UNIVERSITY OF CAPE TOWN

Faculty of Engineering & the Built Environment

Transport Studies Programme

THE DESIGN OF A GEOGRAPHICAL INFORMATION SYSTEM FOR PROMOTION OF INTEGRATED PLANNING OF TRANSPORT AND SPATIAL AFFAIRS BETWEEN ALL SPHERES OF GOVERNMENT

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DECLARATION

I, LIZELLE BURGER, hereby declare that I know the meaning of plagiarism and that all the work in the document, save for that which is properly acknowledged, is my own.

This thesis is in partial fulfilment of the requirements for the degree of *Master of Science in Engineering: Transport Studies* offered by the Department of Civil Engineering in the Faculty of Engineering and the Built Environment at the University of Cape Town.

LIZELLE BURGER DATE

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ABBREVIATIONS

APOPS	Asset Procurement and Operating Partnership System
ASPX	Active Server Pages
BMS	Bridge Management System
CD	Compact Disk
CIO	Chief Information Officer
CMS	Congestion Management System
CPTR	Current Public Transport Record
CSIR	Centre for Scientific and Industrial Research
CTMM	City of Tshwane is a Metropolitan Municipality
DACE	Department of Agriculture, Conservation and Environmental affairs
DFA	Development Facilitation Act
DFEA	Department of Finance and Economic Affairs
DMS	Drawing Management System
DVD	Digital Versatile Disk
EPWP	Extended Public Works Programme
ERD	Entity Relationship Diagram
FAR	Floor Area Ratio
GDPLG	Department of Development Planning and Local Government
GIS	Geographical Information System
GISTF	Gauteng Integrated Strategic Transport Framework
GIT&S	Geographic Information Technologies and Systems
GITIS	Gauteng Integrated Transport Information System
GITSF	Gauteng Integrated Transport and Spatial Framework
GLIP	Gauteng Labour Intensive Programme
GPDA	Gauteng Planning and Development Act
GPLG	Gauteng Department of Development Planning and Local Government
GPLTF	Gauteng Provincial Land Transport Framework
GPS	Global Positioning System
GPPRTA	Gauteng Public Passenger Road Transport Act
GPTRW	Gauteng Department of Public Transport, Roads and Works
GSDF	Gauteng Spatial Development Framework

GSMRN	Gauteng Strategic Major Road Network
GSPTN	Gauteng Strategic Public Transport Network
GSSC	Gauteng Shared Services Centre
GTFRA	Gauteng Transport Framework Revision Act
GTIA	Gauteng Transport Infrastructure Act
HCI	Human Computer Interaction
HPPTN	High Priority Public Transport Network
HR	Human Resources
ICD	Intersection Control Database
IDP	Integrated Development Plan
IIS	Internet Information Service / Server
IPS	Intrusion Prevention Service
ISO	International Standards Organisation
ISP	Internet Service Provider
IT	Information Technology
ITP	Integrated Transport Plan
JRA	Johannesburg Roads Agency
KPI	Key performance Indicator
LAN	Local Area Network
LUTC	Land-use and Transport Committee
MEC	Member of Executive Council
MMS	Maintenance Management System
MSA	Municipal Systems Act
MSDF	Municipal Spatial Development Framework
NATIS	National Transport Information System
NDLA	National Department of Land Affairs
NDPLG	National Department of Provincial and Local Goverment
NDoT	National Department of Transport
NLTTA	National Land Transport Transition Act (No. 22 of 2000)
NRTA	National Road Traffic Act
OLAS	Operating Licences Administration System
OLS	Operating Licences Plans
PAIA	Promotion of Access to Information Act
PGIS	Participatory Geographical Information Systems

PGIS & T	Participatory Geographical Information Systems and Technology
PLA	Participatory Learning and Action
PLTF	Provincial Land Transport Framework
PRAM	Provincial Road Advertisement Management
PT	Public Transport
PTIS	Public Transport Information System
PTMIS	Public Transport Management Information System
PTP	Public Transport Plan
PWV	Pretoria Witwatersrand Vereeniging
RAS	Registration Administration System
RAT Plan	Rationalisation Plans
RNMS	Road Network Management System
SAN	Storage Area Network
SANRAL	South African National Roads Agency Limited
SARCC	South African Rail Commuters Corporation
SASDI	South African Spatial Data Infrastructure
SCL	Street Centre Line
SDF	Spatial Development Framework
SDIA	Spatial Data Infrastructure Act
SDP	Site Development Plan
SG	Surveyor General
SISF	Spatial Information Strategy Framework
SITA	State Information Technology Agency
SPTN	Strategic Public Transport Network
SMRN	Strategic Major Road Network
SUMS	Subsidy Management System
SUS	System Usability Scale
SWOT	Strengths, Weaknesses, Opportunities, Threats
TAs	Transport Authorities
TAZ	Traffic Analysis Zones
TCC	Transport Co-ordinating Committee
TrafMan	Traffic Management System
UCD	User Centered Design
WAN	Wide Area Network

WIMP	Windows, icons, menus and pointing
WMS	Wayleave Management System

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SUMMARY

With the common goal of improving Gauteng's transport sector in mind, the Member of Executive Council (MEC) for Public Transport, Roads and Works, concluded his recent budget speech by declaring "…. an unwavering commitment from my Department and I (sic), to accelerate our pace of delivery, improve our provision of services and generally contribute to creating the necessary environment for Gauteng to Work Better." (Jacobs, 2006)

Strategically, this thesis is concerned with the primary responsibility and increased efforts of the Gauteng Department of Public Transport, Roads and Works (GPTRW) to obtain and manage the legally required datasets.

It is apparent that information sharing between stakeholders in the transport and spatial planning sectors of Gauteng has become an urgent obligation. The following factors have been identified as compelling incentives:

- The recently propagated legal requirements for surveys and data collection, e.g. the National Land Transport Transition Act (NLTTA, Act 22 of 2000, NDoT), obliging the submission of Current Public Transport Records (CPTRs), the Gauteng Transport Infrastructure Act (GTIA, Act 8 of 2001, GPTRW), requiring road network and pavement condition details and the Spatial Data Infrastructure Act (SDIA, Act No. 54 of 2003, NDLA), necessitating the submission of details regarding the types and extent of land-uses required by national and provincial regulations and the capture of spatial data,
- Legal requirements for information sharing, as required by the Promotion of Access to Information Act (PAIA, Act 2 of 2000, National Constitution) and the SDIA (NDLA, 2003),
- The costs and effort involved in conducting the fieldwork to collect required datasets, and
- The costs and effort involved in doing desktop maintenance on these datasets, as required by legislation.

Furthermore, apart from merely fulfilling legal requirements, information sharing also potentially allows the following to be achieved:

- An improved level of co-operation the between the different spheres of government,
- Increased integration of spatial and transport planning,
- Improved service delivery by government, and
- A better quality of life for all citizens.

The practical topic dealt with in this thesis, was the design of a Geographical Information System (GIS), which would promote integrated planning on the part of transport planners collecting and monitoring spatial and transport data. Selected modules of the system were developed as part of the study. System users benefiting from the initiative is the Sub-directorate Ribbon Development, Directorate Planning of GPTRW. GPTRW has a primary responsibility of promoting the integration of transport and land-use. This integration was particularly important for the assessment of the following:

- The impact of land-use on road network infrastructure,
- The impact of land-use on the strategic public transport network, and
- The impact of land-use on the Gautrain Rapid Rail planned route and station precincts, in order to ensure that such precincts are conducive to the promotion of integrated public transport.

The integration of land-use and transport could be achieved either through pro-active or re-active measures. GPTRW had already invested in the implementation of both types of measures. However, the Sub-directorate responsible for the evaluation of development applications for their impact on the primary transport system of the province, and monitoring of land-use development over time in selected areas or corridors, had not been equipped with the necessary tools and guidelines to administer the workload.

The challenges that the Sub-directorate faced, necessitated the development of appropriate supporting tools, as these would enhance performance and result in the improvement of the management of transport related land-use in the province.

The need, therefore, was for the design and development of a web-enabled GIS database, which would provide capturing and reporting mechanisms to assist the responsible officials to do their work effectively and efficiently. The objectives of the study are summarised as follows:

- To identify the legal requirements for:
  - sharing of spatial and transport information,
  - establishing information systems,
  - the cooperation between different spheres of government, and
  - integrating spatial and transport planning practices.
- To conduct a status quo investigation of data and information systems in use by Gauteng provincial government and involved municipalities,
- To determine the extent and nature of information which was required for complying with legislative and operational mandates,
- To do a gap analysis to identify the missing links in an integrated planning information system,
- To conduct a prioritisation exercise of datasets to be managed, as motivation for the selection of land-use and transport planning as the beneficiary to the project,
- To select an applicable development methodology,
- To design a GIS based on business requirements that adhere to the identified legal requirements and that will make the information accessible to the Gauteng transport planning fraternity,
- To develop selected components of the GIS designed,
- To evaluate the components developed for promoting integrated spatial and transport planning,
- To make recommendations regarding data collection, system development and organisational matters peculiar to GPTRW, and
- To make recommendations regarding system development, GIS and integrated planning as topics for further research.

The literature review of relevant national and provincial land-use and transportation policies and legislation, specifically focussing on planning frameworks that mandate

spatial and transportation planning, provided strong evidence that GPTRW has the necessary mandate to develop mechanisms and processes to assess and monitor transport related land-use development in Gauteng. In addition, it became evident that GPTRW could be regarded a planning authority in its own right in terms of protecting its Strategic Major Road Network (SMRN, GPTRW, 1994) and Strategic Public Transport Network (SPTN, GPTRW, 2003). Furthermore, the review proved that the successful integration of the two planning disciplines is dependant on the co-operation and consultation between different spheres of government. The need for co-operation was clearly demonstrated by citing requirements stipulated in relevant policies and strategies. Lastly, the development and implementation of information systems to promote information sharing and support transport planners, was supported by national legislation and provincial strategies.

A status quo analysis was conducted in order to evaluate the transport and land-use planning information systems utilised by GPTRW and two major municipalities in the study area, and provided the basis for an extensive data and system gap analysis. Prioritisation applied to the results of the gap analysis, provided motivation for rating the integration of transport and land-use as primary area to require assistance from an immediate system development initiative.

Extensive involvement of system users and owners contributed to the use of the dedicated user centered design approach, during which a number of philosophies and practices considered to be beneficial to this project, were exercised. These included in-depth interviews, User Centered Design (UCD), Participatory Geographical Information Systems (PGIS), Human Computer Interface (HCI), Geographical Information Systems and paper prototyping. Each practice was subsequently applied to the incremental system development methodology for the design, development and testing of the system components. The most suitable solution arrived at, entailed a web-based GIS with data capturing, analysis and mapping functionalities. Despite the fact that the design included all the features of the ideal system, only selected components could be developed, due to financial, technical and data availability constraints.

System development commenced soon after the finalisation of the functional design. The GIS tool was developed in line with the incremental development methodology, resulting in the installation of a dedicated test environment, from where the user could provide feedback subsequent to the release of each component. Following the integration of all the components, the final GIS tool was implemented at the client's premises for an evaluation period, in order to allow for a comprehensive review of the system capabilities and usability, from the users' perspective.

The evaluation phase investigated the utilisation of the tool in relation to the daily task of assessing applications for change in land-use, as performed by the Sub-directorate Ribbon Development. Feedback from users was summarised in consolidated System Usability Scale (SUS) test results. From this feedback it became evident that the GIS tool was considered to be a useful instrument, assisting officials with daily responsibilities.

The data capturing functionality enabled the users to capture the identified land-use applications' variables directly onto the system. The map component linked the

application data to the spatial entities, through the use of the Surveyor General property data (the 21–digit code). In the case of an application for a new township, the free-hand drawing tool allowed the user to specify the footprint of the area affected by the application, on the map. The spatial representation of the application and the overlay thereof with the base spatial layers contained in the map, allowed the official to make an informed conclusion with regards to the application's impact on the SMRN and the SPTN. Templates of standard letters used for feedback to applicants, were populated with the details captured by the officials, obviating the need for them to complete these fields manually. An e-mail functionality was provided to enable the electronic dissemination of these letters, containing GPTRW's feedback on the assessment of the applications, to the involved municipalities and applicants.

The administration of the spatial data maintenance of new townships was enabled through a checklist and a map with thematic layers, indicating new townships for which spatial maintenance was still required. Advanced back-end procedures were developed to enable spatial updates through a user-friendly interface, to ensure that the database tables and related spatial layers were synchronised.

The map component was designed to provide access to road designs, based on database procedures for the identification of relevant records from the Drawing Management System (DMS). Base layers providing ample details of the surrounding area assisted the technical and land-use/public transport assessors in their decision-making responsibilities. The GIS tool allowed the identification of the approved applications, so that the conditions of approval could be recorded. The monitoring map was developed in order to present the location of the approved applications. From this information, approximate development trends were inferred and the possible need for amending or adjusting plans and programmes, for both land-use and transport, e.g. Integrated Transport Plan (ITP) and Integrated Development Plan (IDP), were determined.

It can be concluded that the GIS tool successfully addressed the majority of the user needs. The test results were supplemented by comments by system users indicating the desirability of developing those components that had been discontinued, as part of a complete solution where user needs and legal requirements will be fully satisfied.

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CHAPTER 1

INTRODUCTION

1.1 Background

The design of a Geographical Information System for promotion of integrated planning of transport and spatial affairs between all spheres of government

With the common goal of improving Gauteng's transport sector in mind, the Member of Executive Council (MEC) for Public Transport, Roads and Works, concluded his recent budget speech by declaring ".... an unwavering commitment from my Department and I (sic), to accelerate our pace of delivery, improve our provision of services and generally contribute to creating the necessary environment for Gauteng to Work Better." (Jacobs, 2006)

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It is apparent that information sharing between stakeholders in the transport and spatial planning sectors of Gauteng has become an urgent obligation. The following factors have been identified as compelling incentives:

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The practical topic dealt with in this thesis, is the design of a Geographical Information System (GIS), which promotes integrated planning on the part of transport planners collecting and monitoring spatial and transport data. Selected modules of the system are developed as part of the study. System users benefiting

from the initiative is from the Sub-directorate Ribbon Development, Directorate Planning of GPTRW. GPTRW has a primary responsibility of promoting the integration of transport and land-use. This integration is particularly important for the assessment of the following:

- The impact of land-use on road network infrastructure,
- The impact of land-use on the strategic public transport network, and
- The impact of land-use on the Gautrain Rapid Rail planned route and station precincts in order to ensure that such precincts are conducive to the promotion of integrated public transport.

The integration of land-use and transport can be achieved either through pro-active or re-active measures. GPTRW has already invested in the implementation of both types of measures. However, the Sub-directorate responsible for the evaluation of development applications for their impact on the primary transport system of the province, and monitoring of land-use development over time in selected areas or corridors, are not equipped with the necessary tools and guidelines to administer the workload.

The challenges that the Sub-directorate faces necessitates the development of appropriate supporting tools, as this will enhance performance and result in the improving the management of transport related land-use in the province.

The need, therefore, is for the design and development of a web-enabled GIS database providing capturing and reporting mechanisms to assist the responsible officials to do their work effectively and efficiently.

1.2 Objectives and scope of the study

Taking into account the details provided in the background section, the objectives of this study can be summarised as follows:

- Identify the legal requirements for sharing of spatial and transport information,
- Identify the legal requirements for establishing information systems,
- Identify the legal requirements for cooperation between different spheres of government,
- Identify the legal requirements for integrating spatial and transport planning practices,
- Conduct a status quo investigation of data and information systems in use by Gauteng provincial government and involved municipalities,
- Determine the extend and nature of information which is required for complying with legislative and operational mandates,
- Do a gap analysis in order to identify the missing links in an integrated planning information system,
- Conduct a prioritisation exercise of datasets to be managed, as motivation for the selection of land-use and transport planning as the beneficiary to this project,
- Select an applicable development methodology,
- Design a GIS based on business requirements that adhere to the identified legal requirements and that will make the information accessible to the Gauteng transport planning fraternity,

- Develop selected components of the GIS designed,
- Evaluate the components developed for promoting integrated spatial and transport planning, and
- Make recommendations regarding data collection, system development and organisational matters peculiar to GPTRW and
- Make recommendations regarding system development, GIS and integrated planning as topics for further research.

1.3 Project limitations and constraints

This project assesses the application of GIS technology as a tool to promote information sharing and the increased integration of transport and land-use planning and development. The author's design of the GIS forms part of a project undertaken by Khuthele Projects, APS Plan Africa, Nametso Consulting and AfriGIS. The scope of the assignment undertaken by the companies but excluded from this thesis was the following:

- To confirm land-use control and monitoring functions and responsibilities of the GPTRW, in addition to the responsibilities of the Department of Development Planning and Local Government and municipalities in Gauteng,
- To develop a procedure/training manual providing guidelines for the relevant Sub-directorate within the Directorate Planning regarding its responsibility to comment on draft strategic land-use and related plans prior to its finalisation, as well as commenting on day-to-day development applications prior to their approval,
- To propose an organisational structure and post establishments in order for the Directorate Planning to carry out its responsibility regarding transport and land-use integration, and
- To develop a brief and focussed change navigation strategy and rollout plan.

Refer to section 1.5 for the discussion on the outline of the thesis. Chapters 2 - 6, 8 and 9 of this thesis are conducted by the author, without aid from project members and falls outside the scope of the official project. The content of Chapter 7 is based on the system designed for GPTRW, but includes the design permutations and workflow descriptions prepared independently by the author. The coding of the system is excluded from this study. Other constraints impacting on the execution of the study included:

- Budget: Adequate financing needs to be available to complete the proposed deliverables, specifically with regards to the system development funded by the appointment of the consultants by GPTRW,
- Existing technology: Complications are created by the introduction and integration of new technologies with the existing infrastructure,
- Legislative constraints: The deliverables conformed to the current set of legal requirements but future amendments to the legislation will have an impact on the success of the system.

1.4 Methodology

The selected methodology for system design and development is the advanced spiral life cycle model, also known as the incremental development model. The selected model can be summarised by the following steps:

- Determine objectives, alternatives and constraints,
- Identify and resolve risks,
- Evaluate alternatives,
- Develop the deliverables for the current iteration and verify that they are correct,
- Plan the next iteration, and
- Commit to an approach for the next iteration.

The incremental development methodology is modified slightly in order to accommodate the custom requirements of the study. Refer to Figure 1-1 for the representation of the over-all methodology, also indicating main activities per step.

The preliminary analysis stage includes the following:

- Literature review,
- Interviews,
- Gap analysis, and
- Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis.

The preliminary and architectural design stage includes the compilation of business requirements and the preparation of a functional design.

Component spirals are applied for the main components of the system and include the following steps per component:

- Design,
- Develop,
- Test and review,
- Integrate, and
- Release.

The design and development principles and technologies considered applicable to this study include the User Centered Design (UCD) principles, Human Computer Interaction (HCI), paper prototyping and Participatory Geographical Information Systems (PGIS), as well as in-depth interviews, GIS and System Usability Scale (SUS) testing.

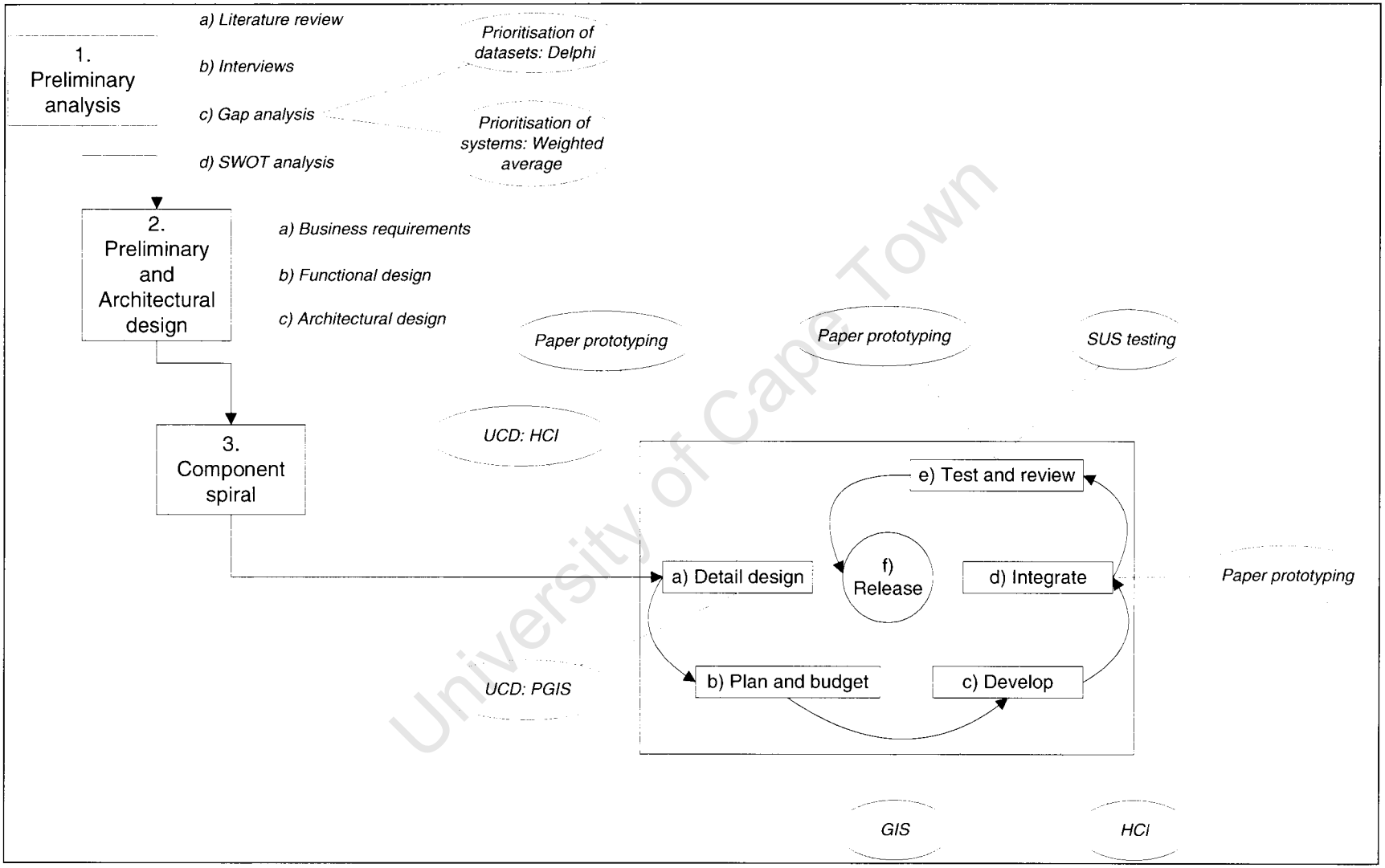

Figure 1-1: Combined research and product development methodology

1.5 Content

This thesis is organised in the following manner:

Chapter 1 presents a background and introduction to the study.

Chapter 2 provides an overview of South African policy, legislation and the planning frameworks mandating spatial and transportation planning, with specific focus on legislation dealing with integrated planning of provincial and municipal planning spheres. The successful integration of the two planning disciplines dependants on the co-operation and consultation between different spheres of government. The need for co-operation is demonstrated by quoting requirements from several relevant policies and strategies. Likewise, national legislation and provincial strategies are cited in order to motivate the development of information systems for implementation of information sharing and support of transport planners.

Chapter 3, focusing on two major municipalities, reports on the status quo of information systems for transport and land-use planning, as well as the level of integrated planning catered for by these systems. A brief overview is provided with the planning status in Johannesburg and Tshwane. The systems supporting the planning processes are evaluated in terms of system content, update frequency and technology, including the application of GIS, if any. The status quo investigation is limited to a discussion of only two of the metropolitan municipalities, because district municipalities, for the most part, lack the relevant systems managing transport or spatial planning. A framework is implemented for a more detailed status quo analysis of planning information systems in GPTRW.

Chapter 4 offers support for the conclusions drawn in Chapter 3, by investigating the data component. Firstly, the chapter reports on the total repository of transport datasets to be managed by government, by investigating ten major legal source documents. A checklist of datasets compiled in a comprehensive questionnaire is derived from this legislative literature review. A round of interviews are conducted in order to identify the datasets that are currently being managed and to ascertain additional data needs. The information obtained from the interviews is used to derive a formula for prioritisation. The weighted average method is applied to assist with the prioritisation of the outstanding functional solutions.

The methodology to be applied during the product development is discussed in Chapter 5. An overview on the traditional Waterfall Model is provided, after which the more advanced incremental development model is discussed. Philosophies and tools considered to be applicable to this project includes in-depth interviews, User Centered Design (UCD), Participatory Geographical Information Systems (PGIS), Human Computer Interface (HCI), Geographical Information Systems (GIS), Paper Prototyping and usability testing, including System Usability Scale (SUS). Thereafter, the application of each tool or practice in the system development methodology is discussed along with the typical core content of a functional and a technical design.

Chapter 6 expands on the business requirements driving the functionality of the web-based GIS, which is recommended as a suitable tool to assist the officials of the Sub-directorate Ribbon Development. A primary benefit of the envisaged system will be the monitoring functionality, allowing for strategic evaluation and intervention in the transport and spatial planning in the study area. Legislation to be reviewed as part of the business requirements analysis includes the Promotion of Access to Information Act (PAIA, Act 2 of 2000, National Constitution), Gauteng Planning and Development Act (GPDA, Act 3 of 2003, DPLG) and Gauteng Transport Infrastructure Act (GTIA, Act 8 of 2001, GPTRW). Furthermore, the Gauteng Provincial Land Transport Framework (PLTF, GPTRW, 2002)), the Gauteng Spatial Development Framework (SDF Phase III, GPTRW, 2002), the Gauteng Strategic Public Transport Network (SPTN, GPTRW, 2003) and the Gauteng Strategic Major Road Network (SMRN, GPTRW, 1994) will be considered, as these constitute primary frameworks guiding the preparation of base data. An analysis is conducted of the environment in which the GIS tool will be deployed, listing Strengths, Weaknesses, Opportunities and Threats (SWOT).

Chapter 7 includes the functional design of the envisaged solution, i.e. a tool for the capturing of applications for change in land-use, based on a GIS application accommodating a graphical representation of existing and new land-use developments, with capabilities to monitor development trends in specific areas. Selected functional screen designs and process flow diagrams are provided. These designs serve as basis for programming and are developed in cooperation with the client and all role-players, including potential system users, before development can commence. The product life cycle model selected in Chapter 5, i.e. the incremental development model, is applied for each component of the GIS solution. The results of the SWOT analysis obtained from Chapter 6 are taken into account when applying the User Centered Design (UCD) and participatory design principles. This chapter is concluded with a discussion of GIS features and design details for integration with existing systems.

System development commences soon after the finalisation of the functional specification. The GIS tool is developed in line with the incremental development methodology, resulting in the setup of a dedicated test environment from where the user could provide feedback per component after its release. Following integration of all components, the final GIS tool is implemented at the client's premises for an evaluation period in order to allow for a comprehensive review of system capabilities and usability from the users' perspective. Chapter 8 firstly aims at comparing the actual system developed and deployed with the ideal system as designed in Chapter 7. Components not included in this phase of the system are identified, and rationale for the exclusion is discussed. Secondly the chapter investigates the utilisation of the tool in relation with the daily tasks of assessing applications for change in land-use, as performed by the Sub-directorate Ribbon Development. Feedback from users is summarised in consolidated SUS test results.

Conclusions drawn from the study are provided in Chapter 9, followed by recommendations on the way forward regarding data collection, system development and organisational matters peculiar to GPTRW. Furthermore, recommendations are made regarding system development, GIS and integrated planning as topics for further research.

CHAPTER 2

OVERVIEW OF TRANSPORT PLANNING LEGISLATION AND RELATED SPATIAL FRAMEWORKS

This chapter provides an overview of South African policy, legislation and planning frameworks mandating spatial and transportation planning, with specific focus on legislation dealing with integrated planning in provincial and municipal planning spheres. The successful integration of the two planning disciplines is dependant on the co-operation and consultation between the different spheres of government. The need for co-operation is demonstrated by requirements quoted from relevant policies and strategies. The development and implementation of information systems to promote information sharing and support transport planners, is motivated by national legislation and provincial strategies.

2.1 Transport plans and associated spatial frameworks

2.1.1 Integrated Transport Plans: Required by National Land Transport Transition Act

Section 7 of the National Land Transport Transition Act (NLTTA, Act 22 of 2000, NDoT) specifies a number of statutory plans that will guide land transport in South Africa. These are the following:

- Current Public Transport Records (CPTR),
- Operating Licenses Plans (OLS),
- Rationalization Plans (Rat Plan),
- Public Transport Plans (PTP), and
- Integrated Transport Plans (ITP).

The Act, furthermore, stipulates that an Integrated Transport Plan (ITP) is to be drafted annually by Transport Authorities (TAs), Core Cities and specific Municipalities, as required by the Member of Executive Council (MEC). The following chapters are compulsory, forming the minimum content of the ITP:

- Chapter 1: Introduction,
- Chapter 2: Land transport vision, goals and objectives,
- Chapter 3: Land transport status quo,
- Chapter 4: Spatial framework,
- Chapter 5: Needs assessment,
- Chapter 6: Public transport proposals,
- Chapter 7: Private transport and freight proposals,
- Chapter 8: Stakeholder consultation,
- Chapter 9: Prioritised multi-modal transport proposals and implementation programme, and
- Chapter 10: Financial implications.

The minimum requirements listed above, clearly indicate that the ITP requires the integration and alignment of spatial and transport planning, with reference to Chapter 4 (d) of the plan. It is stipulated that the municipalities develop their ITPs for a five-year period, after which it should be reviewed on an annual basis. The transport planning status in two of the Metropolitan Municipalities in Gauteng Province are reviewed in Chapter 3 of this thesis.

Figure 2-1 emphasises the interrelationships between different transport plans, and the correlation between these plans and the Integrated Development Plan (IDP).

The building blocks of the IDP are discussed in the next subsection.

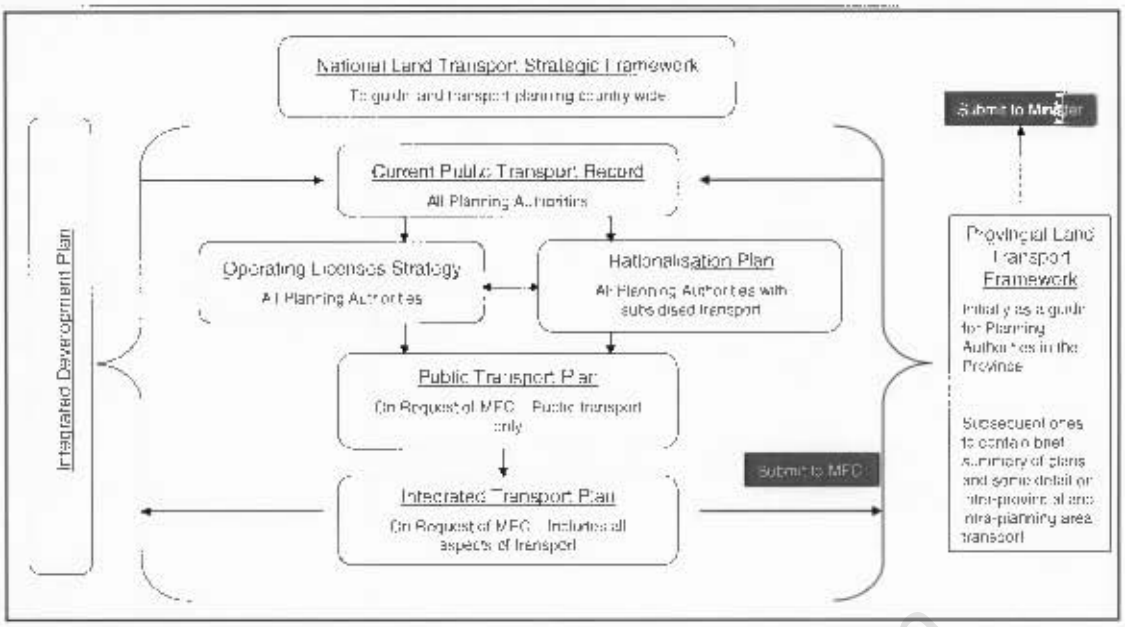

Figure 2-1: Interrelationships between different transport plans
Source: CSIR, 2002

2.1.2 Integrated Development Plan: Required by Municipal Systems Act

The local government elections of December 2000 marked the end of the transitional phase of local government and introduced new democratic local government. Legislation supporting the transformation of local government includes Chapter 5 of the Municipal Systems Act (No 32, NDPLG, 2000), which stipulates that each municipality prepares and adopts an Integrated Development Plan (IDP) for its area of jurisdiction.

Integrated development planning has to take place in alignment with the municipal boundaries as per the Local Government Municipal Demarcation Act (No 27, NDPLG, 1998). Part 3 (section 27) of the Municipal Systems Act stipulates the process or framework for planning, drafting, adopting and reviewing IDPs. In terms of Chapter 4 (Section 16.1) of the Municipal Systems Act, municipalities should provide for public participation in the affairs of the municipality. It requires municipalities to develop a culture and encourage public involvement in local governance.

The components of the IDP should at the very least include the following:
- A vision of the long-term development of the municipality,
- An assessment of the existing level of development in the municipality, which must include an identification of the need for basic municipal services,
- The municipality's development priorities and objectives for its elected term,
- The municipality's development strategies, which must be aligned with any national or provincial sectoral plans and planning requirements,
- A Spatial Development Framework (SDF), which must include the provision of basic guidelines for a land-use management system,
- The municipality's operational strategies,
- A disaster management plan,

- A financial plan, which must include a budget projection for at least the next three years, and
- Key Performance Indicators (KPIs) and performance targets.

It is required that the Municipalities develop their IDPs for a five-year period after which it should be reviewed on an annual basis. The spatial planning statuses of the three Gauteng Metropolitan Municipalities are reviewed in the third chapter of this thesis.

The Spatial Development Framework (SDF) and its components are discussed in the following subsection.

2.1.3 Spatial Development Framework: Required by Development Facilitation Act

According to spatial planning regulations, the preparation of the Spatial Development Framework (SDF) must give effect to Chapter 1 of the Development Facilitation Act (DFA, Act 67 of 1995, NDLA). Chapter 1, Section 3(1), reports thirteen general principles for land-use planning in South Africa. The third principle focuses on the promotion of integrated land development. The fourth principle states that public participation should form a major part in the process of land development. The primary purpose of a spatial framework is to create an adequate municipal spatial structure or suitable spatial form. Additional goals of such a structure include redressing past imbalances and promoting equity, promoting an improved system of access and providing a framework for managing development, which includes identifying areas for investment, rehabilitation and protection.

The components of the SDF include at a minimum, the following:

- Objectives that reflect the desired spatial form of the municipality,
- Strategies and policies regarding the manner in which to achieve the objectives,
- Basic guidelines for a land-use management system,
- Capital investment framework for the municipality's development programs,
- Programs and projects for the development of land within the municipality,
- Visual representation of the desired spatial form of the municipality, including:
    - Identification where public and private land development and infrastructure investment should take place,
    - Delineation of the urban edge, if feasible,
    - Strategic interventions, and
- Priority spending areas.

The SDF forms part of the IDP and should be reviewed by the municipalities on an annual basis as part of the update of the IDP. The statuses of the SDF in the three Gauteng Metropolitan Municipalities are reviewed in Chapter 3 of the thesis.

2.1.4 Synopsis of frameworks and plans required for integrated spatial and transport planning

In summary of the legislation review, the findings are consolidated by emphasising the interrelationship between the relevant plans and touching on Gauteng-specific requirements for integrated planning stipulated by the Gauteng Transport Framework Revision Act (GTFRA, Act 8 of 2002, GPTRW) and the Gauteng White Paper on Transport Policy (NDoT, 1997).

Interrelationship between the SDF, ITP and IDP and the role of adjacent municipalities in the preparation of the plans

The Municipal Systems Act (MSA, Act 32 of 2000, NDPLG) compels Municipalities to draw up an IDP as a singular, inclusive and strategic development plan that is aligned with the deliberate efforts of the surrounding Municipalities and other spheres of government. In terms of the MSA, a municipality is required to formulate an IDP made up of nine components, including a spatial development framework (SDF), which must include the provision of basic guidelines for a land-use management system. As an integral component of the IDP, the SDF must also adhere to the requirements of the Local Government: Municipal Planning and Performance Management Regulations of 2001 (Government Notice 22605, 24 August 2001).

The NLTTA (NDoT, 2000) requires land transport planning to be integrated with the land development process. The transport plans must be developed within the context of the Integrated Development Plans (IDPs) and land development objectives. The preparation of the ITP must include the consultation and participation of interested and affected parties required for the preparation of Integrated Development Plans in terms of chapter 4 and section 29(1)(b) of the Local Government: Municipal Systems Act (NDPLG, 2000).

An ITP, as described in the NLTTA (NDoT, 2000) and the GTFRA (GPTRW, 2002), is a statutory plan, which is prepared to guide the development of the transport system in a Municipal area. As a statutory plan, it is important that the contents of the ITP be treated as one of the sectoral plans, which comprise input into the IDP. The ITP should not dictate the SDF nor vice versa. The plans should guide one another, to facilitate the management of demand for land-use and transport, within the IDP. The correlation between the IDP, SDF and ITP are illustrated in Figure 2-2.

The legal requirement for cooperation between neighbouring municipalities and their consultation with provincial government, in order to ensure alignment of statutory transport and spatial plans, are discussed in section 2.2 of this chapter.

Figure 2-2: Interrelationships between IDP, SDF and ITP

Integrated planning: Legislative requirements in Gauteng

The Gauteng Transport Framework Revision Act (GTFRA, GPTRW, 2002) Contains statements concerning the integration of spatial development and transport:

- Section 24(1): "Land transport planning must be integrated with the land development process....",
- Section 34(2)(a): "No substantial change or intensification of land-use on any property may be undertaken without the written consent of the relevant planning authority", and
- Section 34(2)(b): "developments on property within a transport area are subject to traffic impact assessments and public transport assessments as prescribed by the MEC".

The Gauteng White Paper on Transport Policy (NDoT, 1997) includes policy statements covering the integration of spatial development and transport:

- "The Department, in association with the Department of Development Planning and Local Government and other departments involved and in consultation with local government, will undertake broad, integrated land-use and transport planning. The Department, in association with the Department of Development Planning and Local Government and in consultation with other role-players, will actively promote the densification, infilling and mixed land-use of urban development to support public transport",
- "It is essential for integrated land-use and transport planning that input pertaining to transport is given on land-use and development proposals and applications. The Department will, in conjunction with local government, therefore develop simple, efficient and effective channels, which expedite such, an integrated planning process and which provide for the appropriate evaluation and input on land-use and development applications. The Department will ensure that in the development of land development objectives, land-use and development applications, the promotion of public transport and transport related environmental considerations are addressed", and
- "In order to optimise the usage of transport infrastructure and facilities, and especially to promote the integration of land-use and public transport, the Department will, in consultation with other departments and other levels of government, identify, propose, plan and actively support strategies which promote development in corridors and nodes within these corridors".

2.2 Requirement for co-operation and alignment of planning responsibilities between provincial and local government spheres

In this section of the chapter the need for inter-governmental co-operation is demonstrated by citing requirements from relevant policies and strategies.

Gauteng can be divided into four sets of institutional arrangements:

- National Department of Transport (NDoT): Responsible for establishing planning frameworks,

- Province: Responsible for province-wide planning and coordination,
- Local Government: Responsible for delivery of transport at local level, addressing integration of land-use and transport and other municipal functions, and
- Rationalised service delivery agencies: Responsible for implementation and maintenance of road and rail infrastructure.

The hierarchy of government spheres in Gauteng is illustrated by Figure 2-3.

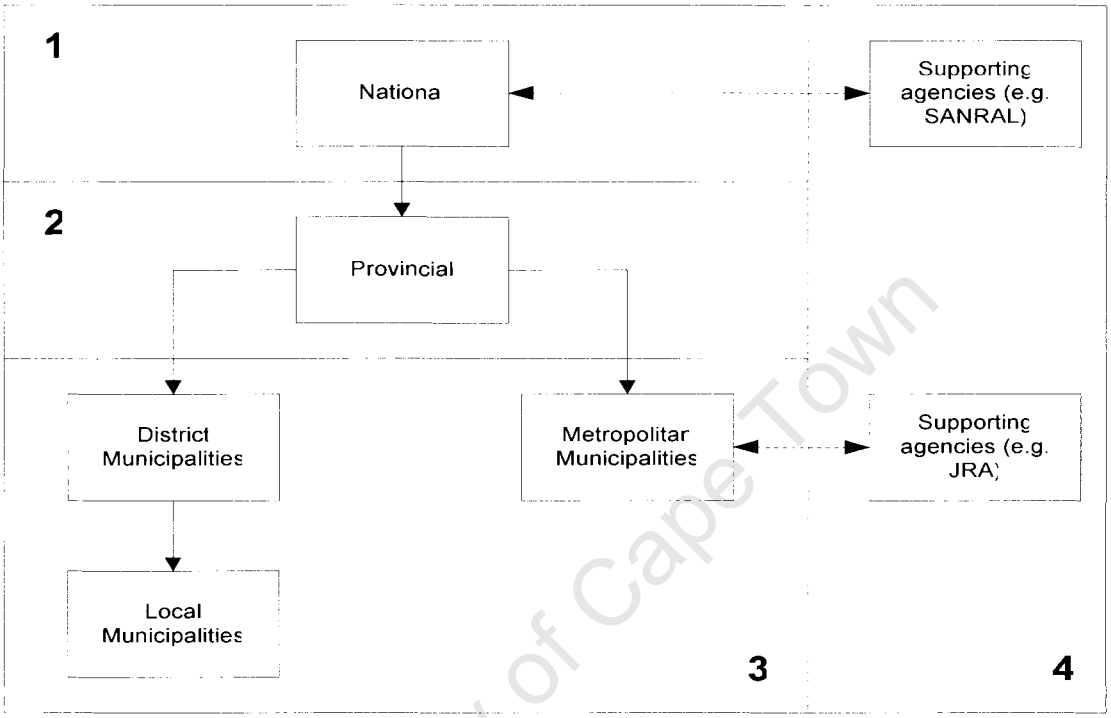

Figure 2-3: Government spheres in Gauteng province

2.2.1 Gauteng Inter-Governmental Transport Charter

The Gauteng Inter-governmental Transport Charter (Seftel, 2006) was developed as a joined initiative between Gauteng Public Transport, Roads and Works (GPTRW) and the District and Metropolitan Municipalities in the province. As the title suggests, the charter aims at "combining politics, process and intellectual endeavour".

The charter highlights the following urgent transport challenges as prominent in the province:

- High levels of population growth and increased mobility demands,
- Apartheid settlement patterns not addressed after10 years of democracy, resulting in long travel times,
- Public transport that is considered to be unsafe, unaffordable and unreliable,
- Increased levels of congestion resulting in a deteriorating road network,
- Little sustainable business development exists among small public transport operators, and
- High level of non-compliance with traffic laws.

More challenges include the gap between policy, planning and implementation and the lack of integration and alignment between:

- Land-use and transport planning,
- Transport objectives and economic development objectives,
- Province and local government,
- Metropolitan and district municipalities,
- Local governments in the district municipalities,
- Public transport modes,
- Public and private transport, and
- Gautrain rapid rail link and rest of transport system.

According to section 5.4 of the charter, transport plans should facilitate implementation. Different spheres of government need to fund their own planning processes while the role of the province should be to ensure adequate supporting resources to prepare plans. Information sharing is a key requirement in ensuring proper alignment of responsibilities in the preparation of plans as well as in the content of the plans. In section 2.3 of this thesis the motivation for the development of information systems to support this need, is discussed.

Linked to the lack of integration between planning disciplines and planning bodies, the charter also indicates the urgent need for clarification of roles and responsibilities allocated to the different planning spheres. Two levels of integration that need to be reinforced include, on the one hand, the seamless integration of transport infrastructure and operations and, on the integration of transport, land-use and economic development planning.

Responsibilities stipulated by the charter can be summarised as the following:

- Municipalities should prepare ITPs and the Province should prepare the Provincial Land Transport Framework (PLTF) in terms of relevant laws and regulations,
- The Province will fund province wide mutually agreed data collection for information and modelling,
- Transportation modelling should be done by the Province and the Municipalities, and
- With regards inter-governmental relations, the Province and Municipalities will provide feedback to each other about bilateral matters.

2.2.2 Moving SA Agenda

Moving South Africa Action Agenda is a 20-year Strategic Framework for Transport in South Africa (NDoT, 1998). The framework proposes strategies for land-use restructuring which include the densification of transport corridors, co-operative local sphere governance, the implementation of local transport and land-use solutions and customer-based transport planning. The strategy dealing with the densification of transport corridors, emphasises the need of cooperation across government spheres:
"The corridor vision will take 10-20 years to implement and will require aggressive use of development controls and incentives... In addition, transport infrastructure in new developments should be designed to encourage public transport-friendly land-use patterns (e.g. street networks which provide easy access to a corridor). Strong co-

operation within and across the different spheres of government will be required including a substantial co-ordination agenda across the functions of housing, land-use, utility services, transport infrastructure and transport services..."

2.2.3 Gauteng White Paper on Transport Policy

The Gauteng White Paper on Transport Policy (NDoT, 1997) relates policy statements regarding the integration of land-use development and transport, as highlighted in section 2.1. The paper also indicates that there will be and should be cooperation between role-players in the planning discipline, as demonstrated by these quotations:

- "The Department, in association with the Department of Development Planning and Local Government (now Finance and Economic Affairs) and other departments involved and in consultation with local government, will undertake broad, integrated land-use and transport planning. The Department, in association with the Department of Development Planning and Local Government (now Finance and Economic Affairs) and in consultation with other role-players, will actively promote the densification, infilling and mixed land-use of urban development to support public transport",
- "The Department will, in conjunction with local government, ...develop simple, efficient and effective channels which expedite an integrated planning process and which provide for the appropriate evaluation and input on land-use and development applications", and
- "In order to optimise the usage of transport infrastructure and facilities, and especially to promote the integration of land-use and public transport, the Department will, in consultation with other departments and other levels of government, identify, propose, plan and actively support strategies which promote development in corridors and nodes within these corridors".

2.2.4 GPTRW Strategic Plan for 2004 - 2009

According to the Gauteng Department of Public Transport, Roads and Works (GPTRW) Strategic Plan (2004 – 2009) the goal of GPTRW is to: "Ensure increased mobility and accessibility of Gauteng citizens, particularly the poor, to transport and socio-economic infrastructure that facilitates their meaningful participation in economic and social activities." Furthermore, the Plan indicates that he vision of GPTRW is: "For socio-economic growth, development and an enhanced quality of life for all people in Gauteng".

The mission defined by of GPTRW is to: "Develop and integrate, sustainable infrastructure, which promotes a people-centred, innovative, developmental public works and an accessible, safe and affordable movement of people, goods and services".

The strategic plan developed by GPTRW for the period of 2004 – 2009 stipulates the following strategic objectives for the department:

- Provision of an accessible, affordable, reliable, safe, integrated and environmentally sustainable public transport system,

- Effective management and transformation of transport and socio-economic infrastructure related institutions, systems and processes,
- Support of economic growth and investments through the provision of appropriate transport systems and socio-economic infrastructure,
- Integration of transport systems and socio-economic infrastructure systems in the Gauteng Growth and Development Strategy and development plans of other spheres of government,
- Implementation of the Expanded Public Works Programmes in a manner that optimizes employment and addresses economic and social needs of the poor, and
- Efficient and effective management of the Department.

The fourth objective focuses on the requirement for integration and co-operation between government spheres. According to this objective, GPTRW will strive to ensure that development plans are inclusive of transport matters on both provincial and municipal spheres. The integration will be a joined goal in collaboration with other relevant departments, particularly the Departments of Finance and Economic Affairs (DFEA), and the Local Government. Integration of transport issues should be able to ensure that development occurs within a "holistic, inclusive and sustainable framework and approach."

