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The Benefits of Operational Modelling for Bicycle Infrastructure Planning and Design

Research summary & outcomes

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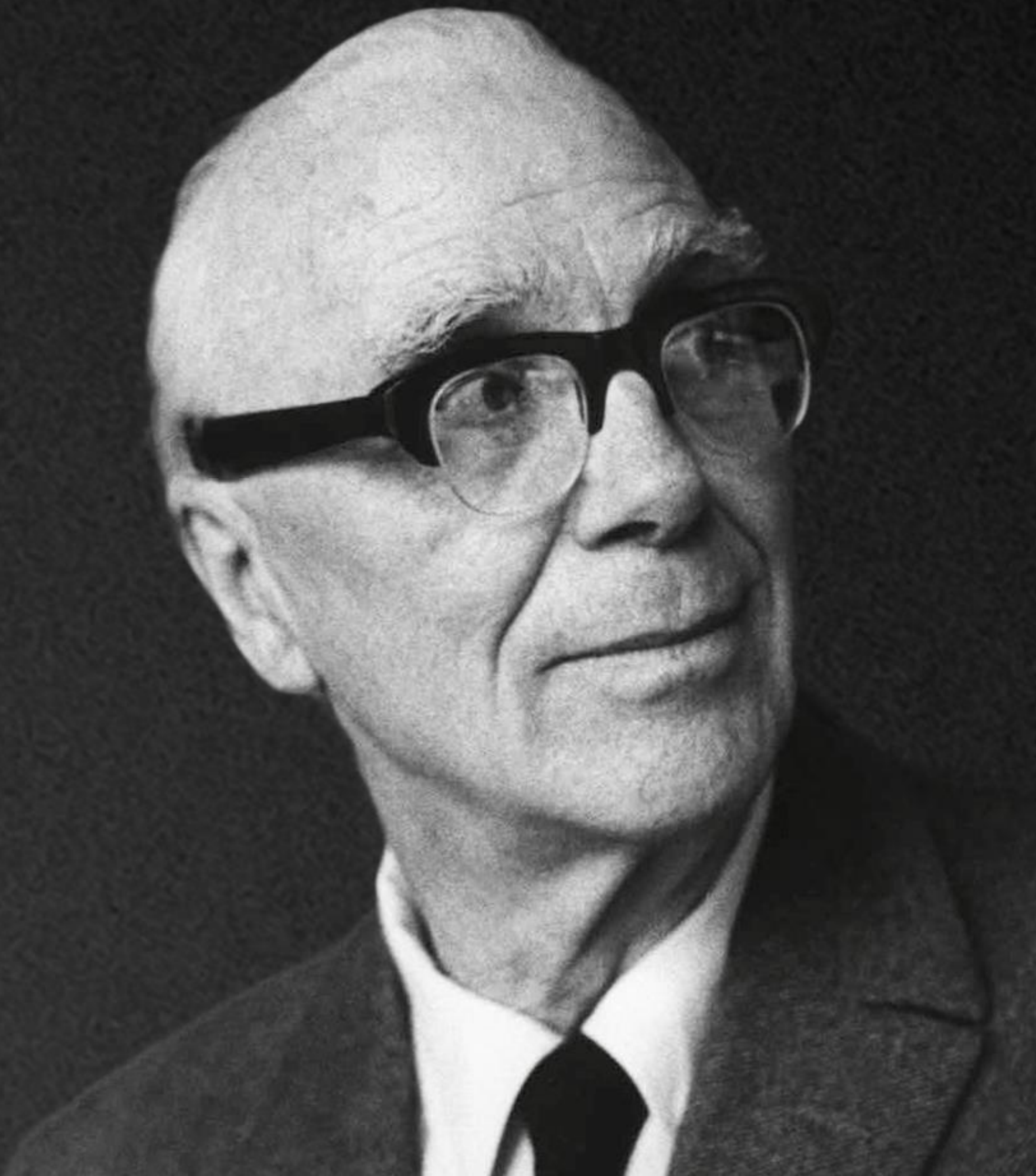


Arup University ensures our firm evolves and adapts over time and delivers excellence in everything we do – for the benefit of our members, our clients, and the communities we serve – both today and in the future.

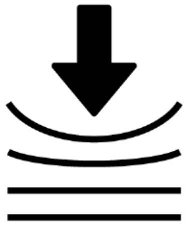
Arup research

At Arup, we conduct high quality research projects in collaboration with each other, with our partners and our clients.

Each year, our Research team set priority research themes to maximise our research impact, strengthen our existing business and set the foundation for emerging businesses.

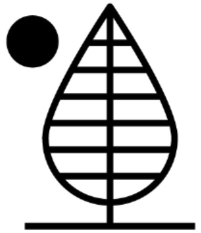
Our research helps us to create new knowledge or use existing knowledge in novel and creative ways to create new insights, methods, processes and skills.

