

A STUDY INTO THE PROVISION OF A MANAGEMENT INFORMATION SYSTEM FOR THE SOUTH AFRICAN TRANSPORTATION ENGINEERING INDUSTRY

L. DU PLOOY and M. VANDERSCHUREN

iCE Group (Pty) Ltd, P O Box 131, Stellenbosch, 7600
Tel: 023 316 2264; Email: liezl@icegroup.co.za
University of Cape Town, Private Bag X3, Rondebosch, 7701
Tel: 021 650 3499; Email: marianne.vanderschuren@uct.ac.za

ABSTRACT

Transportation data is required in the public sector in order to manage road networks, to evaluate development applications, to do transport planning and to address traffic safety concerns. Transportation data is, likewise, required in private practice by consulting engineers, academic institutions and non-governmental agencies concerned with transportation. The aim of the paper is to outline a proposed Transport Management Information System intended to fulfil the above mentioned requirements - a tool that can assist transportation practitioners in the decision making process.

The paper discusses the system development process, with specific reference to user and legal requirements. The availability of transport information in South Africa is discussed, and the shortcomings are listed. The full system development falls outside the scope of this paper, but a framework is described in which required datasets can be developed, processed and displayed. The intention is not to develop entirely new technology and the adaptation and integration of existing systems and software packages were investigated.

The paper is concluded by stating that users require information on traffic flow, public transport, non-motorised transport, traffic safety, road signs and -markings and traffic signals and that there is a need for the inclusion of this information in a centralised, accessible and user friendly information system.

1. INTRODUCTION

1.1 Background

South Africa is currently encountering a shortage of experienced municipal engineers, due to factors such as an ageing work-force, emigrating professionals and the transformation of local government (Lawless, 2007). Consulting Engineers South Africa (CESA) estimates that the number of registered engineers employed in government fell from 5100 in 2005 to an estimated 1800 in 2010 (Pirie, 2011). Many large municipalities have dedicated transport engineers, but at smaller municipalities these tasks form part of the whole array of civil engineering functions that have to be managed by a handful of engineers and technicians. Due to a high work load and/or inexperience, these engineers are often not aware of the expectations and imperatives that exist through transport legislation and neither do they have access to the information required to make informed transport related decisions.

Through the author's own employment at, and interaction with, government institutions, it has become clear that there is also a shortage in relevant, recent information on aspects ranging from traffic flow data, to accident statistics, to public transport licensing information.

Mokonyama and Schnackenberg (2006) concur, stating that the formulation of transport plans, for example, has encountered numerous stumbling blocks, both technical and administrative in nature. They reason that South Africa lacks a knowledge base, which can only be built through continuous research, and that engineers and transport officials in public office are often driven to trial and error tactics in order to deliver plans as required by government.

One step towards the establishment of a knowledge base is the provision of a Transport Management Information System (TMIS) that will include the transport information required by municipal engineers, in order to conduct their daily work. Information systems for reticulation networks and pavement management have been developed and successfully implemented, but no such system exists for transportation. It is proposed that the transport management information system should have the same main features as the existing systems: a database populated with transport data linked to tools which will assist municipal engineers with decision making, displayed on interactive, GIS-based maps.

1.2 Problem statement

In order to develop the TMIS, it had to be determined:

- a) Whether a transport management information system is needed and who would find such a system useful;
- b) What the user requirements are;
- c) The extent of currently available transport information in South Africa, and what the gaps are;
- d) Which types of information the system should include;
- e) The data requirements of the system and data sources;
- f) What the system should look like; and
- g) How the system will be implemented.

2. **SYSTEM DEVELOPMENT METHODOLOGY**

The needs of the end users were always going to guide the development process and for this purpose a User Centred Design (UCD) software development approach was followed.

Burger (2007) investigated various system life cycle models in order to select the appropriate model for the development of a GIS system, which had to be able to accommodate the continuous revision of user requirements during the development phase. Modules in the existing Infrastructure Management Query Software (IMQS), which was investigated as a possible software platform, are also developed using the incremental or "agile" model (Meyer, 2011). The incremental model was selected for the development of the TMIS.

3. DETERMINING THE USER REQUIREMENTS

A need for a TMIS was identified in the author's own company, but this had to be confirmed or refuted by other transport engineers. Transport practitioners, representing different institutions, were consulted in order to test the proposal and, if a positive response was received, to determine the user requirements.

