L.E.K.

Infrastructure NSW

Sydney CBD access strategy

26 June 2012

The materials contained in this document are intended to supplement a discussion between Infrastructure NSW and L.E.K. Consulting in June 2012. These perspectives are confidential and will only be meaningful to those in attendance.

L.E.K. Consulting Pty Ltd, Level 26, Aurora Place, 88 Phillip Street, Sydney NSW 2000, Australia
T: 61.2.9323.0700 F: 61.2.9323.0600 www.lek.com

Context and Disclaimer –Terms of Access and Receipt

- L.E.K. Consulting (*L.E.K.*) wishes to draw the following important provisions to your attention prior to your receipt of or access to the L.E.K. report 'Sydney CBD access strategy, 26nd June 2012' (*the L.E.K. Report*) including any accompanying presentation and commentary (*the L.E.K. Commentary*).
- The L.E.K. Report and any L.E.K. Commentary have been prepared for Infrastructure NSW *(the Client*) in accordance with a specified scope of work described in the letter of engagement with the Client (*the Engagement Letter*). L.E.K. may provide upon request a copy of the Engagement Letter;
- Any person or entity (including without limitation the Client) which accepts receipt of or access to the L.E.K. Report and any L.E.K. Commentary (*the Recipient*) agrees to be bound by the terms and conditions set out below;
- In receiving or accessing any part of the L.E.K. Report and any L.E.K. Commentary, the Recipient acknowledges that:
  - L.E.K. has not been asked to independently verify or audit the information or material provided to it by or on behalf of the Client or any of the parties involved in the project;
  - the information contained in the L.E.K. Report and any L.E.K. Commentary has been compiled from information and material supplied by the Client and other third party sources and publicly available information which may (in part) be inaccurate or incomplete;
  - L.E.K. makes no representation, warranty or guarantee, whether express or implied, as to the quality, accuracy, reliability, currency or completeness of the information provided in the L.E.K. Report and any L.E.K. Commentary or that reasonable care has been taken in compiling or preparing them;
  - no part of the L.E.K. Report or L.E.K. Commentary may be circulated, quoted or reproduced for distribution outside the Client's organisation without the prior written approval of a Partner of L.E.K.;
  - the analysis contained in the L.E.K. Report and any L.E.K. Commentary are subject to the key assumptions, further qualifications and limitations included in the Engagement Letter and the L.E.K. Report and L.E.K. Commentary, and are subject to significant uncertainties and contingencies, some of which, if not all, are outside the control of L.E.K.; and
  - any L.E.K. Commentary accompanying the L.E.K. Report is an integral part of interpreting the L.E.K. Report. Consideration of the L.E.K. Report will be incomplete if it is reviewed in the absence of the L.E.K. Commentary and L.E.K. conclusions may be misinterpreted if the L.E.K. Report is reviewed in absence of the L.E.K. Commentary. The Recipient releases L.E.K. from any claims or liabilities arising from such an incomplete review;
- L.E.K. is not responsible or liable in any way for any loss or damage incurred by any person or entity relying on the information in, and the Recipient unconditionally and irrevocably releases L.E.K. from liability for loss or damage of any kind whatsoever arising from, the L.E.K. Report or L.E.K. Commentary including without limitation judgements, opinions, hypotheses, views, forecasts or any other outputs therein and any interpretation, opinion or conclusion that the Recipient may form as a result of examining the L.E.K. Report or L.E.K. Commentary. The L.E.K. Report and any L.E.K. Commentary may not be relied upon by the Recipient, and any use of, or reliance on that material is entirely at their own risk. L.E.K. shall have no liability for any loss or damage arising out of any such use.
- The L.E.K. Report and L.E.K. Commentary are strictly confidential and for the sole benefit of the Client. No person other than the Client (and the employees, partners, and officers of, and professional advisers to, the Client) or a Recipient (who has agreed to be bound the terms herein) may access the L.E.K. Report or L.E.K. Commentary or any part thereof. The Recipient undertakes to keep the L.E.K. Report and L.E.K. Commentary confidential and shall not disclose either the L.E.K. Report or L.E.K. Commentary or any part thereof to any other person without the prior written permission of a Partner of L.E.K.

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis

Introduction and context

- Infrastructure NSW is currently developing a 20-year State Infrastructure Strategy (SIS) that identifies and prioritises critical public infrastructure for NSW with the goals of creating a future for Sydney that provides:
  - connectivity
  - resilience
  - a better life
  - public transport infrastructure of reasonable cost and risk

- Commuter transit into the CBD is a significant infrastructure challenge for Sydney, with current modes of public transport into the CBD already approaching capacity during the peak periods and volumes expected to grow by c.20% by 2036

- This report reviews a series of options for the Sydney CBD and inner suburbs, with a focus on bus and light rail infrastructure that could provide access to the CBD and complement a significant number of heavy rail initiatives planned for completion by 2036. In particular the purpose of this report is to:
  - explore how modal choices can help realise the 2036 vision for the Sydney CBD as characterised by both the NSW Government* and the City of Sydney**
  - provide Infrastructure NSW with a set of high level strategic network options for addressing access to the CBD in the long-term, for consideration in the development of the overall 20-year SIS
  - identify key trade-offs associated with each option (rather than propose a specific single solution)
  - explore current assumptions and provide new perspectives on a complex debate

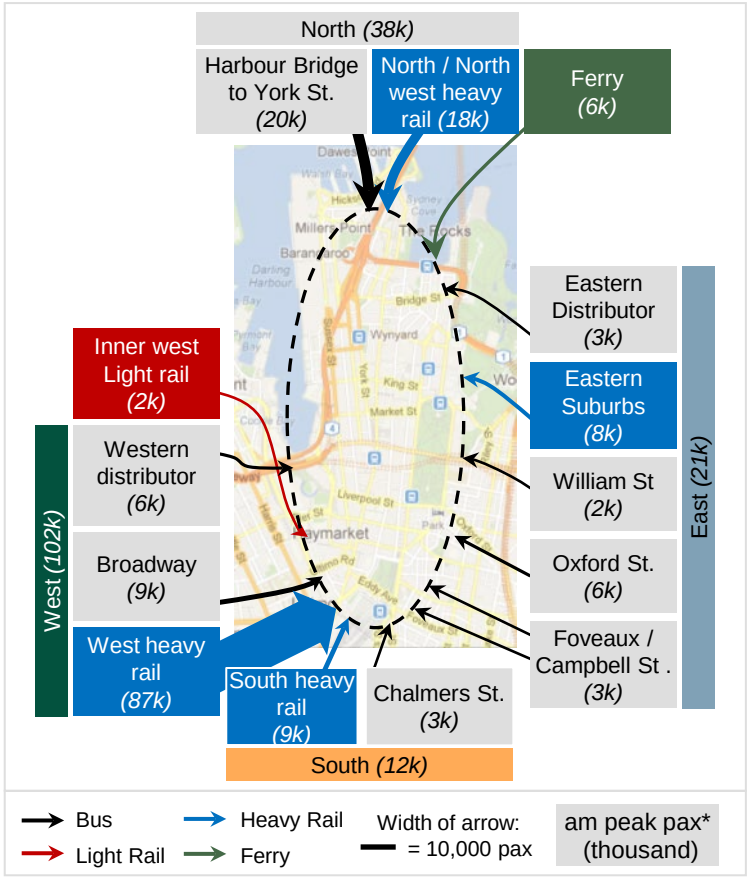
- Work was conducted over six weeks, necessitating a high-level review
  - heavy rail options were not assessed
  - re-configuring existing timetables and routes was not assessed
  - there was no direct access to Transport for NSW staff

This report contains a high level assessment of conceptual CBD network access options in order to inform debate and further detailed assessment

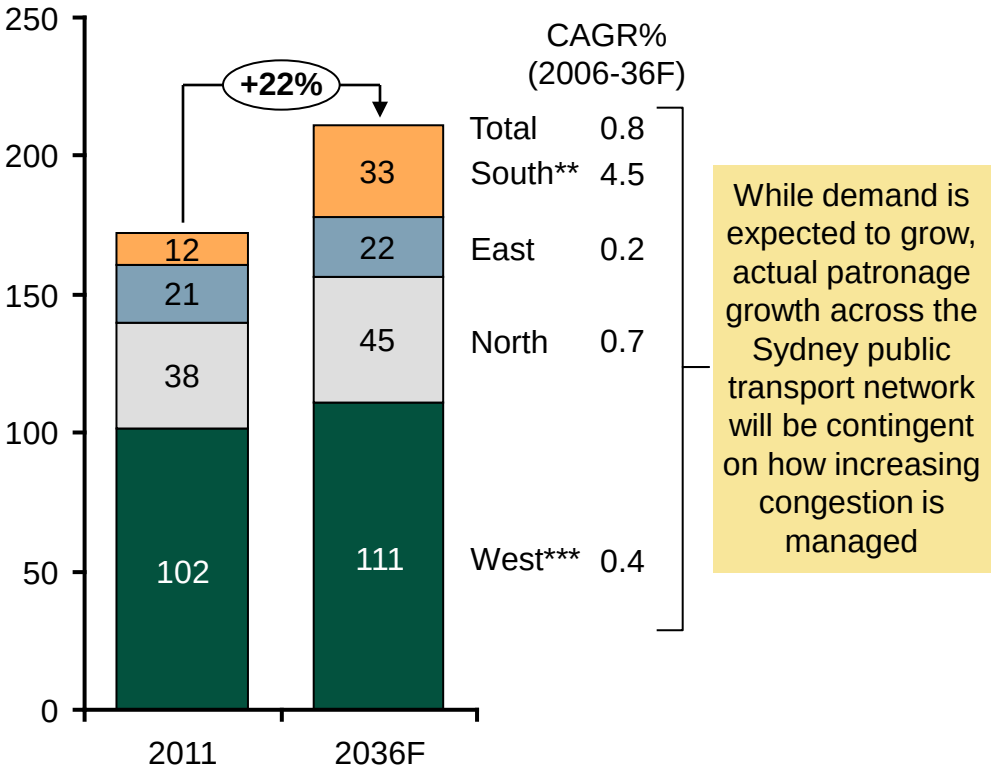
Note: *Metropolitan plan for Sydney 2036; **City of Sydney – Connecting our City
Source: TfNSW Sydney Strategic Travel Model 2010; NSW Government; City of Sydney

In 2011, 52 thousand of the 180 thousand journeys into and through the CBD during the am peak* were via bus, with overall journeys into the CBD expected to grow 22% by 2036

CBD access – 2011



Heavy Rail and Bus Travel into and through the CBD (am peak 2011-36F)



While demand is expected to grow, actual patronage growth across the Sydney public transport network will be contingent on how increasing congestion is managed

Note: * 2 hour am peak (7-9am); ** South represents Illawarra and airport train line services with a further c.20k pax increase expected on the airport line by 2036; *** West / South-West includes services from the Strathfield, and Bankstown lines

Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW; L.E.K. Analysis

Commuter access into the Sydney CBD is hampered by several challenges

Unreliable access to / from the CBD

- Variation in journey time into the CBD due to near-capacity utilisation of system and sensitivity to factors such as accidents, breakdowns, events, weather, etc

Congestion on routes in and out of the CBD

- Bus routes compete with private and commercial traffic at key CBD access points
- Slow bus movement is experienced by passengers on the Harbour Bridge during the peak 8:30am to 9:00am peak period

Congestion within the CBD

- Congestion along key CBD spines due to public, private and commercial vehicles
- Sydney CBD congestion is further complicated by surface intersections between busy North-South and East-West traffic routes

Increasing competition for street space

- High density of vehicle and pedestrian traffic during peak hours on roads and footpaths
- Streets mostly serve to facilitate movement through the corridor and discourages ambient interaction with the side-street scape (eg. retail)

A long term CBD access strategy aims to address each of these barriers

Source: Parsons Brinckerhoff; Gehl Architects; images – dailytelegraph.com.au, parkingconsultants.com, Sydney Morning Herald; L.E.K. analysis

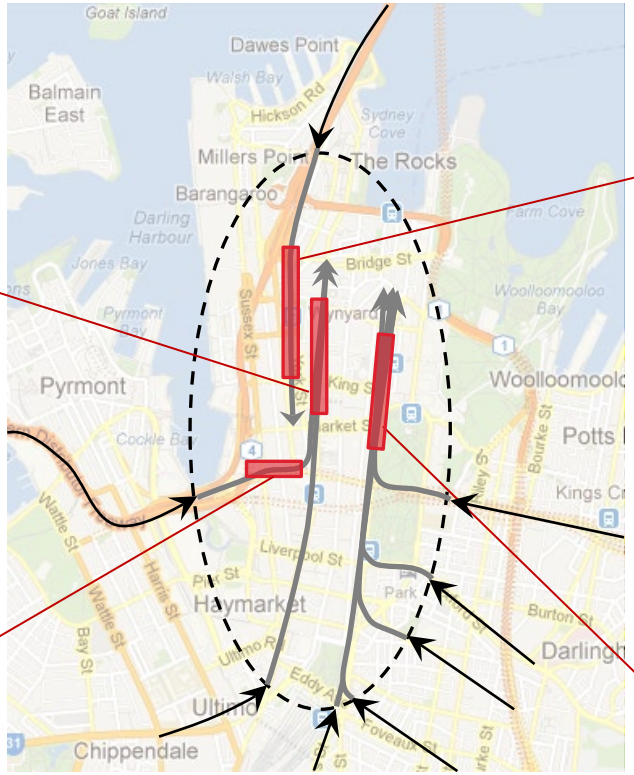
Several bus choke points exist across the CBD, created by a combination of large bus volumes and multiple intersections with other traffic movements

George St.

- Combination of bus flows from Western Distributor and Broadway
- Bus lanes used for bus and taxi transit and embarking / disembarking of passengers
- Flow hampered by intersection with East-West moving traffic and pedestrian crossings

Western Distributor to Druitt St.

- Buses slow to disperse after Druitt St. bus stop due to use of bus lanes for both bus transit and disembarking
- Flow complicated by intersection with North-South traffic on Sussex and Kent Streets



York St. (from Harbour Bridge)

- High volumes of bus services from the Harbour Bridge
- Flow hampered by intersections with East-West moving traffic
- Passengers bound for the Southern CBD often disembark at Wynyard and walk the remaining distance

Elizabeth St

- Combination of bus flows from East, South and South-East access points
- Flow hampered by intersection with East-West moving traffic

The options considered in this report aim to address several of these choke points

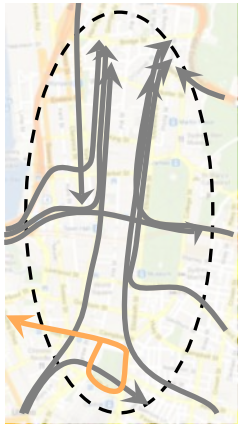
Source: Parsons Brinckerhoff; L.E.K. analysis

Three strategic network options were assessed against the status quo

Option 1: Base case – status quo

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✗	✗	✗	✗

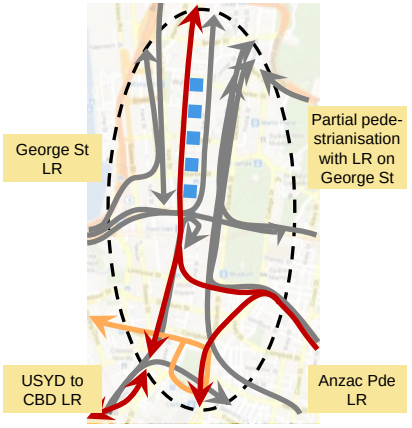


- Represents the current Sydney CBD bus network

Option 2: Dedicated Light Rail (LR)

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	✗	✗	✓

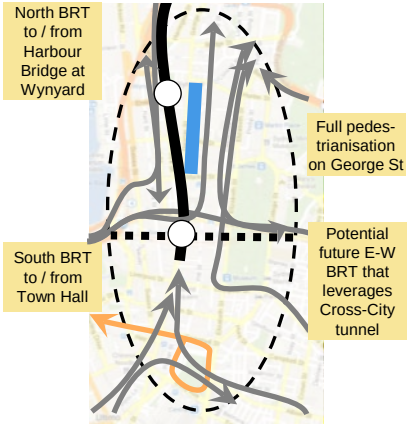


- Based on publicly available information relating to the 'Sydney Light Rail Strategic Plan' currently being developed by TfNSW
- No optimisation of Light Rail network or services was considered
- Anzac Pde. bus routes replaced with Anzac Pde. Light Rail that links with George St. Light Rail

Option 3: Underground Bus Rapid Transit (BRT)

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	?	✓	✓

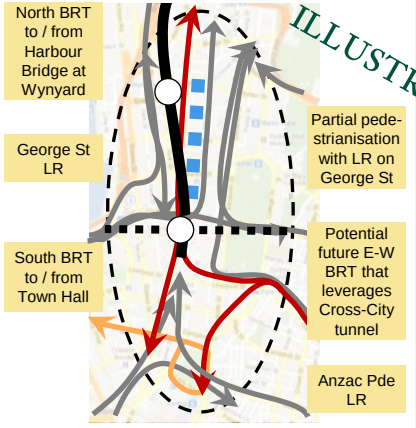


- Underground BRT network based on high level concepts
- c.75% of peak Harbour Bridge buses moved to underground BRT
- All peak Broadway and c.50% of South-East buses moved to BRT
- Makes use of tram tunnels from Wynyard to Harbour Bridge
- Assumes planned redevelopment of Wynyard and Town Hall stations

Option 4: Underground BRT and LR

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	?	✓	✓



ILLUSTRATIVE

- Network based on a combination of options 2 and 3
- USYD to CBD Light Rail removed due to route being addressed by both options 2 and 3

Potential BRT | Potential Light Rail | Existing Light Rail | Surface Bus | Sub surface station | Pedestrianised George St. | Partially pedestrianised George St. with Light Rail

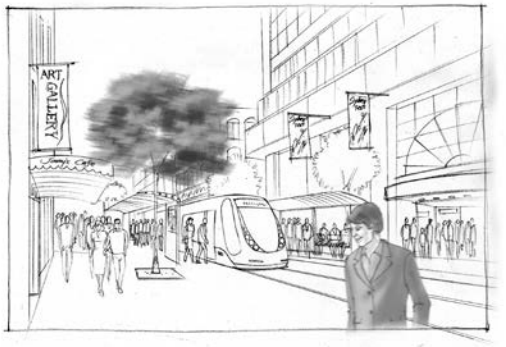
Source: TfNSW 'Sydney Light Rail Strategic Plan' information web page (www.transport.nsw.gov.au/lightrail-program/sydney-light-rail-strategic-plan); L.E.K. analysis

Each of the strategic network options creates a different type of urban CBD environment at street level

Option 1: Base case – status quo

"…Vehicles and pedestrians vying for street space in the CBD…"

Option 2: Dedicated Light Rail



"…George St. boulevard for pedestrians and Light Rail only…"

Option 3: Underground BRT

"…Removal of buses from the CBD surface with parts of George St fully pedestrianised and other parts with broadened sidewalks…"

Option 4: Underground BRT and LR

Combined amenity from options 2 and 3

"…Pedestrian boulevard with Light Rail on surface and majority of buses moved underground…"

Source: L.E.K. analysis

Underground BRT could provide full pedestrianisation and greater travel time benefits to more passengers, but could be more technically challenging to build than a surface light rail line

Summary of implications for strategic CBD access options

	Option 2: Dedicated Light Rail				Option 3: Underground Bus Rapid Transit (BRT)				Option 4: Underground BRT and Light Rail			
	Choke points potentially addressed				Choke points potentially addressed				Choke points potentially addressed			
	George St	Western Distributor	York St.	Eliz. St.	George St	Western Distributor	York St.	Eliz. St.	George St	Western Distributor	York St.	Eliz. St.
	✓	×	×	✓	✓	?	✓	✓	✓	?	✓	✓
Impact	• Improved urban amenity along George St. with road space shared between Light Rail and pedestrians from Hunter St. to Park St. • Provides a transit option with improved on-board amenity for some South-East pax (c.10% of all am peak* journeys into the CBD)				• Improved urban amenity along George St. with pedestrian-only area from Hunter St. to Market St., facilitated by the shift of buses underground • Could address c.40% of all am peak* journeys with improved journey times • Potential opex savings of c.$10m p.a. through journey time savings from the BRT tunnel				• Combined amenity benefits of options 2 and 3 with potential congestion in other parts of the CBD mitigated through the shift of buses underground • Light Rail component could address a further c.10% of am peak* journeys on top of the c.40% already addressed by BRT			
Considerations	• Potentially worsens congestion by shifting buses and private vehicles away from George St. onto other limited routes • With some buses terminating upon entry to the CBD, some journeys may require additional interchange and associated journey time penalty				• Facilitates potential Light Rail on George St. by shifting bus traffic onto a viable alternative route below the CBD surface • Technical feasibility of tunnelling is unknown and construction is likely to be disruptive to other CBD access modes • Requires / complements redevelopment of Town Hall and Wynyard stations				• Indicative capex of over c.$1.8bn comprised of c.$1bn+ for Light Rail and c.$800m+ for BRT • Technical feasibility of tunnelling is unknown and construction is likely to be disruptive			

