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UNSW

Transport Systems 2

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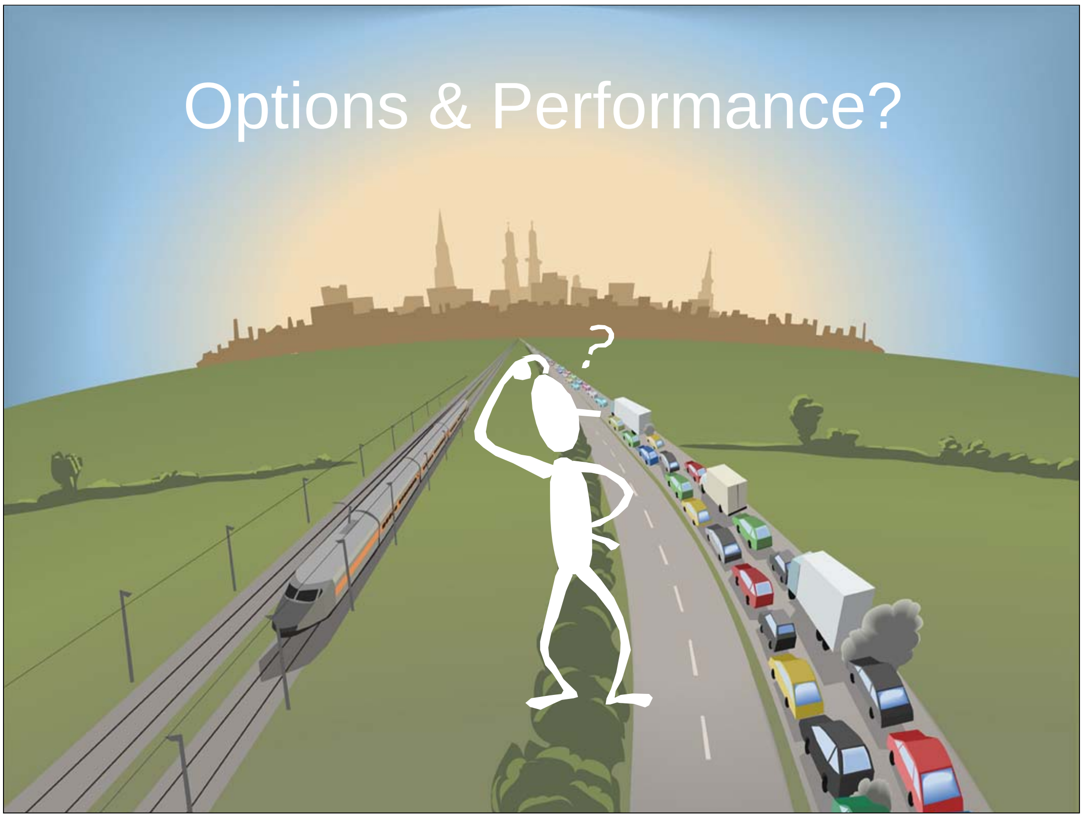
INTRODUCTION - Transport Systems 2: Methods to assess sustainability performance of city wide transport system options

- Options & Performance
- Building Block Methods
- Identifying option characteristics
- Sustainability assessment: case study



Whilst community and government have been able to develop shared visions for the character of the cities into the future and suggest the goals and options, community participation beyond this has been limited.

When it comes to the question of which scenario should be selected, there is little scope for government and community to interactively shape the choice. This risks a disconnect between community and the planning agencies beyond this point.

Without quantifiable assessment methods, the connection between scenarios and sustainability outcomes are extremely subjective to the point where little benefit may come from public discussion.

City Sustainability Optioneering

- relating to individual community sectors and their needs
- specific goals as requirements for parts of the urban system and sectors of the city,
- identify the functions it is expected to deliver, putting a boundary around the contribution.

- Interactive community /government “what if and sustainability performance” process
- Use of simple visible assessment methods to display the system wide sustainability outcomes for each option

Improving the visibility of these connections for community and decision makers alike will increase the opportunity for better choices and community ownership of the options that are to be progressed.

City Sustainability Optioneering

- Assess against requirements
- How to assess
- How to visualise

Use the sustainability requirements but assess the city wide sustainability performance change.

Use building block methods of transport planning to provide the analytical basis and traceability to the levers that drive sustainability.

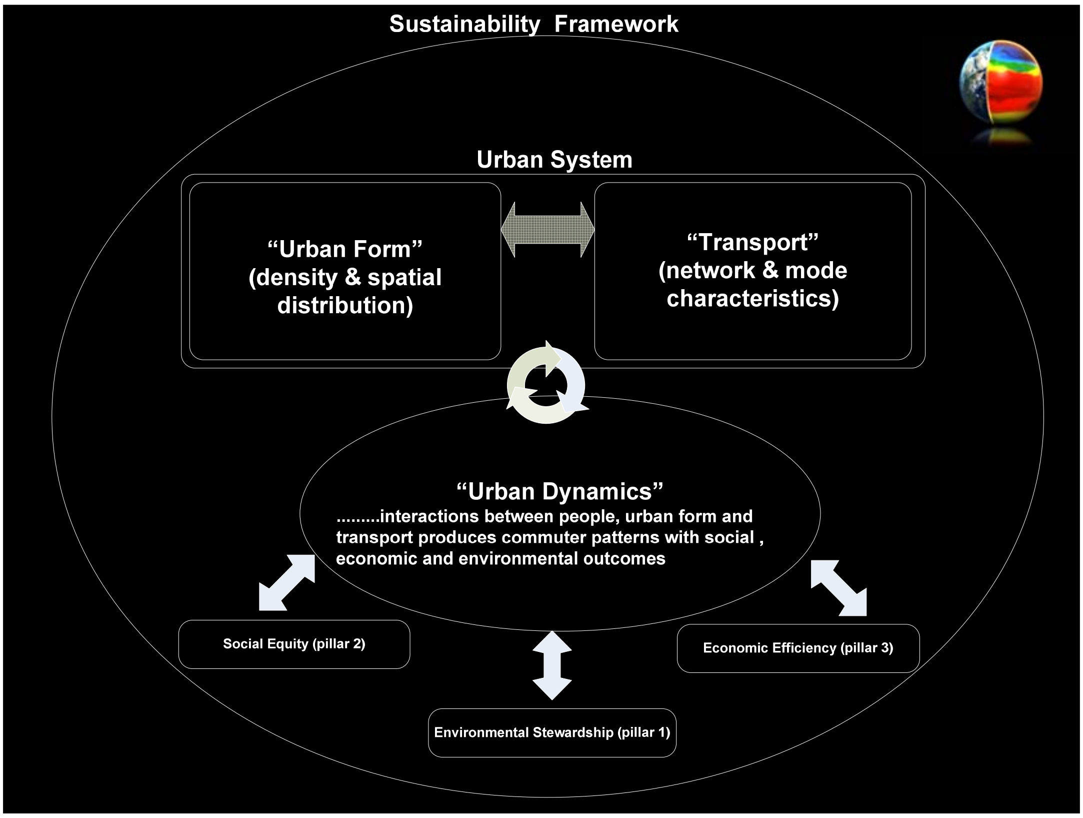
City Sustainability
Macro Scale Methodology

Building Block Methodologies

- Fundamentals of Urban System
- Fundamentals of Urban Dynamics

Use the sustainability requirements but assess the city wide sustainability performance change.

Use building block methods of transport planning to provide the analytical basis and traceability to the levers that drive sustainability.



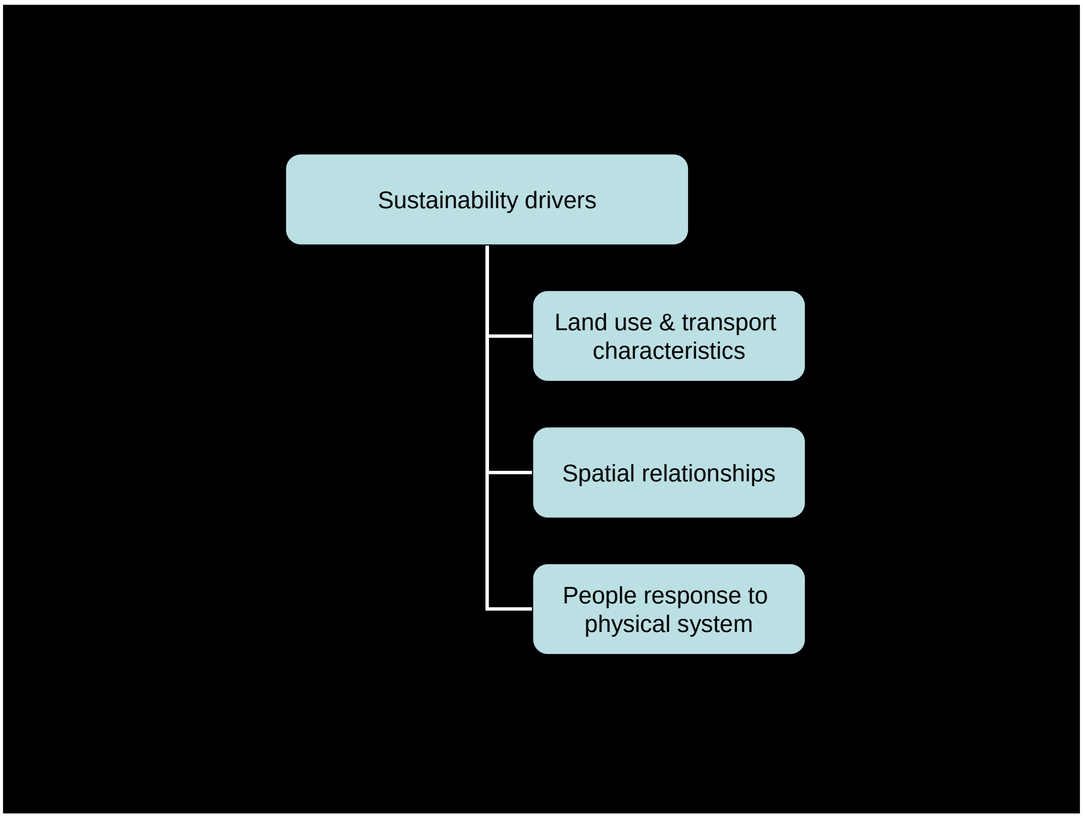
In a new approach to sustainability analysis , a sustainability framework is formulated to bring not only the three pillars of sustainability together, but also a holistic consideration of the urban system, the urban dynamics and the resulting sustainability performance.

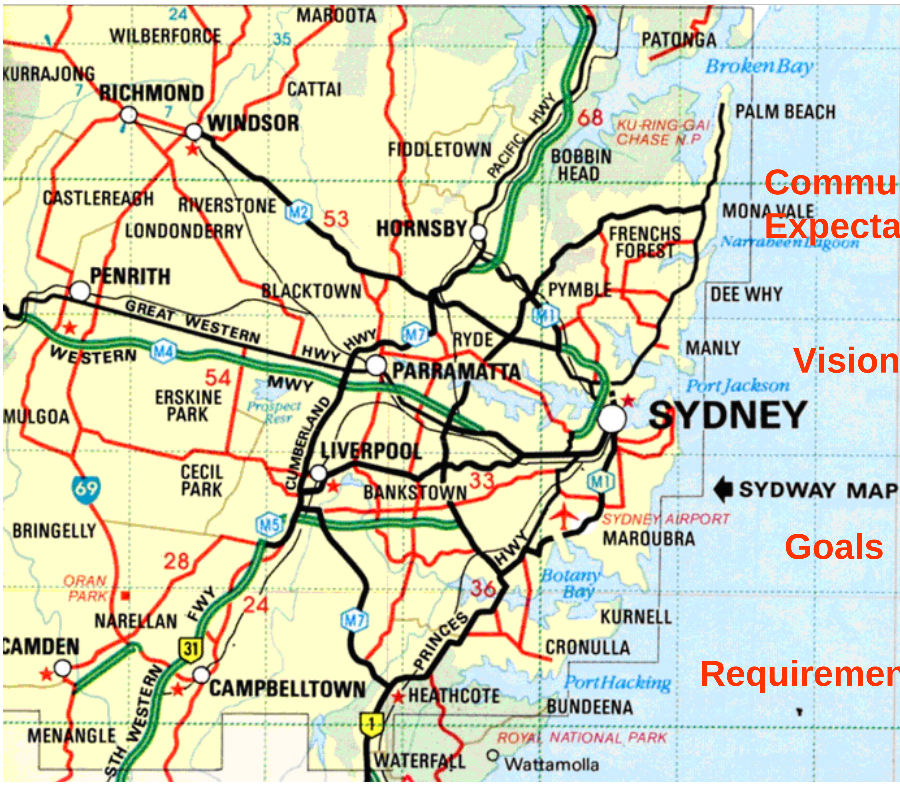
Figure summarises this framework, showing the interconnection between the urban system elements, the urban dynamics and identifying the three pillars of sustainability. This framework lays out the frame points for ensuring that the systems elements and interactions that drive the sustainability performance of the city are visible and measured.