Towards net zero carbon



Shaping resilient systems

Data and digital solutions



Renew, restore and regenerate

Inclusive places and communities

Research motivations

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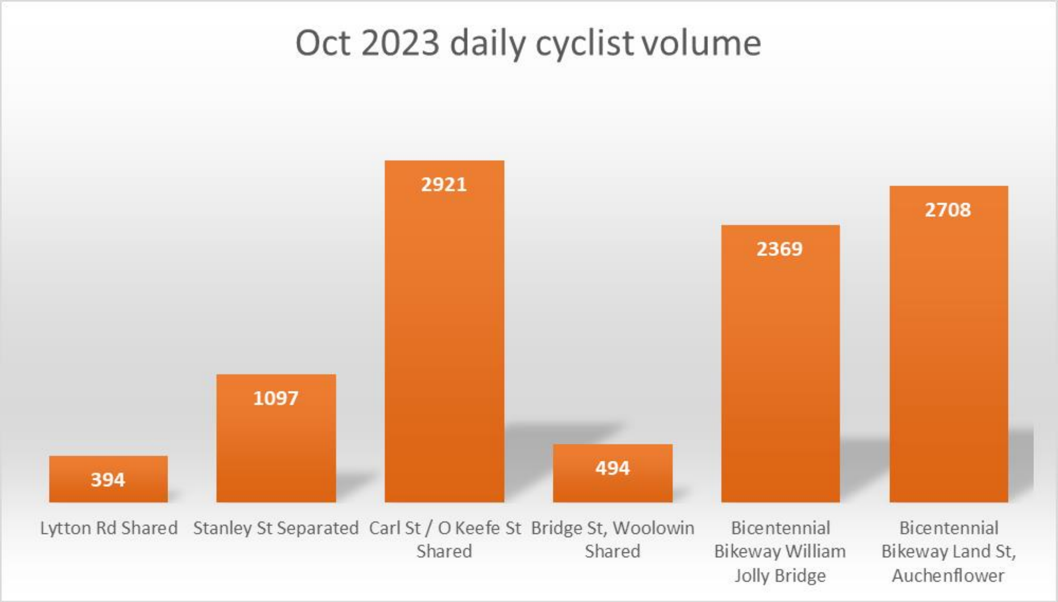
- Increasing need for equitable, resilient multi-modal transport systems for Australia's growing cities
- Nuances of design/ operational requirements for designing for bikes often not well considered
- Benefits of priority cycling infrastructure often not quantified at the micro level and therefore not well understood
- Challenges in visualising cycling infrastructure benefits and gaining stakeholder support for solutions
- Significant potential for induced cycling demand – if infrastructure is planned/ designed effectively to minimise active transport delays.

Arup motivations

- Arup skills development and learning
- Tools to apply and support planning/ design work in urban environments - such as strengthening business cases



Research objectives

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1. Review industry-prevalent operational transport modelling software packages to determine cycling modelling functionality
2. Demonstrate how operational transport modelling can be used to inform cycling infrastructure planning and design
3. Highlight the design/ operational complexities involved in providing highly efficient cycling infrastructure through micro-level analysis
4. Identify software strengths, limitations and potential areas for future research
5. Develop bicycle operational modelling skills within Arup
6. Share knowledge with industry.

Research methodology

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Stage 1

Literature & software review

- Desktop literature/ guidelines review
- Software review/ familiarisation/ learning

Scoping

Research & assessment scoping

- Engage with external collaborators
- Develop research methodology

Development

Stage 2

Model development

- QLD context – Aimsun cycleway corridor
- VIC context – Viswalk shared space environment

Analysis

Scenario testing

- Testing of improvement scenarios (network & demand changes)
- Analysis of outputs

Dissemination

Stage 3

Reporting

- Final Research Report
- Dissemination and knowledge sharing

Software review outcomes

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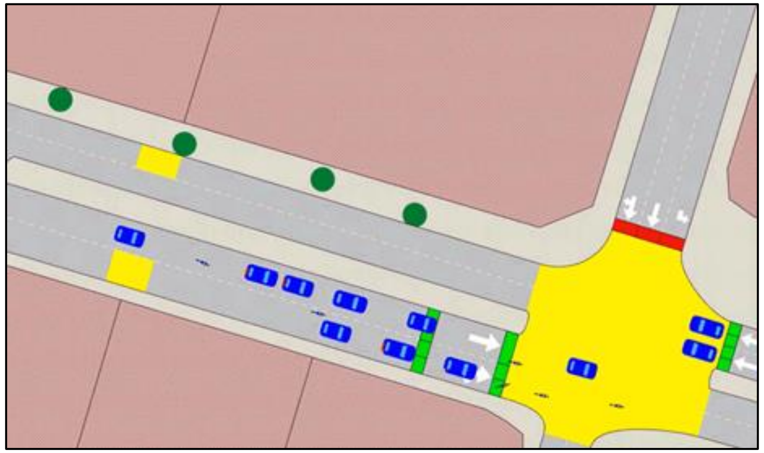
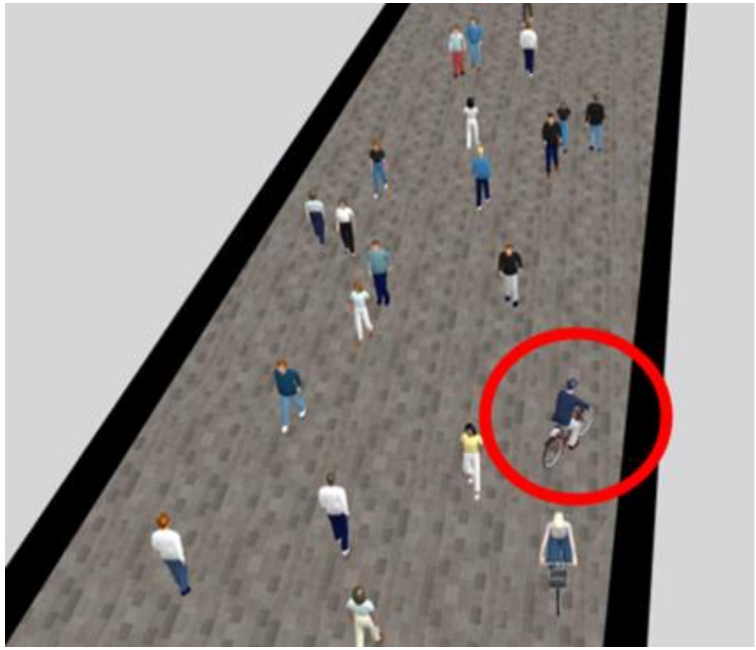
Aimsun & Vissim	Viswalk
Simulates bikes as a ‘vehicle type’ with the same calibration parameters	Simulates bikes using a pedestrian agent profile (Social Force Model)
On-road, mixed within traffic lanes (non-lane-based behaviour) or off-road cycleways	Off-road environments with spatial interaction between bikes and peds
Interaction between bikes and peds/ vehicles at intersections (but not in off-road shared spaces)	Documented in the literature to require careful calibration of agent profiles for use as people on bikes
Considers gradient impacts using TWOPAS slope model	Capable of modelling impacts of/ interaction with obstacles within areas, including dynamic re-routing
Capable of detailed signal operation for bike riders e.g., dedicated phases, actuation	Capable of detailed signal operation at controlled crossings
Bespoke features such as advanced stop lines/ bike boxes	Can’t easily transition a bicycle trip between Vissim links and Viswalk areas
Traditional ‘vehicle’ performance outputs	Traditional vehicle-type and pedestrian performance outputs