2.2.5 GPTRW Budget Vote 2006-2007

The annual budget vote delivered by the MEC of GPTRW is in line with the departmental strategic plan. The current MEC, Ignatius Jacobs, indicates that his department, since 2004, has endeavoured to contribute to shared economic growth and development in Gauteng by establishing the necessary strategies and frameworks for turning around transport infrastructure planning and the provision of services. GPTRW's focus for this financial year (April 2006-March 2007) is on "matters over which we have direct powers and functions, and increased facilitation and co-operation with other spheres of government over matters that fall within their jurisdiction."

"Making Gauteng Work Better", according to Jacobs, includes increased co-ordination and co-operation between all spheres of government within the Inter-Governmental Relations Framework Act (IRFA, Act 13 of 2005, NDPLG) in the spirit of co-operative governance.

2.3 Legal requirements: Information systems enabling information sharing in the transport planning discipline

The necessity of developing information systems to enable the sharing of planning information between government spheres, is highlighted by the NLTTA (NDoT, 2000), CPTR regulations (Government Notice 1005 of 2002), the GPTRW Strategic Plan and the Gauteng Inter-governmental Charter. The Promotion of Access to Information Act (PAIA, Act 2 of 2000, National Constitution) stipulates the requirements of transparent governance.

2.3.1 NLTTA: National integrated land transport information system

As stipulated by section 6 of NLTTA (NDoT, 2000), a national land transport information system must be established and maintained by the Minister, based on sound business processes, and be integrated with the provincial information systems.

The Act requires that each MEC, transport authority, core city and municipality must provide the information about their activities and progress in achieving the objectives of the Act, the national land transport policy, and their utilisation of funds provided by the national department. It is also note that a municipality may arrange with the MEC that the provincial department will provide this information on its behalf.

Moreover it is emphasised that an information system should be developed that has the capacity to capture national land transport information. Such a system must be used to monitor policy implementation and planning, and to assist all spheres of government in making decisions on investing in public transport. This information may be made available to interested parties or in the media.

2.3.2 NLTTA: Transport information system for Transport Authorities

According to NLTTA (NDoT, 2000), Section 68, the responsibilities of transport authorities include, as a minimum, the following functions and competencies:

- The promotion of security in public transport,
- The promotion of optimal use of the available travel modes in order to enhance the effectiveness of the transport system and reduce travelling time and costs,
- The development, operation and maintenance of a land transport information system,
- Marketing, promotion and publicity associated with the public transport system, and
- Providing operational information, e.g. schedules and fares, to users or potential users of public transport.

2.3.3 CPTRs: Planning requirements in terms of NLTTA

The minimum requirements for the preparation of Current Public Transport Records (CPTRs, Government Notice 1005 of 2002) necessitate the development of information systems in the following two sections:

- Section 2.3: "Although it is not required by these minimum requirements, over time the CPTR should be developed into a more comprehensive public transport information system", and
- Section 9.2.1.2: "The location of the facility must be described as a minimum, e.g. corner of X and Y street, or, if so desired, by means of a Geographical Information System (GIS)."

2.3.4 Gauteng Inter-Governmental Transport Charter

The Gauteng inter-governmental transport charter (Seftel, 2006) aims at "combining politics, process and intellectual endeavour". The following planning objectives are highlighted by the charter:

- Align and integrate planning processes to achieve public transport prioritisation and good land-use management,
- Maximise public and stakeholder participation in planning and policy making, and
- Be responsive to the access needs of rural communities and enterprises.

The charter's envisaged outputs include:

- The strengthening and consolidation of governance structures between the state and transport stakeholders,
- The identification of commonly agreed key public transport and freight nodes and corridors to promote effective land-use patterns and densification,
- Province wide SPTN drawing on respective transport plans, and
- The development of a rationalised and coordinated transport information system to support planning.

2.3.5 GPTRW strategic plan for 2004-2009

GPTRW's strategic plan for the period of 2004-2009 stipulates that the department will, in order to meet the six strategic objectives, develop monitoring and evaluation tools and systems for both its internal operational efficiencies and its service delivery priorities. The department will focus on innovative approaches to service delivery and will establish clear service delivery targets and indicators to meet provincial goals and developmental objectives. Information sharing will be promoted by putting in place relevant systems, and will enable the department to operate a modern information system and improve its business processes. Systems of provincial importance include:

- Asset Procurement and Operating Partnership System (APOPS),
- Computerised Maintenance Management System,
- Geographic Integrated System (GIS),
- Provincial Government Asset Register,
- Integrated Transport Information System,
- Integrated Infrastructure Management System,
- Extended Public Works Programme (EPWP), Gauteng Labour Intensive Programme (GLIP) monitoring system, and
- Natus systems administration.

2.3.6 The Promotion of Access to Information Act

The Promotion of Access to Information Act (PAIA, Act 2 of 2000, National Constitution) is the national legislation, which was promulgated to give effect to the constitutional right of access to information. The PAIA (National Constitution, 2000) came into operation on 9 March 2001. Subject to the PAIA (National Constitution, 2000), all South African citizens should have access to records held by the state and private bodies.

The following are the objectives, which the PAIA (National Constitution, 2000) seeks to achieve:

- To ensure that the state takes part in promoting a culture of human rights and social justice,
- To encourage openness and to establish voluntary and mandatory mechanisms or procedures which give effect to the right of access to information in as speedy, inexpensive and effortless a manner as reasonably possible, and
- To promote transparency, accountability and effective governance in all public and private bodies, by empowering and educating everyone to understand their rights in terms of the PAIA, so that they are able to exercise their rights in relation to public and private bodies,
- To understand the functions and operation of public bodies, and to
- Effectively scrutinise, and participate in decision making by public bodies that affects their rights.

According to section 2.2.2 of the Guide to the PAIA (National Constitution, 2000), all public bodies must have information manuals. The minimum content of these manuals are stipulated by section 14 of the PAIA (National Constitution, 2000). The purpose of the manuals is to assist the public regarding the manner in which access to records of public bodies may be requested. The public bodies' manuals must be published in three of the official languages. Where necessary, information manuals must be updated annually.

The development of information systems enabling information sharing between different spheres of government, their agencies and service providers, will practically execute the principles of the PAIA (National Constitution, 2000).

2.3.7 Spatial Data Infrastructure Act

The needs analysis appearing in Chapter 4 will identify not only the functional solutions to be developed in order to facilitate information sharing and integrated planning, but will also pinpoint the spatial data required by these solutions.

The Spatial Data Infrastructure Act, (SDI, Act 54 of 2003, NDLA) was approved by Parliament in December 2003. The aim of SDIA (NDLA, 2003) is to provide for the establishment of the South African Spatial Data Infrastructure (SASDI) in order to regulate the collection, management, maintenance, integration, distribution and use of spatial information.

The cover page of Government Gazette February 2004 (No. 25973) proclaims that the SDIA attempts the following: "To establish the South African Spatial Data Infrastructure, the Committee for Spatial Information and an electronic metadata catalogue; to provide for the determination of standards and prescriptions with regard to the facilitation of the sharing of spatial information; to provide for the capture and publishing of metadata and the avoidance of duplication of such capture; and to provide for matters connected therewith."

The SDIA promotes the efficient and effective use of government spatial information resources by the sharing of the information between government spheres. The SDIA

(NDLA, 2003) gives effect to the constitutional right of access to information held by the State.

This chapter provided an overview of South African policy, legislation and planning frameworks mandating spatial and transportation planning. The need for co-operation between government spheres as well as the development and implementation of information systems to promote information sharing to assist planners, was highlighted. The next chapter will focus on the status quo of the development of the ITP, IDP and SDF in Tshwane and Johannesburg Metropolitan Municipalities, as well as reporting the status of the information systems and technology in place to support planning matters in Gauteng Province.

CHAPTER 3

REVIEW OF TRANSPORT AND SPATIAL PLANNING AND INFORMATION SYSTEMS AT MUNICIPAL AND PROVINCIAL SPHERES

This chapter reports on the status quo of information systems for transport and land-use planning in two major municipalities in the study area, as well as the level of integrated planning catered for by these systems. A brief general overview is provided together with the planning status in each municipality, after which the systems supporting the planning processes are evaluated. The evaluation is done in terms of system content, update frequency and technology, including the application of GIS, if any. Due to the fact that the district municipalities do not have relevant systems for managing transport or spatial planning in place, only two of the metropolitan municipalities form part of the status quo investigation. The status quo analysis of planning information systems in Gauteng Department of Public Transport, Roads and Works (GPTRW) is rendered in detail by means of a spatial information framework.

3.1. Planning and information systems status quo in metropolitan municipalities

3.1.1 City of Tshwane

General overview

The City of Tshwane is a Metropolitan Municipality (CTMM) falling mainly within the proclaimed boundaries of Gauteng Province and borders on North West Province in the west and the north, West Rand District Municipality and Johannesburg and Ekurhuleni Metropolitan Municipalities in the south and Metsweding District Municipality in the east. The CTMM stretches from Centurion in the south to Temba in the north and from Mabopane in the west to Mamelodi in the east. A locality plan of CTMM is provided in Figure 3-1.

The total population of CTMM is 1.96 million, according to the 2001 Census published by StatsSA, of which 0.66 million are employed. The population growth was 3.3 % per annum between 1996 and 2001, while the number of employed increased by about 2.0 % per annum.

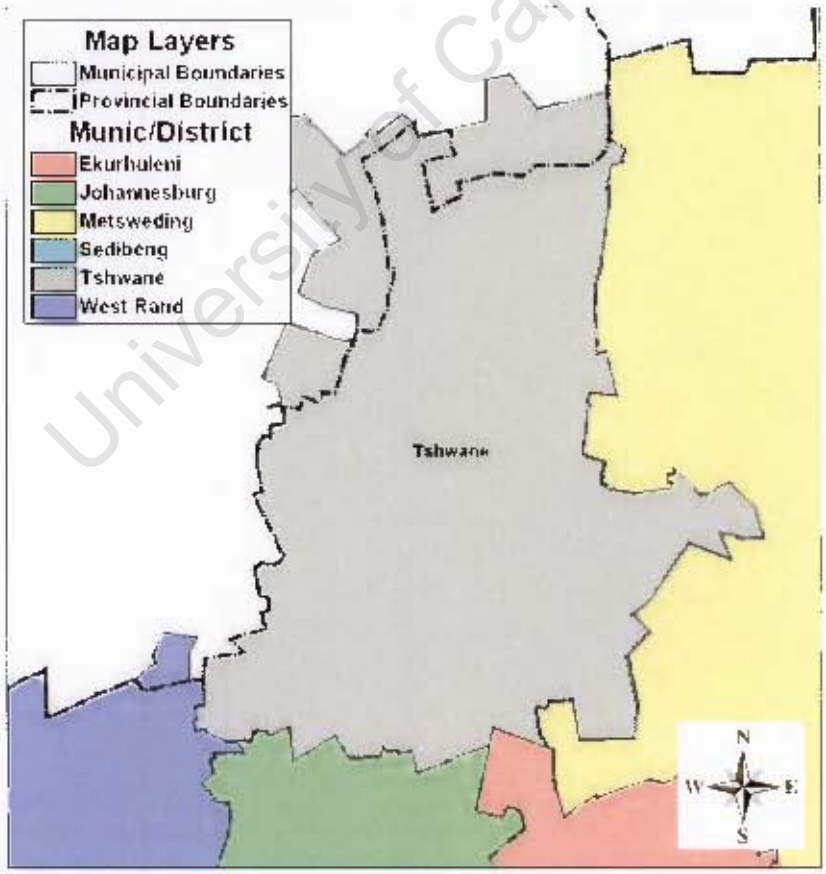

Figure 3-1: Locality plan of City of Tshwane Metropolitan Municipality

Planning status

The current uncertainty regarding the status of the Tshwane Council's Integrated Transport Plan (ITP), emphasises the alignment and communication gap between the provincial and municipal government spheres:

In March 2004, the first ITP was submitted to the Tshwane Council. This ITP prepared for the planning cycle commencing on 1 July 2003, was approved by Council, and subsequently, submitted that same month for the consideration of the MEC for Public Transport, Roads and Works, Gauteng Provincial Government (GPTRW).

However, up to the present, this ITP has neither been approved nor rejected, with uncertainty surrounding the reason for this lack of feedback. CTMM has since commenced their planning, without the approval of the MEC.

The Tshwane ITP 2004-2009 was the second ITP to be submitted to the Tshwane Metropolitan Council. This ITP was the first annual update of the ITP and complied with the requirements of the National Land Transport Transition Act (NLTTA, NDoT, 2000) for the preparation of an ITP, as well as with the conditions stipulated by the Tshwane Council that all comments and queries on the previous plan (2003-2008 ITP) be accommodated.

The submitted ITP 2004-2009 has been approved of by council, with the ITP update commencing soon after approval and currently underway.

The first Integrated Development Plan (IDP) was prepared in 2002. Since the approval of this IDP, three revisions have been prepared to date. The Draft 2006-2010 IDP was published in March 2006.

According to the 2006-2010 Tshwane IDP (DRAFT), integrated development planning involves a process through which the municipality compiles a five-year strategic plan, known as the IDP. This plan is comprehensive, providing the framework for planning and development in the municipality. The IDP should be submitted to the City Council for approval, after which all development and projects should comply with the stipulations contained in the IDP. The approved IDP is deemed the major strategic plan, so that all other plans or strategies compiled by the municipality should be considered to be secondary to the IDP.

The current draft Tshwane Municipal Spatial Development Framework (MSDF) comprises the second phase in the process of preparing a comprehensive MSDF. The 2002 IDP included the Integrated Spatial Development Framework, which represented the first phase of the MSDF. The MSDF was reviewed in 2005 to take into account the updated City Strategy, the Gautrain Rapid Rail Link and the 2010 Soccer World Cup. The reviewed MSDF is based on the following hierarchy:

- Gauteng Spatial development Framework (SDF),
- The City Strategy, and
- The Regional and District SDFs.

Information systems

Tshwane's transport planning data is hosted by the Public Transport Management Information System (PTMIS) and contains the data from the Current Public Transport Records (CPTR) for the bus and taxi modes as well as information from the South African Rail Commuters Corporation (SARCC) rail census. Also included with the transport planning data, is a map component driven by ESRI ArcMap, which displays detailed public transport routes as well as the location of public transport facilities.

Key statistics are provided in tabular format, calculated on capacity (total seats available) and utilisation (total passengers) of the services, based on the minimum requirements for summary tables stipulated by the CPTR guidelines. The system is a standalone tool, which can be installed from CD-Rom on the user's personal computer. The data is updated with a frequency that is determined by updates of the CPTR and the availability of funds allocated for system updates during a given financial year.

Another system that is being utilised is the Provincial Public Transport Information System (PTIS), which is a web-based system, hosted on the Provincial Local Area Network (LAN), containing less detail than the PTMIS. The PTIS is discussed in more detail as part of the GPTRW status quo analysis in section 3.2 of this chapter.

Integrated planning

Tshwane currently has no system in place to integrate or monitor land-use and transportation planning on a strategic level. The following information regarding the status quo is available:

- Only technical comments on land-use applications and policies are obtained from the transportation engineers,
- No monitoring system is in place, but Tshwane is working on the development of such a system. This intended system is due for completion in 2006,
- The monitoring system will relate to approvals of applications to be fed into a Geographic Information System (GIS) based system. This information will be intelligently analysed in order to derive meaningful conclusions,
- Opportunity exists to link transport-related planning into the said GIS-based system, and
- Historically, good integration existed through the Committee of Urban Transport Authorities. Nevertheless, little integration between land-use planning and strategic transport planning has taken place since 1997.

3.1.2 City of Johannesburg

General overview

The City of Johannesburg is a Metropolitan Municipality falling completely within the proclaimed boundaries of Gauteng Province. Figure 3-2 provides a locality plan of Johannesburg Metro. The Metro borders on Tshwane Metro in the north, Sedibeng District in the south, West Rand District in the West, and Ekurhuleni Metro in the east.

The city covers 1620 square kilometres of land and, with a population estimated at 3.2 million people, is the largest city in South Africa. Johannesburg is a hastily growing city: a growth rate of 4% per annum implies that the City will double in size by 2020. Furthermore, addressing distorted migration patterns, caused by apartheid, is a major challenge.

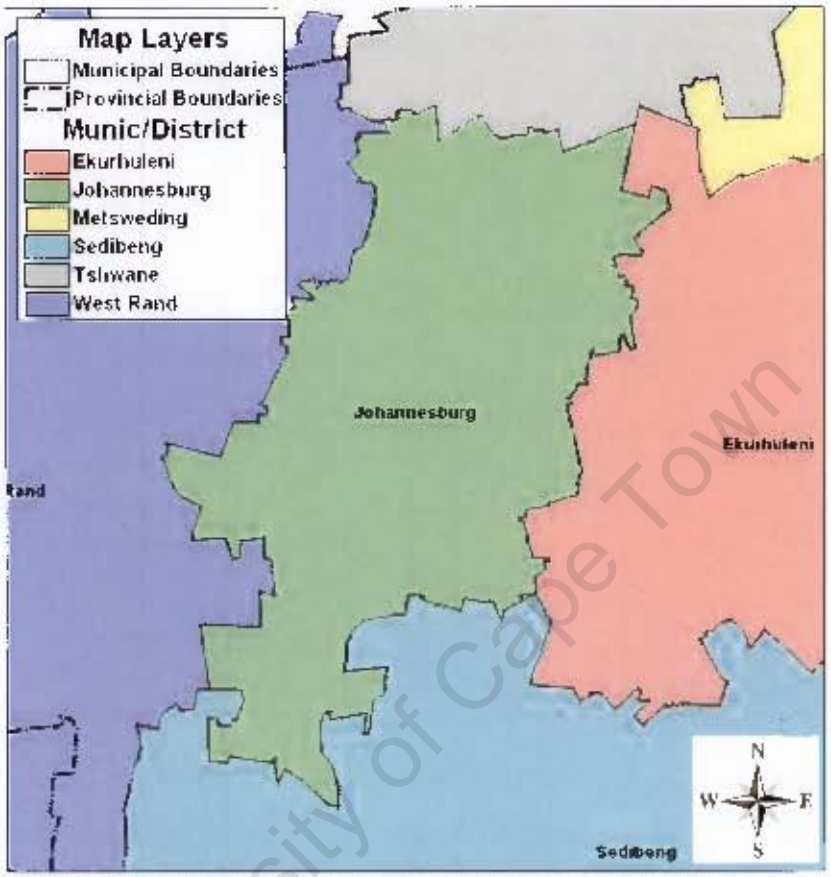

Figure 3-2: Locality plan of City of Johannesburg Metropolitan Municipality

Planning status

The first Integrated Transport Plan (ITP 2003 – 2008) was approved by Johannesburg Council in August 2003. The July 2004 update of the ITP is the current plan guiding transport in the Metropolitan Municipality and consists of two volumes, i.e. Volume I: Status Quo and Needs Analysis, and Volume II: Proposals and Financial Implication. The next update will be submitted to Council and relevant committees for approval in September 2006. Updates to the ITP include more current information on public transport, new developments and an updated list of priority projects for implementation.

The City of Johannesburg has already produced four Integrated Development Plans (IDPs), including:

- 2002/03,
- 2003/04,
- 2004/05, and
- 2005/06.

In 2006, for the first time, the City produced a full five-year IDP covering the five-year political term of office, namely 2006 to 2011.

Three Spatial Development Frameworks (SDFs) have been developed by the City to date, including:

- SDF 2004/05,
- Review of 2004/05 SDF (July 2005), and
- SDF 2005/06

A broad performance management framework has been developed by the City, which links the SDF and other individual sectoral plans as part of the Integrated Development Plan (IDP) process and output. This framework is a confirmation of the relationship between the SDF and the IDP. Refer to Figure 3-3 for the Johannesburg IDP process.

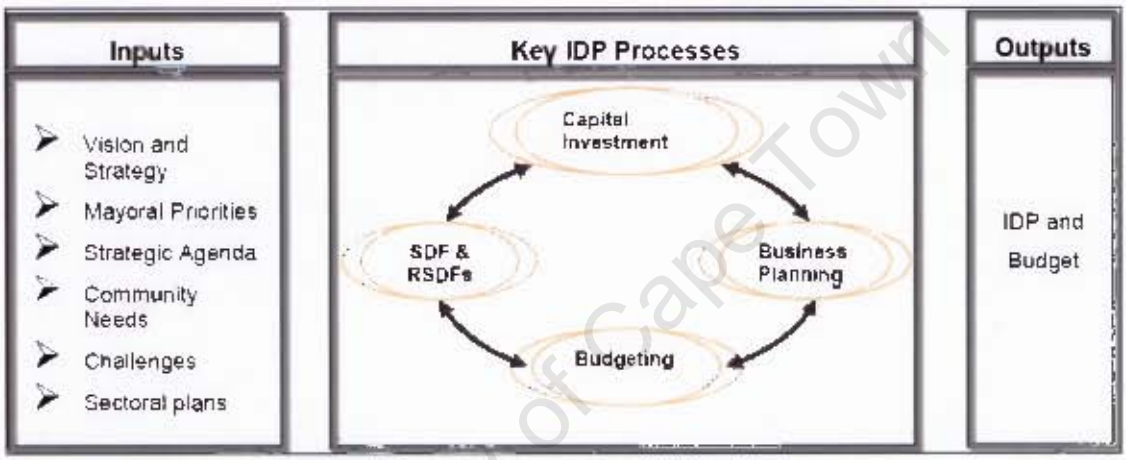

Figure 3-3: Johannesburg IDP process
Source: Johannesburg IDP 2006 - 2011

Information systems

The Johannesburg municipality utilises the similar information system than Tshwane, namely the PTIS developed by GPTRW, namely the PTIS. As stated previously, the system is comprised of a map component, utilisation reports, grid reports and photographs.

Additional supporting data was collected during field surveys undertaken by the City, including cordon counts, vehicle and passenger volume counts and waiting-times surveys. The survey data was captured in a MS Access database not linked to the GIS component of the PTIS. However, as the most recent surveys were conducted in 2003, the PTIS and the in-house developed database are both considered to be outdated.

The PTIS is discussed in more detail as part of the GPTRW status quo analysis in section 3.2 of this chapter.

Integrated planning

Johannesburg currently has no system in place to integrate or monitor land-use and transportation planning on a strategic level. The following information regarding the status quo is available:

- No monitoring system, other than the electronic application capturing system, is in place,
- There is a lack of available human resources to monitor land-use development,
- The hope was expressed that the Integrated Transport Plan would assist in improving the integration between transport and land-use development,
- Internally, there is confusion within the planning department regarding the function of forward planning and policy implementation, and
- Currently, transportation comments on land-use applications are limited to technical inputs with limited strategic direction being given.

3.2 Information systems and GIS status quo in GPTRW

The second section of this chapter focuses on the status quo of transportation and spatial planning frameworks, information systems for planning and the application of GIS in the department. The 2003 - 2008 Provincial Land Transport Framework (PLTF), the Gauteng Spatial Development Framework (GSDF) and the Gauteng Integrated Spatial and Transport Framework are discussed, followed by the representation of system audit results, including the level of utilisation of GIS tools and spatial datasets. This section commences with a brief discussion of the organisational structure, in order to provide a context for the status quo analysis conducted in GPTRW.

3.2.1 Organisational structure

The Gauteng Department of Public Transport, Roads and Works underwent an organisational restructuring at the end of 2005. The result of the restructuring is represented in figures 3-4 to 3-6, displaying only the structure of branches relevant to this project, i.e. Corporate Services Branch and Transport Branch. Directorates envisaged as future users to benefit from the integrated planning system, are indicated in greyscale.

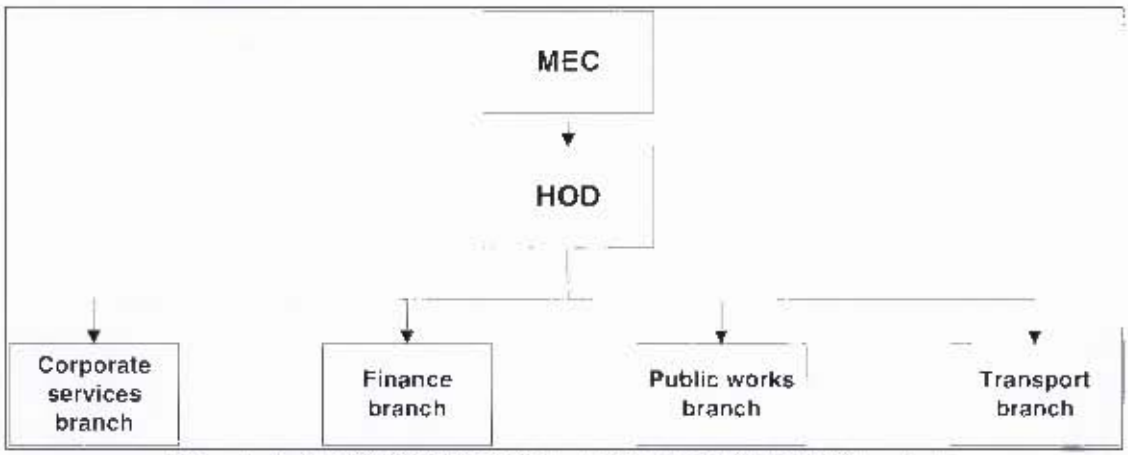

Figure 3-4: GPTRW High-level Organisational Structure

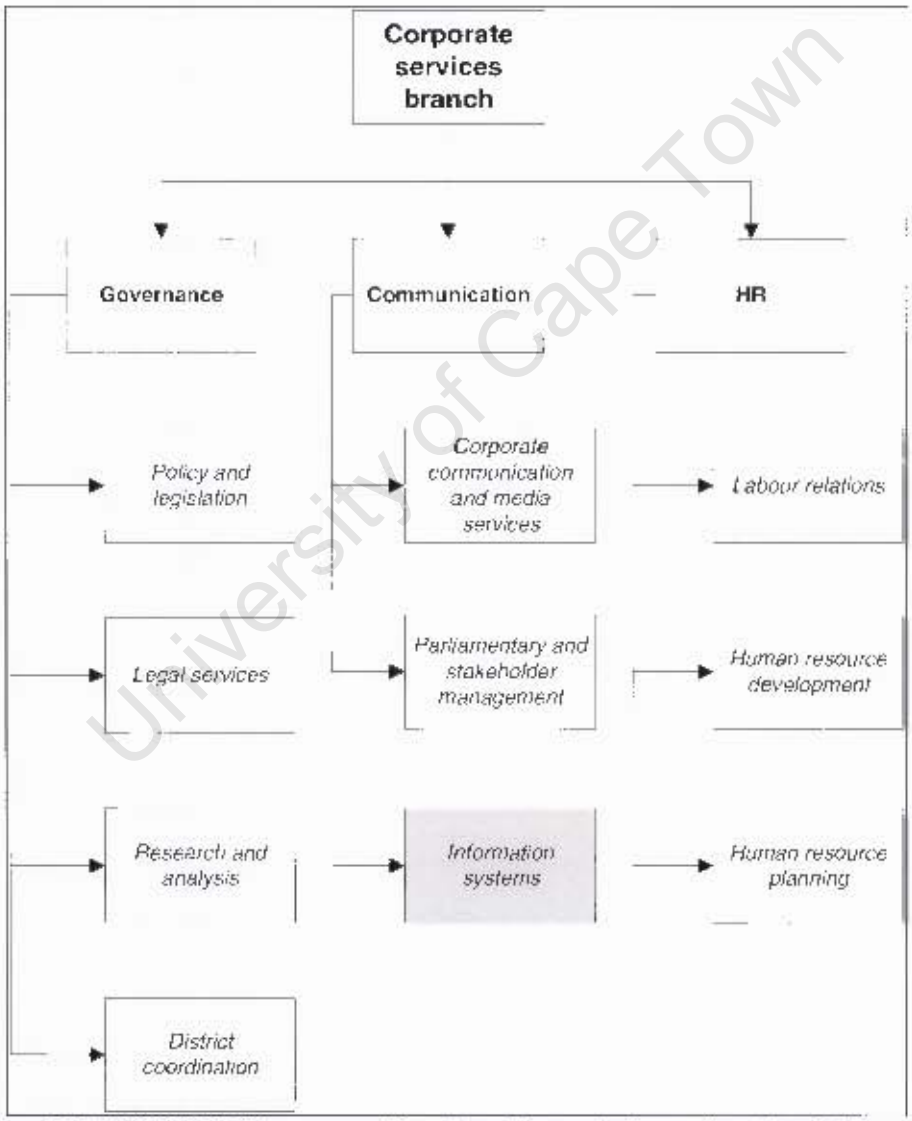

Figure 3-5: GPTRW Corporate Services Branch Organisational Structure

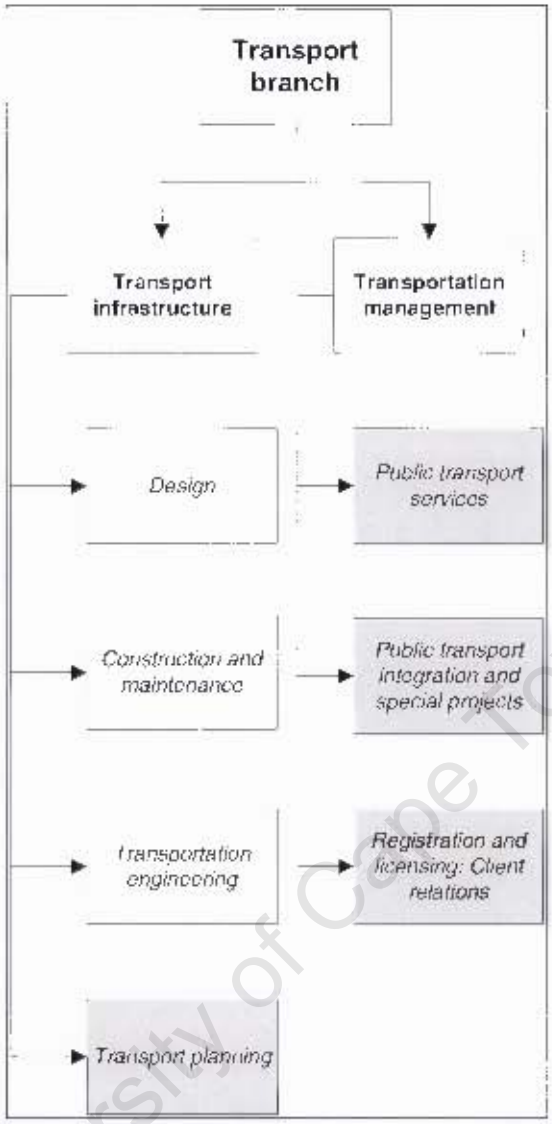

Figure 3-6: GPTRW Transport Branch Organisational Structure

3.2.2 Planning status

Specific frameworks and strategies were implemented pro-actively by GPTRW in order to promote integrated land-use and transport planning. The relevant frameworks are discussed in this chapter as part of the planning status of GPTRW, whilst the strategies, including the strategic major road network and the strategic public transport network, are scrutinised in Chapter 5 as part of the functional design of the integrated planning system.

Gauteng Provincial Land Transport Framework

The 2003-2008 Gauteng Provincial Land Transport Framework (PLTF, GPRW, 2003) was submitted to and approved by the Minister of Transport. The framework is scheduled to be updated in 2006. Section 4.3 of the latest Gauteng PLTF contains a discussion regarding measures to resolve conflict with land-use planning. The future considerations and anticipated short and medium-term actions are indicated by the following quotations:

- "Bearing in mind that the integration of transport and land-use is clearly a legal requirement, the objective of such integration is to promote harmonious development, to achieve this it is necessary to create practical and workable mechanisms to ensure that applications for developments are assessed by transport planning authorities for compatibility with the ITP", and
- "Procedural guidelines will have to be developed by the Transportation Coordination Committee (TCC) in anticipation of the structures to be established following the enactment and coming into operation of the national and provincial land-use management legislation. Until such time as the new systems are in place it will be expected from present core cities to scrutinise land-use amendment applications and to refer them to the Gauteng MEC for Public Transport, Roads and Works for consideration and decision, in collaboration with the MEC for Development Planning and Local Government where appropriate. This must be done in terms of the Urban Transport Act and other existing legislation."

Gauteng Spatial Development Framework

The Gauteng Spatial Development Framework (GSDF, GPTRW, 2002) Phase III is intended to guide decisions related to the location and nature of the physical development of Gauteng. The historical inadequacies of the settlement pattern in Gauteng, coupled with increasing urbanisation pressures, has resulted in the need for spatial guidelines that will direct development towards a more efficient, effective and equitable settlement pattern. The GSDF provides the guidelines by means of a spatial framework that represents the principles contained in Chapter 1 of the Development Facilitation Act (DFA, Act of 67 of 1995, NDLA). The above implies that the GSDF provides an indication of the most desirable settlement pattern for Gauteng. This is achieved by means of the following:

- An indication of where growth and development should and should not occur,
- An indication of the most desirable form and nature of future growth and development, and
- An indication of areas requiring public/provincial intervention to direct actions towards altering historically problematic settlement issues, and defining the way forward for the province.

The role of the GSDF is bilateral. Firstly, it provides information on the current state of the province, and secondly, it puts forward certain planning proposals, which should direct development at a provincial level. This latter aspect, being the primary focus of the process, requires implementation at provincial, metropolitan and local levels. The GSDF Phase III is a follow -up and refinement of Phase II. Whilst Phase II provides a broad conceptual development framework, Phase III has extended the analysis of Phase II, refined the contents and findings, and focused on five critical factors to determine the way forward. The result is a refined final plan providing concrete proposals to structure the future growth path of Gauteng.

Gauteng Integrated Spatial and Transport Framework

The main objective of the Gauteng Integrated Spatial and Transport Framework (GISTF, GPTRW, 2000) is to guide spatial and transport planning towards the focussed and simultaneous development of the urban structure and the transport network, in such a manner that it would result in the integration of land-use and

transport, and the improvement of the viability of public transport. The framework also identifies corridors considered to be political priorities for the current planning cycle.

3.2.3 Information systems

The systems and functional solutions currently in use and managed by the GPTRW include the following types:

- Web-based systems with and without spatial components for GPTRW use only,
- Web-based systems with and without spatial components for public and GPTRW use, and
- "Standalone" systems.

Refer to Figure 3-7 below for a screenshot of the Gauteng Spatial Information Portal, which contains links and brief descriptions of all existing systems.

Figure 3-7: Gauteng Spatial Information Portal

Table 3-1 provides a summary of the existing systems in GPTRW, categorised according to planning discipline, i.e. infrastructure, traffic and public transport. The Sub-directorate responsible for initial development and ongoing maintenance is indicated next to the system name. Refer to Figures 3-5 and 3-6 in earlier sections of this chapter for reference to the organisational position of the sub-directorates within GPTRW.

Most systems are maintained on an annual basis, either through in-house initiatives by the department, or as part of responsibilities assigned to service providers. The application and utilisation of GIS in a system is indicated in terms of vector data versus raster data used in the map component. Refer to section 3.2.4 for a more in-depth analysis of the status of GIS in GPTRW. Datasets utilised by the systems consist of custom datasets relevant to, and maintained by, the specific system and its users, in addition to the base spatial dataset shared amongst the systems. The maintenance of the shared (base) datasets is the responsibility of the directorate Information Systems.

Table 3-1: Existing systems in GPTRW

Discipline	System	GPTRW Sub-directorate	Other users	Map	Maintained
Infrastructure	Roads DMS	Design	Consultants	Vector	Yes
	Advert Management	Construction and maintenance	Municipalities	Vector; raster	Yes
	Works DMS	Facilities management	Consultants	Vector	Yes
	Wayleaves	Construction and maintenance	Applicants	Vector	Yes
	Inventory	Information systems	Consultants	Vector	Yes
	Bridge MS	Design	Consultants	Vector; raster	Yes
	Road Structure MS	Design	Consultants	Vector; raster	Yes
Traffic	Traffic Information System	Transportation engineering	Public	None	Yes
	Traffic Reporting System	Transportation engineering	Public	Vector	No
	Intersection Control Database	Transportation planning	None	Vector	No
Public Transport	Public Transport Information System	Transportation planning	Municipalities	Vector	Yes
	Gautrain Website	Transportation planning	Public	Raster	Yes
	Call Centre	Transportation planning	GSSC	Vector	Yes

From the table above it is evident that no system is in place for land-use monitoring and management. This observation will be discussed in more detail in the next chapter dealing with the gap analysis.

3.2.4 Geographical Information Systems

Framework for GIS status quo analysis

The status of Geographical Information Systems (GIS) in the GPTRW is measured against the Spatial Information Strategy Framework (SISF). This framework deals with important components to consider when setting up a GIS capability for an organisation. Figure 3-8 presents the components of, and relationships between, spatial information and GIS in an organisation.

The purpose of the GIS status quo analysis is twofold:

- Determine the extent of GIS awareness in GPTRW in order to verify a potential user profile for the envisaged system, and
- Determine GIS standards in order to include these requirements in the design of the envisaged system.

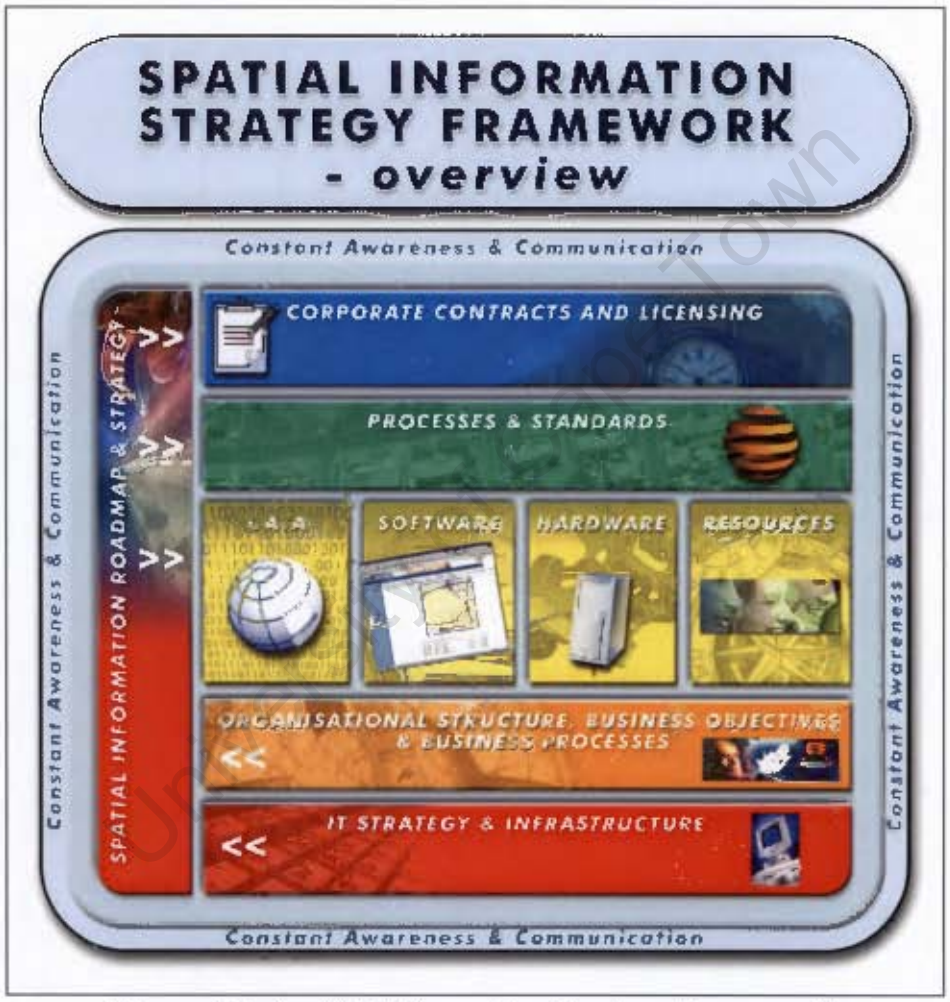

Figure 3-8: Spatial Information Strategy Framework
Source: AfriGIS, 1999

The remainder of this subsection briefly discusses each component and provides the status quo within the GPTRW.

Processes and standards

The extensive nature of spatial information and the multitude of factors influencing and impacting on it, call for the establishment of vital processes and standards. As

data forms one of the core components of GIS, it is vitally important to take the processes and standards into consideration, when maintaining and updating the datasets. In addition, attention should be paid to following the processes that have been determined for the addition of new (necessarily quality assured) data. It is paramount that existing standards are constantly taken into consideration, as the danger exists that software tools that manipulate the data in different ways can in fact reduce accuracy, quality and integrity. It is also vital that the basic processes and standards are put into place at an early stage, to ensure maintainability as well as sustainability.

The following standards are currently in place within the department:
- Gauteng Transport Datamodel,
- Gauteng Draft White Paper on GIS, and
- Software development standards and methodology.

Each item is discussed briefly in turn in the sub-sections that follow.

Gauteng transport datamodel

A datamodel containing the base data has been developed for the province. One of the major objectives of the model is to prevent the unnecessary duplication of data and to promote and enforce the sharing of information. To date, a comprehensive set of alphanumeric and spatial data has been established. This model is maintained on a continuous basis and all current and future service providers, specifically those involved in data collection, data processing and system development, need to comply with the database standards stipulated by the model.

Gauteng Draft White Paper on GIS

In the first half of 2004 a Draft White Paper on GIS (Burger, 2004) has been compiled for GPTRW. The purpose of this document, discussing the functional and technical details and business rules for the implementation of standardised GIS classes (basemap/datasets) throughout Gauteng, is to set a standard for the province. The paper covers the following aspects:
- Information sharing initiatives,
- The Gauteng datamodel,
- Data acquisition and maintenance,
- Data dissemination,
- Identification of role players and clients, and
- GIS classes: Street Centre Line (SCL) detail discussion.

Software development standards

A software development standards guideline has been developed for GPTRW in 2003. These guidelines have been written to set a minimum level of coding standards to be applied by service providers who develop software for the department. It is not intended to be prescriptive, but rather to lead developers towards a consistent application of sound practices normally associated with premium quality workmanship. Application of code standards derives the following benefits:
- It is Simpler to maintain by the author and others,
- Better planned code is derived,
- Programming efficiency is improved,

- Re-use of software functions and modules is made possible,
- Software documentation is improved,
- The modification of legacy software, without having to spend time relearning old code is made possible, and
- The readability of algorithms is improved, so that errors are reduced.

As coding standards are specific to a certain development language, the document sets a minimum outline standard that is of a generic nature. Thereafter, it allows for standards to be set for each specific development language.

Data

The data component comprises one of the most important parts of a successful GIS. It encompasses data in its raw format as well as the contextualised information. The most economical and effective means of capturing and maintaining data (normally extremely costly and time-consuming), is by applying the GIS strategy. To date a comprehensive set of alphanumeric and spatial data has been established. A datamodel containing the base data has been developed for the province according to the Gauteng Integrated Transport Information System (GITIS) framework.

Software

The software component of the SISF deals with all the software technologies that are involved in setting up a GIS. Software products fall into the following categories:
- GIS Web engines,
- Desktop GIS tools,
- Power User GIS tools,
- Image processing tools,
- Location-based tools for mobile phones, and
- GIS software for handheld devices.

Custom software solutions are listed in Table 3-1 as part of the information systems subsection (3.2.3).

Standard software products

GPTRW has set the following standards in terms of GIS and web-based off-the-shelf software solutions:

a) Databases
   - SQL Server 2000, and
   - Focus.
b) GIS engines
   - Autodesk MapGuide 6.0,
   - Autodesk MapGuide Lite, and
   - Transcad for the Web 4.7.

3.3 Synopsis

The conclusions reached in this chapter include the following:

- Planning status: both municipalities investigated are on track with the preparation and submission of the transport and spatial plans required by legislation. Provincial planning frameworks are well developed and up to date.
- Information systems: although both municipalities and GPTRW have fairly advanced technology in place in terms of information systems, the main initiatives lacking are the functional solutions providing functionality / decision support for enabling integrated planning.
- Application of GIS as a transversal management tool is above average for Johannesburg, Tshwane and GPTRW, compared to other municipalities in the province, but it has not been applied as a tool for integrated planning yet.

Chapter 4 reports on the findings after conducting a needs analysis, gap analysis and prioritising data and functional solutions to be developed for GPTRW. In support to the findings reached in this chapter, Chapter 4 will also report on a more in-depth data investigation, to provide concrete proof of the gap in the current information system anthology.

CHAPTER 4

NEEDS ANALYSIS AND PRIORITISATION OF DATA AND FUNCTIONAL SOLUTIONS

Chapter 4 aims to support the conclusions reached in the previous chapter, by investigating the data component. Firstly, this chapter reports on the total repository of transport datasets to be managed by government, by investigating ten major legal source documents. The result of the legislative literature review is a checklist of datasets compiled in a comprehensive questionnaire. Subsequently, the currently managed datasets are identified, and additional datasets recognised by means of a round of interviews. In addition, he gaps between legal requirements, the additional data needs and the actual information being managed, are discussed. Accordingly, a formula is derived for the prioritisation of development of functional solutions for enabling the capturing, processing, dissemination, evaluation and utilisation of these datasets. The weighted average method is applied to assist with the prioritisation of the outstanding functional solutions.

4.1 Data needs analysis

The following high-level workflow is applied in order to arrive at a list of dataset priorities.

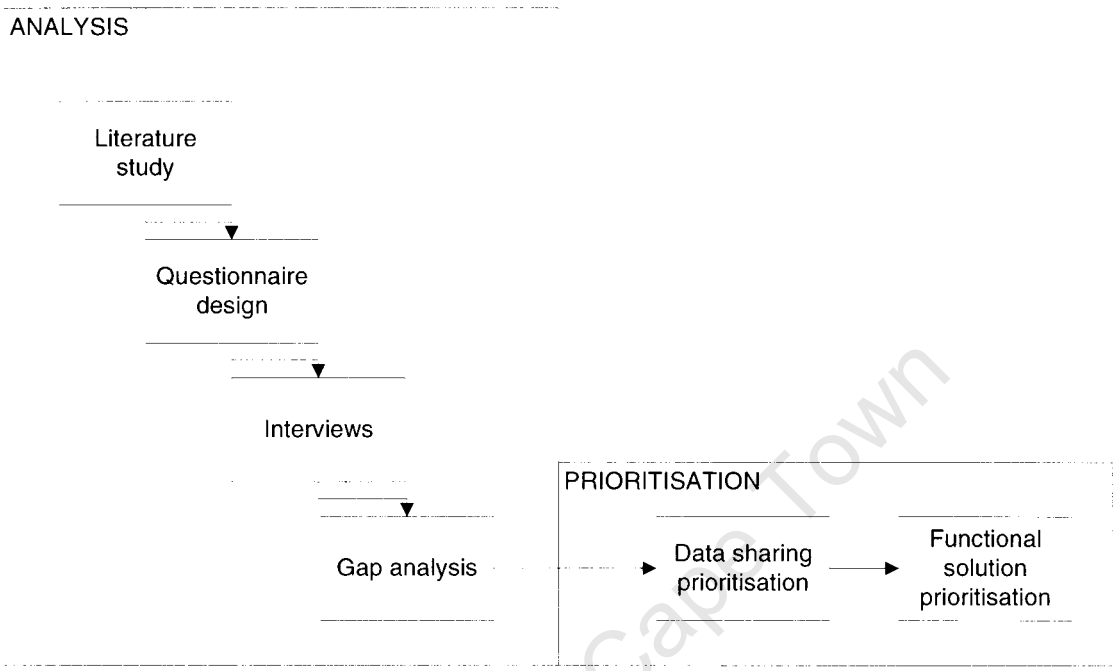

Figure 4-1: Prioritisation workflow

The process followed during each step of the workflow is discussed in sufficient detail in the remainder of section 4.1. The output of each step forms a significant part of the input for the consecutive step.