The “Urban System” is the physical aspect of the framework, consisting of the “Urban Form” and “Transport” elements which define the structural configuration of the city. Interaction between these two elements shows their interdependencies. “Urban Form” is characterised by density and spatial distribution of land-use. “Transport” on the other hand is characterised by the transport network spatial layout and the specific mode characteristics.

The system function is to provide for the needs of the community (including industry). Response by the community to the “Urban System” produces interactions – the selection of location of residence and workplace, industry and travel patterns, and so on. These interactions are collectively known as “Urban Dynamics”. It is an iterative process as indicated by the circular arrow having feedback effect between each element.

The resulting “Urban Dynamics” outcomes generate the sustainability performance in terms of the three pillars included as elements in Figure 2. Each pillar has a feedback to the “Urban Dynamics” and consequently the “Urban System”. This is indicated by the double headed arrows in the figure.


Sustainability drivers
Land use & transport characteristics
Spatial relationships
People response to physical system

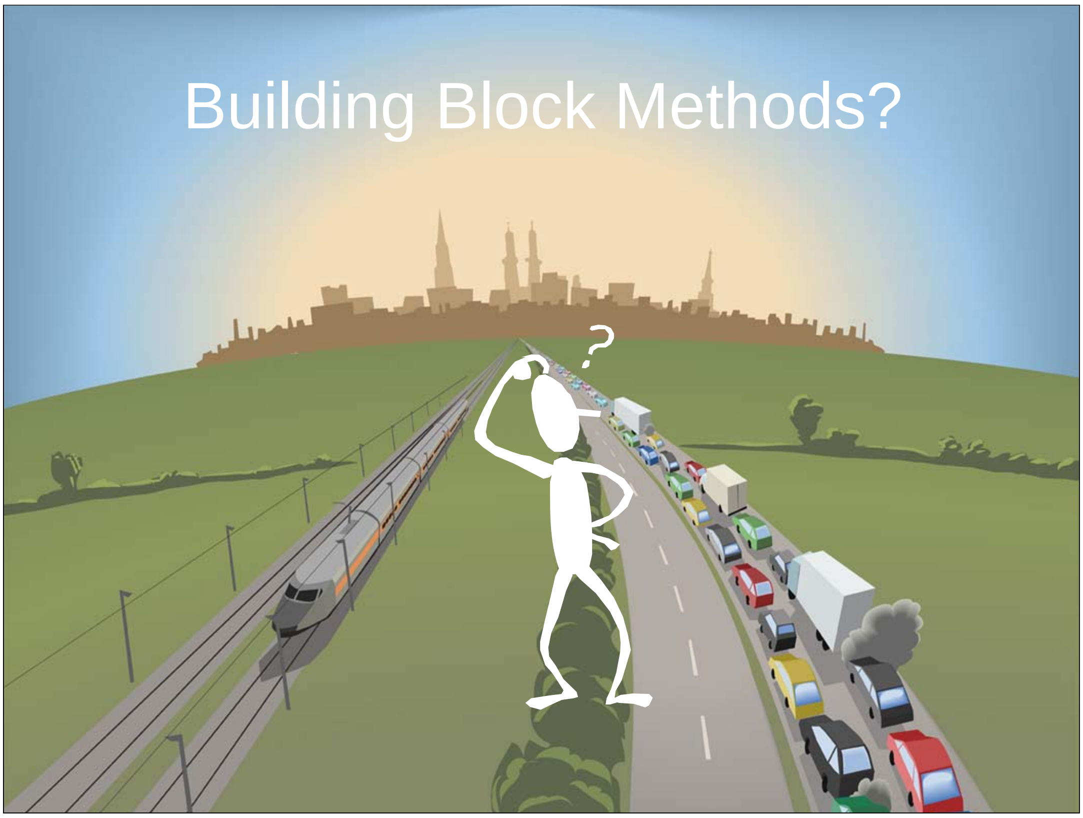


Community Expectations

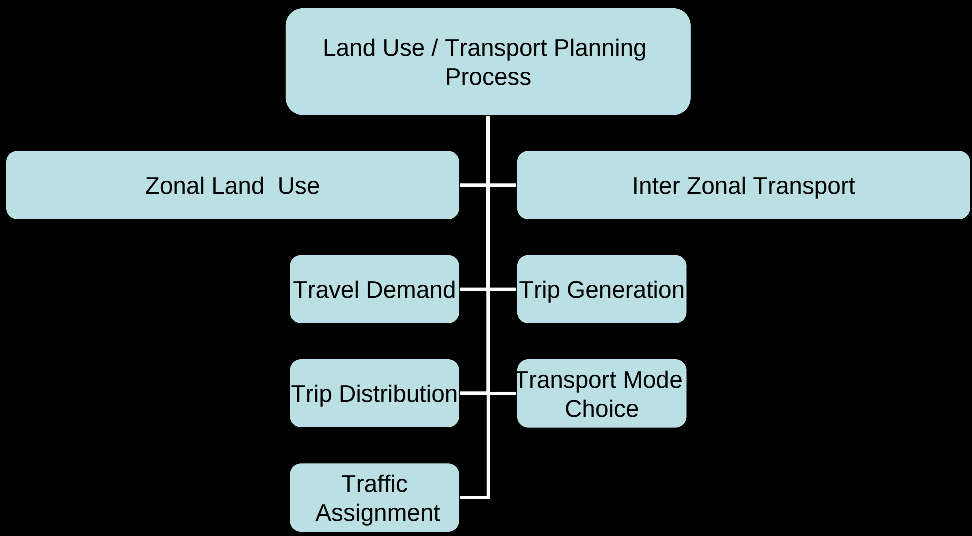
Visions

Goals

Requirements

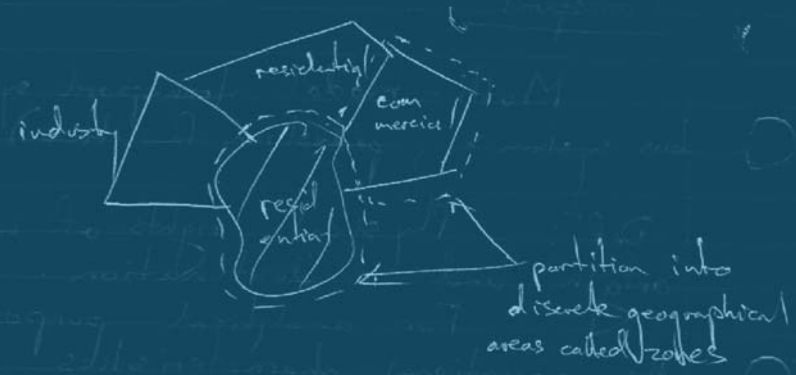

Building Block Methods?

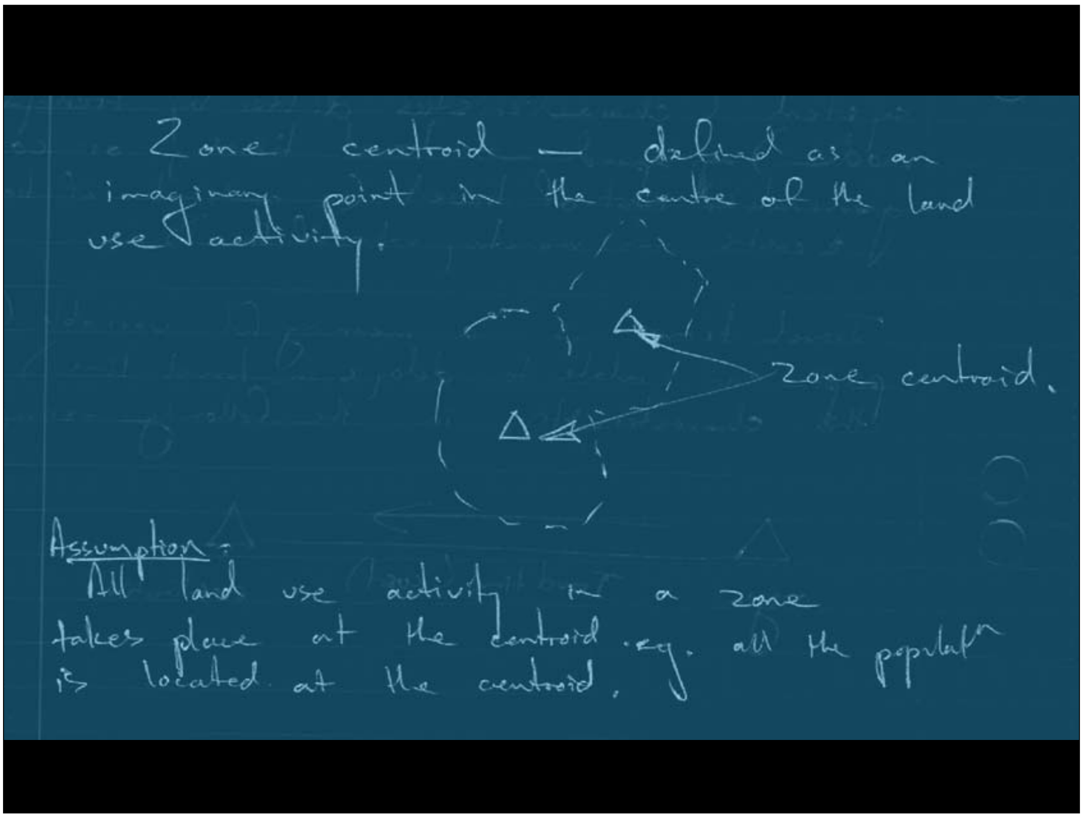
(Building Block Methods) – Data, Analysis & Forecasts

