

## Movie file 1



# Transport planning in the South African Context

Dr. Johan W. Joubert  
Industrial and Systems Engineering  
University of Pretoria, South Africa  
29 November 2007



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UNIVERSITY OF PRETORIA  
YUNIBESITHI YA PRETORIA

# Views of South Africa



# Views of South Africa



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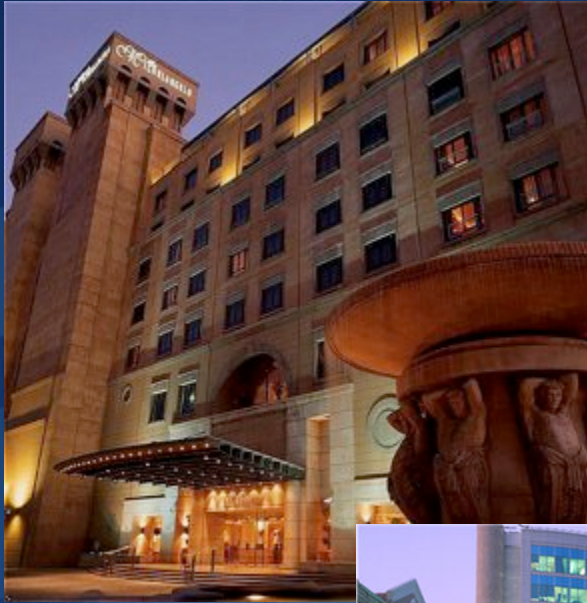
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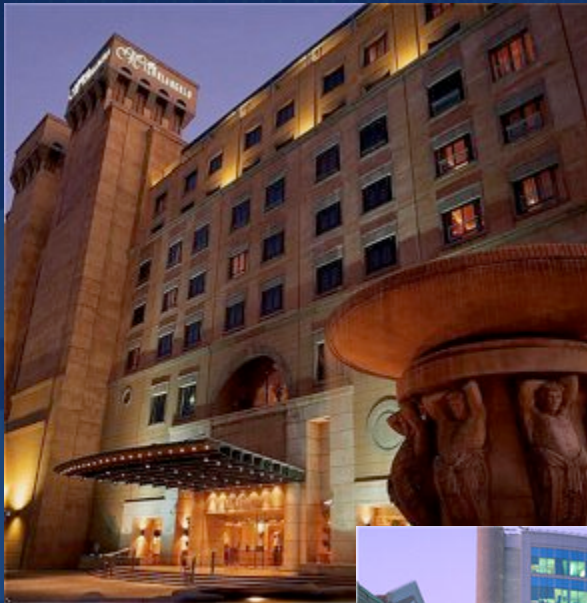


# Views of South Africa





# Views of South Africa



# Presentation outline

- Positioning South Africa
  - University of Pretoria and Industrial Engineering
  - Philosophy of modelling
- The transport environment
  - Status quo
  - A case for unique South African solutions
- Research progress and establishing a research agenda
  - Our stumbling across agent-based modelling
  - Simulating reality
  - Network design
  - Data acquisition
- Discussion



# University of Pretoria

- Centenary in 2008
- Six campuses
  - 38 389 contact students
  - 10 837 distance learning
- Highest research output in South Africa since 1996
- Nine faculties
  - Economic and Management Sciences
  - Education
  - Engineering, Built Environment and Information Technology
  - Health Sciences
  - Humanities
  - Law
  - Natural and Agricultural Sciences
  - Theology
  - Veterinary Science
  - Business School: Gordon Institute of Business Science (GIBS)

# Industrial Engineering

- First Industrial Engineering graduates in 1963
- Independent department (from Mechanical) since 1975
- Largest in South Africa
- Accredited by Engineering Council of South Africa (ECSA)
  - Signatory of the Washington Accord
- Degrees offered:
  - BEng(Industrial), 4-year programme
  - BEng(Hons)
  - MEng(Industrial) by research
  - MSc(Applied Sciences)
  - PhD

# Industrial Engineering



# Industrial Engineering

- Three focus areas
  - Enterprise Architecture
  - Business Engineering
  - Resource optimisation



# Industrial Engineering

- Three focus areas
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  - Business Engineering
  - Resource optimisation
- Optimisation Group
  - Applied Operations Research
  - Philosophy of modelling

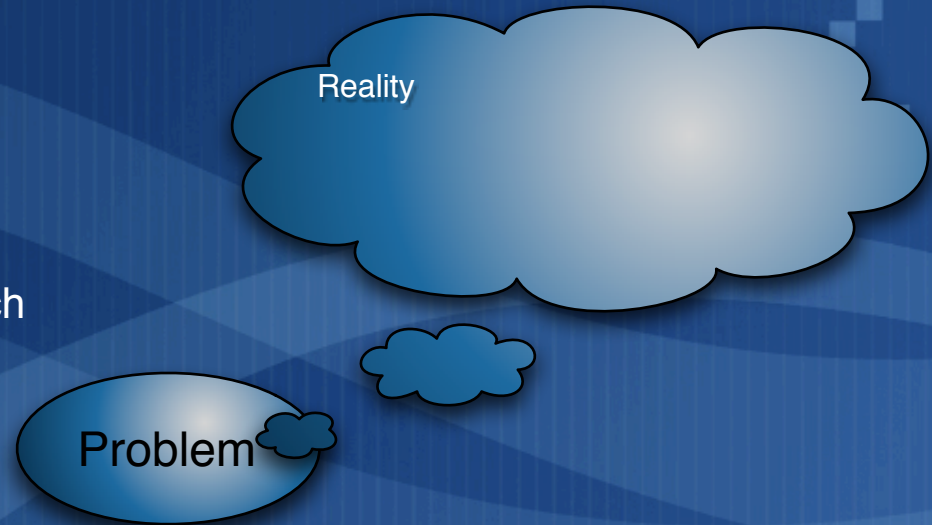


Problem



# Industrial Engineering

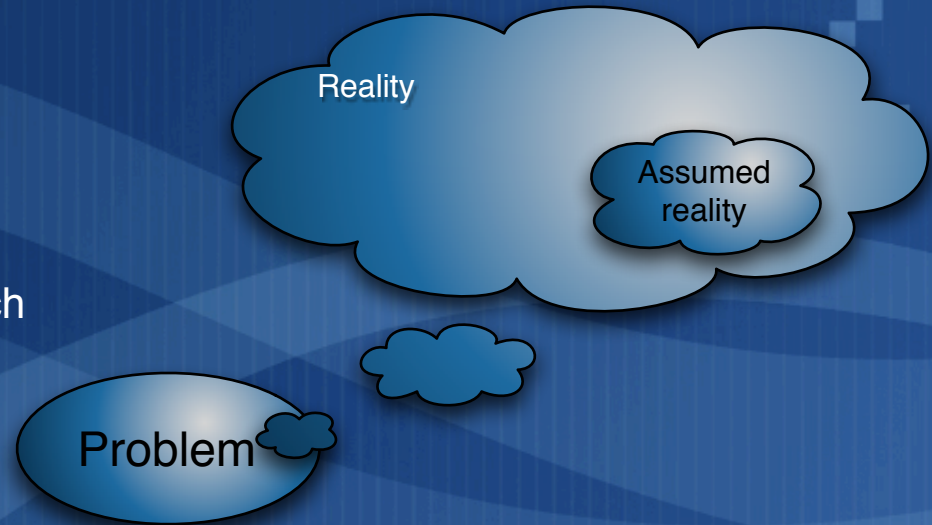
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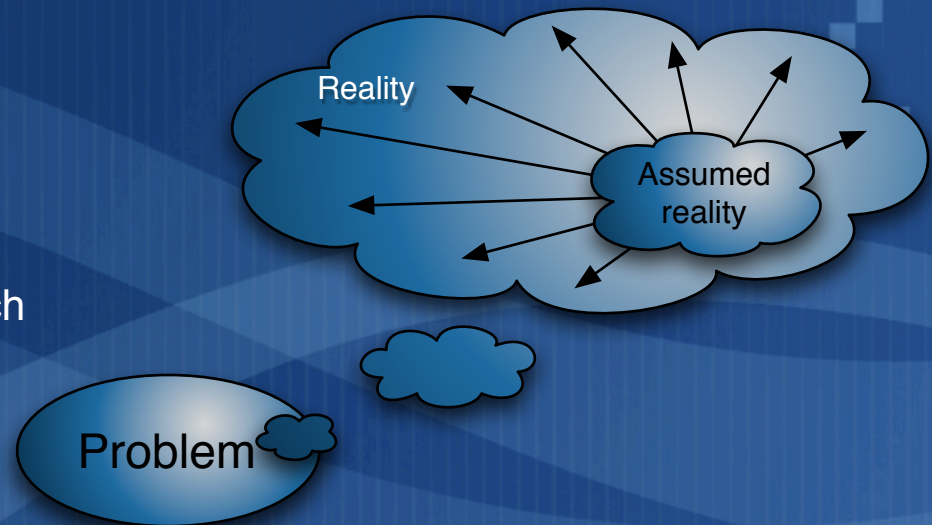
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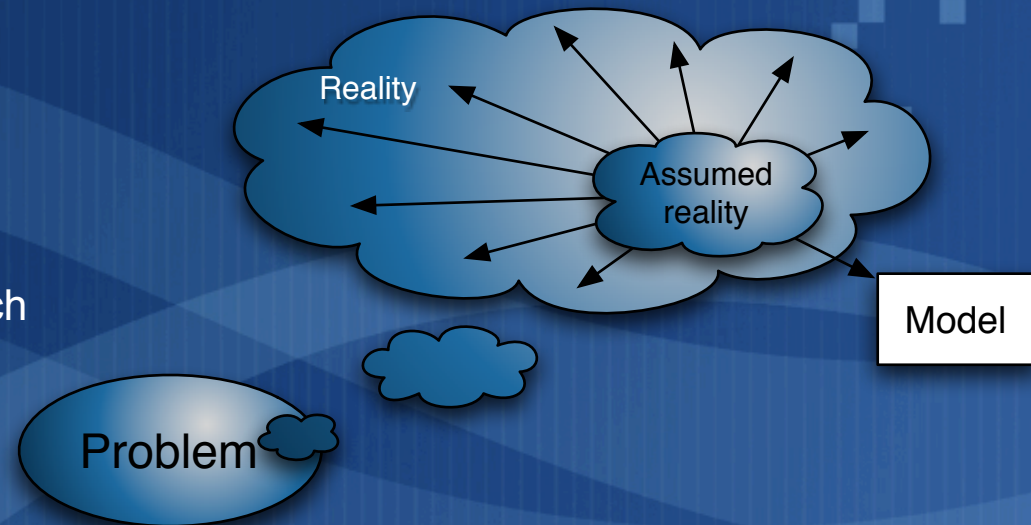
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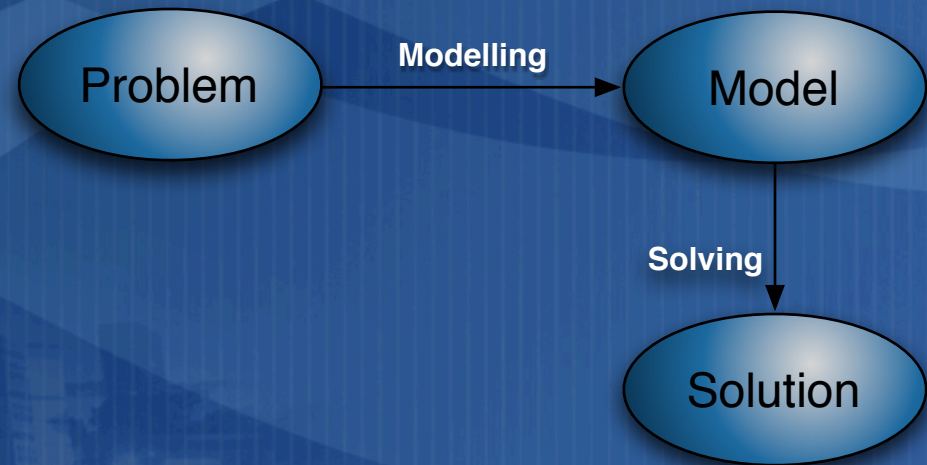
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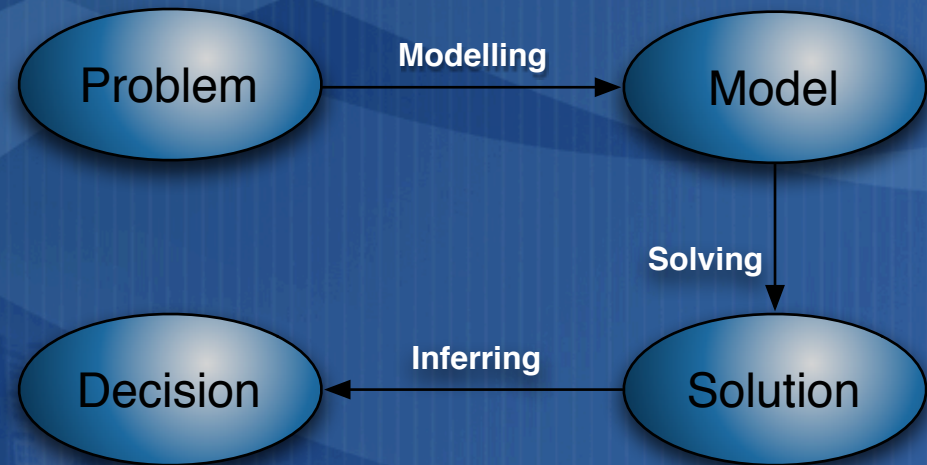
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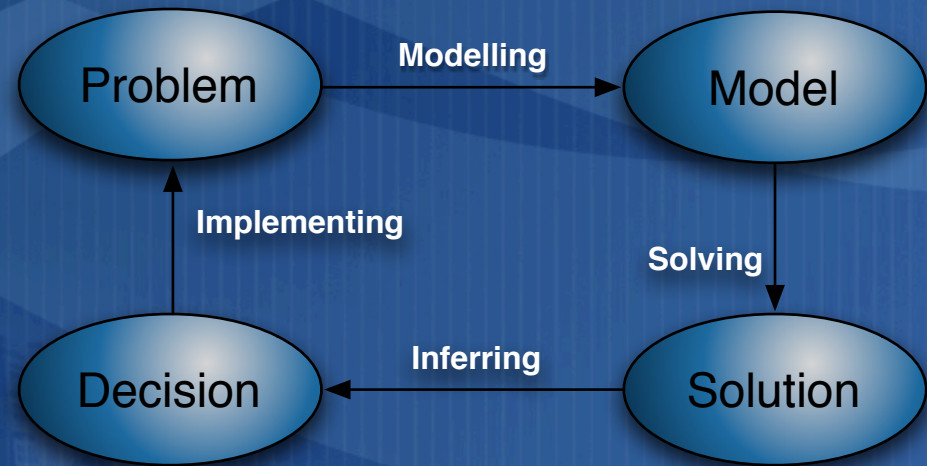
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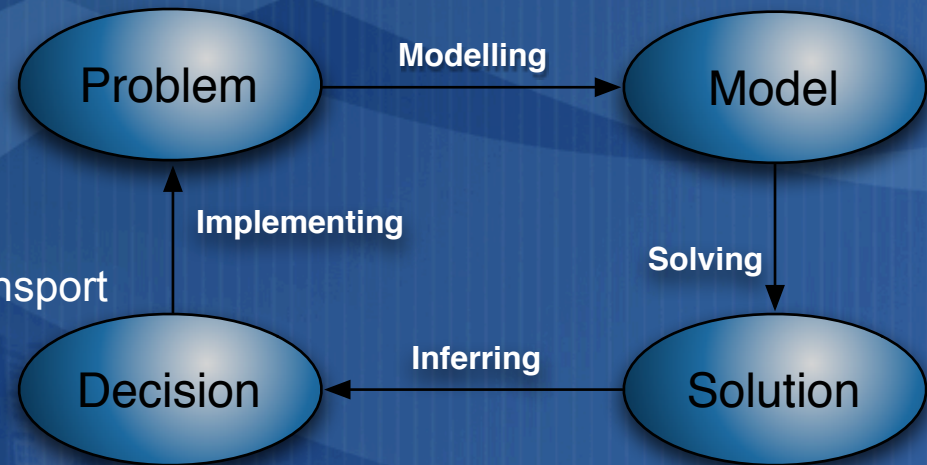
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- Freight modelling
  - Result of land use
  - Economic sensitivity
  - Interdependent of public transport