4.1.1 Legislative requirements for data collection and maintenance

As supplement to the literature study conducted in Chapter 2, providing an overview of South African policy, legislation and planning frameworks mandating spatial and transportation planning, this sub-section of Chapter 4 investigates the transport legislation from another angle. The aim of this literature study is two-fold, namely: firstly, to identify information items to be used and/or managed by a specific role player in order to comprehensively perform the transport responsibilities required by relevant legislation, regulations, policy documents or business plans; secondly, to design a questionnaire or checklist to compare the information items extracted from the source documents with actual information items currently being used and/or managed by role players in Gauteng.

Ten source documents are used as reference. Only information considered to be required by either national or provincial legislation is classified as a legal requirement. The literature study's structure is designed to serve as a blueprint summary of

requirements, and relates to the findings of this study. The main source documents consulted during the literature study are as follows:

1. National Land Transport Transition Act (NLTTA, Act 22 of 2000, NDoT).
2. National Road Traffic Act (NRTA, Act 93 of 1996, NDoT).
3. National Regulations for the Implementation of the National Land Transport Transition Act (NLTTA, Act 22 of 2000, NDoT).
4. National Land Transport Strategic Framework 2002 – 2007 (Third Draft, 2002, NDoT).
5. Gauteng Public Passenger Road Transport Act (GPPRTA, Act 7 of 2001, GPTRW).
6. Gauteng Transport Infrastructure Act (GTIA, Act 8 of 2001, GPTRW).
7. Gauteng Transport Framework Revision Act (GTFRA, Act 8 of 2002, GPTRW).
8. Gauteng White Paper on Transport Policy (GPTRW, 1997).
9. Gauteng Provincial Land Transport Framework 2002 – 2007 (PLTF, GPTRW, 2003).
10. Gauteng Department of Public Transport, Roads and Works (GPTRW). Key Programmes of the Transport Branch in Strategic Alignment with Provincial and Departmental Priorities and Focus Areas. 15 March 2002.

Annexure A contains the results of the literature study. The form in which the results of the literature study are presented covers the following aspects:
a) Focus area,
b) Element,
c) Sub-element or module, i.e. data required to perform focus area or element, and
d) Source document.

This format is necessary, in order to ease the process of comparing information items required in terms of legislative and policy documents with those information items actually being used and/or managed by role players, as indicated during the interviews.

An attempt is made to ensure that the results contained in the literature study exactly reflect the object of the relevant source document with minimal (if any) interpretation, in order to ensure an unbiased approach. Notwithstanding the aforementioned, the reader is encouraged to consult the source documents, in order to ascertain the context within which the source document requires the relevant information to be collected and/or managed.

4.1.2 Structured interviews

The questionnaire designed for the interviews includes a checklist of all focus areas, elements and sub-elements identified during the legislation literature review, in order to audit the datasets and systems in place. Apart from the items contained in the

checklist, the interviewees are offered the opportunity and encouraged to indicate their needs in addition to the legal requirements per focus area. Questioning is carried out during in-depth interviews, ensuring that the full spectrum of needs surfaces. Figure 4-2 presents the breakdown of the questionnaire structure. Focus areas include:

a) Public transport operations,
b) Infrastructure,
c) Traffic operations,
d) Traffic management,
e) Public transport management regulation and control,
f) Freight, and
g) Land-use.

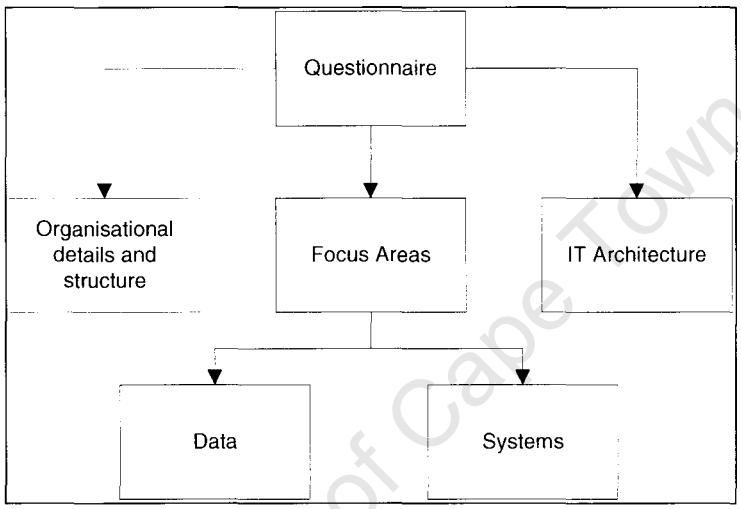

Figure 4-2: Questionnaire structure

The series of structured interviews were conducted primarily within GPTRW. Each director, or his/her technical representative, listed in the organisational structure in Figures 3-4 to 3-6 (refer to Chapter 3), is interviewed. In addition to these interviews, other role-players interviewed are divided into five groups and include key figures from:

a) Group 1: District municipalities,
b) Group 2: Metropolitan municipalities and Johannesburg Roads Agency (JRA),
c) Group 3: National Department of Transport (NDoT) and South African National Roads Agency Limited (SANRAL),
d) Group 4: Rail organisations and agencies, and
e) Group 5: Other relevant provincial departments.

Data, systems and models currently managed

The data currently being managed is listed in Table 4-1 below. Where data is managed but no attendant system is indicated in the far right column, management and manipulation of data is usually preformed manually, with the application of paper-based procedures.

Table 4-1: Status quo datasets and systems

FOCUS AREA	ELEMENT	AUTHORITIES	GROUP(S) OF ROLE PLAYERS	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	SYSTEMS & MODELS IN PLACE
Public transport operations	Public transport operations	District Municipalities, Metropolitan Municipalities, GPTRW, SARCC, Metrorail	Group 1, Group 2, Group 3, Group 4	Y	Y	PTIS-GPTRW; PTMIS-Metropolitan Municipalities; SUMS-NDoT
	Modal Integration			N	Y	
	Accessible transport			N	Y	
	Learner transport	GPTRW	Group 3	Y	Y	PTIS GPTRW/GDE
	Metered taxis	GPTRW	Group 3	N	Y	PTIS-GPTRW; PTMIS-Metropolitan Municipalities
	Non-motorised transport			N	Y	
	Tourism related transport			N	Y	
	Public transport security			N	Y	
Infrastructure	Road Network	JRA, GPTRW, SANRAL	Group 3	Y	Y	Digital GIS database of Gauteng Strategic Major Road Network-GPTRW; PVW Model; RNMS-GPTRW
	Road Design	JRA, GPTRW, SANRAL, Metropolitan Municipalities	Group 2, Group 3	Y	N	CMS-GPTRW; MMS-GPTRW; Borrow Pit Management System-GPTRW; Bridge Management System-GPTRW; Compensation Management System-GPTRW; Declarations-GPTRW; Design Management System-GPTRW; Drawing Office GIS-GPTRW; Plan Management System-GPTRW; JRA Standard Details-JRA

Table 4-1: Status quo datasets and systems (continued)

FOCUS AREA	ELEMENT	AUTHORITIES	GROUP(S) OF ROLE PLAYERS	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	SYSTEMS & MODELS IN PLACE
	Pavement Management	JRA, GPTRW, SANRAL, Metropolitan Municipalities, District Municipalities	Group 1, Group 2, Group 3	Y	N	RNMS-GPTRW; Dynatest-JRA; Gravel Management System-GPTRW; Pavement Management System-GPTRW
	Roadway furniture	JRA, GPTRW, SANRAL, Metropolitan Municipalities	Group 2, Group 3	Y	N	Outdoor Advertising-JRA; Outdoor Advertising Management System (PRAM)-GPTRW; National and Provincial Accident Register-GPTRW
	Roadway statistics	JRA, GPTRW, SANRAL	Group 3	Y	N	Dynatest-JRA
	Bus facilities	JRA, GPTRW, Metropolitan Municipalities, District Municipalities	Group 1, Group 2, Group 3	Y	Y	PTIS-GPTRW; PTMIS-Metropolitan Municipalities; RPTFF-Ekurhuleni Metropolitan Municipality
	Minibus-taxi facilities	JRA, GPTRW, Metropolitan Municipalities, District Municipalities	Group 1, Group 2, Group 4	Y	Y	PTIS-GPTRW (in process)
	Rail facilities	GPTRW, SARCC, Metrorail	Group 3, Group 4	Y	Y	
	Rail network	District and Metropolitan Municipalities, GPTRW,SARCC, Metrorail	Group 1, Group 2, Group 3, Group 4	Y	Y	

Table 4-1: Status quo datasets and systems (continued)

FOCUS AREA	ELEMENT	AUTHORITIES	GROUP(S) OF ROLE PLAYERS	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	SYSTEMS & MODELS IN PLACE
	Modal Transfer facilities	JRA, GPTRW	Group 2, Group 3	N	Y	PTIS-GPTRW (in process)
	Metered taxis			N	Y	PTIS-GPTRW (in process)
	Pedestrian and Cycle facilities			Y	Y	
	Development and maintenance of Infrastructure			Y	Y	Wayleaves Management System-GPTRW
	Land acquisition			Y	N	
Traffic Operations	Traffic Movements	JRA, GPTRW, Metropolitan Municipalities, District Municipalities	Group 1, Group 2, Group 3	Y	N	EMME/2-PWV; EMME/2-Metropolitan Municipalities; TCS-GPTRW; SignalInfo-City of Tshwane; TrafMan-GPTRW
	Traffic Control	Metropolitan Municipalities, GPTRW	Group 2, Group 3	Y	N	ICD-GPTRW; SignalInfo-City of Tshwane; Route determination register-GPTRW
	Congestion management	District Municipalities, GPTRW	Group 1, Group 3	Y	N	EMME/2-PWV; EMME/2-Metropolitan Municipalities; TCS-GPTRW; TrafMan-GPTRW
	Travel demand management			N	Y	
	Intelligent Transport Systems			Y	Y	SANRAL BEN SCOEMAN PILOT
Traffic Management	Road traffic safety	GPTRW	Group 3	Y	Y	Arrive Alive-GPTRW; National Accident Register-GPTRW/NDoT; NATIS-NDoT; TrafMan-GPTRW; Incident Management System-GPTRW

Table 4-1: Status quo datasets and systems (continued)

FOCUS AREA	ELEMENT	AUTHORITIES	GROUP(S) OF ROLE PLAYERS	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	SYSTEMS & MODELS IN PLACE
	Law enforcement	GPTRW, NDOT	Group 3	Y	Y	Arrive Alive-GPTRW; NATIS-NDoT; TrafMan-GPTRW; CTN Solutions-West Rand District Municipality; TCS-West Rand District Municipality
	Incident Management	District Municipalities	Group 1	Y	Y	Incident Management System-GPTRW
	Education	GPTRW	Group 3	Y	N	Arrive Alive-GPTRW
	Pedestrian management	District Municipalities, GPTRW	Group 1, Group 3	Y	N	Arrive Alive-GPTRW; TrafMan-GPTRW
	Hazardous loads and Substances	GPTRW	Group 3	Y	Y	
	Overload control facilities	GPTRW	Group 3	Y	N	
	Registration and Licensing of motor vehicles	NDoT	Group 3	Y	Y	NATIS-NDoT
	Import of motor vehicles	NDoT	Group 3	Y	Y	NATIS-NDoT
	Driving licenses	NDoT	Group 3	Y	Y	NATIS-NDoT
Public Transport Management Regulation and Control	Registration of associations and members	NDOT, GPTRW (Registrar)	Group 3	Y	Y	OLAS-NDoT; RAS-NDoT; SUMS-NDoT
	Disposal of Operating Licenses	NDOT, GPTRW (OL Board)	Group 3	Y	Y	OLAS-NDoT ; Taxi Conflict Reporting System-GPTRW (in process)
	Public Transport tenders and subsidies	NDOT, GPTRW	Group 3	Y	Y	SUMS-NDoT
	Inspection / Law Enforcement	Metropolitan Municipalities, GPTRW	Group 2, Group 3	Y	N	TrafMan-GPTRW

Table 4-1: Status quo datasets and systems (continued)

FOCUS AREA	ELEMENT	AUTHORITIES	GROUP(S) OF ROLE PLAYERS	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	SYSTEMS & MODELS IN PLACE
	Transport appeals			N	N	
Freight transport	Freight operations			Y	N	
	Abnormal loads	GPTRW	Group 3	Y	N	AVP-GPTRW; AVR-GPTRW; Super Route Map-GPTRW
Land Use	Spatial framework	District Municipalities, GPTRW, DDP and LG, DACEL	Group 1, Group 3, Group 5	Y	N	
	Land use characteristics	GPTRW, DDP and LG, DACEL	Group 3, Group 5	N	N	
	Corridors and nodes / Mixed land-use	DACEL	Group 5	Y	N	
	Monitoring and control	DACEL	Group 5	N	N	
	Environmental Planning	DACEL	Group 5	N	N	

Additional user needs

The role-players identified the following datasets per focus area as additional business requirements, in alignment to the data prescribed by legislation:

Table 4-2: Additional data and system needs

FOCUS AREA	ELEMENT	SUB-ELEMENT
Public Transport Operations	Minibus taxi operations (commuter)	Vehicle details
		Route details
		Timetables
Infrastructure	Roads	Length of road by type
	Development and maintenance	Yellow fleet
Traffic Operations	Traffic movements	Turning movements
		Classification
	Traffic control	Route numbering
		Intersection detail
	Congestion management	V/C ratio
		Vehicle delay
		Vehicle speeds
Public Transport Regulation and Control	Inspection / law enforcement	Extent of permit violations
Freight transport	Operational Characteristics	Road
	Operational Characteristics	Rail
	Operational Characteristics	Air
	Abnormal Loads	Route detail plan
		Permit details
Land Use	Monitoring development trends	Land use growth by type

4.1.3 Identification of gaps in data management and sharing

The following formula is derived from the results obtained from the gap analysis:

Gaps = Legal requirements + additional user requirements - data being managed

Refer to Figure 4-3 for a diagram depicting the formula described above. The gaps are indicated by the greyscale multi-faceted shape.

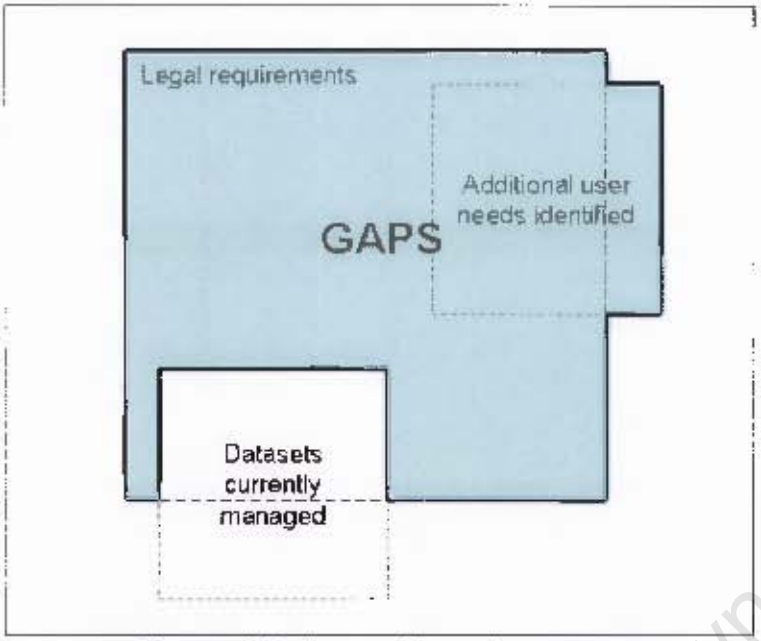

Figure 4-3: Scope of gaps in data sets

The gaps identified, including all elements lacking datasets and/or functional solutions, are presented in the table below.

Table 4-3: Gaps identified

FOCUS AREA	ELEMENT	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)
Public transport operations	Modal Integration	N	Y
	Accessible transport	N	Y
	Non motorised transport	N	Y
	Tourism related transport	N	Y
	Public transport security	N	Y
Infrastructure	Rail facilities	Y	Y
	Rail network	Y	Y
	Pedestrian and Cycle facilities	Y	Y
	Land acquisition	Y	N
Traffic Operations	Travel demand management	N	Y
Traffic Management	Hazardous loads and Substances	Y	Y
	Overload control facilities	Y	N
	Traffic training college	N	N
Public Transport Management Regulation and Control	Transport appeals	N	N
Freight transport	Freight operations	Y	N
	Abnormal loads	Y	N
Land Use	Spatial framework	Y	Y
	Land use characteristics	N	N
	Corridors and nodes / Mixed land-use	Y	N
	Monitoring and control	N	N
	Environmental Planning	N	N

4.1.4 Prioritisation of information to be managed and shared

It is a certainty that the extent of datasets and systems identified during the gap analysis, will, in the case of most businesses, be too immense to address at once, in particular when taking time, budget and other resource constraints into account as well. The need therefore exists to apply a prioritisation method that proves to be fair and applicable to the current environment and conditions. The Delphi methodology was selected to prioritise the datasets to be managed and shared amongst role-players in the transport industry.

Delphi is a tool to aid in the anonymous survey of expert judgments obtained in a series of interview rounds. Delphi thinking can be applied to a small group or it can be done with hundreds of people, however, around 20 people is a fairly common size. With Delphi work, it is seldom necessary to call together an actual meeting, which makes it ideal for virtual teams. Delphi is designed exclusively for use with questions that yield either rankings or quantitative estimates and the typical steps are applied as follows during this prioritisation exercise (Creating Minds, 2007):

1. Define the problem or topic to be voted for: This entails the compilation of the literature study checklist, the execution of interviews with role-players and experts to gather their needs and information regarding base data managed, and the processing of results to subsequently identify gaps (Table 4-1).
2. Present the problem to the team: Arrange a workshop with transport experts, present Table 4-1 to them and request a response by using a democratic voting system allowing seven votes per individual. Distribute a softcopy of the table to these role-players not able to attend the workshop.
3. Collate the responses: Take the responses and collate these into a single anonymous list (Table 4-3).
4. Distribute the collation to the team: Send the collation back out to everyone with the request to score each item on a given scale, typically one to five, where one is the lowest score and five the highest.
5. Repeat, as necessary: The process may now be repeated as many times as is deemed appropriate if you are seeking consensus and there was a wide range of responses. It was not necessary to repeat the process for this prioritisation exercise.
6. Analyse the scores: Count the results and calculate the rankings. The results of the prioritisation process are displayed in Table 4-4

Table 4-4: Prioritisation of information sharing needs

RANK	FOCUS AREA	ELEMENT	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)
1	Public transport operations	Modal Integration	N	Y
2		Accessible transport	N	Y
3		Non-motorised transport	N	Y
4		Tourism related transport	N	Y
5		Public transport security	N	Y
6	Traffic Operations	Travel demand management	N	Y
7	Traffic Management	Hazardous loads and Substances	Y	Y
8		Overload control facilities	Y	N
9	Infrastructure	Rail facilities	Y	Y
10		Rail network	Y	Y
11		Pedestrian and Cycle facilities	Y	Y
12		Land acquisition	Y	N
13	Land Use	Spatial framework	Y	Y
14		Land use characteristics	N	N
15		Corridors and nodes / Mixed land-use	Y	N
16		Monitoring and control	N	N
17		Environmental Planning	N	N
18	Public Transport Management Regulation and Control	Transport appeals	N	N
19	Freight transport	Freight operations	Y	N
20		Abnormal loads	Y	N

4.2 Prioritisation of functional solutions

4.2.1 Functional solution needs

Functional solutions are considered to be technologically advanced tools and systems assisting and enabling human resources to execute a specific task. The results obtained during the interviews listed both the focus areas and sub-elements for which no data was managed (inherently indicating that there will not be a system in place) as well as those where the data was managed without the presence of a system (hard copy or paper process). Refer to Table 4-3 for the list of functional solution gaps.

4.2.2 Functional solution prioritisation

Once a project reaches the phase of system development, prioritisation can be complicated by more than merely legislative constraints. Some constraints should also be considered to be more important than others and should therefore carry a greater weight when prioritisation takes place. For this reason the weighted average method is applied during the identification of system development priorities. The weighted average formula calculates an average that takes into account the proportional relevance of each component, rather than treating each component equally. The

following aspects were identified as having an impact on the decision to be made (the weight, as allocated by the author, is provided in the formula below the table):

Table 4-5: Prioritisation of information sharing needs

Variable Nr	Variable description
VAR1	Legal requirement
VAR2	Additional need
VAR3	No system in place / System not addressing current requirements
VAR4	Ranking obtained in data prioritisation
VAR5	More than one Government sphere involved as potential user
VAR6	Private sector / service provider users involved
VAR7	Total Number of users > 20
VAR8	Cost implications < R500K
VAR9	Possible to include GIS
VAR10	Business requirements determined

The formula designed to develop the prioritisation strategy is as follows:

$$Score = 10(VAR1) + 9(VAR2) + 6(VAR3) + 1/5(VAR4) + 4(VAR5) + 2(VAR6) + 1(VAR7) + 7(VAR\ 8) + 3(VAR9) + 8(VAR10)$$

The results of the weighted average method are provided in the Table 4-6 below.

Table 4-6: Prioritisation of information sharing needs

DATA RANK	FOCUS AREA	ELEMENT	DATA MANAGED (Y/N)	LEGAL REQUIREMENT (Y/N)	W.A VALUE
1	Public transport operations	Modal Integration	N	Y	3.1
2		Accessible transport	N	Y	2.9
3		Non-motorised transport	N	Y	3.3
4		Tourism related transport	N	Y	4.4
5		Public transport security	N	Y	3.9
				Sub-total	**17.6**
6	Traffic Operations	Travel demand management	N	Y	4.5
				Sub-total	**4.5**
7	Traffic Management	Hazardous loads and Substances	Y	Y	4.7
8		Overload control facilities	Y	N	5.0
				Sub-total	**9.7**
9	Infrastructure	Rail facilities	Y	Y	6.9
10		Rail network	Y	Y	7.3
11		Pedestrian and Cycle facilities	Y	Y	7.7
12		Land acquisition	Y	N	7.3
				Sub-total	**29.2**
13	Land Use	Spatial framework	Y	N	8.5
14		Land use characteristics	N	N	8.9
15		Corridors and nodes / Mixed land use	Y	N	9.3
16		Monitoring and control	N	N	9.7
17		Environmental Planning	N	N	10.1
				Sub-total	**46.4**
18	Public Transport Management Regulation and Control	Transport appeals	N	N	9.5
				Sub-total	**9.5**
19	Freight transport	Freight operations	Y	N	9.1
20		Abnormal loads	Y	N	9.5
				Sub-total	**18.6**

4.2.3 Top priority functional solution to be developed

The results obtained from the prioritisation exercises conducted for data and functional solutions scored the transport related the land-use focus area and its elements as the top priority. It is evident that no system, toolset or database is in place to address the need for capturing, updating and publishing information on land-use monitoring and management. The high-level business requirements for the integrated land-use and transport system, as submitted by the Sub-directorate Ribbon Development, are summarised as follows:

- Provide up-to-date information on applications for change in land-use,
- Enable capturing of key variables of new applications which impact on the road network,
- Provide key reports, including maps for time series data and location specific data,
- Provide automatic land-use suitability analysis to evaluate new applications,

- Provide intuitive user-friendly interfaces that would limit training and increase uptake,
- Ensure compliance to provincial standards on spatial data and software development,
- Ensure compliance to GPTRW datamodel standards and base tables, and
- Maximise accessibility and scalability for possible future enhancements and system integration.

The subsequent chapter focuses on the compilation of a functional requirements integrated system, to be developed for providing planning information for the integration of land-use and transport, on provincial and municipal government spheres. The development methodology and theories to be applied during design and development phases are selected, and the application of GIS in the envisaged system is motivated.

4.3 Synopsis

In summary, the following conclusions can be reached at this stage of the study:

The dataset needs and gaps analysis conducted in Chapter 4 complimented the argument reached in Chapter 3: that there is a need for an information system enabling the transport role-players in Gauteng province to capture and monitor related land-use and transport planning data. Furthermore, the development of a functional solution / system is also encouraged by the findings in Chapter 2, where relevant planning legislation was related.

CHAPTER 5

SYSTEM DEVELOPMENT METHODOLOGY AND RELATED PHILOSOPHIES AND PRACTICES

In this chapter, an investigation is conducted in order to select the appropriate methodology to be applied during the product development. An overview is provided of the traditional waterfall model, after which the more advanced incremental development model is discussed. Philosophies and tools considered to be beneficial and applicable to this project include in-depth interviews, User Centered Design (UCD), Participatory Geographical Information Systems (PGIS), Human Computer Interface (HCI), Geographical Information Systems (GIS), paper prototyping and System Usability Scale (SUS) testing. The application of each tool or practice in the system development methodology is discussed, after which the typical core content of a functional and a technical design is briefly reviewed, as closure to this chapter.

Summarised briefly:

- UCD is a philosophy. Relevant practices include PGIS, HCI, paper prototyping, SUS testing,
- Geographic Information Systems (GIS) is a technology, and
- In-depth interviewing is a method.

5.1 System design and development methodology

5.1.1 System development lifecycle

Lifecycle models, in summary, include the following (Riordan, 2004:146):

- Pure waterfall model: The classical system development model, consisting of discontinuous phases, allowing no overlaps between the phases,
- Spiral model: A risk-reduction oriented model that breaks a monolithic software project up into sub-projects, each addressing one or more major risks,
- Modified waterfall model: A model using the same phases as the pure waterfall, but is not done on a discontinuous basis, thus enabling the phases to overlap when needed,
- Evolutionary prototyping: Uses several iterations of requirement gathering and analysis, design and prototype development. The user analyses the result after each iteration and his/her feedback creates the next level of requirements and defines the next iteration,
- Staged delivery: The first phases cover the deliverables of the pure waterfall but the design is broken into deliverables stages for detailed design, coding, testing and deployment,
- Evolutionary delivery: Evolutionary delivery includes evolutionary prototyping and staged delivery,
- Design-to-schedule: A staged release model where the number of stages to be accomplished is not known at the onset of the project.

Life cycle models reviewed during the development of a methodology for this study include the pure waterfall model, the spiral model, and the incremental development or evolutionary prototyping model.

The majority of literature reviewed criticises the pure waterfall model as being too theoretical and rigid. In the author's own experience, this model is naïve, as it implies that each phase of the system design can be signed-off after completion, leaving no room to revisit the needs, should it be required. The waterfall model is also not considered suitable for rapid development projects.

A more flexible model is the spiral model, which is also a lifecycle model, but differs from the waterfall model in allowing revisions of the design after a first round of implementation. The more advanced and complex spiral model is known as incremental development. This methodology includes micro-level design, development, integration and testing. Each component of the system is therefore developed as a miniature system, independent of the bigger system development tasks, after which it is integrated with the relevant components it needs to interact and collaborate with.

As the primary topic of this study is software design and development with a final deliverable aimed at system installation, for which low-level user requirements need to be revised throughout the design and development phases, the model selected is the advanced spiral life cycle model, also known as the incremental development model.

The selected model can be summarised by the following steps (Khul, Business eSolutions, 2002):

a) Determine objectives, alternatives and constraints,
b) Identify and resolve risks,
c) Evaluate alternatives,
d) Develop the deliverables for that iteration and verify that they are correct,
e) Plan the next iteration, and
f) Commit to an approach for the next iteration.

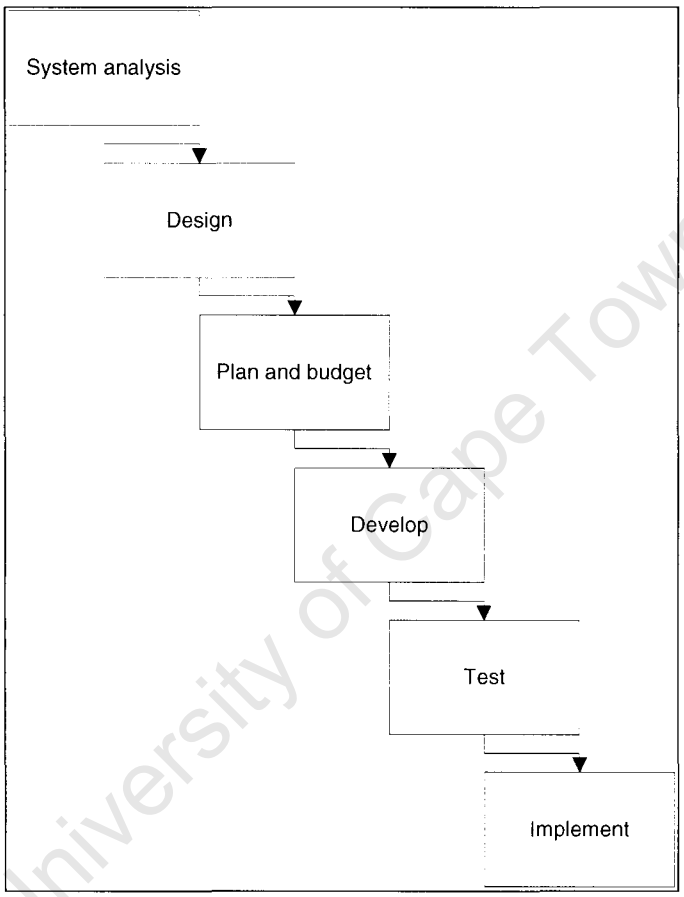

Figure 5-1: Traditional waterfall model

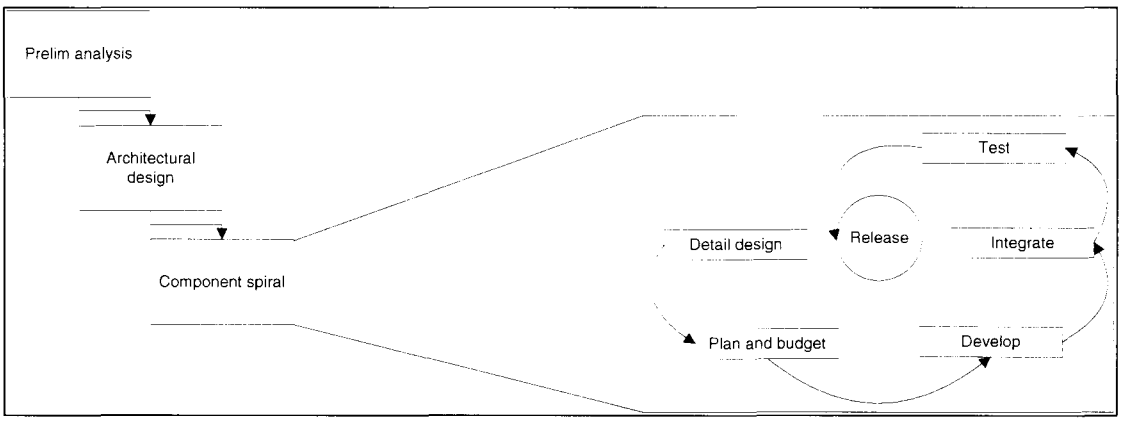

Figure 5-2: Incremental development model
Source: Riordan, 2004

Guidelines that drive the implementation and analysis include (Wikipedia, 2007):

- Any difficulty in design, coding and testing a modification should signal the need for redesign or re-coding,
- Modifications should fit easily into isolated and easy-to-find modules. If they do not, some re-design is needed,
- Modifications to tables should be especially easy to make. If any table modification is not quickly and easily done, re-design is indicated,
- Modifications should become easier to make as the iterations progress. If they are not, there is a basic problem such as a design flaw or a proliferation of patches,
- Patches should normally be allowed to exist for only one or two iterations. Patches may be necessary to avoid re-designing during an implementation phase,
- The existing implementation should be analyzed frequently, to determine how well it measures up to project goals,
- Program analysis facilities should be used whenever available, to aid in the analysis of partial implementations, and
- User reaction should be solicited and analyzed for indications of deficiencies in the current implementation.

5.1.2 In-depth Interviews

Background

The in-depth interview methodology is a qualitative method carried out when face-to-face discussions are held with a target audience to investigate a specific issue or to understand a factual problem.

Envisaged application

In-depth interviews will take place during the analysis, design, testing and review stages:

Interviews are arranged with relevant experts in the land-use and transport fields of study as well as with potential system users. Interviews are planned for three stages of this research:

- With experts, during the business requirements and status quo analysis,
- With future system users, during the design of the system, to obtain input for the detailed design of the solution, and
- With system users and experts, during the evaluation and validation of the system, to obtain feedback on the effectiveness of the solution.

Results obtained from the first series of interviews will feed into the first stage of the product development methodology, namely the development of the business requirements as part of the preliminary analysis. The second series of interviews will provide input into the functional design addressed during the component spirals' detail design tasks and the third series of interviews will form part of the last task of the component spirals, namely the testing and review stage.

The majority of interviews are conducted within Gauteng Department of Public Transport, Roads and Works (GPTRW). Other experts consulted with, are from

district and metropolitan municipalities, Johannesburg Roads Agency (JRA), rail organisations and other provincial departments.

Refer to Figure 5-3 below for the envisaged application of the in-depth interview method as part of the system development methodology.

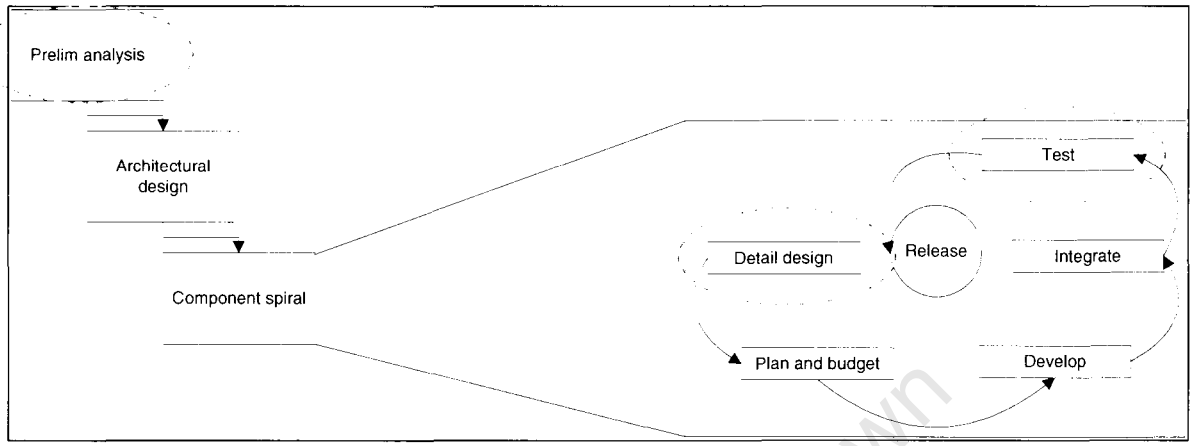

Figure 5-3: Application of in-depth interview method

5.1.3 User-Centred Design

Overview

User Centered Design (UCD) is a modern design philosophy and procedure, where the user's needs and limitations form the main focus of the design process. It is widely practiced and the users, designers and technical teams work closely together to address all requirements. The testing procedures followed in the UCD approach cater for the validity of assumptions made by the designers when predicting user behaviour. One of the most important principles of UCD, and the essence of the philosophy, is that the system is designed to cater for the user's needs and work scenario rather than forcing the users to change their working habits to accommodate the system or function (Katz-Haas, 1998).

Greenbaum and Kyng (1991:4) identified four issues for design:

- Designers need to seriously consider work practice, and be attentive to their own restricted understanding of the work situation, where work is done as an evolving and evolved solution to a complex set of circumstances,
- Designers should realise that they are dealing with human actors and that the systems need to focus on users' concerns: users should be treated as people, rather than as the mere performers of functions in a clearly defined work role,
- Work tasks must be seen within their context and considered situated actions, whose meaning and effectiveness cannot be evaluated in isolation from the context, and
- Work should be recognized as being fundamentally social, involving extensive cooperation and communication.

Application

The following UCD principles will be applied to the design phase of this project:
- Users need to be involved from the beginning of the project,
- Designers and developers will get to know (most of) the users,
- User tasks and goals will be analysed, and
- Usability will be tested

The following UCD design tools and methods will be applied during this study:
- Participatory design and PGIS,
- Design for Human Computer Interaction (HCI),
- Paper prototyping, and
- SUS testing and usability testing.

5.1.4 Participatory design and GIS combined

Overview

Participatory design entails that end-users are encouraged to cooperate with researchers and developers during the design process. This practice is the result of a spontaneous consolidation of Participatory Learning and Action (PLA) methods with Geographic Information Technologies and Systems (GIT&S). The Open Forum on PGIS & T indicates that proper PGIS practice is flexible, adaptable and empowers the users or community to take part in spatial data related activities.

GIS allows for the display of data in various advantageous ways, including tables, maps and graphs, empowering users and decision makers to make informed and effective decisions by clearly relating data to location. By displaying information in layers, GIS makes it easier for the users to understand how issues interrelate (Local Government Commission, Sacramento, 2004)

Application of PGIS

Participatory Geographic Information Systems (PGIS) will be applied during the design stage of the components:

End-users will be consulted with in the detailed design processes and iterations of each system map, in order for them to provide input to influence the envisaged designs and their daily service delivery in a positive manner.

PGIS will be applied to the preliminary analysis phase as well as during each map's component spiral for detail design and testing phases. Refer to Figure 5-4.

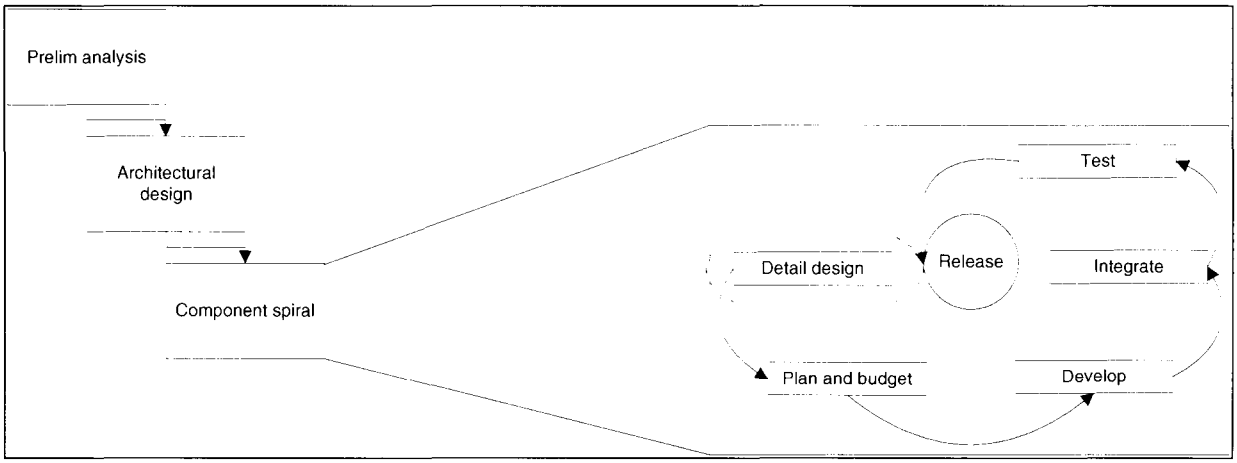

Figure 5-4: Application of PGIS

The participation of users can be measured according to the following indicators (T. Erickson, Participatory Design Conference, Apple Computer, 1994):

- Directness of interaction with the designers,
- Length of involvement in the design process,
- Scope of participation in the overall system being designed, and
- Degree of control over the design decisions.

5.1.5 Human Computer Interaction

Overview

Human Computer Interface (HCI) is a practice used to apply UCD design philosophies. Chapter 6 will provide feedback on the SWOT analysis (listing Strengths, Weaknesses, Opportunities and Threats) to be conducted on the envisaged environment. At this early stage of the project, it is already evident that high staff turnover and the anticipated (low) average skills level of users can be considered to be the major threats. This finding motivates the decision that HCI principles be applied during system design, so that sound interaction between the user and the tool is ensured.

Modern HCI practices focus on the user needs rather than wrapping user experience around a completed system. Users, designers and developers interact closely when designing the interfaces.

To ensure the optimization of HCI, the design must take into consideration the physical and mental characteristics of the users, such as the end users' needs, skills, and habits (Egenhofer, 1995, quoted by Wang), as well as other factors related to the work tasks, system functionalities, and the physical environment. As pointed out by Wang (2002:5) the challenge for GIS designers is to understand the relevant human factors and develop procedures for optimizing HCI in GIS in terms of a user-centered and task-based model.

HCI application

HCI as principle will be applied during the Design and Development stages of the system components (refer to Figure 5-5 below):

HCI is a broad concept and can be included as part of most designs where technology plays a major role, including in the design of a web-based information system, as is the case with this project. Since the late 1980s, the HCI of GIS has been overwhelmed by interfaces characterised by Windows, Icons, Menus, and Pointers (WIMP) (Egenhofer & Kuhn, 1999, quoted by Wang). Therefore, it is imperative that the memory load of GIS users be reduced.

The following HCI principles will form part of the design (Wang, 2002):

- Ensure that the design provides the optimum user-friendly and easy-to-use maps to address typical GIS user issues, e.g.
  - Memory limitation
  - Communication habits
- Design a clear and understandable map navigation tool bar
  - When interacting with GIS through such visual interfaces, the user(s) directly manipulates the GIS commands or receives help directly from the interfaces. The users would not need to memorize as many commands and parameters as they would through the command line interface. The visual interfaces give the user(s) many clues and help on how to use GIS commands, by means of visual aids, such as graphics, menus, icons, and pointers.

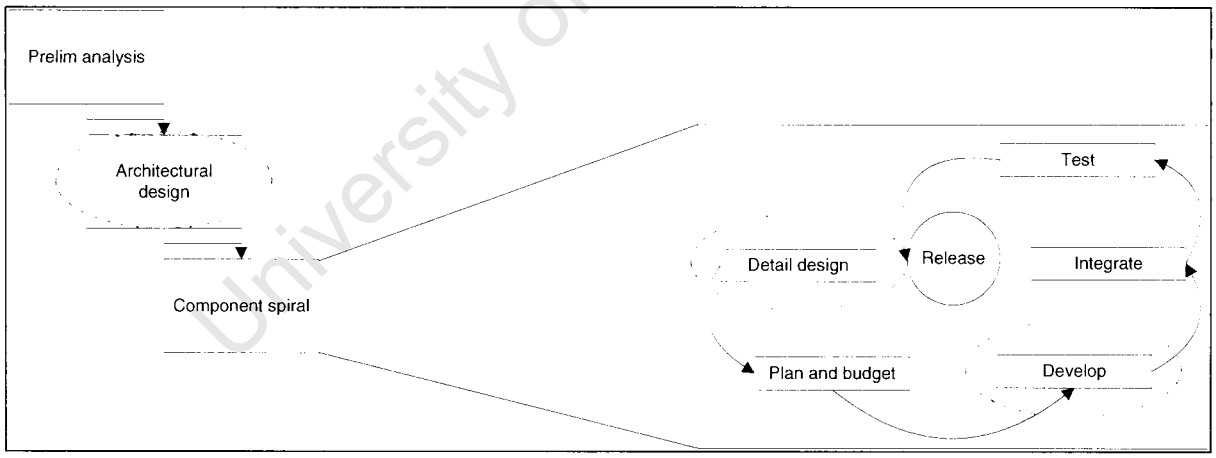

Figure 5-5: Application of HCI

5.1.6 Paper prototyping

Overview

Paper prototyping is a variation of usability testing, where representative users perform realistic tasks by interacting with a paper version of the interface. Some paper prototypes are hand-drawn, while others use printed-out screen shots. The interface is controlled by a person performing the role of the computer who does not explain how the interface is intended to work.

Paper prototyping can be used for testing almost any type of human-computer interface software, web sites, hand-held devices, or even hardware. The purpose of this basic exercise is to elicit quick feedback from users while the design is still on the drawing board and can be adjusted with relatively little effort.

The following exemplifies the typical results of a paper prototyping exercise (Snyder, 2003):

- Usability issues: Confusing concepts, poor terminology, layout problems, lack of feedback,
- Missing or miss-specified functional requirements: Users often have needs that the development team is not aware of, or the team may have a mistaken assumption about what functionality will satisfy a user requirement,
- Preference for a design alternative: There is, mostly, a multiplicity of ways to provide a function, but users may have a manifest preference for one way over another.
- Priorities: No company has unlimited resources and paper prototyping can assist greatly in separating the core requirements for the nice-to-haves, and
- Issues outside the user interface: A product is more than just a user interface. The brand and the company's reputation are important, as is the context in which the product will be used. Paper prototypes are often sufficiently realistic that they encourage test participants to extrapolate to real-world situations of use. Thus, they can uncover issues beyond the user interface.

Paper prototyping should be considered inappropriate when addressing the following design tasks or testing the following parameters:

- Technical feasibility,
- Download time or other response time,
- Scrolling, and
- Colours and fonts.

Application of paper prototyping

As indicated previously, paper prototyping is applicable during the design and testing / review stages of the system components.

During a design session, users receive draft functional screen design printouts. The facilitator encourages users to work through a typical workflow by making use of each screen in the process. Screens are modified by adding missing fields, removing unnecessary fields and adding buttons, links or other functionalities, as required. This process will be repeated for as many repetitions as are required to reach the final bug-free design.

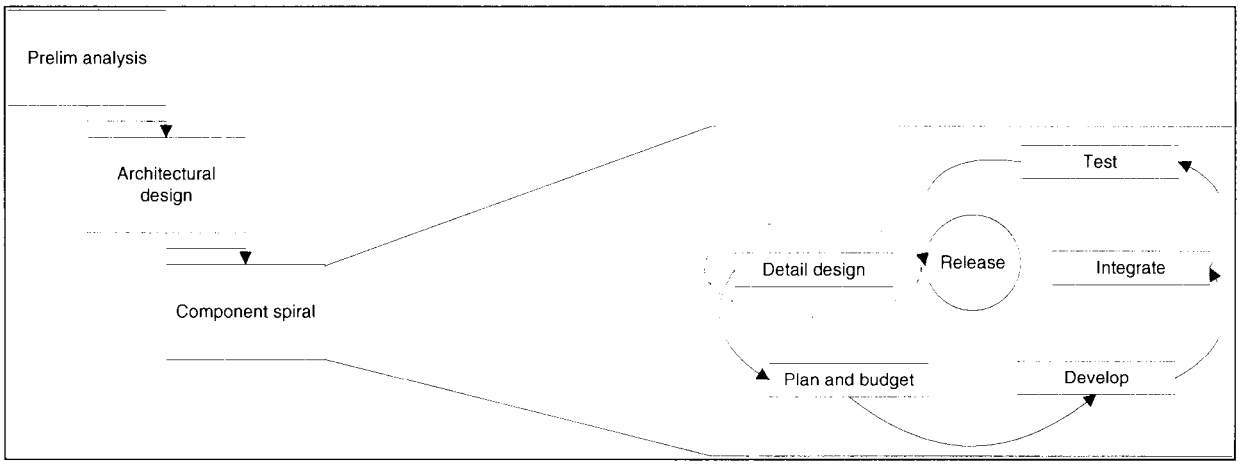

Figure 5-6: Application of paper prototyping

5.1.7 Usability testing

Overview

Usability testing is an iterative process, which needs to be conducted throughout the development cycle. Usability testing allows flexibility, and can be conducted either with elaborate equipment, or with more simple and affordable means, according to the budget. This method assures the designer and developer that the design meets the needs of the user to a great extent. One-on-one interviews, when customers are merely providing their opinions about a prototype, are sometimes incorrectly referred to as usability testing.

Assessment testing allows early feedback on potentially problematic issues that may be fixed with relative ease. This phase of testing usually takes place during the later phases of development (Graham, 2000).

According to Graham evaluation testing is applied in order to assess a site following its release. The site is normally measured against its peers.

Application

Usability testing will be applied during the testing and review stage of the component spirals. In addition to the paper prototyping, SUS testing will be applied during the component spiral as the final task before release.