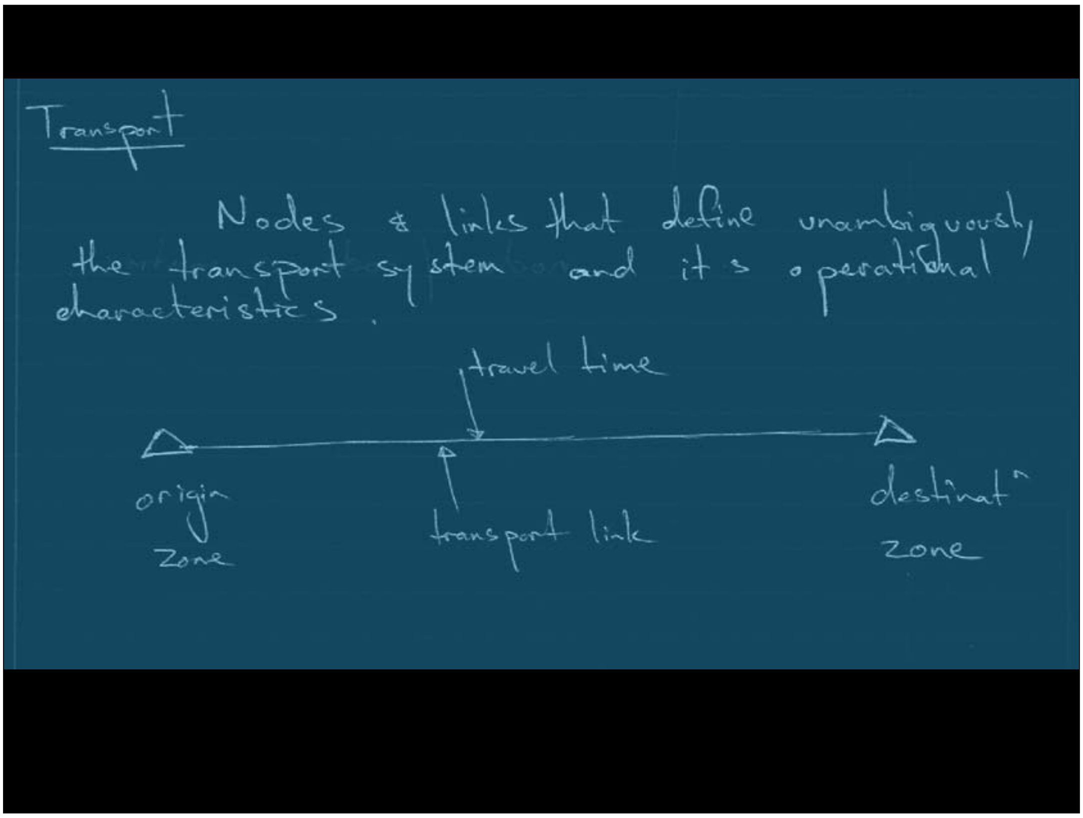


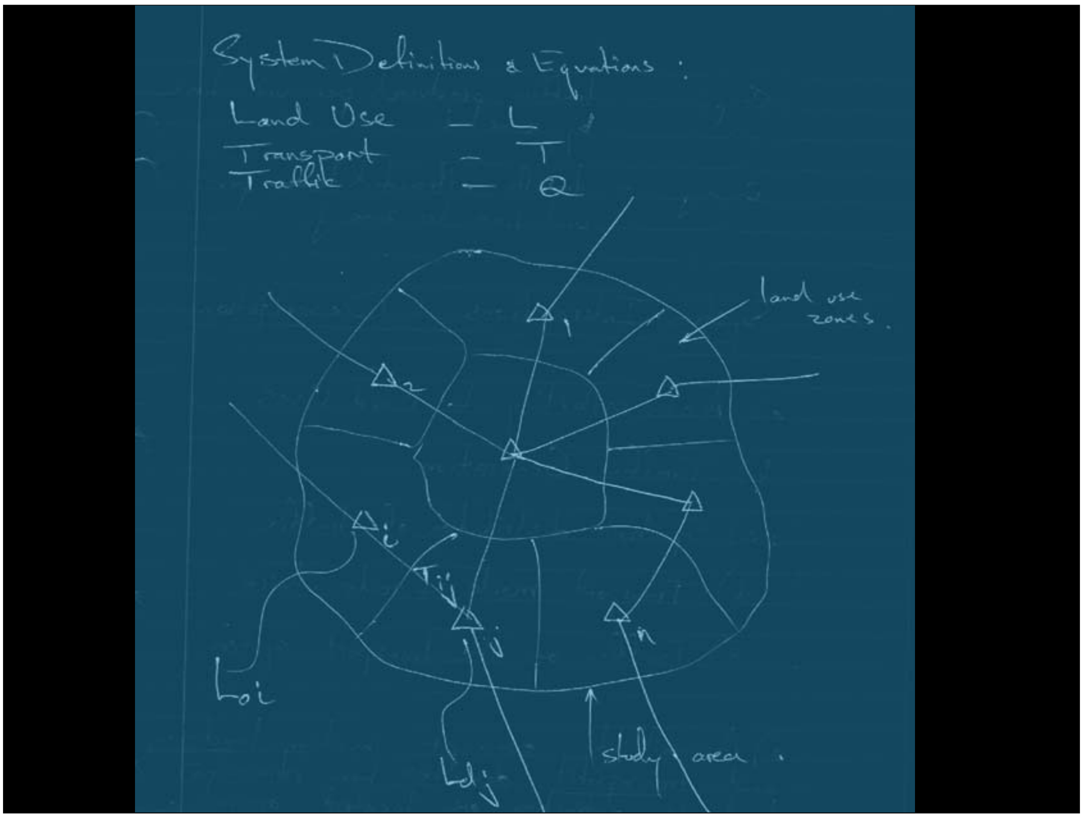
Land Use

Land Use Zone – defined spatially by an imaginary boundary around a Homogeneous land use.




Zone centroid — defined as an imaginary point in the centre of the land use activity.
Zone centroid.
Assumption:
All land use activity in a zone takes place at the centroid. eg. all the populatⁿ is located at the centroid.


Transport
Nodes & links that define unambiguously the transport system and it's operational characteristics.
travel time
origin
zone
transport link
destinat^{n}
zone



System Definitions & Equations :
Land Use — L
Transport — T
Traffic — Q
land use zones .
study area .

i — origin zone

j — destination zone

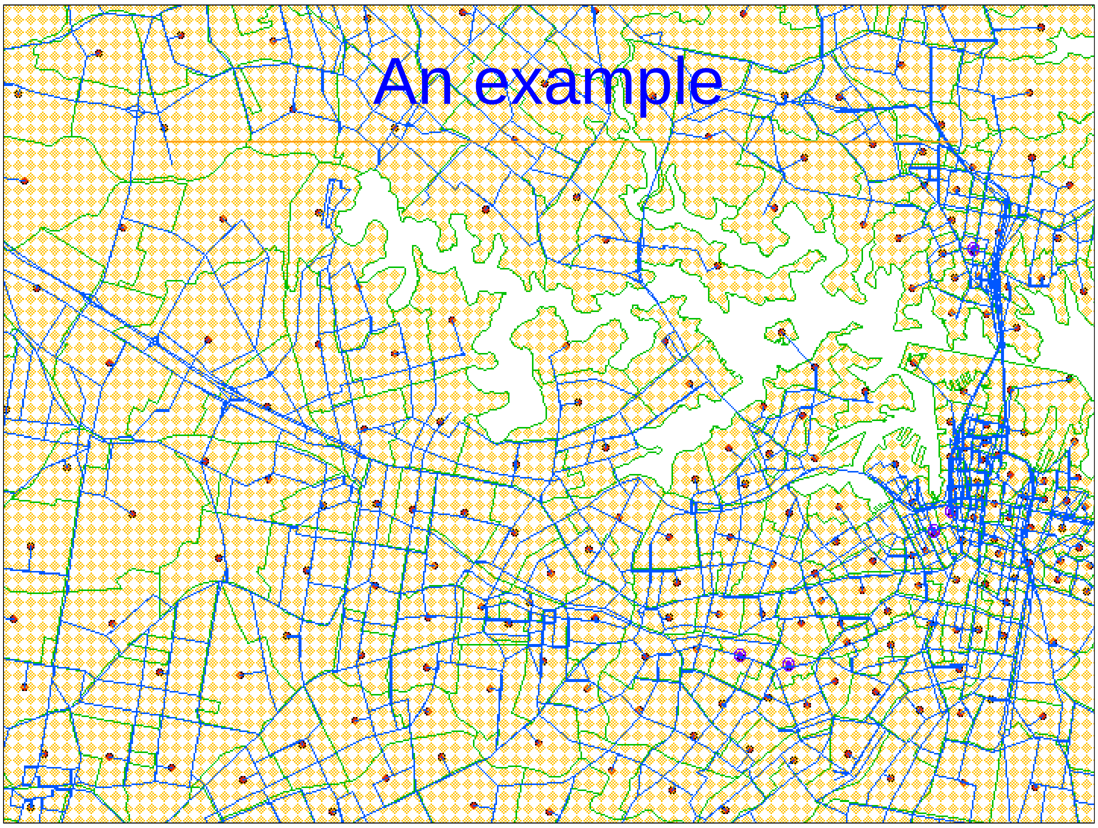
L_{oi} — land use in origin zone i

L_{dj} — " " " destinat^n zone j

T_{ij} — travel time from zone i to zone j

Q_{ij} — traffic per unit time from zone i to zone j

An example



Q_{pi} – traffic produced per unit time by zone i

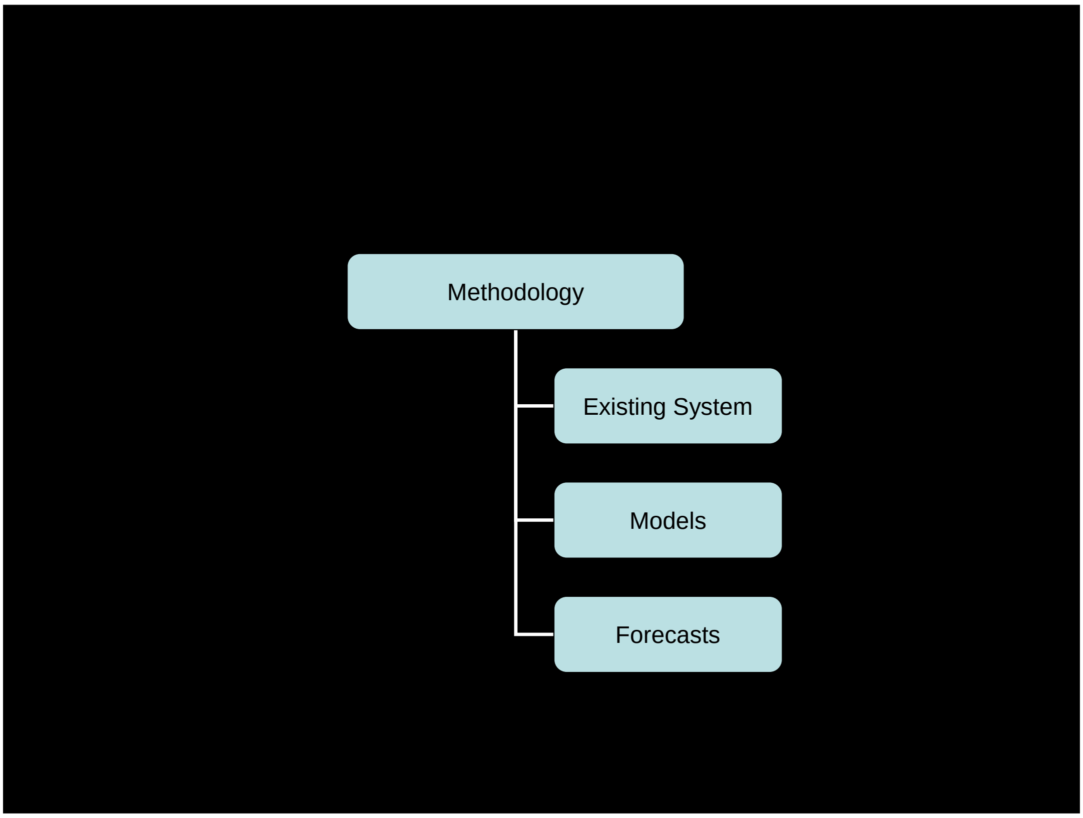
Q_{aj} – traffic attracted per unit time to zone j

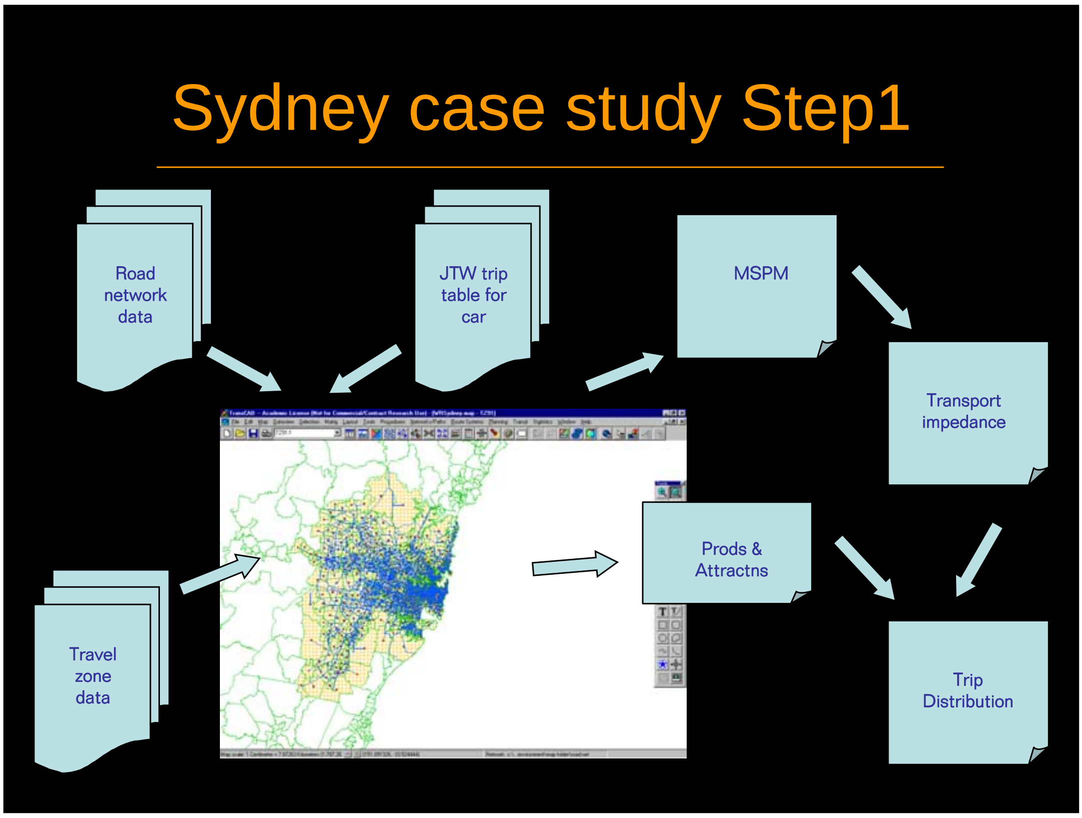
System Interactions - Description.

a) Accessibility to Land Uses
b) Traffic Generation
c) Spatial distribution of traffic
d) Transport mode & route choice.
e) Traffic on the transport system.

a) Accessibility concept involving landuse and transport describes how convenient land use activities are located around a reference point and how easy or difficult they are to reach via the transport system.