# Transport policy in South Africa

Period	Legislation	Notable events & research themes
Pre 1950	Motor Carrier Transportation Act (1930)	Railway infrastructure focus. Protecting railway services from competition.
1950 - 1970	Black Services Levy Act (1952) Black Transport Services Act (1957)	Birth of transport subsidies for the “poor”.
1970 - 1980	Urban Transport Act (1977)	Transport planning becomes legal requirement for local authorities: 4-Step modelling. Peak of capital spending for municipal bus services.
1980 - 1990	Deregulation of taxi industry	Emergence of tendered contracting ideology. Travel patterns of black workers and urbanisation.
1990 - 1994	Negotiated settlement: division of authority responsibility	EMME/2 four-stage travel demand modelling software. Taxi violence.
Post 1994	White paper (1996) and National Land Transport Transition Act (2000)	Devolution of responsibilities, agencies, labour protest. Spatial integration. Customer focus... Taxi recapitalisation.

# South African transport environment



# South African transport environment

- Current spending initiatives are mode specific
  - Intelligent Transportation Systems (ITS) for private travel (R51-million)
  - Taxi Recapitalization for taxi industry (R7.7-billion)
  - Gautrain as an alternative for private travel, with limited integration (R25-billion)
  - Transport subsidy review
  - MetroRail rolling stock and infrastructure upgrades for rail commuters (R16-billion)
  - Airport upgrades (R19.2-billion)



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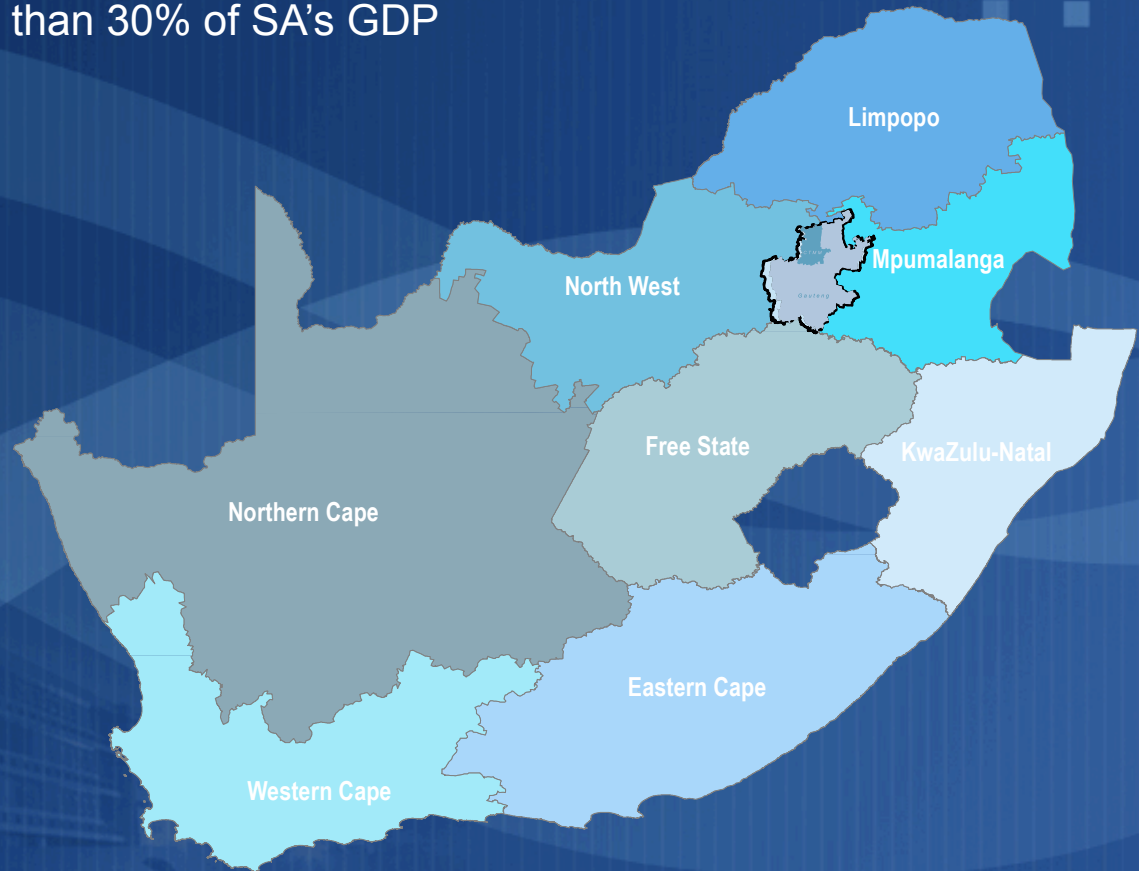
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- Where is the commuter in any of the decision making?
  - Safer vehicles on an inefficient network competing for the same commuter pool.

# Addressing unique South African problems



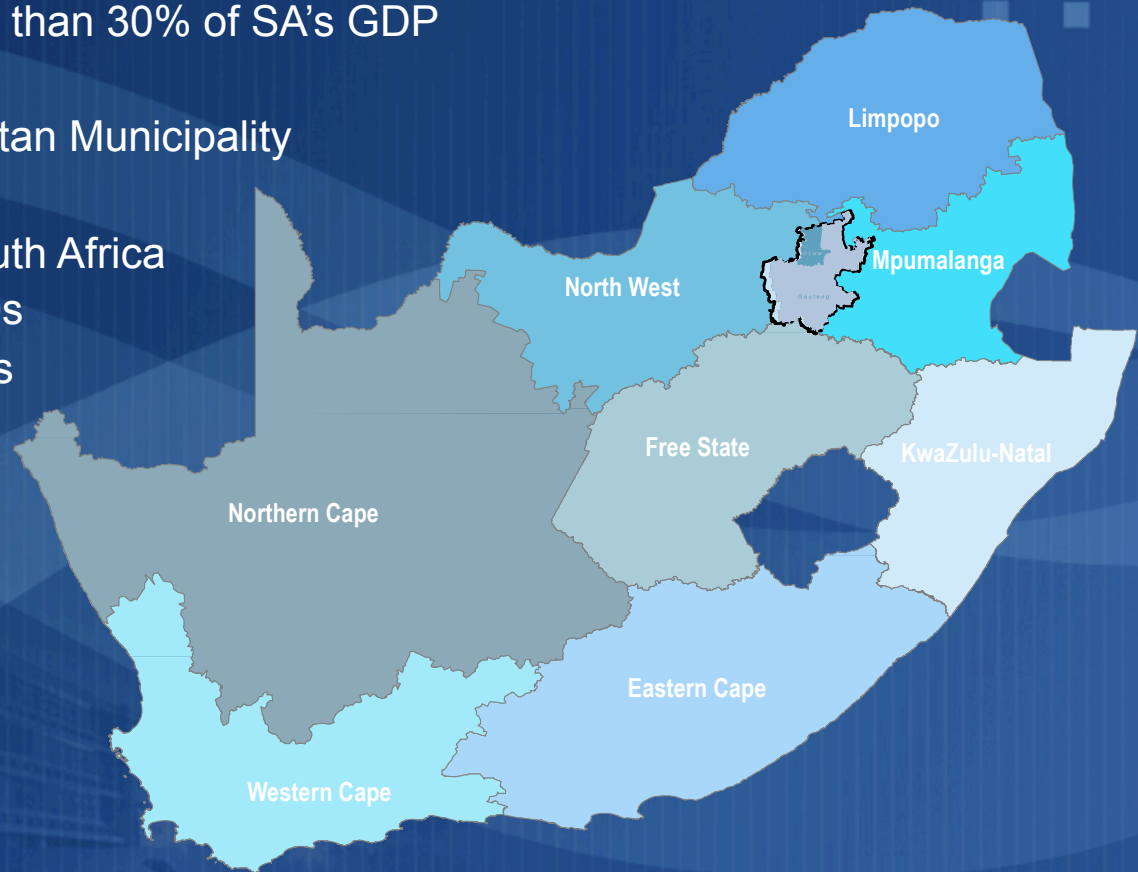
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- Gauteng
  - Responsible for more than 30% of SA's GDP