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Worthy real life locations to test

- Confirmed through engagement with TMR, BCC and VicDoT
- Discussions with BCC on suitability of route selection
- Seeking different use cases

Brisbane, Queensland

Stanley Street Bikeway

(Separated/protected cycle track)

Melbourne Victoria

South Bank Promenade

(Off road Shared path)

QLD Stanley St bikeway Aimsun model

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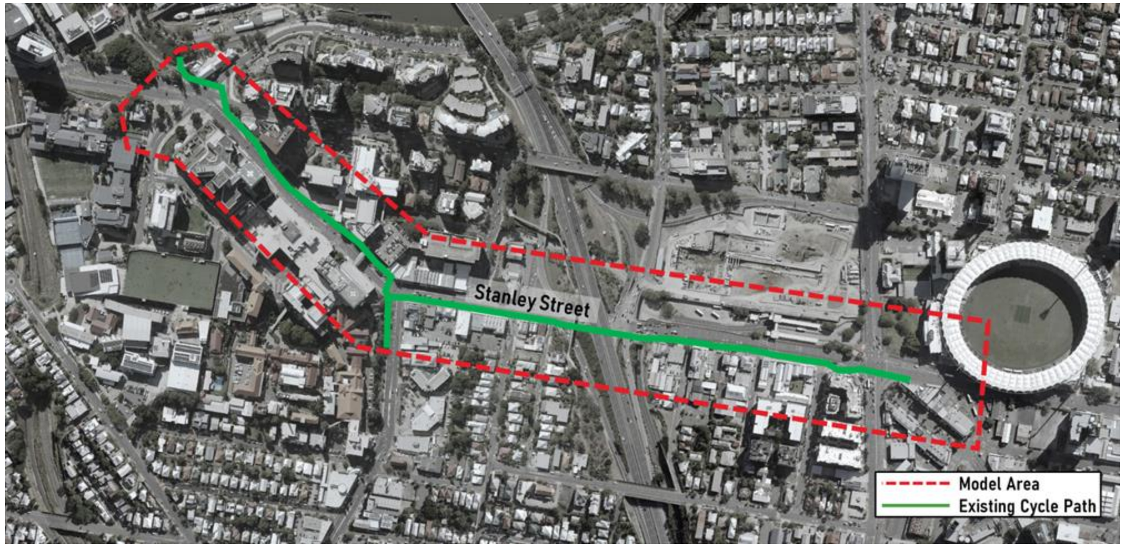
- Stanley Street bikeway selected as test-case Aimsun model location following consultation with Brisbane City Council (BCC)
- Approx. 1.25km of existing cycleway in Woolloongabba – numerous signalized intersections between the Gabba and Southbank parklands
- Established cycleway with high volumes of cycling demand to test model calibration capabilities
- Existing cyclist delays/ pinch-points/ inefficiencies for potential improvement testing



VIC Southbank Promenade Viswalk model

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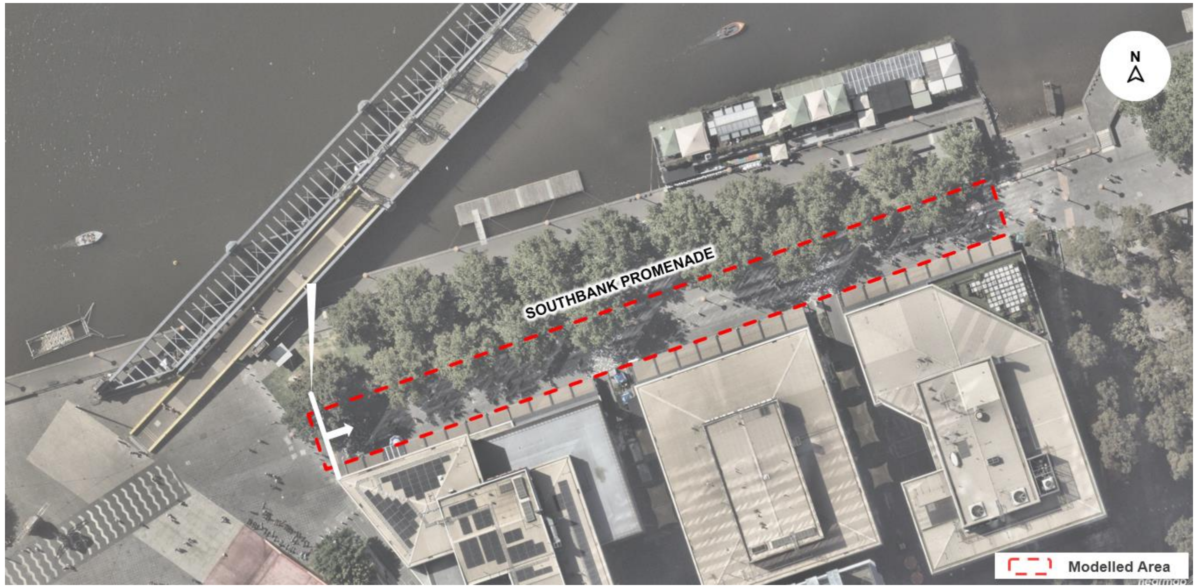
- Melbourne Southbank Promenade selected as test-case Viswalk model location
- Existing off-road shared-use walking/ cycling area
- Includes street furniture to assess obstacle interaction
- Experiences high volumes of peds and cyclists during weekday peak hours
- Suitable for calibration/ validation of cycling movement & ped interaction
- Good basis for testing impacts of demand/ geometry changes against expected behaviour/ shared path capacity guidance.



