Accessibility Instruments in Planning Practice

Spatial Network Analysis for Multi-Modal Transport Systems (SNAMUTS): Adelaide

Prof Carey Curtis, Dr Jan Scheurer, Roger Mellor, Oscar Thomson
Curtin University, Perth
Day 1 - Agenda...

3:00  Welcome & Introductions
3:10  Project Objectives
3:15  Accessibility experience - Pre-Workshop
3:25  Introduction to SNAMUTS
3:35  SNAMUTS Adelaide: Current Accessibility
3:50  Afternoon tea
4:00  Accessibility questions for Adelaide
The ARC project....

Continue the development of an interactive accessibility tool to assist in examining scenarios for activity centres framed around:
- the accessibility of the transport network, and
- the accessibility of place.

25 Cities in Australia, Europe, N. America & Asia
ARC objectives

- SNAMUTS as a benchmarking tool
- SNAMUTS methodology and robustness in a range of city types
- SNAMUTS - USE & USEABILITY
EU COST Project...

- Concerted Action in Research - Accessibility Instruments in Planning Practice
- 22 European Countries & Australia
- Local (National) Workshops -
  - USE & USEABILITY
The purpose of SNAMUTS...

the quantification of the effect of
- transport infrastructure improvements and modifications, and
- of land use intensification...

...on the accessibility of activity centres and corridors by different modes of transport (primarily public transport).
The tool can enable the testing of a range of scenarios to assist in the development of a hierarchy of activity centres by exploring and measuring the effect of the following scenarios across the metropolitan area ...

- Changes in public transport accessibility resulting from service improvements

- Comparative accessibility by car and by public transport (to examine how and where public transport can be more competitive)

- Exploring potential changes in activity levels (different patterns of jobs/residents defined by regional/local catchments) in each activity centre
Context - Land use transport integration in Australian cities

- clear policy intentions in Metropolitan Plans
- but selective implementation resulted in low density and dispersed form
- not only are cities spread out but land use activity is scattered... a myriad of centres
- possibility of supplying a high frequency public transport system to serve these centres a challenge.
...developing the decision tool
Perth to Mandurah Railway

Opened in December 2007 and may have been the largest single infrastructure insertion to date into Perth’s public transport system.

Could we quantify its benefits for mobility and accessibility locally and across the metropolitan region?
Compiling a Base Network

How can we measure distance (or travel impediment) in ways that come close to user perceptions and motivations?

- Public transport users are only marginally interested in geographical distance: the main factors of travel disutility are travel time, and the ubiquity of travel opportunities (service frequency)
spatial network analysis for multimodal urban transport systems (SNAMUTS)

Purpose: To assess and quantify how transport networks, in terms of geographical configuration and service levels, perform in their urban context (distribution of land use activities).

SNAMUTS was inspired by the Space Syntax approach (Hillier and Hanson, 1984), and the Multiple Centrality Analysis tool (Porta, Crucitti and Latora, 2006)

SNAMUTS is a supply-side tool: it does not provide predictions about usage or capacity levels. Rather it asks: What is the role of the public transport system in facilitating movement and activity across a city region?
Create a ‘network effect’ by local optimisation to routes, good interchange facilities, high and standardised service frequencies, timetable coordination and the presence of orbital/cross-suburban routes to maximise market penetration for public transport.

Spatial separation or impediment measure: Travel time divided by service frequency \( (d=\frac{4t}{\sqrt{f}}) \)

Minimum service standard (SNAMUTS 23): 20 min frequency during the weekday interpeak, 30 min on Sat/Sun (buses, trams), 30 min weekdays and 7 day service (rail)

Identifying activity nodes: SNAMUTS matrix of activity nodes derived from activity centre hierarchy in strategic planning documents and from field observation. Adelaide’s average activity node catchment is approximately 10,000 residents and jobs.
overview of snamuts indicators

1. **Service intensity**: How much operational input is required to run the network at the defined minimum service standard?

2. **Closeness centrality**: What is the ease of movement between a node and the rest of the network?

3. **Degree centrality**: How many transfers separate a node from the rest of the network?

4. **Catchment size of 30-minute travel time contour**: How many residents and jobs are accessible within half an hour?

5. **Betweenness centrality**: How are travel opportunities geographically distributed across the network?

6. **Network Stress**: Where on the network can we find mismatches between route or node significance and level of service?