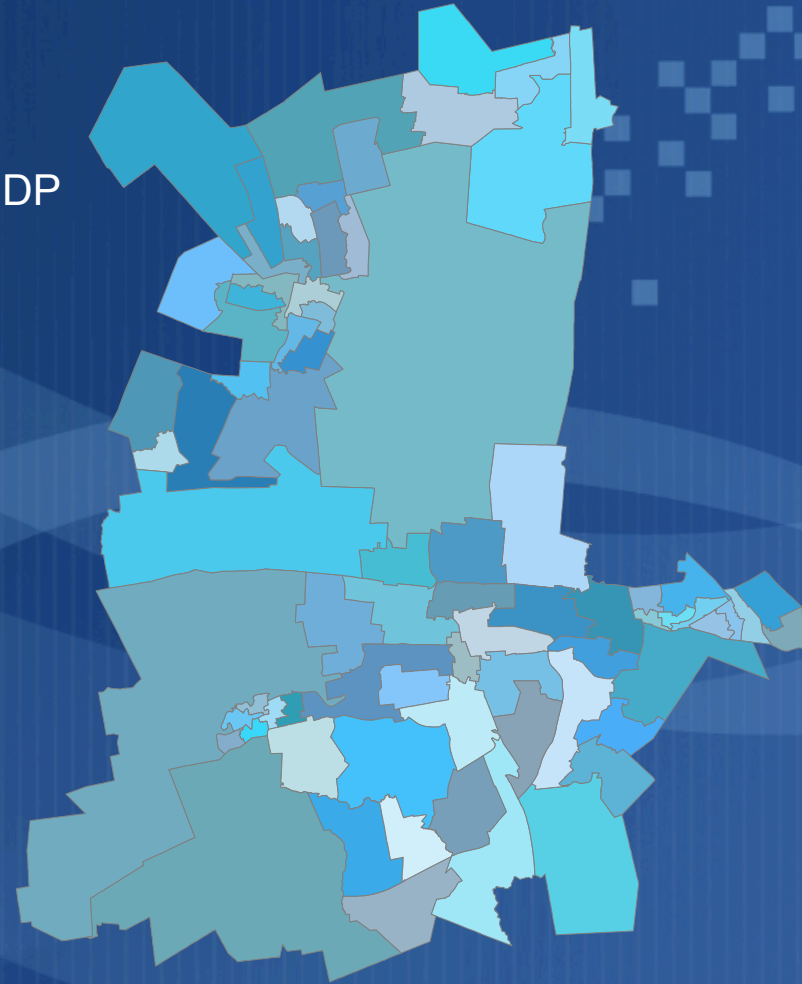
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  - “Pretoria”
  - Political capital of South Africa
  - Bus routes from 1970s
  - Multiple bus operators



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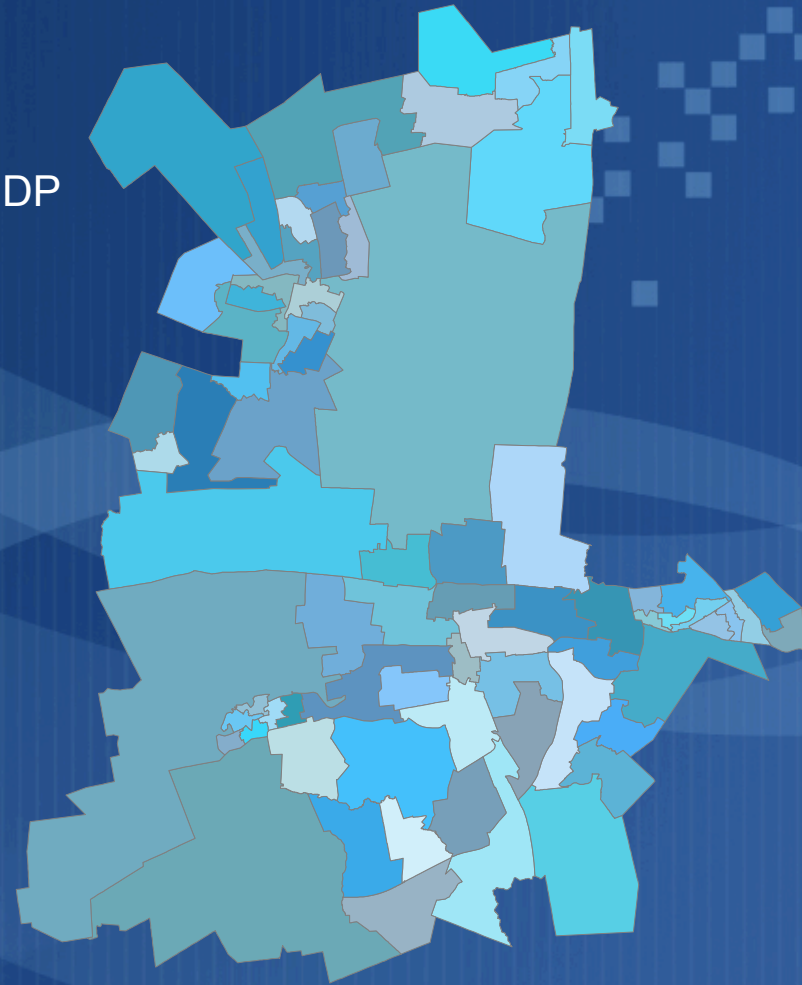
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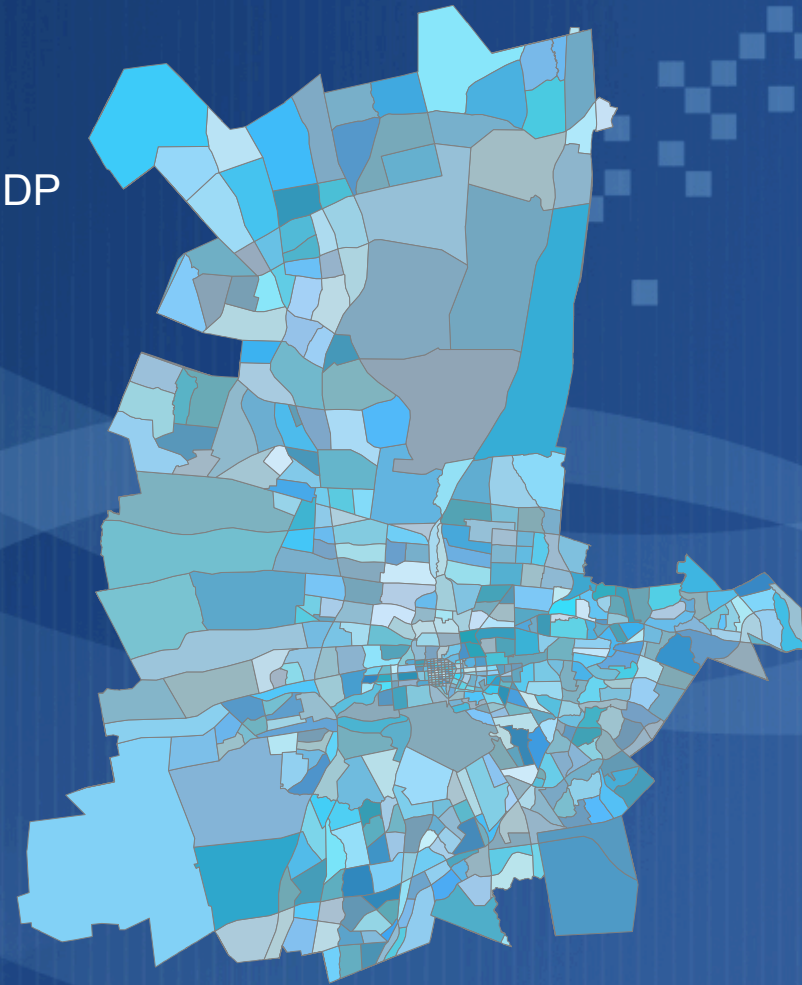
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  - Multiple bus operators
- Different data views
  - Political wards
  - Transport zones
  - Mezoframe of economic activity



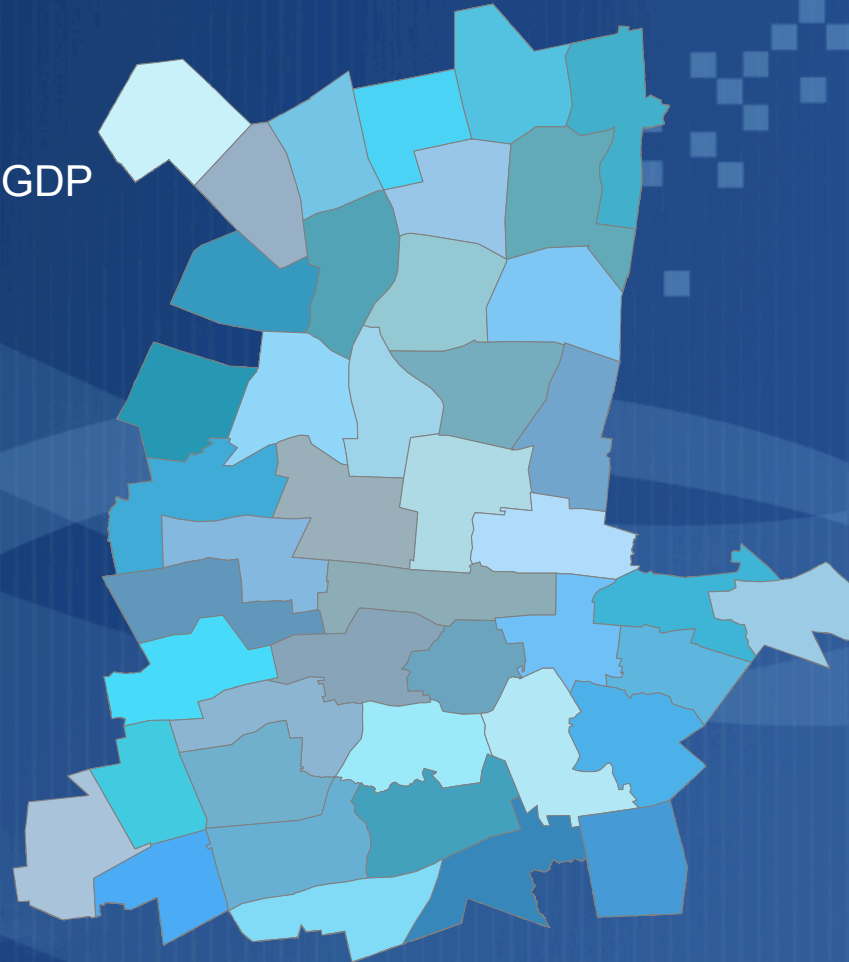
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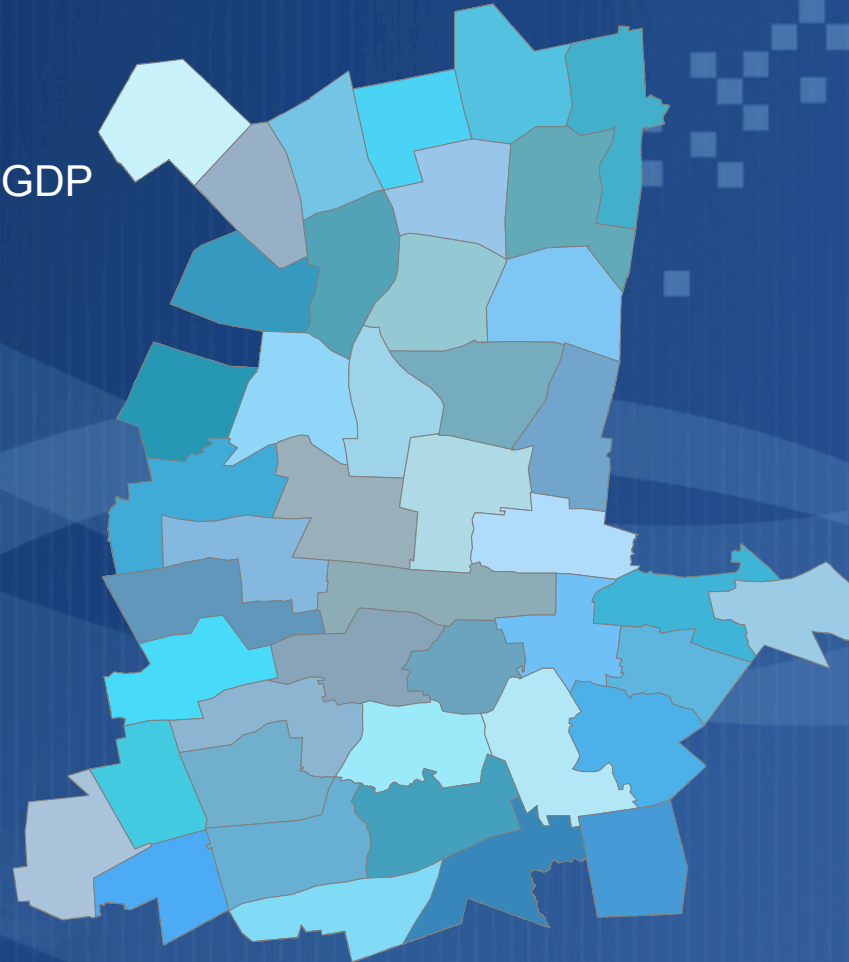
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  - Mezoframe of economic activity
- South Africa requires unique solutions
  - Why?