Land Use Activities	Transport system: Poor	Transport system: Good
Large	Medium Accessibility	High Accessibility
Small	Low accessibility	Medium Accessibility


Methodology
Existing System
Models
Forecasts

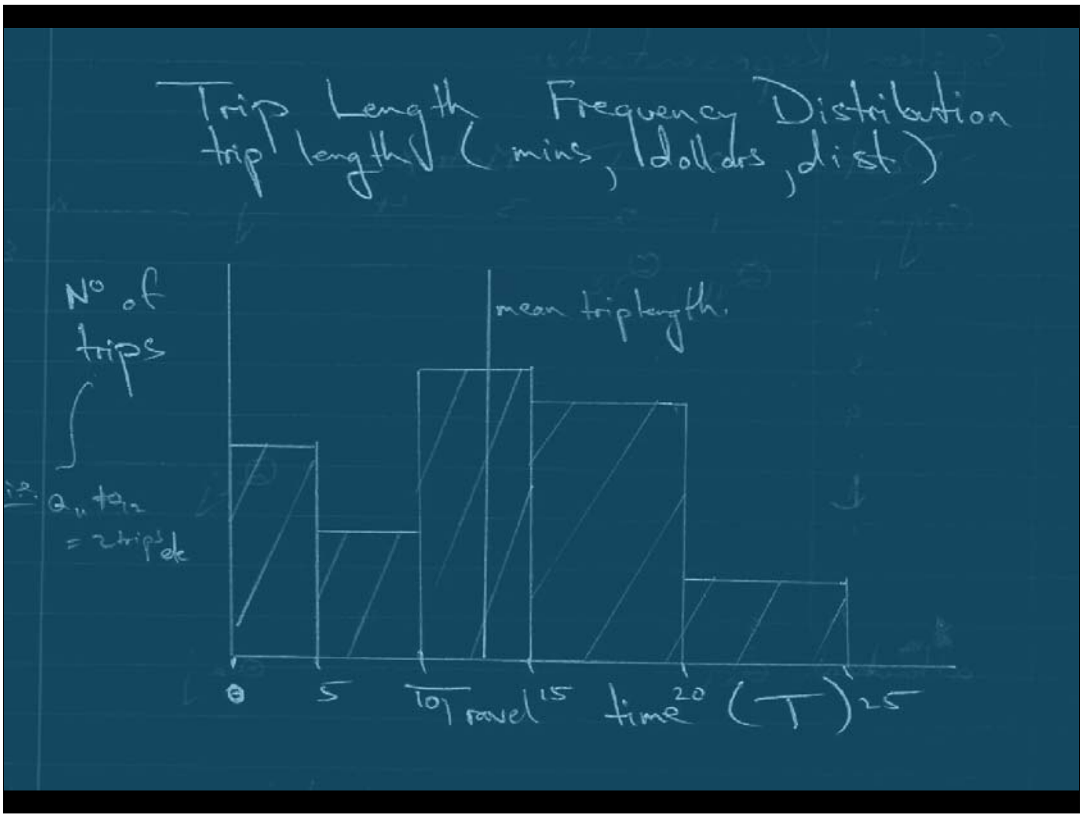


Prepare a Conventional Distribution Model

O – D Matrix

Dest / Origin	1	2	3	4	j	... n	Prod
1	Q_{11}	Q_{12}					$\Sigma =$
2							
3							
4							
i					Q_{ij}		
n							
attractions	$\Sigma = Q_{a1}$				Q_{aj}		

N.b. Q_{11} implies origin & destination in zone 1



Trip Length Frequency Distribution
trip length (mins, dollars, dist)
N° of trips
mean trip length.
i.e. Q_{11} + Q_{12} = 2 trips etc
0
5
10 Travel 15
time 20
(T) 25

Factors Influencing Mode Split

1. The Traveller & Urban Environment
   - car ownership
   - income
   - sex
   - urban density of dev't
2. The trip
   - journey purpose
   - direction & orientation
3. The Transport System
   - the relative characteristics of public & private transport
     - door to door travel times
     - costs
     - convenience
     - comfort
     - safety

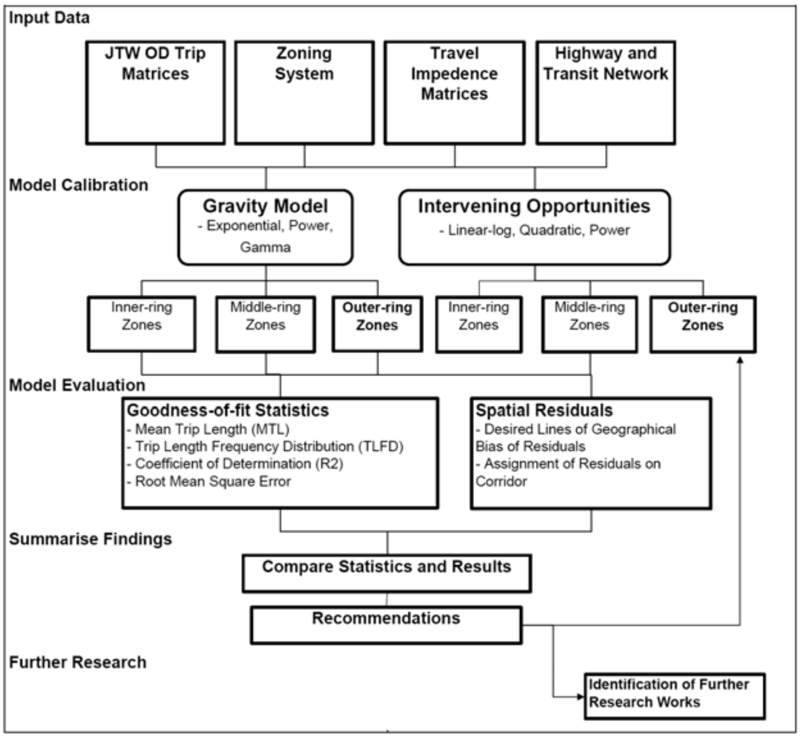
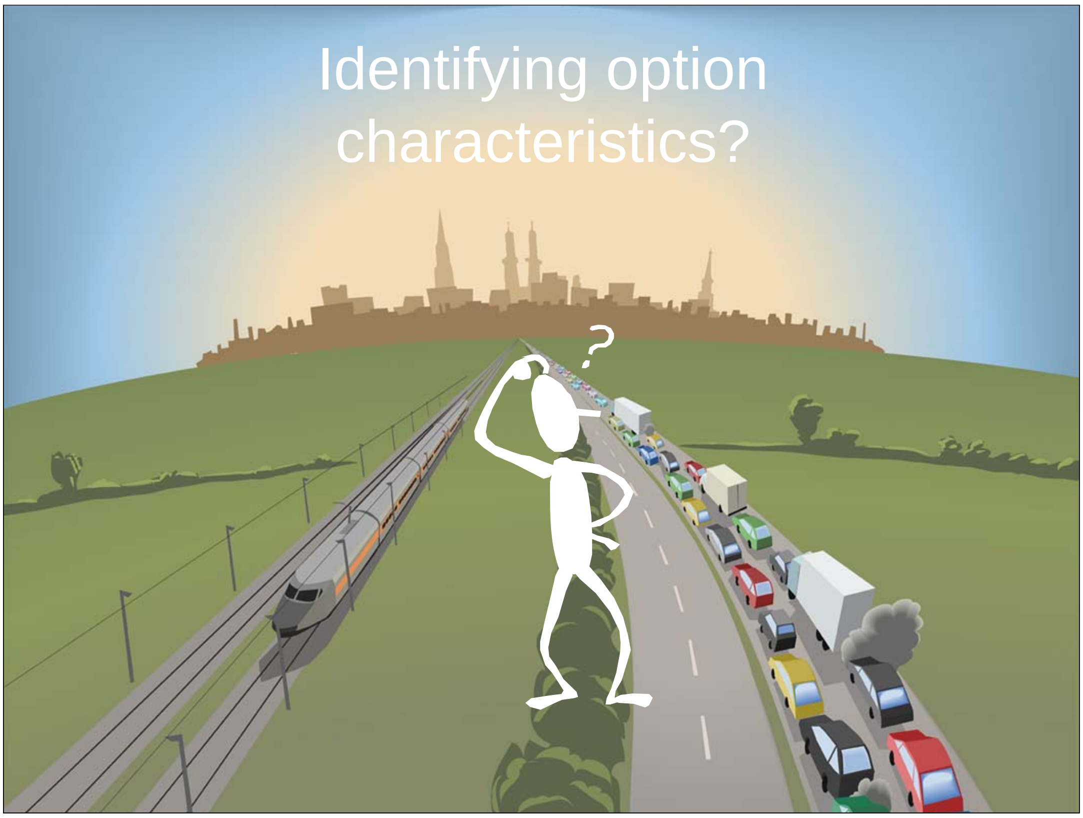
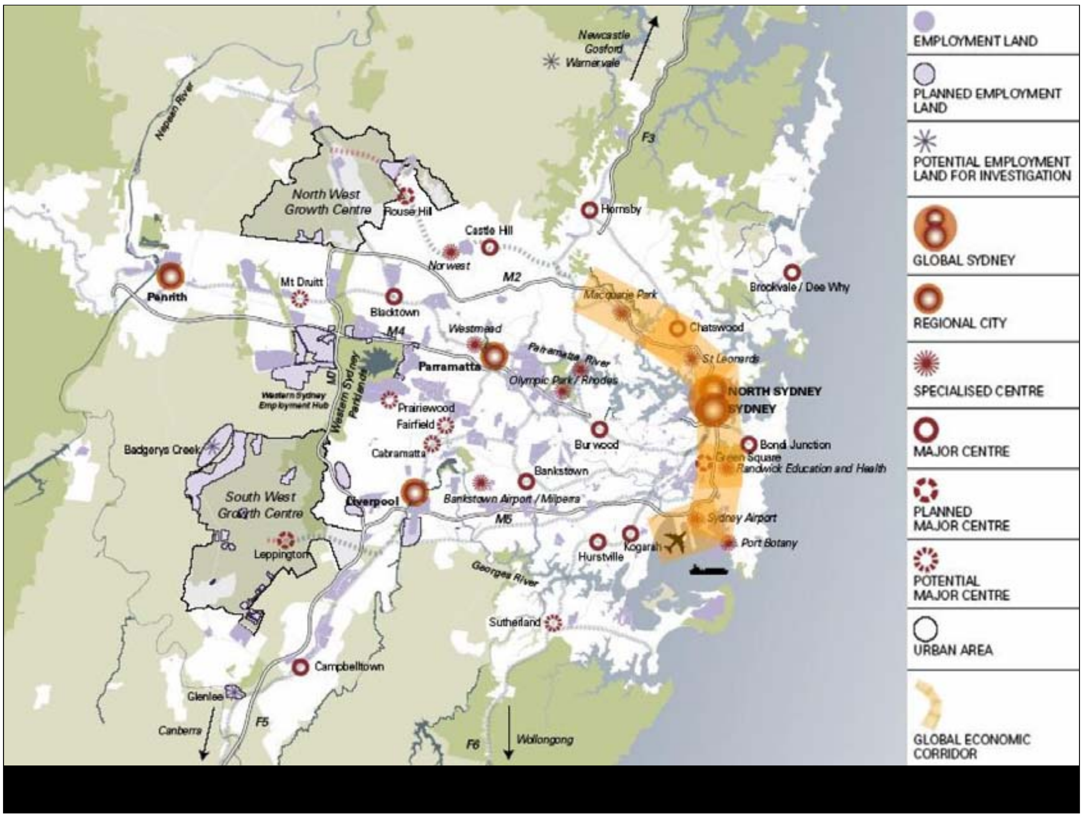


Figure 1 Model Development and Evaluation Framework

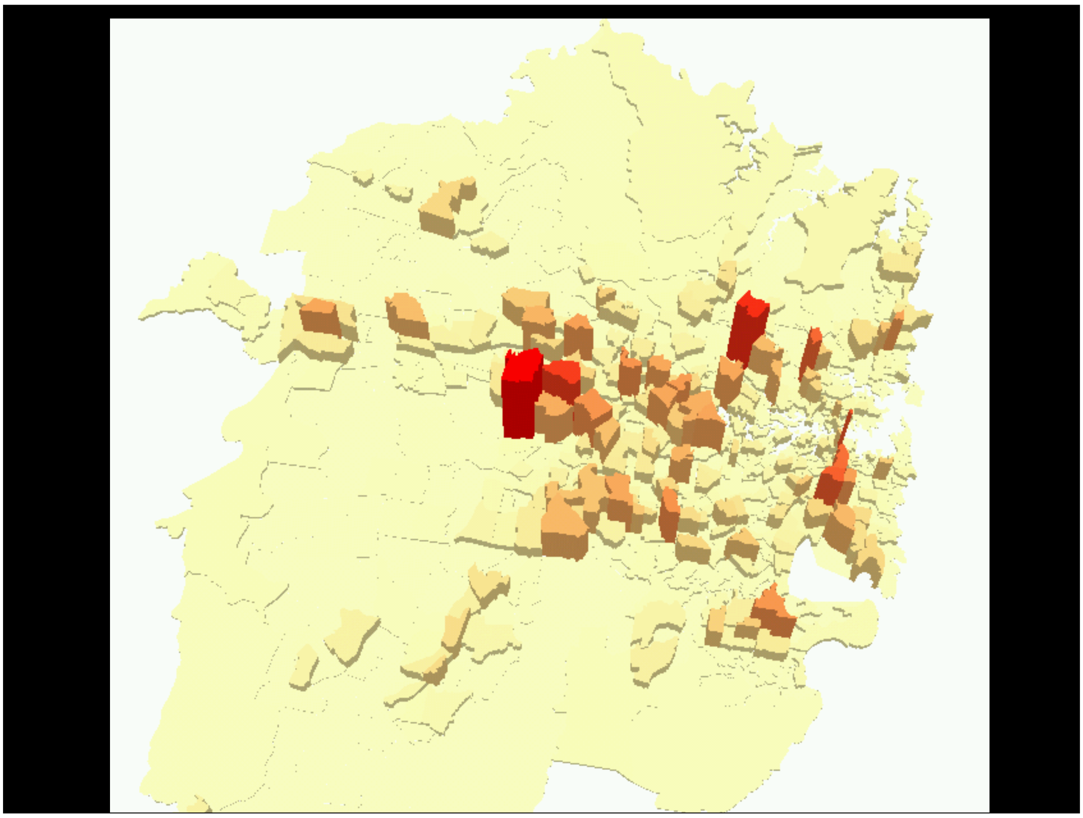


Identifying option characteristics


A Case study:
"a high speed limited stop guided transport system"