Note: *2 hour am peak (7-9am)
Source: MRCagney; L.E.K. Analysis

A broad range of criteria has been used to assess each strategic option

	Assessment criteria	Definition: The proposed strategic option…	Assessment approach: Analyse and compare…
Connectivity	CBD access journeys addressed	…positively impacts on a large proportion of passengers who access the CBD each day	…the estimated number of passengers positively impacted by each option across all CBD access points
	Broad Sydney network flexibility	…can respond to changes in the needs of the broader Sydney network, eg. re-routing to improve cross-suburb connectivity	…each network's ability to implement new route plans
	Facilitates 'within' CBD travel	…facilitates reasonable options for travel within the CBD	…each network's ability to provide options for travel from one part of the CBD to another
	Legibility	…allows commuters to quickly and easily make decisions around the right mode and service to use for their journey	…the ease to which a commuter could understand and identify the most appropriate travel option
Resilience	Route capacity	…provides capacity that meets current demand and supports patronage growth	…each option's potential to increase capacity for travel into the Sydney CBD
	Reliability	…is resilient in response to incidents en route and is less sensitive to other traffic movements	…each option's ability to minimise disruption in the event of an incident, and any sensitivity it may have to intersecting traffic
	Effect on vehicle traffic	…facilitates reduced congestion for private and commercial vehicles in the CBD	…the net impact on overall vehicle traffic in the CBD as a result of pedestrianisation and changes to vehicle movements
A better life	Journey time	…reduces current average journey times for commuters travelling into the CBD	…a high level estimation of the overall annual am peak journey time saved across impacted commuters
	Urban amenity and liveability	…improves the Sydney CBD's attractiveness as a place to live and work	…each network's impact on the street environment, in particular the pedestrian experience at street level
	Passenger on-board amenity	…provides a comfortable and efficient transit mode for passengers	…each network's impact on the overall comfort and experience of passengers across the CBD access network
Cost / Risk	Capital expenditure	…will cost $A-Bm to build	…a top-down estimate of the overall infrastructure and rolling stock capital expenditure required for each network option
	Operating expenditure	…will cost $X-Ym to operate each year	…a top-down estimate of the annual operating costs involved with running each network option
	Reliance on other infrastructure work	…is not heavily reliant on the implementation of other major infrastructure projects	…any other major infrastructure works which must proceed in order to facilitate the development of each network option
	Risk and continuity during build	…minimises any potential disruption or risk to the operation and integrity of surrounding infrastructure	…the level of risk and disruption that each network option poses to other key infrastructure (eg electricity, trains, etc)
	Leverages existing assets	…is able to leverage existing public transport assets in implementation and ongoing operations	…how existing assets and expertise could be utilised in the implementation and ongoing operations of each option

Each of the strategic network options have been assessed across a range of assessment criteria

Summary of assessment of strategic options against key criteria

		Criteria	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Connectivity	A	CBD access journeys addressed	-	-	↑↑	↑↑
	B	Broad Sydney network flexibility	-	↓	-	↓
	C	Facilitates 'within' CBD travel	-	↑	-	↑
	D	Legibility	-	↑↑	↑	↑↑
Resilience	E	Route capacity	-	-	-	↑
	F	Reliability	-	↑	↑	↑
	G	Effect on vehicle traffic	-	↓	-	↓
A better life	H	Journey time	-	↓	↑	↑
	I	Urban amenity and liveability	-	↑	↑↑	↑
	J	Passenger on-board amenity	-	-	↑	↑
Cost / Risk	K	Capital expenditure	-	↓	↓	↓↓
	L	Operating expenditure	-	↓	↑	↓
	M	Reliance on other infrastructure work	-	-	↓↓	↓↓
	N	Risk and continuity during build	-	↓	↓↓	↓↓
	O	Leverages existing assets	-	↓	↑	↑

Score key: Much worse than base case; Worse than base case; Negligible change over base case; Improvement over base case; Strong improvement over base case

Source: L.E.K. Analysis; MRCagney

Potential way forward

Collaborative options review

- Collaborate with TfNSW to jointly review materials and reconcile with Draft Transport Master Plan
- Understand existing investigations being conducted by TfNSW
- Review potential to optimise current surface bus options
- Refresh view of journey time savings in light of actual current journey time data (either from BTS or direct observation) and modal interchange plan
- Develop / assess a revised surface bus strategy (with or without Light Rail), including detailed bus re-routing, interchange requirements, traffic management plans and uptake of Inner West Light Rail extension
- Consider implications for the appropriate timing of BRT and Light Rail infrastructure investment

Subject to the above, consider detailed development and evaluation of the BRT option:

Detailed feasibility assessments

- Conduct detailed feasibility study into whether key infrastructure can be built. eg.
  - tunnel routing
  - use of existing tram tunnels for buses
  - station location
  - dive point locations

Detailed network design

- Develop key components of the future network design, including:
  - optimisation of overall bus network (eg bus routes and timetabling)
  - detailed assessment of impact on other modes (car, train, walking)
  - traffic flow design (eg one way streets)
  - surface lane configuration (eg bus and turning lanes)

Conduct detailed assessments of benefits and risks

- Conduct detailed BCR
- Quantify expected benefits and detailed capex and opex costings including size and type of rolling stock and design of required infrastructure (eg station redesign)
- Develop a view of likely BCR resulting from recommended CBD access option

Exploration of infrastructure levers

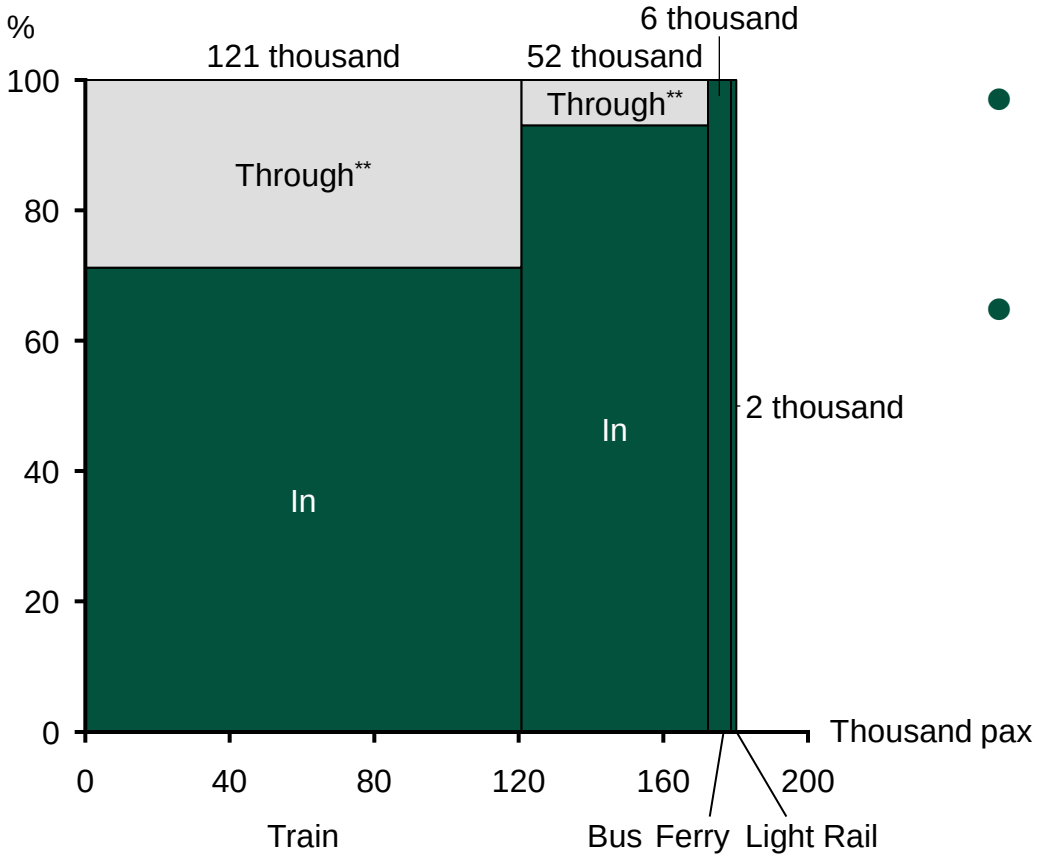
- Consider whether further initiatives are required to help enable the vision for the CBD in 2036. eg.
  - encouraging active transport (eg Barangaroo city walk, raised walkways)
  - introducing traffic management (eg congestion charging, parking management, bypass roads)

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis

Current bus services serve c.30% of am peak* CBD commuter trips, but cross-suburb connectivity is potentially limited by the need to interchange

Train, Bus and Ferry Travel into and through the CBD by Journey Type (am peak 2011*)**

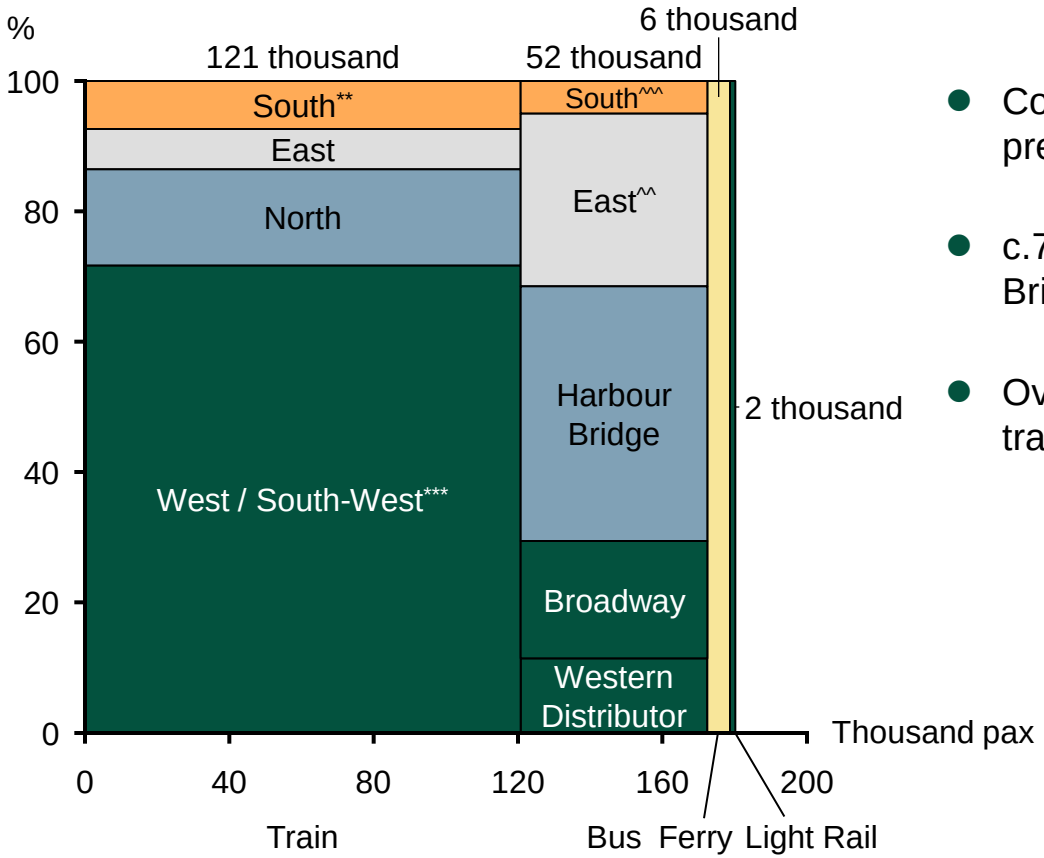


- c.65% of morning peak public transport journeys are by heavy rail
  - c.85% of remaining journeys are by bus
- c.20% of trips are through trips that involve no interchange, of which only c.10% are served by bus
  - potentially driven by poor cross-suburb connectivity on bus routes
  - some 'in' journeys may actually be 'through' journeys with passengers potentially changing modes in the CBD to continue onto their destination outside the CBD

Note: * 2 hour am peak (7-9am); ** does not include journeys involving interchange between bus and rail in the CBD
Source: TfNSW Sydney Strategic Travel Model 2010; L.E.K. Analysis

c.70% of all bus demand is from the North, West and South-West

Train, Bus and Ferry Travel into the CBD by Origin (am peak 2011*)



- Commuters travelling from the East are predominantly serviced by bus
- c.70% of all bus demand is from the Harbour Bridge, Broadway and Western Distributor
- Over half of all CBD access journeys are via trains through Central Station^

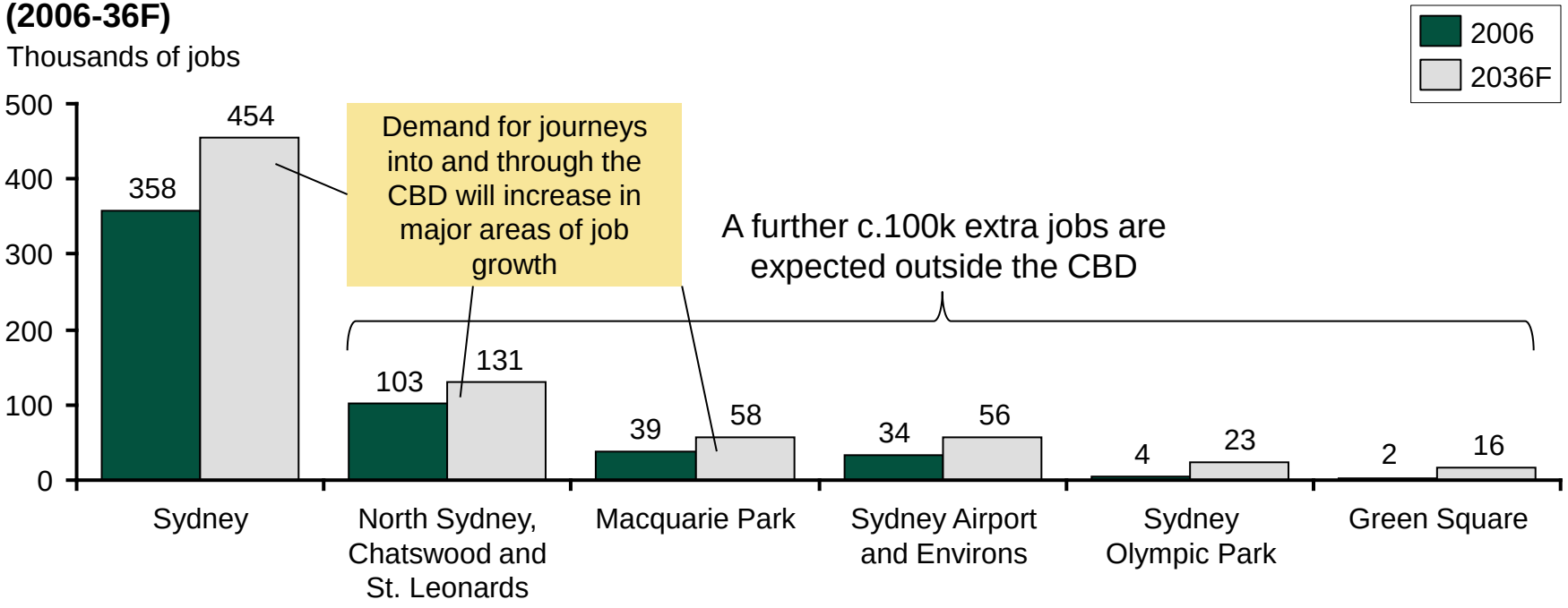
Note: * 2 hour am peak (7-9am) ** South represents Illawarra and airport train line services; *** West / South-West includes services from the Strathfield, and Bankstown lines; ^ South, West and South-West lines; ^^ East includes services from Campbell St., Foveaux St., Oxford St., William St. and the Eastern Distributor; ^^^Chalmers St. access point, contains one service (M50) from the South-East via Anzac Pde.

Source: TfNSW Sydney Strategic Travel Model 2010; L.E.K. Analysis

Demand for journeys into and through the CBD will increase

Sydney and surrounds employment growth (2006-36F)

Thousands of jobs



96	28	19	22	19	14	**Jobs created (k)**

Sydney's public transport network needs to build long-term capacity to meet future demand for travel into and through the CBD

Source: NSW Department of Planning and Infrastructure Metropolitan Plan for Sydney 2036

Recognising there are a significant number of heavy rail initiatives planned for completion by 2036, this work focusses on bus and light rail options into the CBD

Modes of public transport into the CBD

Heavy rail initiatives

2016

- South West Rail Link

FOR CONTEXT ONLY

2021-36

- North West Rail Link (Rouse Hill to Chatswood with potential to expand into the CBD)
- Long-term Rail Strategy (eg. Three Tier Railway Plan)

Bus and Light Rail initiatives

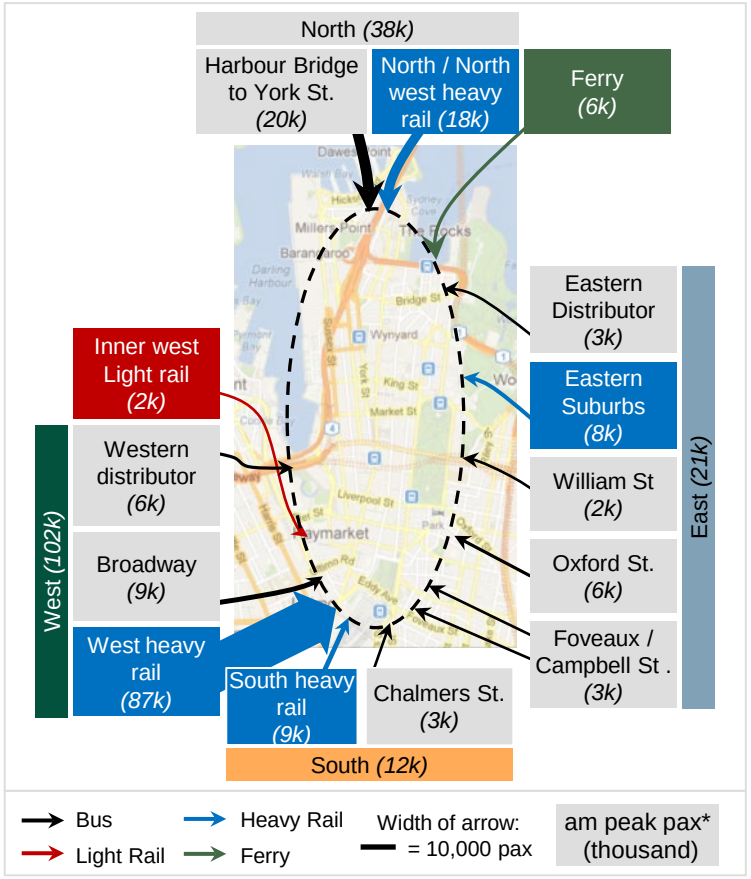
This report focuses on how bus and light rail routes into the CBD can be addressed to reduce CBD congestion and facilitate improved 'within' and 'cross' CBD travel

In addition to improving the broader Sydney public transport network, these initiatives increase capacity into the CBD

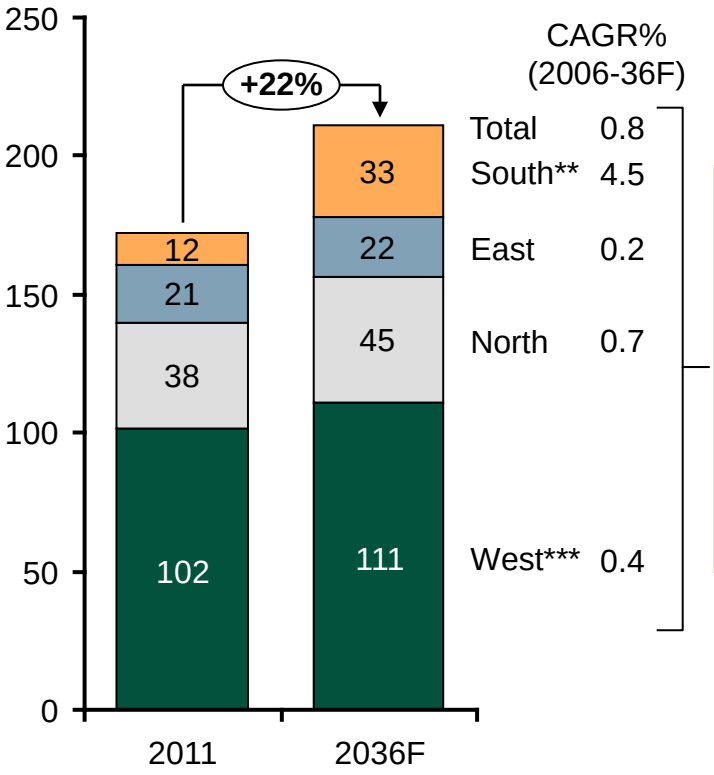
This report does not focus on increasing capacity into the CBD

In 2011, 52 thousand of the 180 thousand journeys into and through the CBD each day were via bus, with overall journeys into the CBD expected to grow 22% by 2036

CBD access – 2011



Heavy Rail and Bus Travel into and through the CBD (am peak 2011-36F)



While demand is expected to grow, actual patronage growth across the Sydney public transport network will be contingent on how increasing congestion is managed

Note: * 2 hour am peak (7-9am); ** South represents Illawarra and airport train line services with a further c.20k pax increase expected on the airport line by 2036; *** West / South-West includes services from the Strathfield, and Bankstown lines
Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW; L.E.K. Analysis

Commuter access into the Sydney CBD is hampered by several challenges

Unreliable access to / from the CBD

- Variation in journey time into the CBD due to near-capacity utilisation of system and sensitivity to factors such as accidents, breakdowns, events, weather, etc

Congestion on routes in and out of the CBD

- Bus routes compete with private and commercial traffic at key CBD access points
- Slow bus movement is experienced by passengers on the Harbour Bridge during the peak 8:30am to 9:00am peak period

Congestion within the CBD

- Congestion along key CBD spines due to public, private and commercial vehicles
- Sydney CBD congestion is further complicated by surface intersections between busy North-South and East-West traffic routes

Increasing competition for street space

- High density of vehicle and pedestrian traffic during peak hours on roads and footpaths
- Streets mostly serve to facilitate movement through the corridor and discourages ambient interaction with the side-street scape (eg retail)

A long term CBD access strategy aims to address each of these barriers

Source: Parsons Brinckerhoff; Gehl Architects; images – dailytelegraph.com.au, parkingconsultants.com, Sydney Morning Herald; L.E.K. analysis

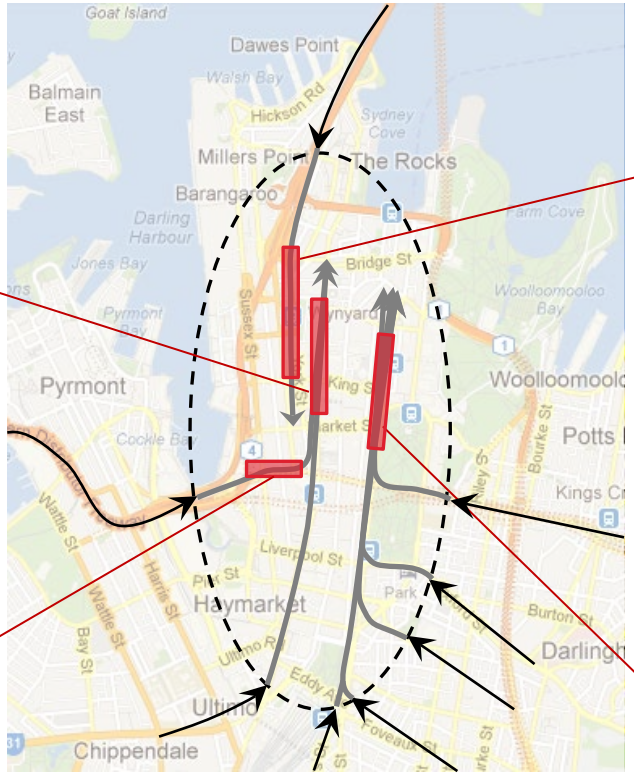
Several bus choke points exist across the CBD, created by a combination of large bus volumes and multiple intersections with other traffic movements

George St.

