and public transport improvements programs on both demonstrated needs and sound strategic planning. This planning is based on current transport infrastructure, traffic, spatial, social, economic and other considerations, which are interpreted scientifically to reflect future scenarios and the resultant required transport system.

It is quite clear at this stage that Pretoria's road system will not be able to accommodate the current growth in private vehicles in a sustainable way over an extended period. Alternative solutions involving public transport need to be found and implemented. By using appropriate computer simulation models and strategies to effectively develop suitable transport alternatives, which will best integrate and utilize all transport modes, can be tested mathematically prior to being implemented. This includes the determination of a cost to benefit ratio for each alternative development scenario.

A study tour, to determine the “state of the art” of traffic modelling in relevant cities and countries, was undertaken. To assist in ensuring that transportation planning issues were evaluated within the full context of a developing city, the modeller was accompanied by a city councilor who is the chairman of the relevant transport committee. This proved to be of exceptional value in maintaining the relevancy of the study tour.

4.3.2 Study Tour Highlights

A summary of the various stopovers and highlights within the context of the study follows:

Curitiba, Brazil:

Curitiba (population 1,6 million) in the south of Brazil, has a proud record as the “ecological capital of Brazil” as well as being the leading city in applying a successful transportation system based on road public transport. This system is considered to be sustainable in terms of a city with significant social challenges and relatively limited financial resources.

The city of Curitiba controls its growth by setting boundaries and land use, and strictly enforcing this. It was thus possible to develop high density development corridors served by high capacity, dedicated right-of-way, bus services. Sophisticated transportation and land use planning is undertaken by a specialist institute consisting of both transportation engineers and town planners (IPPUC).

Santiago, Chili:

Exceptionally high standards of metropolitan transportation and land use planning is undertaken directly by a National Ministerial Secretariat (SECTRA).

The secretariat consist of a full time professional staff complement of approximately 40 experts (educational standards in Chili appears to be exceptionally high) and includes transportation engineers and town planners. The Secretariat directs a group of consultants for assistance and specific tasks on a basis of their its expertise, which have resulted in excellent transportation planning and feasibility studies.

During the interview with professor Ortuzar of the Catholic University in Santiago, he expressed himself in favor of well informed transport planning and modelling with individual choice trip making as a basis.

Transportation in Santiago has significant similarities with cities in South Africa, in terms of overall modal split, types of vehicles used, etc.

THE UNITED STATES OF AMERICA

HOUSTON:

Houston is known for the fact that it does not apply strict land use zoning, but rather allows market forces to direct development. However it does exercise strict building control, and this has resulted in a well structured and operated city, with a transportation system that operates efficiently.

It is usual practice in bigger cities the USA to have a Metropolitan Transport Organization (MTO), with a Metropolitan Transit Authority (MTA) reporting to it.

Transportation planning and modelling in Houston, as in many other American cities, is relatively simple, as they are basically single mode (private car) cities, which makes strategic transportation modeling significantly simpler. It is simply easier to model virtual single mode transport systems,

where route choice and street capacity are the main constraints. The complicated aspects of travelers (and politicians !) having to make decisions with regard to which mode of transport (or combination of modes) they will use is thus not a major consideration.

AUSTIN, TEXAS

The University of Texas at Austin is well known for its high standards of teaching and research in transportation. The objective of the visit was to meet Professor Hani Mahmasami, a world renowned expert on transportation planning. He has researched decision (choice) based modelling and is a proponent of transport simulation based on a knowledge of the decision making criteria of commuters, combined with a traffic model that allows trip decision making at intermediate transfer points.

In an in depth discussion with Prof Mahmasami, he indicated that certain levels of Activity Based Modelling (ABM-including individual choice modelling) is currently feasible and is a logical direction to move to.

BOSTON (NEWTON)

The purpose of visiting the Caliper Organization in Newton, Boston, was to obtain first hand knowledge of a typical modern GIS based integrated land use and transportation simulation model.

In interviews with members of the organization, it became clear that significant improvements in modelling techniques and analyses have been achieved during the past decade, which makes certain forms of activity based traffic simulation possible. This, linked with discrete multilomial choice trip making, can represent trip making that includes various modal choices during a single trip, thus enabling effective integrated, multi-modal transportation modeling.