The review of legal requirements for transport engineers showed that municipalities are expected to perform transport planning functions as part of integrated development planning. Some municipalities have to comment on applications for public transport operating licences. For the operating licence function, municipalities need information on the public transport operations in their area, including the location of interchanges and stops, the number of vehicles operating and the routes on which they operate, as well as details on the utilisation of the service. This information has to be updated regularly.

Municipal officials are responsible for the display and maintenance of road traffic signs and markings, but these functions are mostly outsourced to private companies with expert knowledge of the Road Traffic Signs Manual. There is no legal imperative attached to the road markings, road signs and traffic signals functions of municipalities.

The only legal imperative in terms of road safety is that accidents have to be reported to the South African Police Service (SAPS). There are no laws that compel officials to keep accident or safety records.

The National Land Transport Act (South African Government, 2009) requires the establishment and integration of provincial and national land transport information systems (NLTIS). The NLTIS is currently in the process of redevelopment and it is uncertain what the extent of the information will be, but it may be of some assistance to municipal engineers.

The first Transport and Environment Science Technology (TEST) network stakeholder meeting was used as platform to discuss the objectives of the proposed system with transport practitioners in the public and private sectors. The TEST Network is led by the Stockholm Environment Institute at the University of York in the United Kingdom and is funded by the European Union. The project is a collaboration between European and African countries, with the purpose of strengthening networking, sharing knowledge and enhancing research capacity on transport, environment science and technology issues. (Vanderschuren, 2010). Local government officials at the TEST stakeholder meeting indicated that they would like to have access to traffic data, specifically the traffic counts that are done by consulting engineers from time to time, and that they would be willing to make traffic information under their management available to engineers in private practice. The officials expressed a strong need for an independent body to integrate available data into a single set. Consulting engineers stated that the quality of data would be crucial, and that someone had to take responsibility for quality assurance.

The need was also expressed for the inclusion of the public and non-motorised transport modes, with further differentiation between minibus taxis and buses, and between pedestrians and bicycles. It was stated that the source and reliability of accident data was key to its utilisation in accident reports and road safety projects. The absence of inventories on road traffic signs and markings, and information on traffic signals were mentioned during interviews with specialists.

Details on the adequacy and range of public and non-motorised transport services in the vein of the National Household Travel Survey (NHTS, 2003) and the status of private and freight transport are needed by municipalities in order to formulate transport plans.

It was concluded that, although current legislation does not explicitly state requirements for transport related information systems, these systems are required by transport practitioners in both the private and public sector to fulfil their daily tasks.

4. PURPOSE OF THE INFORMATION

The intention is that consulting engineers will use traffic flow and transport information in the compilation of traffic studies, roads projects and transport plans. Authorities may use traffic flow information to gauge congestion levels and to assist when prioritising and budgeting for road improvement projects. Traffic safety information may be used to determine problem areas.

Public transport information should be used to evaluate operating licence applications (as was the intention with the CPTR / OLS process), and to highlight over- or under serviced routes. Information on road signs and markings will assist with maintenance and asset management.

5. EXISTING TRANSPORT INFORMATION SYSTEMS

The investigation into the extent and availability of transport information was limited to national databases and information available in the Western Cape.

Public transport information for metropolitan areas and transport authorities are generally up to date, but there is a lack of recent information in smaller municipalities and in rural areas. The information is mostly contained in documents (such as CPTR's) and is not readily available in databases.

The National Roads Agency employs a private company to gather traffic flow information on roads within their jurisdiction. The information is quite extensive, with historical records, traffic loading and traffic volumes available. The Western Cape Provincial Government (PGWC) has an ongoing traffic counting programme in which link volumes on provincial roads are determined. These volumes are available through the provincial government's Road Network Information Reports website. The site is accessible to the public, but a basic understanding of the Provinces road classification system is required to make sense of the information. Some large cities have teams who collect traffic flow data. This data is, however, collected at ad hoc locations and is not readily available to the private sector.

There are road accident databases at various local and provincial governments, which feed into a single database managed by the Road Traffic Management Corporation (RTMC), but that the records are often incomplete or contain conflicting information (Roodt, 2010).

The RTMC also runs the eNATIS system, which is a record of vehicle registrations and licensing. The information is not generally available to the public. The Corporation issues road safety reports on an annual basis. Table 1 summarises the availability and extent of transport information.