7. **Nodal connectivity**: How are activity centres placed to act as hubs for the network?
Number of vehicles/train sets required in simultaneous operation for the minimum standard network (20 min weekdays, 30 min weekends for trams and buses, 30 minutes weekdays for trains)

- Trains: 18
- Trams: 10
- Buses: 191

Total: 219

16.3 per 100,000 pop (2011)
Comparison of service intensity per 100,000 inhabitants (snamuts 23 standard)

<table>
<thead>
<tr>
<th>City</th>
<th>Service Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adelaide</td>
<td>16.3</td>
</tr>
<tr>
<td>Sydney</td>
<td>14.3</td>
</tr>
<tr>
<td>Melbourne</td>
<td>13.1</td>
</tr>
<tr>
<td>Perth</td>
<td>12.0</td>
</tr>
<tr>
<td>Brisbane</td>
<td>11.4</td>
</tr>
<tr>
<td>Auckland</td>
<td>9.2</td>
</tr>
</tbody>
</table>
Operational efficiency: Networks dominated by slow modes (especially buses) tend to require greater operational input (in number of vehicles/drivers) than networks dominated by fast modes (especially light or heavy rail).

Performance expectation: Does a higher outlay of operational resources consistently result in better public transport accessibility and network performance?
Networks have **topological properties** (how many degrees of separation from A to B) and **metric properties** (how many units of distance/impediment from A to B)

*Source: Porta, Crucitti and Latora 2006*
closeness centrality

What is the ease of movement across the network?

[smaller values indicate better accessibility performance]
## Comparison of Closeness Centrality average per network

<table>
<thead>
<tr>
<th>City</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>59.0</td>
</tr>
<tr>
<td>Perth</td>
<td>59.9</td>
</tr>
<tr>
<td>Adelaide</td>
<td>61.1</td>
</tr>
<tr>
<td>Melbourne</td>
<td>62.3</td>
</tr>
<tr>
<td>Brisbane</td>
<td>64.1</td>
</tr>
<tr>
<td>Sydney</td>
<td>81.5</td>
</tr>
</tbody>
</table>
Closeness Centrality: what does and what doesn’t this index tell us?

Ease of movement: Closeness scores are a spatial separation measure for the activity centre network. They are inflated by
(1) dispersed settlement patterns,
(2) detours forced by geographical barriers or missing links,
(3) slow travel speeds,
(4) low service frequencies,
or a combination of several of the above.

Network size: Larger networks with a greater number of activity centres will generally produce higher (poorer) average closeness centrality scores than smaller ones.
degree centrality

What is the transfer intensity of the network?

[smaller values indicate better accessibility performance]
## Comparison of Degree Centrality average per network

<table>
<thead>
<tr>
<th>City</th>
<th>Degree Centrality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne</td>
<td>0.91</td>
</tr>
<tr>
<td>Brisbane</td>
<td>0.91</td>
</tr>
<tr>
<td>Auckland</td>
<td>0.95</td>
</tr>
<tr>
<td>Perth</td>
<td>1.03</td>
</tr>
<tr>
<td>Sydney</td>
<td>1.04</td>
</tr>
<tr>
<td>Adelaide</td>
<td>1.09</td>
</tr>
</tbody>
</table>
degree centrality: what does and what doesn’t this index tell us?

Network organisation:
Is the public transport network organised around a modal hierarchy with lower-capacity modes acting as feeders and distributors to higher-capacity nodes (greater transfer intensity)?

Or do the networks of modes with different performance coexist (compete?) in spatial terms (lower transfer intensity)?
contour catchments

How many residents and jobs can you access within 30 minutes from each activity node?

Some assumptions:

One transfer is allowed within 30 min, but only between services that both run at least every 15 min

A flat deduction applies for making the transfer, equivalent to the actual average transfer time across the network (usually between 6 and 8 minutes)
Comparison of network coverage and average contour catchments percent of metropolitan residents and jobs

<table>
<thead>
<tr>
<th>City</th>
<th>Network Coverage</th>
<th>Contour Catchments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney</td>
<td>53.9%</td>
<td>8.2%</td>
</tr>
<tr>
<td>Melbourne</td>
<td>49.1%</td>
<td>9.3%</td>
</tr>
<tr>
<td>Adelaide</td>
<td>48.1%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Perth</td>
<td>44.5%</td>
<td>11.7%</td>
</tr>
<tr>
<td>Brisbane</td>
<td>35.9%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Auckland</td>
<td>32.8%</td>
<td>10.2%</td>
</tr>
</tbody>
</table>
Network coverage and contour catchments: what do and what don’t these indexes tell us?

Network coverage describes the quantity of people with access to public transport, while the contour catchment measure expands this with a qualitative message (how many people can you access within 30 minutes?)

Ideally, a city would score 100% on both counts. What are the barriers in each metropolitan region that currently work against this (or merely separate present conditions from world best practice)?

And what are the levers a city has to close these gaps?
betweenness
Centrality

How are travel opportunities distributed across the network?