- Combination of bus flows from Western Distributor and Broadway
- Bus lanes used for bus and taxi transit and embarking / disembarking of passengers
- Flow hampered by intersection with East-West moving traffic and pedestrian crossings

Western Distributor to Druitt St.

- Buses slow to disperse after Druitt St. bus stop due to use of bus lanes for both bus transit and disembarking
- Flow complicated by intersection with North-South traffic on Sussex and Kent Streets



York St. (from Harbour Bridge)

- High volumes of bus services from the Harbour Bridge
- Flow hampered by intersections with East-West moving traffic
- Passengers bound for the Southern CBD often disembark at Wynyard and walk the remaining distance

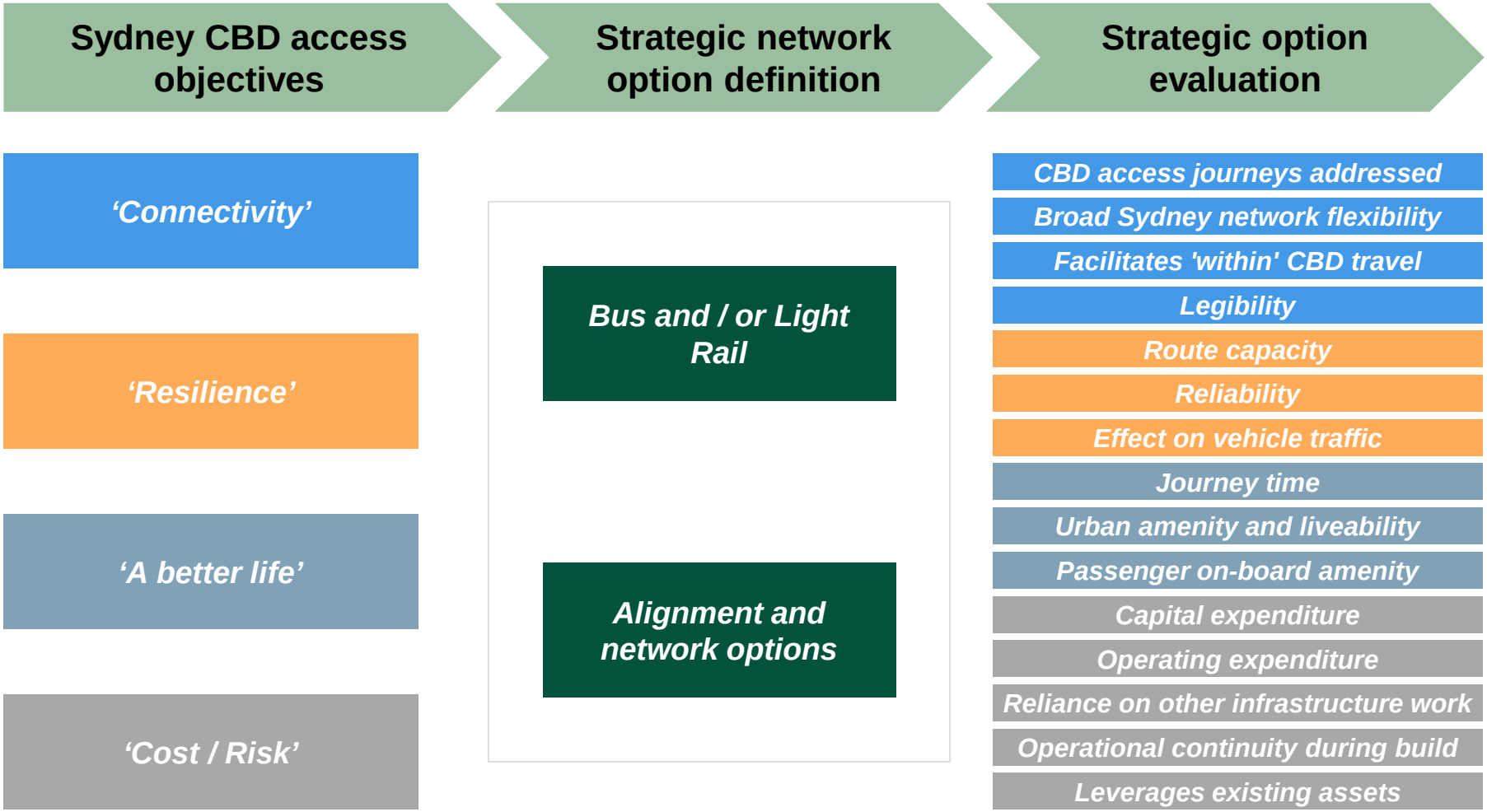
Elizabeth St

- Combination of bus flows from East, South and South-East access points
- Flow hampered by intersection with East-West moving traffic

The options considered in this report aim to address several of these choke points

Source: Parsons Brinckerhoff; L.E.K. analysis
Infrastructure NSW. Sydney CBD Access strategy.

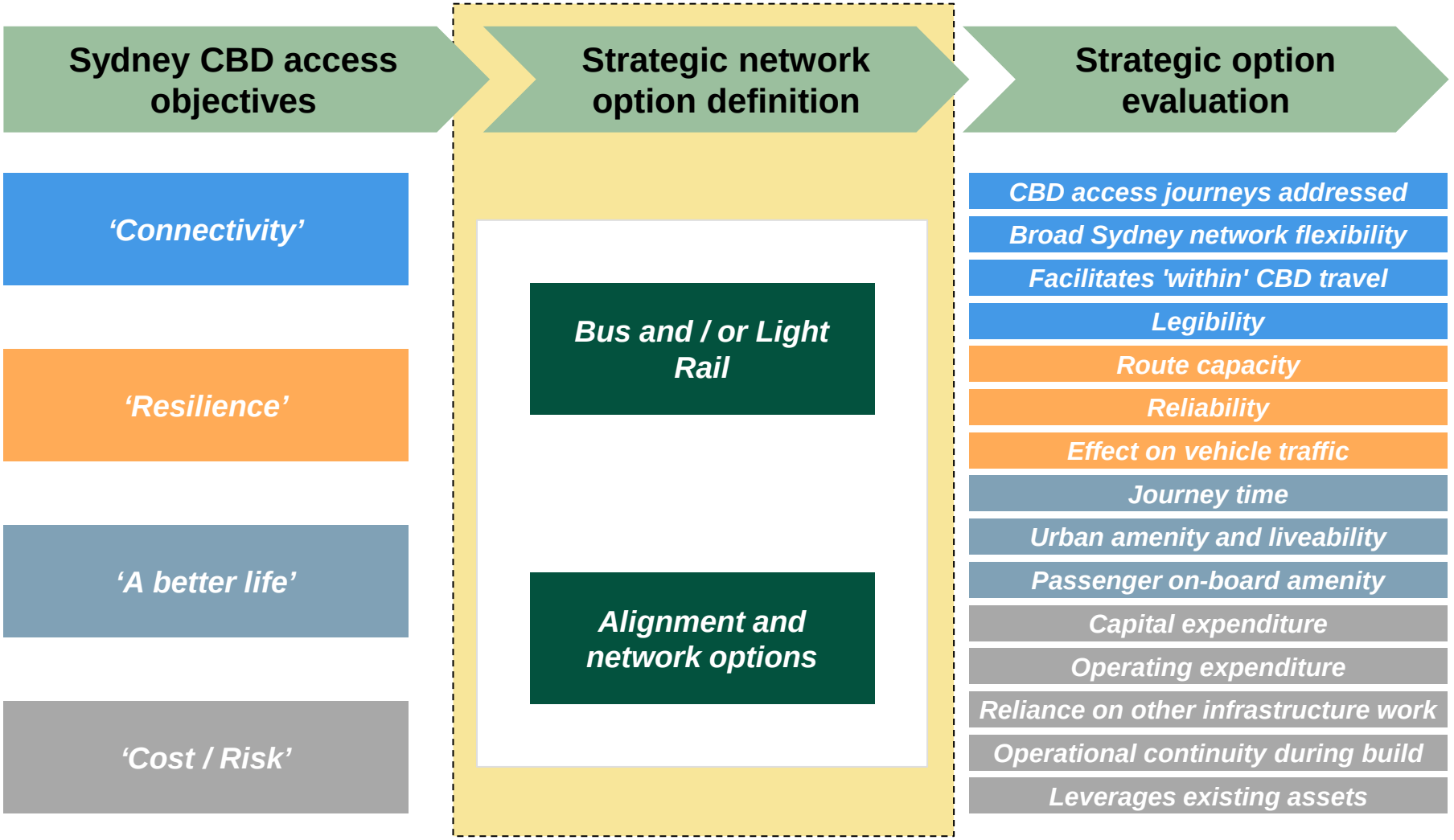
Potential CBD access strategies have been developed and assessed using a broad mix of modal and strategic criteria



Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis

Potential CBD access strategies have been developed based on high-level modal decisions



Surface bus, dedicated surface Light Rail and Underground Bus Rapid Transit (BRT) are considered as potential modes for bringing commuters into the CBD

Definition of transport modes for the purposes of this report

Surface bus (status quo)

- Surface buses do **not** operate on **dedicated** routes and instead share street space with other vehicles
- Surface buses operate at street level and **intersect** with other cross traffic movements
- In some sections buses operate in bus lanes which are shared with taxis, hire cars, motorcycles and bicycles

Dedicated surface Light Rail

- Light Rail operates on dedicated rail lines
- Dedicated Light Rail road space is not shared with other vehicles with increased space allocated to pedestrians
- In some areas, Light Rail operates in shared pedestrian zones
- Light Rail services operate at street level and intersect with other cross traffic movements

Underground Bus Rapid Transit (BRT)

- Underground BRT services operate in dedicated tunnels
- Once underground, BRT services do not intersect with other traffic movements
- Allows for the creation of pedestrianised streets on CBD surface
- In the Sydney CBD, underground BRT tunnels are assumed to be single lanes

Other variations of Bus, Light Rail and BRT exist (eg. dedicated surface bus, underground Light Rail, etc), but are not considered in this report

Source: Sydney Morning Herald; Bombardier; CnK Travelscapes

The three modes of transport considered vary in their potential route capacity, speed, infrastructure requirements and cost

	Surface Bus	Dedicated Surface Light Rail	Underground Bus Rapid Transit
Route capacity (pax capacity* per hour)	Up to 12,000 per corridor	6,000 to 12,000 *(Swanston St. Melbourne 6000)* *(12,000 theoretical maximum with optimised operations)*	Up to 20,000 *(Brisbane SE Busway 15,000)*
Maximum service frequency	Once every c.30 seconds	Once every minute	Once every 10-15 seconds
Average speed capability (km/h)	8km/hr (Sydney CBD) 15-25km/hr (Sydney Bus network)	5-10km/h (Pedestrianised CBD) 15-20km/h (CBD streets) 30-40km/h (Suburban streets)	30-50km/hr (dependent on tunnel section length)
Infrastructure required	Business as usual	11.5km of Surface Rail Approximately 12 Stations/Stops	Driven tunnel (2.5km) 2 underground stations Steep portal entry and exit
Infrastructure capital expenditure (per route km)	No capital expenditure	$90 million per km	$300 million per km (driven tunnel and underground bus stations)
Rolling stock capital expenditure (per pax capacity)	$6,000 12.5m Rigid Bus $0.45m (75 pax)	$25,000 LRT SVU $5m (200 pax)	$6,000 12.5m Rigid Bus $0.45m (75 pax)
Opex (per pax capacity* km)	$5 per v/km $0.066 per pax capacity per km	$17 per v/km $0.085 per pax capacity per km	$5 per v/km $0.066 per pax capacity per km

Note: * includes seating and standing

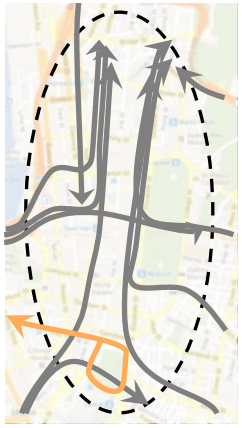
Source: MRCagney

Three strategic network options were assessed against the status quo

Option 1: Base case – status quo

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✗	✗	✗	✗

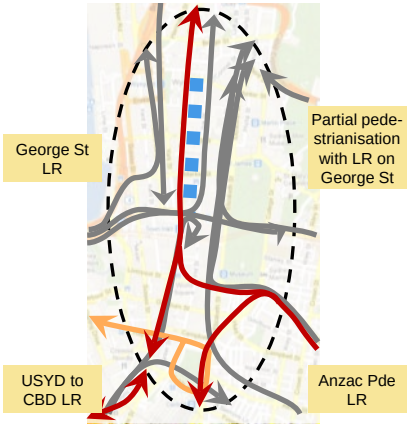


- Represents the current Sydney CBD bus network

Option 2: Dedicated Light Rail (LR)

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	✗	✗	✓

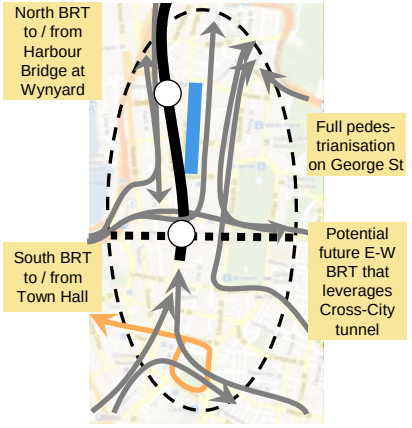


- Based on publicly available information relating to the 'Sydney Light Rail Strategic Plan' currently being developed by TfNSW
- No optimisation of Light Rail network or services was considered
- Anzac Pde. bus routes replaced with Anzac Pde. Light Rail that links with George St. Light Rail

Option 3: Underground Bus Rapid Transit (BRT)

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	?	✓	✓

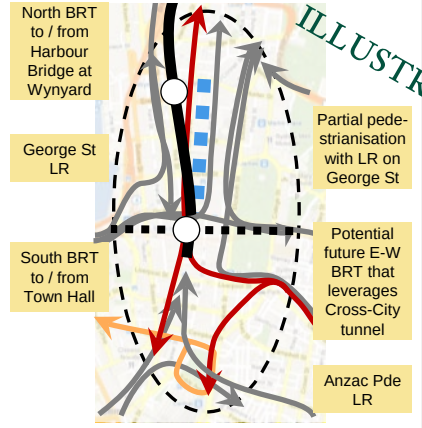


- Underground BRT network based on high level concepts
- c.75% of peak Harbour Bridge buses moved to underground BRT
- All peak Broadway and c.50% of South-East buses moved to BRT
- Makes use of tram tunnels from Wynyard to Harbour Bridge
- Assumes planned redevelopment of Wynyard and Town Hall stations

Option 4: Underground BRT and LR

Choke points potentially addressed

George St	Western Distributor	York St.	Eliz. St.
✓	?	✓	✓



ILLUSTRATIVE

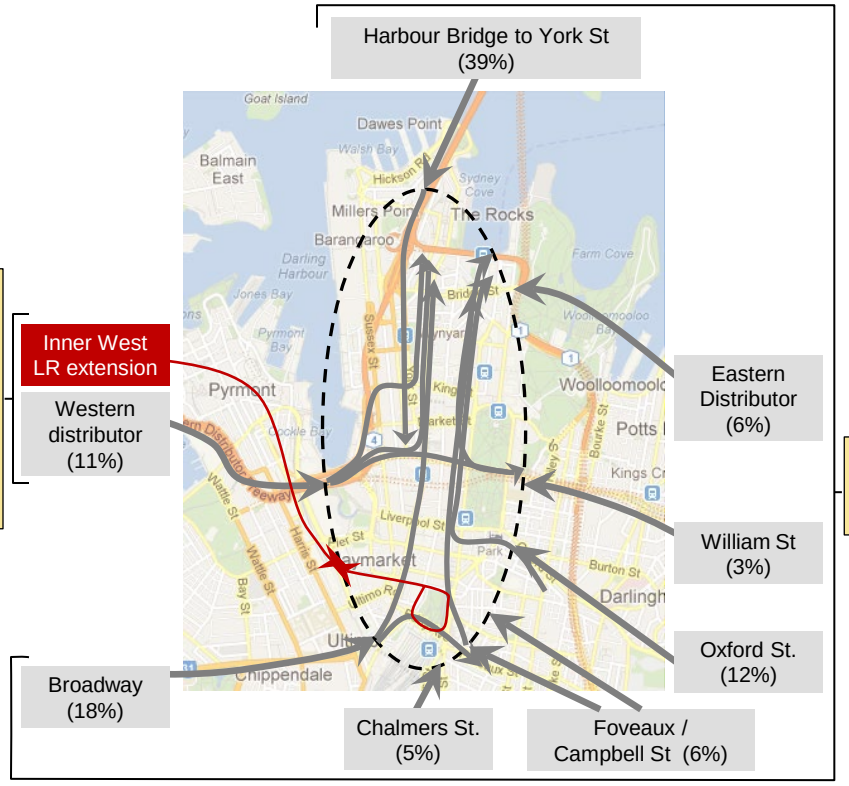
- Network based on a combination of options 2 and 3
- USYD to CBD Light Rail removed due to route being addressed by both options 2 and 3

Potential BRT | Potential Light Rail | Existing Light Rail | Surface Bus | Sub surface station | Pedestrianised George St. | Partially pedestrianised George St. with Light Rail

Source: TfNSW 'Sydney Light Rail Strategic Plan' information web page (www.transport.nsw.gov.au/lightrail-program/sydney-light-rail-strategic-plan); L.E.K. analysis

Option 1: Base case – status quo**

The Inner West Light Rail extension is not expected to reduce patronage on Western Distributor bus services as its catchment is primarily served by Broadway buses***



No change to current surface bus routes

This analysis has not considered possible optimisation of the surface bus network