5.1.8 GIS

Overview and perceived benefits

Geographical Information Systems (GIS) are computer-based systems for the management and analysis of spatial information. Since its advent, GIS have been broadly applied in diverse fields, such as business, academia, and government agencies. In pace with its own prodigious development, the technology has rapidly

gained widespread acceptance and has been thoroughly integrated in these fields. GIS have obvious advantages over outdated manual operations.

Government can benefit from a GIS in many ways. For instance, the application of GIS will enable the departmental users to view the data without requiring any significant knowledge regarding any software. The changing needs of government have shifted its perspective on GIS technology: once regarded as a niche application, GIS is now a necessity and a strategic component of any government's technological infrastructure. Envisaged benefits of the Gauteng Department of Public Transport, Roads and Works (GPTRW) are as follows:

GIS will enable the following in terms of reporting:

- Increased access to accurate and reliable data,
- The ability to report and compare from a common geographic base, and
- Dissemination of information in a fast, effective way that can carry multiple sets of information and still be absorbed by a quick glance at a map.

GIS will enable the following in terms of analysis:

- Identification of trends that would be invisible from conventional two-dimensional reporting,
- Enabling certain monitoring, analysis and prediction activities not easily achievable without spatial information. The results of this analysis provide information that is critical in making decisions to reach the departmental goals,
- Printing maps that can be used to aid in locating facilities and in forecasting, planning and budgeting,
- Providing a bird's eye view of areas for immediate action in terms of e.g. infrastructure maintenance management and marketing intelligence, and
- Serving as an information base for enhanced decision support, e.g. utilisation of facilities.

GIS will enable integration and information sharing:

- Provision of accurate information to more role-players, both internal and external to the organization,
- Provision of a data integration pathway. GIS has the ability to access and use data from many different sources,
- Reducing maintenance of software and data by channeling through one source, and
- Integration of information between units, in such a way that datasets can be correlated and effectively compared. There exists a real need to be able to integrate information from across the different business units quickly and reliably, and to be able to geo-reference the information.

GIS plays an important role in enabling better service delivery:

- Ability to view location of roads and transport facilities;
- Maintenance and administration of transport facilities is done more effectively,

- Improving service delivery through support of non-duplicated, client-focused and rationalized information systems, and
- Promoting the utilisation of technology as a key enabler in delivering information and services to enhance transformation of government service delivery.

Role of GIS in this project

GIS will play a major role in achieving the goals of this project. The application of GIS will initially form part of the PGIS design initiative, after which it will become the main development technology for the following components, sub-components and activities:

- Map component with base layers,
- Data capturing component,
- Standard, public transport and land-use assessment components,
- Monitoring component to enable trend analysis and strategic intervention in spatial and transport planning,
- Map production,
- Base data maintenance, and
- Integration with existing systems

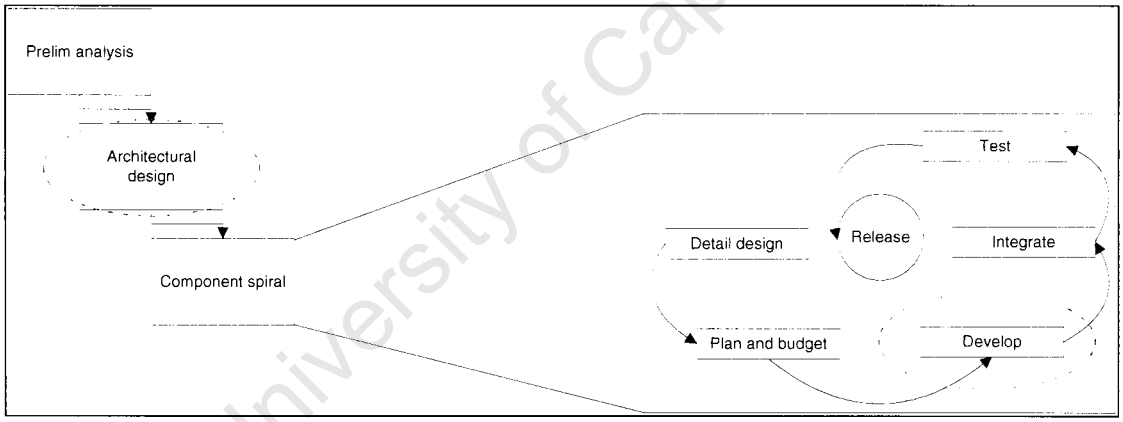

Figure 5-7: Application of GIS

5.2 Functional and technical design specifications

The content considered as key to the functional and technical design of this system is derived from the author's own interpretation and synthesis of templates developed by State Information Technology Agency (SITA) and AfriGIS.

5.2.1 Functional design framework

The functional design of a system should, as a minimum, include the following components:

- Scope: High-level explanation of what the system will do,

- Business Context: Overview of the business sponsoring the development, business mission statements, organisational objectives and goals,
- Functional Requirements: The user problem statement, the functions of the system, diagrams of high-level representation of system process
- System Context: An indication of whether the system will be self-contained or form part of a larger system with a description of the functions of the larger system and how it will interface (on a high-level) with the proposed system,
- User Characteristics: The number of users to the system, the characteristics of the users that will affect functionality (e.g. their Level of computer literacy, Technical expertise), as well as the frequency with which the system will be used.
- Assumptions: Describe the assumptions made i.t.o. hardware, software, components.
- Detailed Requirements (from the user's perspective): Functional, Performance, Design constraints, Non-functional requirements, Group requirements in functional areas (related functionality). Each requires that information regarding the following be provided: full description, process, criticality, technical issues involved, as well as algorithms, techniques, inputs, outputs, etc.
- Implementation: Integration of remote users, if applicable,
- Performance Requirements: Including speed, memory, etc, all of which must be measurable,
- Design Constraints: Including the constraints imposed, other standards, the industry protocols, hardware and customer requirements, and
- Data Specification: Including attribute data, information regarding the nature of the descriptive information required by the system, as well as spatial information requirements.

5.2.2 Technical design framework

The technical design of a system should, as a minimum requirement, include the following components:

- Hardware configuration, including the minimum specifications for processors, memory and storage for user machines, the web server and the database server,
- Software requirements, including the operating systems, development language and framework, database and map engines,
- Database design, in the form of an Entity Relationship Diagram (ERD) listing all tables, fields and data specifications as well as relationships between database tables. Integration with other systems and datasets should be clearly indicated in the ERD,
- Backups: Specifications for backups will be determined by business requirements. The source code needs to be archived after implementation. Regular backups of the database, once the system is operational, are of utmost importance and these backup tapes and disks should preferably be stored off-site. Regular testing of the backups is done by restoring the database to a SQL server (not involved in running the system), where all tables are checked to ensure that data is intact. Testing of data integrity is also done by pointing the system to the imported database and testing all system functionality,

- Site layout: This section describes the physical site layout of the system in terms of Active Server Pages (ASPX) files. In addition to the site layout diagram, a short description of each ASPX file and its parameters should also be provided,
- Test specifications: This addresses the test framework, test plans, test design specifications and test case specifications. The test plans and test specifications are an integral part of the planning and control processes,
- Test framework: Identify the hardware and software required to support the testing activities. In addition, identify and define the testing tools and the support required from computer operations during the testing period,
- Test plans: State the approach, tasks and methods to be used in the evaluation of the ability of the system to satisfy the goals and objectives of the design, and
- Each test design specification should include:
  - a test identifier,
  - features to be tested,
  - feature-requirements cross-reference,
  - a testing approach,
  - pass/fail criteria,
  - test procedure, and
  - expected test results.

This chapter discussed the system methodology selected for the project, as well as the philosophies and tools considered to be beneficial and applicable to each stage of the project. Chapter 6 will focus on the application of these theories during the functional and technical design of the system.

CHAPTER 6

BUSINESS REQUIREMENTS AND SWOT ANALYSIS

Chapter 4 discussed the prioritisation results for data sharing and system development, from which it became evident that a functional solution is required to equip the Sub-directorate Ribbon Development with the protection of the Strategic Major Road Network (SMRN). This will alleviate the burden carried by the sub-directorate in their daily assessment if applications for change in land-use.

This chapter expands on the business requirements driving the functionality of the envisaged system. A web-based GIS is recommended as a suitable tool to assist the officials. Another primary benefit of this system will be the monitoring functionality, which allows for strategic evaluation and intervention in the transport and spatial planning in the study area. Legislation to be reviewed as part of the business requirement analysis includes the Promotion of Access to Information Act (PAIA, Act 2 of 2000, National Constitution), Gauteng Planning and Development Act (GPDA, Act 3 of 2003, DPLG) and Gauteng Transport Infrastructure Act (GTIA, Act 8 of 2001, GPTRW). Furthermore, the Gauteng Provincial Land Transport Framework (PLTF, GPTRW, 2002), the Gauteng Spatial Development Framework (SDF Phase III, GPTRW, 2002), the Gauteng Strategic Public Transport Network (SPTN, GPTRW, 2003) and the Gauteng Strategic Major Road Network (SMRN, GPTRW, 1994) will be considered, as these constitute primary frameworks guiding the preparation of base data. An analysis is conducted of the environment in which the GIS tool will be deployed, listing Strengths, Weaknesses, Opportunities and Threats (SWOT) involved.

6.1 Business requirements

6.1.1 Interviews

The purpose of the first series of structured interviews with experts and future users were two-fold: firstly, it was performed in order to provide input for the status quo analysis and, secondly, it enabled the compilation of a list of high-level business requirements.

Status quo processes and procedures

The status quo processes and procedures involved in the daily responsibilities of the Ribbon Development Sub-directorate are presented by the workflow diagram in Figure 6-1. Immediate conclusions reached from the status quo map include the following:

- Documentation is prepared and filed in hardcopy format in all cases,
- All activities are manual,
- No tools used during assessment are computer-based,
- No capacity or tool exists to perform assessment of the public transport and land-use aspects of the application, and
- No capacity or tool exists to monitor development trends or to affect strategic intervention in the land-use and transport planning fraternity.

High-level requirements

High-level system requirements for a typical land-use management and monitoring tool, identified by key experts and future system users, include the following features:

- Provide up-to-date information on applications for change in land-use,
- Enable identification and capturing of key variables of new applications which impact on the road network,
- Provide key reports, including maps for time series data and location-specific data,
- Provide an automatic land-use suitability analysis to evaluate new applications,
- Provide intuitive user-friendly interfaces that would limit the amount of necessary training and increase uptake,
- Ensure compliance to provincial standards on spatial data and software development,
- Ensure compliance to datamodel standards and base tables, and
- Maximise accessibility and scalability for possible future enhancements and system integration.

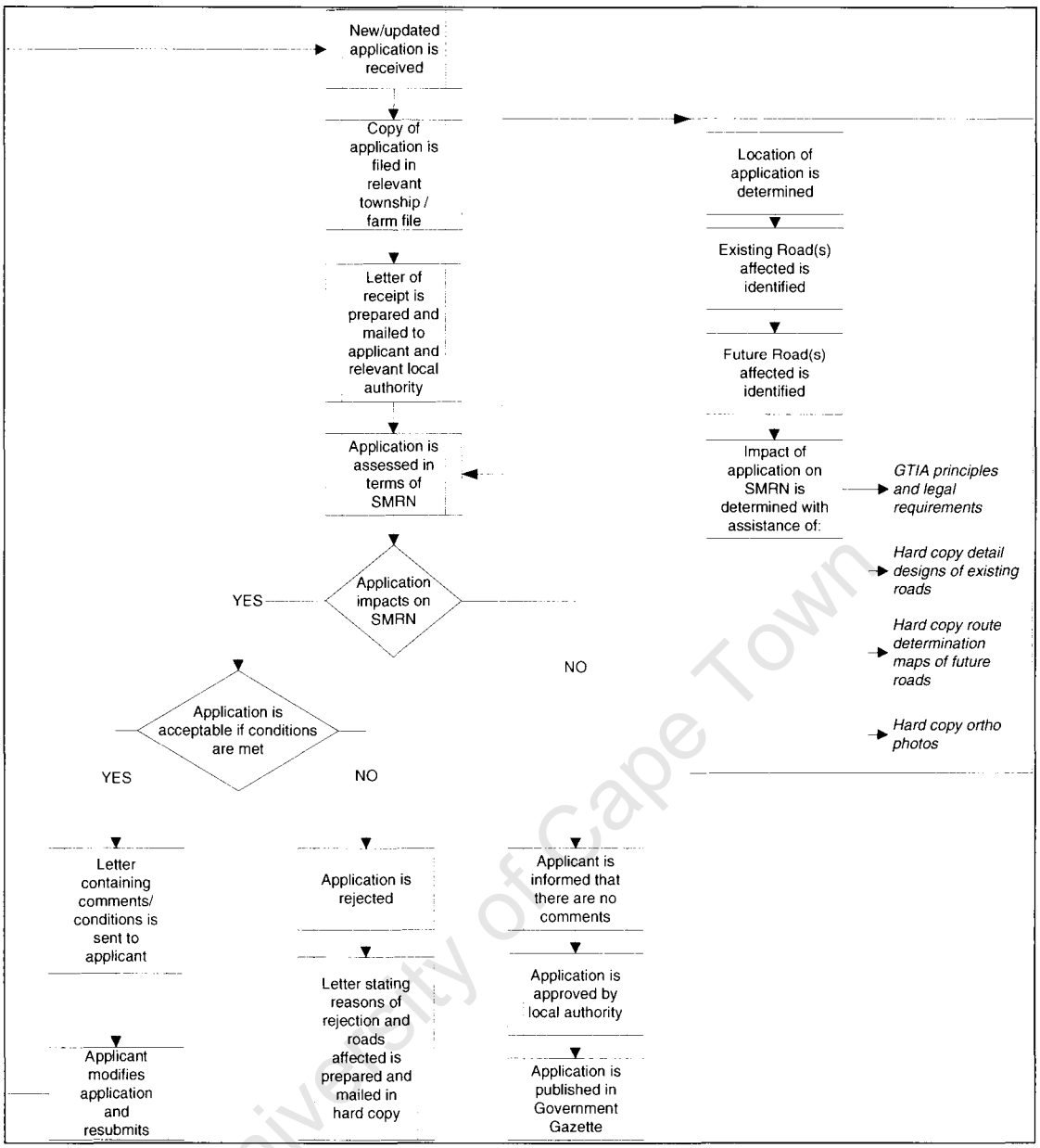

Figure 6-1: Status quo processes

6.1.2 Gauteng Transport Infrastructure Act

The Gauteng Transport Infrastructure Act (GTIA, Act 8 of 2001, GPTRW) stipulates the prescribed procedures to follow in matters concerning:

- Part 1: Introductory provisions,
- Part 2: Route determination and the preliminary design of provincial roads and railway lines,
- Part 3: Proclamation of provincial roads and railway lines, expropriation and compensation,
- Part 4: Activities in relation to transport infrastructure,
- Part 5: Powers and duties of the MEC, and
- Part 6: General provisions.

Previous chapters identified and provided motivation for determining the focus area for which a system should be developed. Part 4 of the GTIA (GPTRW, 2001), mentioned above, is applicable when determining the business requirements for the system. The following sections in particular are relevant in this regard:

- Section 38: Closing of Provincial Roads on application,
- Section 39: Gates and fences,
- Section 40: Leading of water,
- Section 41: Disposal of storm water,
- Section 42: Connection of roads and paths with provincial roads,
- Section 43: Access to and exits from provincial roads and railway lines,
- Section 44: Advertising on or visible from provincial roads and railway lines,
- Section 45: Disused vehicles and refuse on or near provincial roads and railway lines,
- Section 46: Structures and other works on, over or below provincial roads, railway lines or certain other land,
- Section 47: Trading on provincial roads or railway lines or in building restriction areas,
- Section 48: MEC's approval necessary for the establishment of certain townships and the division of certain land, and
- Section 49: Mining operations on or under provincial roads, railway lines or building restriction areas.

According to Section 38 of the GTIA (GPTRW, 2001), the Ribbon Development Sub-directorate should assess the applications for change in land-use and, within the space of 30 days, motivate in writing, whether or not they are in favour of the proposal.

The following abstract of the GTIA (GPTRW, 2001) stipulates the mandate of Gauteng Department of Public Transport, Roads and Works (GPTRW). I quote extensively:

"(10) The MEC may make regulations limiting the uses to which land in building restriction areas or land adjacent to provincial roads in urban areas may be put, where the MEC is of the opinion that such uses will –

(a) pose a danger to traffic on a provincial road;

(b) increase the traffic on a provincial road beyond its capacity; or

(c) frustrate any of the objects of this Act.

(11) Regulations under subsection (10) may provide that contravention thereof or failure to comply therewith shall be an offence.

(12) This section shall be in addition to, and not in substitution, of other laws relating to division of land or township development.

(13) A person who is aggrieved by a decision of the MEC in terms of this section may appeal in the prescribed manner and on payment of the prescribed fee to the Townships Board."

6.1.3 The Promotion of Access to Information Act

The Promotion of Access to Information Act (PAIA, Act No. 2 of 2000, National Constitution) is the national legislation, which was enacted to give effect to the

constitutional right of access to information. PAIA came into operation on 9 March 2001, with the exception of sections 10, 14, 15 and 51, which came into operation on 15 February 2002. Section 32(1)(a) of the Constitution of the Republic of South Africa Act, No. 108 of 1996 provides that everyone has a right of access to any information held by the state and any information held by another person that is required for the exercise or protection of any rights.

The Promotion of Access to Information Act (Act No. 2 of 2000) includes the following parts and chapters:

- Part 1: Introductory provisions,
- Part 2: Access to records of public bodies,
    - Chapter 1: Right of access and specific application provisions
    - Chapter 2: Publication and availability of certain records
    - Chapter 3: Manner of access
    - Chapter 4: Grounds for refusal of access to records
    - Chapter 5: Third party notifications and intervention
- Part 3: Access to records of private bodies,
- Part 4: Appeals against decisions,
    - Chapter 1: Internal appeals against decisions of information officers of certain public bodies
    - Chapter 2: Applications to court
- Part 5: Human Rights Commission,
- Part 6: Transitional arrangements, and
- Part 7: General provisions.

PAIA interprets the following as the objectives, which the Act seeks to achieve:

- To ensure that government takes part in promoting a human rights culture and social justice,
- To encourage openness and to establish voluntary and mandatory mechanisms which give effect to the right of access to information in as prompt, economical and easy a manner as rationally possible, and
- To promote lucidity, accountability and the effective governance of all public and private bodies, by empowering and educating everyone to understand their rights in terms of PAIA. This will enable people to exercise their rights in relation to public and private bodies, to understand the functions and operation of public bodies, and to effectively scrutinise, and participate in the decision-making of public bodies that affect their rights,

The following specific sections of the Act provide input into the business requirements of the Sub-directorate under discussion:

- "Section 2.2.2 Public bodies. All public bodies must have information manuals in terms of section 14 of PAIA, to assist you on how to request access to records of public bodies", and
- "Section 3.1 Manner of request. A requester has a right of access to a record of a public body or a private body and must be given access to a record of a public body or private body if the requester complies with the following procedural requirements: That the request is made on the request form to the information officer of the public Body"

6.1.4 Gauteng Provincial Land Transport Framework

Section 4.3 of the 2003 - 2008 Provincial Land Transport Framework for Gauteng (GPLTF) relates methods by which opposition to land-use planning can be minimised. The future considerations and short- and medium-terms actions are quoted as follows:

- "Bearing in mind that the integration of transport and land-use is clearly a legal requirement, the objective of such integration is to promote harmonious development, to achieve this it is necessary to create practical and workable mechanisms to ensure that applications for developments are assessed by transport planning authorities for compatibility with the ITP", and
- "Procedural guidelines will have to be developed by the Transportation Coordination Committee (TCC) in anticipation of the structures to be established following the enactment and coming into operation of the national and provincial land-use management legislation. Until such time as the new systems are in place it will be expected from present core cities to scrutinise land-use amendment applications and to refer them to the Gauteng MEC for Public Transport, Roads and Works for consideration and decision, in collaboration with the MEC for Development Planning and Local Government where appropriate. This must be done in terms of the Urban Transport Act and other existing legislation. "

6.1.5 Gauteng Planning and Development Act

The purpose of the Gauteng Planning and Development Act (GPDA, Act 3 of 2003, GDPLG) is to achieve the following:

- Provide for a single system of development, planning and land management in the Province,
- Set out principles for planning and development in the Province,
- Establish planning bodies and provide for appeals to the Appeal Tribunal,
- Create a framework for the preparation of development plans and frameworks,
- Provide for the creation of zoning schemes,
- Create unified procedures for development applications,
- Provide for the repeal of legislation and transitional measures,
- Provide for general matters such as enforcement procedures, and
- Provide for matters connected therewith.

The content of the Act is organised in the following manner:

- Chapter 1: Definitions
- Chapter 2: Principles for development
- Chapter 3: Development implementation bodies
- Chapter 4: Development plans
- Chapter 5: Zoning schemes
- Chapter 6: Development procedures
- Chapter 7: General provisions

The applicable sections providing primary input into the business requirements of the Sub-directorate Ribbon Development, amount to the following:

Implications for the applicant

According to section 61 of GPDA (GDPLG, 2003), a development application may propose one or more of the following projects:

- to establish a township,
- to extend the boundaries of a township,
- to establish a settlement,
- to subdivide land,
- to simultaneously consolidate and subdivide land,
- to amend the provisions of a zoning scheme in respect of land,
- to amend, suspend or remove a restrictive condition, servitude or reservation registered against the title deed or leasehold title of land,
- to amend conditions for the establishment of any township,
- to obtain the consent or approval of the municipality for any purpose provided for in a zoning scheme or in a condition of a development approval by a planning body or a condition of establishment of a township, unless otherwise prescribed,
- to close and alienate any public place, including roads,
- to limit the manner or purpose for which a public place, including a road is used,
- to deal with any matter for which an application was required in terms of any repealed legislation dealing with planning and development in the Province, or
- any other application prescribed.

According to section 62 of GPDA, the following is relevant for an applicant with regards to development procedure:

- A development application contemplated in section 61 must be lodged with the municipal manager of the municipality concerned,
- When a development application is lodged, the municipal manager should acknowledge receipt thereof, and
- After receipt of an application has been acknowledged, the municipal manager should register the application and notify the applicant thereof, as prescribed.

Implications for GPTRW and the municipality

The following legal requirements have relevance for GPTRW and the concerned municipality:

- According to section 62 of GPDA, the acknowledgement of the receipt of the application must be communicated to the applicant, as stated above,
- According to section 49 of GPDA, GPTRW must, within 56 days after publication of the notice of the draft zoning scheme, object or make representations in writing to the municipality concerned, in respect of the provisions of the draft scheme,
- According to section 45 of GPDA, the zoning scheme shall be administered and enforced by the municipality and be binding on all persons including all organs of state, and
- According to section 62 of GPDA, where a municipal manager refuses to register an application he or she shall, within fourteen days of it being lodged, return the application to the applicant and specify, in writing, the registration requirements that had not been complied with.

6.1.6 Synopsis

Table 6-1 briefly categorises the benefits GPTRW Sub-directorate Ribbon Development will derive from the implementation of a custom Geographic Information System (GIS) tool, which meets their business requirements.

Table 6-1: Summary of perceived benefits to be obtained from implementation of GIS tool

Benefit	Benefit Description
Process automation	GPTRW will be able to take advantage of available technology to automate relevant project based processes and procedures.
Process integration	The solution will accommodate the integration of different relevant project processes thereby improving the integrity of the information.
Process simplicity	Integration will lead to the processes being simplified with associated time, cost and quality benefits.
Communication speed	The communication speed will improve significantly, especially for management and executive information.
Information relevance	Users will be able to specify and obtain information relevant to their requirements
Information quality	The reduction of work effort and duplication in processes and data will lead to information that is more accurate.
Strategic planning	Users will be able to obtain statistical information for analysis and planning purposes far more easily than is currently possible. The link between spatial and attribute data will make analyses and interpretation of data much easier.

6.2 GPTRW policies and strategies influencing design

Frameworks and policies with a major influence on the design, content and base data of the GIS tool are discussed in this section of the chapter.

6.2.1 Gauteng Spatial Development Framework

The Gauteng Spatial Development Framework (GSDF, GPTRW, 2002) Phase III is intended to guide decisions relating to the location and nature of physical development in Gauteng. The historical inadequacies of the settlement pattern, coupled with increasing urbanisation pressures, result in the need for spatial guidelines that will direct development towards a more efficient, effective and equitable settlement pattern. The GSDF provides these guidelines by means of a spatial framework that represents, at a provincial level, the principles contained in Chapter 1 of the Development Facilitation Act (DFA). The above implies that the GSDF provides an indication of the most desirable settlement pattern for Gauteng. This is achieved by means of the following:

- An indication of where growth and development should and should not occur,
- An indication of the most desirable form and nature of future growth and development, and

– An indication of areas requiring public/provincial intervention to direct actions towards altering historically problematic settlement issues, and defining the way forward for the province.

Essentially, the role of the GSDF is two-pronged. Firstly, it provides information regarding the current state of the province, and secondly, it puts forward certain planning proposals, which should direct development at a provincial level. The second aspect, being the main focus of the process, requires implementation on provincial, metropolitan and local sphere levels. The GSDF Phase III is a follow-up and refinement of Phase II. While Phase II provided a broad conceptual development framework, Phase III has extended the analysis of Phase II, refined the contents and findings, and focused on five critical factors to determine the way forward. The result is a refined final plan, providing concrete proposals to structure the future growth path of Gauteng.

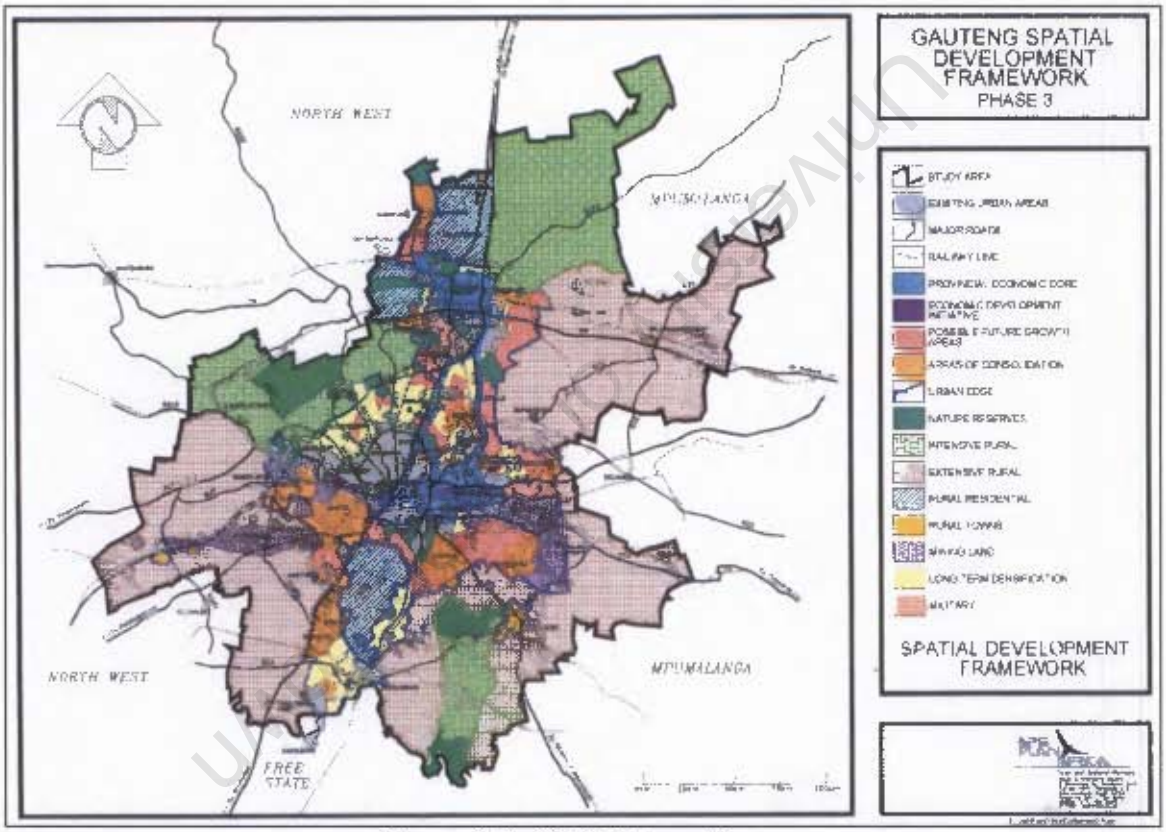

Figure 6-2: GSDF Phase III
Source: GPTRW, APS Plan Africa

6.2.2 Gauteng Strategic Public Transport Network

The proposed strategic public transport network for Gauteng Province comprises a network of road and rail infrastructures intended to function as a single, integrated system. In order to achieve the integration of different modes of transport it is essential to make provision for modal transfer facilities and park and ride facilities along the Gauteng Strategic Public Transport Network (GSPTN, GPTRW, 2003). There is a range of objectives potentially catered for by the GSPTN:

- In the first place, the GSPTN serves as a strategic framework for all public transport stakeholders in Gauteng Province to plan according to, so that public transport in the province is enhanced,
- It is also based on an overall public transport concept or vision for the Province, which indicates a network of public transport corridors, routes and areas where land-use development should be planned and managed in such a manner that it supports public transport services and operations. This development concept must be simple, easy to understand, and durable, and
- The GSPTN also provides the opportunity to expand in future, should the urban structure of the province expand.

All authorities and other stakeholders dealing with public transport decision-making and implementation in Gauteng Province should be able to use the GSPTN as a guideline. The pre-eminent principle guiding the GSPTN is the creation or structuring of the environment, so that the development of high density, mixed uses around the public transport network in Gauteng Province is promoted as far as possible: the objective is to increase the number of people within functional reach of the public transport service, and to provide as diverse a range of land-uses as possible around the public transport network. Refer to Figure 6-3 for the map indicating the GSPTN.

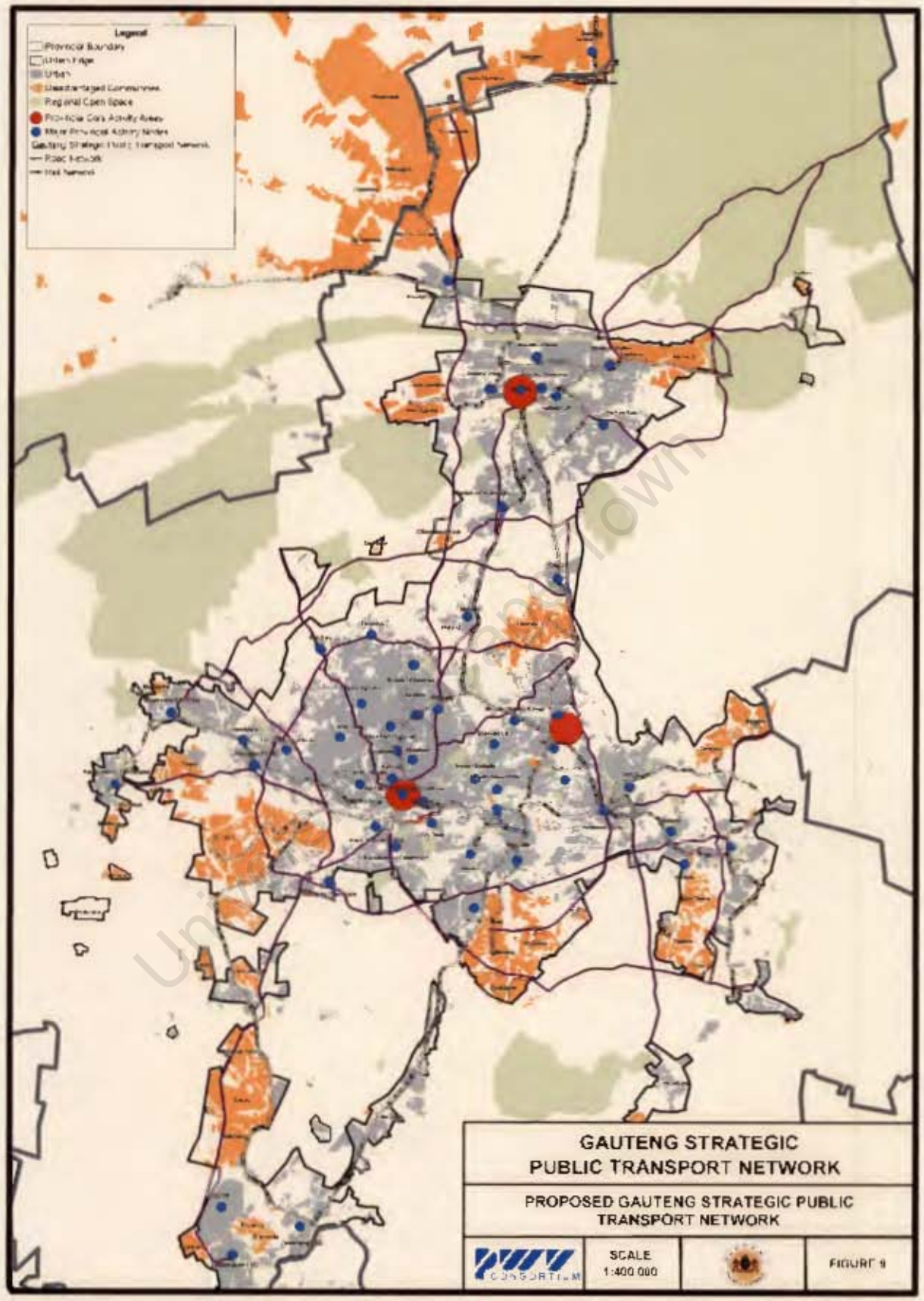

Figure 6-3: Gauteng Strategic Public Transport Network (GSPTN)

Source: GPTRW, PWV Consortium

6.2.3 Gauteng Integrated Spatial and Transport Framework

The main objective of the Gauteng Integrated Spatial and Transport Framework (GISTF, GPTRW, 2000) is to guide spatial and transport planning in Gauteng to achieve the focussed and simultaneous development of the urban structure and the transport network in such a manner that it would result in the integration of land-use and transport, and the improvement of the viability of public transport.

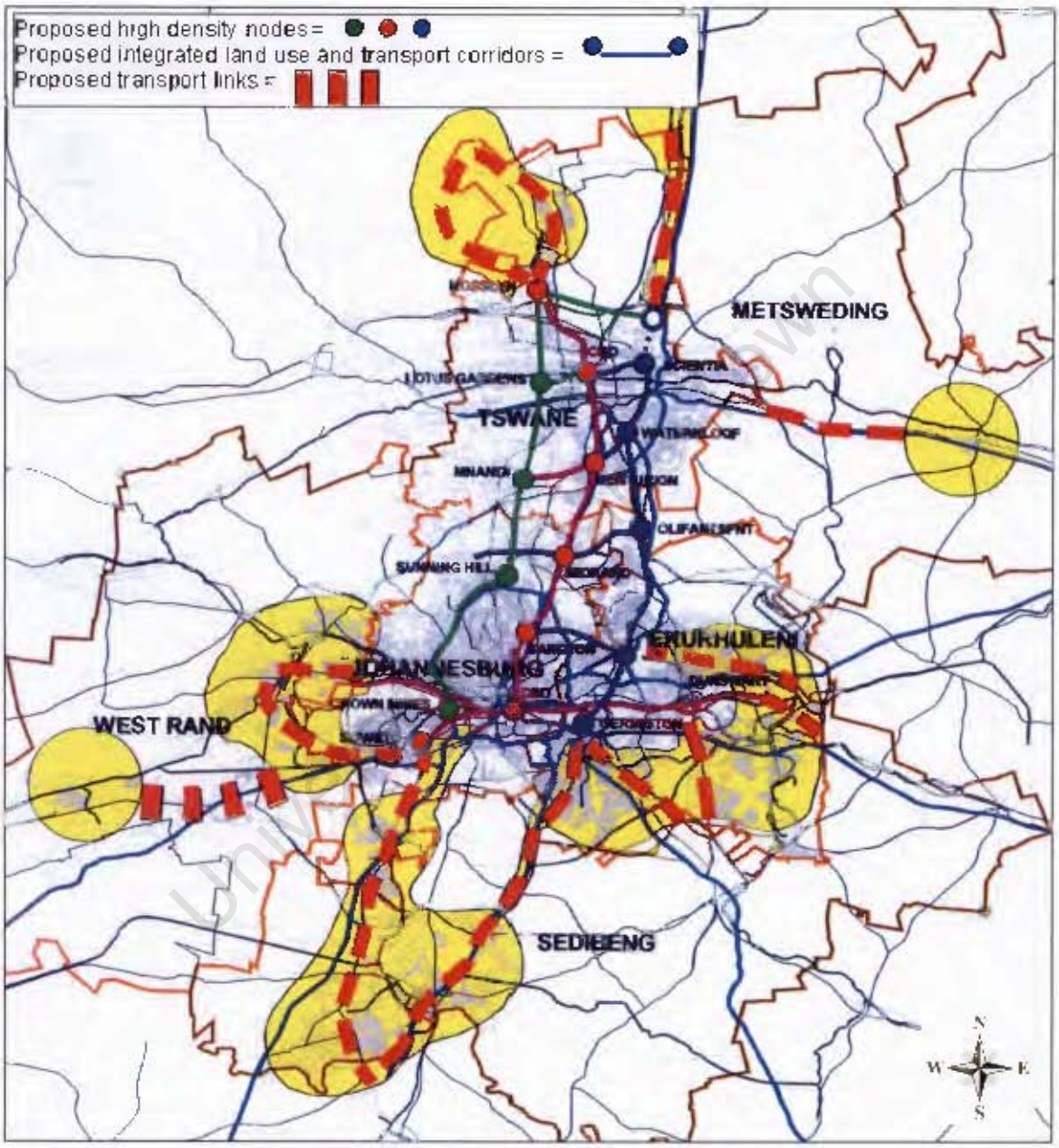

Fig 6-4: Map of the GISTF indicating, amongst other things, corridors.
Source: GPTRW

6.2.4 Gauteng Strategic Major Road Network

An ever-increasing demand for land for development, stimulated by high economic growth rates, has created tremendous pressure for Gauteng's planning authorities to

ensure orderly and integrated development. Consequently, there exists a pressing need for an adequate and holistically planned transport system and road network, will also serve as a framework for orderly long-term development. It should be noted that road-based public transport routes have always been part of the planning of the Gauteng Strategic Major Road Network (GSMRN, GPTRW, 1994).

The network has brought certainty to developers regarding the long-term intentions of GPTRW's road infrastructure development. The network has also eased GPTRW's planning burden with regards to ad-hoc or crisis management planning, to enable the authority to provide transportation services to various land-use development scenarios. As such, the network forms a key element in the overall transportation strategy of Gauteng.

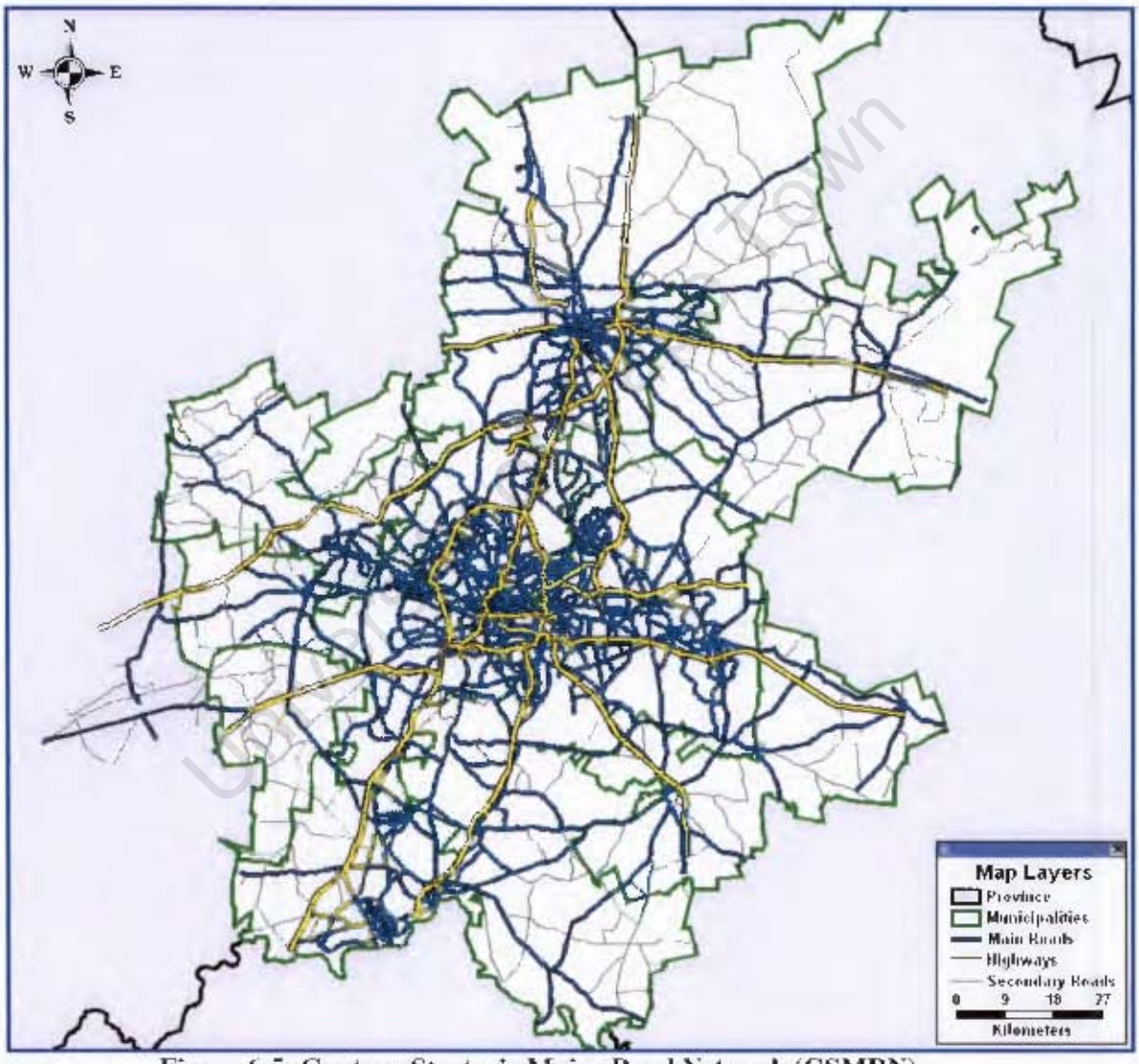

Figure 6-5: Gauteng Strategic Major Road Network (GSMRN)

The GSMRN has been supplemented by the development and application of sophisticated transportation demand models for all modes of travel, which enable the projection of future traffic movements on the road and rail networks and the testing of the effect of various land-use development scenarios. This has been a particularly valuable tool, assisting in a balanced approach to the provision of transport infrastructure.

In order to safeguard the GSMRN, it is important to ensure that the effects of overloaded vehicles on the transport infrastructure is minimised. Unless this is done, the network will deteriorate rapidly. Control is exercised not only not only by ensuring that vehicles comply with axle mass legislation, but also by ensuring that land-uses do not distort modal split towards heavier vehicles more than what is desirable.

It is envisaged that the implementation of the network will keep pace with travel demand, taking into consideration the major role that public transport will play and allowing, in this regard, for dedicated road-based infrastructure provisioning within identified road reserves. Road implementation planning has been based on transport modelling, finding substance in construction programmes that are regularly reviewed in terms of available funding. The future need for supporting rail-based public transport services has also been acknowledged, but strategic planning for this has not been done to the same degree as for road-based transport.

6.2.5 Synopsis

From section 6.2 it may be concluded that the following datasets play a major role in the strategic planning of transport and land-use, and need to form part of the map component of the system in order to enable the assessors to make informed decisions regarding the applications received for change in land-use:

- Gauteng Strategic Public Transport Network (GSPTN),
- Gauteng Spatial Development Framework (GSDF),
- Gauteng Integrated Spatial and Transport Framework (GISTF), and
- Gauteng Strategic Major Road Network (GSMRN).

6.3 SWOT analysis

Figure 6-6 represents the results of a basic SWOT analysis conducted on the environment in which it is foreseen that the integrated planning system will be implemented.

SWOT analysis is a straightforward tool for auditing an organization and its environment. It usually forms part of the first stage of planning or design and helps designers to focus on key issues. SWOT is an acronym for "Strengths", "Weaknesses", "Opportunities" and "Threats". Strengths and weaknesses are internal factors, whereas opportunities and threats refer to external factors. A disadvantage of the SWOT analysis is the fact that it is based on the opinion of the analyst and is therefore considered as being a subjective result.

The three major threats and weaknesses observed in the solution's anticipated environment are discussed in the following section.

6.3.1 Hardware and IT architecture

GPTRW Directorate Information Systems were responsible for centralising the department's major data repositories and web page servers during the past 12 months. Negative consequences arising from this centralisation exercise, included the following:

- The server specifications prepared before acquiring the new hardware did not take into account predictions for future growth and, immediately after setup of the spatial datasets and drawing and thermal images on the new environment, disk space already proved to be inadequate,
- Network and bandwidth capacity limitations reduced the performance of systems, a problem particularly experienced by remote users located at branch offices,
- Security settings and policies on the new servers were not planned or documented properly, which resulted in the occurrence of a number of map and database errors by various different levels of users,
- Roles and responsibilities regarding routine and ad-hoc maintenance activities were not confirmed between stakeholders, resulting in conflict and unnecessary reworking,
- Communication channels to ensure satisfactory support to users were not mapped, resulting in miscommunication between stakeholders, as well as confused and frustrated system users,
- Lack of data standards: In general there has been a lack of standards in terms of previous data collection exercises. This leads to different datasets that had been captured over a period of time being incompatible, because there is not a common reference framework. This deficiency has, however, been the topic of many discussions and is starting to receive the type of attention it deserves,
- Lack of data exchange policy and standards: Linking up to the point above, there has never been much attention given to standards for data exchange between organisations that would allow different datasets to be seamlessly or easily integrated and analysed, and
- Lack of Information Technology (IT) and GIS strategies: In general, there is a shortage of an overall IT and GIS or spatial information strategic frameworks within organisations. Thus, when a new dataset requires field surveys, it is not clear what format should be used, where the captured information will be stored, which other systems and datasets it relates to or influences and, finally, how the information is to be disseminated.

6.3.2 User skills

The future user of the envisaged integrated planning system will need at least average computer literacy skills and basic GIS knowledge. The current skills level of officials is not adequate and is considered a major risk for the successful deployment of the system. GPTRW developed a Skills Retention Strategy in 2005/2006 in order to address the skill-level issue and develop these skills in-house. Large proportions of the Human Resources (HR) budget were and are being dedicated to training and skills transfer. Service providers are also required to sign a contractual clause to include the formal training of selected officials as part of project deliverables for each contract awarded to them. The above-mentioned attempts to address skills transfer are only

partially successful, due to the high rate of staff turnover and frequent organisational restructuring.

Skilled resources, in terms of both the collection of the information to be shared and the implementation of the shared information, are scarce. It is deemed important that there be a least one resource within the organisation that will be allocated this responsibility

6.3.3 Organisational structure and staff turn-over

GPTRW and its underlying directorates have undergone a number of restructuring processes during the past 40 months. The average time it takes for a restructured organisational structure to be implemented, and all vacancies to be filled is estimated to be between 6 and 18 months. The impact of a restructuring on the continuity of planning, system development, enhancement and maintenance, maintenance of datasets and the training and capacity building of officials and systems users, is considered to be fruitless and unwanted. Restructuring is regarded as a major risk for the development and implementation of the envisaged integrated planning system, even more so due to the fact that the municipalities, which are considered to be future users of the system, could also undergo restructuring in an ad-hoc and unexpected fashion.

Chapter 6 expanded on the business requirements driving the functionality of the web-based GIS. Legislation reviewed as part of the business requirements analysis includes PAIA (National Constitution, 2000), GPDA (GDPLG, 2003) and GTIA (GPTRW, 2001). Furthermore, the GPLTF, the GSDF, the GSPTN and the GSMRN were identified as constituting primary frameworks to guide the preparation of base data. Chapter 7 will include the functional design of the envisaged solution.