Base model data inputs

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- Qld model – using Council's count data and detector counts
  - Opportunity to get actual survey and validation
- Vic model, benefited because it is an off-road path from video observations derived from the counts
- *Ability to critique the model development /outputs using lived experience and video observations is beneficial.*

Data type	Location and purpose	
	Stanley Street Aimsun model	Southbank Promenade
Pedestrian and cyclist volumes	Stanley St/ Annerley Rd intersection turn count survey 10 October 2023	Southbank Promenade video survey on 23 January 2024
Signal timing and intersection detector counts	Signal phase timings and detector counts for the period 20 November to 26 November 2023 for the following intersections: • Stanley St / Main St / Ipswich Rd • Stanley St / Leopard St • Stanley St / Allen St • Stanley St / Annerley Rd • Stanley St / Raymond Tce • Stanley St / Vulture St / Dock St.	N/ A
Pedestrian and cyclist travel times	N/ A	Derived from the 23 January 2024 video survey and used to validate cyclist speeds
Survey video footage	N/ A	Derived from the 23 January 2024 video survey and used to calibrate cyclist behaviour and interactions in the shared space.

Base model calibration/ validation

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- **Qld Stanley Street Aimsun model:**
  - One-hour weekday AM peak model
  - Calibrated to cycleway counts and signal timing/ traffic detector data
  - Significant e-scooter cycleway demand: simulated as cyclists
  - Cyclist profile parameters adjusted to produce observed on-site queuing
  - No travel time validation undertaken

- **Vic Southbank Promenade Viswalk model:**
  - One-hour weekday PM peak model
  - Video survey demand inputs
  - Agent Social Force model parameters adjusted to align with survey video observations
  - Validated against bicycle rider and pedestrian travel times/ speeds (see tables) [use of video survey]

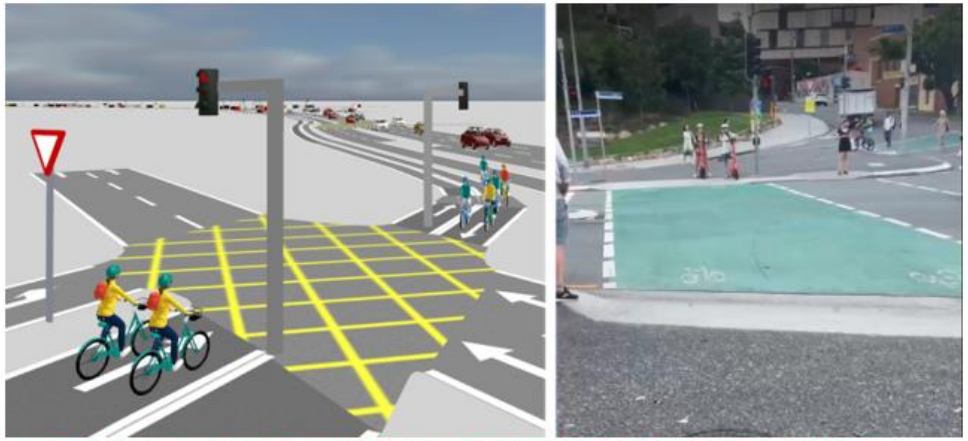

Figure 4-5: Aimsun base model vs. observed queueing behaviour at Vulture Street cycleway crossing

Table 4-5: Southbank Promenade observed travel times and speeds

Metric	PM peak hour			
	Eastbound		Westbound	
	Pedestrian	Cyclist	Pedestrian	Cyclist
Avg travel time (s)	106	26	115	39
Avg speed (km/h)	4.6	18.8	4.2	12.3

Table 4-6 Southbank Promenade base Viswalk area measurement results

User type	Nearest Neighbour Average distance (m)	Average Speed (km/hr)	Average Speed deviation (km/hr)	Number of stops	Total stopped time (s)
PM peak hour base year					
Pedestrians	1.44	3.86	0.1	5	0.25
Cyclists	1.56	18.96	1.85	4	0.6

Stanley Street bikeway option scenarios

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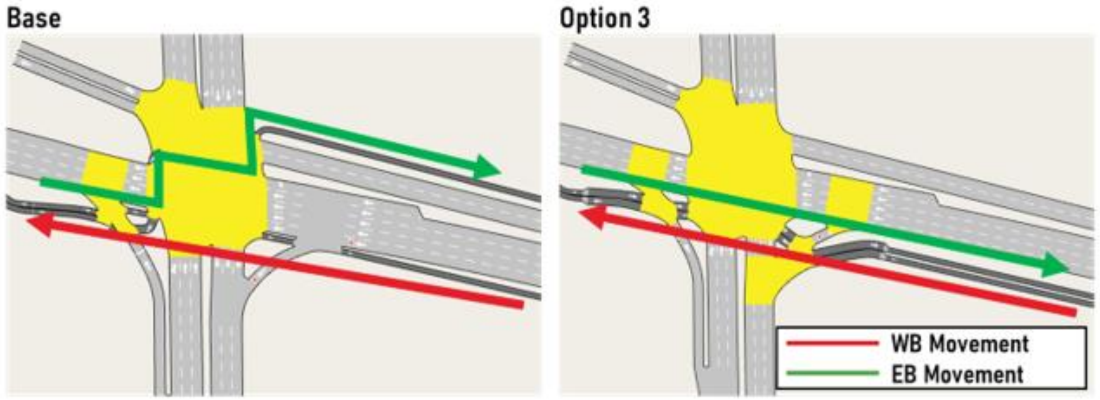
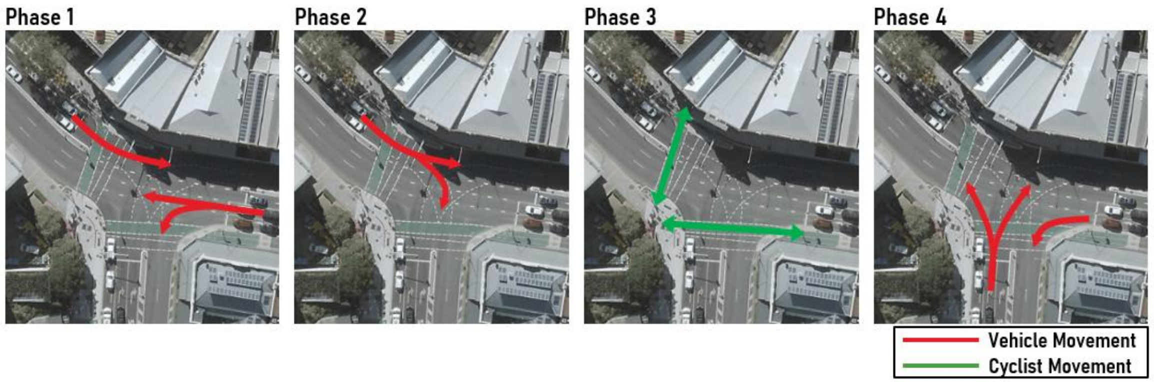
- Option 1: doubling of base cycleway demand:

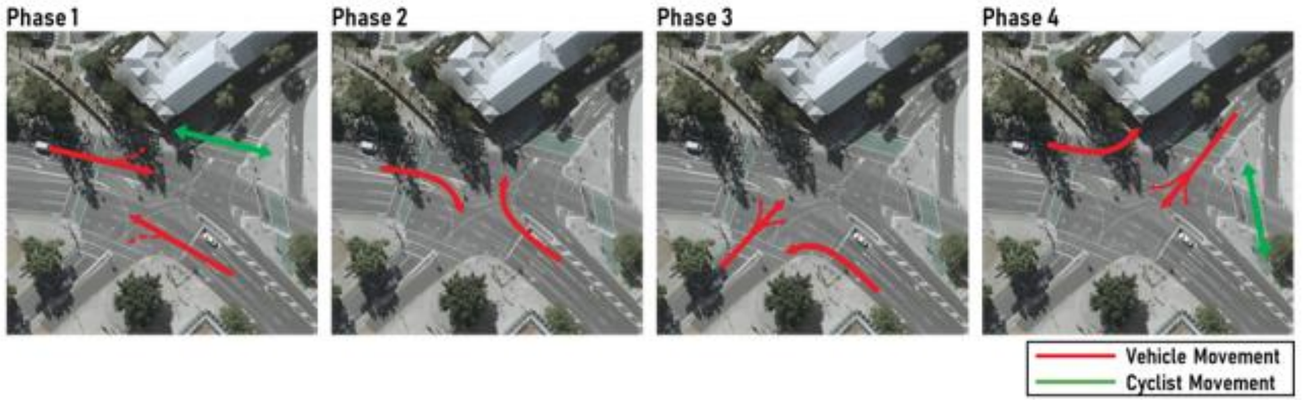
Route	Base demand	Option 1 demand
Main Street to Annerley Road	4	8
Annerley Road to Main Street	2	4
Southbank Precinct to Main Street	11	22
Main Street to Southbank Precinct	52	104
Annerley Road to Southbank Precinct	104	208
Southbank Precinct to Annerley Road	29	58



- Option 2: improved cycleway signal progression/ priority at Vulture St, Annerley Rd and M1 southbound on-ramp intersections