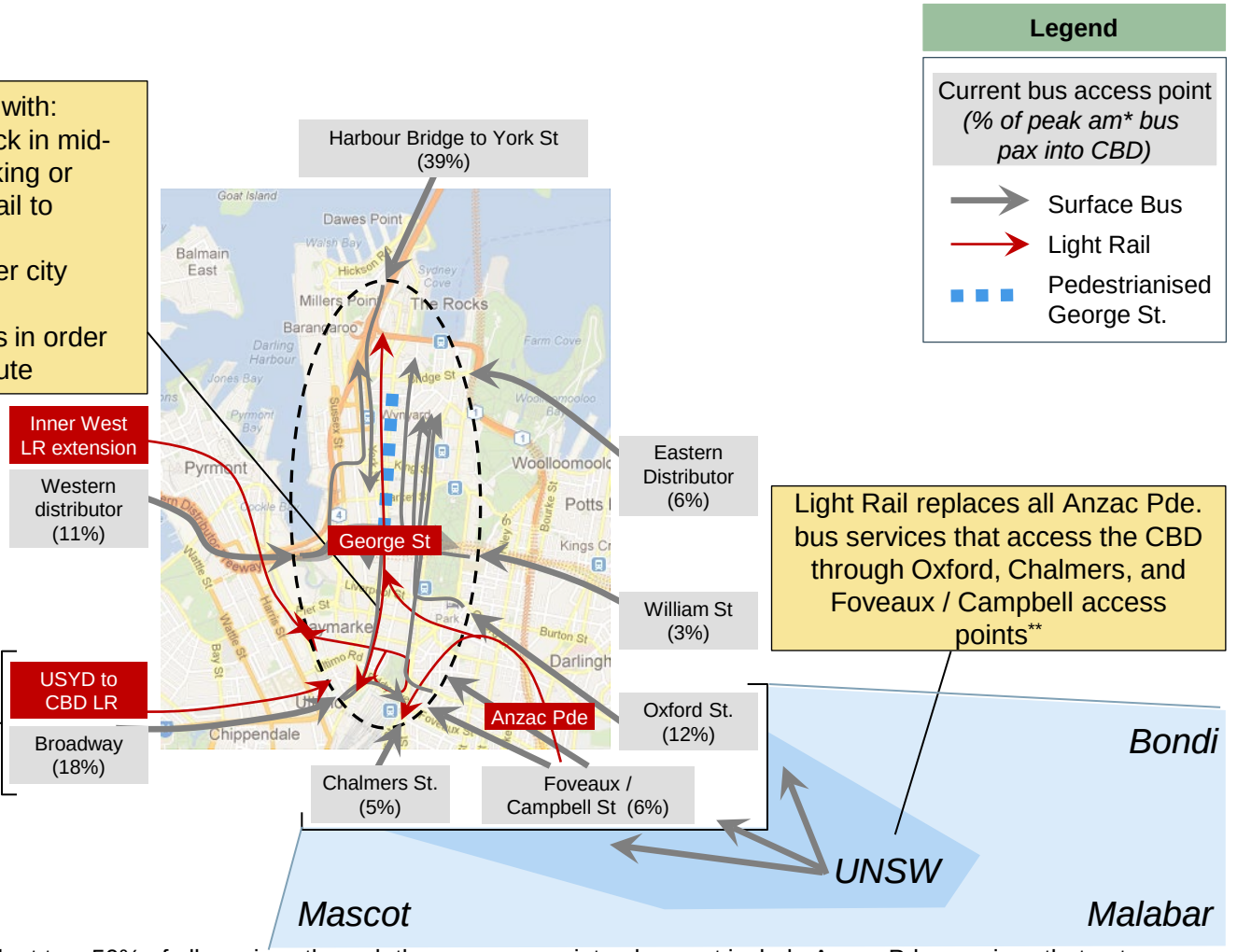
Note: *2 hour am peak (7-9am); **option represents current Sydney CBD access network, improvements to status quo surface buses are possible
*** LR network assumed to not materially reduce patronage on existing Broadway bus services

Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW

Option 2: Dedicated Light Rail network (Anzac Pde, USYD, George St.)

All buses removed from George St with:
- 50% terminating and looping back in mid-CBD with commuters either walking or changing travel mode to Light Rail to complete their journey
- 25% through-routed to other inner city suburbs
- 25% routed down parallel streets in order to continue along north-south route

Minimal volumes shift from Broadway bus routes to Light Rail as Light Rail service only extends to USYD



Note: *2 hour am peak (7-9am); **equivalent to c.50% of all services through these access points, does not include Anzac Pde. services that enter the CBD via the Eastern Distributor

Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW; L.E.K. Analysis

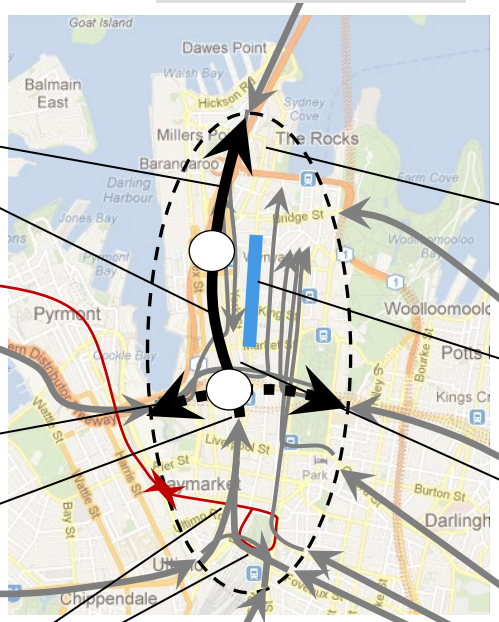
Option 3: Underground Bus Rapid Transit network

BRT moves c.40%** of all surface buses underground, significantly reducing congestion along York, George and Elizabeth Streets

Potential expansion that provides East-West access to the BRT via Cross City Tunnel^

South-BRT dive-point entrance at south end of Town Hall plaza

Bus services transit on CBD surface in the southern CBD prior to entering underground BRT



Legend

- Current bus access point *(% of peak am* bus pax into CBD)*
- Proposed BRT
- Light Rail
- Surface Bus
- Sub surface station
- Pedestrianised George St.

Potential to make use of tram tunnels for northern BRT access

Pedestrianisation of George St between Market St and Hunter St

Broadening of George St. sidewalk south of Market St

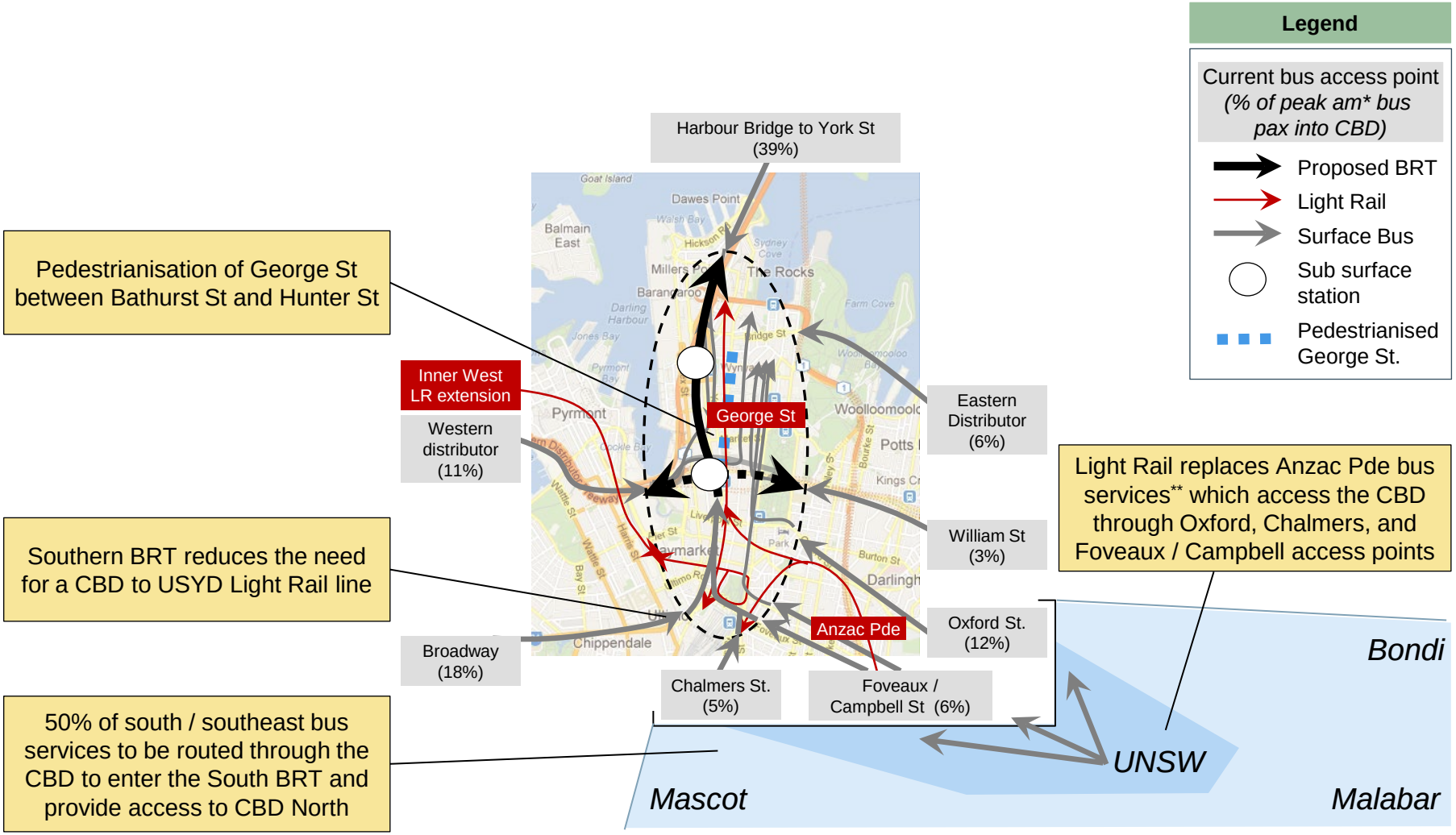
50% of south / southeast bus services to be routed through the CBD to enter the South BRT and provide access to CBD North

Surface bus network optimised to fully utilise BRT

Note: *2 hour am peak (7-9am); **derived based on estimated capacity limitations of the underground BRT system; ^not assessed in this report

Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW; L.E.K. Analysis

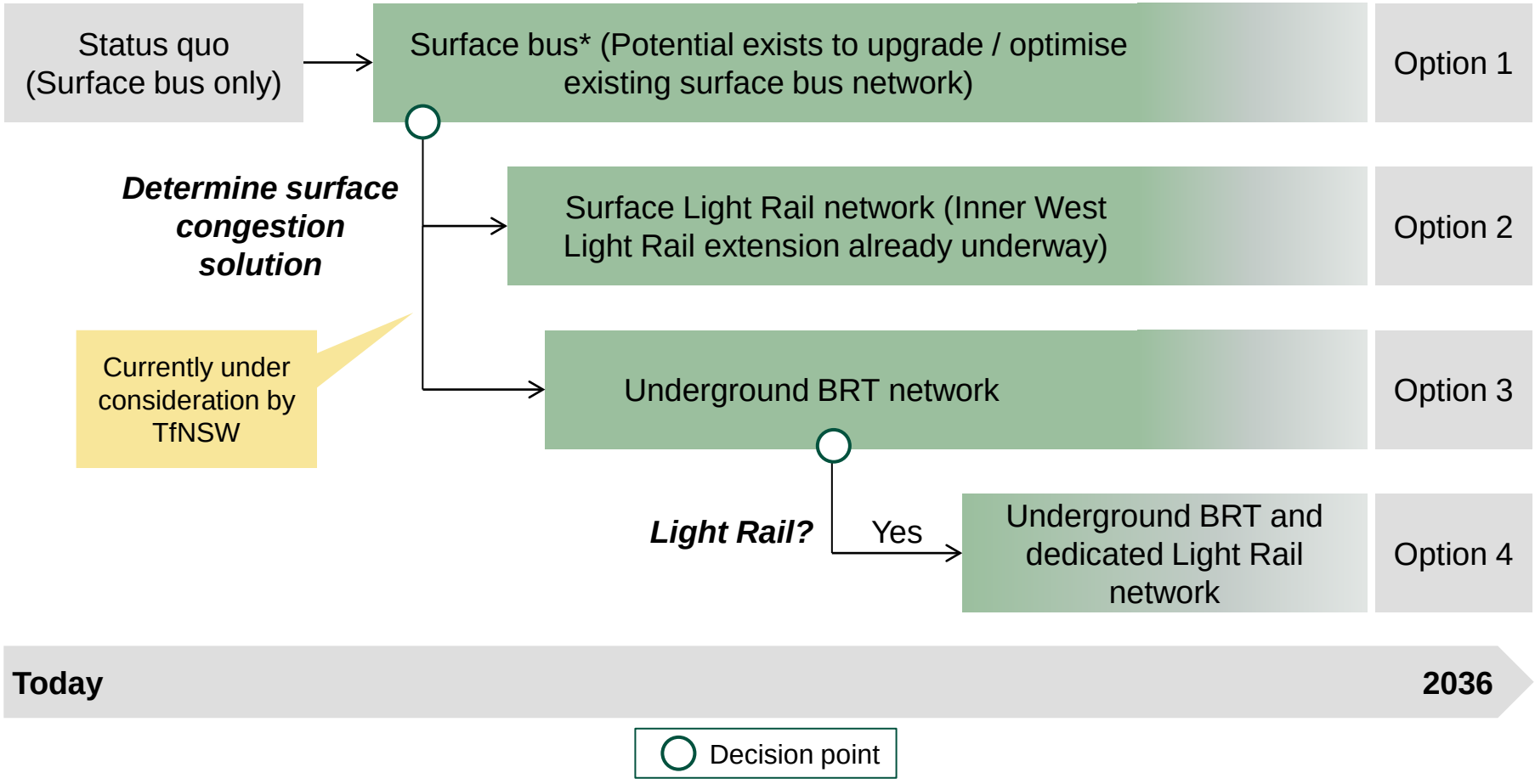
Option 4: Underground Bus Rapid Transit network and Dedicated Surface Light Rail



Note: *2 hour am peak (7-9am); **equivalent to c.50% of all services through these access points
Source: TfNSW Sydney Strategic Travel Model 2010; Transport for NSW; L.E.K. Analysis

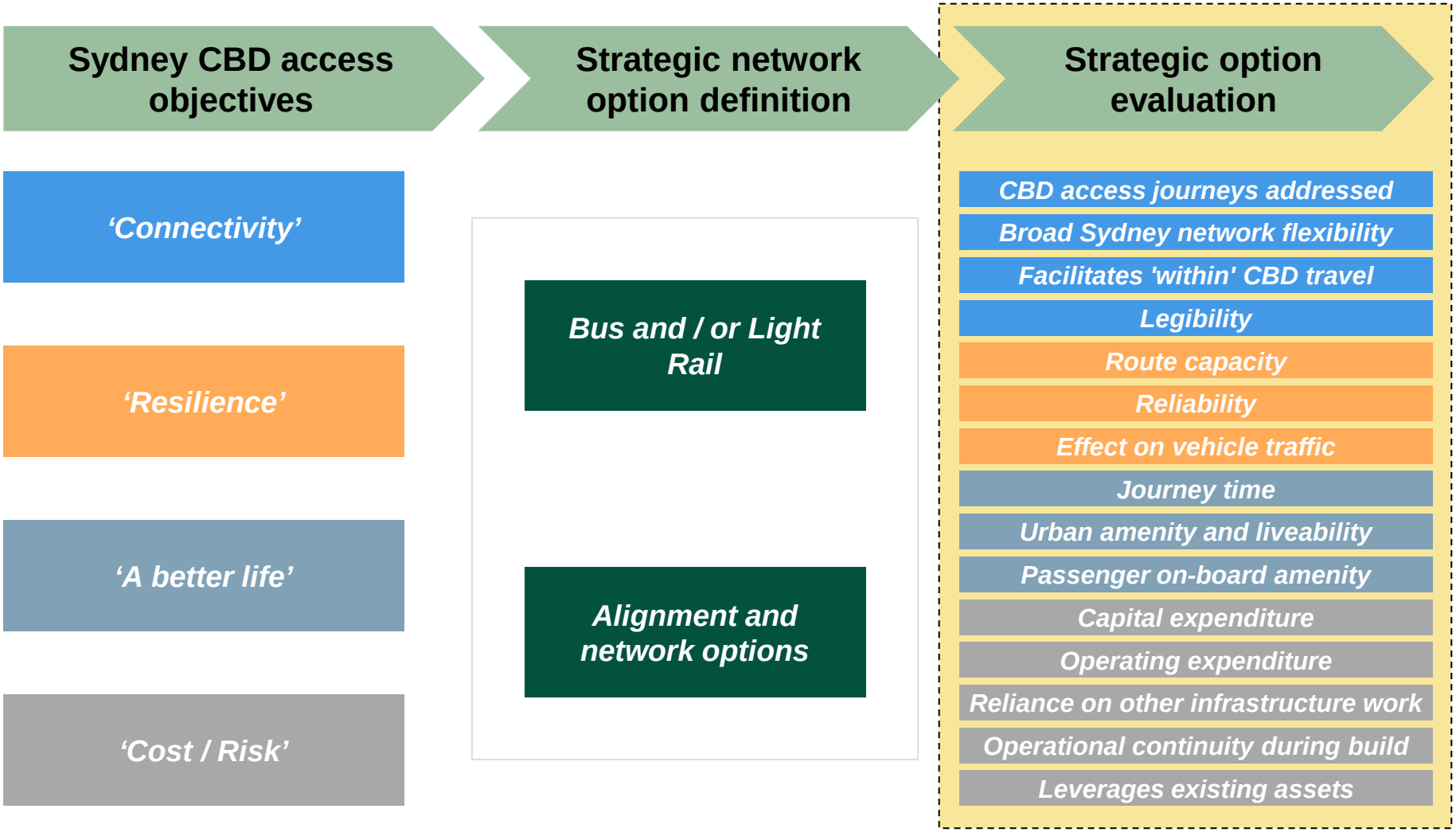
An underground BRT could facilitate Light Rail. A long-term surface congestion strategy should be resolved before any infrastructure investment is made

Phasing of infrastructure decisions and development



Note: * This analysis has not considered possible optimisation of the surface bus network

Potential CBD access strategies have been assessed using a broad range of strategic criteria



A broad range of criteria has been used to assess each strategic option

	Assessment criteria	Definition: The proposed strategic option…	Assessment approach: Analyse and compare…
Connectivity	CBD access journeys addressed	…positively impacts on a large proportion of passengers who access the CBD each day	…the estimated number of passengers positively impacted by each option across all CBD access points
	Broad Sydney network flexibility	…can respond to changes in the needs of the broader Sydney network, eg. re-routing to improve cross-suburb connectivity	…each network's ability to implement new route plans
	Facilitates 'within' CBD travel	…facilitates reasonable options for travel within the CBD	…each network's ability to provide options for travel from one part of the CBD to another
	Legibility	…allows commuters to quickly and easily make decisions around the right mode and service to use for their journey	…the ease to which a commuter could understand and identify the most appropriate travel option
Resilience	Route capacity	…provides capacity that meets current demand and supports patronage growth	…each option's potential to increase capacity for travel into the Sydney CBD
	Reliability	…is resilient in response to incidents en route and is less sensitive to other traffic movements	…each option's ability to minimise disruption in the event of an incident, and any sensitivity it may have to intersecting traffic
	Effect on vehicle traffic	…facilitates reduced congestion for private and commercial vehicles in the CBD	…the net impact on overall vehicle traffic in the CBD as a result of pedestrianisation and changes to vehicle movements
A better life	Journey time	…reduces current average journey times for commuters travelling into the CBD	…a high level estimation of the overall annual am peak journey time saved across impacted commuters
	Urban amenity and liveability	…improves the Sydney CBD's attractiveness as a place to live and work	…each network's impact on the street environment, in particular the pedestrian experience at street level
	Passenger on-board amenity	…provides a comfortable and efficient transit mode for passengers	…each network's impact on the overall comfort and experience of passengers across the CBD access network
Cost / Risk	Capital expenditure	…will cost $A-Bm to build	…a top-down estimate of the overall infrastructure and rolling stock capital expenditure required for each network option
	Operating expenditure	…will cost $X-Ym to operate each year	…a top-down estimate of the annual operating costs involved with running each network option
	Reliance on other infrastructure work	…is not heavily reliant on the implementation of other major infrastructure projects	…any other major infrastructure works which must proceed in order to facilitate the development of each network option
	Risk and continuity during build	…minimises any potential disruption or risk to the operation and integrity of surrounding infrastructure	…the level of risk and disruption that each network option poses to other key infrastructure (eg electricity, trains, etc)
	Leverages existing assets	…is able to leverage existing public transport assets in implementation and ongoing operations	…how existing assets and expertise could be utilised in the implementation and ongoing operations of each option

A BRT network could improve CBD access along many important dimensions, but is relatively expensive and would require addressing significant implementation risks. Further benefits could potentially be realised in combination with Light Rail