Betweenness centrality defines preferred travel paths between each pair of nodes, and counts them at nodes and route segments to determine their strategic significance.
<table>
<thead>
<tr>
<th>City</th>
<th>Betweenness</th>
<th>Total/ Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney</td>
<td>1,140</td>
<td>34.2</td>
</tr>
<tr>
<td>Melbourne</td>
<td>906</td>
<td>30.9</td>
</tr>
<tr>
<td>Perth</td>
<td>594</td>
<td>28.6</td>
</tr>
<tr>
<td>Brisbane</td>
<td>560</td>
<td>28.4</td>
</tr>
<tr>
<td>Adelaide</td>
<td>502</td>
<td>24.4</td>
</tr>
<tr>
<td>Auckland</td>
<td>463</td>
<td>30.5</td>
</tr>
</tbody>
</table>
Public transport ‘movement energy’: Betweenness centrality attempts to quantify the presence of public transport opportunities in each centre, and across the metropolitan area, as well as visualise how this presence flows across the network.

Balanced and unbalanced nodes/places, stressed locations and routes: Betweenness can help identify pressures on network elements originating from either their land use or their transport function (or both in conjunction).

Betweenness scores are not necessarily proportional to usage levels, but correlations with usage can point to under- or over-utilised potential for public transport movement.
betweenness centrality: what does and what doesn’t this index tell us? (ii)

The betweenness centrality index rewards urban compactness/contiguity as well as high settlement density - two influences that can either amplify or neutralise each other in the real world.

Is this bias towards urban compactness a **problem for this index**?
network stress: what does and what doesn’t this index tell us?

A ‘troubleshooting’ tool to pinpoint mismatches in public transport supply and (potential) demand (ie. demand as derived from urban form and network configuration)

Includes a feedback loop, as isolated measures to improve service levels to relieve stress (ie. frequency upgrades) will also add to network stress through greater ease of movement.

Responds most vigorously to more comprehensive solutions, such as network reconfigurations and mode upgrades.
# Comparison of Network Stress

<table>
<thead>
<tr>
<th>City</th>
<th>Average Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perth</td>
<td>18.5</td>
</tr>
<tr>
<td>Brisbane</td>
<td>21.4</td>
</tr>
<tr>
<td>Melbourne</td>
<td>21.6</td>
</tr>
<tr>
<td>Adelaide</td>
<td>22.4</td>
</tr>
<tr>
<td>Auckland</td>
<td>24.7</td>
</tr>
<tr>
<td>Sydney</td>
<td>25.0</td>
</tr>
</tbody>
</table>
To what extent do network nodes function as hubs for movement?

The connectivity index measures each node’s connectedness to other nodes, and its capacity for making transfers or stopovers.
## Comparison of nodal connectivity average per network

<table>
<thead>
<tr>
<th>City</th>
<th>Connectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne</td>
<td>82</td>
</tr>
<tr>
<td>Sydney</td>
<td>77</td>
</tr>
<tr>
<td>Brisbane</td>
<td>42</td>
</tr>
<tr>
<td>Perth</td>
<td>19</td>
</tr>
<tr>
<td>Adelaide</td>
<td>12</td>
</tr>
<tr>
<td>Auckland</td>
<td>NA</td>
</tr>
</tbody>
</table>
6 key snamuts indicators

- Closeness Centrality
  ‘Ease of Movement’
- Degree Centrality
  ‘Transfer Intensity’
- 30-minute Contour Catchment
- Betweenness Centrality
  ‘Geographical Distribution of Travel Opportunities’
- Network Stress
  ‘Identifying Squeeze Points and Underused Potential’
- Nodal Connectivity
  ‘Attractiveness for PT-oriented Land Use Intensification’

Composite Index: combines all 6 measures by allocating between 0 and 10 points to each (maximum 60)
snamuts composite index

Good, average and poor public transport accessibility on a scale map
Adelaide has the highest proportion of network coverage (residents and jobs within walking distance to public transport) at a minimum service frequency standard of 30 minutes (weekday interpeak in conjunction with 7-day operation) among Australian cities.

Adelaide provides for the highest operational input (vehicles or train sets in simultaneous revenue service) relative to population of all Australian cities.

Adelaide has a CBD surface network whose connectivity and provision for multidirectional movement is second only to Melbourne among Australian cities (though it remains less legible due to the greater dominance of buses over trams in Adelaide).
Adelaide’s uncomplicated urban geography between the coastline and the Adelaide Hills facilitates the provision of a well-connected network across most of the urbanised area (however, low service frequencies on rail lines as well as on orbital and secondary radial bus links impact negatively on its transfer-friendliness).

The modal hierarchy between trains, trams and buses remains relatively flat, and efficient task-sharing between modes of different performance (eg. buses feeding rail) remains patchy and underdeveloped.

The network is (even) more dependent on channelling movement through the CBD area than any other Australian (or overseas) city, resulting in the second highest measure of central city network stress across Australia.
Accessibility Questions for Adelaide

- Explore the SNAMUTS maps and ask questions
- How useful are these maps to you?
- What are the accessibility questions for the Adelaide metro area?
  - Aim to work on questions in preparation for day 2