Research in Department of Civil Engineering
Research areas

1. The Department of Civil Engineering
2. Departmental research
3. Allocating road space
4. Design of traffic and parking systems
5. Data and discrete choice simulation models
6. Land use / Transport / Environment models
What do Civil Engineers do?

- Work on planning, designing, constructing, operating, and maintaining infrastructure projects
- Work with community
- Provide water, food, shelter, safety
- Facilitate communication, transport, recreation.
Major construction
eg CityLink
Water supply, dams, spillways, flood management
Pipelines
Bridges
Sports events
Racing Circuits
Transport - rail
Transport - roads
Vehicle and roadside design
Transport - bicycle safety
Major structures and their foundations
Piles support major structures
Novel structures
What are the main areas of Civil Engineering?

- Environmental Engineering
- Transport Engineering
- Water Engineering
- Geotechnical Engineering
- Structural Engineering
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Research in Department of Civil Engineering

- Water
- Structural Engineering
- Geotechnical Engineering
- Transport
Integrated Urban Water Management

- Development of novel treatment technologies to improve quality of stormwater, wastewater, etc
- Water recycling & integrated urban water cycle mgt
- Ecosystem response (partnership with Walsh et al)
- Cost-benefit analysis techniques
- Partnership with UNESCO IHP & INSA France
Waterway Management

- Water allocation and environmental flows
- River rehabilitation
- Techniques for assessing waterway health
Groundwater Management

- Interactions of groundwater & surface water
- Effects of water allocation on groundwater-dependent ecosystems
- Potential impacts of surface water pollution on groundwater (in urban and rural environments)
Flood & Floodplain Management

- Techniques for risk analysis of structural & non-structural approaches to flood mitigation
- Role of flooding in environmental flows & floodplain health
Institute for Sustainable Water Resources

**EXPERTISE**
- Physical & hydodynamic modelling of waterways & hydraulic structures
- Hydrologic uncertainty analysis
- Innovative water quality treatment technologies
- Environmental flow modelling
- Groundwater analysis & modelling
- Estuary mg & modelling
- Urban stormwater management
- Waterway health & ecosystem response prediction
- Monitoring technologies
- Water allocation – physical & economic modelling
- Integrated urban water cycle management (including recycling technologies)

**RESEARCH FOCUS AREAS**
- Groundwater Management
  - Groundwater – waterway interactions
  - Aquifer storage & recovery (re-use)
  - Groundwater quality & quantity modelling
- Integrated Urban Water Management
  - Water treatment technology
  - Water sensitive urban design
  - Water harvesting & re-use
  - Ecosystem impacts
- Waterway Management
  - River rehabilitation
  - Sustainable water allocation
  - Waterway health
  - Environmental flows
  - Waterway structures
- Monitoring Technology
  - Sensor technologies
  - Real-time wireless monitoring & control systems
- Flood Management
  - Risk analysis
  - Flood mitigation structures
  - Floodplain interactions
  - Flood modelling
- Estuary Management
  - Tidal & fluvial flooding
  - Environmental flows
  - Morphology
  - Hydrodynamics

**LINKS**
- Water Studies Centre (Monash University)
- Melbourne Centre for Water Research
- UNESCO Urban Water Programme IHP-VI
- Australian Centre for Biodiversity
- Relevant CRCs (Catchment Hydrology, Freshwater Ecology, eWater)
- International research groups (e.g. Pennine Water Group, UK)
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A methodology for allocating road space for public transport priority
Introduction

– Allocation of road space
– Project for Victorian Road Authority
Vehicle types
Vehicle separation
Vehicle separation

Transit Gates

Transit No Turn Exemption
Vehicle separation

Transit Lane - With Flow

Transit Lane - Contra-Flow
Previous approaches

- Traffic flow (Vuchi)
- Person travel time (Black et al, Sparks and May)
- Semi dynamic modelling (Jepson and Ferreira)
- Traffic flow models (Oldfield et al)
- Quantitative economic analysis (DOTR-UK)
Proposed methodology

- Modelling method
  > Simulation
  > Economic appraisal

- Methodology is still in development stage
Proposed methodology

DIRECT IMPACTS

Transit User Impacts
- Travel Time Impacts
- Reliability Impacts

Road User Impacts
- Travel Time Impacts
- Reliability Impacts

Transit Operator Impacts
- Fleet and Crew Resource Impacts

Infrastructure Impacts
- Capital costs of priority measures
- Operating costs of priority measures

SECONDARY IMPACTS

Mode Shift Impacts
- New Transit User Travel Time Benefits
- Road Congestion Impacts
  - Road User Travel Time Reduction
  - Reduced operating costs
  - Reduced accident costs
  - Reduced environmental emissions
- Farebox Revenue Growth Impacts