Summary of assessment of strategic options against key criteria

		Criteria	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Connectivity	A	CBD access journeys addressed	-	-	↑↑	↑↑
	B	Broad Sydney network flexibility	-	↓	-	↓
	C	Facilitates 'within' CBD travel	-	↑	-	↑
	D	Legibility	-	↑↑	↑	↑↑
Resilience	E	Route capacity	-	-	-	↑
	F	Reliability	-	↑	↑	↑
	G	Effect on vehicle traffic	-	↓	-	↓
A better life	H	Journey time	-	↓	↑	↑
	I	Urban amenity and liveability	-	↑	↑↑	↑
	J	Passenger on-board amenity	-	-	↑	↑
Cost / Risk	K	Capital expenditure	-	↓	↓	↓↓
	L	Operating expenditure	-	↓	↑	↓
	M	Reliance on other infrastructure work	-	-	↓↓	↓↓
	N	Risk and continuity during build	-	↓	↓↓	↓↓
	O	Leverages existing assets	-	↓	↑	↑

Score key: ↓↓ Much worse than base case; ↓ Worse than base case; - Negligible change over base case; ↑ Improvement over base case; ↑↑ Strong improvement over base case

Source: L.E.K. Analysis; MRCagney

An underground BRT network could address the most CBD bus access journeys, covering the key Harbour Bridge, Broadway and South-Eastern access points

CBD access point	Peak am pax* (thousands, 2011)	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Campbell St	1	Status quo	Status quo	50% of south / east bus services (from non Anzac Pde routes) routed through the CBD to access BRT via south dive point	As option 3
Chalmers St	3	Status quo	Anzac Pde LR replaces Anzac Pde bus services** (9% of peak pax)		Combination of options 2 and 3
Foveaux St	2	Status quo			
Oxford St	6	Status quo		Status quo	As option 2
William St	2	Status quo	Status quo	Status quo	Status quo
Eastern Distributor	3	Status quo	Status quo	Status quo	Status quo
Harbour Bridge	20	Status quo	Status quo	c.75% of services shifted underground	c.75% of services shifted underground
Western Distributor	6	Status quo	Some northbound pax required to walk or switch to LR after entering CBD (10% of peak pax)	Status quo	Status quo
Broadway	9	Status quo		All services moved to BRT	All services moved to BRT
Overall 2011 CBD access journeys positively addressed		**As is**	**9%**	**41%**	**50%**

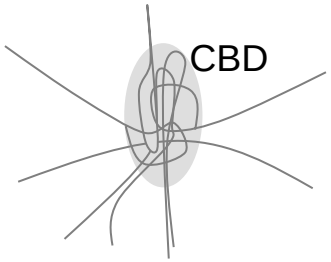
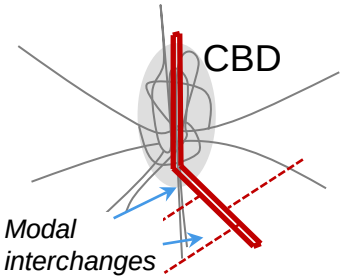
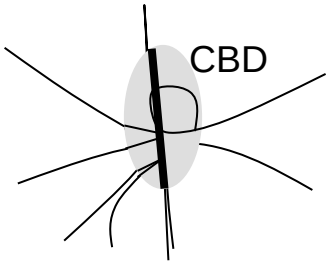
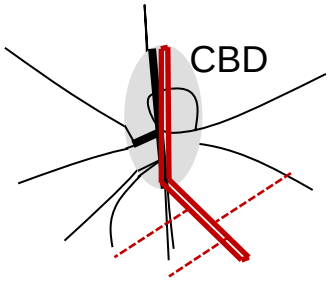
INDICATIVE

Score key: Much worse than base case; Worse than base case; Negligible change over base case; Improvement over base case; Strong improvement over base case

Note: *2 hour am peak (7-9am); **equivalent to c.50% of all services through these access points

Source: TfNSW Sydney Strategic Travel Model 2010; L.E.K. Analysis

The network flexibility of each strategic option is strongly informed by the flexibility of each mode

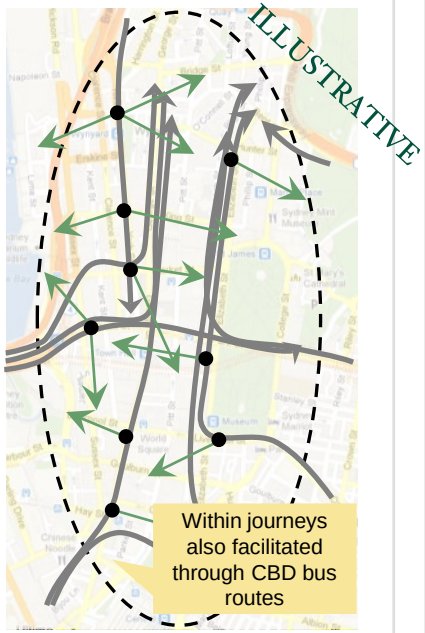
	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Flexibility				
Route planning	Buses are easily re-routed if required	Low flexibility in making route changes as dedicated tracks need to be laid down	Buses along feeder corridors as per status quo and are easily re-routed if required	Combined low flexibility from options 2 and 3
Broad Sydney network flexibility	As is	Less flexible than status quo	Negligible change to status quo but with greater potential for cross suburb connectivity	Low flexibility from option 2

Score key: Much worse than base case; Worse than base case; Negligible change over base case; Improvement over base case; Strong improvement over base case

Source: L.E.K. analysis

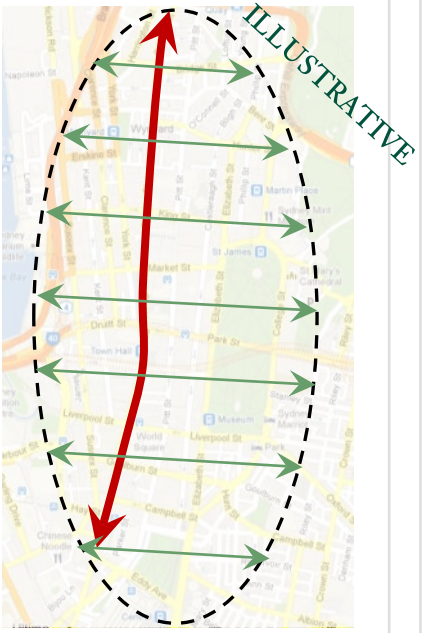
Light Rail and Underground BRT could facilitate improved 'within' CBD travel

Option 1
Base case – status quo



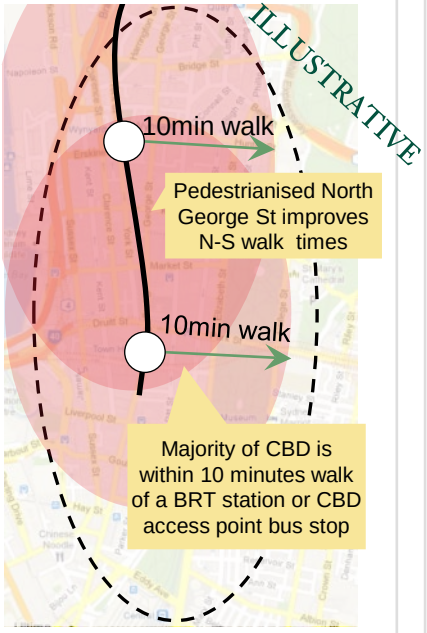
Existing routes provide good coverage of CBD and create potential for short walks

Option 2*
Dedicated Light Rail



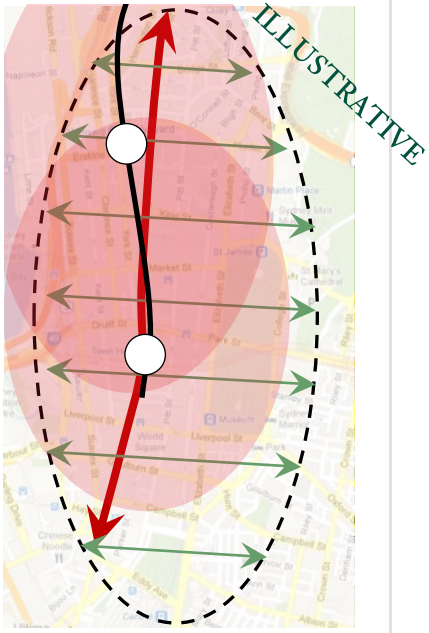
Light Rail facilitates N-S 'within' journeys down CBD spine, after which commuters can walk to their destination. Pedestrianised section of George St. also improves walk times along this segment

Option 3*
Underground BRT



BRT is less conducive to 'within' CBD travel, however it facilitates a less congested CBD with increased pedestrian space which is likely to improve walk time and speed of remaining surface bus routes

Option 4*
Underground BRT and LR



Combined 'within' travel benefits of options 2 and 3

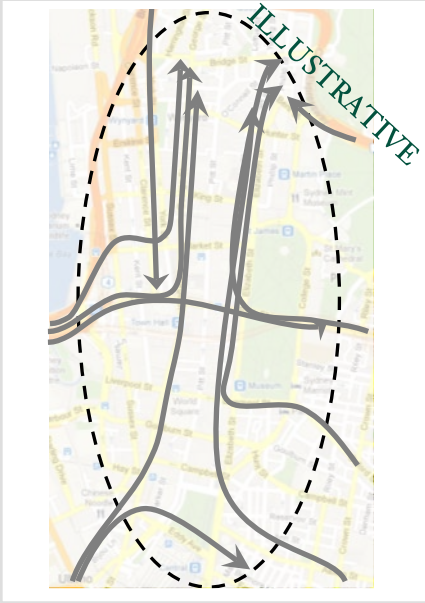
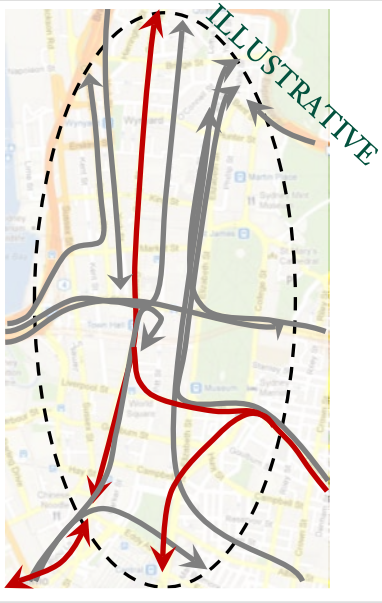
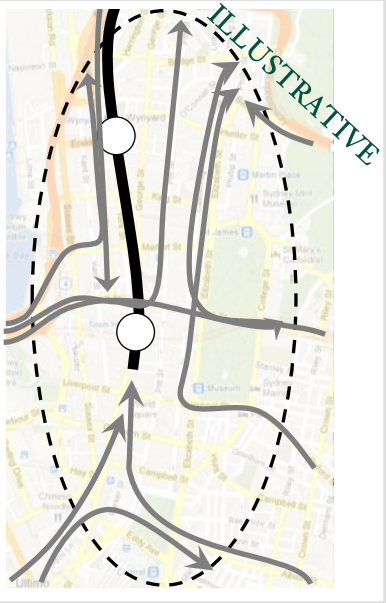
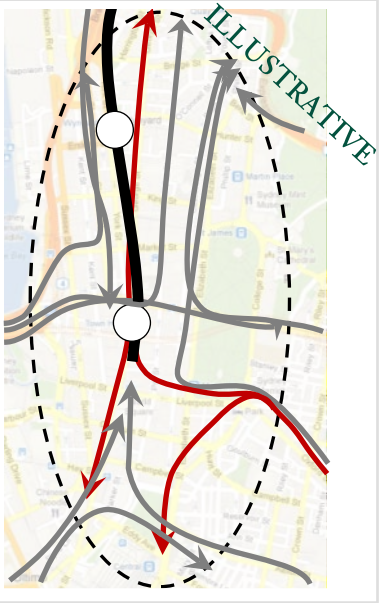
All potential network options require surface pedestrian improvements, particularly East-West routes

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Note: *While the overall 'within' travel option is improved, the network option will inevitably result in some winners and losers

Source: L.E.K. analysis

Network legibility within the CBD could be facilitated through network simplification and / or mode choice

Option 1 Base case – status quo	Option 2 Dedicated Light Rail	Option 3 Underground BRT	Option 4 Underground BRT and LR
			
Complex status quo network with routes directed through a variety of CBD corridors	Improved legibility due to Light Rail routes being more easily understood as a clear transport option with a well defined destination	Simplified bus network with c.40% of services shifted underground and stopping at two key points in the CBD	Combined legibility of options 2 and 3

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: L.E.K. analysis

Each strategic option caters to existing capacity requirements and has the potential to increase capacity for travel into the Sydney CBD

	Option 1: Base case - status quo	Option 2: Dedicated Light Rail			Option 3: Underground BRT			Option 4: Underground BRT and LR
CBD access point addressed	none	George St	Broadway	Anzac Pde	Harbour Bridge to York St	Broadway	Chalmers + Foveaux St	Options 2 + 3 *(no USYD to CBD LR)*
Max route Capacity*	12,000* pax / hr	12,000* pax / hr	12,000* pax / hr	12,000* pax / hr	20,000* pax / hr	20,000* pax / hr		Combination of options 2 and 3
% of all CBD access bus pax impacted	-	10%	Negligible pax expected to switch to LR	9%	29%	9%	3%	50%
Est. patronage am peak (2hr)	As is	c.5,000 pax		c.4,000 pax	c.20,000 pax			c.25,000 pax
Key considerations	Capacity could be increased with fleet vehicle upgrade and improved utilisation of services	Some West. Distr. and Broadway bus commuters are required to walk or switch to LR after entering CBD These pax equate to c.20% of theoretical max route capacity Capacity could be increased with introduction of more services		Anzac Pde pax equate to c.15% of theoretical max route capacity	BRT network will be at near full utilisation at launch, addressing: - 75% of all Harbour bridge bus services - all Broadway services - half of Chalmers / Foveaux St services Capacity could be increased with fleet vehicle upgrade and improved utilisation of feeder services			Combined impact of options 2+3, with no bus pax required to switch modes as BRT brings them directly to CBD stations
Overall effect on CBD access capacity	Potential for increased capacity	Potential to increase capacity is similar to the status quo			Potential to increase capacity is similar to the status quo			Improvement over status quo

INDICATIVE

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Note: *Assuming full utilisation of services and fully optimised operating environment along route
Source: MRCagney; L.E.K. analysis

Underground BRT could be a more reliable mode of transport due to the flexibility of buses combined with a dedicated, uninterrupted underground route

	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Incident response	Flexible mode of transport with ability to overtake and be re-routed	Lower flexibility due to dedicated track, however Light Rail breaks down 5-6* times less than buses	Low flexibility due to dedicated tunnel	Low flexibility from option 3
+				
Variability / sensitivity to other traffic	Varying traffic conditions and multiple interactions lead to high variability	Low variability despite intersections on route as light rail traffic is generally given signaling priority	Low variability with no intersections along dedicated route	Combined low variability from options 2 and 3
=				
Overall reliability	As is	Improvement in reliability over status quo	Improvement in reliability over status quo	Improvement in reliability over status quo

Score key: Much worse than base case; Worse than base case; Negligible change over base case; Improvement over base case; Strong improvement over base case

Note: * 5.5x more bus breakdowns than Light Rail breakdowns during 2009 (bus) and 2010 (Light Rail) throughout the Santa Clara Valley
Source: Santa Clara Valley Transport Authority; L.E.K. analysis

Private and commercial vehicle congestion could be made worse under a Light Rail network. Any benefits to this traffic from a BRT may be offset by pedestrianisation

Private and commercial vehicle traffic

Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
As is	Pedestrianisation of sections of George St. shifts private vehicles to other parts of the CBD, resulting in less available space 50% of George St. buses routed through other parts of the CBD adding to road congestion In non-pedestrianised zones, fewer lanes are available to private vehicles due to dedicated Light Rail corridor East-West traffic movements stifled with signaling priority given to Light Rail and active transport	Net zero balance between - Significant reduction in street traffic due to buses being removed from CBD surface + - Less road space available to traffic due to pedestrianisation of George St - De-prioritisation of east-west traffic movements at intersections with George St	Slightly worse than status quo resulting from balance between: - BRT: Negligible change as per option 3 + - LR: Further road space taken away from vehicle traffic due to dedicated Light Rail corridor
As is	Worse than status quo	Negligible change over status quo	Slightly worse than status quo

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: L.E.K. analysis

Based on current published bus timetables, a BRT network could be most effective at reducing peak morning journey time in the most frequented corridors

	Estimated annual morning (peak am*) journey time savings for travel within the CBD^									
	Option 1: Base case - status quo	Option 2: Dedicated Light Rail				Option 3: Underground BRT				Option 4: Underground BRT and LR
CBD access point	none	George St	Broadway	Anzac Pde***		Harbour Bridge to York St	Broadway	Chalmers, Foveaux and Campbell St		Options 2 + 3 *(no USYD to CBD LR)*
				Oxford St	Foveaux + Chalmers			To T/H	To CBD North	
Impact on peak am journey time	n/a	Increased journey time and inconvenience for commuters required to switch to Light Rail upon entry to the CBD**	LR only reaches USYD, resulting in negligible improvement in journey time to Central for a small number of commuters	Increase in journey time due to the LR route proceeding slower than current Elizabeth St buses	Decrease in Journey time due to LR route avoiding slow moving traffic on Cleveland and Foveaux St	Improvement in journey time by avoiding congestion on York St	Improvement in journey time due to avoidance of Central CBD congestion on George St	Increased journey time with buses required to route through the CBD to access the BRT	Improvement in journey time once the buses are in the BRT	Combined impact of options 2+3, with no bus pax required to switch modes upon entry to CBD
Change in journey time vs peak am timetable	-	Increase of c.15 minutes** per pax	-	Increase of 2-4 minutes per pax	Decrease in 1-2 minutes per pax	Decrease of 3 - 5 minutes	Decrease of 2 minutes from Town Hall to Wynyard	Increase of 2 minutes to Town Hall	Decrease of 2 minutes from Town Hall to Wynyard	Benefits of option 2, avoiding increase in journey time for George St LR pax
% of bus pax impacted	-	10%	Negligible pax expected to switch to LR	4%	5%	29%	9%	3%		50%
Overall peak am* journey time saved	-	**350-400 thousand hours lost / year**				**200-250 thousand hours saved / year**				**150-200 thousand hours saved / year**

INDICATIVE INDICATIVE INDICATIVE

This report has based journey time savings on published bus timetables which potentially understate the actual average journey time for CBD bus travel. This analysis will need to be updated with actual journey time statistics prior to a detailed BCR study (see page 88)

Note: * 2 hour am peak (7-9am); ** Modal change penalty applied of 3x the combined walk and wait time of 5 minutes; *** Transfer penalty not considered for pax required to transit by bus to the Anzac Pde Light Rail line; ^ For travel sectors within the CBD. No assessment has been made on potential effects on journey times outside of the CBD or on other modes (eg pedestrians, cars)

Source: Transport for NSW; L.E.K. analysis; MRCagney

The type of urban amenity created on the street surface in the Sydney CBD is a major consideration in the assessment of strategic options

Option 1: Base case – status quo

"…Vehicles and pedestrians vying for street space in the CBD…"

Option 2: Dedicated Light Rail

"…George St. boulevard for pedestrians and Light Rail only…"

Option 3: Underground BRT

"…Removal of buses from the CBD surface with parts of George St fully pedestrianised and other parts with broadened sidewalks…"

Option 4: Underground BRT and LR

Combined amenity from options 2 and 3

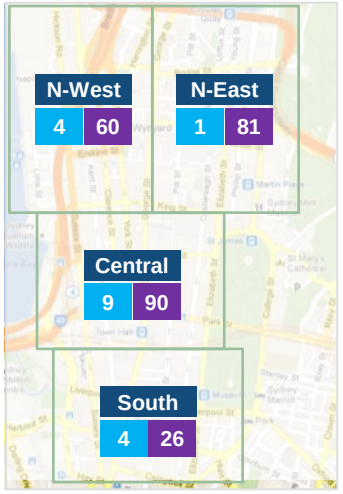
"…Pedestrian boulevard with Light Rail on surface and majority of buses moved underground…"

Source: L.E.K. analysis

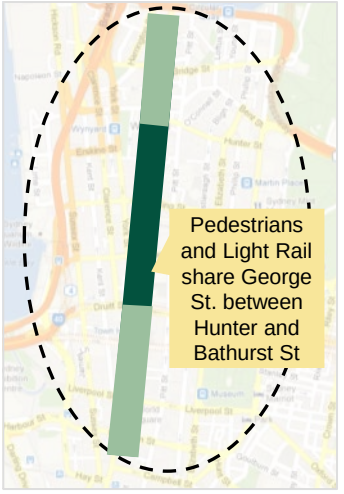
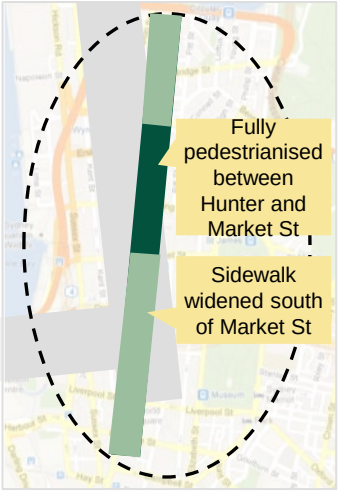
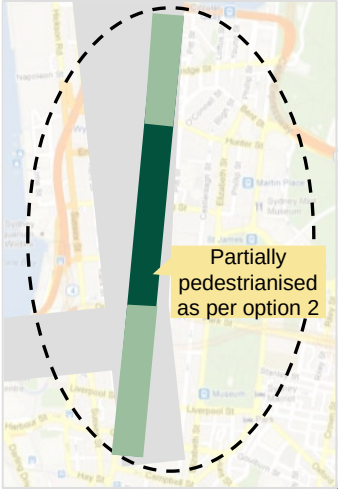
Improved urban amenity and liveability in the CBD could best be facilitated by a combined Underground BRT and surface Light Rail network

