R&D Initiatives for Sustainable Mobility
Singapore demography

Land area: 716 km$^2$
Population: 5.3 millions

Data is accurate as of 2012
Singapore transport: 2002 versus 2012

- **Resident Population**: 4.2m → 5.3m (26.2%↑)
- **Vehicle Population**: 0.7m → 1.0m (42.9%↑)
- **Land Area (km²)**: 685 → 716 (4.5%↑)
- **Road Length (km)**: 3150 → 3425 (8.7%↑)
- **Rail Length (km)**: 89.4 → 148.9 (66.6%↑)

**Demand**

- ++ 6.9 millions (2030)
- +1.5% growth yearly

**Supply**

- +MCE 5km (2013)
- +NSE 21km (2020)
- +DTL 6 stations (2013)
- +DTL 12 stations (2015)
- +DTL 16 stations (2017)
- +JRL (2025)
- +CRL 50km (2030)

Source: LTA (2013)
Singapore Land Transport Master Plan 2013
(source: LTA)

- 200km more sheltered walkways:
  - A more extensive sheltered walkway network to make your walk to the MRT station or bus interchange a pleasant one

- 40 more lifts at POBs:
  - More lifts at pedestrian overhead bridges (POBs) to assist the less mobile and elderly

- Over 700km of cycling paths:
  - More extensive cycling path network – getting around by bicycle will get even easier

- 20km of noise barriers:
  - Less noise for those staying along noisy sections of MRT tracks
Challenges

Walking needs of mobility challenged group

Visually impaired pedestrians

Elderly pedestrians
Geographical residential spread of elderly (SLA, 2013)
Distribution of residential locations of survey respondents
Mobility of elderly in HDB estates
Intra-town walking-cycling (NMT) network

The research focus shall be on walking and cycling in HDB towns, with emphasis on shared/co-located facilities for walking and cycling.
NMT network

- Heavy NMT flow
  - Segregated channels

- Moderate NMT flow
  - Demarcated/widened channels

- Light NMT flow
  - Existing walkways (“no-nothing”)
First/last mile links

1. Large volumes of NMT traffic travelling to/fro major attractors (e.g., transit stations)
   → Wise to provide segregated pedestrian & cyclist channels
   → Where to start/end the segregated channels?

2. NMT volumes get spread out but footpath may still be crowded for sharing
   → Do we need widening?
   → How much to widen?

3. NMT volumes are sparse
   → Do we need widening?
   → How much to widen?
### Microscopic study

#### Users along footpaths (LOSAM) - links

<table>
<thead>
<tr>
<th>#ped/h/m</th>
<th>#cyc/h/m</th>
<th>AAI</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 300</td>
<td>≥ 5</td>
<td>&lt; 2.5</td>
<td>Widen footpath</td>
</tr>
<tr>
<td>150-200</td>
<td>≥ 20</td>
<td>&lt; 2.5</td>
<td>Widen footpath</td>
</tr>
<tr>
<td>100-200</td>
<td>≥ 40</td>
<td>&lt; 2.5</td>
<td>Widen footpath</td>
</tr>
<tr>
<td>≥ 200</td>
<td>≥ 10</td>
<td>&lt; 2.5</td>
<td>Widen footpath</td>
</tr>
<tr>
<td>≥ 240</td>
<td>≥ 37</td>
<td>&lt; 2.2</td>
<td>Demarcate footpath</td>
</tr>
<tr>
<td>≥300</td>
<td>≥ 42</td>
<td>&lt; 2.1</td>
<td>Segregate channel</td>
</tr>
</tbody>
</table>

1=not acceptable, 2=tolerable, 3=acceptable, 4=comfortable

![Graph showing decision criteria for footpath design](image)

Engineers can collect 10 min peak hour pedestrian and cyclist counts and channel width, convert to #/h/m and look for AAI.

- E.g. 450 p/h & 45 c/h @1.5m width → 300 p/h/m & 30 c/h/m (AI < 2.1)
- For AI > 2.5, \( \frac{450}{150} = 3 & \frac{45}{3} = 15 \) → Widen footpath to 3.0 m

AAI = 2.9, 2.8, 2.7, 2.6, 2.5, 2.4, 2.3, 2.2, 2.1

- [Demarcated shared footpath](#)
- [Segregated dual channels](#)
Microscopic study

Applications of LOSAM
Components of SAI

1) Security 10 pts 11 pts
2) Detour 9 pts 9 pts
3) Delay 9 pts 8 pts
4) Directional signs 8 pts 9 pts
5) Comfort 10 pts 9 pts
6) Rain shelter 12 pts 9 pts
7) Stairs/slope 9 pts 9 pts
8) Accident risk 10 pts 11 pts
9) Crowdedness 9 pts 11 pts
10) Shops 7 pts 7 pts
11) Good scenery 7 pts 7 pts

Total 100 pts 100 pts
Route choice models

For walking:

\[ P(Y = 1) = \frac{e^{4.19+0.96\text{Scenery}+1.44\text{Shops}-0.75\text{Crowdedness}}}{1 + e^{4.19+0.96\text{Scenery}+1.44\text{Shops}-0.75\text{Crowdedness}}} \]

For cycling:

\[ P(Y = 1) = \frac{e^{-3.09-0.38\text{Crowdedness}+1.14\text{Stairs}-0.39\text{Accident risk}}}{1 + e^{-3.09-0.38\text{Crowdedness}+1.14\text{Stairs}-0.39\text{Accident risk}}} \]

\( e^{0.96} = 2.6 \) (260% increase in the odds)

Macroscopic study

Mode choice model

**Probability of selecting mode, m**

\[ m = f(\text{distance or time, built environment, personal, infrastructural compatibility}) \]

- Land use, bus services
- Age, gender, trip purpose, HH income, occupation, vehicle ownership

**Multinomial logit model**

\[
\text{Probability (Walking)} = \frac{e^{a_1+b_1x_1} \cdots}{1 + e^{a_1+b_1x_1} \cdots + e^{a_2+b_2x_1} \cdots}
\]

\[
\text{Probability (Cycling)} = \frac{e^{a_2+b_2x_1} \cdots}{1 + e^{a_1+b_1x_1} \cdots + e^{a_2+b_2x_1} \cdots}
\]

\[
\text{Probability (Taking bus)} = \frac{1}{1 + e^{a_1+b_1x_1} \cdots}
\]

(reference category)

Pedestrian shed analysis

Good pedestrian shed (60% and 67%)

Poor pedestrian shed (48% and 51%)

Pedestrian shed percentage = Actual pedestrian network buffer area divided by the theoretical area reached within the straight line distance
Related publications

Journal Papers


Non-Motorised Transport (NMT) Research Team

- A/Prof Wong Yiik Diew (Director - CIS);
- A/Prof Gopinath Menon (Adjunct Professor; former Chief Transportation Engineer of Singapore);
- Dr Meng Meng (Post-doctoral Research Fellow);
- Ms Koh Puay Ping (PhD candidate; Senior Engineer, Land Transport Authority);
- Ms Nguyen Phuong Nga (Research Associate);
- Mr Leow Bok Wee (Project Officer);
- Mr Zhang Jie (Project Officer);
- Ms Lu Ping (Manager, CIS);
- Ms Dwi Phalita Upahita (PhD candidate);
- Ms Rojas Lopez Maria Cecilia (PhD candidate).