DIRECT IMPACTS

SECONDARY IMPACTS

Mode Shift Impacts

- New Transit User Travel Time Benefits
- Road Congestion Impacts
  - Reduced operating costs
  - Reduced accident costs
  - Reduced environmental emissions
- Farebox Revenue Growth Impacts
Proposed methodology

– Travel time
– Reliability impacts
– Transit operator impacts
– Infrastructure impacts
– Mode split impacts
– Trip diversion impacts
Proposed methodology

- Future items to be included
  - Traffic disruption on transit bunching
  - Long term growth impacts
  - Network impacts
  - Trip generation, re-timing, trip redistribution
Comparative methodology application

- Road configuration
- Intersection signal configuration
- Transit service
- Base case
- Option case
- Traffic volume
- Traffic direction
Comparative methodology application

![Graph showing the Net Present Value ($Aust 000) vs Buses/Hour for three different methods: Method A - Proposed, Method C - Time Time Alone, and Method B - A - Reliability. The Vuchic Threshold is indicated on the graph.](image)
Conclusion

- Methodology for allocating road space
- Dynamic approach
- Improvement of volume based approach
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The efficient design of traffic systems in and around multi-storey parking facilities
Outline of Presentation

- Need for research
- Objectives of paper
- Model structure of EPSILON
- Field application
- On-going developments
- Conclusions
Need for Research

- Multi-storey parking is an important land-use component in urban areas, this is particularly true as the demand for road space for moving vehicles increases.
- Traffic impact of developments with mixed uses.
- ITS and effect of parking information on driver behaviour needs to be understood.
Objectives of Paper

- To describe development of a micro-simulation model of traffic and parking
- To apply model to an existing multi-storey car park
The EPSILON Model

• EPSILON = Evaluation of Parking Systems using microsimulation on a Local Road Network
• Extension of PARKSIM (1985) and SAPTSIM (1998) models for surface car parks
• Simulates movement of individual vehicles on road network
Model Structure

- **Object-oriented design**: represents problem in terms of objects (e.g. vehicles, links, spaces) that interact; addresses relationships between them
- **Time-update**: speeds and positions of individual vehicles updated every 1 s
Institute of Transport Studies

Generate vehicle

Moving

Pass by

To a car park

Continue search

Search for a space

To an exit node

Remove vehicle

Parking

Look for gap to park

Parking manoeuvre

Parked

Unparking manoeuvre

Look for gap to unpark

To a car park

Pass by

Continue search

Search for a space

To an exit node

Remove vehicle

Moving

Queue

Give way

Go to next link

MOVEMENT STATES
Route Choice

- Drivers passing by site attempt to minimise perceived travel costs to exit nodes
- Drivers entering car park attempt to minimise perceived costs to bldg ent; “search for space” mode
- Perceived costs to capture uncertainty in driver perception
- Minimum paths from Dijkstra’s algorithm that considers turn penalties (Kirby & Potts 1969)
Vehicle Movement

- Car-following: Gipps model (1981)
- Lane-changing: Gipps model (1986)
- Intersection model: unsignalised & signalised
- Car park entry/exit control: service delay at entry/exit gate
Parking Search

- **Choice set generation:**
  - Examines whether considered spaces are vacant;
  - Examines whether considered spaces are blocked by building structures using line-of-sight calc;
  - Examines whether considered spaces are blocked by moving and parked vehicles.

- **Evaluation of choice set:**
  - If considered spaces visible, evaluates attributes of each space (driving & walking time) to determine overall worth.
Visual Representation of Traffic & Parking Environment

Network editor → Simulation engine (EPSILON) → User interface → Responses

Travel scenario
Field Application

- **The Heeren SC**
  - Mixed use with 90° parking; mainly 1w circulation
- **Coded network**
  - 45 nodes
  - 62 links
  - 150 spaces
  - 99 struc objects
- **Simulation period**
  - 06:00 to 22:00 (16)
Field Application

• **Surveys for model inputs & comparisons**
  – License plate survey at entry/exit point
  – Patrol survey
  – Random-sample interview of drivers who parked
Speeds
Park/Unpark Manoeuvre Times

![Histogram showing observed and theoretical frequency distribution of speed (km/h). The histogram is labeled with observed and theoretical data.](image-url)
Simulation Runs
Comparisons

![Graph showing comparisons between observed and modelled accumulation of vehicles. The graph includes data points for Level B2, Level B3, and Level B4, along with a line of perfect agreement.](image-url)
Conclusions

- EPSILON was capable of producing logical and stable results
- Has potential for providing simulation support to conduct virtual travel & parking experiments
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Traffic simulation, Driver risk and Modeller’s liability
Outline of paper