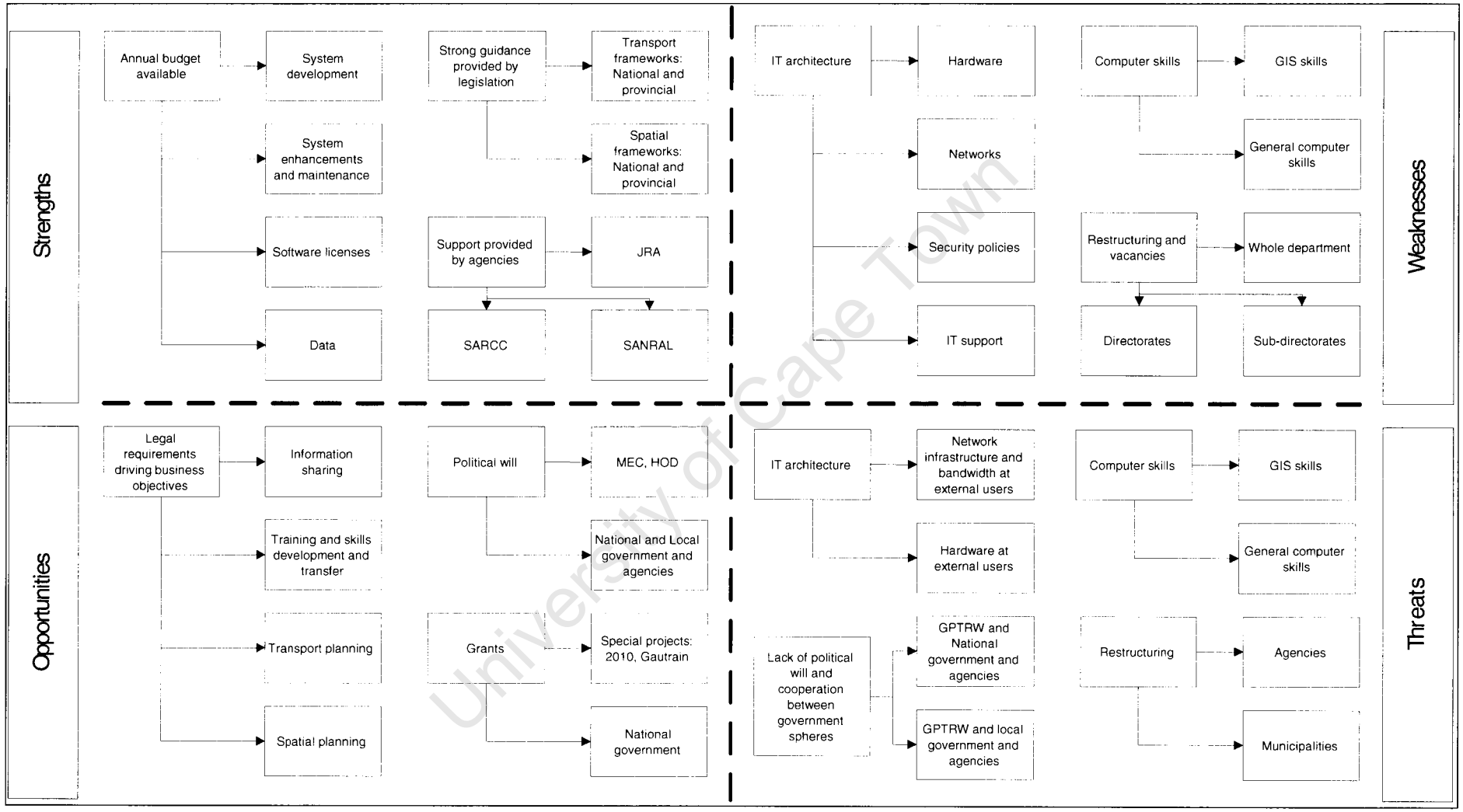

Figure 6-6: SWOT analysis

CHAPTER 7

FUNCTIONAL DESIGN OF THE IDEAL SYSTEM

The functional design of the ideal solution, a tool for capturing and assessing applications for change in land-use, is described in this chapter. As indicated previously, the anticipated tool will be based on a Geographic Information System (GIS) application, accommodating a graphical representation of existing and new land-use developments, and will be able to monitor development trends in numerous areas. Selected functional screen designs and process flow diagrams will be provided. These designs, serving as a basis for programming, will be developed in cooperation with the client and other role-players (including potential system users). The product life cycle model selected in Chapter 5, i.e. the incremental development model, will be applied to each component of the GIS solution. The results of the SWOT analysis obtained from Chapter 6 are taken into account when applying the User Centered Design (UCD) and participatory design principles. The chapter closes by providing a synopsis of GIS features and design details for integration with existing systems.

7.1 Component spirals

During the functional design phase, the system requirements are documented according to the business needs identified and the requirements highlighted by the literature review. The proposed functional design of the system is discussed with the client and documented in the functional specification document. The system will be designed and developed per component, according to the selected methodology, and by applying the incremental development principles. Main components include:

- System and user administration,
- Static and informative pages: Home page and notice board,
- Administrative tasks: Capturing of applications, look-up table maintenance, and notice board maintenance,
- Technical tasks: Standard assessment, Public Transport and Land-use assessment,
- Data maintenance, and
- Strategic monitoring and intervention.

Refer to Figure 7-1, below, for an indication of the principles applied to each component's spiral.

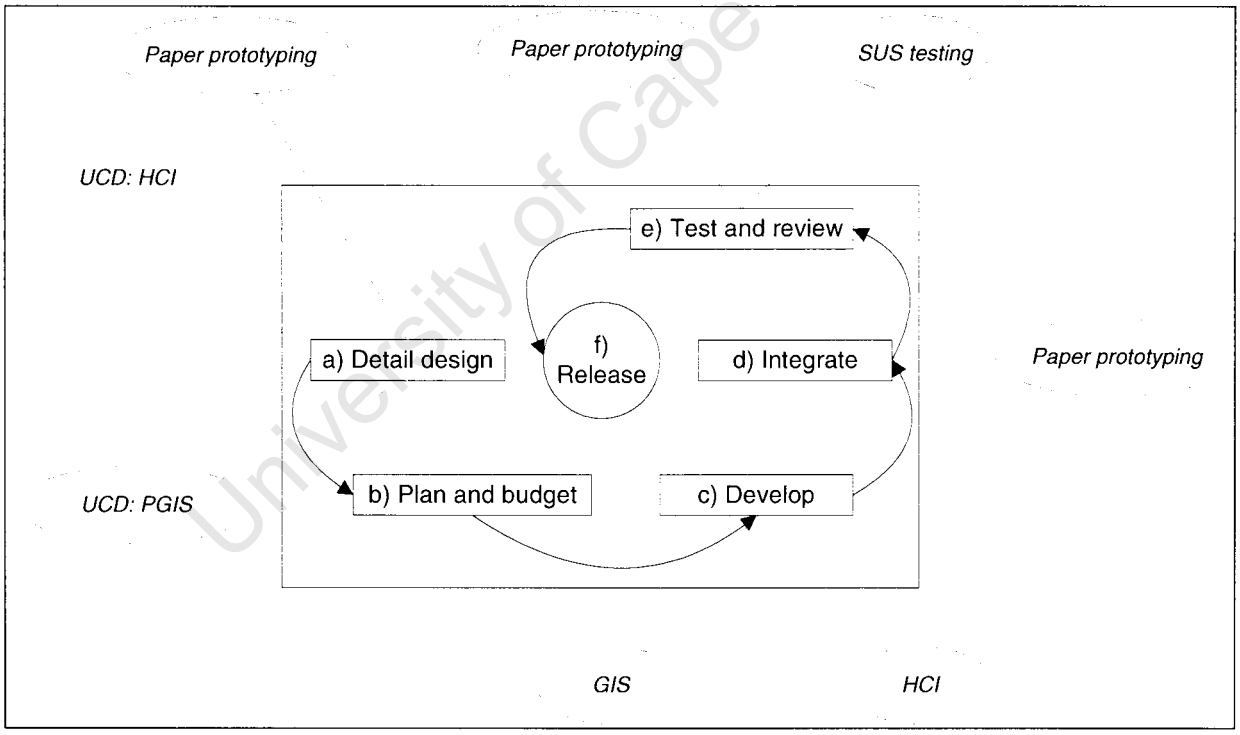

Figure 7-1: Design and development principles applied to component spirals

Due to the manifold revisions required for each system component, not all permutations will be documented in this chapter. Refer in this regard to Appendix B, which contains a compilation of the figures indicating the amendments made to each component.

7.2 System and user administration

7.2.1 Access control, user roles and security considerations

It is considered to be advantageous and relevant to use user groups and roles for the purpose of user administration. Roles are named groups of related privileges that are granted to users. Security administrators managing a database with many users, applications, or objects should take advantage of the benefits offered by roles, as they, to a great extent, simplify the task of privilege management in such complicated environments. The following user roles and privileges are relevant in this case:

- System administrator:
  - Create users,
  - Edit user roles / rights,
  - Remove users, and
  - View log history.
- Administrative user:
  - Maintain land-use type look-up table,
  - Maintain application type look-up table,
  - Maintain file number look-up table for all property types, including farms, townships and agricultural holdings,
  - Capture of applications,
  - Maintain notice board, and
  - Capture gazetted applications.
- Technical user:
  - Assess of applications in order to protect the Major Strategic Road Network (MSRN), including the capture of map locations,
  - Assess land-use and public transport matters of the applications in order to preserve the Strategic Public Transport Network (SPTN) and Gautrain, and
  - Conduct data maintenance: for instance the new townships layer, town planning schemes, spatial development frameworks, the Strategic Major Road Network (SMRN) and the SPTN.
- Municipal user and private town and regional planner users:
  - Log applications on system, and
  - Receive acknowledgement notices, standard and public transport assessment comments.
- Land-use and transport committee (LUTC) user
  - View location and type of applications,
  - View location of gazetted applications,
  - Compare development trends with municipal and provincial frameworks, including Provincial Land Transport Network (PLTF), Spatial Development Framework (SDF), Integrated Transport Plan (ITP) and Integrated Development Plan (IDP), and
  - Identify conflicts in transport and spatial planning and submit concerns to parties responsible for implementation and review of ITPs and IDPs per area.

7.2.2 Process flow and screen layout designs for user administration

As indicated above, the system administrator has the authority to create users, edit user roles and rights, remove users and view log history. After the user logs onto the system via the log-in page, the system categorises the user as belonging to one of the following types: system administrator, administrative user, technical user, municipal user or Land-use Transport Committee (LUTC) user. The system administrator maintains the username and password log-in table by adding records to the user administration table in the database, via the front-end provided. The e-mail address of the system administrator appears on the log-in page, in order for users to apply for usernames and passwords.

Figures 7-2 to 7-4 provide flow diagrams for system administration. Figure 7-5 provides a draft front-end for user administration, while Figures 7-6 to 7-8 indicate the design permutations that are executed before reaching a final user administration page.

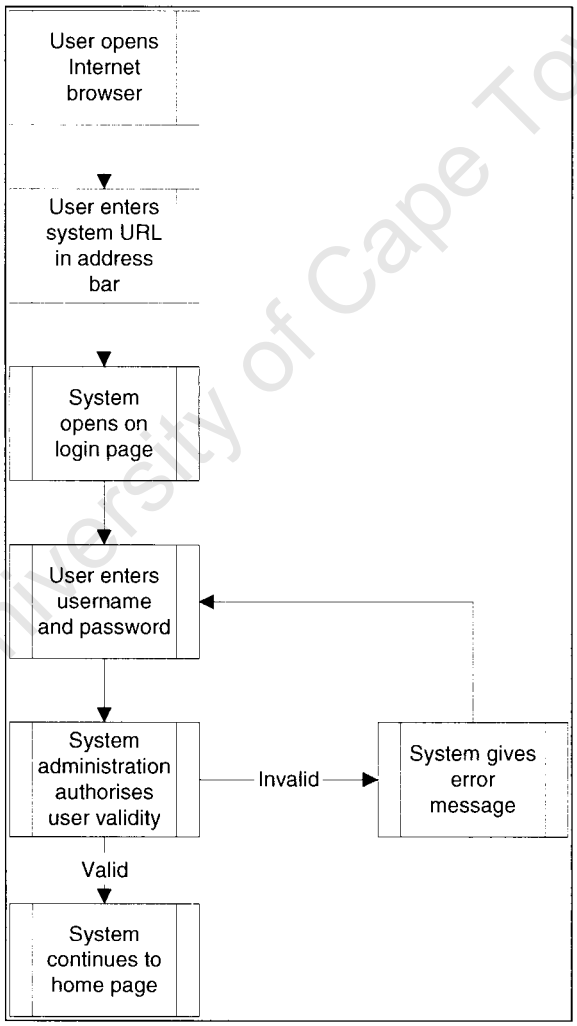

Figure 7-2: Log-in page process flow

The first page displayed after log-in is the home page. From the home page, via the menu structure appearing at the top of the page, the user is able to access any page he/she is authorised to view. Figure 7-3 describes the flow from the home page.

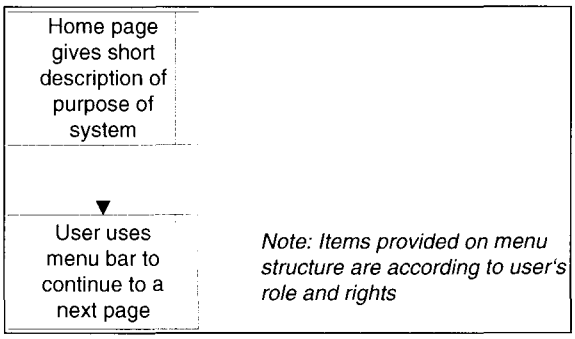

Figure 7-3: Home page process flow

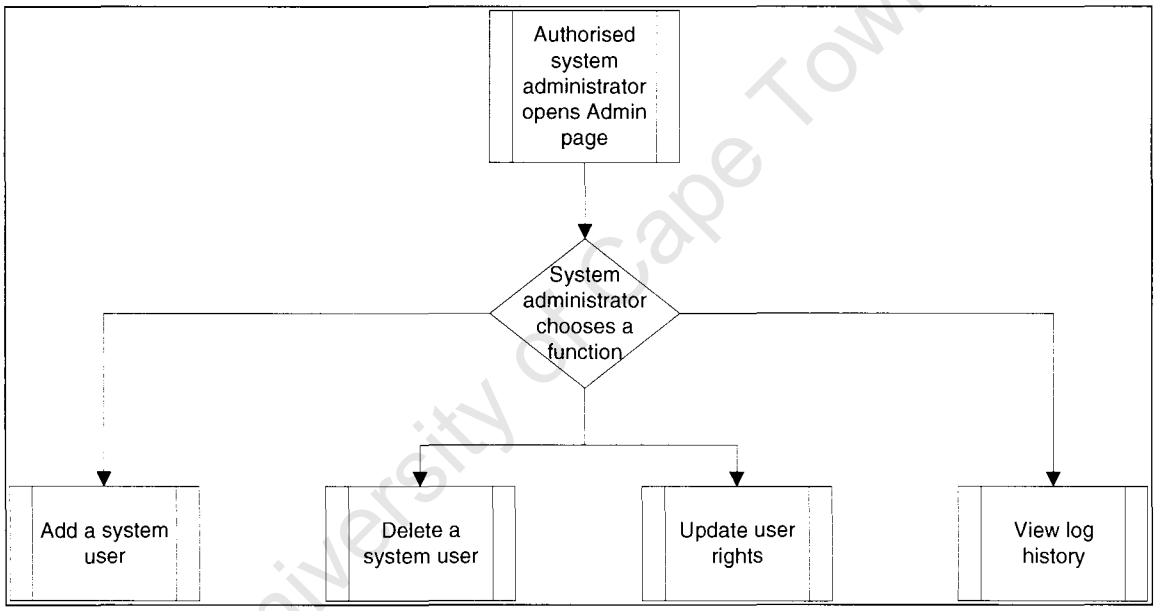

Figure 7-4: Administrator menu process flow

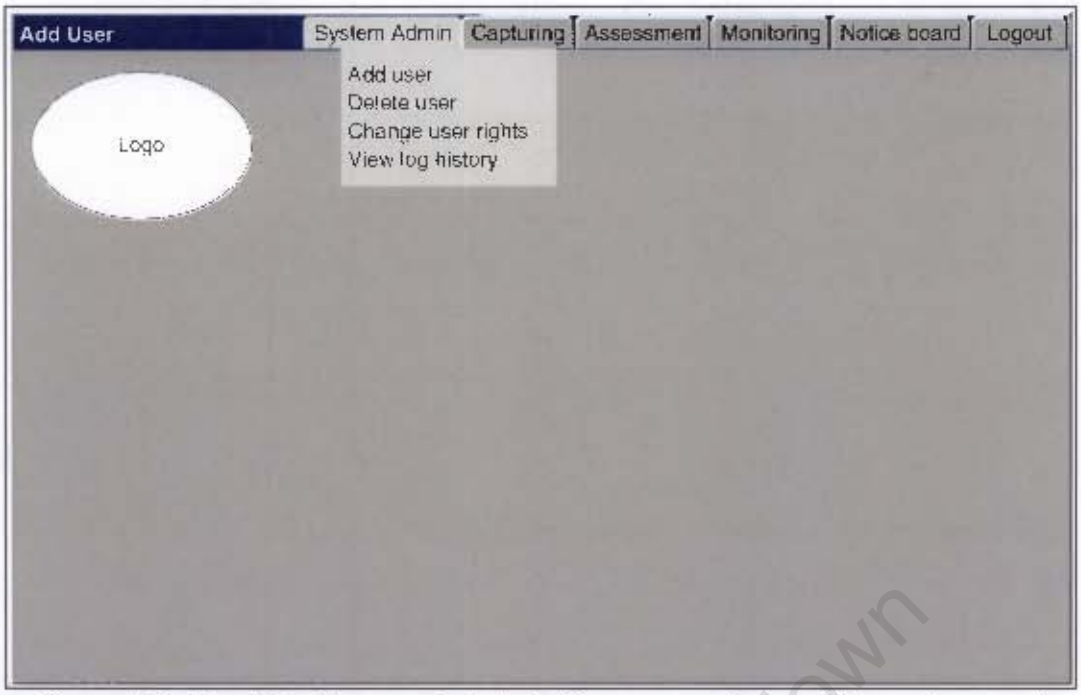

Figure 7-5: First draft user administration screen design (Menu structure)

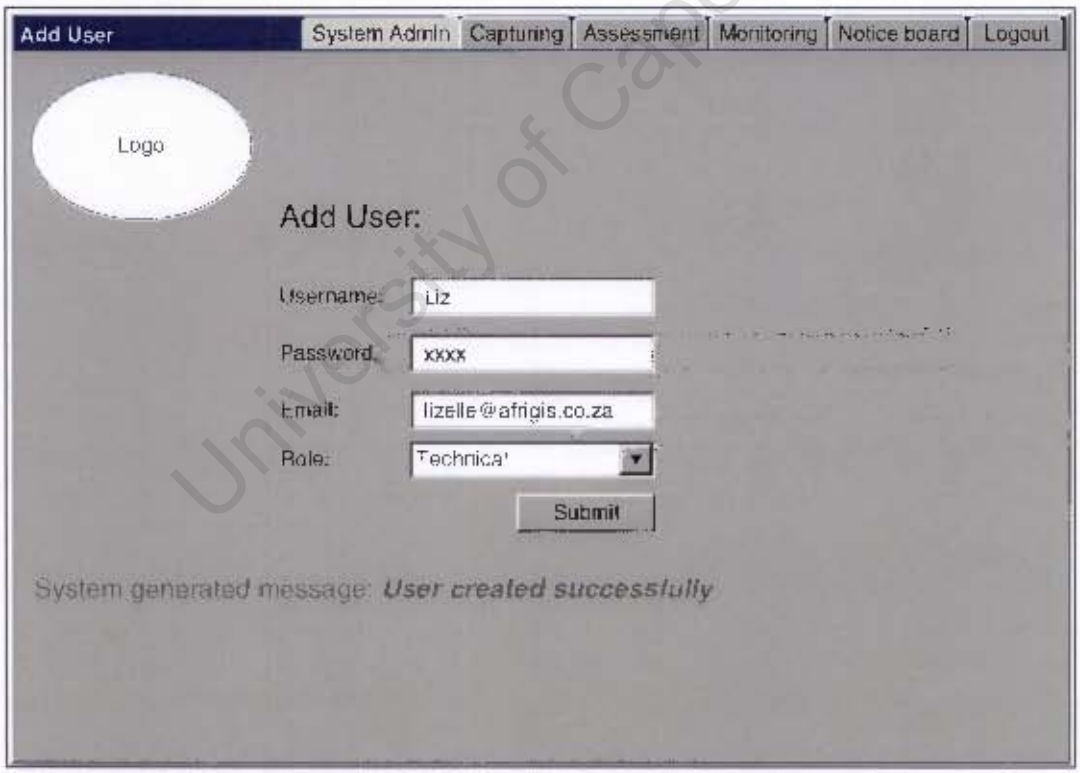

Figure 7-6: First draft user administration screen design (Add user)

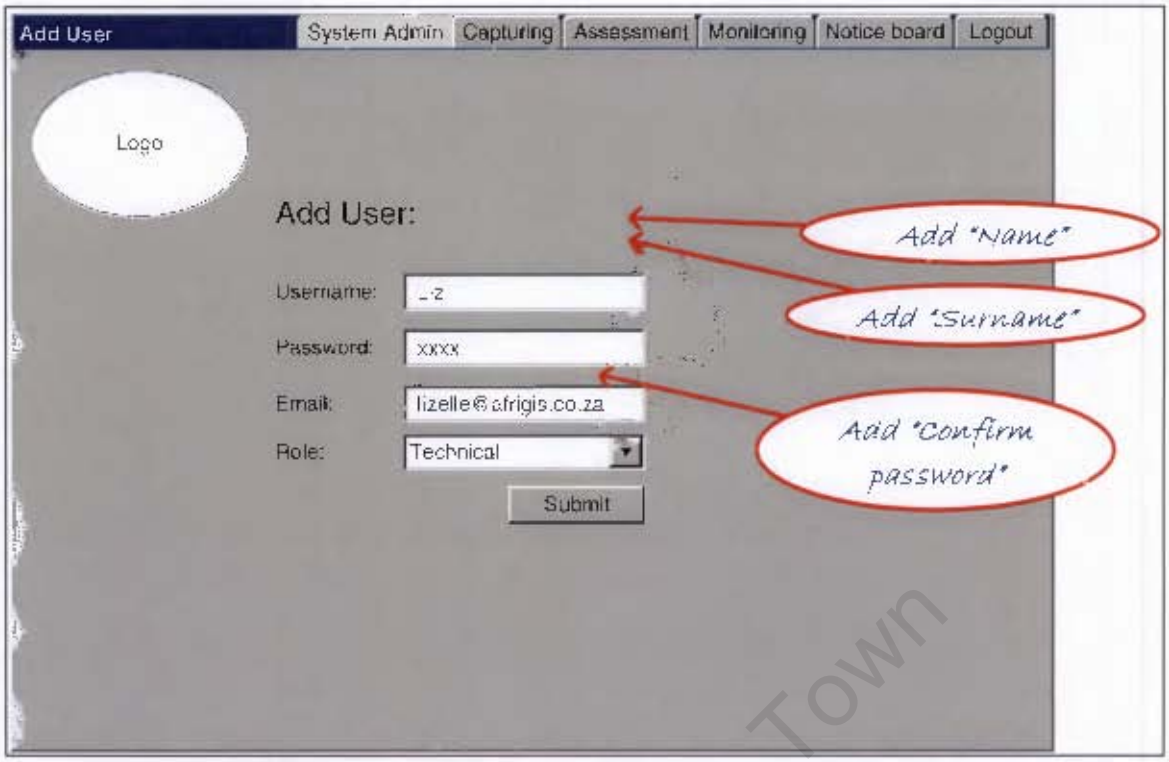

Figure 7-7: Paper prototyping applied to get user feedback

Figure 7-8: Final user administration screen design

7.3 Administrative tasks

The administrative user is responsible for the maintenance of the land-use type look-up table, the application type look-up table, the applicant look-up table, the file number look-up table for farms, townships and agricultural holdings, the capturing of applications, the maintenance of the notice board and the capturing of gazetted applications.

7.3.1 Capturing applications

The administrative user captures the general details of applications received by Gauteng Department of Public Transport, Roads and Works (GPTRW). This task also involves communicating acknowledgement of receipt to the applicant.

It is not compulsory that all fields on the capturing page be completed. The applicant look-up table is maintained, in order for a complete list with applicant details to be available. The user is able to add a new applicant to the table, regardless of whether the applicant's name appears on the list, or not. The status of the application will be determined by the system. A receipt letter to the applicant is generated from this page, according to the date the application was received by GPTRW. The departmental reference number is a system-generated attribute and includes the property description, file number and sequential number for the current financial year. The date stamped field indicates the commencement date of the allowed evaluation period. Different types of applications are necessarily allocated different evaluation periods. (Refer to the business requirements from the Gauteng Planning and Development Act (GPDA, GDPLG, 2003) in Chapter 6).

Refer to Figure 7-9 and Figure 7-10 below for the design permutations performed in order to arrive at the final design of the capturing page. Figure 7-11 provides the workflow involved in the utilisation of this system page.

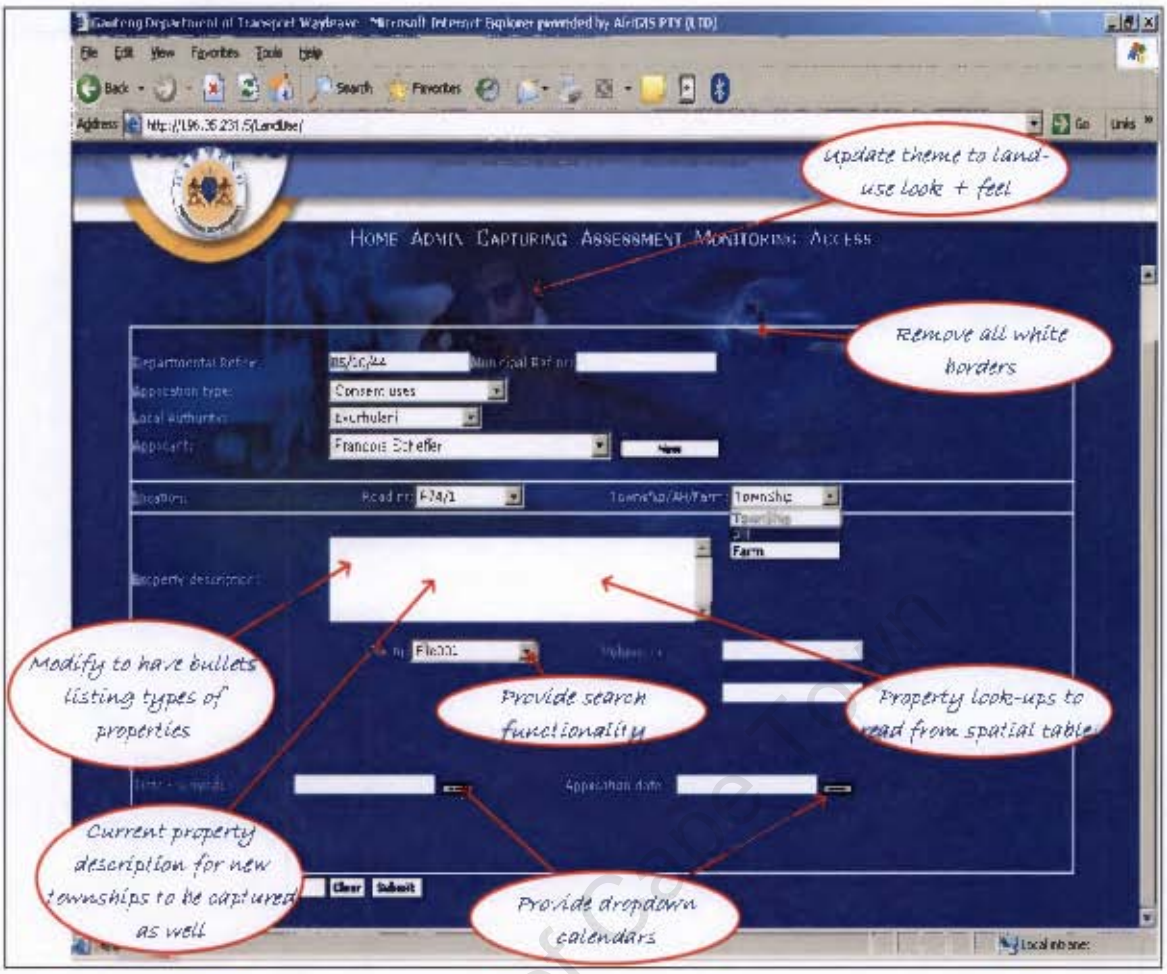

Figure 7-9: Paper prototyping applied to second draft page design for capturing applications

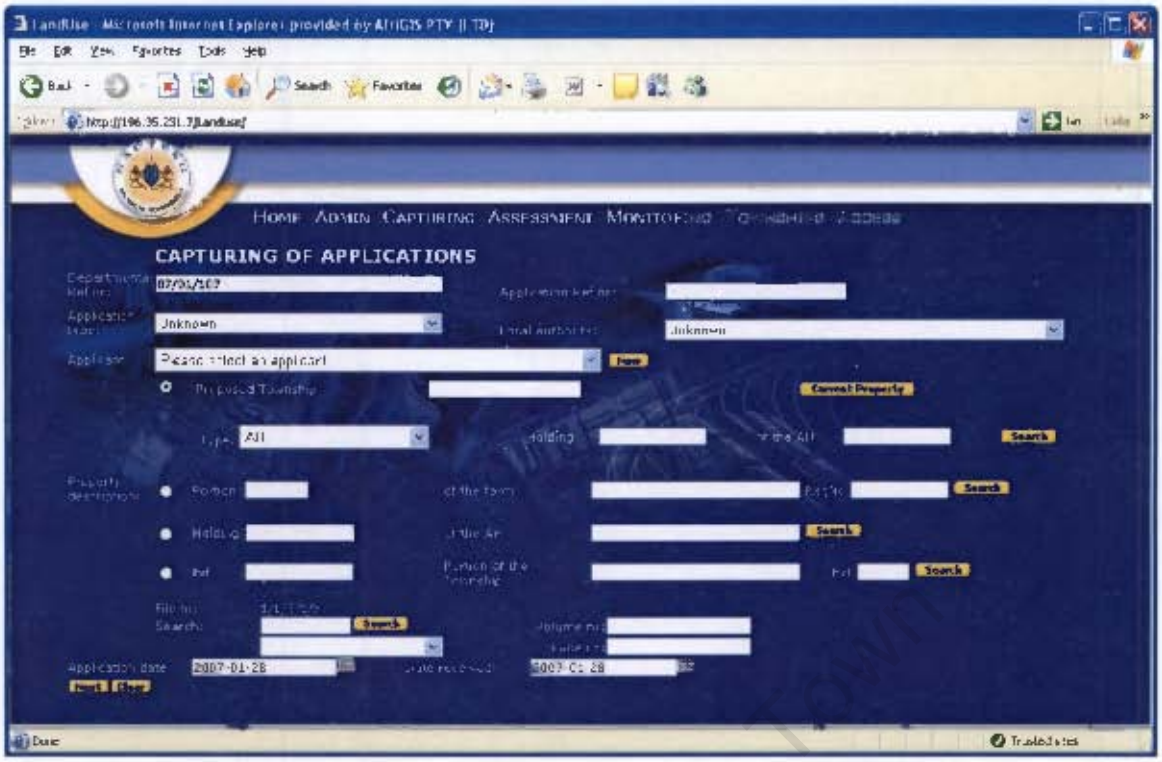

Figure 7-10: Final page design for capturing applications

Table 7-1 provides a list of standard application types included in the initial look-up table.

Table 7-1: Application types to be included in the initial database

Application type	Description
Township establishment	Creating an urban development on farmland
Rezoning/amendment scheme	Changing the zoning of a particular erf to permit different land-uses
Consent use application	Changing the land-use of an erf without changing the zoning
Subdivision/consolidation	Dividing the erf into smaller erven or joining them to create a larger erf
Subdivision of farmland	Subdividing farmland within the boundaries of a municipality
Removal of restrictions	Removing, amending or adding conditions to a title deed that has an impact on the developability of the land
Street/park closure	Applying for the permanent closure of a street or a park
Restriction of access	Closure of a neighbourhood by restricting access via a gate or boom or guards

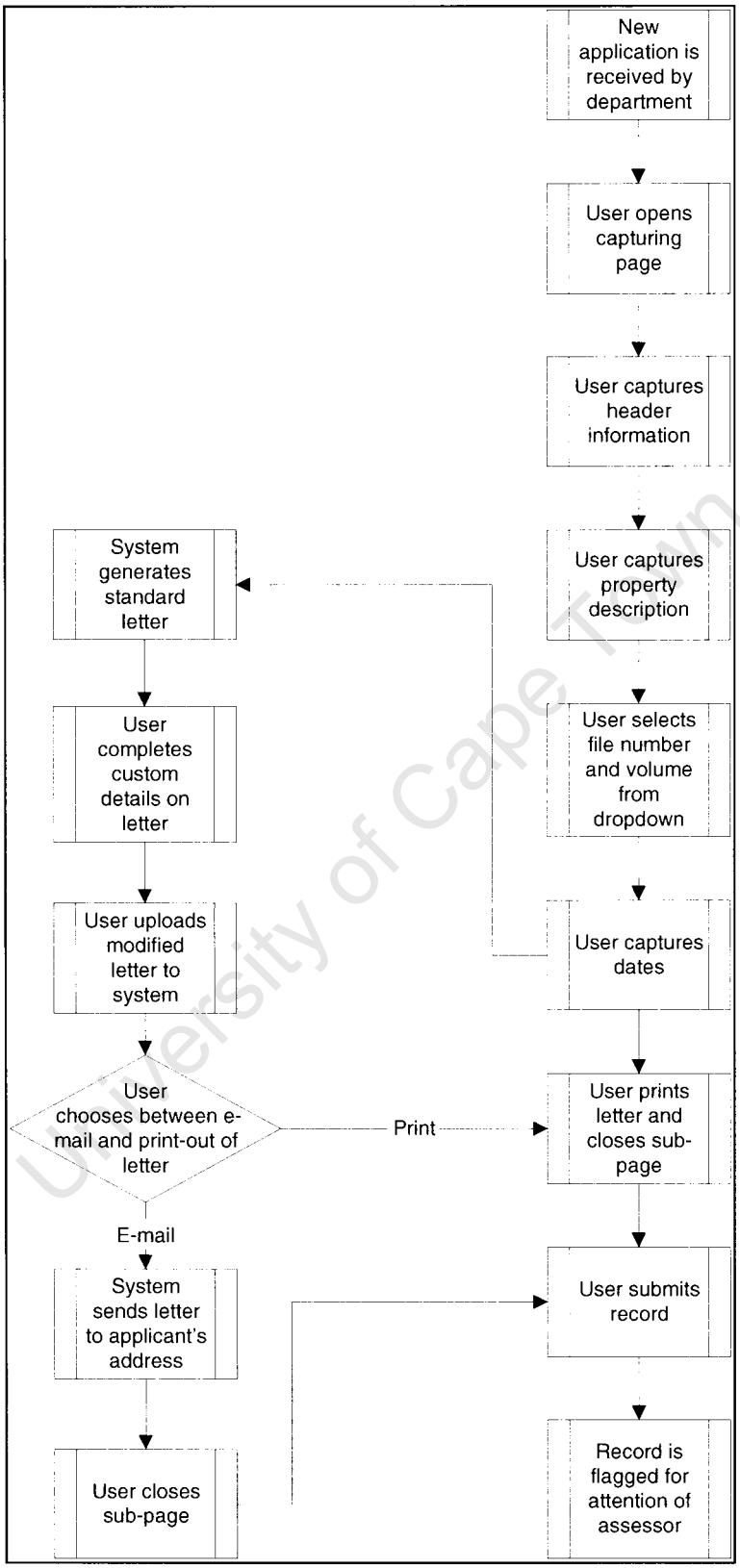

Figure 7-11: Workflow for the capture of applications

7.3.2 Look-up table maintenance

The administrative user is responsible for maintaining look-up tables, however, the responsibility of tending to particularly the look-ups reading from the spatial data tables, i.e. road numbers, municipalities and properties, is not included in this case. The administrative user is responsible for the maintenance of: application type, land-use type, applicants and file numbers. The actions involved in maintaining the land-use type and application type look-ups is described by the flow diagram below (Figure 7-12).

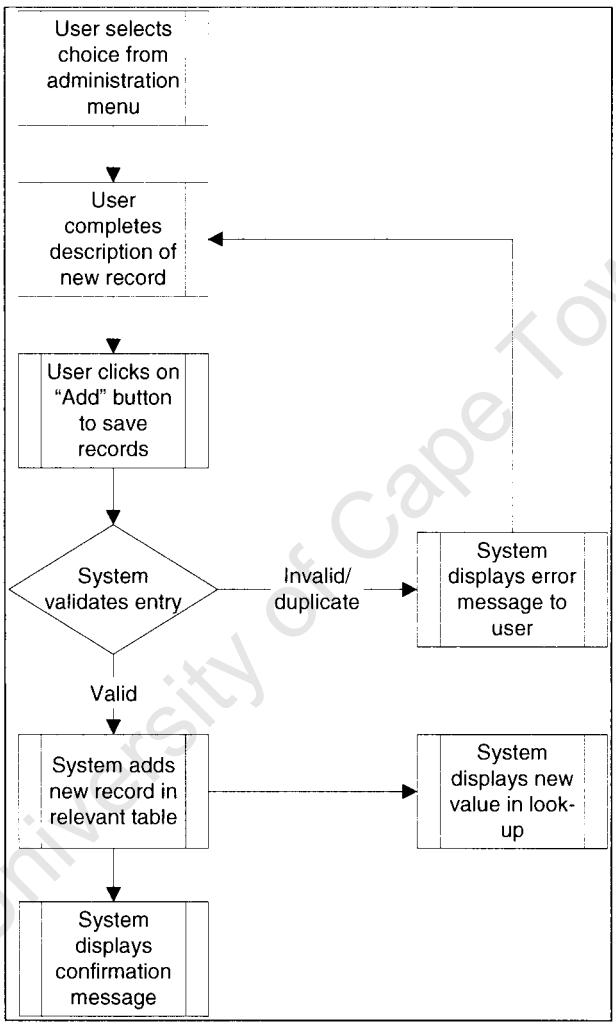

Figure 7-12: Look-up table maintenance workflow

The design for the file number look-up is discussed as part of the system integration later in this chapter. The screen design for the maintenance of the applicant dropdown has undergone design permutations, as indicated in Appendix B.

7.3.3 Notice board maintenance

As stated previously, the administrative user is held accountable for the maintenance of the notice board. The purpose of the notice board is to provide the functionality

from where users can view and download notices, legislation, speeches, maps or transport and spatial plans, e.g. ITP, SDF, Current Public Transport Record (CPTR) and IDP. The notice board is able to accommodate most common file types, including text files (*.txt and *.dat), MS Excel (*.xls), MS Word (*.doc), Acrobat reader (*.pdf) and image files (*.bmp, *.jpg, *.gif and *.tif).

The administrative user maintains the notice board by regularly uploading files to the page. The notice board maintenance functionality is described by the flow diagram below (Figure 7-13).

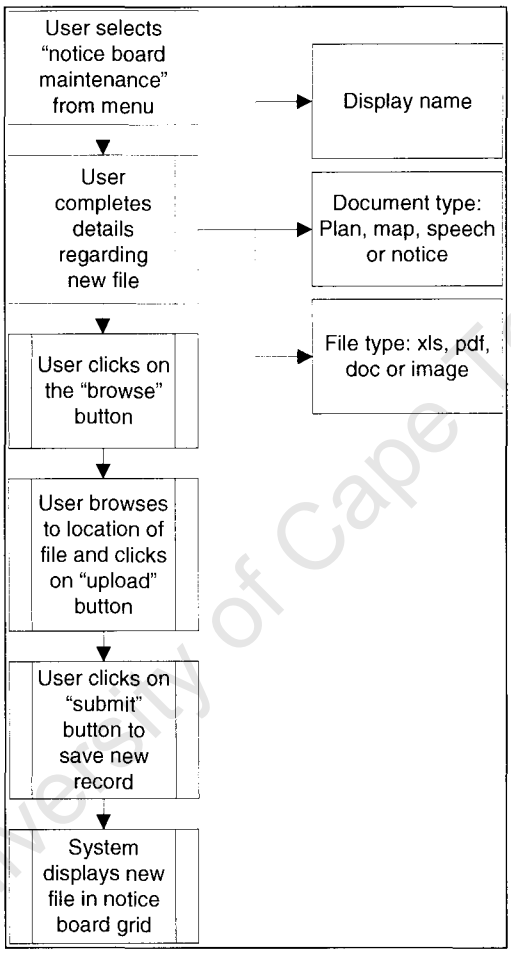

Figure 7-13: Notice board maintenance workflow

7.3.4 Gazetted applications

The approved applications are published in the Government gazette, as stipulated by the GPDA (GDPLG, 2003). Once these are approved by the municipality, the administrative user searches for the original record submitted to the system, changes the status of the application to "gazetted" and captures the conditions of approval. The conditions of approval are used as input for the strategic monitoring and intervention functionality, which is discussed later in the chapter. Details of approved applications are forwarded by Municipalities to GPTRW to aid the monitoring system. The page design permutations of the status updates are provided in Annexure B.

The workflow of updating an application's status is presented by the following flow diagram:

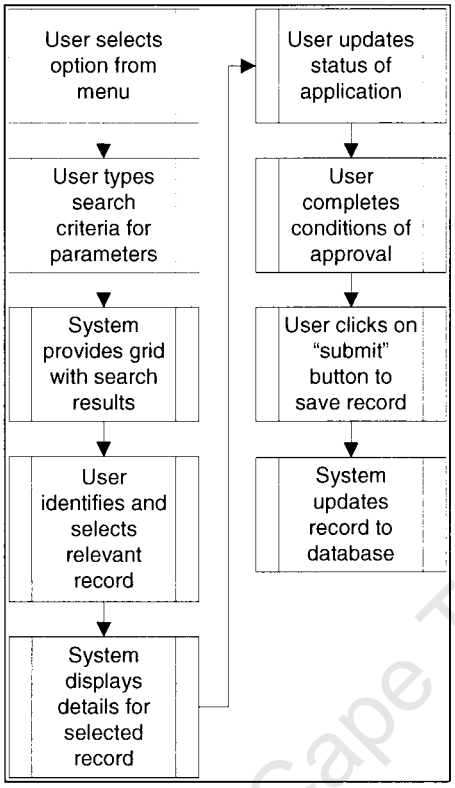

Figure 7-14: Application status updating workflow

7.4 Technical assessment

The technical assessment of development applications is one of the main functions of the Sub-directorate Ribbon Development. During assessment the technical user searches for an application that had been captured at an earlier stage by an administrative user. The purpose of the technical assessment is to protect the SMRN, SPTN and Gautrain planned route from land-use developments' possible negative impact. The technical user is responsible for capturing the map location of applications and assessing the applications, based on business regulations determined by legislation (GPDA, GDPLG, 2003). Comments regarding the application are then formulated in the form of a system-generated letter, which is sent to the applicant, as well as the relevant local authority (the municipality).

The high-level process, commencing with the receipt of an application, and concluding with the submission of a gazetted application, is indicated by the flow diagram below. All system / automated tasks are indicated in greyscale. A comparison of the level of automation with the status quo high-level process flow presented by Figure 6-1 in Chapter 6 indicates that, ideally, the system aims to substantially enhance productivity.

Section 7.4.1 and 7.4.2 provide more detailed write-ups, process flows and screen layout designs for the design permutations of the SMRN and SPTN assessment functionalities, respectively.

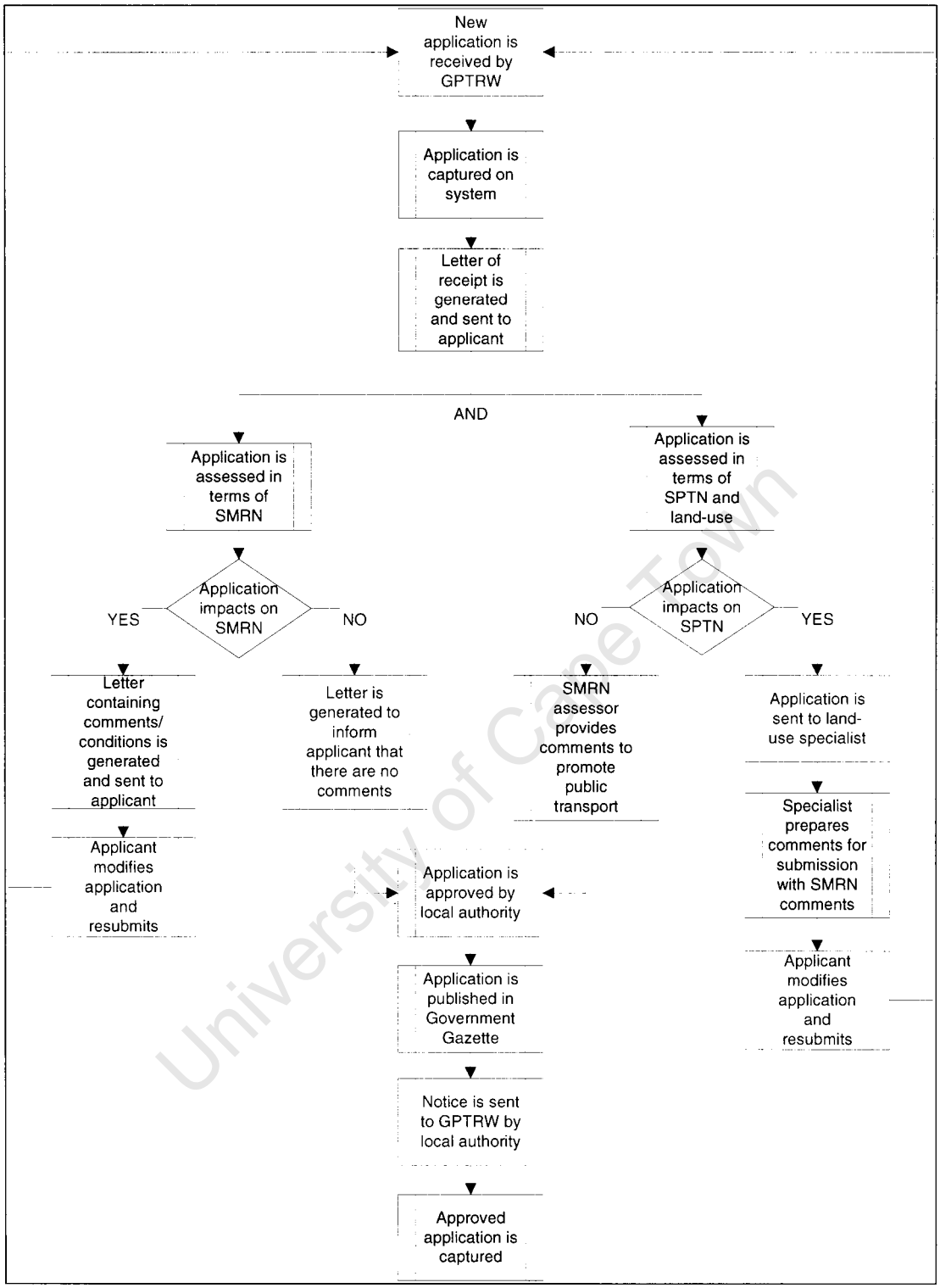

Figure 7-15: High-level workflow for technical assessment (system processes indicated in greyscale)

7.4.1 Standard assessment – SMRN protection

The impact of the application on the SMRN is assessed by the technical user. Evaluation criteria include the location of the application in relation to existing and future roads, the land-use type applied for and the amount of traffic to be generated by the planned land-use.