- Option 3: cycleway extension east through Main Street intersection





Stanley Street bikeway option outputs

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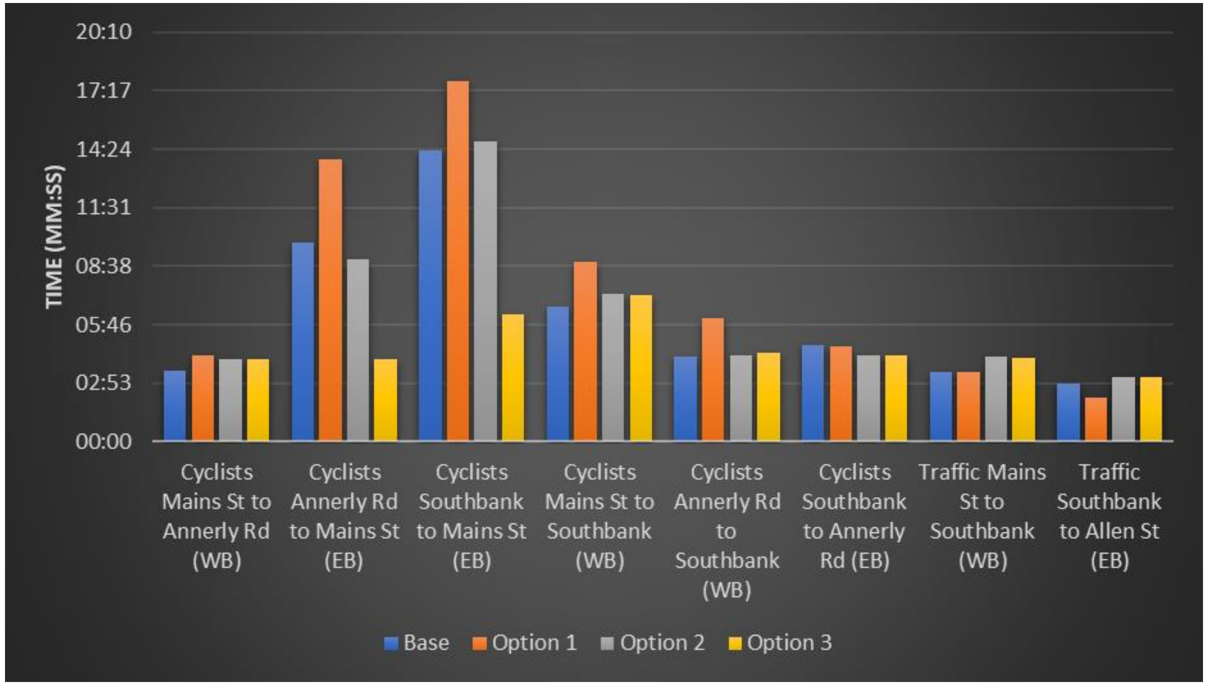
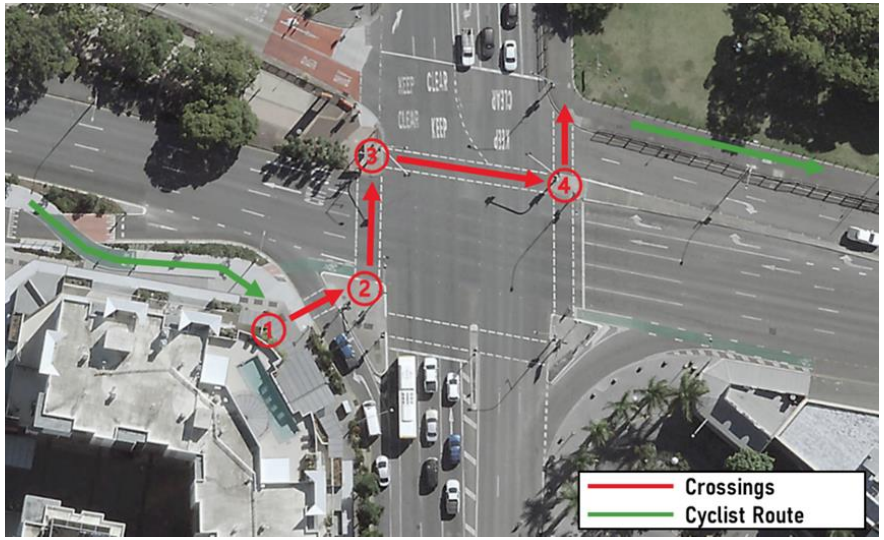
Route	Scenario travel times (mm:ss)			
	Base	Option 1	Option 2	Option 3
Cyclists Mains St to Annerly Rd (WB)	03:32	04:16	04:03	04:03
Cyclists Annerly Rd to Mains St (EB)	09:49	13:53	08:58	04:03
Cyclists Southbank to Mains St (EB)	14:21	17:46	14:47	06:16
Cyclists Mains St to Southbank (WB)	06:39	08:53	07:19	07:11
Cyclists Annerly Rd to Southbank (WB)	04:11	06:06	04:17	04:22
Cyclists Southbank to Annerly Rd (EB)	04:45	04:43	04:16	04:16
Traffic Mains St to Southbank (WB)	03:25	03:25	04:13	04:09
Traffic Southbank to Allen St (EB)	02:51	02:11	03:12	03:12



- Significant increase in cycling travel time in Option 1 – insufficient signal green times with increased demand
- Eastbound cyclist times to Mains Rd particularly impacted – insufficient crossing storage
- Cyclist travel times reduce to similar level as base in Option 2
- Significant improvement in eastbound cyclist times to Mains Rd in Option 3
- Slight impact to traffic travel times in all options vs base



Southbank Promenade option scenarios

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- Scenario 1: Reduced effective path width (7m)
- Scenario 2: Reduced effective path width (7m) with 75%/25% directional split of agents
- Scenario 3: Increased demand
- Scenario 4: Segregated central cycling path
- Scenario 5: Reduced effective path width (3m effective width) with 75%/ 25% directional split (high pedestrian volumes, low cyclist volumes)
- Scenario 6: Reduced effective path width (3m effective width) with 75%/25% directional split (low pedestrian volumes, high cyclist volumes

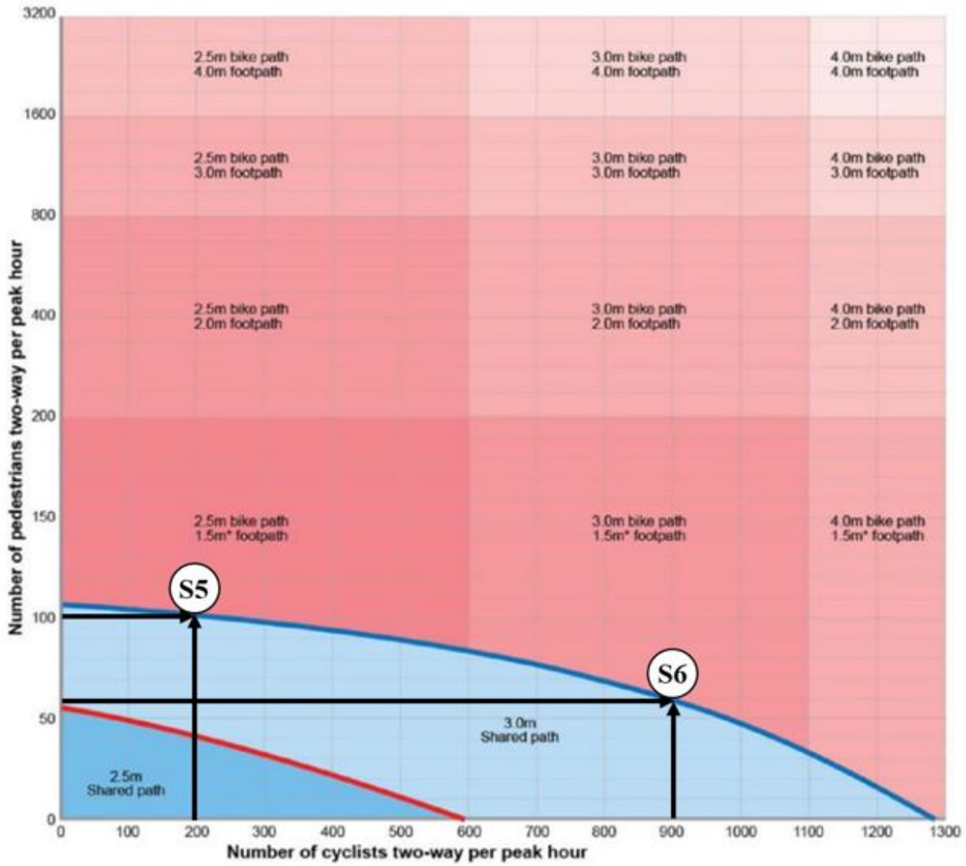
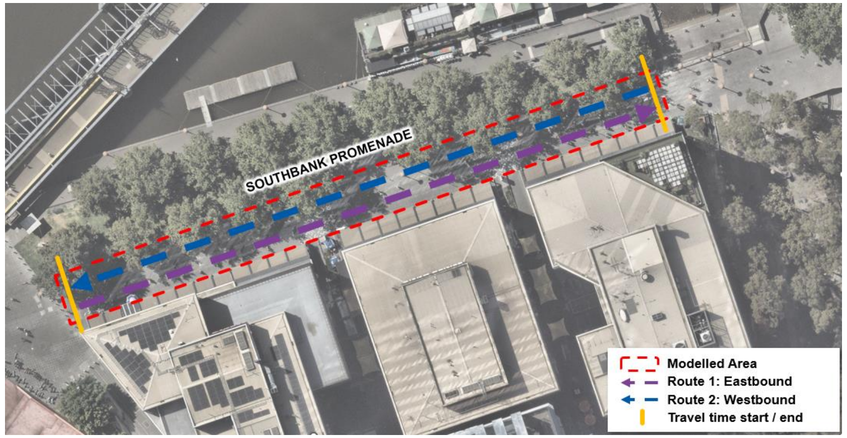