NEW YORK

The delegation obtained an interview with Mr. Robert Newhauser, Unit Head, Transportation Planning for the Metropolitan Transit Authority (MTA); New York City Transit, and senior members of his team of specialist transport planners and modellers.

In 1981 the City declared a transportation 'state of emergency, and since then had spent over \$ 24 Billion on upgrading the system. The main lesson learnt during this time was that public transport users are customers who must be kept satisfied (through understanding their reasons for trip making), or lost to other modes of transport.

Extensive travel surveys, capital investment, innovative fare collection policies, good management and planning and a commitment to quality, brought back ridership to record levels and major expansion programs are being undertaken and planned. GIS based modelling and activity related modelling is used for both strategic planning and as the basic infrastructure, rolling stock and transport services database.

4.3.2 *Lessons learnt*

The study tour indicated clearly the important role of decision making traffic modelling in the preparation of effective transportation development programs and the role it should play in a city's decision making processes.

However it also became clear that in cities with significant public transport usage the need is for models that can be used to simulate passenger decision making and that can evaluate alternative public transport systems and strategies. The technology to do this exists, but it needs to be properly addressed, maintained and applied. It is also essential for cities to be politically committed to an integrated planning process and to manage the city's growth along clear and well enforced guidelines resulting from, amongst others, this process.

5 AN APROPRIATE STRATEGY FOR SOUTH AFRICA

Clear trends were identified in the earlier sections with regards to transportation modelling, specifically focusing on three prime areas, namely:

- full integration of GIS with transportation planning suites:
- understanding and incorporating modal choice decision making
- gradual movement from a trip based approach to an activity based approach.

We need to determine to what extent one has to adhere or follow the above trends, and how it relates or addresses other needs unique to our local environment.

Three issues really need to be addressed:

- is the strategic modelling software we use still appropriate?
- should we move towards an activity based approach?
- what are the practical implications of the previous aspects as applied in our local environment?

5.1 Choosing the Appropriate Software

A key aspect is to determine whether the software we are currently using, is still appropriate within a changing environment. Four initial steps to assist with this issue are recommended below:

- Step 1** : Identify the key (and appropriate) criteria for your environment
- Step 2** : Identify possible candidate software through an initial screening process
- Step 3** : Rate or rank the various software with respect to the identified criteria
- Step 4** : Undertake pilot projects whereby candidate software is compared with the status quo, utilizing a similar framework for comparison

5.2 Appropriate Implementation of the Activity Based Approach

The decision to move towards an activity based approach is not straightforward. Although this area of modelling has proved itself and has been under development for more than two decades, South Africans have not had much exposure to developments in this field. Some steps are again proposed to assist with this process:

- Step 1** : Identifying the elements of activity based modelling that is appropriate and required within the South African context (related to the earlier needs analysis)
- Step 2** : Establish an appropriate migration path towards activity based modelling
- Step 3** : Determine the cost and quantify the benefits for introducing the appropriate activity based modelling approach as determined in Step 2.

5.3 Practical Considerations

It is hoped that this paper made a contribution in putting modelling software and modelling trends in perspective. The onlooker or uninformed (sometimes even the informed!) is confronted by a multitude of software options or directions – with the one looking as promising as the other one. Furthermore, current practice in South Africa is that consultants invest in new modelling software with a specific application in mind to give them a competitive edge. If accepted by clients, other consultants soon follow suit. This approach does not always guarantee the purchase of the optimum software from the perspective of the various tiers of government.

Initial capital costs as well as the yearly support fee payable to software suppliers are extremely high for the consulting industry to carry . There are not adequate modelling projects countrywide for all modelling consultants to purchase the software, pay their annual fee and expect to earn enough fees to cover the costs of their expenditures in this regard. The challenge is to determine ways to alter the status quo.

Some thoughts in this regard are as follows:

- standardize on modelling software as far as possible
- purchasing of software should be done at a National or Regional level by the responsible public authorities
- a pool of modelling experts should be developed and maintained
- a cursory overview of modelling software and trends should be done every 5 years to ensure awareness of worldwide trends
- a more comprehensive overview should be compiled over 10 years. Consideration should be given to the possible purchasing of new products at such time
- it is proposed that a national modelling symposium be held to discuss all of the above and to agree on a way forward.

6 CONCLUSIONS

It is clear that, for the purpose of evaluating short, medium and long term transport policies and strategies, especially when public transport is important, it is practical to use simulation techniques which are sensitive to people's perceptions and opinions, and the way in which they make trip making decisions.