The incremental design method entails the incessant revision of components up to the point where involved users indicate their full satisfaction. Paper prototyping is applied to determine the final draft screen layouts. All input received from users has been summarised and presented by Figures B-1 to B-2 in Appendix B.

Letter templates with standard comments are generated by the system, enabling the user to review the automated comments and provide additional input if required. Templates loaded onto the system include:

- Acknowledgement of receipt of application,
- Existing roads affected by establishment of new townships,
- Future roads affected by establishment of new townships,
- Subdivision of farm land,
- Subdivision of agricultural holdings,
- Subdivision of erven in existing townships,
- Construction of a lapa,
- Building line encroachments,
- Impact of application on the Gautrain Rapid Rail alignment,
- National roads agency comments, and
- Confirmation of compliance.

Figure 7-16 and Figure 7-17 provide process flows describing the assessment procedure to be undertaken, as well as the validation activities to be performed by the technical assessor.

The SMRN assessment procedure is considered to be more straightforward than the SPTN and land-use assessment, due to the fact that concrete evaluation criteria are provided as measure. The effort involved in assessing the applications' possible impact on the SPTN and land-use is discussed in the subsequent section.

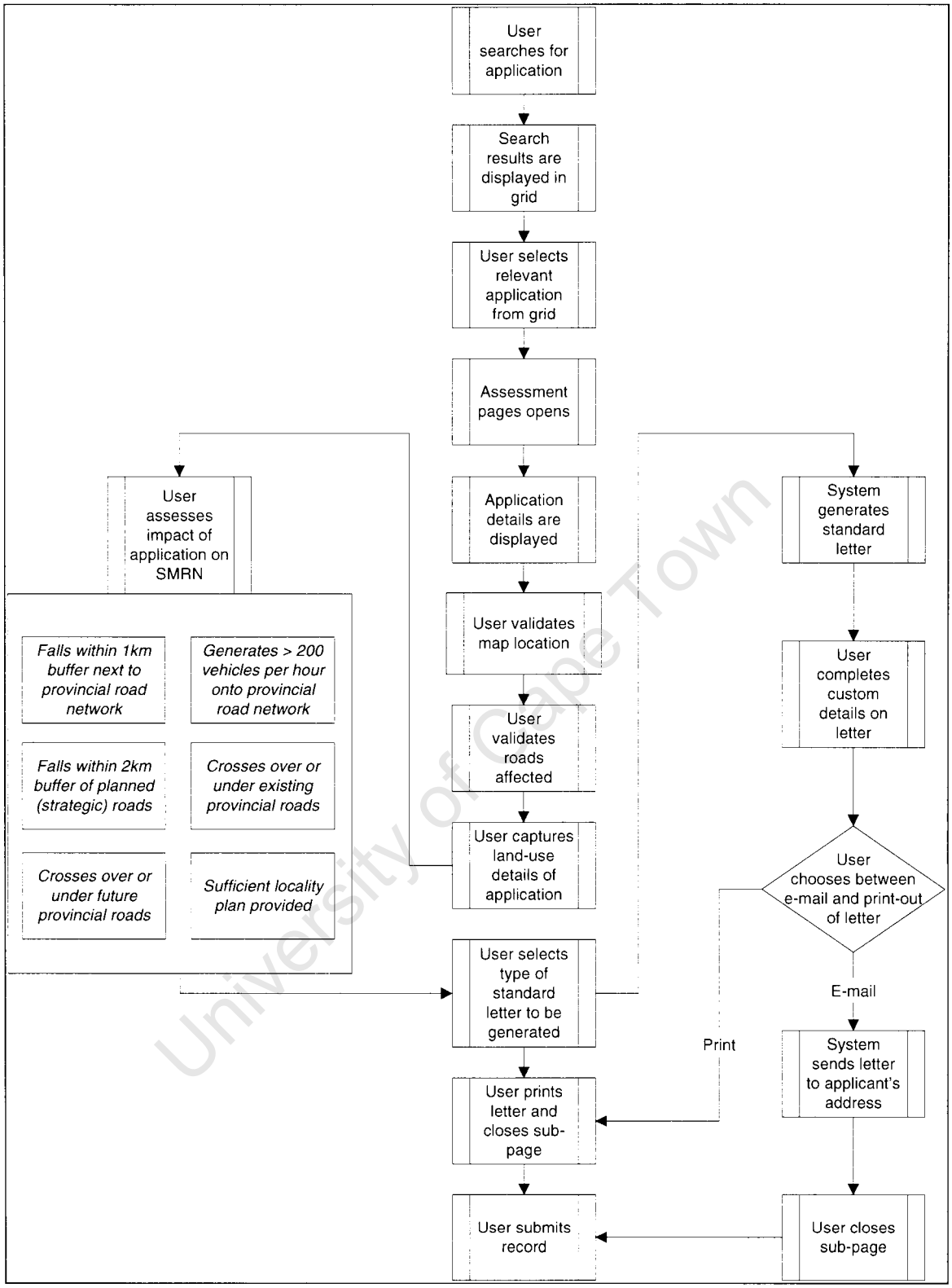

Figure 7-16: Technical assessment of applications with regard SMRN protection

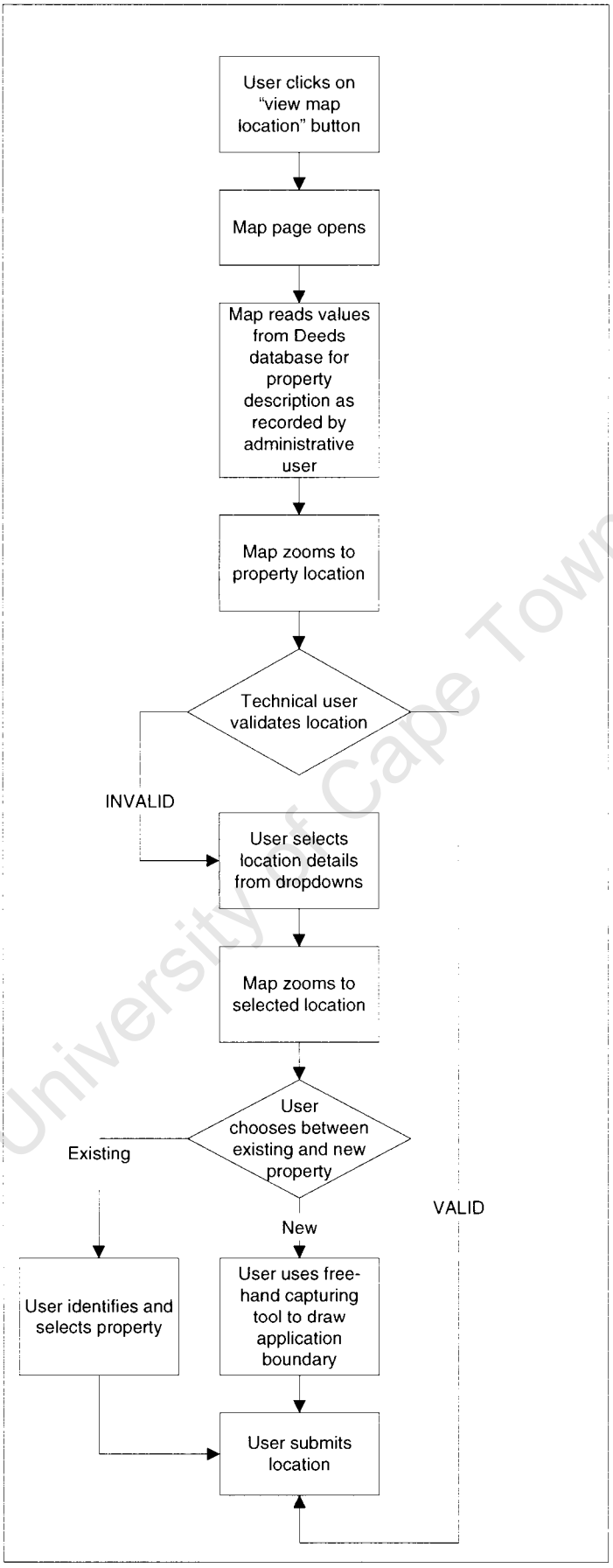

Figure 7-17: Workflow for capturing map location, as part of SMRN assessment

7.4.2 Public transport and land-use assessment

The technical user is responsible for assessing the impact of applications on the SPTN, land-use and Gautrain. High-level assessment criteria include situating the application in relation to the existing and future components of the SPTN, determining the land-use type applied for and determining whether provision has been made for public transport accessibility and pedestrian facilities.

Figure 7-18 provides the process flow describing the assessment procedure as well as the validation activities performed by the technical assessor.

Identification of applications to assess

Detailed criteria for the identification of applications to assess include:
- Minimum distance from SPTN: All land-use applications within a distance of 500m (both sides) of any of the routes or facilities of the Strategic Major Road Network or Strategic Public Transport Network should be assessed according to its proximity to the sphere of influence. This is calculated according to the acceptable walking distance associated with public transport, and
- Sifting of applications: Should a land use application with a possible impact on SPTN be received, which exceeds and falls outside the prohibited distance, the technician must make a judgment call as to whether or not it should be excluded from the commenting process.

Assessment guidelines

The following land-uses are not considered to be hindrances to serviceable public transport and should therefore be encouraged:
- Medium to high density residential (>25 units per hectare),
- Retail (>15,000m^2),
- Offices,
- Entertainment,
- Educational facilities (subject to new policy),
- Institutions such as hospitals, large religious institutions, and
- Large sport facilities.

In the immediate proximity of a public transport facility, the following extensive land-uses should preferably not be allowed:
- Commercial,
- Open spaces,
- Cemeteries,
- Extensive industrial, and
- Low-density residential developments.

Caution must also be exercised in the case of security townships, because of the anticipated concentrated increase of vehicle volumes on the collector roads.

The following comments indicate various methods by which public transport is facilitated:

- Encourage residential densities > 25 units per hectare,
- Encourage mixed land-uses on the same site and in the same area,
- Encourage high coverage, floor area ratio (FAR) and height,
- Encourage the provision of bus/taxi stops and facilities,
- Encourage safety and convenience of users,
- Oppose low density residential development,
- Likewise, oppose the development of extensive low density land-uses, and
- Encourage labour-intensive land-uses.

Furthermore, important points to generally take into consideration, include:

- Residential development: The prime land-use for public transport trip generation involves higher density,
- Retail sites generate 10 times more trips per unit than office space, and the trips occur during off-peak periods,
- Compared to retail space, office space has higher peak period trips, and
- Manufacturing and warehousing have a very low impact on trip generation.

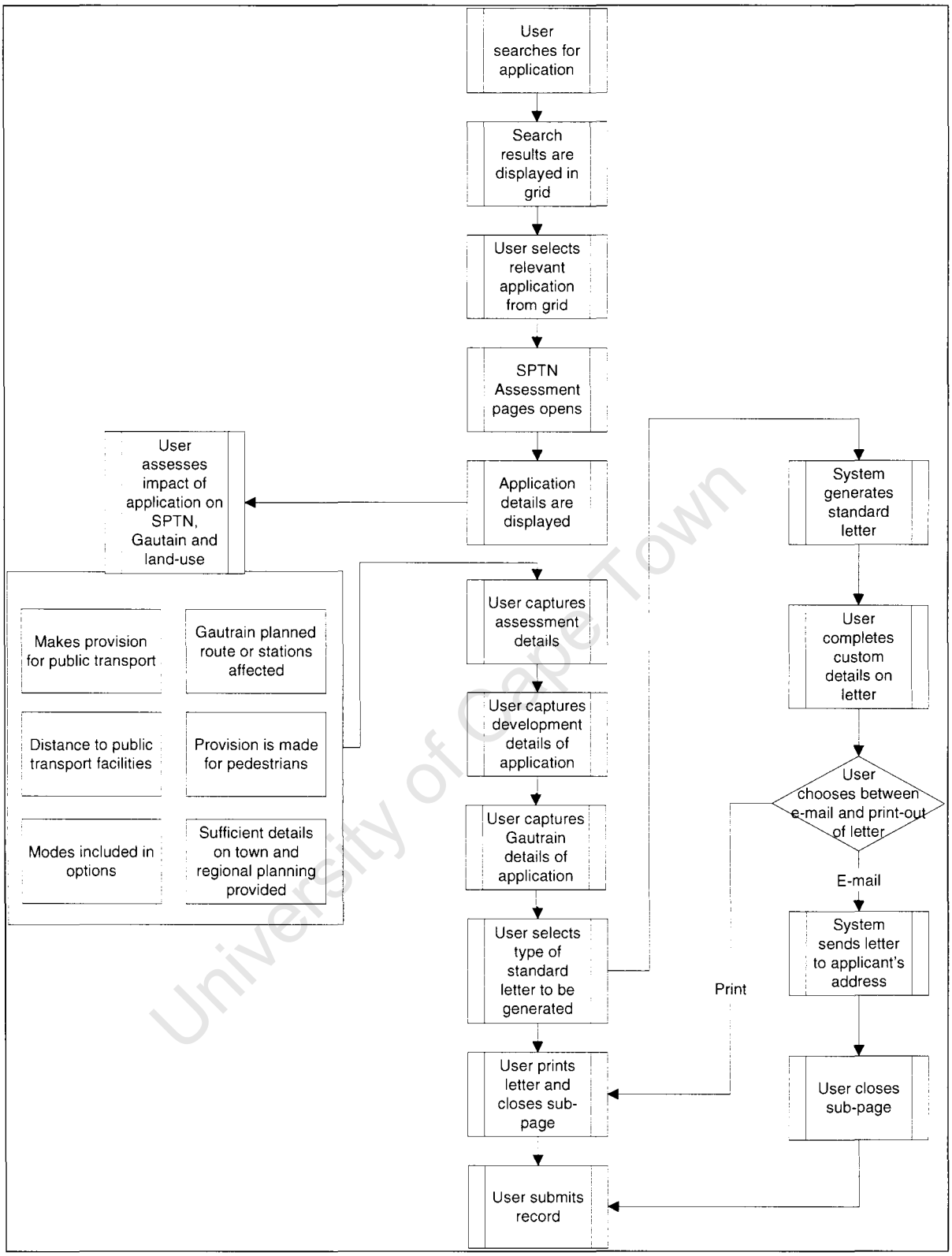

Figure 7-18: SPTN and Land-use assessment workflow

7.5 Data maintenance

The technical user is responsible for maintaining the core spatial datasets on the system maps. This responsibility does not include the editing of layers, but merely the uploading of the most recent layers by the replacement of the previous versions of the map layers. The task of editing the spatial layers resides with the directorates or consultants responsible for the fieldwork, data processing, compilation of the master layers, etc. Refer to Chapter 5 for a thorough motivation for drawing such a clear distinction between allocated tasks. The only dataset to be maintained by the system users is the new township applications polygon layer. The system provides the facility by which the updated layers can be uploaded onto the system.

7.5.1 New townships layer

The need has been identified for the provision of a facility through which the user can capture the new township application boundaries, by tracing it from the aerial photography backdrops. In addition to fulfilling this fundamental need, this system allows the file created on the system map to generate a grid, where records that had already been captured onto the spatial file, can be indicated. Desktop software is used for the maintenance of this spatial file. The user is prompted to upload updated layers on a weekly basis, to ensure that the townships layer presented on the system maps is not outdated.

7.5.2 Existing roads on SMRN

The maintenance of the SMRN for existing roads, forms part of the Road Network Management System (RNMS) consortium's responsibilities. This includes the surveillance of new roads, the capture of road furniture and basic attributes, and the updating of the spatial file. The layer is maintained on a quarterly basis and is made available to all directorates in GPTRW, their service providers and other provincial departments licensed to use the dataset. The updated layer is obtained from the RNMS, after which the user is provided with an uploading feature through which the dataset replaces the previous version of the SMRN on all system maps and related tables. Figure 7-19 provides the flow diagram presenting this process.

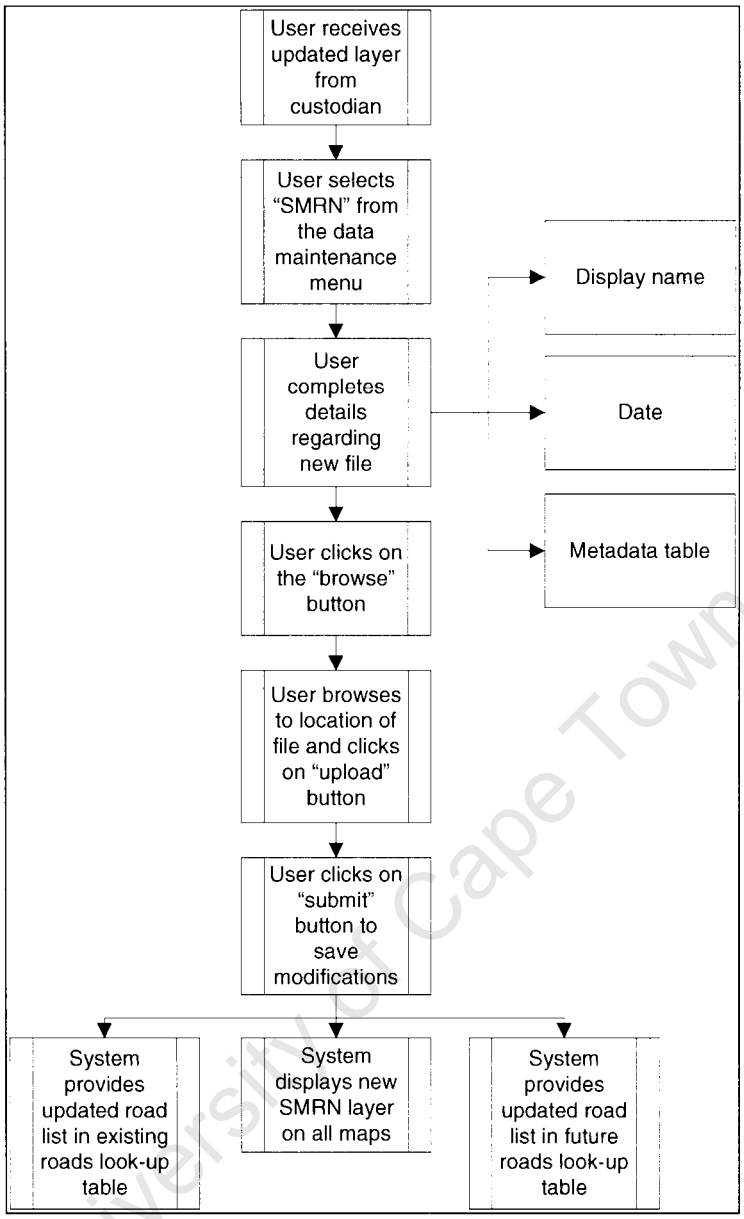

Figure 7-19: Data maintenance procedure for uploading SMRN layers

7.5.3 Future roads on SMRN

In a similar fashion to that of the existing roads, the maintenance of the SMRN for future roads forms part of the RNMS consortium's responsibilities. The maintenance thereof includes the updating of the spatial file, correlative to updates by GPTRW. Designs for future roads normally indicate plans only up to the preliminary plan, and this is used by the consortium to update the geometrical alignment of these roads. The detail design and as-built drawings, together with actual co-ordinates surveyed by road superintendents, form part of the existing road dataset maintenance. The layer is updated on an annual basis and is made available to all directorates in GPRW, their service providers and other provincial departments licensed to use the dataset. The updated layer is obtained from the RNMS, subsequent to which the user is provided with an uploading feature, through which the dataset can replace the previous version of the SMRN on all system maps and related tables. Figure 7-19 provides the flow diagram presenting this procedure.

7.5.4 Cadastral boundaries, SDF and town planning schemes

Cadastral boundaries are maintained by external service providers and are made available to the GPTRW on a quarterly basis. Updates performed by these service providers include erven in new townships, subdivisions, amalgamations and attributes related to the Surveyor General (SG) diagrams. The system user obtains the updated layer from the data custodian and loads it onto the system, thus causing the map to display the most recent layer, and enabling the look-up tables to display the relevant database entries. Figure 7-20 represents the workflow involved in updating the cadastral dataset.

Municipalities or their service providers are the custodians of their region's SDF and town planning scheme datasets. The minimum standard and the file format specifications required by the system are established and enforced by LUTC. Municipalities submit their updated layers to the committee as soon as updated versions are published. The user is provided with a functionality, in a similar fashion as for road file and cadastral layer updates, to upload the latest data received.

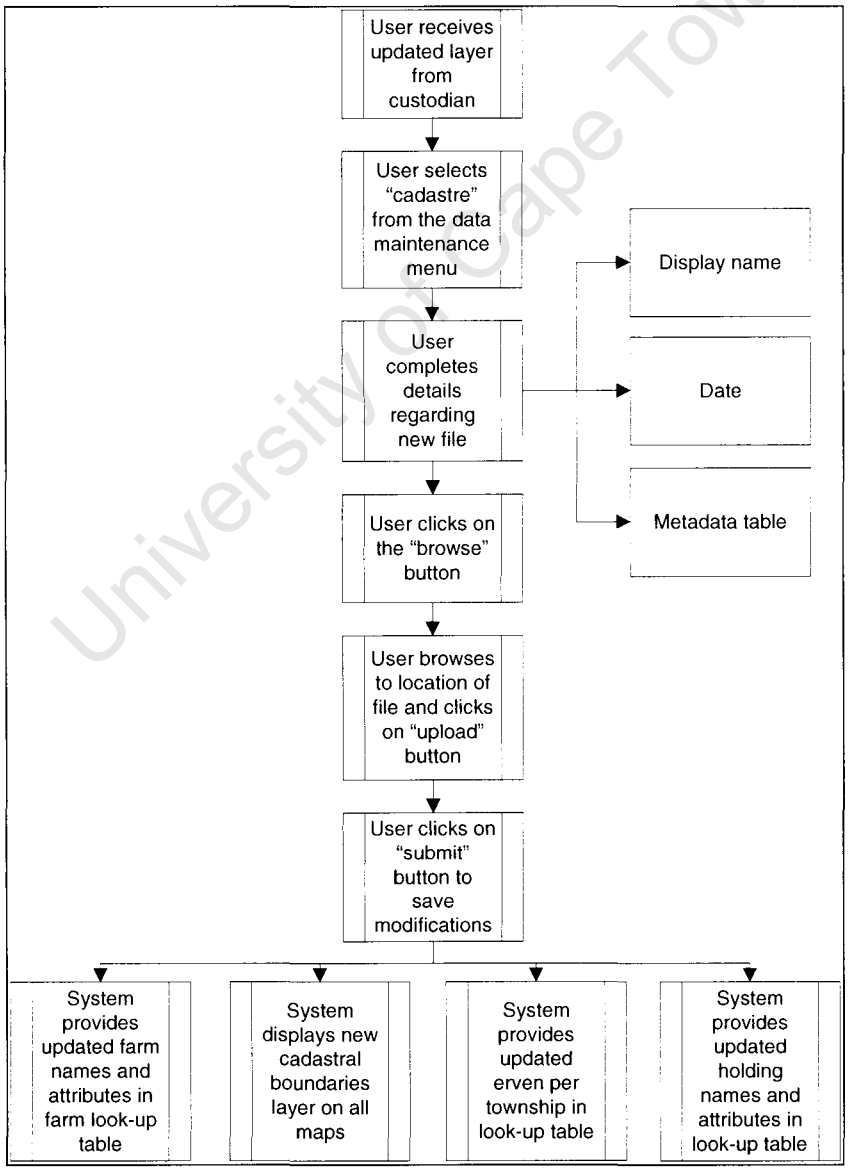

Figure 7-20: Data maintenance procedure for uploading cadastral boundaries

7.6 Strategic monitoring and intervention

In addition to the capture and assessment of development applications, one of the major functions of the system is the monitoring of development trends. This can assist as a pro-active, predictive system for determining future transport network requirements and public transport needs. The development patterns transpiring from such an analysis serve as indication of the potential effectiveness of plans and policies. The analysis indicates potential transport related problems and areas where intervention will be required to effect the desired integration.

7.6.1 Three phases of monitoring

In order to monitor the development trends, all database records are displayed on a map indicating the particular status of each record in a different colour. The records with approved status have additional details attached to it in the form of conditions of approval. These attributes are displayed in the form of a thematic layer, on the monitoring map. As indicated previously, the status of an application will at any time be one the following types: registered, pending, assessment completed, or gazetted.

The monitoring system indicates trends and development patterns, which are analyzed to show inconsistencies with the objectives of the department, regarding the promotion of the integration of land-use and transport, and the promotion of public transportation. The GIS tool will enable three phases of monitoring:

- All applications received by GPTRW Sub-directorate Ribbon Development are electronically captured and presented spatially on a layer to determine development trends,
- Once GPTRW has received notification of the approval of applications from municipalities, the change in the development status is noted on the system in order to for an accurate map, indicating development patterns, to be generated. The critical development details of approved applications, such as land-use types, bulk, height, parking facilities and coverage, are captured to obtain a clear indication of potential development intensity, and
- A third level of development status is to the system, through capture of building plan details that reflect actual exercised rights. This will give an indication of the effectiveness of policies and plans in achieving integration/densification. To complete the spatial presentation, historically approved zonings, as per the different Town Planning Schemes, must be interpreted and spatially presented.

The spatial presentations, as discussed above, indicate different residential densities and areas of intense development. The data must be interpreted to determine the effectiveness of existing policies and plans, in terms of the objectives of GPTRW regarding integration of land-use and transport.

7.6.2 Strategic intervention

The members of the planning and coordination body responsible for the inter-governmental liaison regarding integrated land-use and transport planning, LUTC, are the users accessing the monitoring component of the system. The findings derived from the monitoring process, as discussed in the previous section of this report, are scrutinised by the members of the LUTC, who, in turn, mediate between the department and different local authorities. It is by means of this committee that change in policies and strategies can be achieved, towards the integration of land-use and transport.

The monitoring system provides facts to support arguments in favour of intervention. Better planning, influencing strategic planning efforts and allowing the alignment of public resources towards achieving integration goals, will be effected in this manner. The analysis that is based on the monitoring function also provides general guidance for inputs to the department regarding future SDFs and ITPs. Once the SDFs have been amended by the municipalities to incorporate the objectives of integration, the updates are feed back into the system maps, by amending spatial layers accordingly. This feedback loop will ensure that the tool is up-to-date and has the proficiency to assist with the assessment and evaluation of land-use applications.

The following diagram (Figure 7-21) illustrates the relationship between the monitoring function, the commenting on land-use applications and the strategic intervention. Steps supported or automated by the system are indicated in greyscale. The monitoring and strategic intervention system components are discussed in more detail in section 7.8 as part of the GIS synopsis.

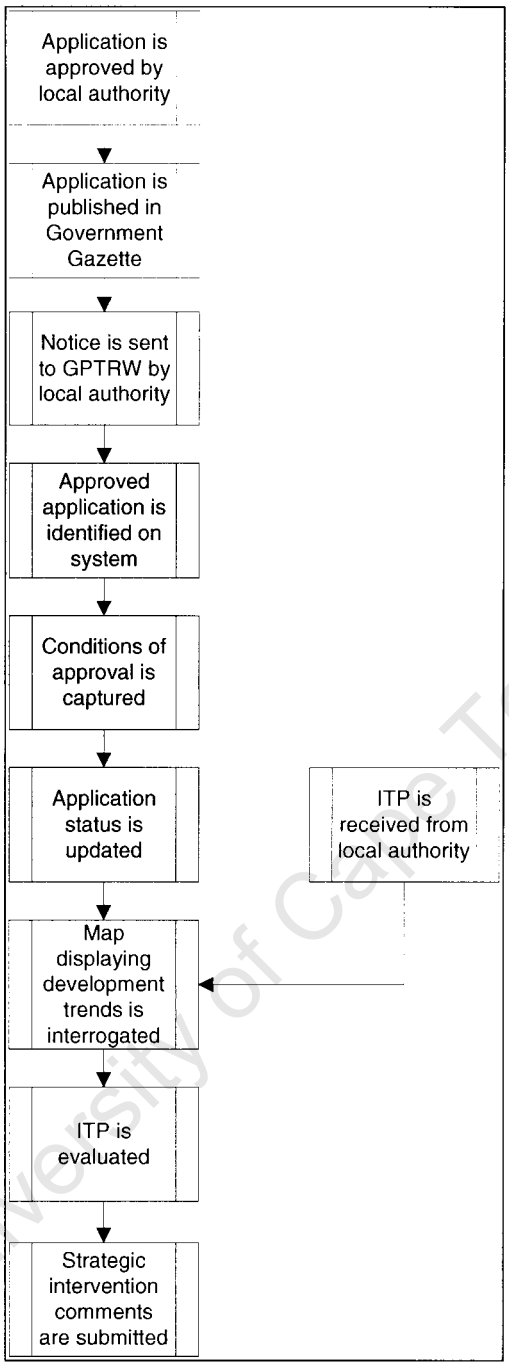

Figure 7-21: Process flow for monitoring and intervention actions

7.7 Integration with existing systems

Integration is required with the following existing systems and databases:

- Departmental filing system,
- Deeds data,
- Drawing management system,
- Traffic analysis zones and model,
- Wayleaves management system, and
- Road network management system and sub-systems.

Numerous technical methods of accessing the above-mentioned systems are possible. Table 7-2 lists each method, along with each method's respective advantages and disadvantages.

Table 7-2: Access to databases of source systems

Nr	Description	Advantages	Disadvantages
1	Full read access: Real-time (live) link between data sources and central data repository	No additional effort required to update data between the source and the repository.	If the data source is not constantly accessible, the repository will not have a (recent) historic set to read from
			The setup of the live link is complex and time-consuming
			The security of the data cannot be guaranteed
			Network speed and performance could impact negatively on the connection
			Political will is key to the success of this data transfer arrangement
2	Web service: Real-time (live) link between specified tables and views from data sources to central data repository	No additional effort required to update data between the source and the repository.	If the data source is not constantly accessible, the repository will not have a (recent) historic set to read from
			The setup of the live link is complex and time-consuming
			Network speed and performance could impact negatively on the connection
			Political will is key to the success of this data transfer arrangement
3	Replication of data source at repository	Minimum effort to keep data updated	The setup of the live link is complex and time-consuming
			If a replication fails, the repository will be reading from an outdated set
4	Manual updates	Human intervention could guarantee that updates are done as and when required	Data custodians should be very disciplined with the scheduled maintenance to ensure the relevance of data at all times
		This is an affordable method of data transfer	
		In IT challenged environments this arrangement is usually the preferred way to address data updates between sources and the repository	

7.7.1 Departmental filing system

The filing system is a decentralised system with MS Access database and front-ends. It is used for the administration of the township, farm, farm portion and agricultural holding files within the department. The file number is allocated according to a fixed format and rules, and will remain the same for the duration of the entity's existence. The assigned file number is made available to the Land-use system, so that a common name and reference number will be used by both systems. Due to technological constraints, based on the decentralised modules, option 4 indicated in the data access methods (Table 7-2) is the current method through which access is gained to the file number administration system.

7.7.2. Deeds

The Deeds Office is the custodian of the data indicating the ownership of properties. The properties are described through a 21-digit code, which enables classification represents attributes with regard to the province, magisterial district, administration area or township in which it resides. The 21-digit code is captured as an attribute to the cadastral boundaries layer. This attribute establishes the link between the ownership data and the surveyor general data, enabling the land-use system to view SG details and deeds attributes, when accessing the maps on the system. The cadastral boundaries are updated on a quarterly basis as has been discussed in section 7.5.4.

7.7.3 Drawing Management System

A comprehensive Drawing Management System (DMS) has been developed for the Department of Public Transport, Roads and Works. This system exists out of two modules, namely, Design and Public Works. The Design DMS is a web-based application developed to make the information and scanned images of plans and road proclamations, electronically available to users, via the intranet. The system is based on the Road Access database developed by GPTRW. Drawing office personnel as well as officials from the Sub- Directorate Ribbon Development are users of the DMS. Currently, instead of physically handling the plans, plans may be printed by drawing office personnel, using the Roads DMS. Furthermore, plans are often made available electronically to consulting civil engineers and other parties, by means of e-mail or per compact disc. Another important functionality of the application is to locate designs on an electronic map background, and, by clicking on the desired design, detailed information and associated plans can be viewed.

The system was recently updated in order to address the scanning backlog as well as to enable the drawing office to capture new records onto the database. Integration with the DMS is useful, simplifying the work of the technical assessor, by making available the designs of involved roads after identification thereof it on the GIS. The user is therefore not required to investigate the area manually, and similarly, needs not identify the roads, meet with the drawing office, or request hard copies of the designs. The system renders such actions superfluous as it makes these available electronically, enabling the user to choose whether to download or print the plans. Access to the system is real-time, full read access (option 1 in Table 7-2).

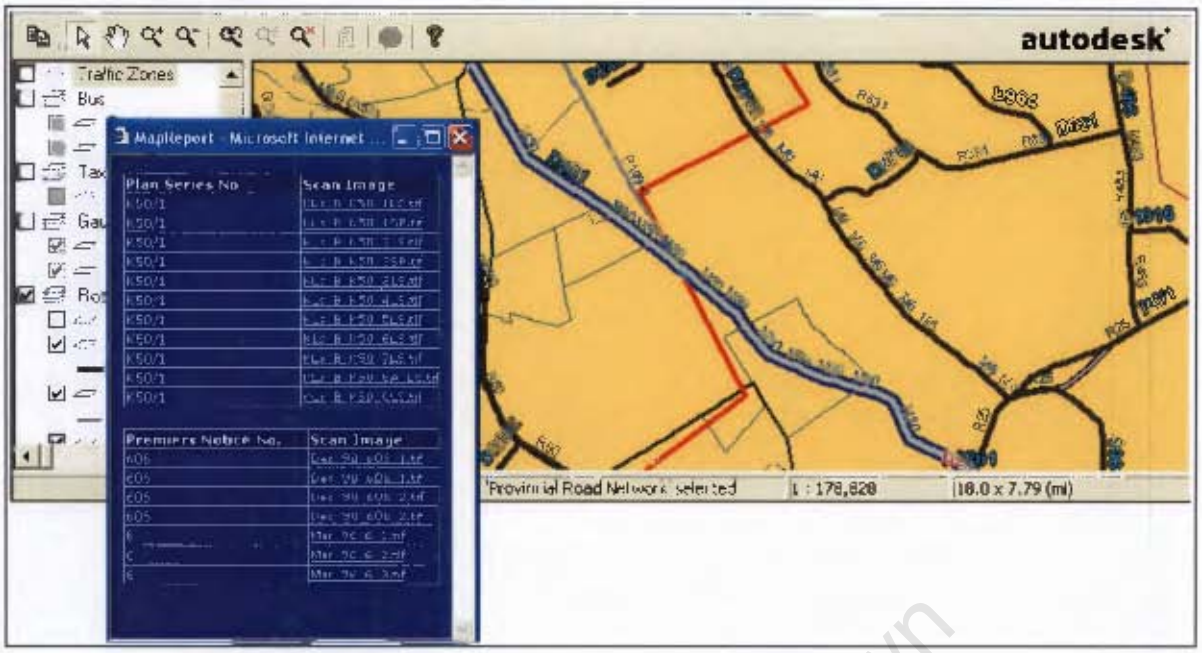

Figure 7-22: Envisaged integration with DMS

7.7.4 Traffic analysis zones and model

The traffic analysis zones (TAZ) system is a model developed to investigate and predict land-use and traffic trends for two periods, for which the base year is 2000 and the anticipated years are 2010 and 2025. The base year model is prepared according to certain inputs, including current land-uses, existing transport infrastructure, current traffic volumes and population and demographic details. The predicted values of these attributes serve as additional information to the strategic assessor when investigating the development trends in relation to the transport plans and development frameworks submitted by the municipalities. Once again strategic intervention is required in cases where the trends and the frameworks show conflicting patterns. Access is gained via the third option, by obtaining the most recent layer and attributes from the custodians.

Figure 7-23: Envisaged integration with TAZ model

7.7.5. Road Network Management System and sub-systems

The purpose of the road network management system (RNMS) is to provide a consistent and logical method for accessing road network related information and relevant attribute data, including spatial information, for all provincial road assets. The primary function of the RNMS is to ensure the effective management of provincial road assets and to provide users with network-level information. The Gauteng RNMS has been developed over many years, having commenced in 1982, where rudimentary Pavement Management Systems were used to manage the resealing programme.

The relevant components, from which the most recent data is obtained and integrated into the land-use system, are the inventory and GIS (together forming and maintaining the SMRN spatial datasets) and wayleave management system. The relevance of the SMRN dataset to this system is discussed in section 7.5.2, and the relevance of the wayleave management system is discussed in the subsequent paragraph. Refer to Figure 7-24, below, for the components of the RNMS. Access is gained via the third option (refer to Table 7-2), by obtaining the most recent layer and attributes from the custodians.

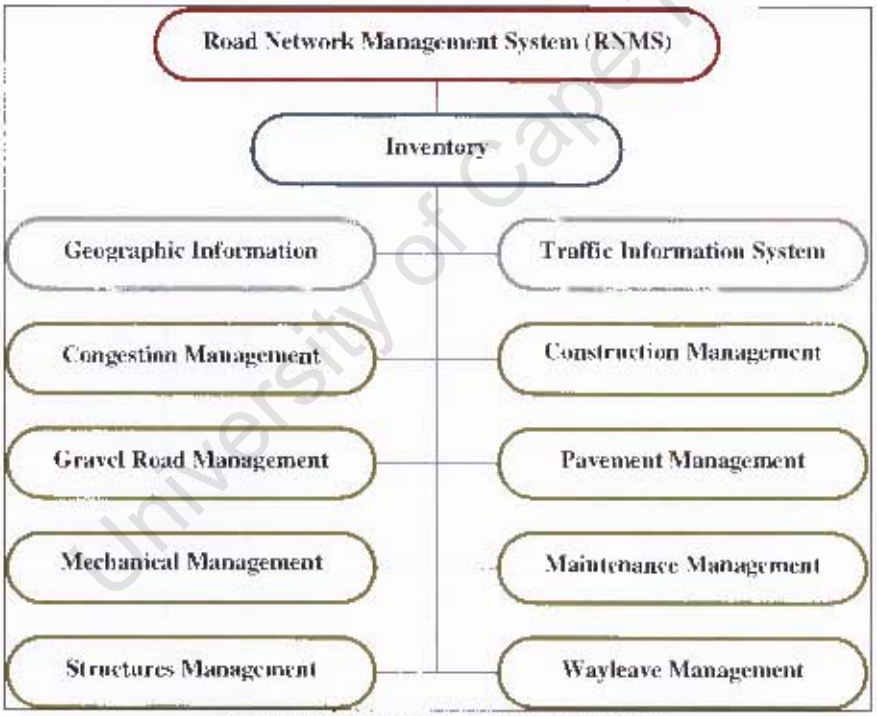

Figure 7-24: RNMS and sub-systems

7.7.6 Wayleaves Management System

A wayleave is a temporary right assigned to a developer, granting access to a provincial road for the performance of a required activity next to, on, above, or under the road. This includes, for example, the drilling of trenches to install optical fibre cables below a road, or the construction of an access road from a new shopping centre or filling station. The Wayleave Management System (WMS) is a sub-system of the road network management system. The WMS captures the applications for wayleaves, as received from private companies and developers. The system assists the

Infrastructure Protection Sub-directorate in administering the interim applications granted to these applicants, providing the details regarding these short-term privileges to the department.

The users of the land-use system are enabled to access the currently authorised wayleaves, in order to assist them in decision-making with regard to the assessment of the land-use applications. In cases where wayleaves were not approved by the Infrastructure Protection technici, based on the legislation regulating the approval of wayleaves, the technical assessor concerned should be notified to do proper investigation of the possible implications of the application to the road network. Access is gained to the WMS by the first option provided in Table 7-2 (real-time, full read access).

7.8 Synopsis of GIS features

7.8.1 Map location capturing/validation

The data capturing functionality enables the administrative user to capture the identified land-use applications' variables directly onto the system, via a free-text search functionality, with look-up table results reading from validated spatial data tables (as discussed in section 7.3.1). The map location of an application is confirmed by the technical assessor. The map component links the application data to the spatial entities, through the use of the SG's property data (21–digit code). Figure 7-25 represents the attributes captured by the administrative user, as referenced on the cadastral dataset.

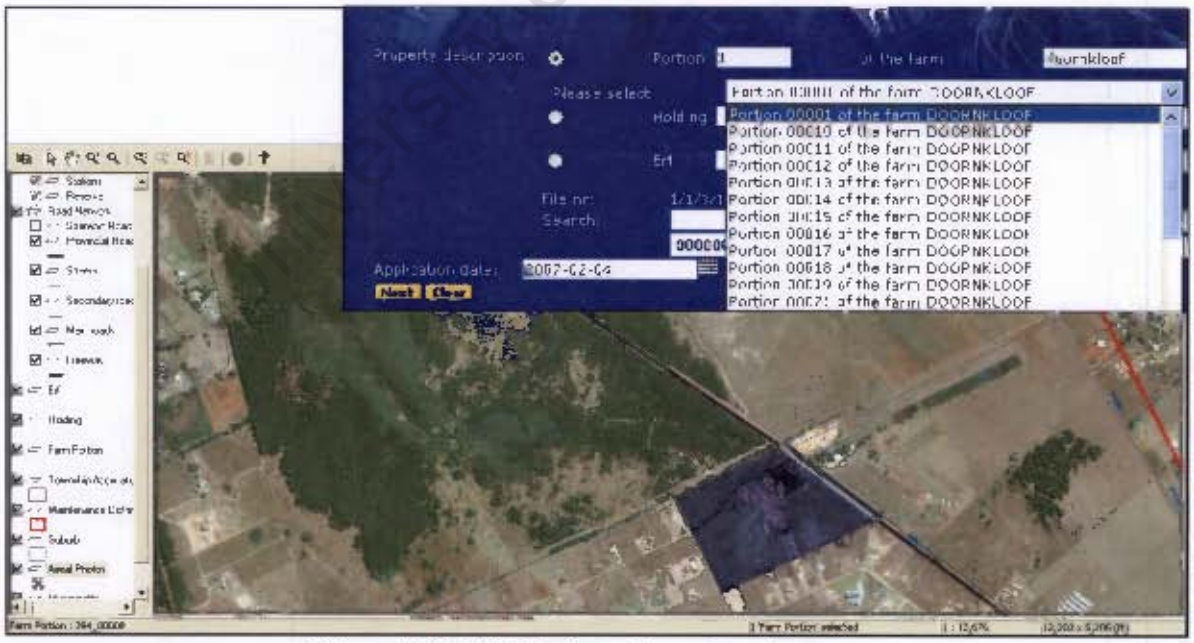

Figure 7-25: Validation of map location

In the case of an application for a new township, for instance, the free-hand drawing tool allows the user to specify the footprint of the area affected by the application. Backdrop layers, including aerial photography and the latest cadastral boundaries for farms, farm portions, agricultural holdings and townships and extensions, are

provided. Figure 7-26 displays the design of the free-hand drawing tool's functionality.

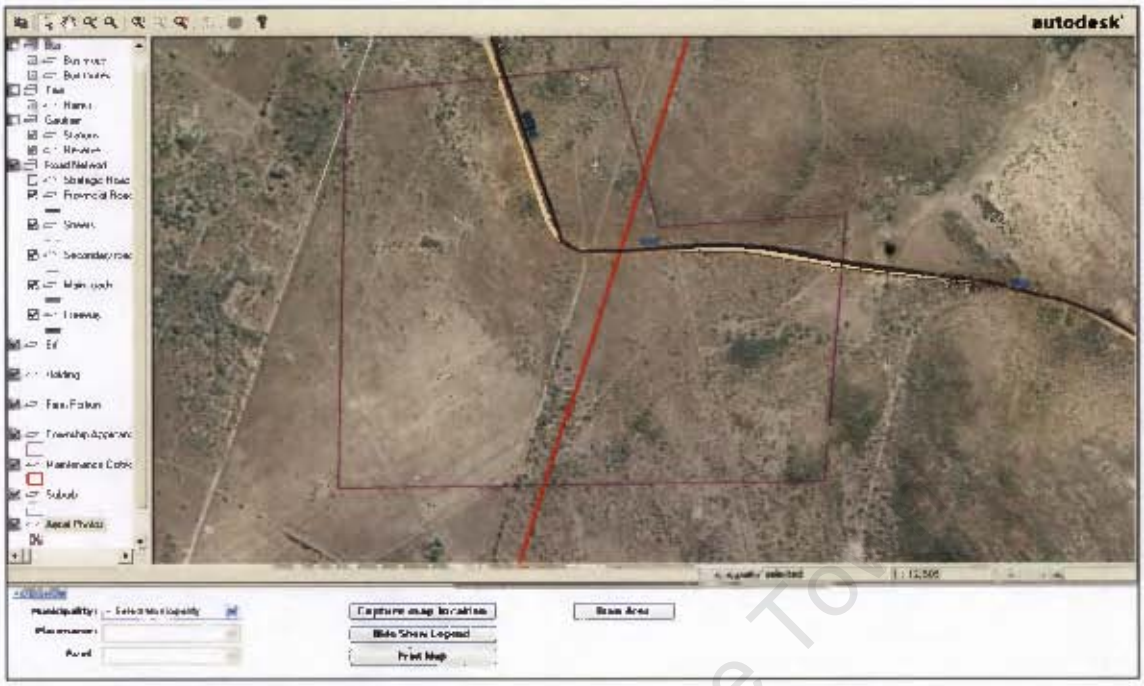

Figure 7-26: Free-hand tool for capturing new township boundaries

7.8.2 New townships maintenance

The administration of the spatial data maintenance of new townships is facilitated by means of a checklist and map with thematic layers that indicate new townships for which spatial maintenance is outstanding. Maintenance of the layer takes place by means of a desktop GIS, after which the updated layer is uploaded onto system in a similar fashion to that of the road and cadastre uploads.

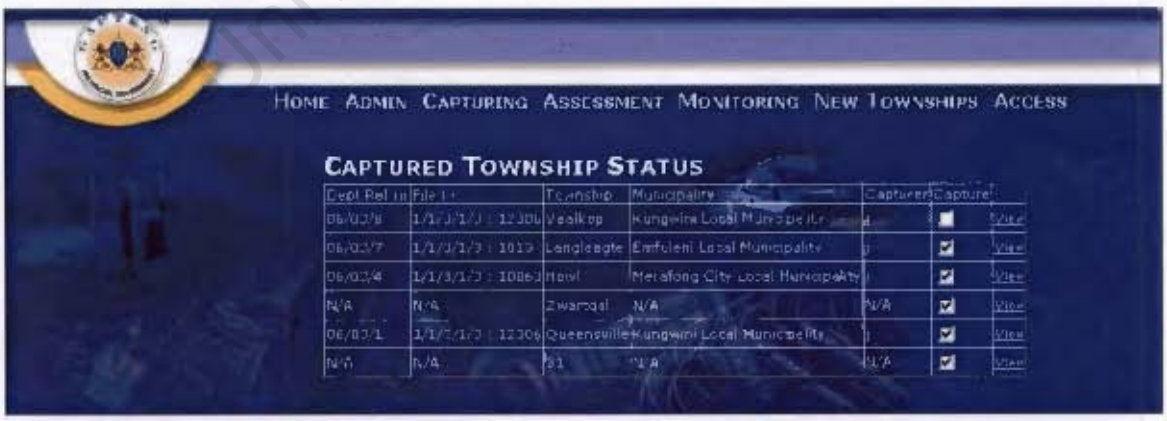

Figure 7-27: Administration component for maintenance of new township boundaries

7.8.3 Base layer maintenance

Advanced back-end procedures will be developed to enable spatial data updates through a user-friendly interface, including the execution and management of a sequence of events to be applied to database tables when the core spatial data is updated. These procedures will ensure that the database tables and related spatial layers are synchronised. Base layers included in this feature are existing roads, planned roads, cadastral boundaries, town planning schemes and SDFs.