# Establishing a research programme



# Establishing a research programme

- Evaluate government spending on transport infrastructure
  - Simulate existing transport system as baseline
  - **What-if** simulations on proposed changes
    - Changes to bus routes
    - Impact of electronic fare collection
    - Impact of Bus Rapid Transit (BRT) lines
    - Gautrain and its feeder network
  - Establish business case for formalisation of minibus industry



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- Propose network changes to improve:
  - Reliability
  - Accessibility
  - Commuter spending
  - Commuter travel time
  - Safety



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- Propose network changes to improve:
  - Reliability
  - Accessibility
  - Commuter spending
  - Commuter travel time
  - Safety
- Predict and evaluate land use changes



# Multimodal transport modelling

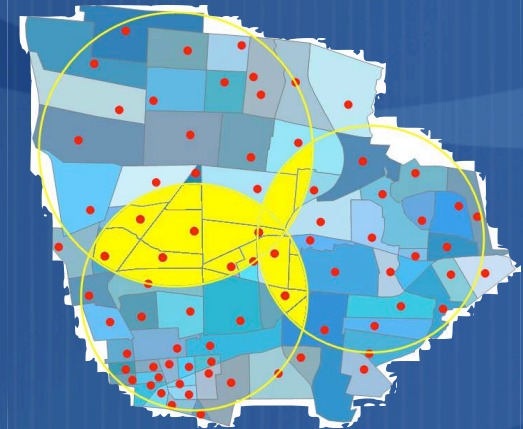


# Multimodal transport modelling

- Agent-based modelling
  - *AnyLogic*<sup>™</sup> to simulate multimodal commuter activity including use of paratransit minibus taxis.
  - Feasible on small-scale (microsimulation) test instances.

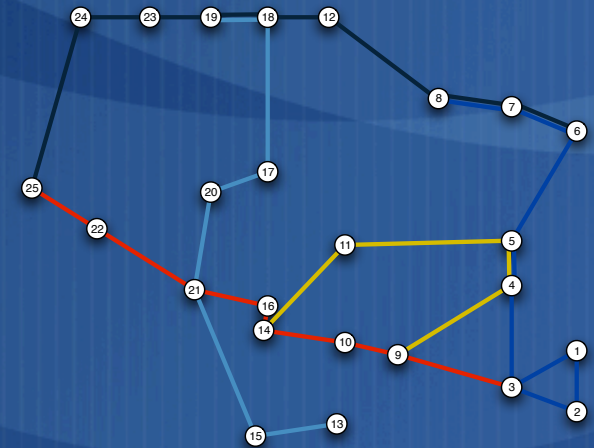
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  - Placement of bus stops.
  - Solve Bus Transit Network Design Problem (BTNDP)
    - Sequential - Genetic Algorithms
    - Simultaneous - Simulated Annealing



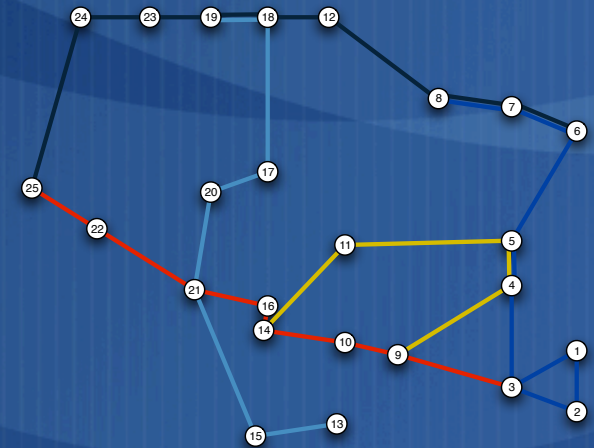
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  - Solve Bus Transit Network Design Problem (BTNDP)
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- Data capturing
  - Cellphone penetration
  - Freight management
  - Geospatial Analysis Platform (GAP2)



Thank you



# A CASE FOR AGENT-BASED MODELLING OF PARATRANSIT MODES IN DEVELOPING COUNTRIES

Pieter J. Fourie

Optimisation Group

Dept. of Industrial Engineering

University of Pretoria, South Africa

November 29, 07



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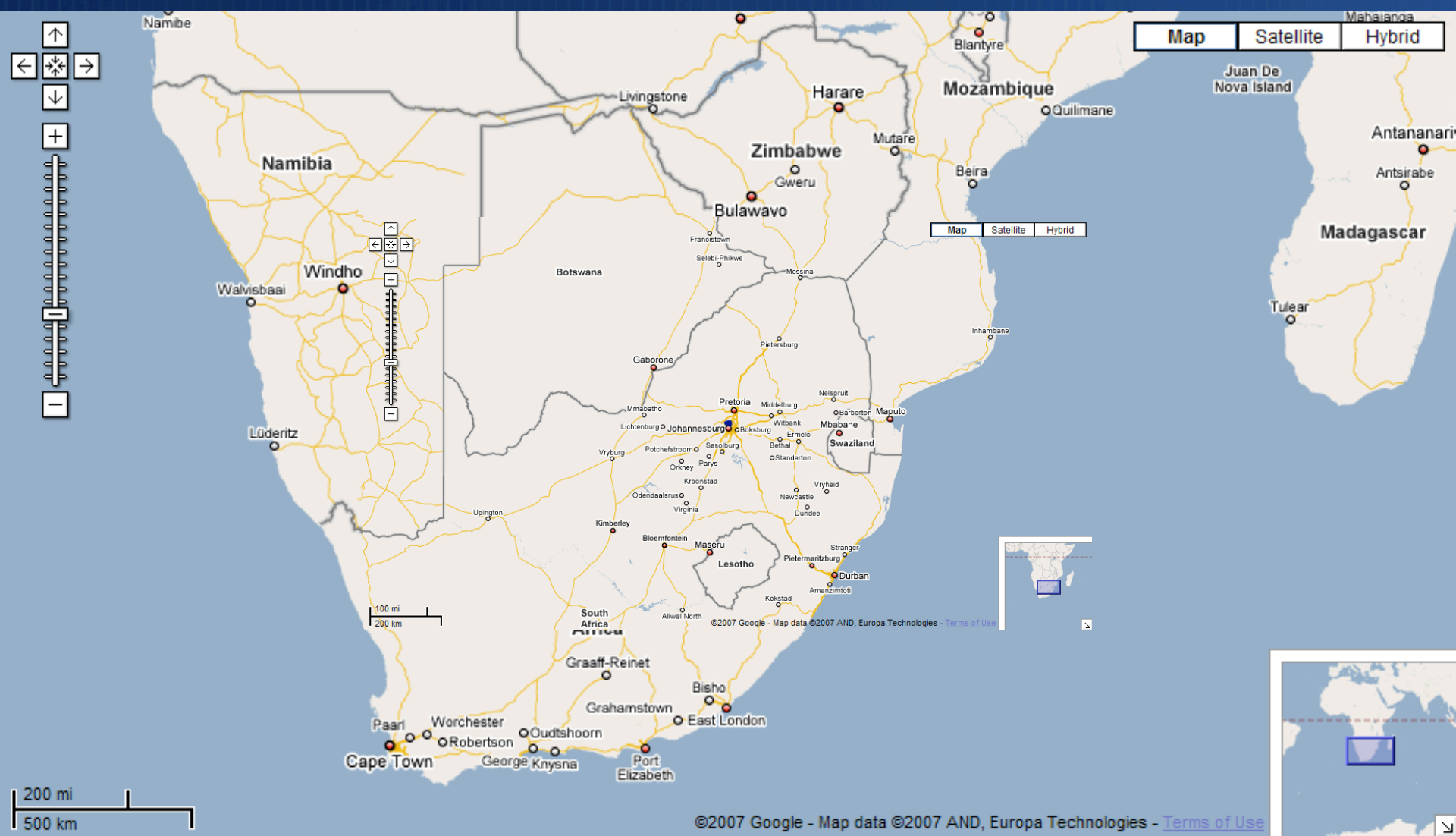
# Agenda

1. Introduction
2. Public Transport in City of Tshwane Metro
3. The South African Minibus Taxi Industry: Organisation and Operation
4. ABM of Minibus Taxis and Commuters
5. Conclusion





# Introduction: A typical morning commute in Gauteng



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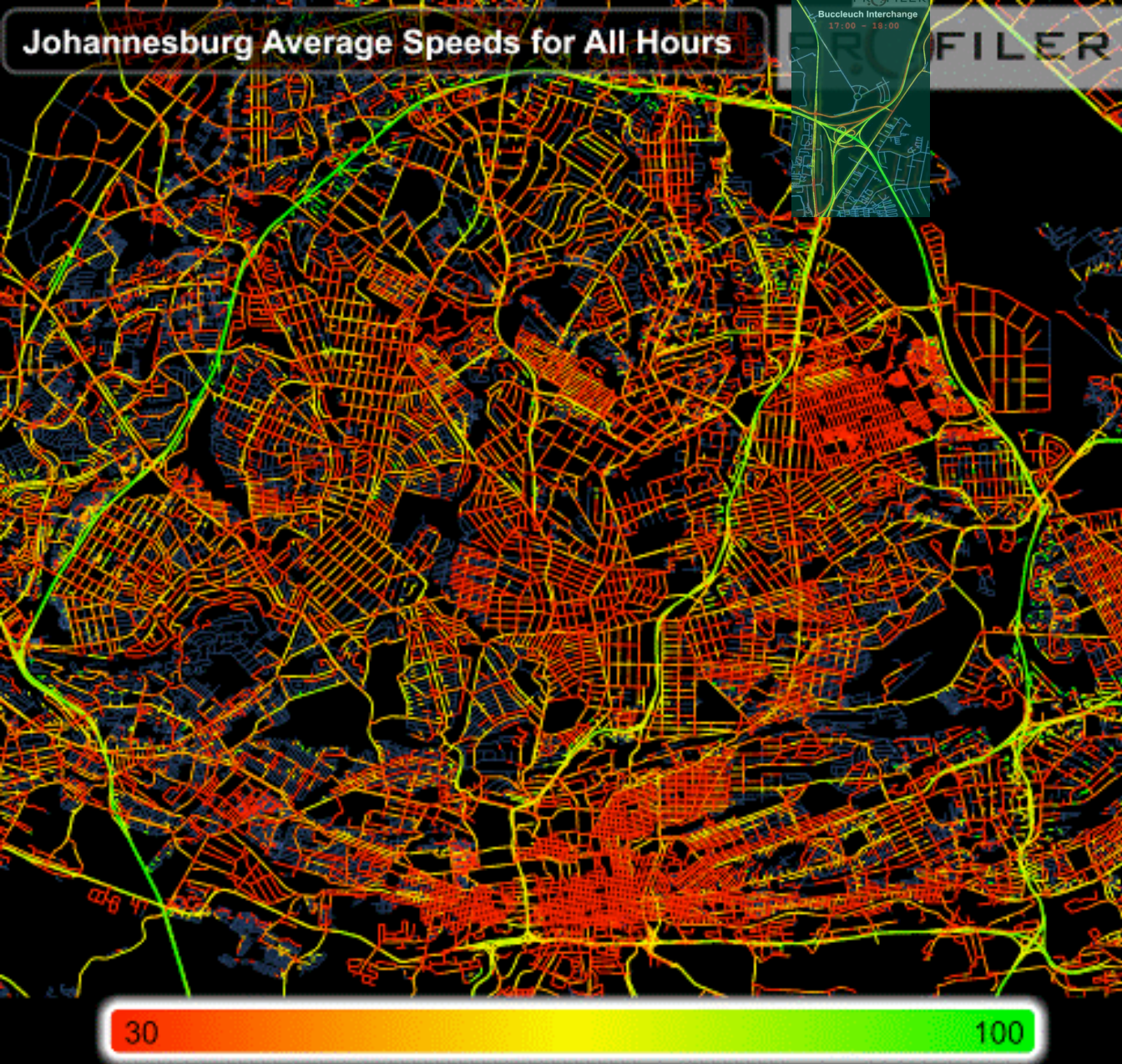