Newcastle
Gosford
Warnervale
F3
Nepean River
North West Growth Centre
Rouse Hill
Castle Hill
Hornsby
Norwest
M2
Mt Druitt
Penrith
Blacktown
Brookvale / Dee Why
Macquarie Park
Chatswood
M4
Westmead
Parramatta
Parramatta River
St Leonards
Olympic Park / Rhodes
NORTH SYDNEY
SYDNEY
M7
Western Sydney Parklands
Western Sydney Employment Hub
Prairiewood
Fairfield
Burwood
Bond Junction
Badgerys Creek
Cabramatta
Green Square
Randwick Education and Health
Bankstown
South West Growth Centre
Liverpool
Bankstown Airport / Milperra
M5
Sydney Airport
Hurstville
Kogarah
Port Botany
Leppington
Georges River
Sutherland
Campbelltown
Glenlee
F5
Canberra
F6
Wollongong
EMPLOYMENT LAND
PLANNED EMPLOYMENT LAND
POTENTIAL EMPLOYMENT LAND FOR INVESTIGATION
GLOBAL SYDNEY
REGIONAL CITY
SPECIALISED CENTRE
MAJOR CENTRE
PLANNED MAJOR CENTRE
POTENTIAL MAJOR CENTRE
URBAN AREA
GLOBAL ECONOMIC CORRIDOR



Employment lands

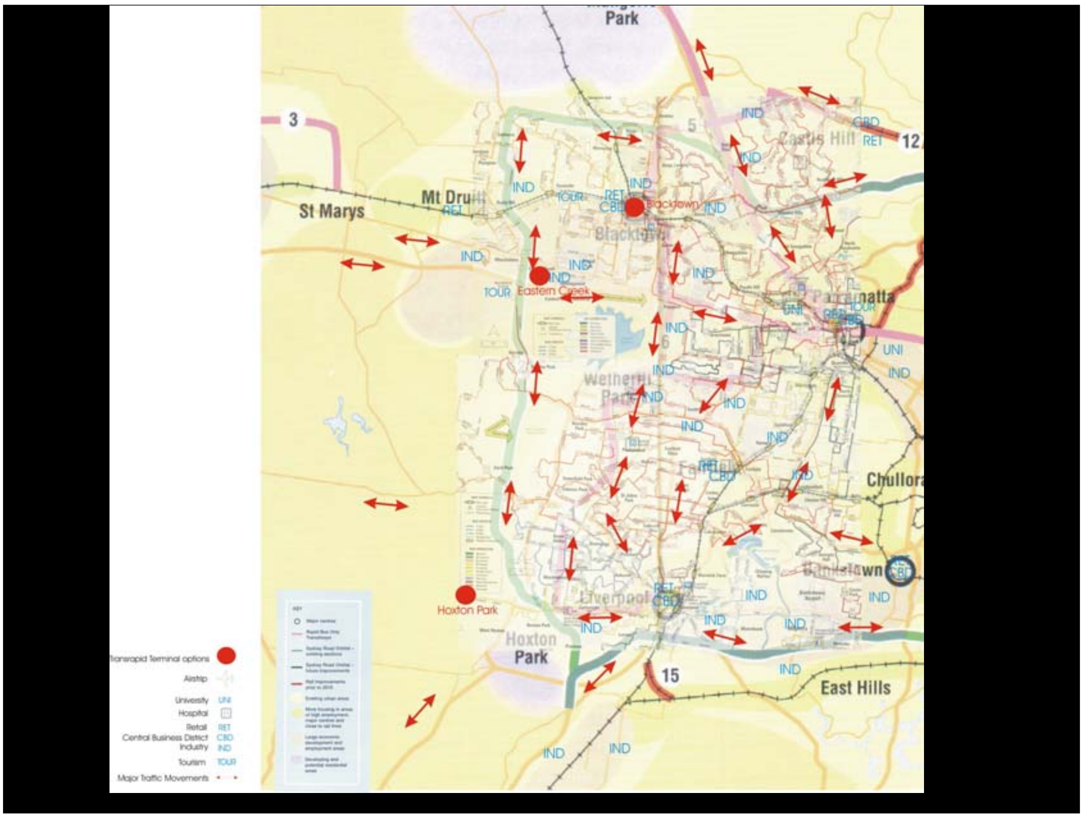
REQUIREMENTS?

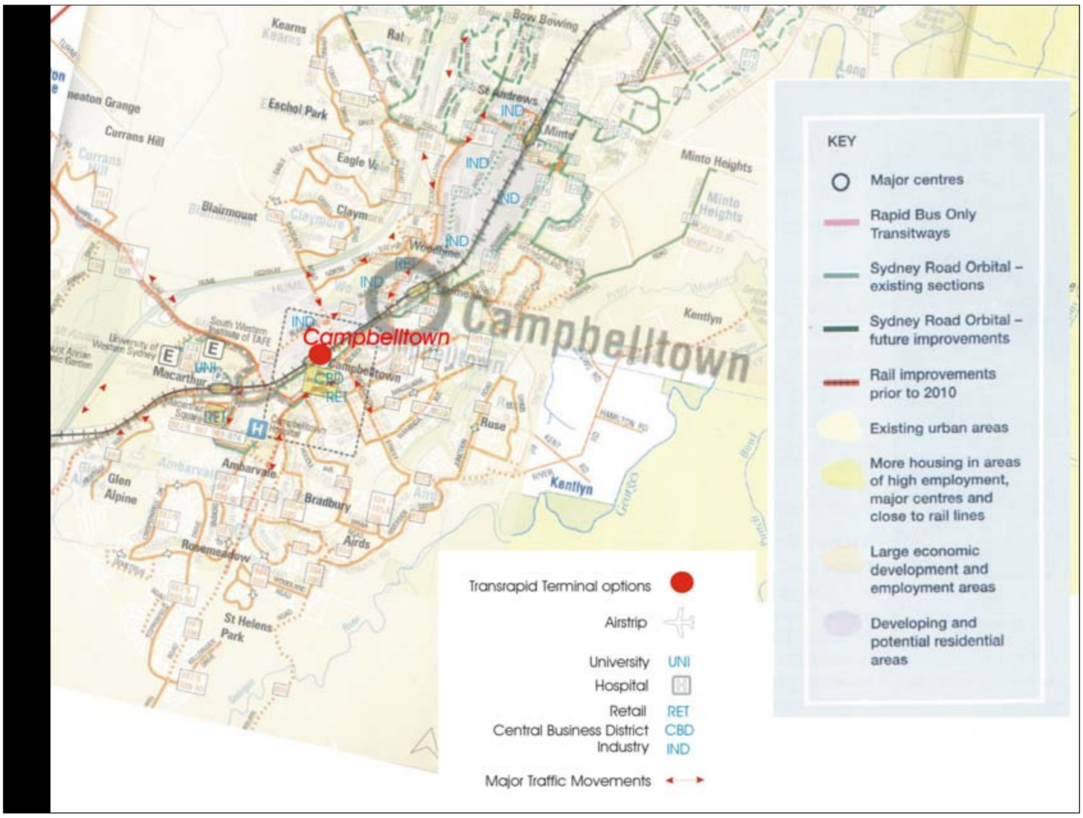
- integration between all links in a multimodal transport web structure.
- when integrated provide door to door trip times for cross regional trips that are significantly (15% to 30%) better than the trip time by car only.
- passenger comfort and personal safety.

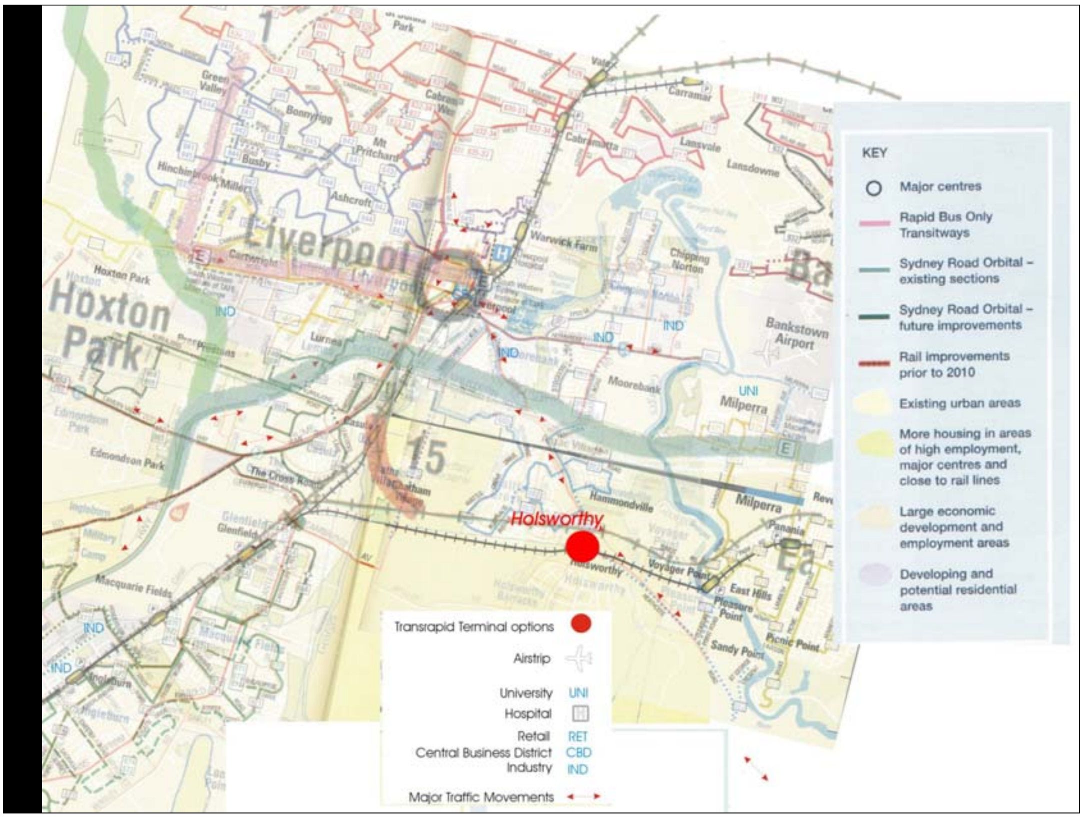
What are the matching characteristics of the trunk orbital public transport arc?

CHARACTERISTICS?

- integration with motorways/buses/rail and other feeders.
- interchanges 5 to 10 km apart
- rapid transit times ….. 2 to 4 minutes between stops
- stay within environmental noise capacity of corridor
- passenger comfort and personal safety onboard and within interchange areas.