7.8.4 Assessment

The spatial representation of the application, superimposed with the base spatial layers contained in the map, allows the official to draw an informed conclusion with regards to the application's impact on the GSMRN and the GSPTN. The map features assist with the assessment of various practical matters, as discussed below, in connection with Figures 7-28 and 7-29.

Map features enable the identification of affected existing roads, by taking into account the location indicated by the application. Refer in this regard to Figure 7-28.

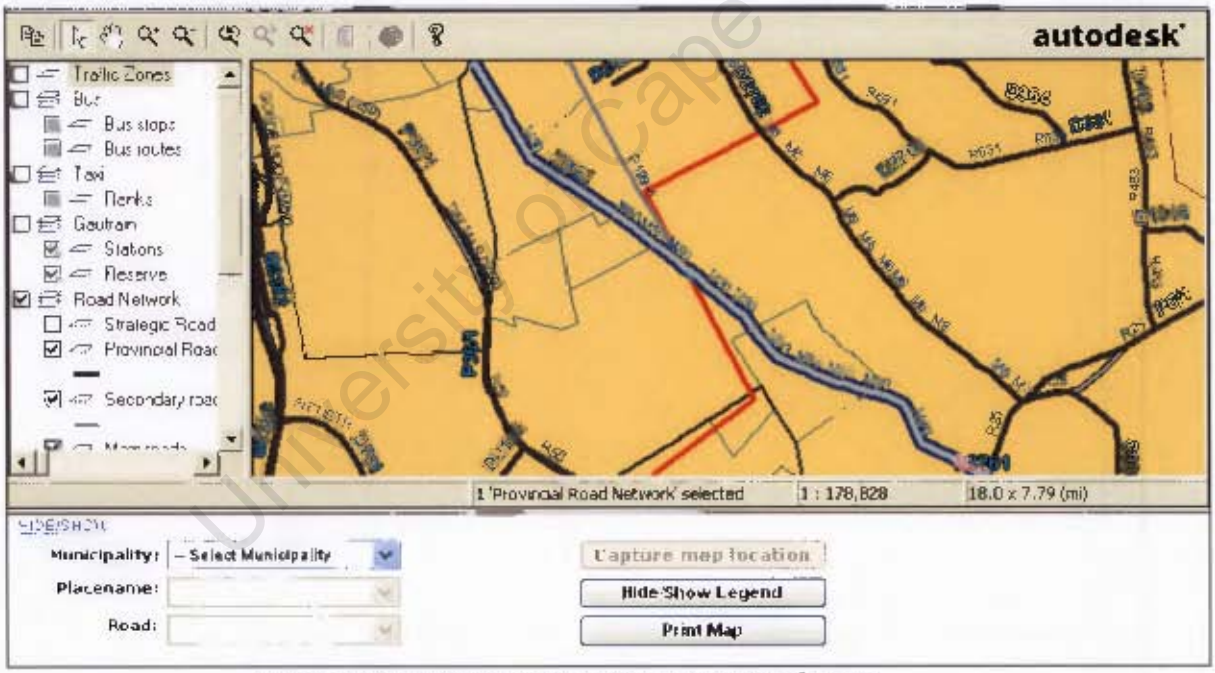

Figure 7-28: Automatic detection of affected road

In addition, map features enable the identification of affected *future* roads, by taking into account the location indicated by the application. Refer to Figure 7-29 in this regard.

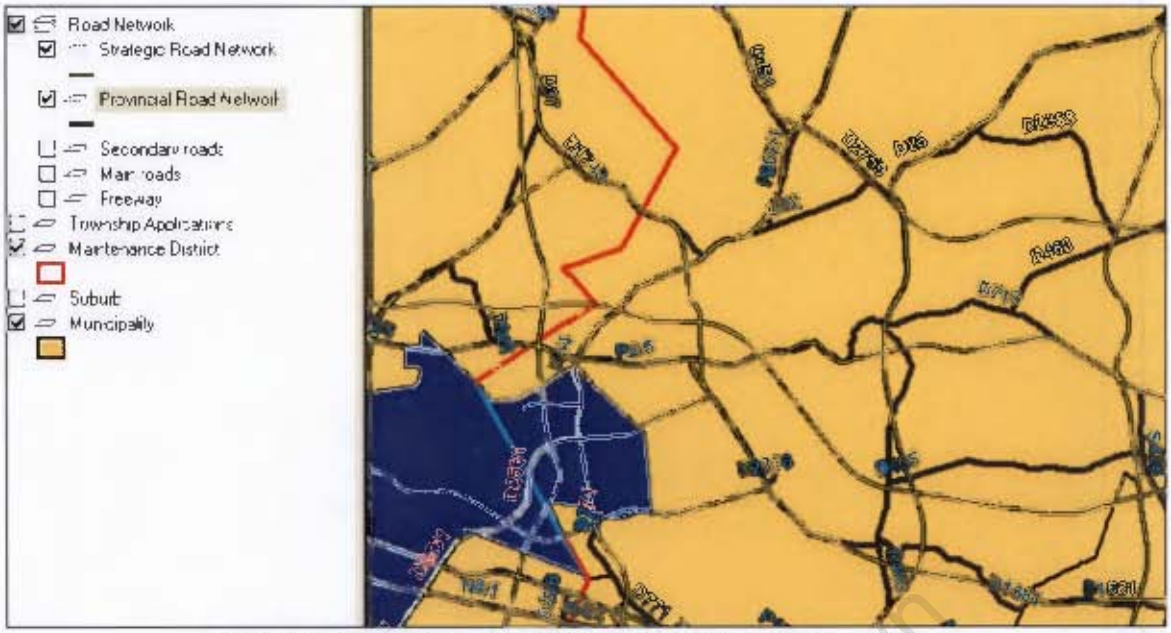

Figure 7-29: Automatic detection of affected future road

The map component provides access to road designs by following database procedures for the identification of relevant records from the DMS. This process is presented by Figure 7-22. 500m buffers are spatially calculated and indicated around the SPTN to adhere to land-use and public transport assessment business rules. Base layers, providing ample details of the environment surroundings assist the technical and land-use/public transport assessors in their decision-making.

It is imperative that the following key datasets are included on the map: SPTN, SMRN, national roads, municipal roads, aerial photography, railway infrastructure and stations, bus termini and stops, road signs, advertisements along provincial roads, built-up areas, population densities, airports, town and suburb boundaries, municipal boundaries, cadastral boundaries, SDF, town planning schemes, IDP projects, traffic counting stations with statistics, wayleaves, culverts, gantries, bridges and Gautrain planned route and stations. Figure 7-30 provides a number map layers displayed by a GIS desktop mapping tool. Not all layers are activated, in order to ensure optimal map performance over the local area network (LAN). Users are able to activate layers from the interactive legend, according to need.

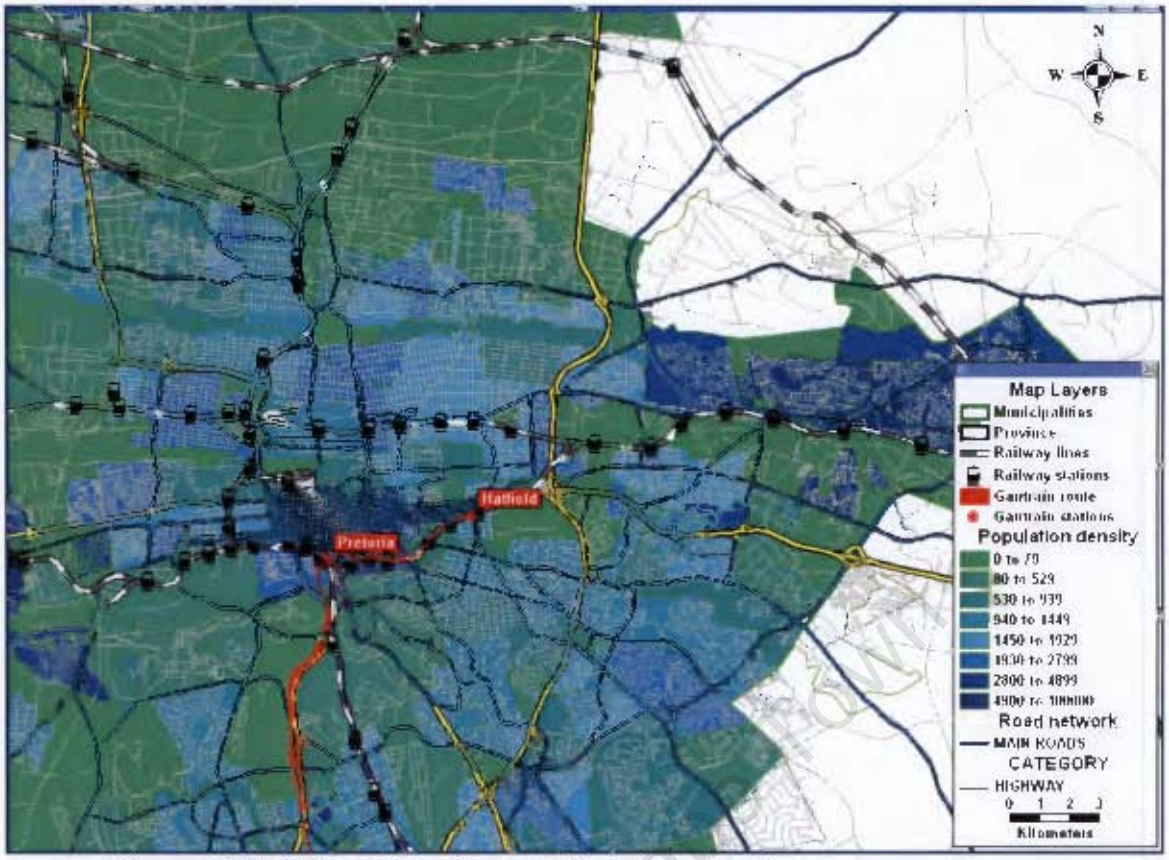

Figure 7-30: Selected base layers to be included in the map component

7.8.5 Monitoring map

The location and status of all applications, including historical applications and the conditions of approval of gazetted applications, are provided on the monitoring map. This information allows the estimation of development trends, and the establishment of whether or not plans and programmes, for both land-use and transport, e.g. Integrated Transport Plan (ITP) and Integrated Development Plan (IDP), require amendment or adjustment. The map enables the strategic evaluator to monitor developing trends and compare the building plans, applications and approved applications with the spatial form prescribed by the development frameworks and town planning schemes. The LUTC members discuss discrepancies at frequent meetings and intervene on a high level, by providing input to municipalities as part of the revision of their plans, and amend regulations in extreme cases and circumstances.

Figure 7-31: One of various layers enabling monitoring of development trends: The location of applications and gazetted applications

This chapter described the functional design of the envisaged solution. Selected functional screen designs and process flow diagrams were provided (refer to Appendix B for additional screen layouts not included in the chapter). These designs will serve as a basis for programming, and have been developed in cooperation with the client and all role-players, including potential system users. The product life cycle model selected in Chapter 5 was applied during the design of each component of the GIS solution. The results of the SWOT analysis obtained from Chapter 6 were taken into account when applying the User Centered Design (UCD) and participatory design principles. A synopsis of GIS features and design details for integration with existing systems were discussed, as closure to this chapter. Chapter 8 will focus on the evaluation of the final product.

CHAPTER 8

EVALUATION OF THE FINAL PRODUCT

System development commenced soon after the finalisation of the functional specification documented in the previous chapter. The Geographic Information System (GIS) tool was developed in line with the incremental development methodology, resulting in the setup of a dedicated test environment, from where the user could provide feedback, concurrently, with the release of each component. Following the integration of all components, the final GIS tool was implemented at the client's premises for an evaluation period, allowing for a comprehensive review of system capabilities and usability, from the users' perspective.

This chapter, firstly, aims to compare the system that was actually developed and deployed, with the ideal system envisioned in Chapter 7. Components excluded from this phase of the system are identified, and a rationale is provided for the exclusion. Secondly the chapter investigates the utilisation of the tool by the Sub-directorate Ribbon Development, in relation to the actual requirements arising from the daily tasks of assessing applications for change in land-use. Feedback from users is summarised in consolidated System Usability Scale (SUS) test results.

8.1 Outstanding components

The logical departure point for this chapter is the comparison of the comprehensive design compiled in the previous chapter, and the system development actually performed. The purpose of Chapter 7 was not only to design a system that would potentially be funded by the Gauteng Department of Public Transport, Roads and Works (GPTRW) project, but also to include advanced system features and technology in the design of a comprehensive GIS, in order to put on paper the best possible system, which would provide for all the business requirements and user needs. In reality not all system components could be developed, due to the financial, data-related and technical constraints.

8.1.1 Datasets and data-related items

The ideal system is designed based on the underlying assumption that all the required datasets will be available and be maintained in a suitable spatial format. Two types of datasets, namely town planning schemes and the Spatial Development Frameworks (SDFs), could not be prepared as part of the GPTRW process.

The reasons for exclusion of these datasets are:
- The level of detail of the SDF and town planning schemes respectively differ,
- There is an inconsistency in the use of terminology and spatial presentation,
- Some information would require the interpretation thereof in the context that it was drawn from,
- Most SDFs are not readily available in electronic format or in spatial data format,
- Some planning areas are subject to more than one SDF, but at different levels of detail, and therefore overlap, and
- Some areas entirely lack an SDF.

In addition to the outstanding data items, in-house maintenance of the spatial data is also not considered to be a suitable approach, due to the widespread lack of GIS skills. The following components and features were not developed due to data-related issues:
- Map intelligence for identification of affected roads,
- Publishing of public pages with restricted access granted to the municipalities and town planners, and
- Functionality to view previous applications on the same property.

The implication of the above-mentioned exclusions can be managed in the short-term, as the components and features do not form and integral part of the critical solution, and are not required for the day-to-day operations of the Sub-directorate. The collection, processing and maintenance of the spatial data are, however, important for the survival and maximum exploitation of the system in the future. This argument will be discussed in more detail in the subsequent chapter, which is concerned with conclusions and recommendations.

8.1.2 Technical constraints

The following technical constraints prevented the full development and utilisation of the ideal system:

- The system could not be made available on the World Wide Web, due to Information Technology (IT) architecture constraints driven by hardware and network policies in GPTRW. The system is, however, web-based, and can therefore be accessed by all users on the Gauteng provincial Local Area Network (LAN),
- A real-time link to the TAZ model could not be established or automated due to the fact that the TAZ system is not web-based and its data is not hosted in a central data repository,
- A real-time link to the EMME2 model could not be secured, as the EMME2 system is not web-based. Furthermore, the data is not hosted in a central data repository and the base data used in the EMME2 model is not compatible with the spatial base data, and
- The maintenance of the file number look-up table could not be implemented, due to the decentralised database locations of the filing system modules currently in use by GPTRW.

8.1.3 Operational constraints

The operational constraints limiting the full deployment of the solution include the following matters:

- The Drawing Management System (DMS) Roads is not properly maintained by the directorate responsible for it, therefore the functionality developed to enable technical users to access the relevant road design plans for existing and planned roads, cannot be fully utilised.
- In-house maintenance of the spatial data is not possible, due to the lack of GIS skills. Therefore, the functionality designed for the uploading of updated spatial datasets as well as the in-house maintenance of the townships layer, cannot be fully utilised.
- The Land-Use and Transport Committee is not operational to date,
- To date, due to vacancies in key positions in the Sub-directorate, strategic intervention has not taken place, and
- Public transport and land-use assessment of applications has not been addressed, due to capacity constraints and a high staff turnover.

8.2 Consolidated results from SUS testing

8.2.1 Defining usability

The International Standards Organisation (ISO) provides a number of standards by which usability can be evaluated, depending on the context of the tool under investigation.

According to the ISO 9241-11 standard (Guidance on Usability, 1998), usability is the extent to which a product can be used by specified users, in a predefined context, to achieve specified goals with effectiveness, efficiency and satisfaction. Accordingly, this standard requires that usability measures should include the evaluation of effectiveness (the ability of users to complete tasks using the system, and the quality of the output of those tasks), efficiency (the level of resource consumed in performing the tasks) and satisfaction (users' subjective reactions to using the system).

According to the ISO/IEC 9126 standard (Software product evaluation - Quality characteristics and guidelines for their use, 1991), usability is a set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users.

The ISO/IEC FDIS 9126-1 standard (Software Engineering - Product quality - Part 1: Quality model, 2000) further defines usability as the capability of the software product to be understood, learned, used and appear attractive to the user, when used under specified conditions.

8.2.2 Selecting an evaluation method

Various Internet resources were explored in order to obtain a suitable standard set of questions and an uncomplicated method of analysing the test results. Two appropriate tests were discovered:

Website analysis and measurement inventory

Website Analysis and Measurement Inventory (WAMMI) is an evaluation tool developed particularly for websites and was developed in 1999. It consists of 20 questions addressing overall usability, attractiveness, control, efficiency, helpfulness and learnability. The user is required to respond to questions by allocating a grade between 1 and 5, where 1 is the maximum value on the scale for a positive response. If the user is not able to answer a question, the value 3 is selected, indicating an impartial response.

System usability scale testing

System Usability Scale testing (SUS) is a simple usability metric, containing ten key questions on system usability. The questions were developed in 1986 and SUS is still considered a popular method for obtaining user feedback. The user is required to respond to questions by providing results between 1 and 5, where the value 5 is the maximum positive reference on the scale. If the user is not able to answer a question, the value 3 is automatically selected as the impartial response.

SUS was selected as the most appropriate evaluation method. The reasons for this being that SUS is focussed on system related questions, while WAMMI is designed for websites. In addition, the ten questions provided by SUS are considered to be the more user-friendly option, compared to the 20 questions from WAMMI. As the general attitude towards questionnaires is a negative one, users would rather answer

ten questions than spend double the effort in responding to 20 questions. The method of processing SUS results is also clearer than with the WAMMI calculations.

8.2.3 Conducting the tests

Selected system users and testers were requested to complete the SUS tests. The questions provided to the users comprised the standard SUS questionnaire (Brooke, 1986):

1. *I think that I would like to use this system frequently*
2. *I found the system unnecessarily complex*
3. *I thought the system was easy to use*
4. *I think that I would need the support of a technical person to be able to use this system*
5. *I found the various functions in this system were well integrated*
6. *I thought there was too much inconsistency in this system*
7. *I would imagine that most people would learn to use this system very quickly*
8. *I found the system very cumbersome to use*
9. *I felt very confident using the system*
10. *I needed to learn a lot of things before I could get going with this system*

Testers were requested to evaluate components relevant to their operational responsibilities. From the eight testers selected, the following components were evaluated (a tester could evaluate more than one profile):

- System administrator profile: 4 testers,
- Administrative profile: 3 testers,
- Technical profile: 4 testers, and
- Strategic / monitoring profile: 3 testers.

8.2.4 Test results

Test responses were collected from the testers, were processed in order to obtain the rating of the system. The calculation of the scores included the following steps:

1. Summation of the score contributions from each item. Each item's score contribution could range from 0 to 4.
2. For items 1, 3, 5, 7 and 9 the score contribution was calculated as the scale position minus one.
3. For items 2, 4, 6, 8 and 10, the contribution was calculated as 5 minus the scale position.
4. Multiplication of the sum of the scores by 2.5 obtained the overall value of SU.

SUS scores have a range of 0 to 100. The processed results scored the system components with the following rankings:

Table 8-1: SUS scores

Component / User group	Ranking
System administrator profile	69.4
Administrative profile	63.3
Technical profile	66.3
Strategic / monitoring profile	70

The value added by receiving tangible feedback from system users, provides a proper credibility check. However, Brooke (1986) notes that, in general, the collective pool of users constantly changes, so that usability evaluation should be a periodic, ongoing process and not a one-time event.

Appendix C provides the results of the test for evaluating the utility of the tool in the daily tasks of assessing applications for change in land-use, as performed by the Sub-directorate Ribbon Development. This chapter concludes the practical and factual section of the thesis. Chapter 9 is the final chapter and will focus on conclusions drawn from the study, make research recommendations as well as recommendations regarding the proposed future actions to be undertaken by GPTRW.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions drawn from study

The following objectives have been reached:

It has become evident that the Sub-directorate responsible for the evaluation of applications for change in land-use and selective monitoring of land-use development was not equipped with the necessary tools for administering the workload. As stated previously, approximately 1 000 applications are submitted on a monthly basis to Gauteng Department of Public Transport, Roads and Works (GPTRW).

Integration of land-use and transport, development of information systems and sharing of data between government spheres motivated by legislation

The literature review of relevant national and provincial land-use and transportation policies and legislation, specifically focussing on planning frameworks that mandate spatial and transportation planning, provided strong evidence that GPTRW has the necessary mandate to develop mechanisms and processes to assess and monitor transport related land-use development in Gauteng. In addition it became evident that GPTRW could be regarded as a planning authority in its own right in terms of protecting its Strategic Major Road Network (SMRN) and Strategic Public Transport Network (SPTN). Furthermore, the review proved that the successful integration of the two planning disciplines is dependant on the co-operation and consultation between different spheres of government. The need for co-operation was clearly demonstrated by citing requirements stipulated in relevant policies and strategies. Lastly, the development and implementation of information systems to promote information sharing and support transport planners, was supported by national legislation and provincial strategies.

System identified as a gap and considered as a priority for the development initiative

The status quo analysis conducted in order to evaluate the transport and land-use planning information systems utilised by GPTRW and two major municipalities in the study area, provided the basis for an extensive data and system gap analysis. Prioritisation applied to the results of the gap analysis, provided motivation for rating the integration of transport and land-use as primary area to require assistance from an immediate system development initiative.

Successful application of UCD principles

Extensive involvement of system users and owners contributed to the use of the dedicated user centered design approach, during which a number of philosophies and practices considered to be beneficial to this project were exercised. These included in-depth interviews, User Centered Design (UCD), Participatory Geographical Information Systems (PGIS), Human Computer Interface (HCI), Geographical Information Systems and paper prototyping. Each practice was subsequently applied to the incremental system development methodology for the design, development and testing of the system components. The suitable most suitable solution arrived at,

entailed a web-based GIS with data capturing, analysis and mapping functionalities. Despite the fact that the design included all the features of the ideal system, only selected components could be developed, due to financial, technical and data availability constraints.

Successful application of incremental system development methodology

System development commenced soon after the finalisation of the functional design. The GIS tool was developed in line with the incremental development methodology, resulting in the installation of a dedicated test environment, from where the user could provide feedback subsequent to the release of each component. Following the integration of all the components, the final GIS tool was implemented at the client's premises for an evaluation period, in order to allow for a comprehensive review of the system capabilities and the usability, from the users' perspective.

Usability testing applied as part of system evaluation

The evaluation phase investigated the utilisation of the tool in relation to the daily task of assessing applications for change in land-use, as performed by the Sub-directorate Ribbon Development. Feedback from users was summarised in consolidated System Usability Scale (SUS) test results. From this feedback it became evident that the GIS tool was considered to be a useful instrument, assisting officials with daily responsibilities.

Benefits obtained from the implementation of the GIS tool

The data capturing functionality enabled the users to capture the identified land-use applications' variables directly onto the system. The map component linked the application data to the spatial entities, through the use of the Surveyor General property data (the 21–digit code). In the case of an application for a new township, the free-hand drawing tool allowed the user to specify the footprint of the area affected by the application, on the map. The spatial representation of the application and the overlay thereof with the base spatial layers contained in the map, allowed the official to make an informed conclusion with regards to the application's impact on the GSMRN and the GSPTN. Templates of standard letters used for feedback to applicants, were populated with the details captured by the officials, obviating the need for them to complete these fields manually. An e-mail functionality was provided to enable the electronic dissemination of these letters, containing GPTRW's feedback on the assessment of the applications, to the involved municipalities and applicants.

The administration of the spatial data maintenance of new townships was enabled through a checklist and a map with thematic layers, indicating new townships for which spatial maintenance was still required. Advanced back-end procedures were developed to enable spatial updates through a user-friendly interface, to ensure that the database tables and related spatial layers were synchronised.

The map component was designed to provide access to road designs, based on database procedures for the identification of relevant records from Drawing Management System (DMS). Base layers providing ample details of the surrounding

area assisted the technical and land-use/public transport assessors in their decision-making responsibilities. The GIS tool allowed the identification of the approved applications, so that the conditions of approval could be recorded. The monitoring map was developed in order to present the location of the approved applications. From this information, approximate development trends could be inferred and the possible need for amending or adjusting plans and programmes, for both land-use and transport, e.g. Integrated Transport Plan (ITP) and Integrated Development Plan (IDP), could be determined.

It can therefore be concluded that the GIS tool did successfully address the majority of the user needs. The test results were supplemented by comments by system users indicating the desirability of developing those components that had been discontinued, as part of a complete solution, where user needs and legal requirements will be fully satisfied.

9.2 Recommendations to GPTRW and other stakeholders

As determined in the previous section, feedback from users suggested the benefits that could be obtained should the comprehensive GIS be developed and data maintenance procedures be streamlined. In the following section, recommendations to GPTRW and other stakeholders are categorised as either data related, technical and operational.

9.2.1 Data related recommendations

Obtaining outstanding datasets

Firstly it is recommended that outstanding data sets, i.e. spatial development frameworks and town planning schemes, be obtained. These datasets should be included for all areas within the boundaries of Gauteng. In future a third level of development status could be added to the system, through the capture of building plan details, which will reflect actual exercised rights. This will give an indication of the effectiveness of policies and plans in achieving integration/densification.

Enforcing data standards

Parallel to the recommendation regarding outstanding datasets, is the suggestion that GPTRW should develop a spatial data standard in order for the Land-Use and Transport Committee (LUTC) to be able to request data, manage the quality thereof, and update the system on an ongoing basis. This standard for spatial datasets to be submitted to the committee, should typically include the following key rules:

- The Spatial Development Framework (SDF) and town planning schemes of an area should be compiled in electronic spatial format and should consist of different layers,
- It should use as a basis layer the latest available cadastral information in use by GPTRW,
- Proposals contained in different SDFs, should be indicated on a layer striving to standardize terminology and map notations throughout the plan,

- Proposals through other planning initiatives such as strategic environmental areas and those contained in ITPs should also be indicated and made available in separate layers, and
- Inconsistencies and overlaps between different SDFs should be addressed, as well as the lack of SDFs, in some areas.

Ongoing data maintenance

The maintenance of the spatial data sets is considered a key success factor. Should the department not be able to obtain and build the required GIS skills in-house, they should enter into a service level agreement with dedicated experts to assist them in the maintenance of the spatial data.

9.2.2 Technical recommendations

The technical constraints highlighted in Chapter 8 had a major impact on the deployment of the total solution. The following recommendations are considered to be crucial in the success and future existence of the system:

IT architecture

GPTRW should consider upgrading their current Information Technology (IT) architecture in order to provide an infrastructure for hosting the system on the Internet. This would enable users from municipalities and town planning companies to submit their proposals and applications directly onto the system. As an alternative to hosting the system in-house, the department could also consider the appointment of a third party Internet service provider for the hosting of the site.

File administration

The centralisation of the file number administration system is regarded as a benefit that could be obtained without requiring immense effort or cost. A centralised database containing official file numbers would require the performance of fewer maintenance activities on the part of the administrative user.

TAZ model

GPTRW should investigate the feasibility of enhancing the Traffic Analysis Zone (TAZ) model. Should this model be available on the Internet, web services could be developed in order for the land-use system to read up-to-date data regarding traffic, demographics and land-use patterns from the spatial files for base year and predicted periods.

9.2.3 Operational recommendations

Filling organisational vacancies

Two crucial vacancies have been identified during the study, i.e. an official responsible for the evaluation and assessment of the land-use and public transport concerns of the development applications, as well as an expert planner to represent the Sub-directorate on the inter-governmental planning committee, as discussed in the subsequent recommendation.

Establishment of the Land-use and Transport Committee

A Land-Use and Transport integration Committee (LUTC) should be established, representing of decision-makers from both the land-use and transportation fraternities and comprising of members from both provincial and local government spheres. It is considered that integration of transport and land-use will be best achieved by the existence of such a committee. GPTRW should assert their right to assess regulations such as those being drafted in terms of the Gauteng Planning and Development Act, in order to opportunely evaluate whether the regulations facilitate or impede the integration of land-use and transport. GPTRW should also keep in contact with the Department of Development Planning during the preparation of the provincial IDP to ensure that attention is given to the integration of transport and land-use. The LUTC will play an important role in the maintenance of spatial data, provided that they frequently undertake data maintenance and oblige standard and quality control on these sets. The committee will also enable the strategic monitoring of development trends by utilising the monitoring and strategic intervention components of the system.

Enforce operations of the DMS

Sub-directorate Ribbon Development needs to liaise with Directorate Design in order to highlight the important role of the DMS in the assessment of land-use applications. Should this system not be maintained, the effort required from a technical assessor is considered to be unnecessarily extensive and time consuming.

Monitoring the GIS tool

It is recommended that the effectiveness of the GIS system be monitored on an ongoing basis and improvements made as and when required. Required system enhancements identified from the final series of interviews should be evaluated, prioritised and approved by decision-makers. Sufficient funds need to be made available to the selected service providers, to address the outstanding components and other needs. It is highly recommended that new system users should receive system training prior to system utilisation.

Ongoing maintenance of the GIS tool

It is suggested that a support service level agreement be compiled between GPTRW and system and data service providers, to ensure the constant accessibility and availability of an up-to-date system.

9.3 Research recommendations

This thesis has identified numerous areas for which more research is required. Furthermore, it is recommended that the following GIS, system development and transport- and land-use planning topics be considered for further research.

9.3.1 GIS research

The Geographical Information Systems fraternity could benefit from the following research:

- Development of spatial data standards, including surveys, desktop capturing and sourcing, and maintenance of the data for government organisations,
- Identification of methods to enforce spatial data standards in organisations for all spheres of government,
- Identification of the positive and/or negative impact of spatial data standards on the national rollout of a generic GIS tool,
- Benchmarking of existing off-the-shelf or open source GIS products in order to find the optimum GIS engines for web-based solutions, taking into account performance, cost effectiveness and ease of use, and
- Development of an optimum data maintenance and custodianship cost model for provincial government.

9.3.2 System development research

Effective and successful system development contributes a major part to a productive and economically sustainable environment. The following research topics could provide useful assistance to the designers and developers of these important systems:

- Research on the effectiveness of HCI training for programmers, and the development of methods to increase the effectiveness of such training,
- Development of coding standards for web-based GIS solutions for all major GIS platforms, and
- Identification or development of a custom evaluation model for the testing of web-based GIS systems.

9.3.3 Transport and land-use planning research

Legislation is being amended on an ongoing basis, and new policies and frameworks are constantly being introduced. This dynamic driver of business requirements for government organisations results in the scenario where the planning disciplines need to be flexible and technologically advanced. Some topics to consider as useful and applicable for supplementary research include:

- Development of a model to determine the effectiveness of the application of GIS for transport planning practices, and
- Development of a functional design for a low-cost GIS-based transport-modelling programme to replace the current legacy systems.

Chapter 9 concludes this thesis report. The subsequent sections are comprised of three applicable annexure previously referred to in the document.

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ANNEXURES

ANNEXURE A

Legislative Literature Study

FOCUS AREA	ELEMENT	SUB-ELEMENT	SOURCE DOCUMENT									
			1	2	3	4	5	6	7	8	9	10
Public Transport Operations	Minibus taxi operations (commuter)	Association details	x		x							
		Vehicle details	x		x							
		Rank operational details			x							
		Route (corridor) details			x					x		
		Service capacity			x				x	x		
		Passenger numbers			x				x			
		Service capacity utilisation			x							
		Extent of illegal operations			x							
	Minibus taxi operations (long distance)	Association details	x		x							
		Vehicle details	x		x							
		Rank operational details			x							
		Route (corridor) details			x					x		
		Service capacity			x				x	x		
		Passenger numbers			x				x			
		Service capacity utilisation			x							
		Extent of illegal operations			x							
	Metered taxi	Association details			x							
		Fleet details			x				x			
	Bus operations	Route details			x							
		Fares			x							
		Termini operational details			x							
		Timetables			x							
		Service capacity			x				x	x		
		Passenger numbers			x				x			
		Service capacity utilisation			x							
		Extent of illegal operations	x		x							
	Rail operations	Station operational details			x							
		Line details			x							
		Fares			x							
		Timetables			x							
		Service capacity			x					x		
		Passenger numbers			x							
		Service capacity utilisation			x							
	Modal integration	Fares structures / levels			x					x		x
		Integrated scheduling			x					x		x
		Tickets			x					x		x
	Accessible transport for physically challenged people	Demand for services			x					x		x

FOCUS AREA	ELEMENT	SUB-ELEMENT	SOURCE DOCUMENT									
			1	2	3	4	5	6	7	8	9	10
	Learner transport	Operational			x					x		
		Infrastructure and facilities			x					x		
		Costs			x					x		
		Institutional and management			x					x		
		Monitoring and review			x					x		
	Non-motrised transport	Description of non-motorised transport			x				x			
	Tourism	Transport needs of tourists			x				x			
	Public transport security	Personal security of passengers			x					x		
Infrastructure	Roads	Strategic road network including toll roads and strategic public transport network (planned and existing)			x			x	x	x		x
		Municipal road network			x			x				
		Provincial: Pavement condition						x				x
		Municipal: Pavement condition						x				
		Road network classification						x				
		National: Standards for planning, design, construction and maintenance of roads and infrastructure						x		x		
		Provincial: Standards for planning, design, construction and maintenance of roads and infrastructure						x		x		
		Municipal: Standards for planning, design, construction and maintenance of roads and infrastructure						x		x		
		Roadway furniture						x				
		Rest and service areas along provincial roads								x		
	Bus	Bus Masterplan			x							
		Stops / halts details			x							
		Termini details			x							
		Depot details			x							
		Termini capacity utilisation			x							
	Taxi	Stops / lay byes details			x							
		Ranks / holding areas details			x							
		Rank capacity utilisation			x							
	Rail	Rail network			x				x	x		
		Rail facilities (stations)			x					x		
		Line capacity utilisation			x							

FOCUS AREA	ELEMENT	SUB-ELEMENT	SOURCE DOCUMENT									
			1	2	3	4	5	6	7	8	9	10
	Modal Transfer	Location of network and multi modal transfer facilities			x							x
		Types of Modes (estimate of peak-hour and and 24-hour modal choice statistics)			x							x
	Pedestrian and cyclists	Pedestrian facilities								x		x
		Cycle facilities								x		x
	Metered taxi	Holding areas			x							
	Development and maintenance	Prioritised list of facilities (including budgets)			x				x	x		
		Prioritised list of infrastructure (including budgets)			x				x	x		
		Approved panel of consulting engineers								x		
	Land acquisition	Description of road reserves to safeguard (planned and existing)								x		
		Land required for transportation facilities								x		
	Other major trip generating transport facilities (inland ports – City Deep)	Location								x		
		Access requirements / control								x		
	Backlogs	Statement of any backlogs that exists in transport infrastructure provision			x							
Traffic Operations	Traffic movements	Vehicle counts and occupancy rates								x		
		Traffic forecasts								x		
	Traffic control	Traffic signage		x						x		
		Traffic signals		x								
	Congestion management	Congestion alleviation projects										x
	Travel demand management	Travel demand management programmes and projects			x							
Road Traffic Management	Road traffic safety	HAZLOC / hazardous locations		x						x		x
		Accident frequency (private and public transport)		x						x		x
		Accident / vehicle types (private and public transport)		x						x		x
		Accident severity (private and public transport)		x						x		x
		Research projects and programmes		x						x		
	Law enforcement	Moving violations / speed limits		x								
		Overload control		x	x							x
		Law enforcement programmes and actions								x		

FOCUS AREA	ELEMENT	SUB-ELEMENT	SOURCE DOCUMENT									
			1	2	3	4	5	6	7	8	9	10
	Hazardous loads and dangerous substances	Permit details		x								
		Restricted routing		x	x					x		
		Monitoring overall movement of hazardous loads / substances		x						x		
	Incident management (involving hazardous materials)	Plan and programmes			x					x		
	Training, skills development and capacity building	Public transport industry: training programmes (especially the taxi industry)								x		x
		Driver, pedestrian and scholar training programmes in road safety								x		x
	Pedestrian management	Accident statistics										x
		HAZLOC / hazardous locations										x
		Projects										x
	Intelligent transport systems measures	Intelligent transport systems measures details			x							
	Registration and licencing of motor vehicles	Details relevant to registration and licencing of motor vehicles		x								
		Details regarding fitness of vehicles / roadworthy certificate		x								
	Manufacturers, builders and importers of motor vehicles	Details regarding manufacturers, builders and importers of motor vehicles		x								
	Driving licences and permits	Classification and extent of learner's licence or driving licence		x								
		Details regarding professional driving permits		x								
		Details regarding operator fitness		x								
Public Transport Regulation and Control	Tenders	Specifications for contracted public transport services					x					
	Registration of associations and members / non-members	Registration details					x					
	Operating Licences	Details regarding applications received					x					
		Particulars of holders of operating licences and the vehicle specified					x					
		Particulars to be published by Board regarding the application for an operating licence					x					
		Policy Framework (including for disposal of operating licences and rationalisation process)			x							

FOCUS AREA	ELEMENT	SUB-ELEMENT	SOURCE DOCUMENT									
			1	2	3	4	5	6	7	8	9	10
	Transport subsidies	Tendered Bus Contracts/ Bus Subsidy Information System (SUMS)								x		x
		Rail contracts / subsidies								x		x
	Transport appeals / Conflict Resolution	Transport appeals: Minutes and proceeding details								x		
Land Use	Spatial framework	Provincial integrated development / planning framework (spatial, economic and housing)			x				x	x		
		Municipal integrated development / planning framework (spatial, economic and housing)			x							
		Land use and development proposals and applications								x		x
	Mixed land use	Types of land uses			x					x		
		Extent of land uses			x							
	Corridors	Transport and land use corridors and nodes			x				x	x		

ANNEXURE B

Functional Screen Designs

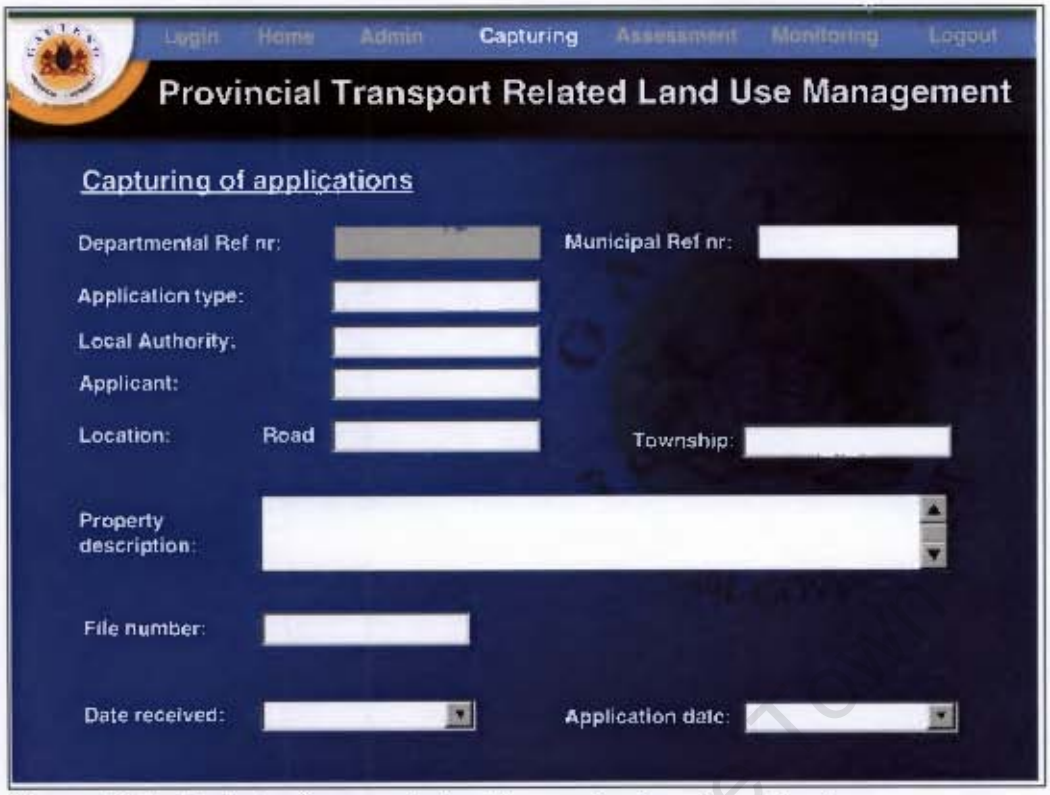

Figure B-5: First draft page design for capturing of applications

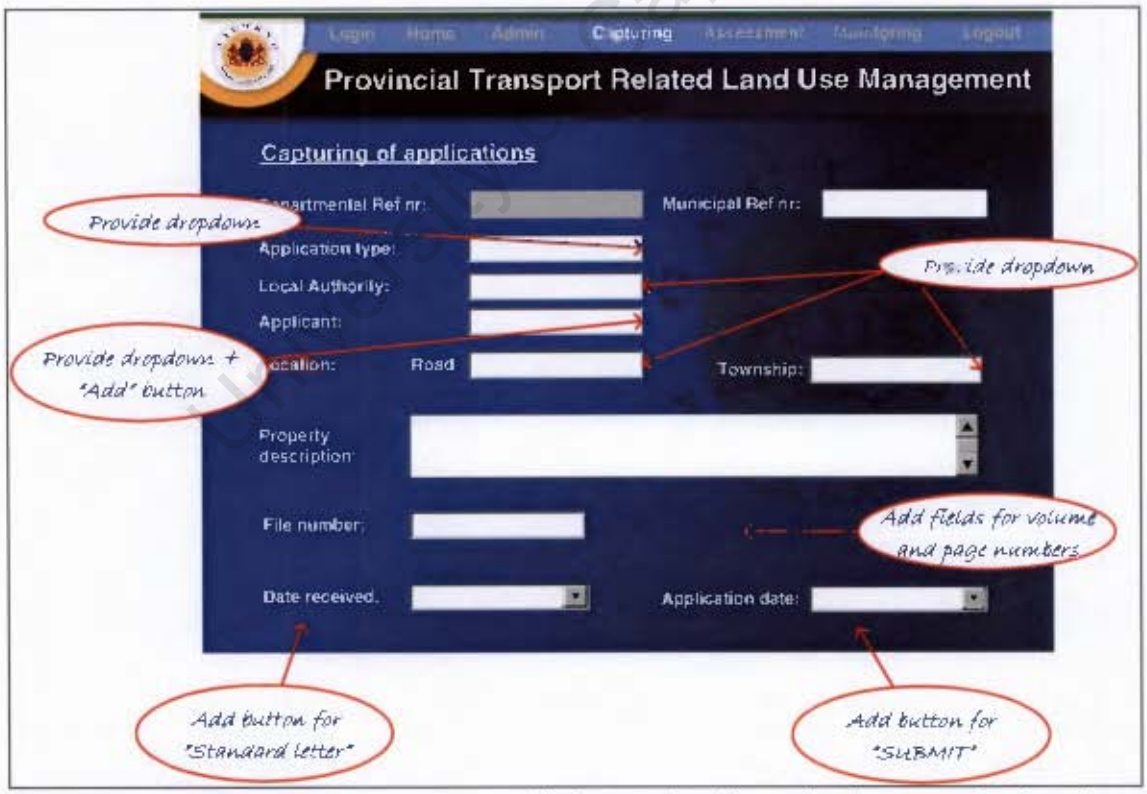

Figure B-6: Paper prototyping applied to the first draft page design for capturing of applications

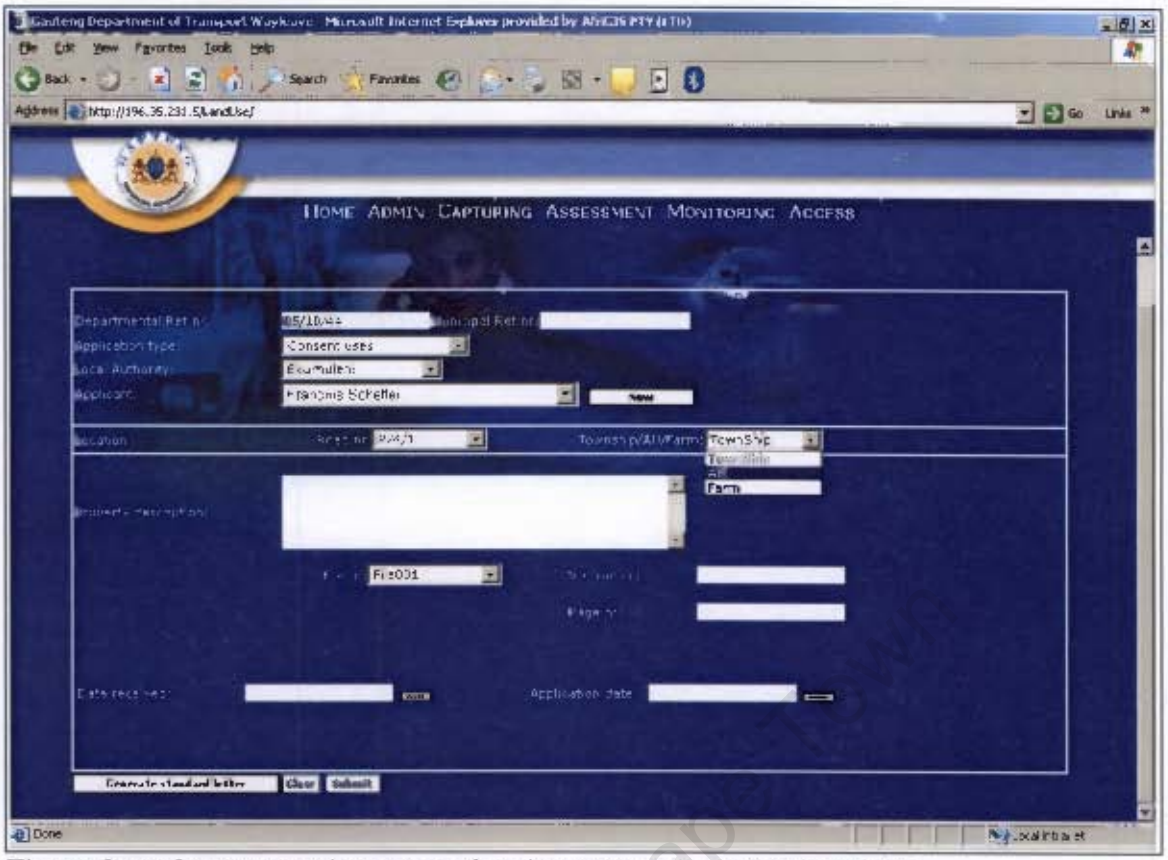

Figure B-7: Second draft page design for capturing of applications

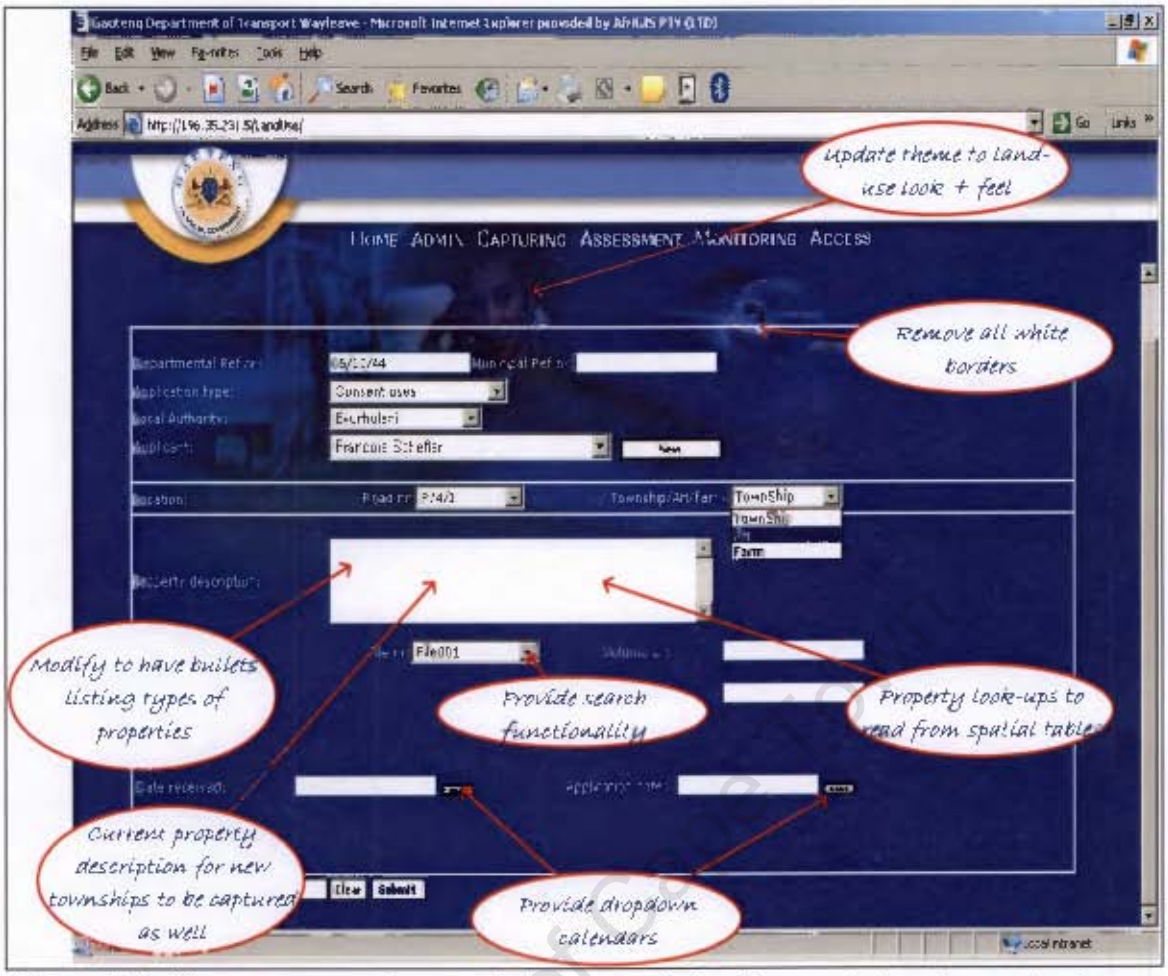

Figure B-8: Paper prototyping applied to second draft page design for capturing of applications