# Introduction: A typical morning commute in Gauteng

Movie file 2



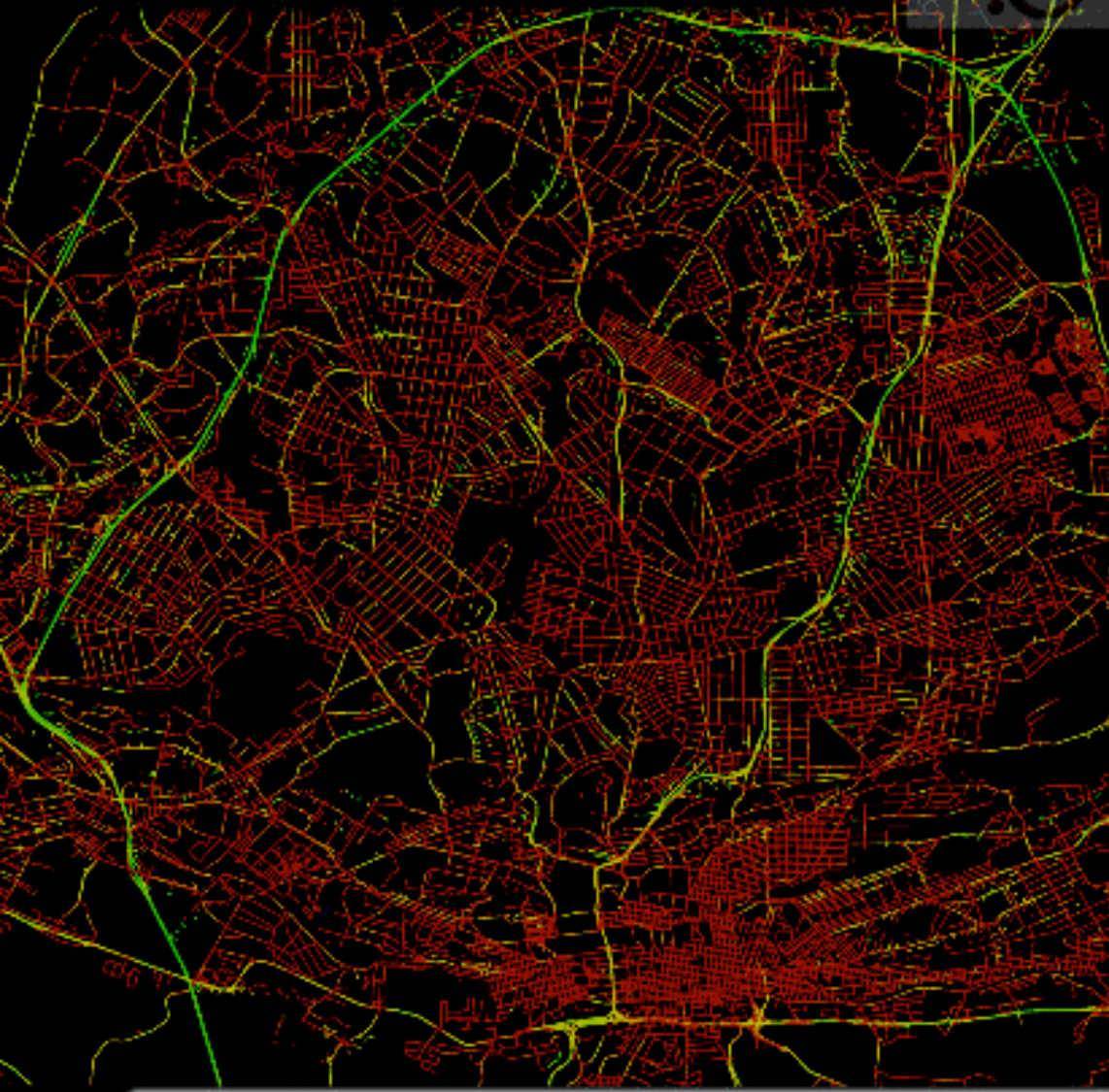
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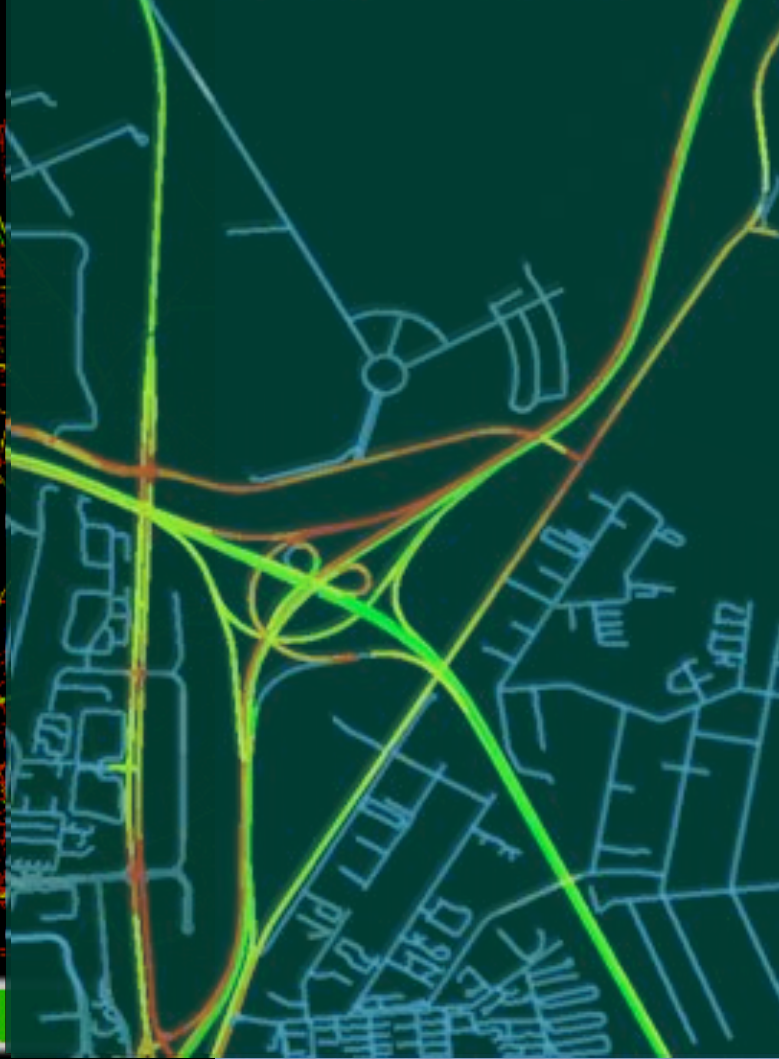
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PROFILER



## Buccleuch Interchange

17:00 - 18:00

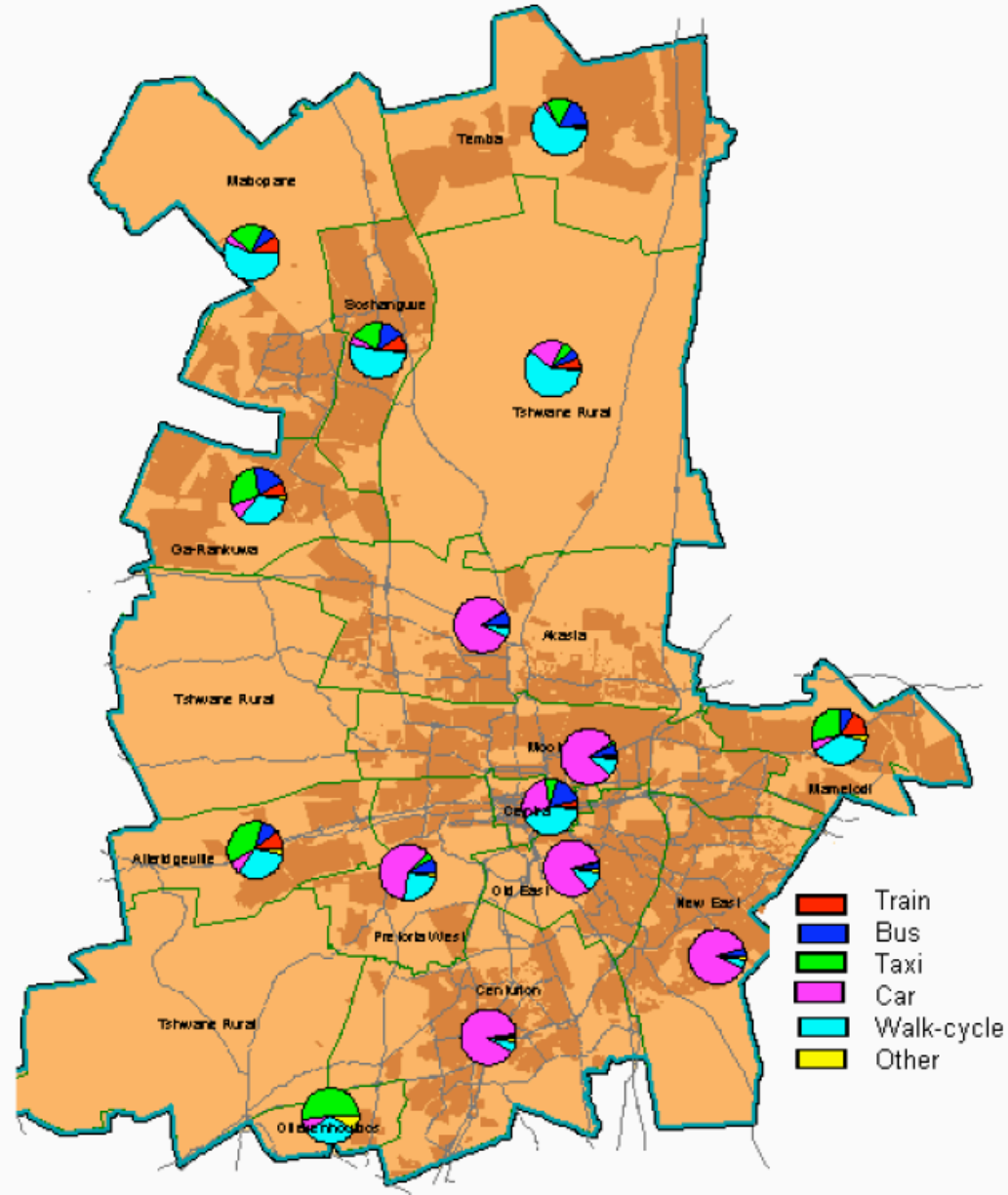


# Public Transport in City of Tshwane Metro

- 1.96 million people, growth rate 3.3 %pa

Source: CTMM ITP 2005

Main Mode Split in Peak Periods



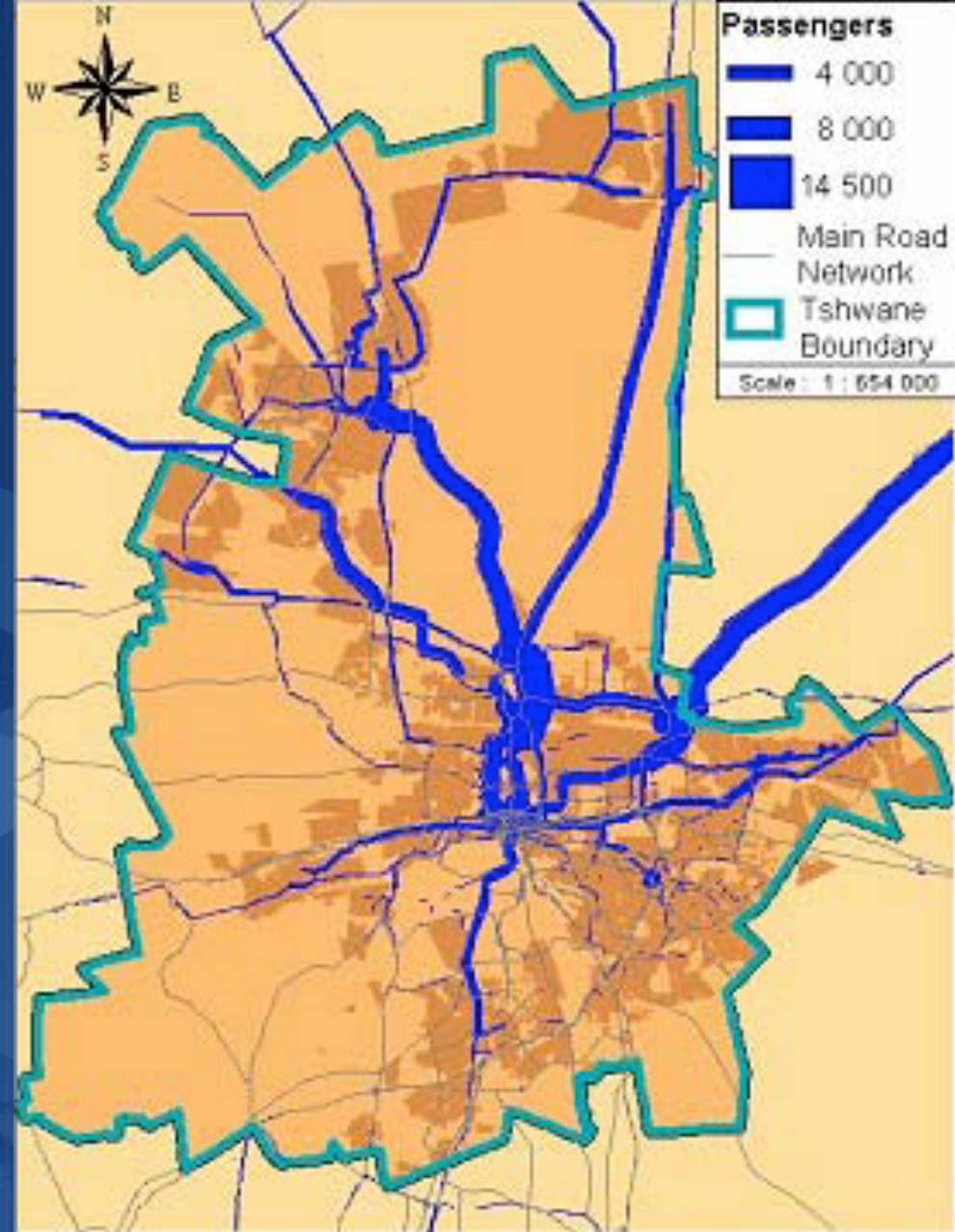
## Public Transport in CTMM :: Mode splits