Table 1: Availability and extent of transport information

	Traffic flow	Traffic safety	Public Transport	Non-motorised transport	Traffic signs & markings	Traffic signals
Data available	some	yes	some	some	no	yes
Ease of access	easy	easy	hard	hard	n/a	hard
Data quality	good	questionable	good	good	n/a	questionable
How recent	recent	old	old	medium	n/a	recent

6. GAPS IN THE INFORMATION

The fact that there is already so much information available begs the question whether there is indeed a need for another database system. The answer lies in the fact that the existing data is available, but in a fragmented, uncoordinated and non-uniform fashion. The quality control of various departments is not to the same standard, as proven by the fact that the records of provincial and metropolitan councils for the same geographical areas have been found to include significant discrepancies. Vanderschuren and Jobanputra (2010) reported that, by October 2010, the PGWC could only supply complete accident databases up to 2007, which means that recent trends cannot be explored. A further problem is that it is very cumbersome and sometimes impossible for private institutions to access the data at government departments, and the data is not always presented in a usable format. There is therefore, principally, a need for a uniform database populated with quality data, which will be easily accessible to the users.

7. INFORMATION SYSTEM CONTENT

A wide range of user requirements were identified during the consultation process and it is intended that the final system should include information on traffic safety (accident statistics), public transport (service and infrastructure information), non-motorised transport (NMT, volumes), traffic flow (volumes and forecasts), road signs and markings (asset inventory) and traffic signals (asset inventory).

Due to the limited resources available for the project, not all of the requirements will be included from the start. The requirements mentioned above were critically evaluated in order to rank the requirements. The following aspects were considered:

- Potential number of users;
- Availability and ease of obtaining data: Whether data could be collected by the system developers or whether it was dependent on other institutions;
- Extent of information required to deliver a quality product: Whether raw data could be used, or whether processing was required;
- Time dependency: The shelf life of the information;
- Quality of data;
- Usefulness in decision-making: Whether the data can be processed to deliver a tool to assist in decision-making.

A multi-criteria method was used to evaluate the alternative requirements, with criteria as listed above. Only a qualitative evaluation was done, as none of the criteria can be measured. The alternatives were given a rating from 1 (worst) to 3 (best) for each of the criteria. The resultant scores were then compared, taking into account the weighting for each alternative. The evaluation indicated that the most needed requirements, in order, were for: traffic flow, non-motorised transport, road signs and markings, traffic signals, road safety and public transport.

The user survey indicated a need for processed traffic flow information, such as service levels and traffic forecasts which can be used in planning and decision-making, and it was originally proposed that the TMIS should have intersection analysis and transport modelling abilities. An investigation into appropriate and compatible modelling and analysis systems indicated that these systems were not dynamic in the sense that a model would not automatically adapt with the input of new data. It was concluded that engineering input is still required to reconfigure zones, nodes, links and origin destination matrices, which is a cumbersome, time consuming and expensive task.

It was therefore suggested that, although modelling output will be displayed in the information and although the data collected for the system may be used as input to the model, there will not be a dynamic link between the system and the model.

8. DATA REQUIREMENTS AND SOURCES

The goal is to draw up a Geographical Information System (GIS) based map that will be linked to a database containing the required transport information. Existing, available GIS maps will be overlaid with layers for traffic flow, traffic safety and the other requirements stated by the stakeholders. The mapping software must have the capability to accept new roads and trip generation nodes in order to ensure that the existing network is kept up to date, and in order to enable the display of future road networks with its respective features.

The information will be accessed by clicking on a road link or intersection, or through a system where users may select parameters for a query, for instance a request to display all Class 3 roads within the Helderberg Sub-Council carrying in excess of 1500 vehicles per hour.

8.1 Traffic flow

The database must accommodate the following input types:

- Mode of transport and vehicle type: private (light / heavy), public (bus, minibus); non-motorised (bicycle, pedestrian);
- Network component: road section (link) or intersection (node); and
- Movements: Per lane and per direction for links; Individual movements (being left, through, right and U-turn) for nodes.

The traffic flow component should be able to display information for each possible permutation of the above mentioned input types, and for time periods varying from peak hour to daily to annual totals, where available and applicable. School term and holiday period traffic volumes should be noted separately. Value may be added to information by giving a basic summary of Average Daily Traffic (ADT), Average Daily Truck Traffic (ADTT), E80 equivalent loads and 30th highest hourly volumes for stations with historic records.