It is essential that effective and sustainable urban planning advances into the field of decision based multi-modal traffic modelling, integrated with land use and economics. To effectively pursue desired strategic outcomes, modal choice sensitive modeling is recommended. This will enable planners to scientifically choose modal stimulation strategies that will achieve, as far as possible, and practical, an optimized transport system.

7 REFERENCES

- 1 Bhat, Chandra R and Frank S. Koppelman (2000). Activity-Based Modelling of Travel Demand. To be published in the Handbook of Transportation Science (Chapter 3).
- 2 Lawton, T.K and E.I. Pas (1996). Resource paper for survey methodologies Workshop, Conference Proceedings on Household Travel Surveys: New Concepts and Research Needs, Transportation Research Board, National Research Council, Washington, D.C.
- 3 Mahmassani, Hani S (1991). Course notes on Travel Demand Modelling, University of Texas at Austin.
- 4 Van Vliet, D (1997). SATURN – Course notes, presented in Pretoria, 17-21 November 1997.
- 5 The Urban Transportation Monitor, October 1, 1999. Urban Transportation Planning Software, Part 1.
- 6 The Urban Transportation Monitor, October 15, 1999. Urban Transportation Planning Software, Part 2.
- 7 The Urban Transportation Monitor, November 1998. Transportation Modelling Software Needs.
- 8 Bagot, Nick. Traffic Technology International. February/March 1999. "Try before you buy – trends in traffic simulation".
- 9 Perold, A J (2000). Study tour to South America and the USA covering transportation planning trends and developments. Internal report submitted to Council, City of Pretoria.
- 10 Gauteng Department of Transport and Public Works. October 1998. The Gautrans regional transportation model: Its use and procedures for obtaining modelling results. Report BL98/11.
- 11 Ettema, Dick and Harry Timmermans (editors). (1997). Activity-Based Approaches to Travel Analysis Pergamon.
- 12 Daly, Peter and William Young. (1996). Activity modelling of Urban Traffic Movement. Proceedings. Roads 96 Conference, Part 7.
- 13 Ortúzar, J. de D. and L.G. Willumsen (1994). Modelling Transport (Second Edition). John Wiley & Sons.

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A D Perold
City Council of Pretoria, PO Box 1409, PRETORIA

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S J Andersen
Africon Transportation Division, PO Box 905, PRETORIA, 0001

C V: A D PEROLD

Matriculate at Hoërskool Hennenman in the Free State and graduate from University of Stellenbosch in 1972 with the degrees B Sc, B Eng in civil engineering.

Major subject is Transport and final year description involves the early use of an all-or-nothing-UTPS traffic modelling program.

Spend two years with the SAR&H on rail related construction (bursar) and surveying, followed by 5 years with consultants in Bloemfontein. During this period work consisted of civil, geometric and pavement design, as well as construction supervision.

Joined Durban corporation in 1978 as a traffic engineer under Richard Moore, responsible for geometric and traffic engineering design and modelling. Also becomes jointly responsible for the preparation and execution of on the Durban Metropolitan Transport Plan. Undertake Deltran traffic modelling in conjunction with De Leuw Cather.

Obtain further bursary from DOT and Durban Corporation and obtained degree M sc. (Eng) in transportation engineering at Wits in 1982 (full time study). Become Chief Engineer (Traffic and Transportation) in 1984. Responsibilities are transport planning, traffic engineering, land use and public transport.

Joined Johannesburg City Council in 1988 as Assistant Director (Metropolitan Transport Planning). Manage development and transport planning, the Integrated Transport Plan and public transport planning, management and co-ordination. Land Use/Transportation plans, Minitramp modelling and the proposed Johannesburg Masstran were major aspects dealt with.

Joined BKS Consulting Engineers (Parktown) in 1990 as member of the transport division undertaking planning and impact assessments. Due to work demand in Durban assigned to establish a transport planning business division in BKS's Durban branch in 1993. This was successfully established with major projects in airport planning and design, public transport services design, and urban and rural transport. Significant international experience gained on urban transport systems and airports.

Accepted the post of Chief Engineer (Transportation Planning) at Pretoria City Council in 1997 leading a professional team undertaking transport planning, land use development applications, major road design and public transport. Developing and maintaining the Pretoria regional land use/transportation model (Emme/2) and Saturn sub-area model.