Main Mode	All Trips		Motorised		Public	
Train	6.5%	65.0% Motorised	9.8%	47.4 % Public transport	20.7% train	
Bus	9.5%		14.4%		52.6 % Private transport	30.4% bus
Taxi	15.3%		23.2%			48.9% taxi
Car driver	22.1%		33.5%			
Car passenger	10.8%		16.4%			
Lift club	0.6%		0.9%			
Motor cycle	2%		0.3%			
Walk	32.9%	33.8% non motorised				
Bicycle	0.9%					
Company transport	1.0%	1.2% other				
Other	0.2%					
<b>Total</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>	

# Public Transport in CTMM :: Bus Services

- 14 depots
- 23 major terminals
- 25 major bus stops
- Large number of normal/  
secondary stops
- 10 operators
- 1491 buses serving 136,300  
people
- 2059 routes
- 7382 trips
- Proposed BRT for 2010

Source: CTMM ITP 2005





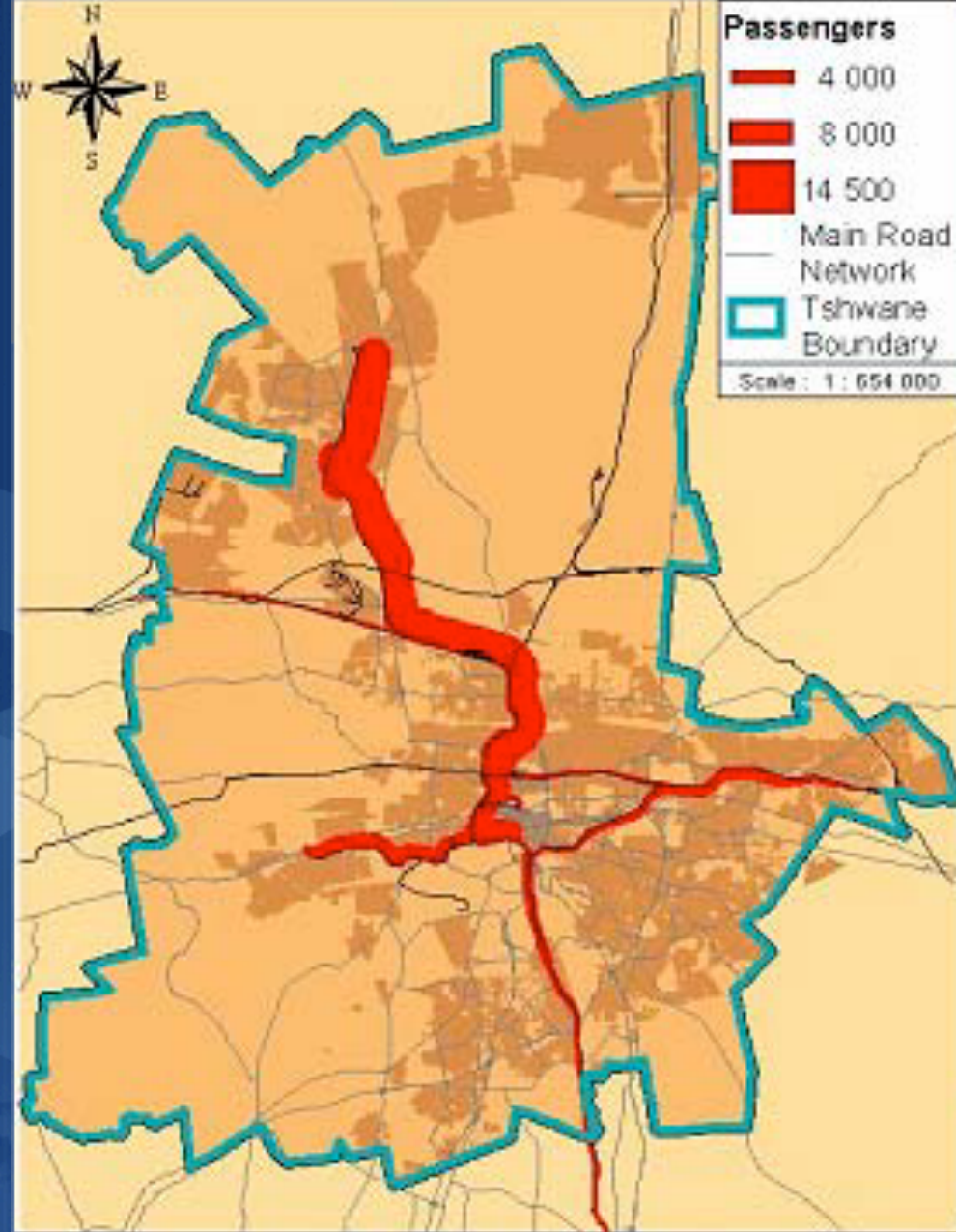
## Public Transport in CTMM :: BRT

- **92 km**, to be operational in time for the 2010 soccer World Cup. The completed system will eventually comprise **472 km** of infrastructure.
- Start mid-2008, end 2010.
- **median lanes**
- to be developed on current road alignments,
- separated from the normal traffic lanes by a semirigid structure, thereby allowing exclusive bus use.
- dedicated stations, placed at **750-m intervals** along the route.

# Public Transport in CTMM :: Rail

- MetroRail
- 72 rail stations
- Connects low-income areas with CBD, major industrial areas
- 930,000 embark/disembark per day
- 70% walk to train
- 23% use taxis to access
- 7% use bus

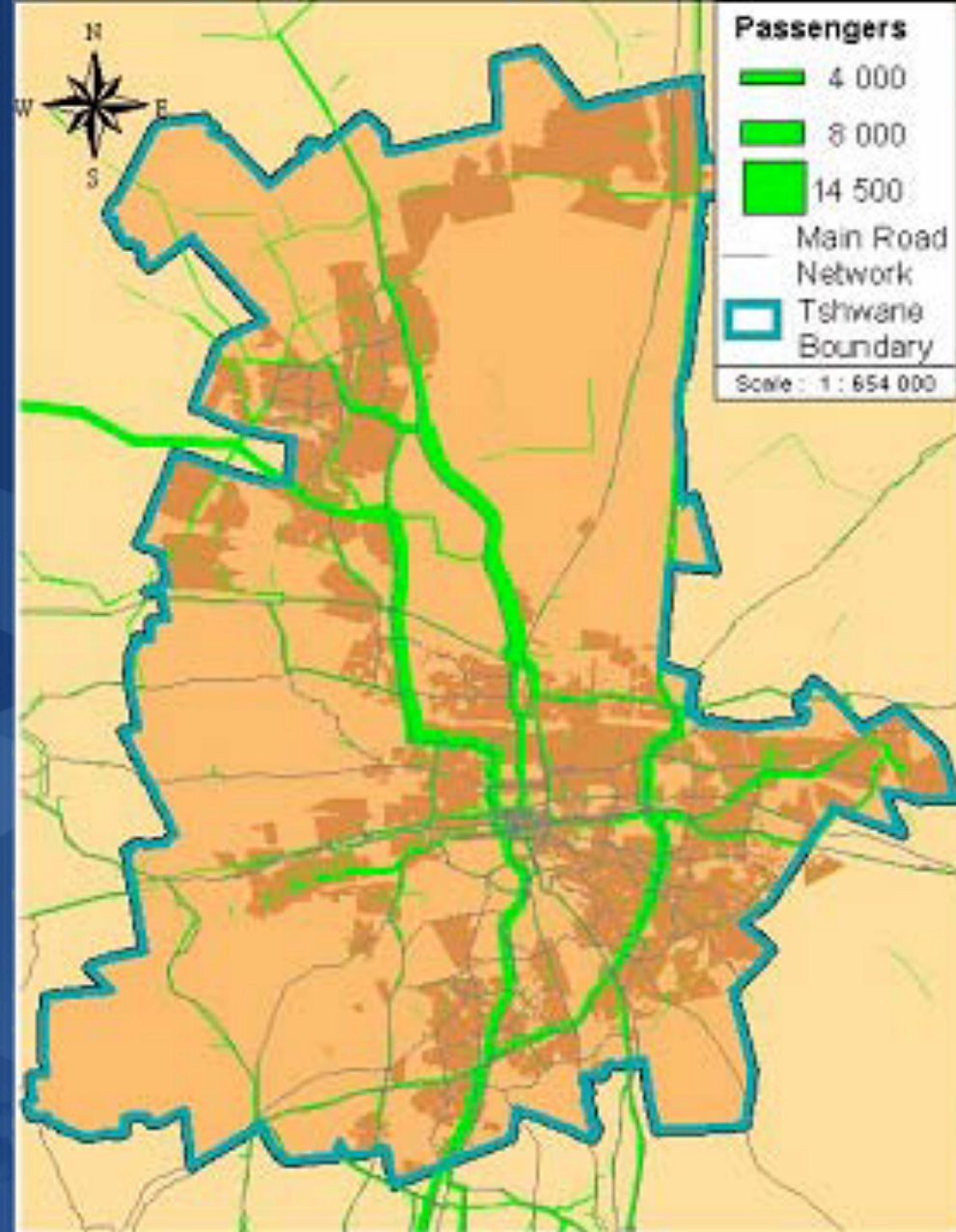
Source: CTMM ITP 2005



# Public Transport in CTMM :: Minibus Taxi

- 43 associations
- 112 ranks (more than half informal)
- 462 routes
- 22,359 vehicle trips
- Nearly half of public transport trips regulated in different and informal ways, difficult to monitor