Figure 5-4: AGRD 6 - Scenario 5 and 6 pedestrians and cyclist demand



Southbank Promenade option outputs

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Table 6-3 Area measurement results – Southbank Promenade scenarios

Scenario	User Type	Nearest Neighbour Average distance (m)	Average Speed (km/hr)	Average Speed deviation (km/hr)	Number of stops	Total stopped time (s)
AM Base year	Pedestrians	1.47	3.9	0.07	3	0.45
	Cyclists	1.61	18.88	1.32	3	1.05
PM Base year	Pedestrians	1.44	3.86	0.1	5	0.25
	Cyclists	1.56	18.96	1.85	4	0.6
Scenario 1 – Reduced path width (7m) (PM)	Pedestrians	1.40 (-3%)	3.82 (-1%)	0.15 (50%)	16 (220%)	1.95 (680%)
	Cyclists	1.47 (-6%)	18.87 (0%)	2.17 (17%)	21 (425%)	5.7 (850%)
Scenario 2 – Reduced path width (7m) with 75%/25% directional split (PM)	Pedestrians	1.42 (-1%)	3.77 (-2%)	0.17 (70%)	14 (180%)	1.8 (620%)
	Cyclists	1.47 (-6%)	18.78 (-1%)	2.27 (23%)	22 (450%)	8.25 (1275%)
Scenario 3 – Increased 50% demand (PM)	Pedestrians	1.42 (-1%)	3.82 (-1%)	0.15 (50%)	20 (300%)	2.8 (1020%)
	Cyclists	1.50 (-4%)	19.38 (2%)	2.42 (31%)	11 (175%)	4 (567%)
Scenario 4 – Segregated central cycling path (PM)	Pedestrians	1.32 (-8%)	3.82 (-1%)	0.14 (40%)	43 (760%)	8.8 (3420%)
	Cyclists	1.41 (-10%)	17.26 (-9%)	1.51 (-18%)	11 (175%)	0.85 (42%)

Figure 4-7: Free flowing conditions (left) and congested conditions (right)

- Calibrated 'cycling' agent not able to realistically replicate cyclist response to other agents
- Issue mainly related to speed – agent profile does not appear well suited to speeds that are faster than walking
- Led to cyclists undertaking unrealistic/ sharp turn movements and moving through densely populated areas at free-flow speed
- Cyclist speed does not vary much even with narrow path widths and high ped demands
- Tendency to bounce off obstacles
- Could not keep to dedicated cycling path in Scenario 4

Southbank Promenade option outputs

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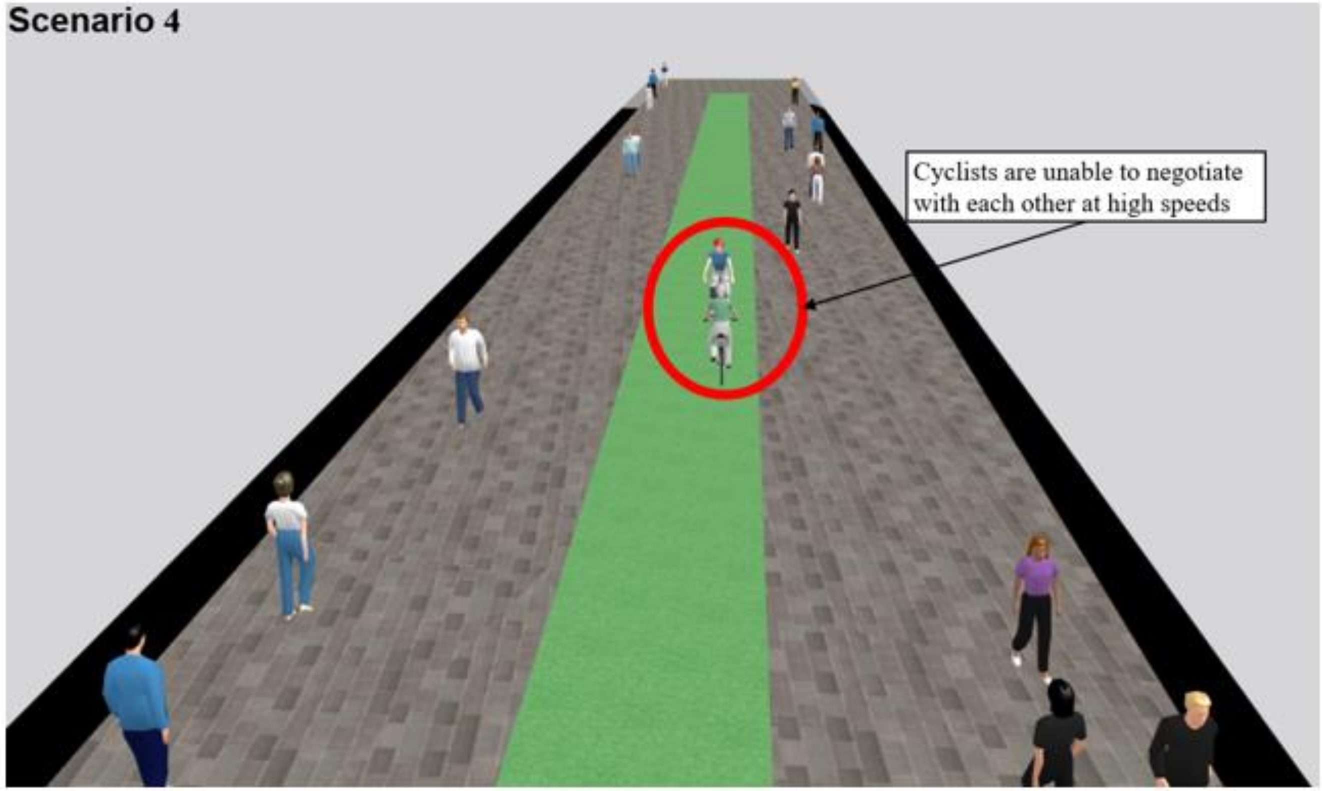