Traffic volume information is available from a number of sources. The following were identified:

- Consulting engineers: Transport engineers in private practice gather transport information for most of the projects with which they are involved. There is an informal information sharing agreement between consulting firms, and between private and public institutions.
- Municipal records: In addition to special traffic count databases kept by some municipalities, all municipalities keep traffic impact assessments on record. These assessments contain a wealth of transport information.

- Provincial traffic counts: The Western Cape Provincial Government has a publicly accessible website with historic traffic counts for most of the provincial roads in the province. The counts differentiates between light vehicles, heavy vehicles, buses and minibus taxis, but only gives approach volumes and no turning volumes.
- SA National Roads Agency Limited: SANRAL has traffic monitoring specialists on permanent contract. The current contract is with Mikros Systems, incorporation Mikros Traffic Monitoring (Pty) Ltd and Syntell (Pty) Ltd. Traffic counts for stations on national roads can be obtained from these entities with permission from SANRAL.

8.2 Road signs, road markings and traffic signals framework

The database for road signs and markings will, essentially, be an asset inventory, which will display the following:

- Location of the sign / road marking element (co-ordinates and physical location);
- Sign identification (SARTSM number);
- Sign details (photograph displaying text and other face details);
- Hardware (types of posts, dimensions);
- Date of installation / date of last maintenance; and
- Condition.

The requirements for traffic signals are similar to those for road signs. The traffic signals database will, in addition to the aspects listed in the previous paragraph, also have to contain details on the controller (type, age) and the staging plans. Signal staging plans can be obtained from the responsible roads authority. Details on the hardware will be gathered on site.

8.3 Traffic safety database framework

The input will consist of traffic accident records, but these can only be obtained from municipal or provincial traffic authorities, or the SAPS. The extent of the database will, therefore, be limited to the information contained in traffic and police reports. The database should make provision for the input of the following:

- Accident location (road section or kilometre marker/intersecting roads/co-ordinates);
- Type of accident (for example head-on, sideswipe, accident with pedestrian); and
- Severity of accident (damage to vehicle, slight injury, major injury, fatal).

Although this information may not provide sufficient data for in depth research, it would give an indication of problem areas and possible causes of accidents.

8.4 Public transport database framework

The most basic requirements for public transport planning are details of the service that is currently provided and the service that is required, or the comparison between supply and demand. For this purpose, the public transport component should contain the information typical to a Current Public Transport Record, as summarised below:

- Registered routes: Route no, origin, destination, distance, description, fares;
- Unregistered routes: Origin, destination, description, distance;
- Vehicle details: Registration details, permit details;
- Facilities: location, type;
- Facility and route utilisation: Capacity (vehicles, persons), utilisation (vehicles, persons, type, e.g. learners), maximum number of vehicles, arrivals & departures per time period.

Much of the current public transport record data required for the Transport Management Information Database is available at District Municipalities or Provincial Governments from previous rounds of the CPTR process. The challenge lies in accessing and standardising the data. Some of the data may be outdated, in which case new surveys will have to be undertaken.

8.5 Display

The user will be able to access information through interactive maps with separate layers for each information type, and with data accessible through drop-down menus. Please refer to Figures 1 and 2 for display examples.