Park
St Marys
Mt Druitt
Blacktown
Eastern Creek
Castle Hill
Chullora
Liverpool
Hoxton Park
East Hills
Transrapid Terminal options
Airstrip
University UNI
Hospital
Retail RET
Central Business District CBD
Industry IND
Tourism TOUR
Major Traffic Movements


Campbelltown
Campbelltown
KEY
Major centres
Rapid Bus Only Transitways
Sydney Road Orbital – existing sections
Sydney Road Orbital – future improvements
Rail improvements prior to 2010
Existing urban areas
More housing in areas of high employment, major centres and close to rail lines
Large economic development and employment areas
Developing and potential residential areas
Transrapid Terminal options
Airstrip
University UNI
Hospital
Retail RET
Central Business District CBD
Industry IND
Major Traffic Movements
Kearns
Eschol Park
Currans Hill
Blairmount
Eagle Vale
Claymore
Minto
Minto Heights
St Andrews
Bow Bowing
Kentlyn
Ruse
Macarthur
Ambarvale
Bradbury
Airds
Glen Alpine
Rosemeadow
St Helens Park
IND
UNI
CBD
RET


KEY
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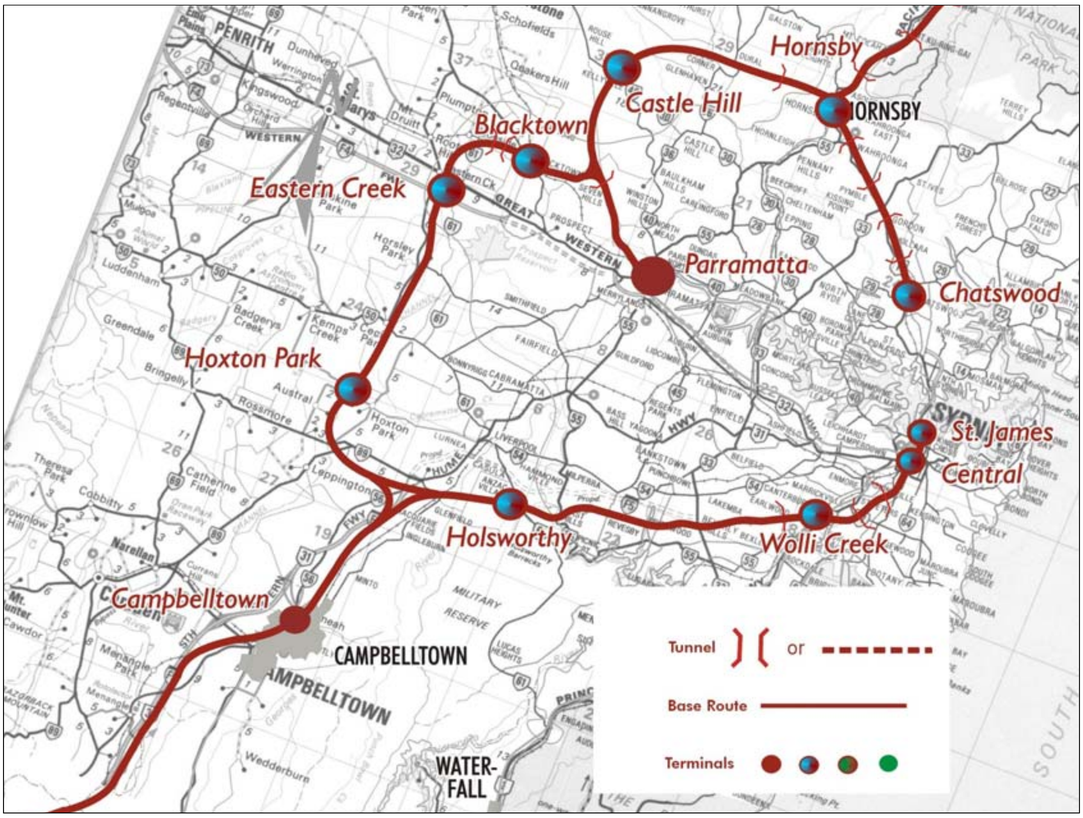
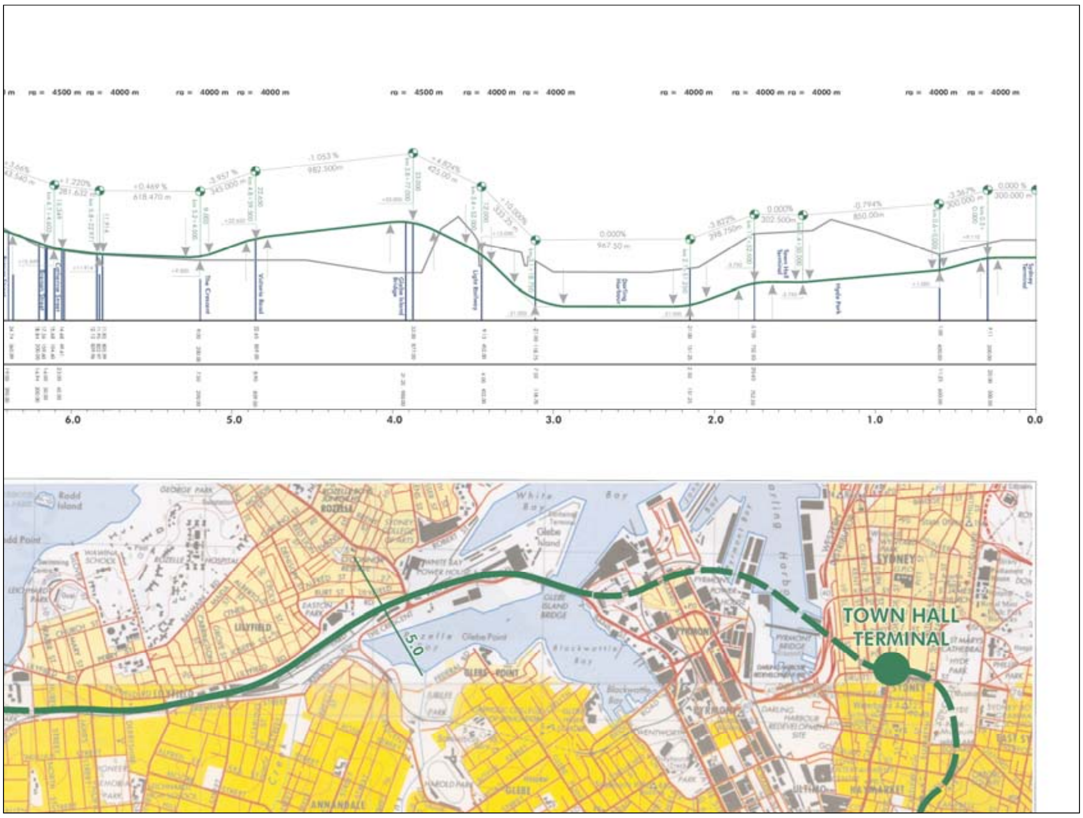
Large economic development and employment areas
Developing and potential residential areas
Transrapid Terminal options
Airstrip
University UNI
Hospital
Retail RET
Central Business District CBD
Industry IND
Major Traffic Movements
Holsworthy
Liverpool
Hoxton Park
Bankstown Airport
Milperra
Moorebank
Hammondville
Warwick Farm
Chipping Norton
Cabramatta
Carramar
Lansvale
Ashcroft
Busby
Green Valley
Mt Pritchard
Glenfield
Macquarie Fields
Edmondson Park
Voyager Point
East Hills
Pleasure Point
Sandy Point
Picnic Point
Panania



Hornsby
Castle Hill
HORNSBY
Blacktown
Eastern Creek
Parramatta
Chatswood
Hoxton Park
St. James
Central
Holsworthy
Wolli Creek
Campbelltown
CAMPBELLTOWN
PENRITH
WATER-
FALL
Tunnel
or
Base Route
Terminals

Eastern Creek
Blacktown
Parramatta
Homebush Bay
St. J
Bonnyrigg Park
car only
re than 74%
% to 74%
Hoxton Park
Sydney Central
Wolli Creek
Holsworthy
Botany Bay
Ingleburn
Cronulla
Campbelltown


CENTRAL



6.0
5.0
4.0
3.0
2.0
1.0
0.0
TOWN HALL
TERMINAL
5.0

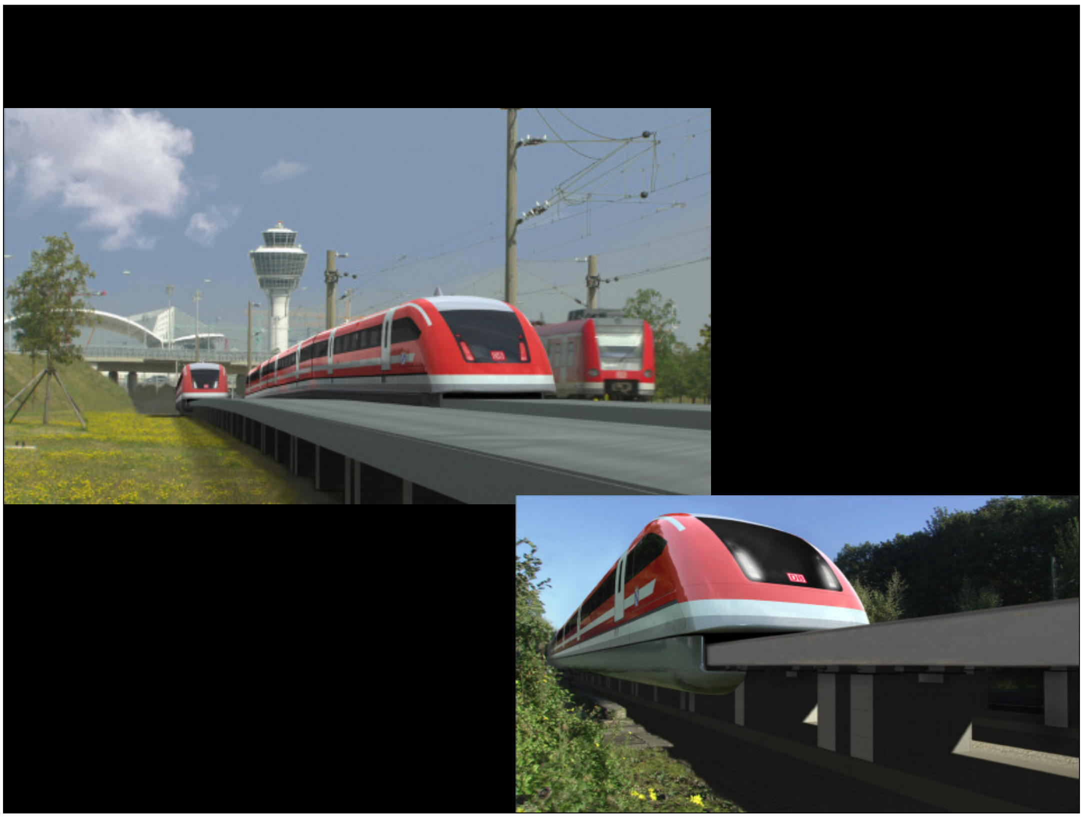
Section : S1F-1				Kilometrage from: 1.06 km west	Kilometrage to: 2.0 km west	
Curvature	**Gradient**	**Clearances**	**Land Resumption**	**Infrastructure Alterations**	**Neighbourhood Acceptability**	**Construction Staging**
* Minimum of 760 metre radius.	* Maximum of 1%.	* 10.1 metre corridor width. * 4.6 metres clearance to ground. * 5.3 metres clearance over Marjorie Jackson Parkway.	* Above ground easement for complete section through Olympic site.	* New bridge over Haslam's Creek and adjacent mangroves (160 metres). * Elevated guideway.	* Elevated guideway while visually more prominent, leaves land beneath clear for other uses. Planting's to screen in sensitive locations. * Noise impact may be an issue in quiet areas such as open parkland and wetlands. * Environmental impact of bridge over Haslam's Creek Wetlands could be an issue.	* Complete Parramatta to Homebush Bay as first stage

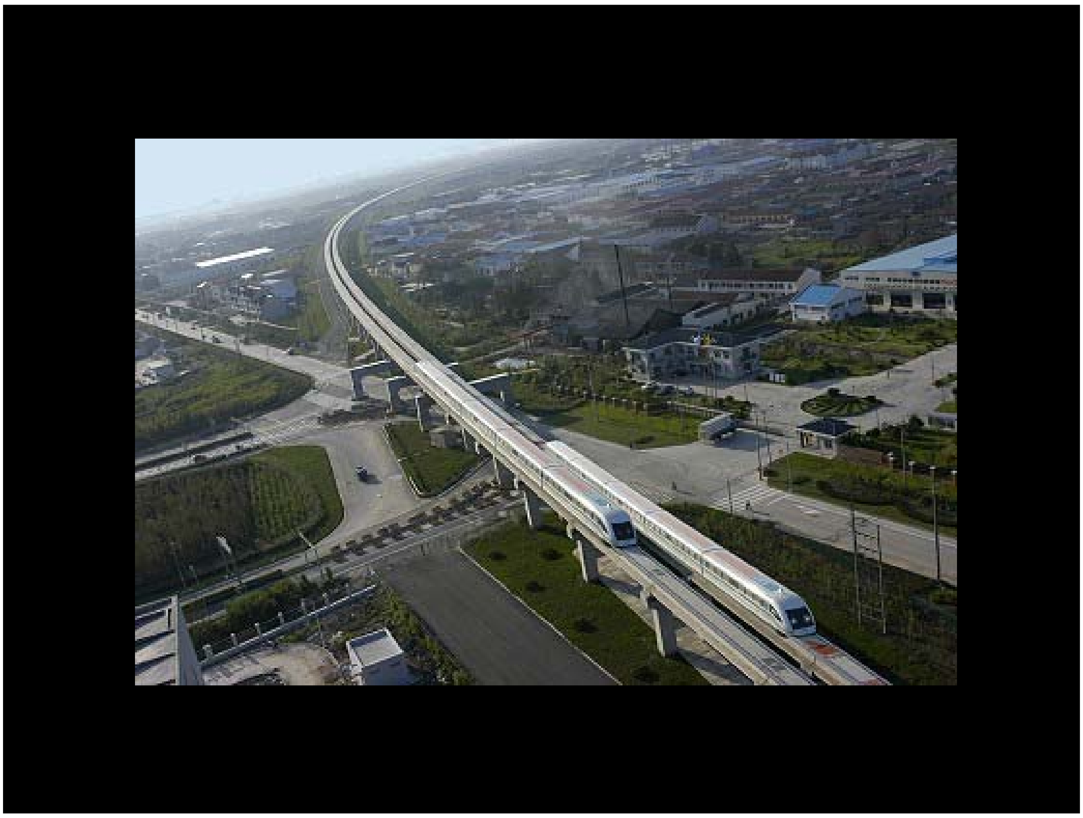
Drawing No.s U0052-91.