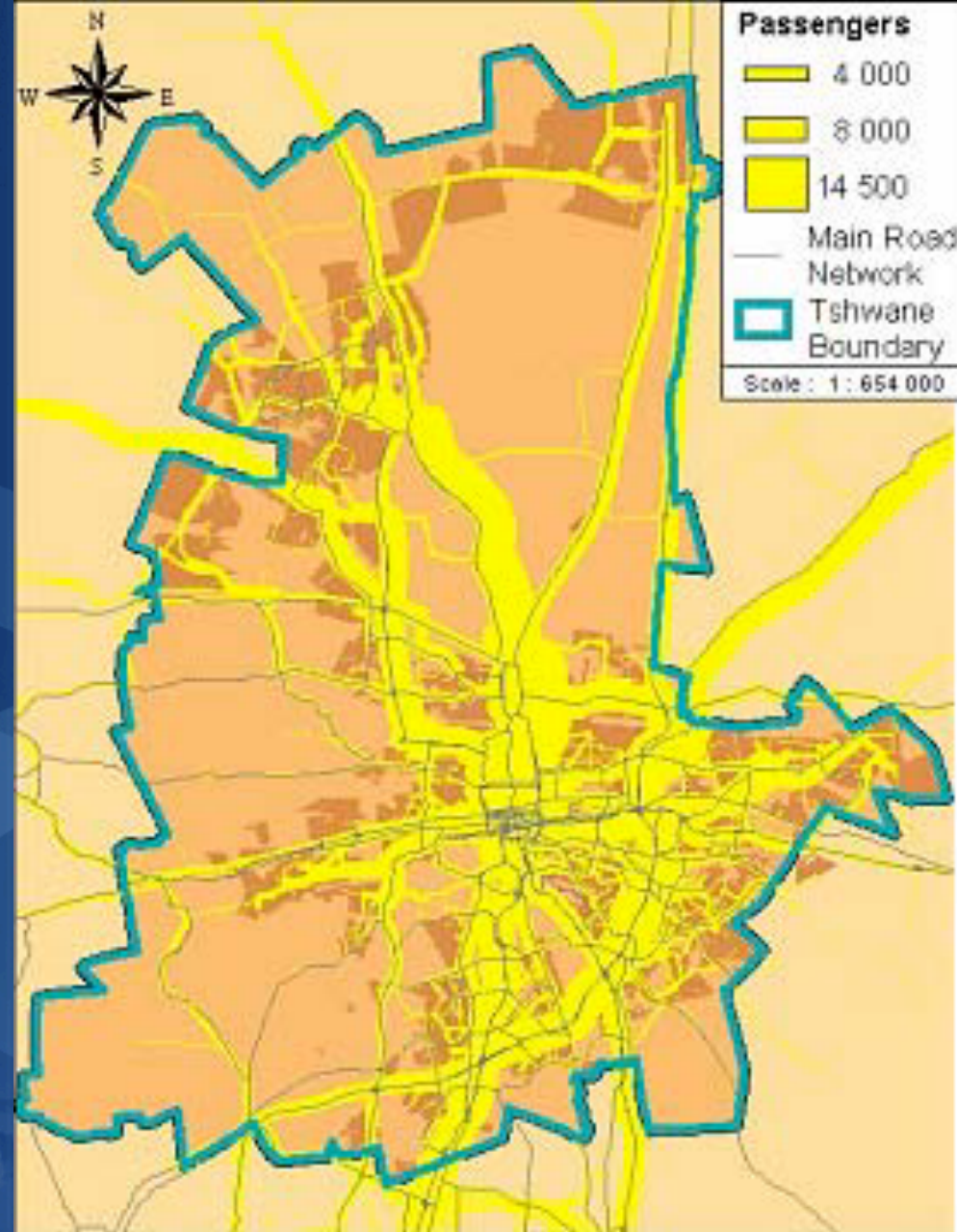
Source: CTMM ITP 2005



# Public Transport in CTMM :: All modes

- Major flow is from the north to CBD, and from southern suburbs to Johannesburg

Source: CTMM ITP 2005



# Public Transport in CTMM :: Current Planning Procedures

- FSM (EMME/2)
- Outdated data
- Wrong prediction
- No integration
- Etc...

# The South African Taxi Industry :: Introduction



Image: Wikipedia



# The South African Taxi Industry :: Introduction

- Little known about the taxi system among academia, people in urban areas generally

## History

- Apartheid Land Act dispossessed people of their land, forced them into labour market
- Emergence of taxi industry provided opportunity to black people to advance economically
- Deregulation in 1980's, uncontrolled growth, violent conflict over routing and ranking facilities

Source: SANTACO, 2007

# The South African Taxi Industry :: Introduction

## History cont.

- 1990's: fragmentation of industry along taxi association lines, power blocks vying for lucrative routes
- 1994: Unity initiatives culminate in formation of SATACO
- 2001: SANTACO recognised as legitimate taxi industry representative
- Currently 65% urban market share

Source: SANTACO, 2007



# The South African Taxi Industry :: Introduction

- Competes heavily with bus industry
- Used to be only buses subsidised, taxis not
- Currently, Taxi Recapitalisation Program (TRP) subsidises scrapping of old taxis, buying of new ones
- Taxis, trains and buses to participate in integrated public transport system

Source: SANTACO, 2007

# The South African Taxi Industry :: Introduction

- 65% of 2.5 billion passenger trips
- National fleet of 130,000 vehicles operating legally Short distance trips:  
2-10 km
- Medium distance: 10-35 km
- Long distance inter-city and rural transport
- Capacity of 12-25 people
- Do not run to schedule, follow demand

Source: SANTACO, 2007

# Share taxis in the developing world



Source: Wikipedia

Kigali, Rwanda

# Share taxis in the developing world



Source: Wikipedia

Dar es Salaam, Tanzania



# Share taxis in the developing world



Source: Wikipedia

Bulgaria, Russia: Marshrutka

# Share taxis in the developing world



Source: Wikipedia

Colombia, Chile: Colectivo

# Share taxis in the developing world



Source: Wikipedia

Haiti: Tap-tap



# Share taxis in the developing world



Source: Wikipedia

Mexico: Pesero



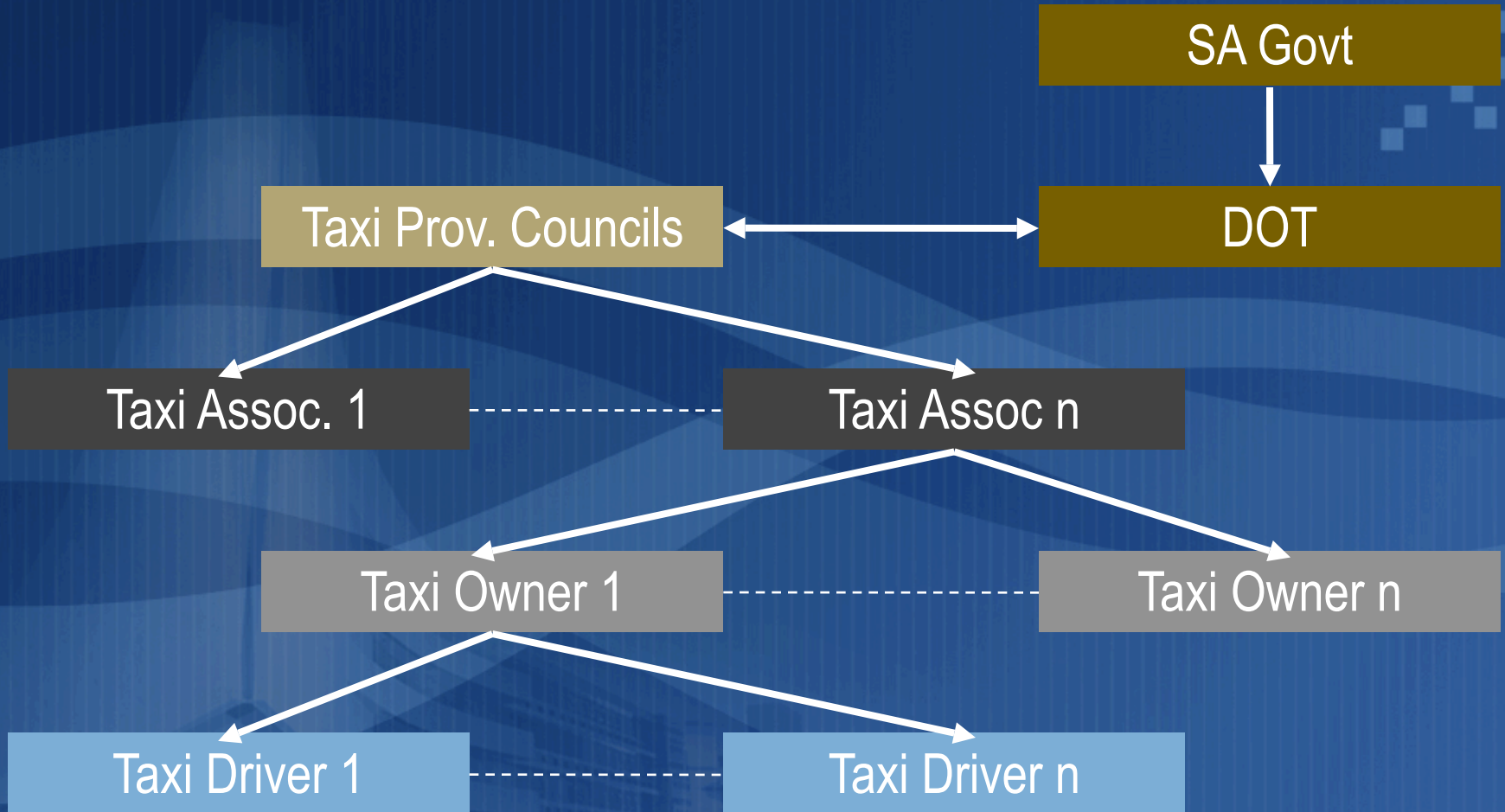
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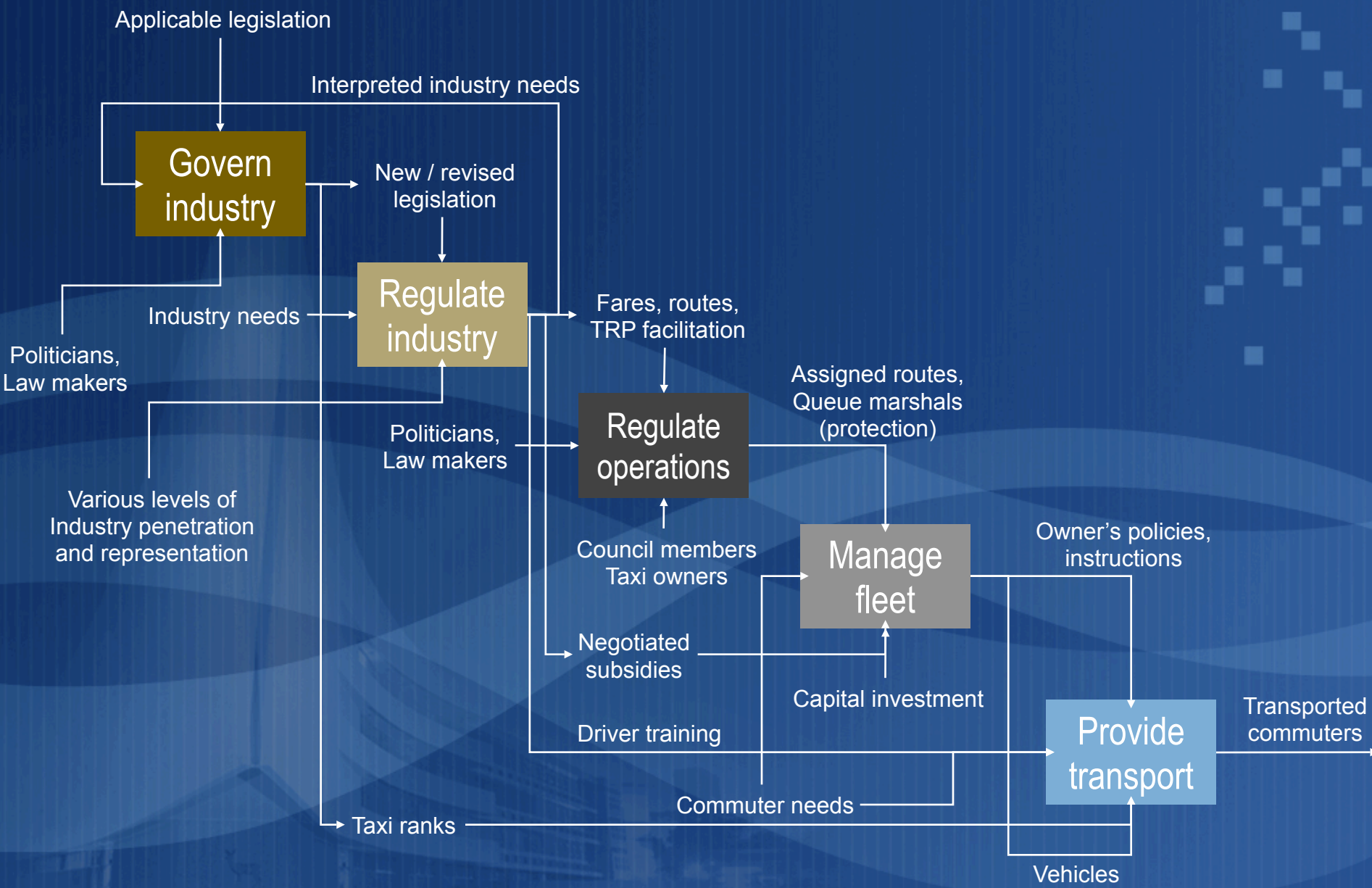