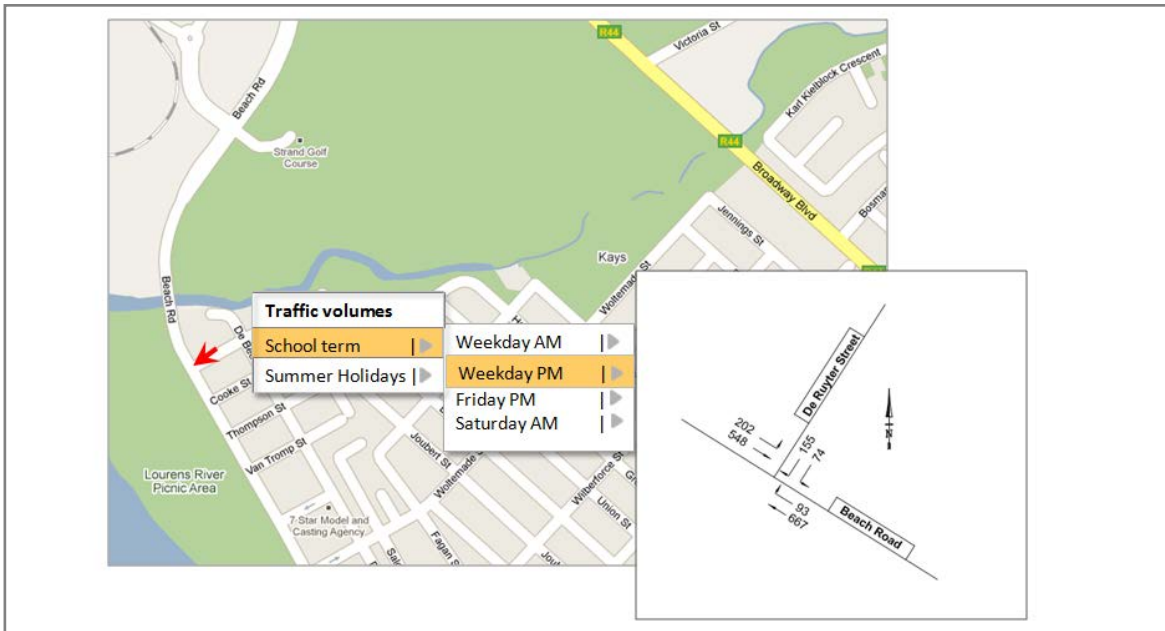


Figure 1: Intersection traffic volume display

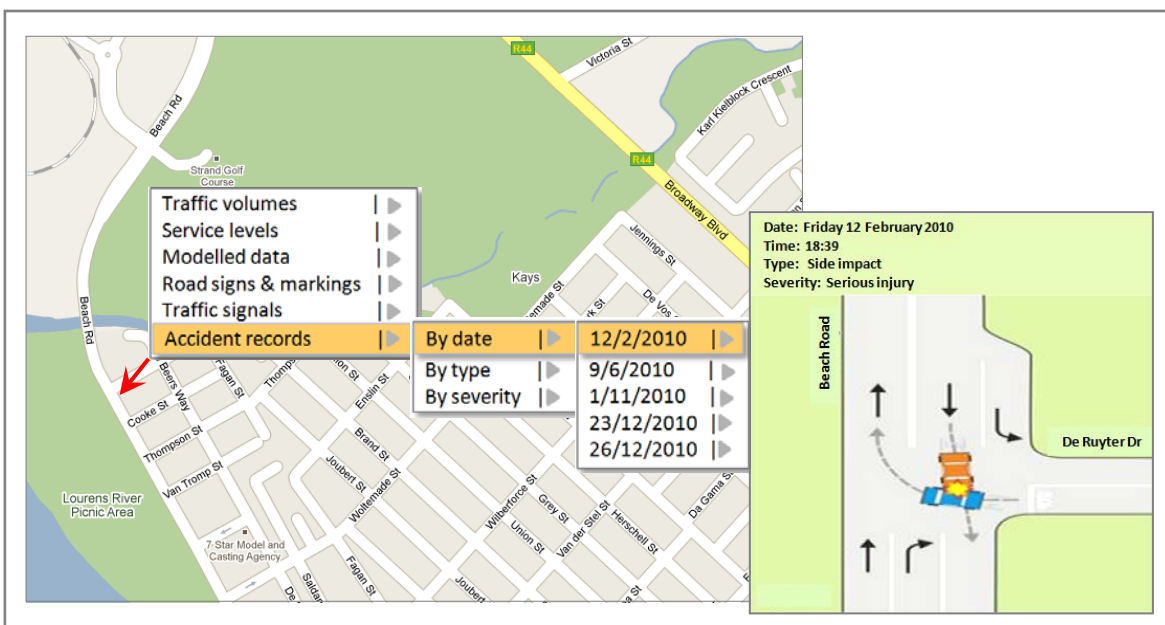


Figure 2: Accident record display

9. IMPLEMENTATION

It has been stated that some transport information is available in databases across the country, but that there are problems in accessing the data, as well as with the quality of the data. It follows that there is a need for a centralised database, with information available to the private and public sectors, and which will be the responsibility of a single entity.

Due to the limitations associated with this project, it is proposed to start small by collating only available traffic flow data in private and public ownership and to keep this data in a simple database linked to, for instance, *Google Earth*TM. Value may be added by analysing the available data.