Where people live and work

X Live – 2006 (thousands) X Work - 2016F (thousands)



Urban Amenity impact on the CBD

Option 1 Base case – status quo	Option 2 Dedicated Light Rail	Option 3 Underground BRT	Option 4 Underground BRT and LR
			
No change to status quo	Improvement in amenity along pedestrianised George St Spine	Improvement in amenity along pedestrianised George St Spine	Improvement in amenity along pedestrianised George St Spine

‘Live and work’ drivers
96k new jobs in Sydney by 2036; Barangaroo area development

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: NSW Department of Planning and Infrastructure Metropolitan Plan for Sydney 2036; Australian Bureau of Statistics 2006 Census; City of Sydney; L.E.K. analysis

Light Rail carriages could provide passengers with the most on-board amenity, but may only impact upon a small number of journeys to the CBD

	Option 1: Base case - status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Seating (assuming full utilisation)	Mixture of seating and standing	Higher proportion of standing than with surface bus	As status quo	Minor decline relative to status quo as LR only addresses 19% of peak pax
Sway movements	Pronounced sway movements throughout journey as buses generally follow street routes that involve a number of turns	Minimal to zero sway movements with largely straight dedicated track	Reduced sway movements relative to surface bus due to underground route with reduced cornering	Combined benefits of options 2 and 3
Stop / start	Frequent stop / start from potentially high speeds	Frequent stop / start at lower speeds	Greatly reduced frequency of stop / start	Combined benefits of options 2 and 3
Embarking and disembarking	Congested at peak times with limited number of doors on vehicle	Reduced congestion at stops due to pedestrian friendly environment Improved passenger movement to and from vehicle due to multiple doors per carriage	Congested at peak times with limited number of doors on vehicle	Benefits from option 2 (LR), however, LR component addresses only a small proportion (19%) of peak pax
% of peak bus pax addressed	0%	19%	41%	50%
Overall passenger on-board amenity	As is	Negligible overall improvement across the broader CBD access network with only 19% of pax expected to use LR	Improvement over status quo	Improvement over status quo

INDICATIVE

Score key: Much worse than base case; Worse than base case; Negligible change over base case; Improvement over base case; Strong improvement over base case

Source: L.E.K. analysis

The work involved with tunnelling and building sub-surface stations for a BRT network will likely require significant capital expenditure, but much less than many heavy rail enhancements under consideration

	Option 1: Base case - Status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT network	Option 4: LR and Underground BRT
Estimated Infrastructure Capital Expenditure	*No further infrastructure capex required*	Capex cost: c.$100m per km Gold Coast Light Rail: $73m per km (2012), Edinburgh Tram*: $92m per km (current estimate) x Estimated network length = 11.5km = **Indicative total project infrastructure capex: $1bn+**	Capex cost of similar sized projects: $300m per km (driven tunnel) Brisbane INB Queen to Roma Street $266 per km (2008$ incl. 2 stations + 1.25km corridor) **Indicative total infr. capex: Over c.$800m** *(not including redevelopment of Wynyard and Town Hall stations)*	Option 2 cost c.$800m+ (less 2.5km @ a cost of c.$100m per km for USYD line) + Option 3 cost c.$800m+ = **Indicative total infrastructure capex: Over c.$1.6bn+**
Estimated Rolling Stock Capital Expenditure	*No further rolling stock capex required*	Rolling stock cost: c.$5m per unit x Estimated units required = 50 = **Indicative rolling stock capex: c.$250m**	*No further rolling stock capex required* **As is relative to status quo**	Rolling stock cost: c.$5m per unit x Estimated units required = 40 = **Indicative rolling stock capex: c.$200m**
Overall capex	**No further capex required**	**Infrastructure and rolling stock capex required**	**Infrastructure capex required**	**Combined capex from options 2 and 3**

Less stock required due to no USYD to CBD LR

Notes: *estimated cost of £770m ($1.2bn) for 13km corridor, equating to $92m / km
Source: MRCagney

BRT could provide savings in annual operational expenditure

	Estimated operating expenditure			
	Option 1: Base case - Status quo	**Option 2: Dedicated Light Rail**	**Option 3: Underground BRT network**	**Option 4: LR and Underground BRT**
	Estimate of current opex in CBD only	Incremental opex from implementation of a new mode	Incremental savings from reduced journey time in tunnel	Combination of options 2 and 3
Base Service Opex Costs	$120 per hour	$235 per hour**	$120 per hour	*Sum of cost savings from options 2 and 3*
	x	x	x	
Services Per Day	5,878 Services into the CBD per day*	700 Services per day per direction***	5,878 Services into the CBD per day*	
	x	x	x	
CBD Travel Time Per Service	10 mins HB to Wynyard 6min Wynyard to QVB 4min	23 minutes Average service length across CBD network	4.3 mins HB to Wynyard 2.3mins Wynyard to QVB 2mins	
	=	=	=	
CBD Opex Cost per year	$17.5 million	$39 million****	$7.5 million	
Opex Cost/Saving per year	**Business as Usual**	**$39 million cost**	**$10 million saving**	**Net $29 million cost**

+ =

Notes: *2342 services Harbour Bridge to Wynyard and 3536 services Wynyard to QVB; **Not including capex or depreciation of LRT vehicles
***6 hrs per day at peak capacity and 8 hrs per day at 80% of peak capacity per direction; ****312 days of operation;
Source: MRCagney

An underground BRT network is highly dependent on the redevelopment of Wynyard and Town Hall stations

Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
As is	A quality intermodal interchange between bus and light rail at CBD access points would potentially require other infrastructure work (eg. street reconfiguration)	Strong dependence on redevelopment of Wynyard and Town Hall stations to provide commuter access to BRT, trains and other 'within' pedestrian travel options	Combined reliance from options 2 and 3
As is	Relatively minor dependence on other infrastructure work	Strong dependence on other infrastructure work	Combined strong dependencies from options 2 and 3

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: L.E.K. analysis

The operational continuity of surrounding transport infrastructure could be strongly impacted by the development of an underground BRT system

	Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
Risk	As is	The implementation of Light Rail tracks may require significant mitigation work to divert and protect critical below-street utilities eg. electricity, gas, water etc.	Detailed geotech and other studies need to be conducted to understand what critical infrastructure could be affected by a BRT and any construction efforts (eg. building foundations, electricity backbone)	Combined risks from options 2 and 3
Operational continuity during build	As is	Traffic management strategies will need to be employed to ensure optimal traffic flows during construction efforts that are likely to take over the majority of George St.	Where a BRT intersects or shares facilities with other transport options (eg. Wynyard and Town Hall train stations), significant mitigation will need to be employed to ensure continuity of services and commuter access	Combined risks from options 2 and 3
Overall risk and continuity during build	As is	High risk and continuity concerns relative to status quo	Significant risk and continuity concerns relative to status quo	Significant risk and continuity concerns relative to status quo

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: L.E.K. analysis

The implementation of a BRT system could leverage some existing infrastructure

Option 1: Base case – status quo	Option 2: Dedicated Light Rail	Option 3: Underground BRT	Option 4: Underground BRT and LR
As is	Requires additional expertise and supporting infrastructure for rolling stock maintenance such as: - light rail yards / depots - specialist engineers, mechanics and fitters	Potential to use existing buses and associated supporting expertise and infrastructure eg. bus depots	Potential to use existing buses and associated supporting expertise and infrastructure eg. bus depots Requires additional expertise and supporting infrastructure for maintenance such as: - light rail yards / depots - specialist engineers, mechanics and fitters
As is	Existing support and maintenance systems are usable but option mostly requires additional infrastructure	Uses some existing support infrastructure	Combined impact of options 2 and 3

Score key: Much worse than base case | Worse than base case | Negligible change over base case | Improvement over base case | Strong improvement over base case

Source: L.E.K. Analysis

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis

Potential way forward

Collaborative options review

- Collaborate with TfNSW to jointly review materials and reconcile with Draft Transport Master Plan
- Understand existing investigations being conducted by TfNSW
- Review potential to optimise current surface bus options
- Refresh view of journey time savings in light of actual current journey time data (either from BTS or direct observation) and modal interchange plan
- Develop / assess a revised surface bus strategy (with or without Light Rail), including detailed bus re-routing, interchange requirements, traffic management plans and uptake of Inner West Light Rail extension
- Consider implications for the appropriate timing of BRT and Light Rail infrastructure investment

Subject to the above, consider detailed development and evaluation of the BRT option:

Detailed feasibility assessments

- Conduct detailed feasibility study into whether key infrastructure can be built. eg.
  - tunnel routing
  - use of existing tram tunnels for buses
  - station location
  - dive point locations

Detailed network design

- Develop key components of the future network design, including:
  - optimisation of overall bus network (eg bus routes and timetabling)
  - detailed assessment of impact on other modes (car, train, walking)
  - traffic flow design (eg one way streets)
  - surface lane configuration (eg bus and turning lanes)

Conduct detailed assessments of benefits and risks

- Conduct detailed BCR
- Quantify expected benefits and detailed capex and opex costings including size and type of rolling stock and design of required infrastructure (eg station redesign)
- Develop a view of likely BCR resulting from recommended CBD access option

Exploration of infrastructure levers

- Consider whether further initiatives are required to help enable the vision for the CBD in 2036. eg.
  - encouraging active transport (eg Barangaroo city walk, raised walkways)
  - introducing traffic management (eg congestion charging, parking management, bypass roads)

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis
  - generic modal definitions
  - generic modal comparison
  - network impact of strategic CBD access options
  - journey time
  - underground BRT plausibility

Surface buses come in a variety of sizes and fuel types, and operate at street level in mixed traffic conditions

Flexible unit capacity

Share route with other vehicles

Intersect with other traffic movements

Variety of fuel types

Source: Sydney Buses; p-plate.com; inside-sydney-australia.com; Sydney Morning Herald; guardian.co.uk; hyer.eu; keetsa.com

Light rail could run a variety of service lengths on dedicated routes, and are powered through electric overhead wires

Flexible unit capacity

Dedicated route, intersecting with other traffic movements

Pedestrianised corridors

Electric powered

Source: wn.com; railwayinsider.com; phoenix.about.com; ymtram.mashke.org; cityofsound.com

An Underground BRT system takes the majority of bus traffic off the surface by routing services through bus-only tunnels with stations at key CBD locations

Sub-surface busways

Downtown Seattle transit tunnel

Co-location of key transit and CBD areas

Brisbane Queen St. mall

Large scale CBD bus station

New York Port Authority bus terminal

Sub-surface bus station

Helsinki Kamppi Centre

The proposed Underground Bus Rapid Transit system is based on concepts that have been successfully implemented in other major cities

Source: 1; Google Streetview; Bing maps; CnK Travelscapes; transportpolicy.org.uk; Helsinki Kamppi Centre

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis
  - generic modal definitions
  - generic modal comparison
  - network impact of strategic CBD access options
  - journey time
  - underground BRT plausibility

Generic modal comparison summary

Comparison of travel modes

Criteria	Surface Bus* (Status quo)	Dedicated Light Rail	Underground BRT
A Urban amenity and liveability	-	↑	↑
B Passenger on-board amenity	-	↑	↑
C Infrastructure flexibility	-	↓	-
D Route capacity	-	-	↑↑
E Reliability	-	↑	↑

Score key: Much worse than status quo; Worse than status quo; Negligible improvement over status quo; improvement over status quo; Strong improvement over status quo

Note: * Defined as services that share route with other vehicles and intersect with other traffic movements
Source: MRCagney; L.E.K. analysis

Dedicated Light Rail is most effective at improving urban amenity

Drivers of urban amenity		Surface bus (status quo)*	Dedicated surface Light Rail	Underground BRT
Environmental	Noise	High noise levels from diesel powered buses, peaking at 90dB - beyond the threshold for hearing damage	Light Rail operates at c.10dB lower than buses	Removal of buses from the CBD surface reduces street noise
	Air	Majority of buses are diesel powered, creating high pollution levels in conjunction with mixed vehicle traffic	Electric powered Light Rail produces no local exhaust fumes	Removal of buses from CBD surface significantly reduces street level pollution, but underground exhaust is managed through extraction systems, shifting pollution elsewhere
	Visual	Large number of vehicles on street with congestion from mix of buses and private and commercial vehicles	Dedicated Light Rail route creates more street space and removes vehicles from street, however overhead LR cables can be intrusive	Buses removed from the CBD surface allow for creation of pedestrianised zones on sections of CBD surface
Pedestrian real estate	Crowding	Significant crowding with pedestrians constrained to limited sidewalk space	Increased street space for pedestrians reduces crowding	Commuters disembarking from buses moved underground, reducing crowding at street level. However, other forms of crowding created with concentration of pedestrians at BRT stations
	Walking times	Pedestrian movement impeded by vehicle dominated roads and multiple intersections	Improved walking times with increased pedestrian street space and minimal intersections	Improved walking times facilitated through removal of bus and disembarking passenger traffic from congested roads and pavements, creation of pedestrianised zones, together with accessible, centralised BRT stations
	Safety	Heavy interaction between pedestrians and public, private and commercial vehicles	Light Rail infrastructure is potentially dangerous to pedestrians and cyclists in shared zones	Buses removed from the CBD surface allow for creation of pedestrianised zones on sections of CBD surface
Overall		Congestion on street level drives noise and air pollution and compromises pedestrian real estate	Improved environment and enhanced pedestrian real estate	Improved environment and enhanced pedestrian real estate

Note: * Surface bus amenity can be improved through hybrid or other 'electric' drive; Surface bus defined as services that share route with other vehicles and intersect with other traffic movements

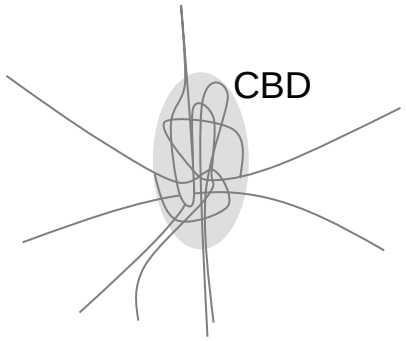
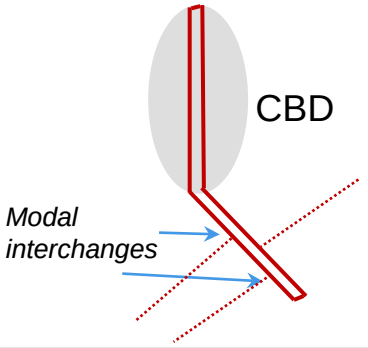
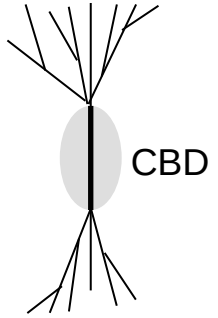
Source: Gehl Architects; Parsons Brinckerhoff; Edmonton Trolley Coalition; L.E.K. Analysis

Dedicated Light Rail provides passengers with the most on-board amenity out of all the considered modes

	Surface bus (status quo)	Dedicated surface Light Rail	Underground BRT
Seating	Mixture of seating and standing	Higher proportion of standing than with surface bus	As status quo
Sway movements	Pronounced sway movements throughout journey as buses generally follows street routes that involve a number of turns	Minimal to zero sway movements with largely straight dedicated track	Reduced sway movements relative to surface bus due to underground route with reduced cornering
Stop / start	Frequent stop / start from potentially high speeds	Frequent stop / start at lower speeds	Greatly reduced stop / start – only at underground BRT stations
Embarking and disembarking	Congested and disorganised at peak times with limited number of doors on vehicle	Reduced congestion at stops due to pedestrian friendly environment Improved passenger movement to and from vehicle due to multiple doors per carriage	Congested at peak times with limited number of doors on vehicle
Overall passenger on-board amenity	As is	Improvement over status quo	Improvement over status quo

Source: L.E.K. analysis

The three modes of transport considered vary in their infrastructure flexibility across the short and medium term

	Surface bus (status quo)	Dedicated surface Light Rail	Underground Bus Rapid Transit
Flexibility			
Response to issues	Buses are able to overtake broken down services	Dedicated track creates poor flexibility in response to breakdown	Single tunnel creates poor flexibility in response to breakdown
Route-planning / stopping pattern	Buses are easily re-routed if required	Low flexibility in making route changes as dedicated tracks need to be laid down	Low flexibility in rerouting through dedicated tunnel
Overall mode flexibility	As is	Less flexible than status quo	Less flexible than status quo (but routes can be changed outside the tunnel)

Source: L.E.K. analysis

Underground Bus Rapid Transit could have the highest route capacity, being able to manage up to 20,000 pax per hr on a single route

	Surface bus (status quo)	Dedicated surface Light Rail	Underground Bus Rapid Transit
Maximum unit capacity	75 pax	200 pax	75 pax
x			
Maximum service capacity (per hr per direction)	160	60	265*
=			
Maximum mode capacity	12,000 pax / hr	12,000 pax / hr	20,000 pax / hr

Note: * Assumes 2 x 55m platforms in bus station for each direction
Source: MRCagney

Underground BRT is a more reliable mode of transport due to the flexibility of buses combined with a dedicated, uninterrupted underground route

	Surface bus (status quo)	Dedicated surface Light Rail	Underground Bus Rapid Transit
Infrastructure flexibility	Flexible mode of transport with ability to overtake and be re-routed	Lower flexibility due to dedicated track, offset by a much lower breakdown frequency relative to bus*	Low flexibility due to single lane tunnel
+			
Variability	Varying traffic conditions and multiple interactions lead to high variability	Low variability despite intersections on route as light rail traffic is generally given signaling priority	Low variability with no intersections along dedicated route
=			
Overall reliability	As is	Improvement in reliability over status quo	Improvement in reliability over status quo

Note: * 5.5x more bus breakdowns than Light Rail breakdowns during 2009 (bus) and 2010 (Light Rail) throughout the Santa Clara Valley
Source: Santa Clara Valley Transport Authority; L.E.K. analysis

The three generic modes of transport considered vary in their general route capacity, speed, infrastructure requirements and cost

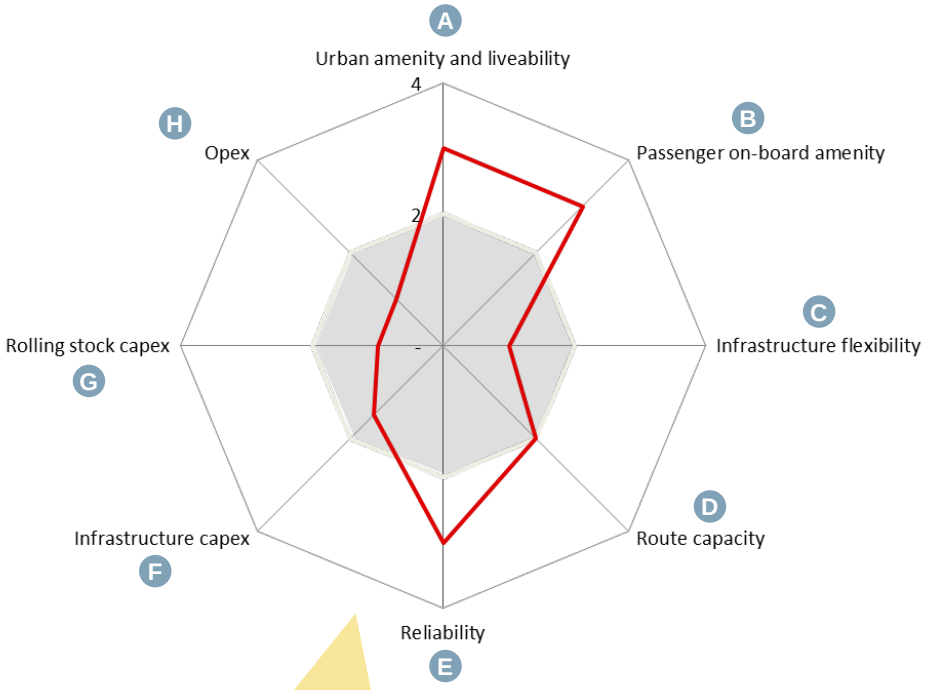
	Surface Bus	Dedicated surface Light Rail	Underground Bus Rapid Transit
F Infrastructure capital expenditure (per route km)	No capital expenditure	$90 million per km	$300 million per km (driven tunnel)
G Rolling stock capital expenditure (per pax capacity)	$6,000 12.5m Rigid Bus $0.45m (75 pax)	$25,000 LRT SVU $5m (200 pax)	$6,000 12.5m Rigid Bus $0.45m (75 pax)
H Opex (per pax capacity* km)	$5 per v/km $0.066 per pax capacity per km	$17 per v/km $0.085 per pax capacity per km	$5 per v/km $0.066 per pax capacity per km
I Average speed capability (km/h)	8km/hr (Sydney CBD) 15-25km/hr (Sydney Bus network)	5-10km/h (Pedestrianised CBD) 15-20km/h (CBD streets) 30-40km/h (Suburban streets)	30-50km/hr (dependent on tunnel section length)
J Infrastructure required	Business as usual	Surface Rail and stops	Driven tunnel Underground stations Steep portal entry and exit