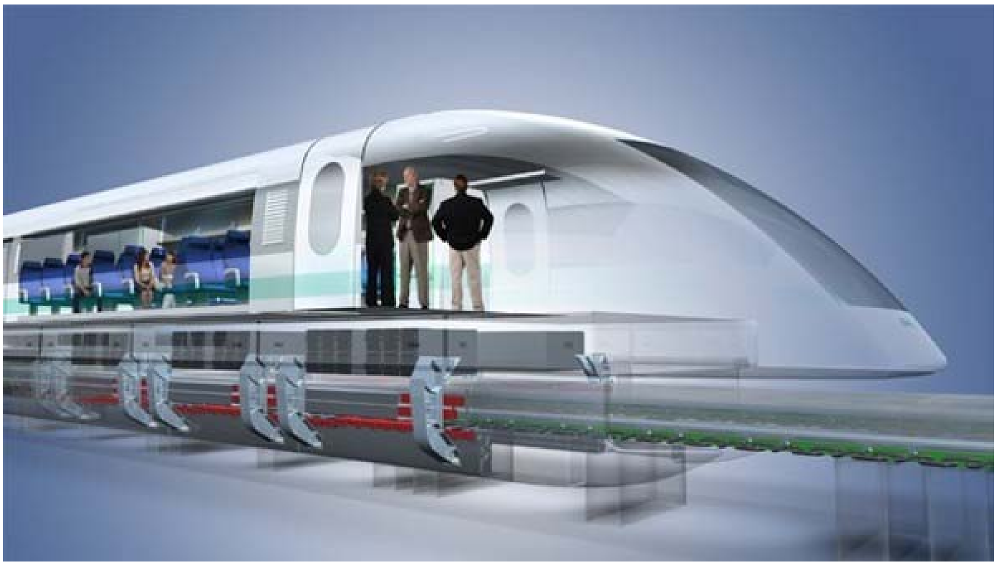
Other Comments:

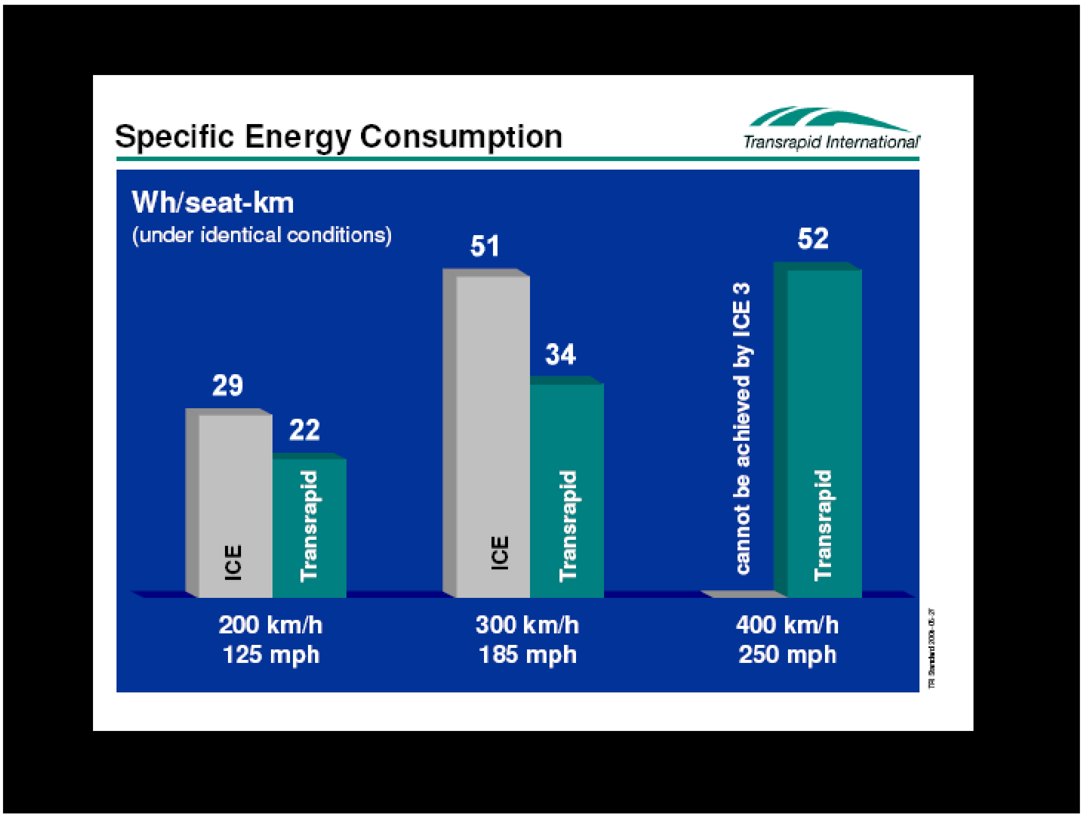
* Guideway elevated for complete section.

Dist from/to	Holsworthy	Wolli Creek	Central	St James
Blacktown	37.0	56.2	63.8	65.5
Eastern Creek	29.9	49.1	56.7	58.4
Hoxton Park	15.4	34.6	42.2	43.9
Holsworthy		19.2	26.8	28.5
Wolli Creek			7.5	9.3
Central				1.7



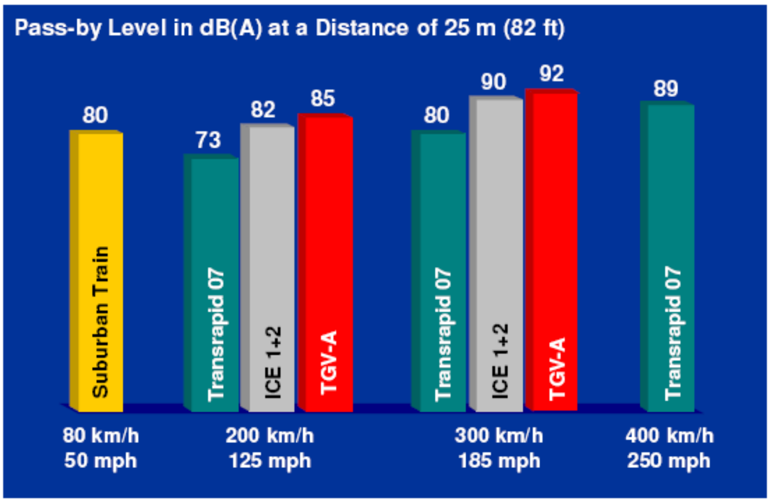


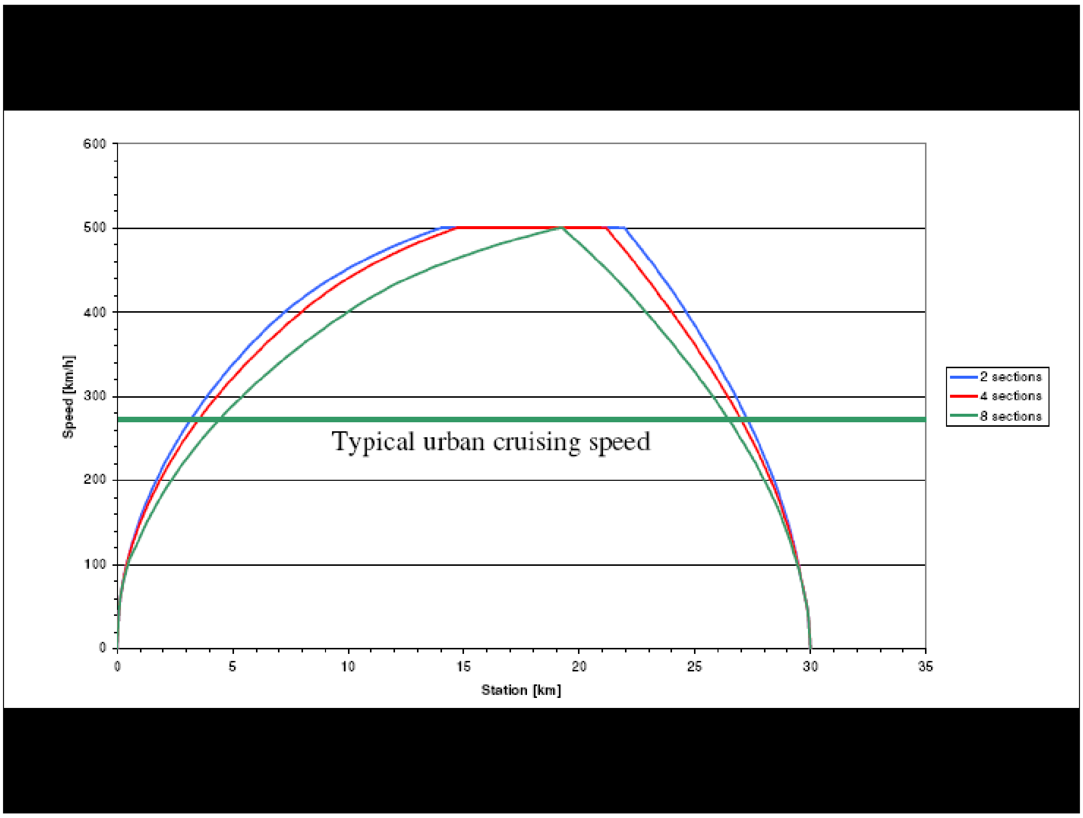


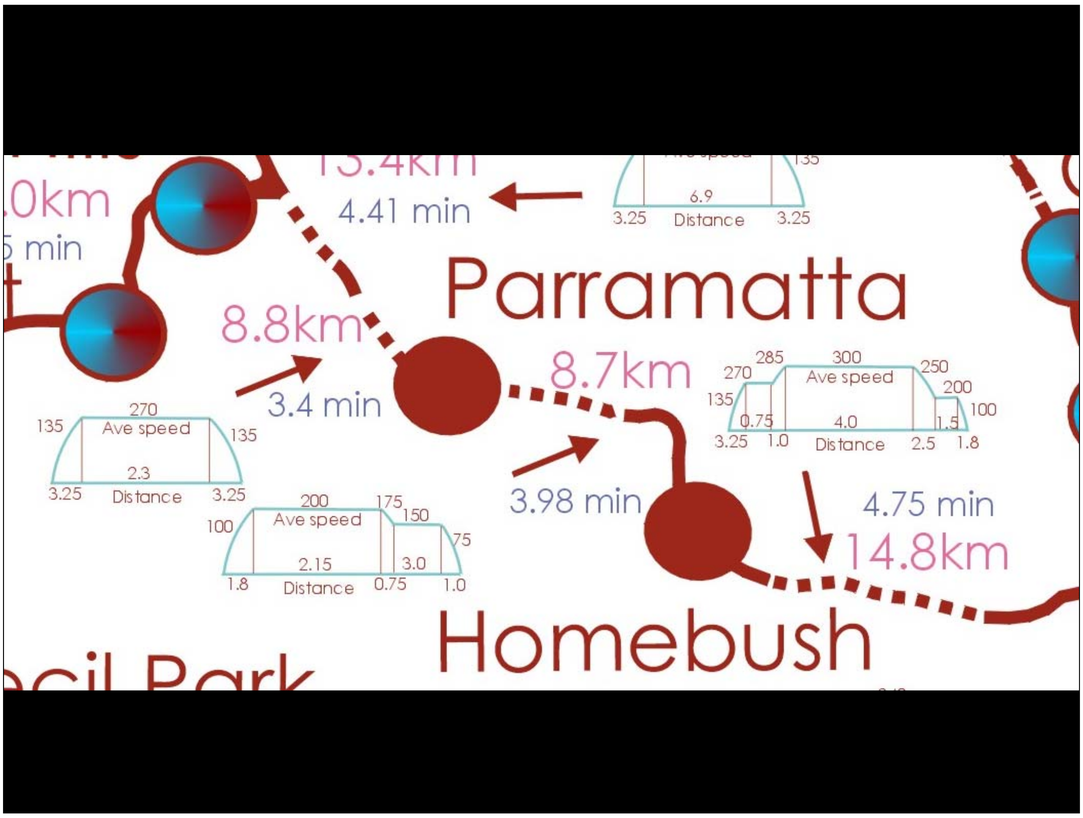

Specific Energy Consumption
Transrapid International
Wh/seat-km
(under identical conditions)
29
22
ICE
Transrapid
51
34
ICE
Transrapid
52
cannot be achieved by ICE 3
Transrapid
200 km/h
125 mph
300 km/h
185 mph
400 km/h
250 mph