A second step may be taken when the system developers are appointed for a transport plan or similar project at a Municipality, as these projects require intensive data capturing and processing exercises. The data can be incorporated into the TMIS as part of the project. As need for the TMIS increases, further value may be added through the inclusion of more differentiated data sets (for example public transport data or accident statistics as per the ranking exercise), and by adding intelligence to the traffic flow data in the form of service levels or modelling outputs. The system has the potential to become a national database, but the initial focus will be on municipalities.

Once the database has developed into a complete package with reliable base data and with intelligence added, this can be sold as an infrastructure management tool as part of an existing management information software package, or as a stand-alone application.

10. CONCLUSIONS AND RECOMMENDATIONS

The paper is concluded by providing answers to the problems that were stated initially.

- a) *Whether a transport management information system (TMIS) is needed and who would find such a system useful:* Transport practitioners in the public and private sectors, including those at academic institutions and non-governmental organisations have indicated that there is a need for a TMIS and that they would find the system useful.
- b) *What the user requirements are:* Current legislation does not explicitly state requirements for transport related information systems, but information on public transport, non-motorised transport, traffic safety, traffic flow, road signs, road markings and traffic signals are required by transport to fulfil their daily tasks.
- c) *The extent of currently available transport information in South Africa, and what the gaps are:* There is information available on accidents, traffic flow and public transport, but in a fragmented, uncoordinated and non-uniform fashion, or outdated, with little or no quality control. Data resident at government institutions is often inaccessible to private institutions and is not always presented in a usable format.
- d) *Which types of information the system should include:* Information is most needed, in order of importance, in the fields of traffic flow, non-motorised transport, road signs and markings, traffic signals, road safety and public transport.
- e) *The data requirements of the system and data sources:* The data requirement for the traffic flow database will be the latest available traffic counts for all modes and time periods. In order to populate the road signs and markings database, information will be required on the location, identification, display, hardware, age and condition of the signs or markings. Information on the location, date and time, type and severity of accidents are required for the traffic safety component. Details on public transport

routes, vehicles, facility, utilisation and fares are needed for public transport planning purposes. Some information is available from government institutions.

- f) *What the system should look like:* The information will be displayed on interactive maps with separate layers for each information type. Data will be accessed through drop-down menus. Users will also be able to select parameters for a query, for instance a request to display all Class 3 roads in a certain suburb carrying in excess of 1500 vehicles per hour.
- g) *How the system will be implemented:* Due to the limitation associated with this project, it is proposed to start small by collating only available traffic flow data in private and public ownership. A second step may be taken when the developers are appointed for a transport plan or similar project at a Municipality, as these projects require intensive data capturing and processing exercises.

It is recommended that the developers of the TMIS should pursue a partnership with established Management Information service providers. It is also recommended that user requirements and the incorporation of processing tools such as transport models should receive further attention.

REFERENCES

Burger, L, 2007. "The design of a geographical information system for promotion of integrated planning of transport and spatial affairs between all spheres of government", University of Cape Town, Cape Town (Masters Degree Thesis) p 7-1 (2007)

Lawless, A, 2007. "Numbers & Needs in local government: Civil engineering – the critical profession for service delivery", The South African Institution of Civil Engineering, Midrand (2007)

Meyer, K, 2011. "Interview with IMQS Technical Head and Development Manager on software development process", Stellenbosch, 13 January 2011

Mokonyama, M and E Schnackenberg, 2006. "Harnessing innovation in passenger transport research in Africa", Paper presented at the 25th Annual South African Transport Conference, 10-13 July 2006

National Department of Transport, 2005. "Technical Report: The First South African National Household Travel Survey 2003", Pretoria (August 2005)

Pirie, G, 2011. "Challenging conditions for consulting industry" in IMESA Volume 36 No. 1 p10 (2011)

Roodt, L, 2010. Interview on road safety legal and data requirements, University of Stellenbosch, Stellenbosch (27 August 2010)

South African Government, 2009. "National Land Transport Act, Act No. 5 of 2009", Government Printers, Cape Town (April 2009)

Vanderschuren, M, 2010. "Network tackles African transport and environment issues" Monday Paper Volume 29.04 29 March 2010 accessed on <www.ebe.uct.ac.za/new/archives>

Vanderschuren, M and R Jobanputra, 2010. "Safely Home Project Report: Phase II: Baseline Study", Cape Town (December 2010)