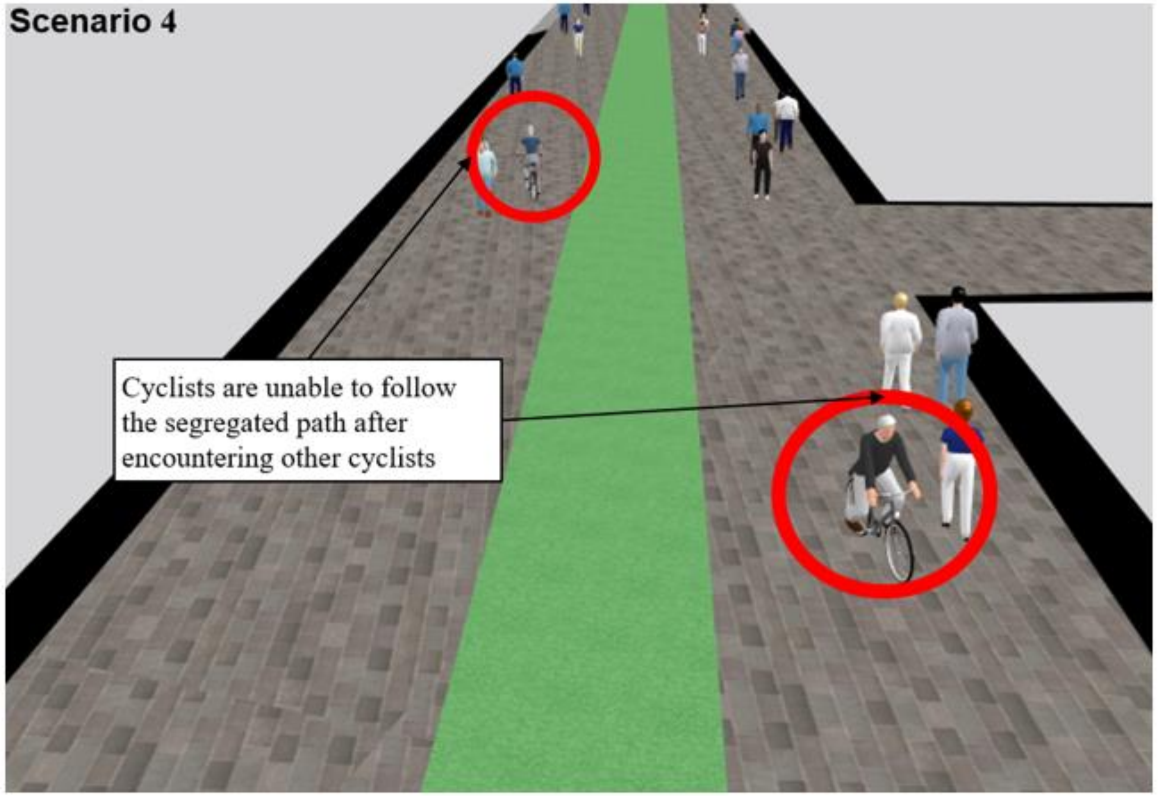

Summary of findings

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- Aimsun/ Vissim:

- Rider vehicle type profiles need careful calibration to ensure appropriate spatial behaviour within lanes [consider local behaviours].

- Can produce well calibrated/ validated cycling infrastructure models to inform delay/ travel time benefits, cycleway capacity, optimisation, detailed signal operation and potential impacts to on-road traffic.

- Basic functionality to simulate interaction between walkers and riders in an off-road environment [*and may require more testing*]

- Can highlight micro-level design/ operational issues that could be easily missed with static-level analysis.

- Viswalk can use a pedestrian agent profile with Social Force Model to simulate cyclists – significant limitations relating to how fast-moving agents react to slow moving agents and pedestrians.

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References

Acknowledgements and reference documents

- TMR TAU and C&W team for input and availability to discuss research project
- Victoria Dept of Transport for support and confirmation of findings they would seek to see
- BCC for provision of count data and advice on potential options to assess

- Reference documents include:

  - Selection and Design of Cycle Tracks, Qld Department of Transport and Main Roads (2019)
  - Microsimulation of Cyclists' Behaviour" Evaluating the Impacts of Traffic Demand and Infrastructure Design on Cyclists' Behaviour, Sven Thijsen, Eindhoven University of Technology (2021)
  - Aimsun software user guide
  - PTV Vissim and Viswalk user guide