Note: * includes seating and standing

Source: MRCagney

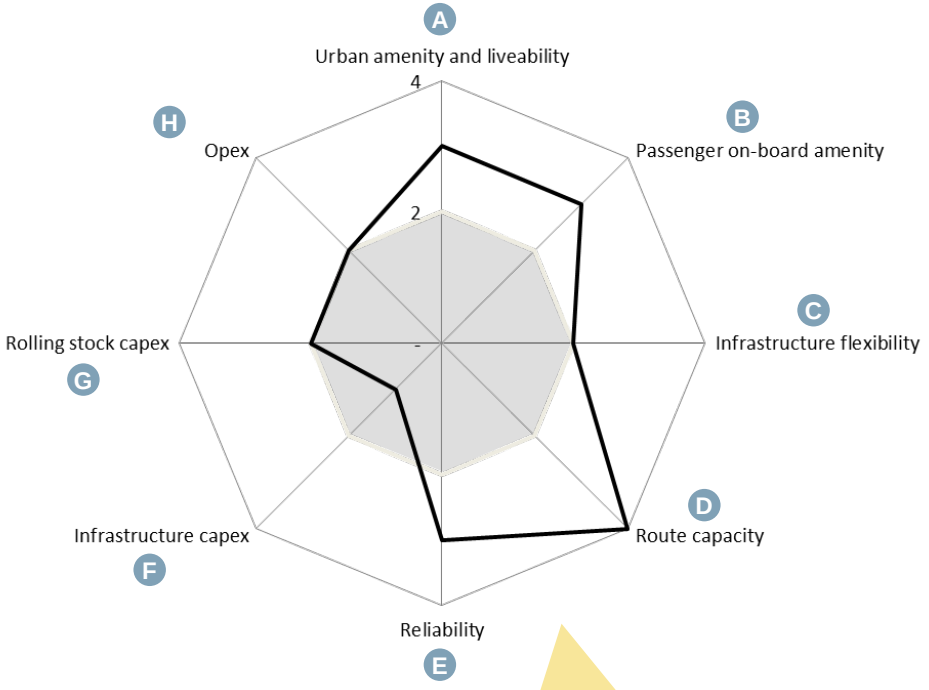
Overview of key trade-offs between transport modes

Light Rail vs Surface bus



Light Rail can improve urban amenity, but it is an expensive and inflexible transport mode

Underground BRT vs Surface bus



Underground BRT provides flexible capacity but at a higher capital cost than surface bus

Option vs status quo

0 Much worse
1 Worse
2 Negligible improvement
3 Improvement
4 Strong improvement

Surface bus
Underground BRT
Light Rail

Source: L.E.K. analysis

Agenda

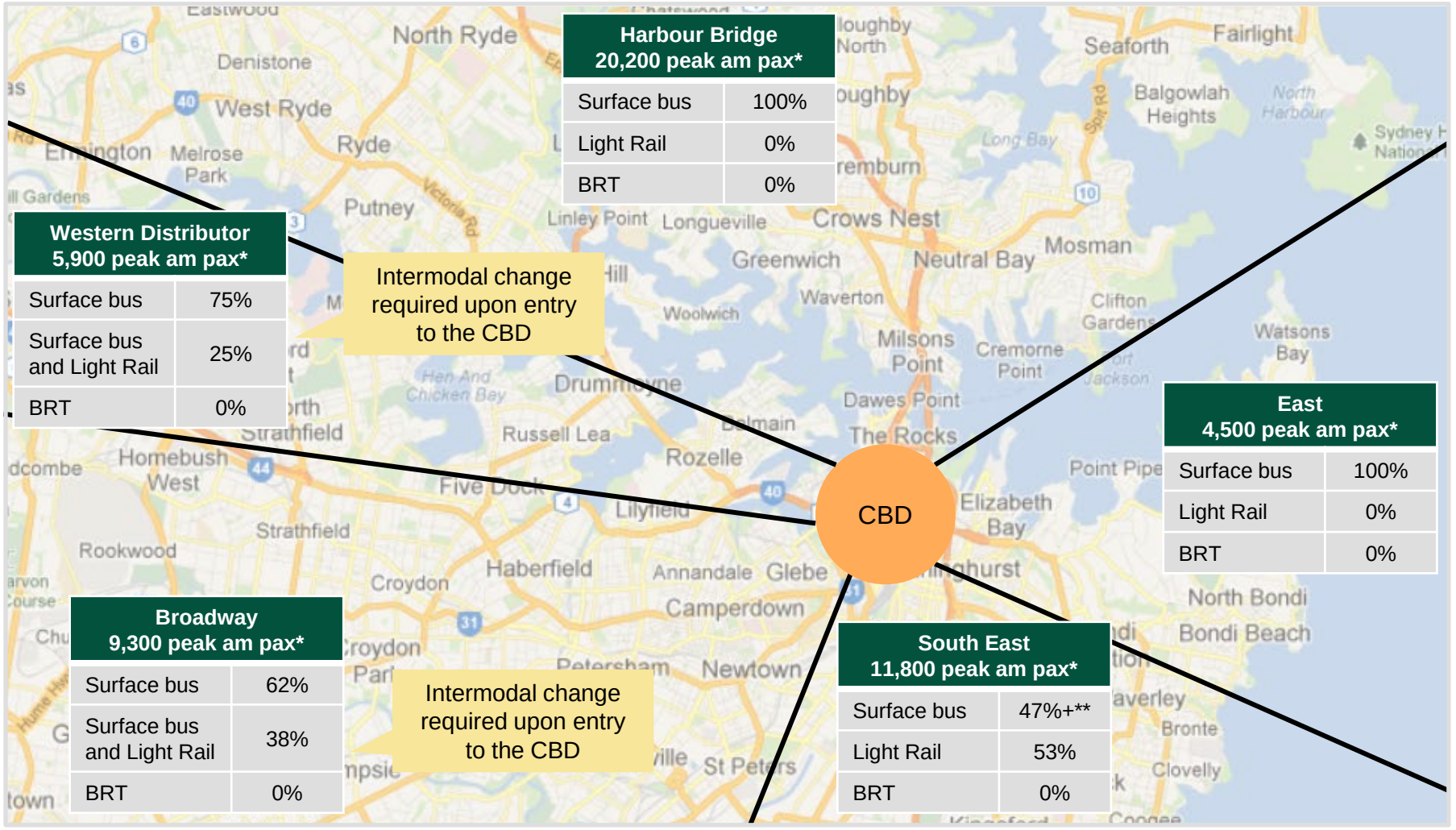
- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis
  - generic modal definitions
  - generic modal comparison
  - network impact of strategic CBD access options
  - journey time
  - underground BRT plausibility

The Broadway CBD access point is currently used by bus services from a broad range of areas across the inner west and south west

Bus services that access the CBD through Broadway

Source: Sydney Transit

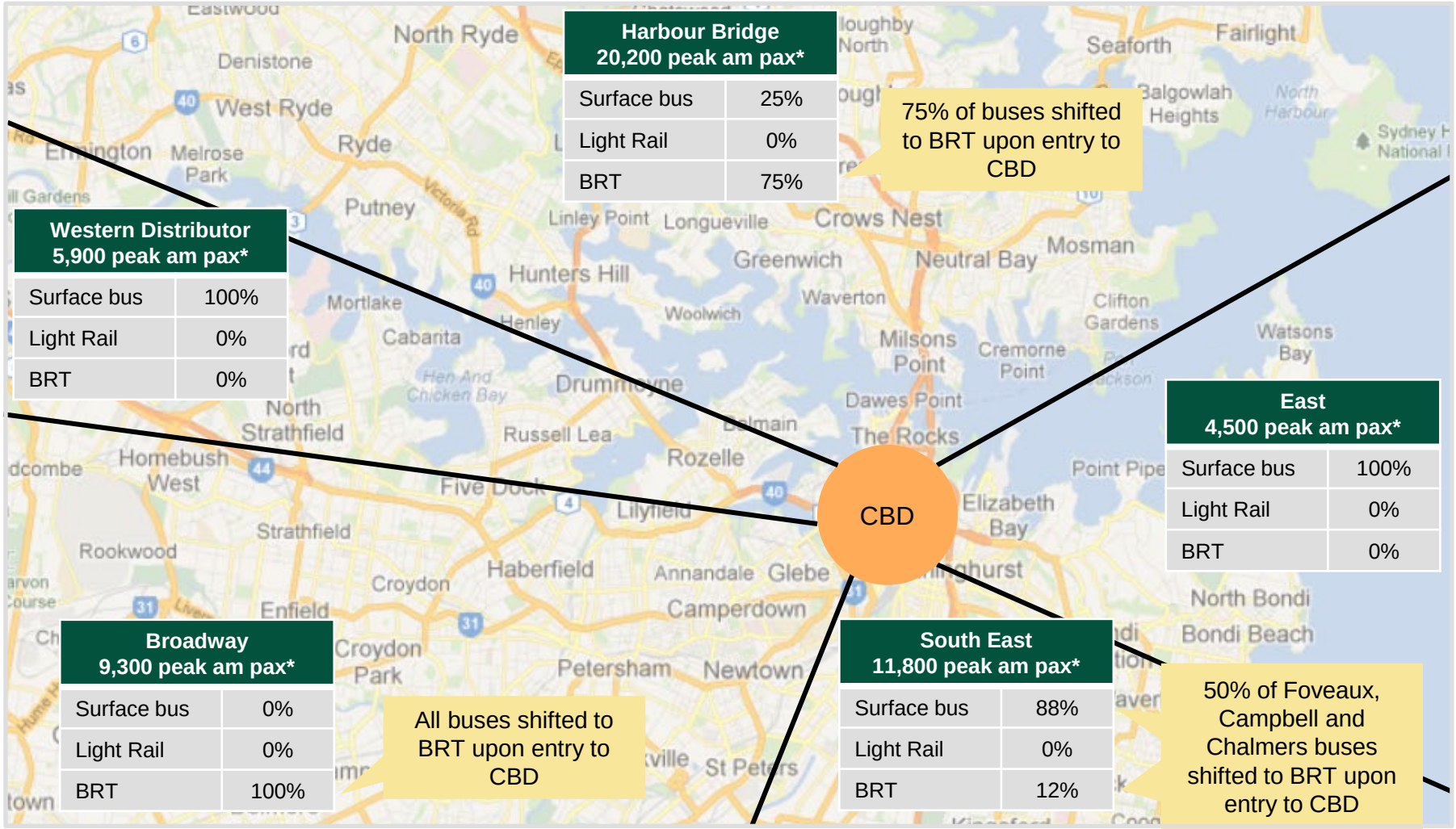
Option 2: Dedicated Light Rail could be used by bus passengers from the Western Distributor, Broadway and South East



Note: * 2 hour am peak (7-9am); ** does not include commuters who need to travel by bus to the Anzac Pde light rail before changing modes

Source: Google Maps; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

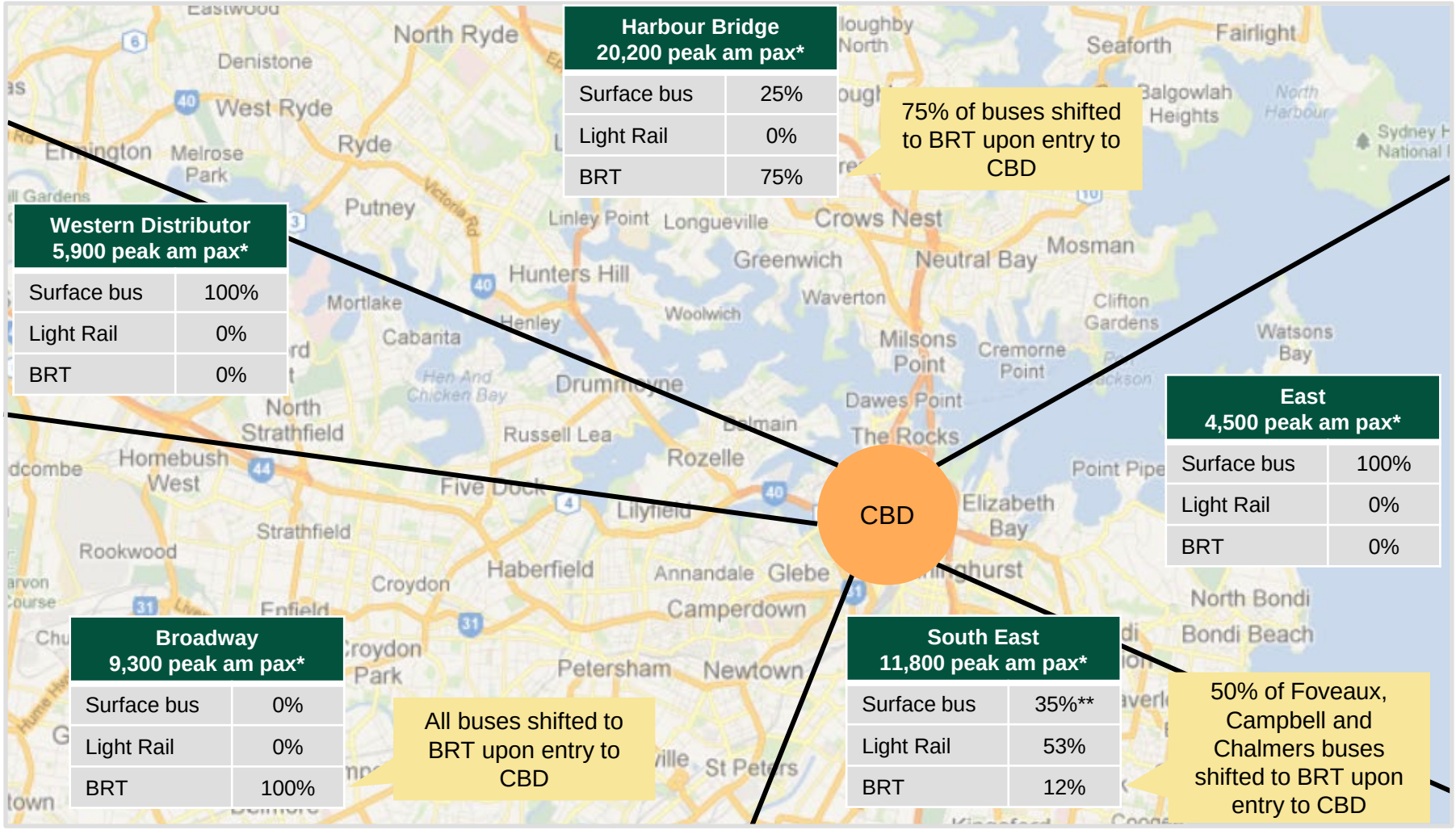
Option 3: Underground BRT could be used by bus passengers from the Harbour Bridge, Broadway and South East



Note: * 2 hour am peak (7-9am)

Source: Google Maps; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

Option 4: A combined Light Rail and Underground BRT network could be used by bus passengers from the Harbour Bridge, Broadway and South East



Note: * 2 hour am peak (7-9am); ** does not include commuters who need to travel by bus to the Anzac Pde light rail before changing modes

Source: Google Maps; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

On balance, taking buses underground may not significantly affect vehicle traffic due to increased vehicle congestion caused by increased pedestrianisation along George Street

INDICATIVE

Road space freed by BRT

10 minutes	Hypothetical time spent in BRT system (i.e. underground)
÷	
0.23 minutes between buses	Average rate buses enter (and exit the tunnel) based on a tunnel capacity of 265 buses/hr
=	
c.40 buses	Average number of buses in the tunnel (going in one direction)
×	
2	Bi-directional tunnel
=	
c.80 buses	Average number of buses taken off surface streets
×	
25 metres	Hypothetical linear road space taken up by a bus
=	
c. 2,000 metres	Linear road space freed by running buses underground

Road space lost to pedestrianisation

(600) metres	Pedestrianised distance from Market to Hunter Streets
×	
4 lanes	Road width from Market to Hunter
+	
(400) metres	Incremental soft pedestrianised distance from Bridge to Druitt Street
×	
2 lanes	Lanes lost due to widening of footpath
×	
50%	Lanes utilised by general traffic(as opposed to bus lanes)
=	
c. (1,600) metres	Linear road space lost by pedestrianisation of George Street

The BRT option may lose a similar amount of road space to pedestrianisation as is gained by moving buses underground

Source: L.E.K. Analysis

Agenda

- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis
  - generic modal definitions
  - generic modal comparison
  - network impact of strategic CBD access options
  - journey time
  - underground BRT plausibility

A bottom up approach was used to estimate journey time savings

Methodology for estimating journey time savings

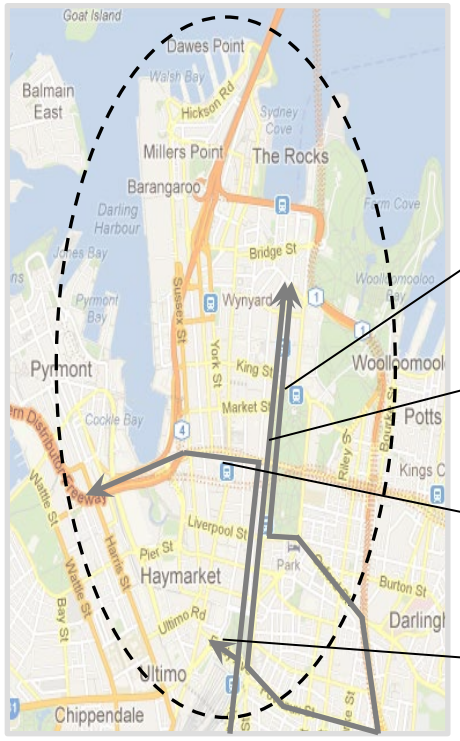
Identify key travel sectors	Determine current morning / peak am travel time	Estimate new travel time	Calculate journey time savings by sector	Calculate journey time savings across all pax
For each impacted access point, the following travel sectors were identified: - access point to Central / Southern CBD - access point to Town Hall / Central CBD - access point to Wynyard / Northern CBD Analysis of time travel savings does not include potential effects on journeys outside the CBD or on other modes (eg. pedestrians, cars)	Utilise existing published bus timetables to capture current peak am journey times across identified travel sectors Further journey time savings could exist as published peak am bus timetables potentially understate actual travel time	New journey times were estimated by multiplying: - travel distance along new route, and - average speed of mode along route Journey time estimates include a penalty of 3x the time spent outside vehicle for intermodal changes. eg: walking between modes, waiting for next service Key assumptions for journey time include: - LR travels at 7, 15, and 30kph along pedestrianised, CBD and urban routes respectively - BRT travels at an average of 40kph	Journey time saving in a sector is the difference between current and new journey time	Estimated pax volume across identified travel sectors are based on high level assumptions against known access point volumes. This includes: - estimated number of services affected by strategic option - estimated number of pax within these affected services that are affected by the strategic option This pax data was then multiplied by journey time savings by sector to give an overall reflection of savings across the CBD network

Source: L.E.K. Analysis

Anzac Pde buses currently enter the CBD via a range of access points

INDICATIVE

Anzac Pde buses in the CBD



Access point	Bus services using Anzac Pde vs total services (*service number*)	Anzac Pde to: Central	Anzac Pde to: CBD centre / Town Hall	Anzac Pde to: CBD North
Oxford St	9 / 14	-	✓	✓
Foveaux St	4 / 4 *(374, 339, 376, 391 services)*	✓	✓	✓
Chalmers St	1 / 12 *(M50 service)*	✓	✓	-
Chalmers St	2 / 12 *(393,395 services)*	✓	-	-

Source: State Transit Authority; L.E.K. Analysis

INDICATIVE

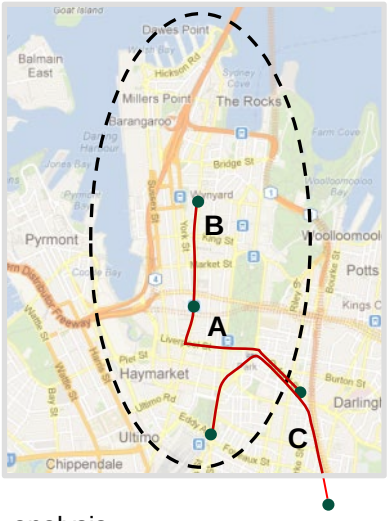
Impact on journey time vs peak am published bus timetable: Anzac Pde Light Rail via Oxford St and Chalmers St