- Introduction
- Vehicle interactions
- Safety related parameters
- Analysis
- Discussion
Introduction

- Models make assumption
- What is the role of risk
Vehicle interaction

- **Car-following** (Update time of model)
- **Gap acceptance** (Shorter as time at intersections passes)
- **Lane changing** (More desperate as approach departure intersection)
- **Intersection simulation** (Adherence to signs)
- **Route choice** (Minimum path)
Safety related parameters

• **Reaction time** (Related to simulation time)
• **Gap acceptance** (Shorter as time at intersections passes)
• **Safe headways** (Freeway headways 0.5 seconds)
• **Stopping at red lights** (More red lights less adherence)
• **Free flowing speeds on links** (Speed limits)
• **Overtaking on links when forbidden** (Double solid lines)
Safety related parameters (cont.)

- **Nearside overtaking** *(Where forbidden)*
- **Nearside turn on red** *(Where forbidden)*
- **Pedestrian walking on red** *(Where forbidden)*
Analysis

• **Application of DRACULA (Leeds) / PARKSIM (Monash)**
  – Speed compliance
  – Aggressive driving (as measured by acceleration/deceleration)
## Analysis

### Speed limit compliance

<table>
<thead>
<tr>
<th></th>
<th>Total travel time (veh hrs) in the network</th>
<th>Travel time (veh hrs) at speeds below 10kph</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle hours in traffic network</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak hour flow (18,000vph)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- normal compliance (80%)</td>
<td>1093</td>
<td>538</td>
</tr>
<tr>
<td>- assumed full compliance (100%)</td>
<td>1155</td>
<td>569</td>
</tr>
<tr>
<td>- difference</td>
<td>(+5.6%)</td>
<td>(+5.7%)</td>
</tr>
<tr>
<td>Off Peak hour flow (12,000vph)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- normal compliance (66%)</td>
<td>440</td>
<td>66</td>
</tr>
<tr>
<td>- assumed full compliance (100%)</td>
<td>453</td>
<td>50</td>
</tr>
<tr>
<td>- difference (%)</td>
<td>(+2.9%)</td>
<td>(-24.2%)</td>
</tr>
</tbody>
</table>
## Aggressive driving

<table>
<thead>
<tr>
<th>Vehicle hours on total network</th>
<th>Priority roundabout</th>
<th>Partially signalised roundabout</th>
<th>difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current flow scenario</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- modest acceleration/deceleration</td>
<td>50.0</td>
<td>52.6</td>
<td>+5%</td>
</tr>
<tr>
<td>- aggressive acceleration/deceleration</td>
<td>46.4</td>
<td>51.4</td>
<td>+11%</td>
</tr>
<tr>
<td>- aggressive acceleration/deceleration</td>
<td>(-7%)</td>
<td>(-2%)</td>
<td></td>
</tr>
<tr>
<td>Future high flow scenario</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- modest acceleration/deceleration</td>
<td>227.5</td>
<td>81.8</td>
<td>-64%</td>
</tr>
<tr>
<td>- aggressive acceleration/deceleration</td>
<td>171.2</td>
<td>70.1</td>
<td>-59%</td>
</tr>
<tr>
<td>- difference</td>
<td>(-25%)</td>
<td>(-14%)</td>
<td></td>
</tr>
</tbody>
</table>
Discussion

• Safety versus accuracy
• Recognition of safety in design and analysis
• Existing model accuracy
• Stability of simulation models
• Modeller liability
• Recommendations (Design system safely but model real behaviour?)
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Impacts of major road investment on urban development
Modelling impacts of road investment (Eastlink)

- Land use
- Transport
- Environment
- CITYPLAN / LAND (Lowry Model)
- TRANUS / MEPLAN (Input Output Model)
## Eastlink

**Travel Time Measures (OCT/NOV 2003)**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Legend</th>
<th>Min(%)</th>
<th>Max(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fridays</td>
<td></td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Measure</td>
<td></td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>PM:Minutes TT &gt; freesflow+50%</td>
<td></td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td></td>
<td>120</td>
<td>300</td>
</tr>
</tbody>
</table>

**Legend**
- Green: 0 - 30
- Yellow: 30 - 60
- Orange: 60 - 120
- Red: 120 - 300

**Map**
- FPMS: Freeway Performance Monitoring System

**Results**
- Eastern
- Monash
- City Link
- Princes
- WGF
- SGF
- MP F
- City Link
- Eastlink
- Ringwood
- Knox
- Dandenong
- Melbourne
- Port Phillip
- Frankston

**Institute of Transport Studies**

[Image of map with routes and locations]
CITYPLAN / LAND: Transport network
CITYPLAN / LAND: Landuse activities
TRANUS / MEPLAN: Transport system