Source: Wikipedia

Philippines: Jeepney

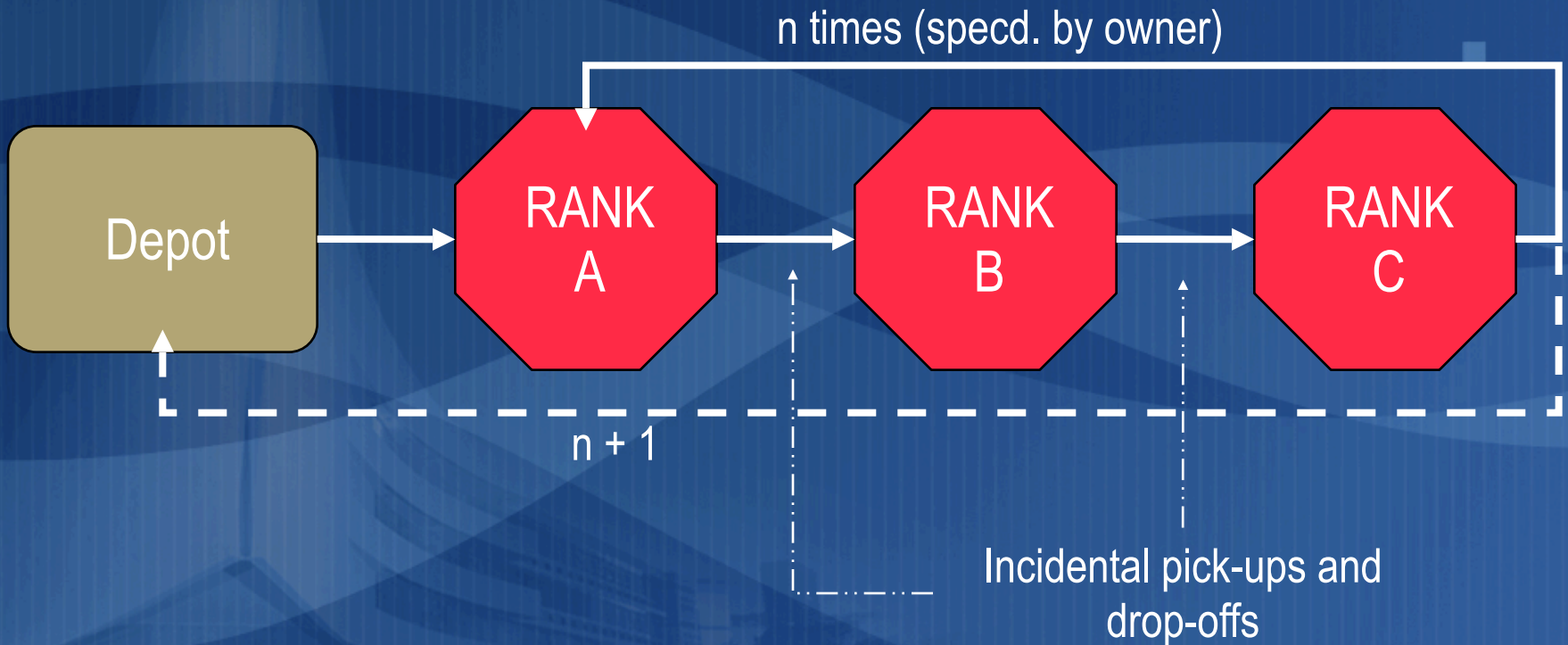
# The South African Taxi Industry: Organisational structure





# The South African Taxi Industry : Operations

## Taxi Movement cycle



# The South African Taxi Industry: Operations

Movie file 3



# The South African Taxi Industry: Operations

Movie file 4



# The South African Taxi Industry: Operations

Movie file 5



# ABM of Minibus Taxis and Commuters :: Motivation

- Proof of concept model confirms it is a workable solution methodology
- Captures emergent phenomena, dynamic effects
- Planning tool for network modification, modal integration, policy changes
- Applicability in rest of sub-Saharan Africa and elsewhere in the world
- Data required are emerging rapidly



# ABM of Minibus Taxis and Commuters :: Ideal operation

Movie file 6



# ABM of Minibus Taxis and Commuters :: Ideal operation

Movie file 7



# ABM of Minibus Taxis and Commuters :: Implementation in MATSim-T

- Purpose of visit is to investigate feasibility of MATSim in South African context
- Foresee a number of functional extensions in MATSim to accommodate SA commuters and taxis
- Also simplifications required to provide practical solutions
- Most notable modification across all modules:

**Multiple modes (rail, bus, pedestrian)**

**Simplified behaviour**

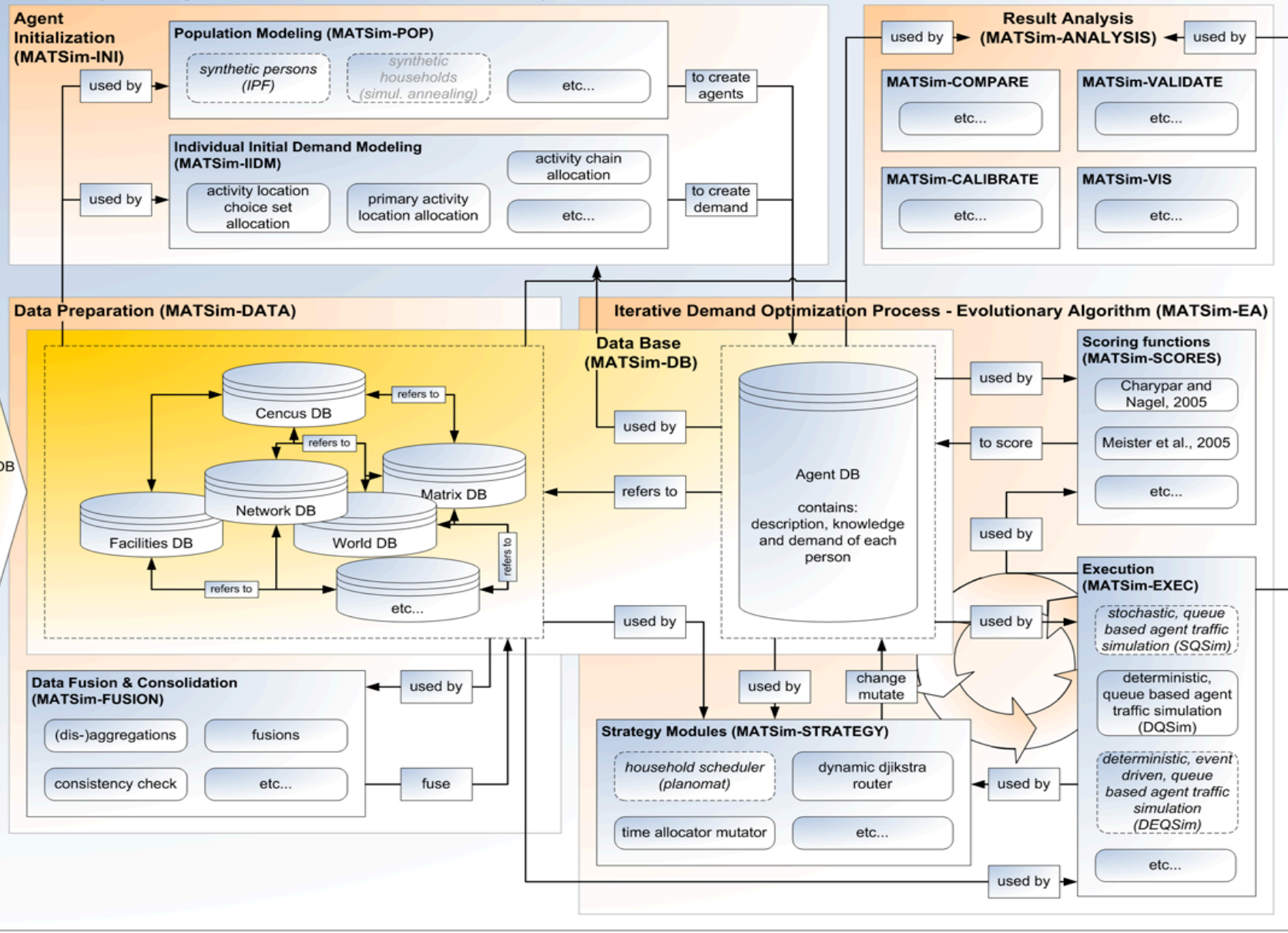


# MATSim-T (Multi-Agent Transport SIMULATION Toolkit)

- world xml
- network xml
- facilities xml
- matrix xml
- census xml
- plans xml
- etc...

MATSim-DB  
Parsers  
and  
Writers

Source: Balmer 2007



## Legende

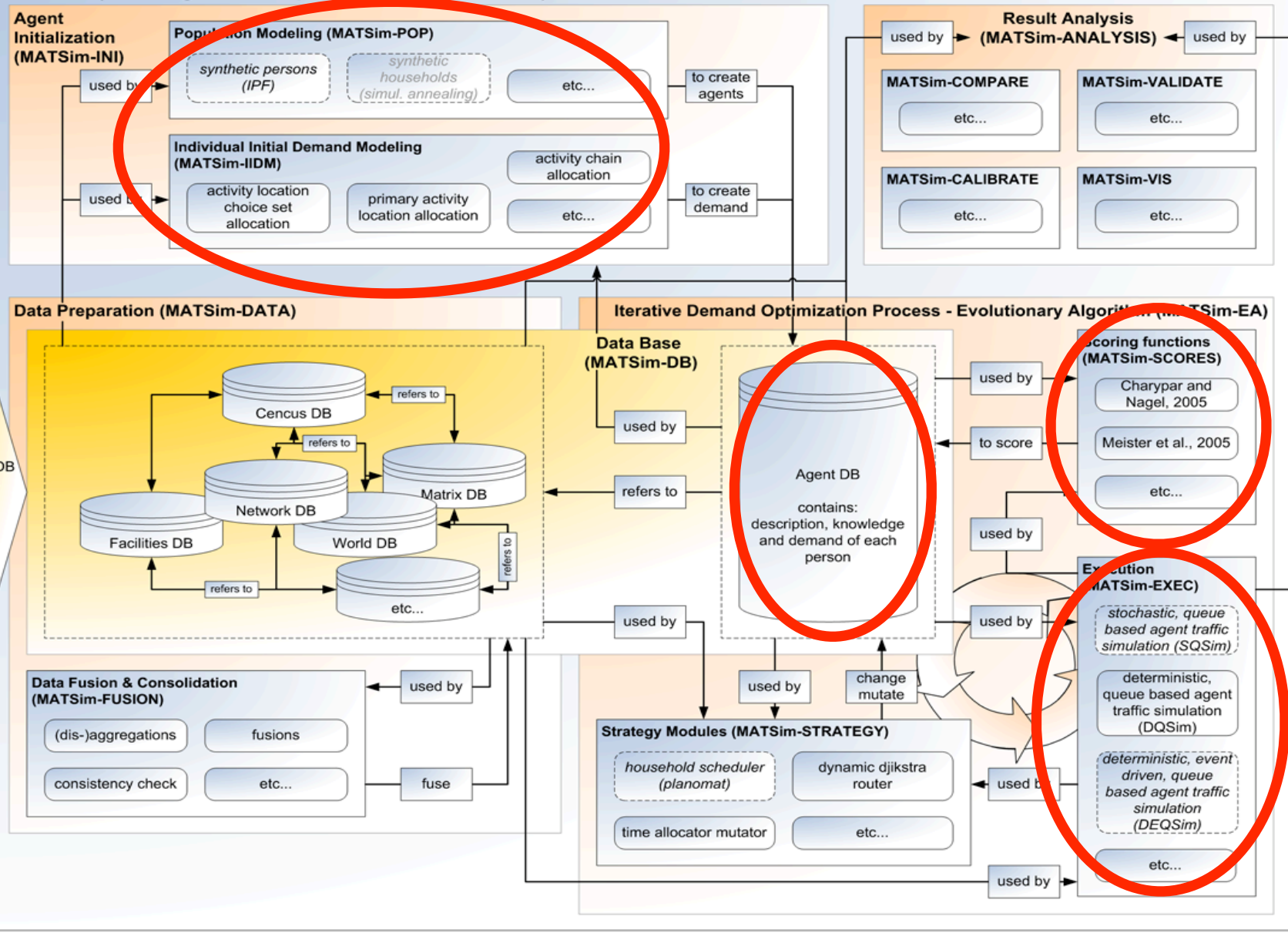
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- sub-groups of the demand modeling process
- external models and algorithms
- memory database
- data representations
- models and algorithms implemented
- models and algorithms planned or in progress

# MATSim-T (Multi-Agent Transport Simulation Toolkit)

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MATSim-DB Parsers and Writers

Source: Balmer 2007



## Legende

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# ABM of Minibus Taxis and Commuters :: Implementation in MATSim-T

## MATSim-INI

- Initialisation of taxis: routes, fares, capacities, initial locations

## MATSim-DB

- Commuter: plans.xml already anticipates multiple modes
- Taxi driver: explicit definition as agent type?
- Commuter knowledge of taxi routes?



# ABM of Minibus Taxis and Commuters :: Implementation in MATSim-T

## MATSim-EXEC

- Additional layers for rail and pedestrian?
- Dynamic change of plans, specifically mode change?
- Interaction between commuter and taxi driver:  
identification of taxi  
(transfer between layers?)
- Interaction between commuters: bandwagon effects

## MATSim-SCORES

- Scoring function to compare utility of mode changes
- Scoring function for taxis/taxi drivers

Movie file 8

# Questions / Discussions