CBD Access point	Access point pax (thousands)	Corridor		Total pax affected (thousands)	Current journey time (mins)	Light Rail journey time (mins)	Comments / Assumptions
Oxford St.	6.0	A	Oxford St. to Town Hall	1.9	3.0	5.2	- LR replaces c.65% of Oxford St. buses which route down Anzac Pde - Assume 50% of passengers go to Town Hall - LR at 15 kph along 1.3 km CBD streets
		B	Town Hall to CBD North	1.0	4.0	8.6	- LR replaces c.65% of Oxford St. buses which route down Anzac Pde - Assume 25% of passengers go to CBD North - LR at 7 kph along 1 km pedestrianised CBD streets
Chalmers St.	2.6	C	Anzac Pde/Cleveland St to Central	0.4	10	9.6	- LR replaces c.25% of Chalmers St. buses which route down Anzac Pde - These buses currently terminate at Central - LR at 30 kph along 1.8km urban route and 15kph for 1.5km in CBD

Does not include further loss in travel time due to modal change for commuters required to transit by bus to reach the Anzac Pde Light Rail

Status quo

Light Rail



Legend

- Origin / destination
- Bus (as is)
- Light Rail

Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

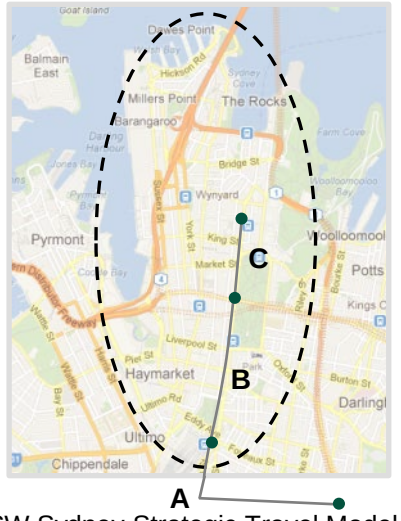
INDICATIVE

Impact on journey time vs peak am published bus timetable: Anzac Pde Light Rail via Foveaux St

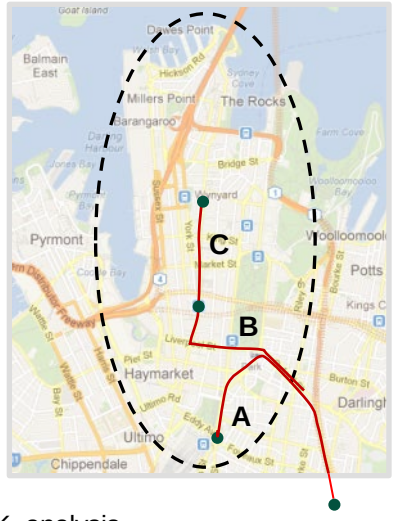
CBD Access point	Access point pax (thousands)	Corridor		Total pax affected (thousands)	Current journey time (mins)	Light Rail journey time (mins)	Comments / Assumptions
Foveaux St.	1.9	A	Anzac Pde at Fitzroy St. to Central	1.9	6	7.4	- LR replaces all Foveaux St bus services - Assume 100% of passengers go to Central - LR at 30 kph along 0.7km urban route and 15kph for 1.5km in CBD
		B	Anzac Pde at Fitzroy St. to Town Hall	0.4	10	6.6	- LR replaces all Foveaux St bus services - Assume 50% of passengers go to Town Hall - LR at 30 kph along 0.7km urban route and 15kph for 1.3km in CBD
		C	Town Hall to CBD North	0.3	4	8.6	- LR replaces all Foveaux St bus services - Assume 25% of passengers go to CBD North - LR at 7 kph along 1 km pedestrianised CBD streets

Does not include further loss in travel time due to modal change for commuters required to transit by bus to reach the Anzac Pde Light Rail

Status quo



Light Rail



Legend

- Origin / destination
- Bus (as is)
- Light Rail

Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

Impact on journey time vs peak am published bus timetable: George St. Light Rail

INDICATIVE

CBD Access point	Access point pax (thousands)	Corridor		Total pax affected (thousands)	Current journey time (mins)	Light Rail journey time (mins)	Comments / Assumptions
Western Distributor	5.9	D	Druitt St. to Wynyard	1.5	6.0	22.3*	- 50% of buses from West. Dist. will terminate upon entry to the CBD - Half of these passengers assumed to continue their journey to the northern CBD via Light Rail - 5 min walk required from Druitt St. bus stop to George St LR* - LR at 7 kph along 0.85 km pedestrianised streets
Broadway	9.3	E	Broadway to QVB	3.5	5.0	20.4*	- 50% of buses from Broadway will terminate upon entry to the CBD - 75% of passengers continue to QVB - Assumed 5 min intermodal change* from bus to Light Rail - LR at 7 kph along 0.16 km pedestrianised streets, 15 kph along 1 km CBD streets
		F	QVB to Wynyard	2.3	5.0	6.9*	- 50% of buses from Broadway will terminate upon entry to the CBD - 75% of passengers continue to CBD North - Half of these passengers assumed to go to CBD North - LR at 7 kph along 0.8 km pedestrianised CBD streets

Status quo

Light Rail

Legend

- Origin / destination
- Bus (as is)
- Light Rail
- Walk to LR

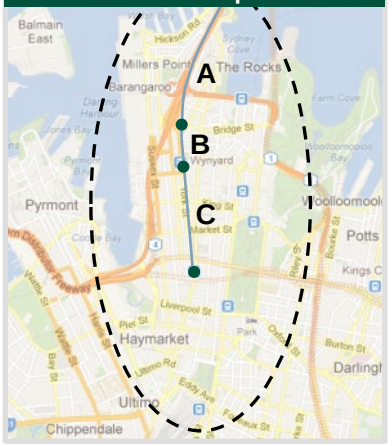
Note: *Modal change penalty applied of 3x the combined walk and wait time of 5 minutes (2.5 min walk + 2.5 min waiting)
Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

INDICATIVE

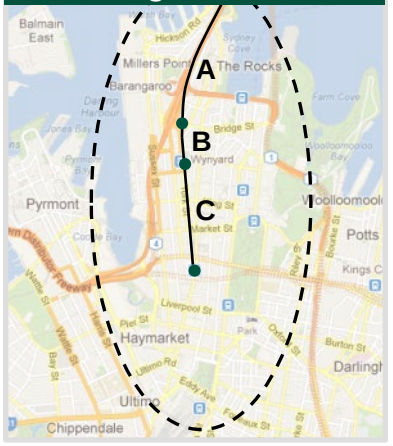
Impact on journey time vs peak am published bus timetable: North CBD underground BRT

CBD Access point	Access point pax (thousands)	Corridor		Total pax affected (thousands)	Current journey time (mins)	BRT journey time (mins)	Comments / Assumptions
Harbour Bridge	20.2	A	Harbour Bridge to Lang Park	5.1	5.0	2.0	- BRT removes congestion that causes bridge gridlock from 8:30am to 9:00am - 25% of peak bus pax using the Harbour Bridge bus services affected by bridge gridlock - Buses able to move at 60 kph across bridge
		B	Lang Park to Wynyard	15.2	1.0	0.3	- 75% of Harbour Bridge bus services moved to underground BRT - BRT at 40 kph for 0.3 km - BRT avoids of Margaret St. and Jamison St. intersection
		C	Wynyard to QVB	7.6	4.0	3.2	- 75% of Harbour Bridge bus services moved to underground BRT - Half of these passengers continue from Wynyard to QVB - 40 kph along 0.8 km - 2 min dwell time at Wynyard

Status quo



Underground BRT



Legend

- Origin / destination
- Bus (as is)
- BRT

Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

INDICATIVE

Impact on journey time vs peak am published bus timetable: South CBD underground BRT

CBD Access point	Access point pax (thousands)	Corridor		Total pax affected (thousands)	Current journey time (mins)	BRT journey time (mins)	Comments / Assumptions
Broadway	9.3	D	Broadway to QVB	7.0	6.0	6.0	- No change to status quo due to dive point being located at Town Hall square
		E	QVB to Wynyard	4.7	5.0	3.2	- All Broadway bus services move to BRT upon reaching Town Hall - 50% of passengers assumed to continue journey to CBD North - BRT at 40 kph for 0.9 km - 2 min dwell time at Town Hall station
Chalmers and Foveaux	5.8	F	Central to Town Hall	1.5	6.0	8.0	- 50% of buses from Chalmers St. and Foveaux St. access point routed to BRT - Increased journey time due to longer route to dive point entrance
		G	Town Hall to CBD North	0.7	5.0	3.2	- 50% of buses from Chalmers St. and Foveaux St. access point routed to BRT - Half of these passengers assumed to continue journey to CBD North - BRT at 40 kph for 0.9 km - 2 min dwell time at Town Hall station

Status quo

Underground BRT

Legend

- Origin / destination
- Bus (as is)
- BRT

Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

If published bus timetables are inaccurate, journey time savings are likely to improve across all options

INDICATIVE

Sensitivity of journey time savings to current journey times				
Basis for current morning / peak am journey time	**Option 1: Base case – status quo**	**Option 2: Dedicated surface Light Rail network**	**Option 3: Underground BRT network**	**Option 4: Underground BRT and LR network**
Current published bus timetables	-	350-400 thousand equivalent* hours lost / year	200-250 thousand hours saved / year	150-200 thousand hours saved / year
2 x journey time implied by published bus timetables	-	50-100 thousand equivalent* hours lost / year	600-650 thousand hours saved / year	750-800 thousand hours saved / year
3 x journey time implied by published bus timetables	-	250-300 thousand hours saved / year	c.1m hours saved per year	c.1.3m hours saved per year

If actual journey times were greater than those implied by the published bus timetables, total journey time savings would significantly increase

Note: * Calculation of equivalent hours includes a penalty of 3x the time required to transfer between modes mid-journey
Source: State Transit Authority; TfNSW Sydney Strategic Travel Model 2010; L.E.K. analysis

Agenda

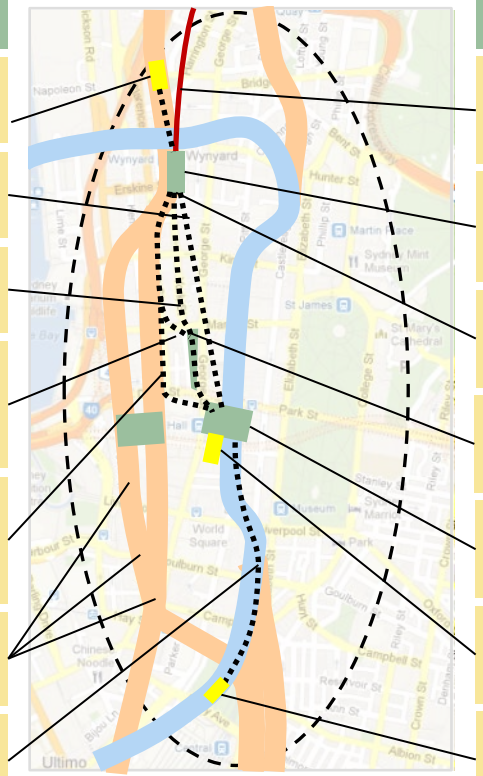
- Executive summary
- Challenges and objectives
- CBD access strategy development and assessment
- Next steps
- Detailed analysis
  - generic modal definitions
  - generic modal comparison
  - network impact of strategic CBD access options
  - journey time
  - underground BRT plausibility

A number of options exist for underground BRT tunnel routes and bus stations

ILLUSTRATIVE

Underground CBD - known alignment and potential BRT routes and stations

Potential tunnel routes	Potential stations and dive points
Potential dive point at toll booths on Harbour Bridge	Existing tram tunnels could be used to provide North BRT access
Potential driven tunnel from Wynyard to Town Hall plaza	Current Wynyard train station could be expanded to cater to underground BRT pax
Potential 'cut and cover' tunnel along York St	BRT could be located underneath current Wynyard station with a deeper BRT route
Potential utilisation of a section of known alignment before creating 'cut and cover' tunnel on Market St to QVB	Potential use of existing QVB car park CBD as a bus station / tunnel
Potential utilisation of a section of known alignment before connecting to station via Cross City tunnel	Potential CBD bus station under proposed Town Hall square
Potential alternative North-South BRT route 1-2 blocks west of George St	Potential dive point at South entrance to Town Hall plaza
Potential utilisation of a section of known alignment before surfacing at dive point	Potential South-BRT dive point at Belmore Park / Eddy Ave



CBD Metro
CBD Rail Link
Potential station location
Potential dive point
Existing tram tunnels
Potential tunnel route

Source: INSW; L.E.K. Analysis

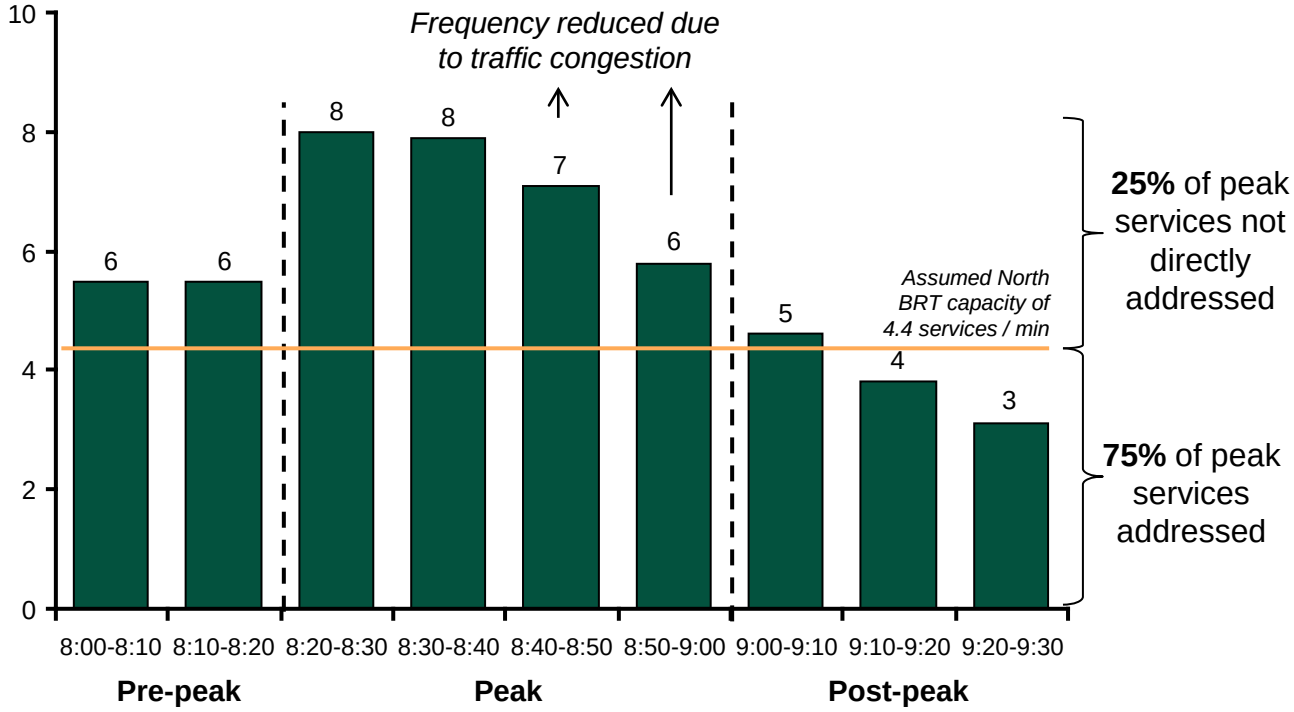
The BRT is estimated to provide capacity that could move c.75% of Harbour Bridge buses underground

Peak corridor capacity

In-station processing time	Up to 60 seconds on average
÷	
Station capacity	2 x 55m Platforms per direction
=	
Corridor capacity	4 to 6 buses per minute

Harbour Bridge bus services

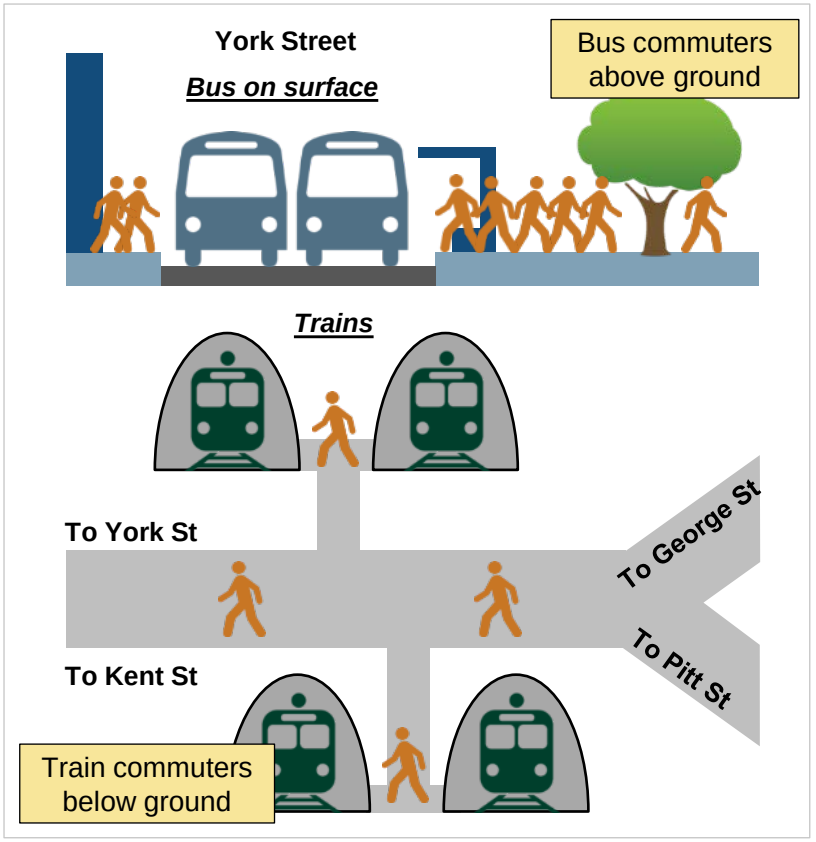
Sydney Harbour Bridge morning southbound bus frequency
number of buses per minute^



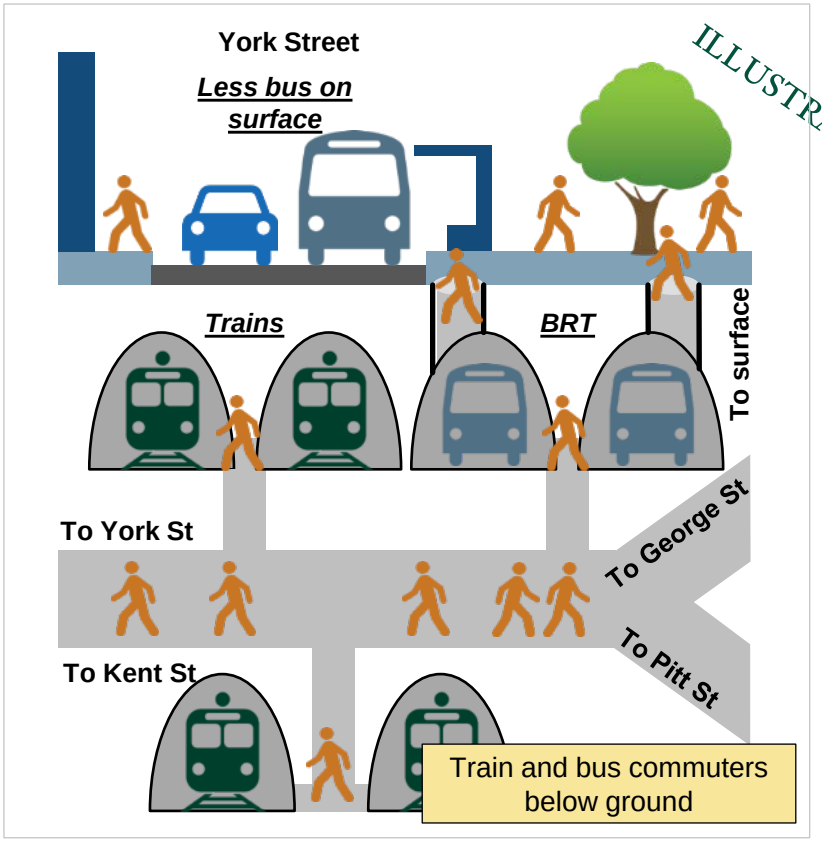
Note: *Strong congestion observed as slow to no southbound bus movement 600m north of York St entrance; ** very strong congestion measured as slow to no southbound bus movement at the northern pylon; ^based on the total number of buses passing through the northern pylon in a 10 minute period
Source: MRCagney; L.E.K. primary research and analysis

The Wynyard station concourse will need to be significantly expanded to cater to bus commuters who will be embarking and disembarking below ground

Current state



Future state



The Wynyard station concourse and connecting underground pedestrian corridors will need to be expanded to cater to a further c.20k commuters during the peak am period (2hr)

Note: * 2 hour am peak (7-9am)
Source: Transport for NSW; L.E.K. analysis