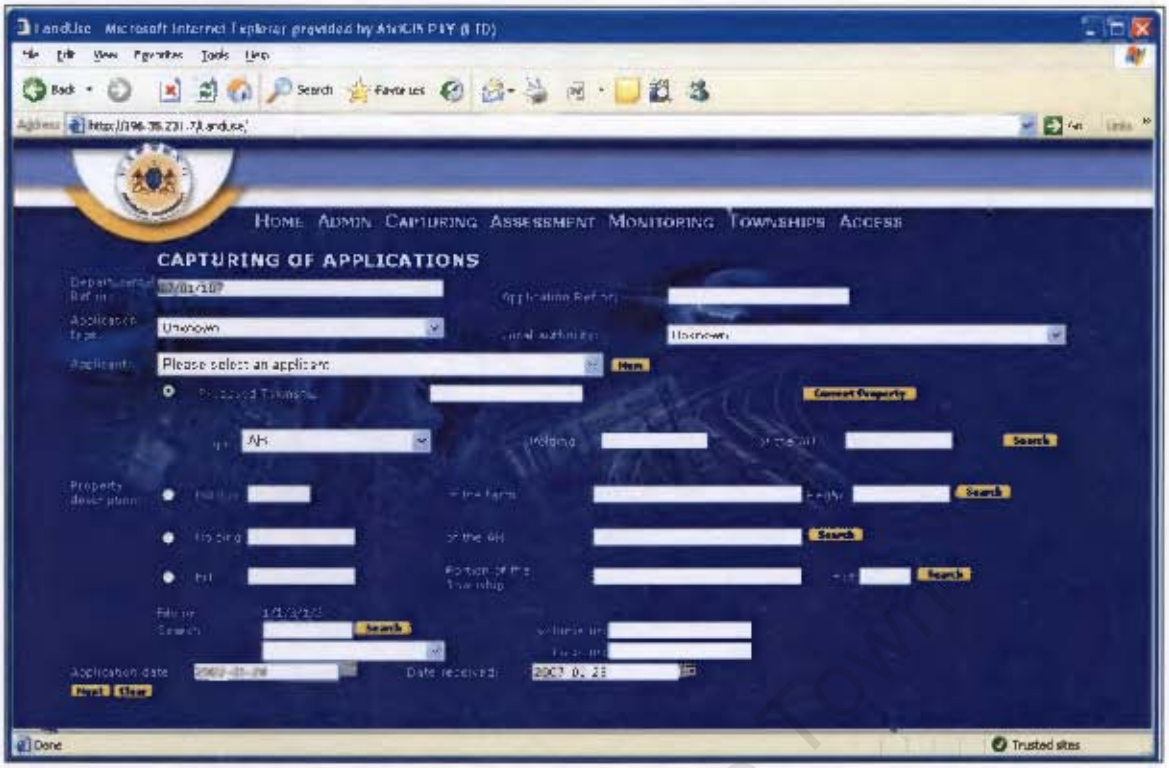

Figure B-9: Final page design for capturing of applications

Figure B-10: Paper prototyping applied to draft design for maintenance of applicant look-up table

Figure B-11: Paper prototyping applied to draft design for maintenance of applicant look-up table

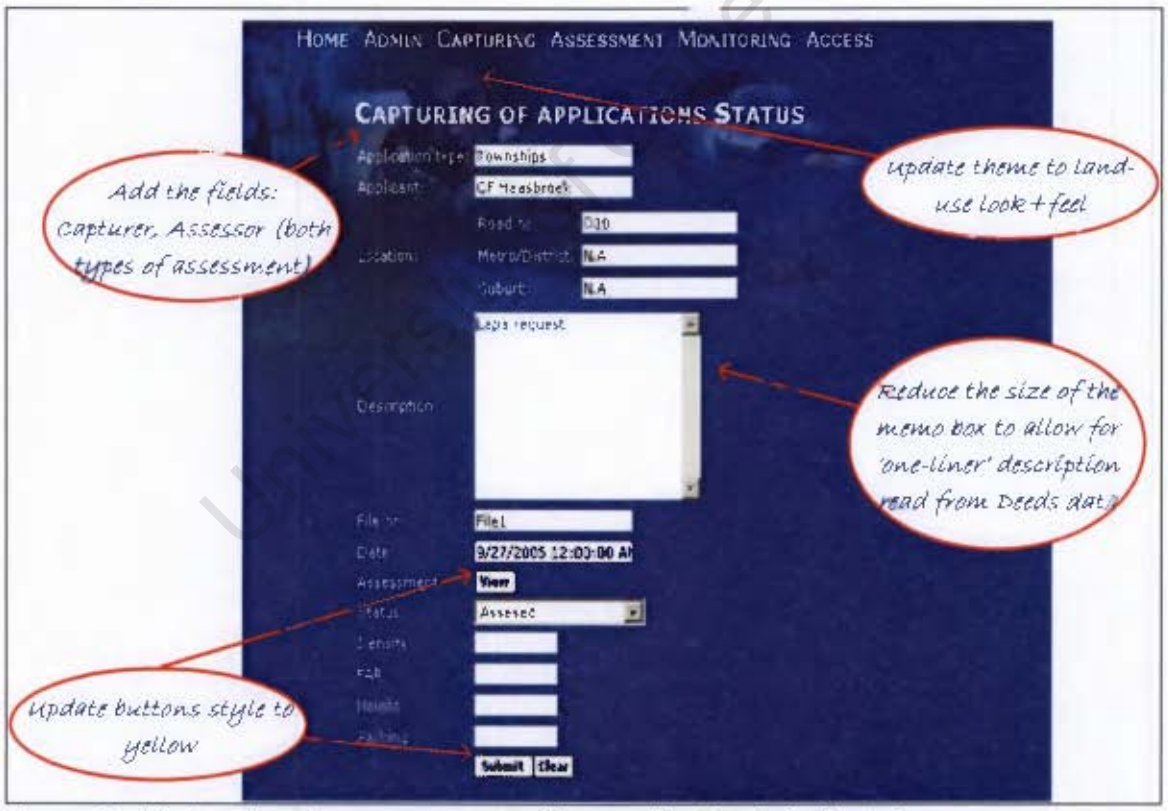

Figure B-12: Application status page with user feedback indicated

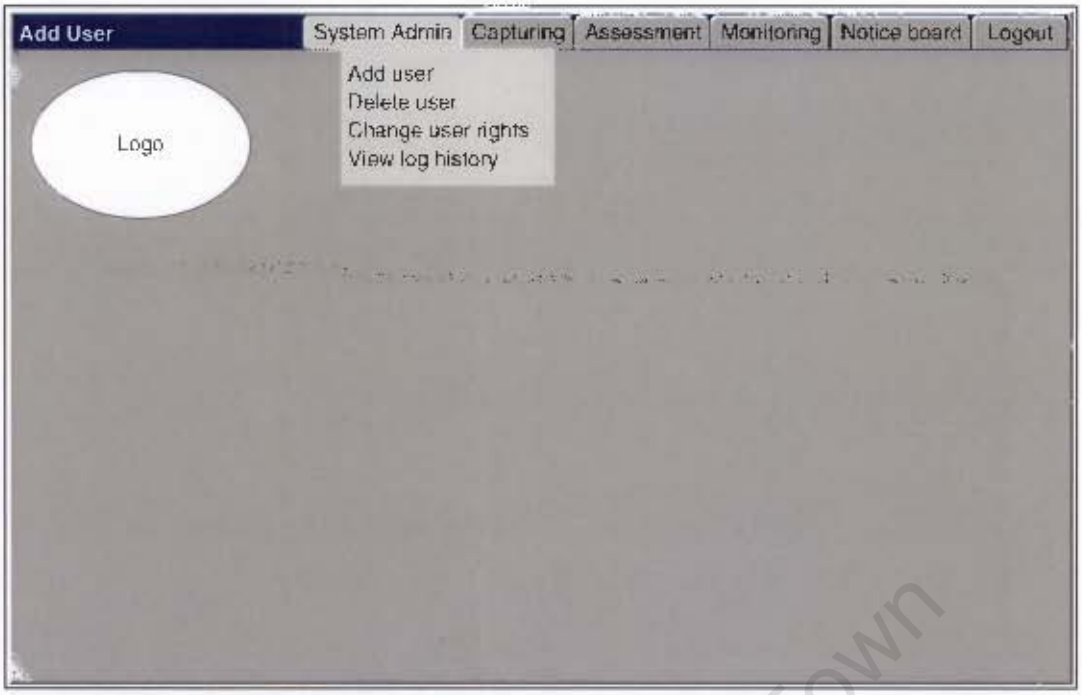

Figure B-1: First draft user administration screen design (Menu structure)

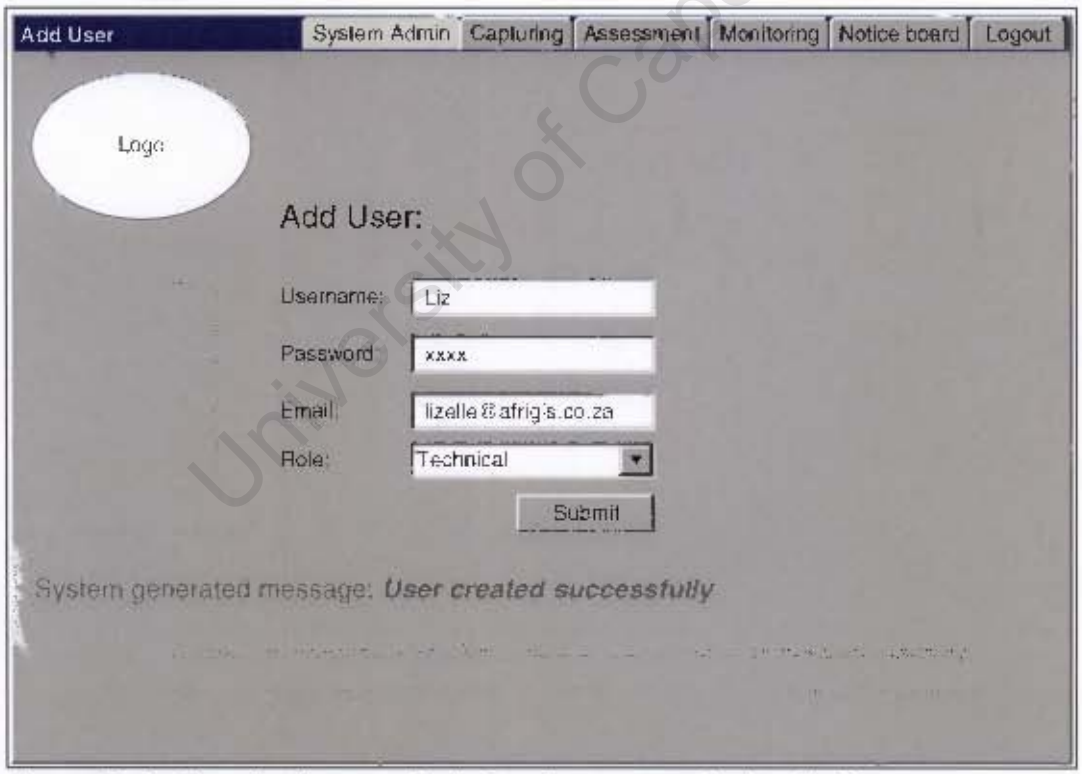

Figure B-2: First draft user administration screen design (Add user)

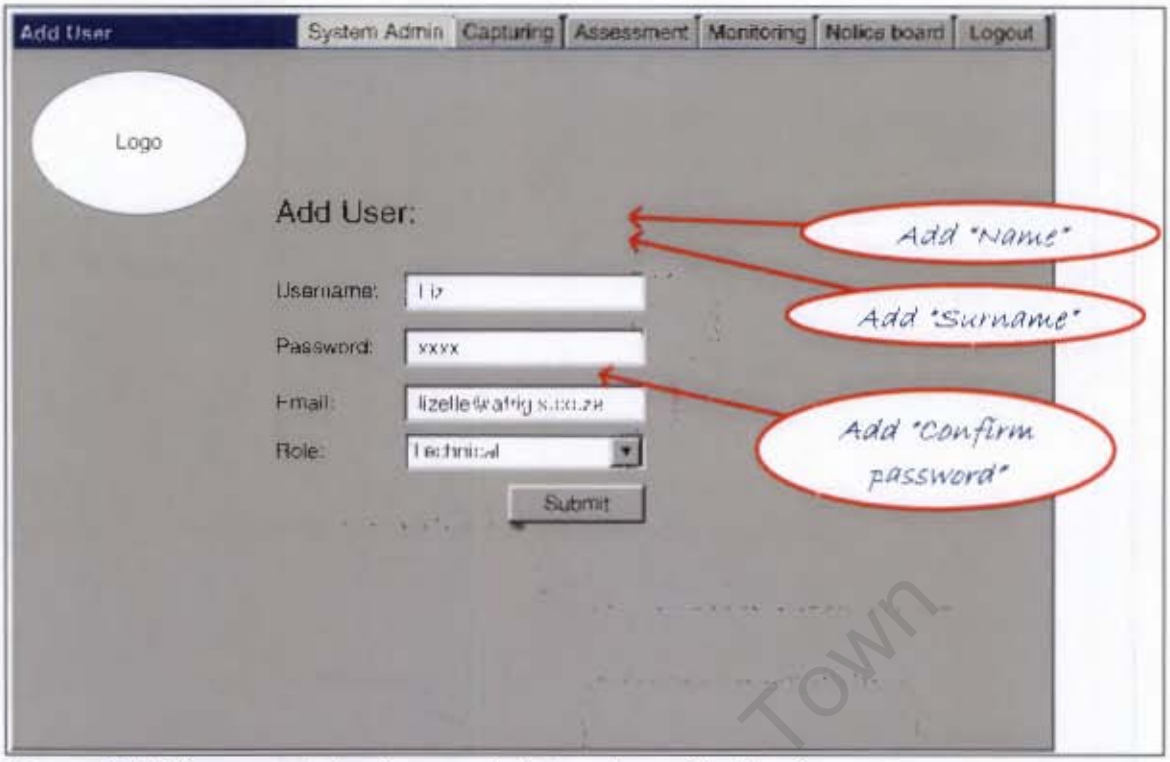

Figure B-3: Paper prototyping applied to get user feedback

Figure B-4: Final user administration screen design

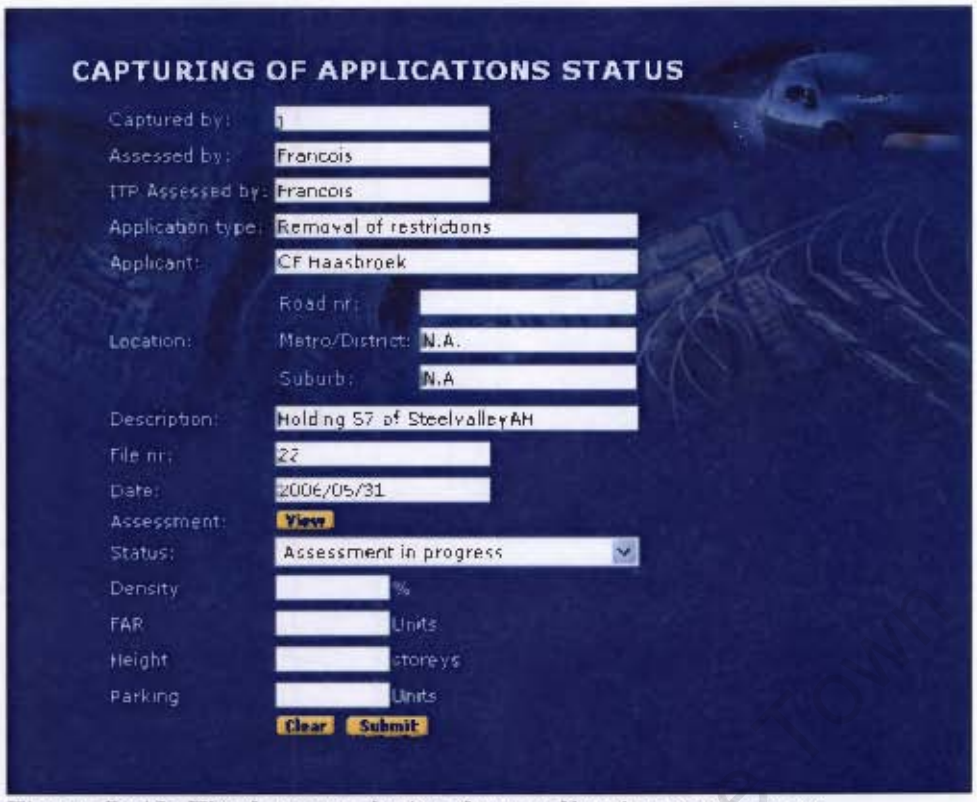

Figure B-13: Final screen design for application status page

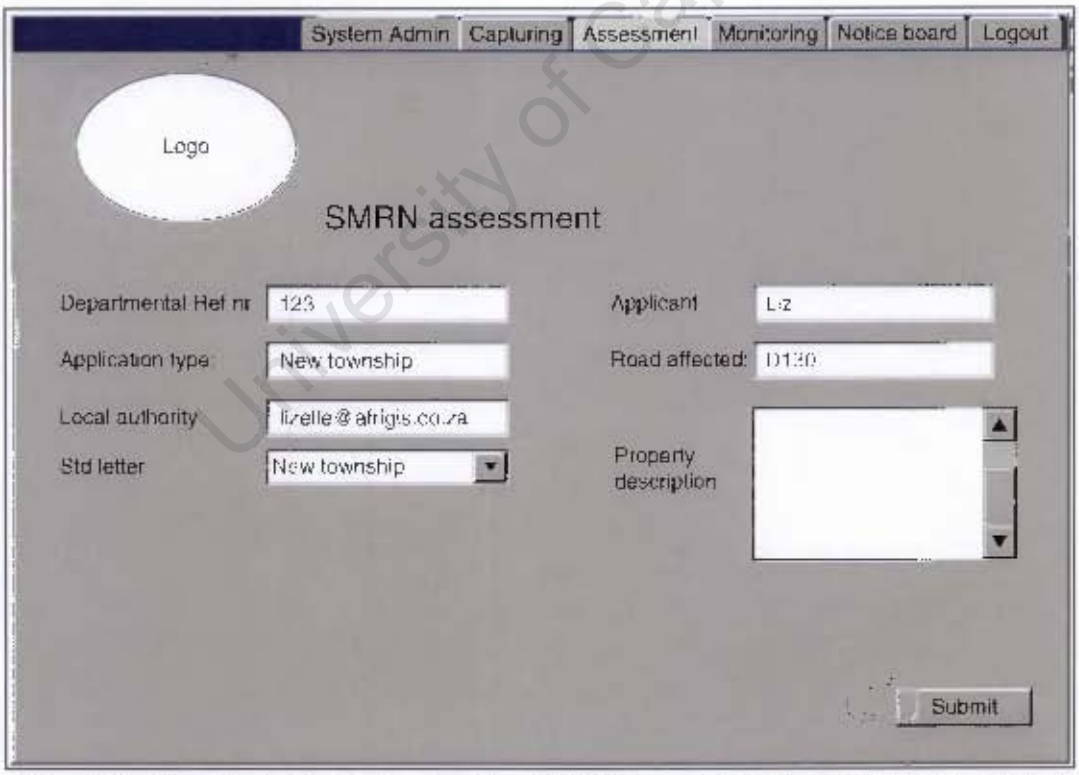

Figure B-14: First draft design for SMRN protection assessment (Standard assessment)

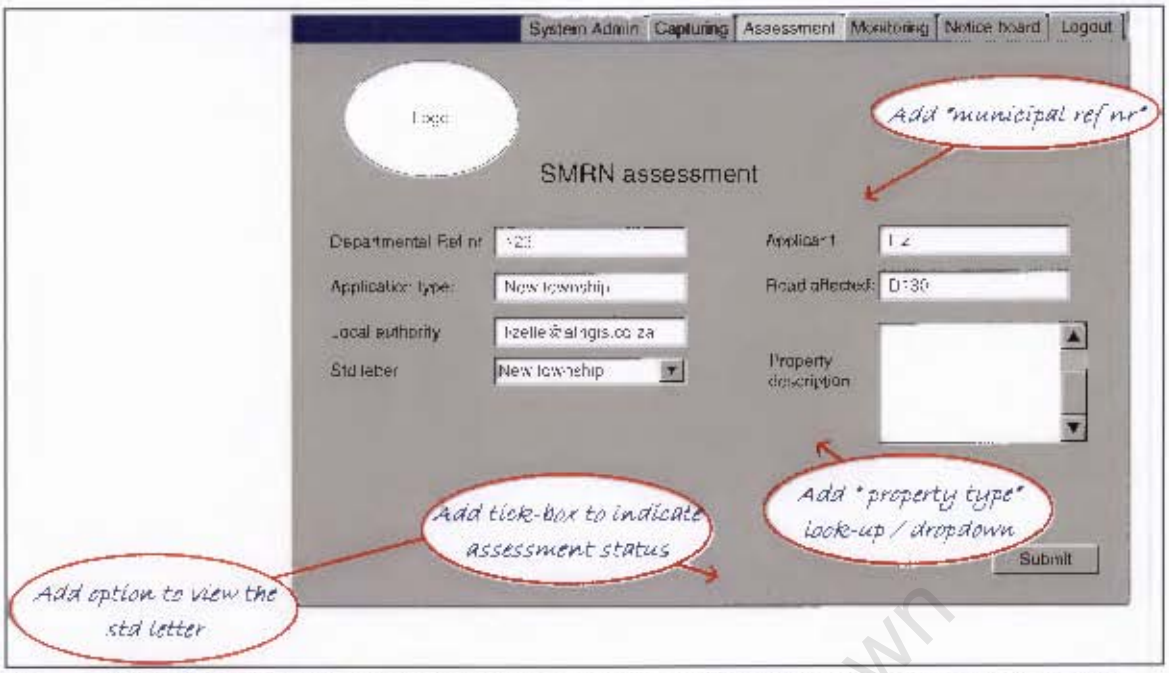

Figure B-15: User feedback indicated on first draft Standard assessment screen design

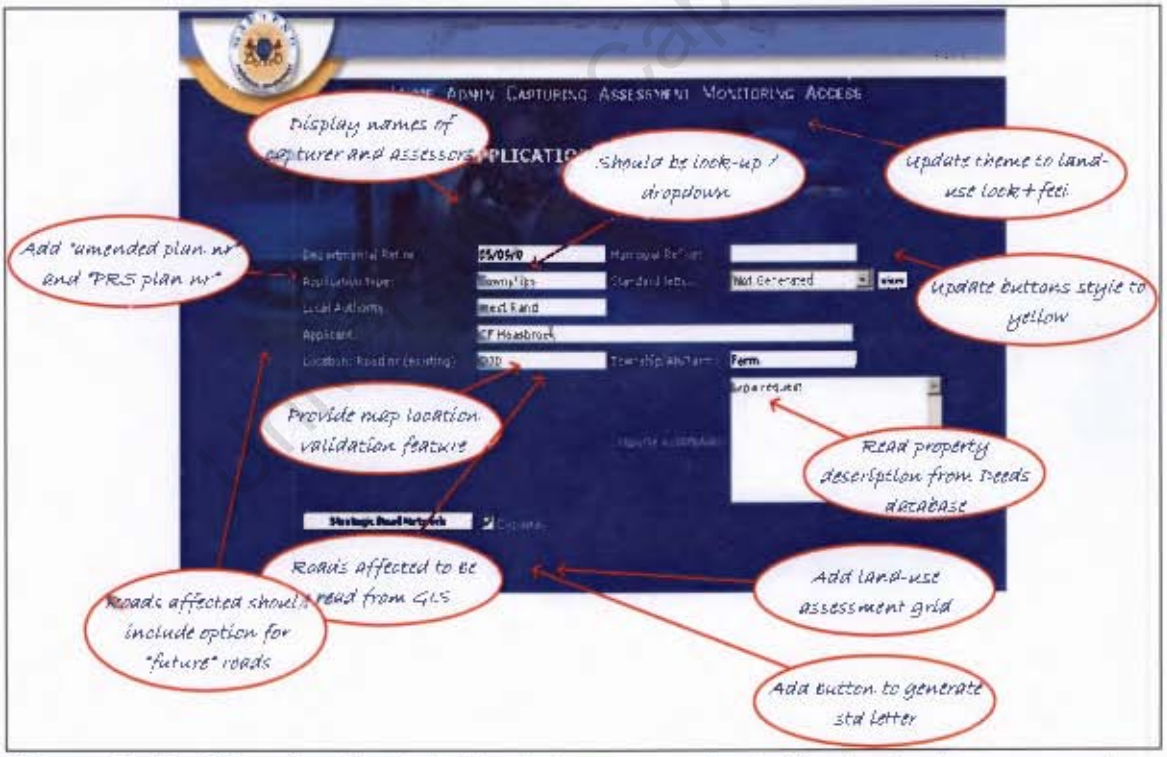

Figure B-17: User feedback indicated on second draft standard assessment screen design

Figure B-18: Final page design for search results from which user select application to assess

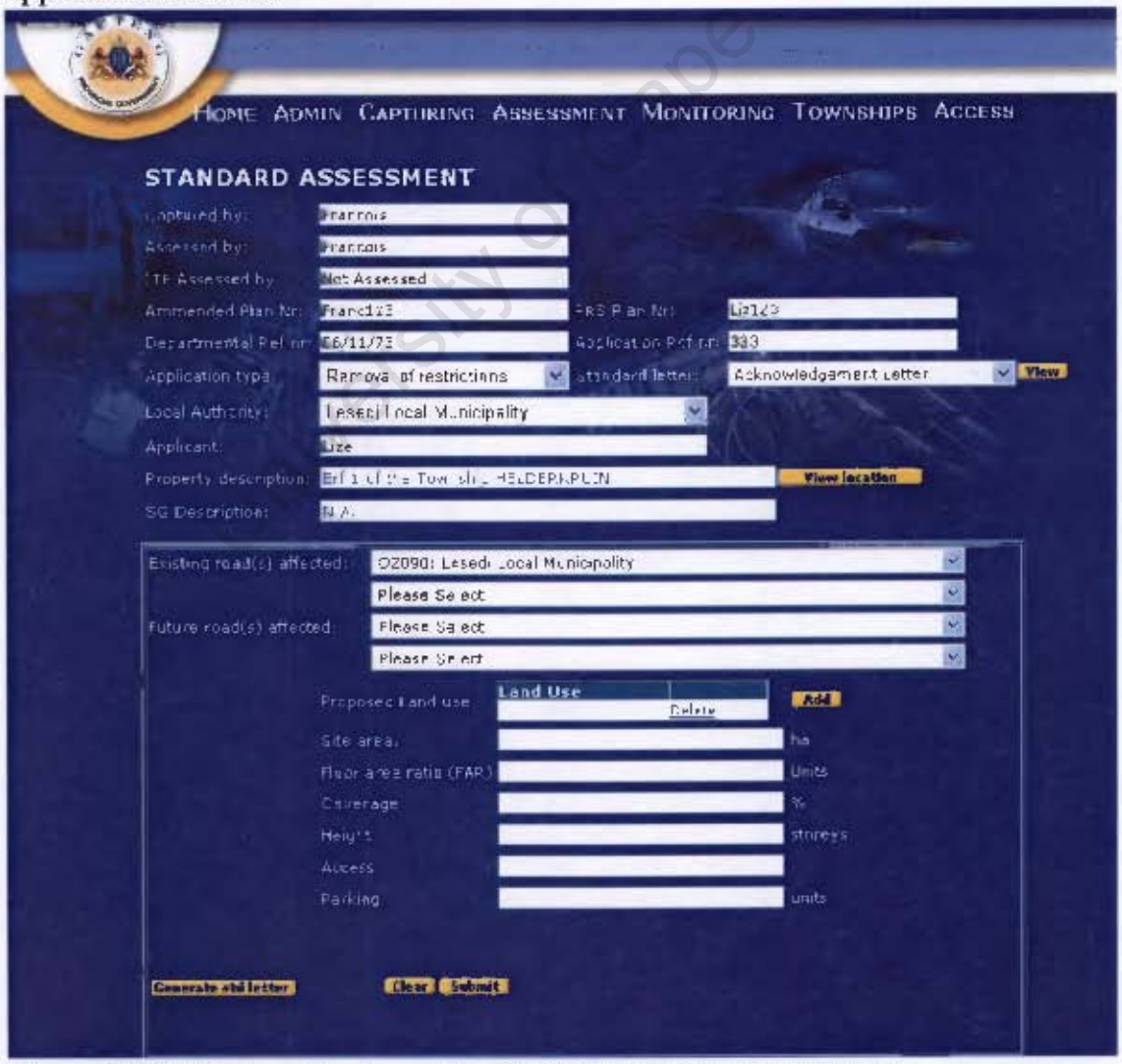

Figure B-19: Final screen layout for SMRN protection assessment

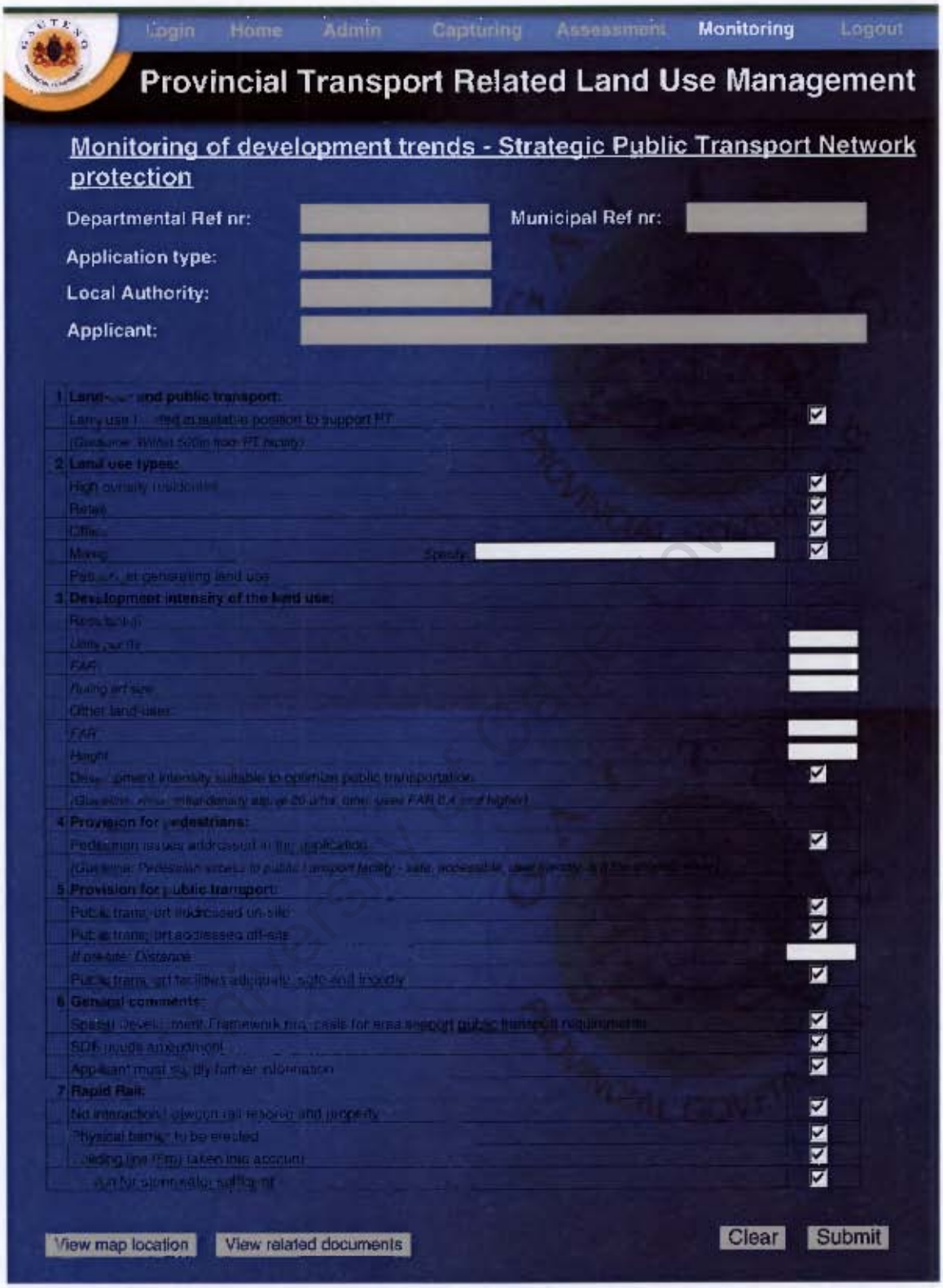

Figure B-20: Draft design for assessment of SPTN protection and land-use aspects of applications

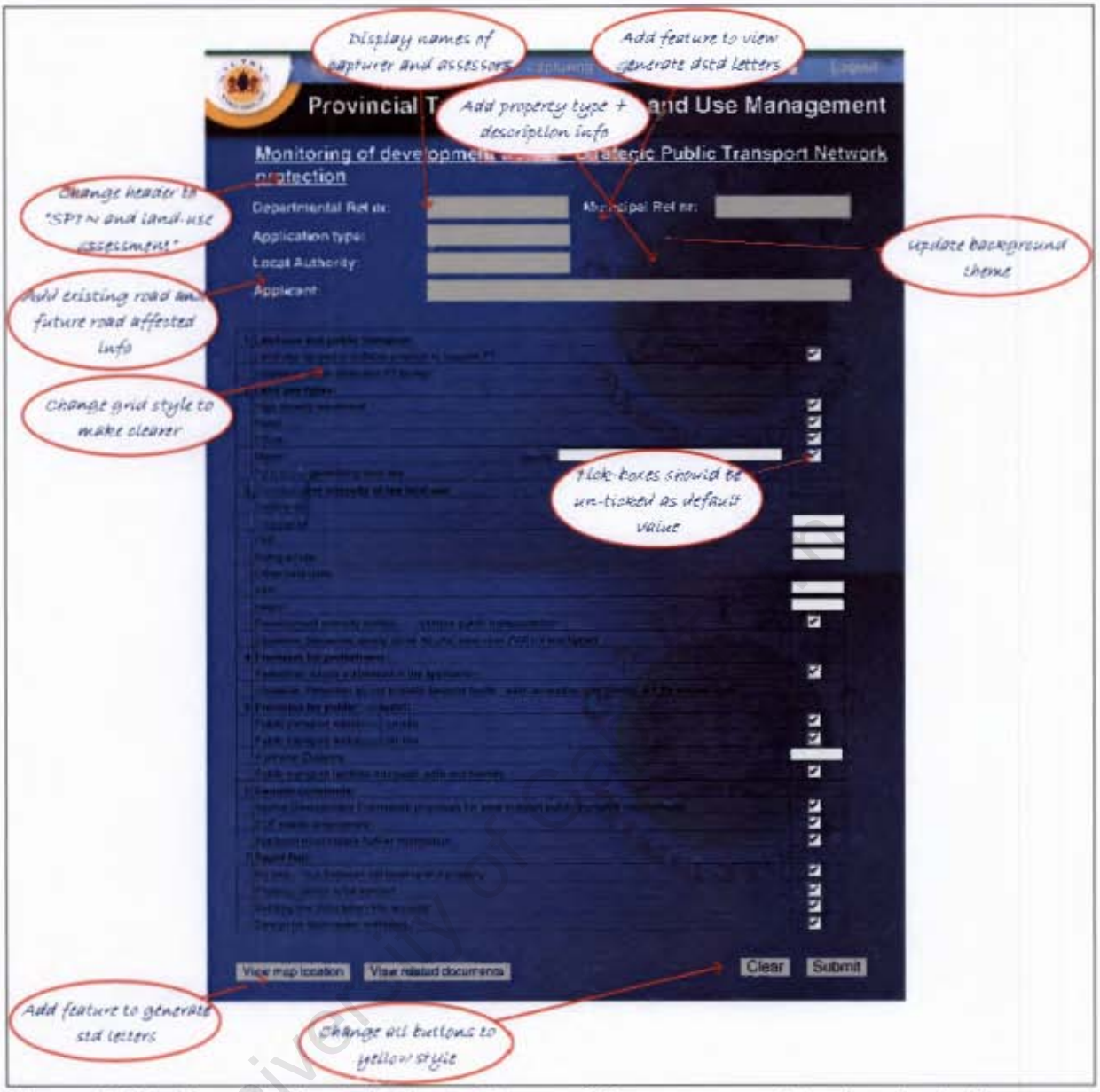

Figure B-21: User feedback indicated by applying paper prototyping to draft SPTN assessment page

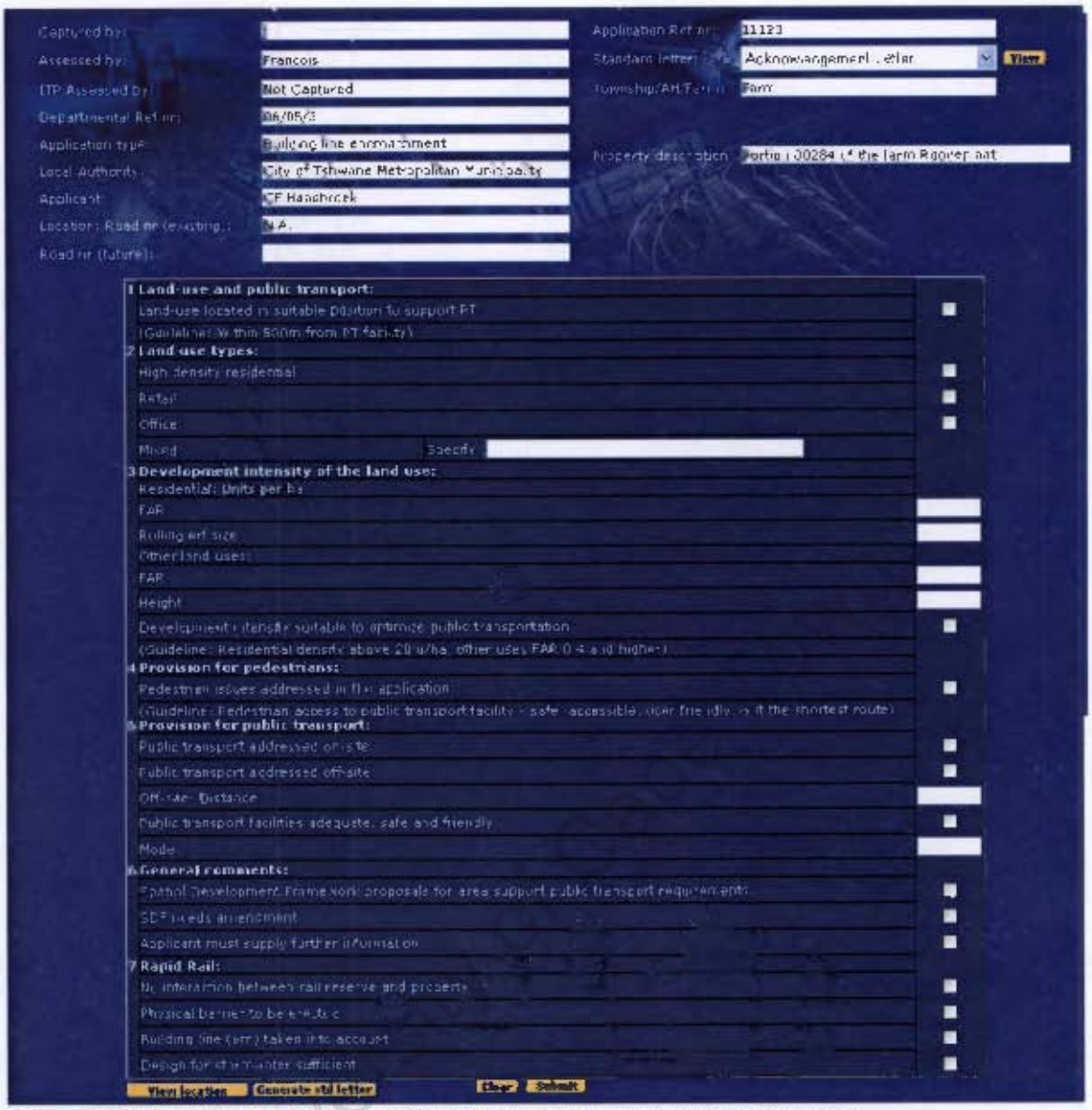

Figure B-22: Final page design for SPTN and Land-use assessment

ANNEXURE C

SUS Testing Results

C.1 System Administration

Table C.1: User 1 – Francois Scheffer

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently				x	
2	I found the system unnecessarily complex				x	
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system			x		
10	I needed to learn a lot of things before I could get going with this system			x		

Table C.1: User 2 – Lize Grobler

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently				x	
2	I found the system unnecessarily complex	x				
3	I thought the system was easy to use					x
4	I think that I would need the support of a technical person to be able to use this system		x			
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly				x	
8	I found the system very cumbersome to use	x				
9	I felt very confident using the system				x	
10	I needed to learn a lot of things before I could get going with this system			x		

Table C.1: User 3 – Dulcie Danzfuss

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently			x		
2	I found the system unnecessarily complex	x				
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system		x			
5	I found the various functions in this system were well integrated				x	
6	I thought there was too much inconsistency in this system				x	
7	I would imagine that most people would learn to use this system very quickly			x		
8	I found the system very cumbersome to use		x			
9	I felt very confident using the system				x	
10	I needed to learn a lot of things before I could get going with this system				x	

Table C.1: User 4 – Johann Combrink

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently				x	
2	I found the system unnecessarily complex		x			
3	I thought the system was easy to use			x		
4	I think that I would need the support of a technical person to be able to use this system		x			
5	I found the various functions in this system were well integrated				x	
6	I thought there was too much inconsistency in this system				x	
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system				x	
10	I needed to learn a lot of things before I could get going with this system		x			

C.2 Administrative Tasks

Table C.2: User 1 – Francois Scheffer

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently				x	
2	I found the system unnecessarily complex				x	
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system			x		
10	I needed to learn a lot of things before I could get going with this system			x		

Table C.2: User 2 – Lize Grobler

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently					x
2	I found the system unnecessarily complex	x				
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system		x			
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use	x				
9	I felt very confident using the system				x	
10	I needed to learn a lot of things before I could get going with this system		x			

Table C.2: User 3 – Dulcie Danzfuss

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently		x			
2	I found the system unnecessarily complex			x		
3	I thought the system was easy to use	x				
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated				x	
6	I thought there was too much inconsistency in this system		x			
7	I would imagine that most people would learn to use this system very quickly		x			
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system		x			
10	I needed to learn a lot of things before I could get going with this system					x

C.3 Technical Assessment

Table C.3: User 1 – Francois Scheffer

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently				x	
2	I found the system unnecessarily complex				x	
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system			x		
10	I needed to learn a lot of things before I could get going with this system			x		

Table C.3: User 2 – Lize Grobler

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently					x
2	I found the system unnecessarily complex	x				
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system			x		
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly				x	
8	I found the system very cumbersome to use	x				
9	I felt very confident using the system					x
10	I needed to learn a lot of things before I could get going with this system		x			

Table C.3: User 3 – Dulcie Danzfuss

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this system frequently			x		
2	I found the system unnecessarily complex			x		
3	I thought the system was easy to use		x			
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated				x	
6	I thought there was too much inconsistency in this system			x		
7	I would imagine that most people would learn to use this system very quickly			x		
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system		x			
10	I needed to learn a lot of things before I could get going with this system					x

Table C.3: User 4 – Johann Combrink

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this system frequently			x		
2	I found the system unnecessarily complex		x			
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system		x			
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system		x			
7	I would imagine that most people would learn to use this system very quickly			x		
8	I found the system very cumbersome to use		x			
9	I felt very confident using the system				x	
10	I needed to learn a lot of things before I could get going with this system		x			

C.4 Strategic Monitoring

Table C.4: User 1 – Francois Scheffer

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently	x				
2	I found the system unnecessarily complex				x	
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system				x	
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use			x		
9	I felt very confident using the system			x		
10	I needed to learn a lot of things before I could get going with this system			x		

Table C.4: User 2 – Lize Grobler

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently					x
2	I found the system unnecessarily complex	x				
3	I thought the system was easy to use				x	
4	I think that I would need the support of a technical person to be able to use this system	x				
5	I found the various functions in this system were well integrated					x
6	I thought there was too much inconsistency in this system	x				
7	I would imagine that most people would learn to use this system very quickly					x
8	I found the system very cumbersome to use		x			
9	I felt very confident using the system					x
10	I needed to learn a lot of things before I could get going with this system	x				

Table C.4: User 3 – Dulcie Danzfuss

		Strongly disagree				Strongly agree
		1	2	3	4	5
1	I think that I would like to use this system frequently			x		
2	I found the system unnecessarily complex		x			
3	I thought the system was easy to use			x		
4	I think that I would need the support of a technical person to be able to use this system			x		
5	I found the various functions in this system were well integrated				x	
6	I thought there was too much inconsistency in this system		x			
7	I would imagine that most people would learn to use this system very quickly				x	
8	I found the system very cumbersome to use		x			
9	I felt very confident using the system			x		
10	I needed to learn a lot of things before I could get going with this system					x