Noise Emission

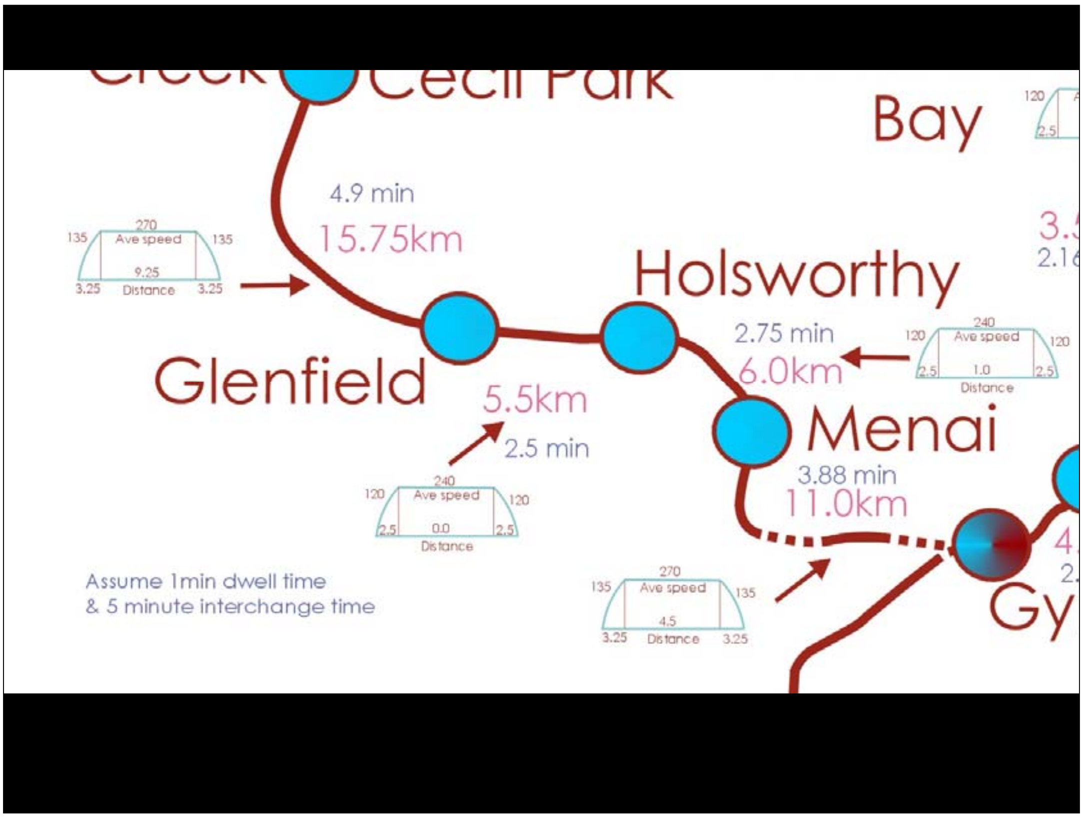
Transrapid International




Speed [km/h]
Station [km]
2 sections
4 sections
8 sections
Typical urban cruising speed
0
100
200
300
400
500
600
0
5
10
15
20
25
30
35



4.41 min
6.9
3.25
Distance
3.25
.0km
5 min
Parramatta
8.8km
3.4 min
8.7km
285
300
270
Ave speed
250
200
135
0.75
4.0
1.5
100
3.25
1.0
Distance
2.5
1.8
270
135
Ave speed
135
2.3
3.25
Distance
3.25
200
175
150
100
Ave speed
75
2.15
3.0
1.8
Distance
0.75
1.0
3.98 min
4.75 min
14.8km
Homebush



Cecil Park
Bay
4.9 min
15.75km
270
135
Ave speed
135
9.25
3.25
Distance
3.25
Holsworthy
Glenfield
2.75 min
6.0km
240
120
Ave speed
120
2.5
1.0
2.5
Distance
5.5km
2.5 min
240
120
Ave speed
120
2.5
0.0
2.5
Distance
Menai
3.88 min
11.0km
Assume 1min dwell time
& 5 minute interchange time
270
135
Ave speed
135
4.5
3.25
Distance
3.25

Time from/to	Holsworthy	Wolli Creek	Central	St James
Blacktown	14.8	22.0	26.4	29.0
Eastern Creek	10.5	17.7	22.1	24.7
Hoxton Park	4.8	12.0	16.4	19.0
Holsworthy		6.2	10.6	13.2
Wolli Creek			3.4	6.0
Central				1.6

	Cumulative Distance (km)	Travel Time (min)	Cumulative Travel Time (min)	Available Capa
Blacktown	0.0			
		3.3	3.3	
Eastern Creek	7.1			
		4.7	9.0	
Hoxton Park	21.6			
		4.8	14.8	
Holsworthy	37.0			
		6.2	22.0	
Wolli Creek	56.2			
		3.4	26.4	
Central	63.8			
		1.6	29.0	
St James	65.5			

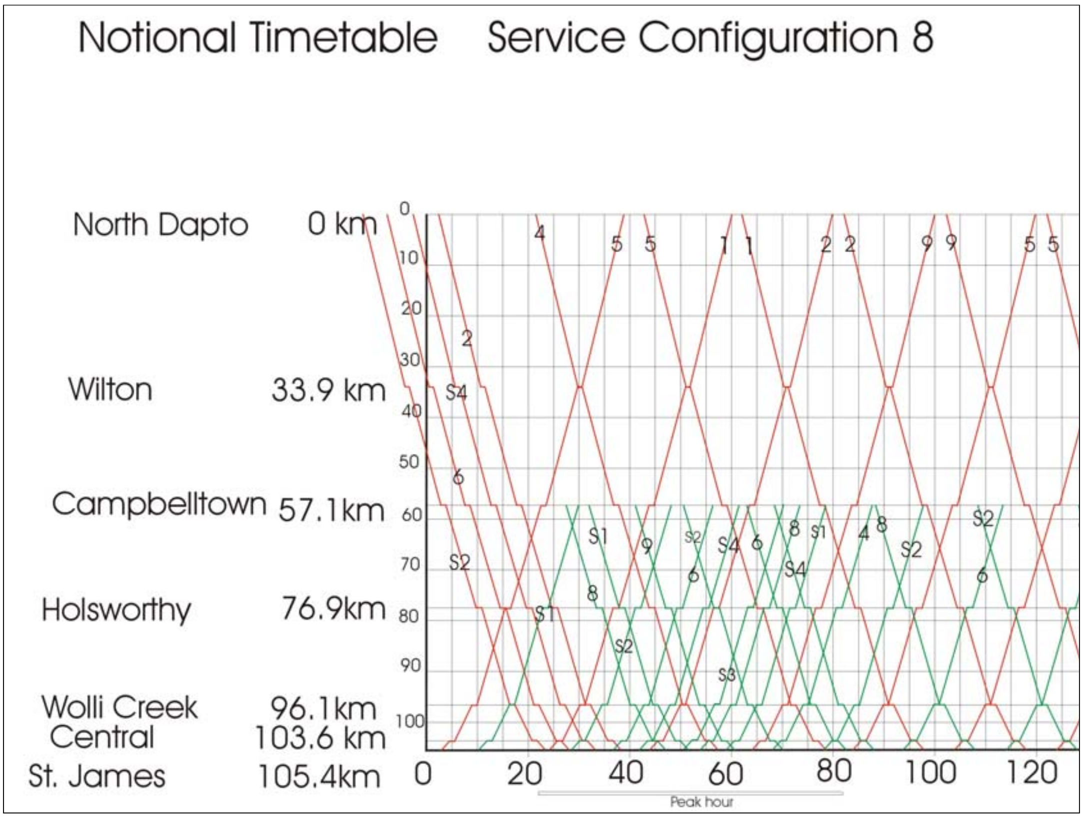
1 min dwell time at each stop

* assuming 20 trains/hr lim
# 2010 Illawarra/Campbellt

Travel Time (min)	Cumulative Travel Time (min)	Available Capacity trains/hr/ guideway *
3.3	3.3	20.0
4.7	9.0	20.0
4.8	14.8	# 9
6.2	22.0	# 9
3.4	26.4	# 9
1.6	29.0	

1 min dwell time at each stop

* assuming 20 trains/hr limiting guideway capacity or 3 minute headways
\# 2010 Illawarra/Campbelltown use of twin guideway capacity


Notional Timetable Service Configuration 8
North Dapto 0 km
Wilton 33.9 km
Campbelltown 57.1km
Holsworthy 76.9km
Wolli Creek 96.1km
Central 103.6 km
St. James 105.4km
0
20
40
60
80
100
120
Peak hour

Eastern Creek/StJames		***1997***	***2005***	***2006***	***2007***
Maximum Up pax loadings (peak hr) without demand management cap & ramping	100.0%	22051	26,867	27,539	28,227
Up pax loadings (peak hr) without demand management cap			13,434	16,523	19,759
Up pax loadings (peak hr) with demand management cap	yes		11,026	13,231	15,436
Annual Pax without demand management cap	1800	45,715	50,129,360	61,659,112	73,734,022
Up pax loadings with demand management (peak hr capacity cap)			14,094	14,094	19,035
Shoulder peak Service (supplementary capacity delivered)			0	3,197	3,197
Total demand management strategy capacity			14,094	17,291	22,232
note: demand management achieved by pricing passengers into the shoulder period each side of the peak hour					
Peak Hour Service Configuration (with demand management)			1(+35%)	1(+35%)	2(+35%)
Supplementary Shoulder peak Service (10cars* 135%*#trains)	1,598		0	2	2
ramp			0.50	0.60	0.70
Number of cars to operate service			76	76	101

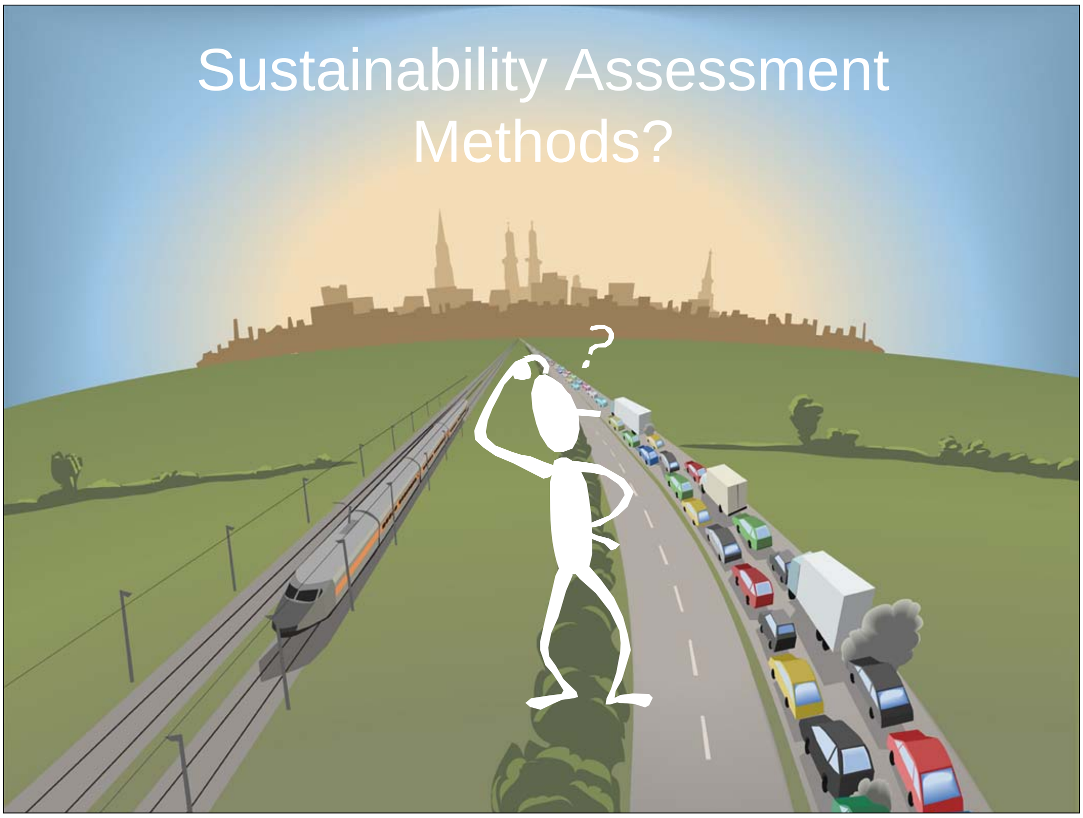
Timetable A

Service Configuration #	Section serviced	Pk Hr train runs	Cars per train	Pk Hr Seated capacity (high density)
1(+35%)	Eastern Creek - St.James	15	6	10,440
2(+35%)	Eastern Creek - St.James	15	8	14,100
3(+35%)	Eastern Creek - St.James	15	10	17,760
4(+35%)	Eastern Creek - St.James	20	8	18,800
5(+35%)	Eastern Creek - St.James	20	10	23,680

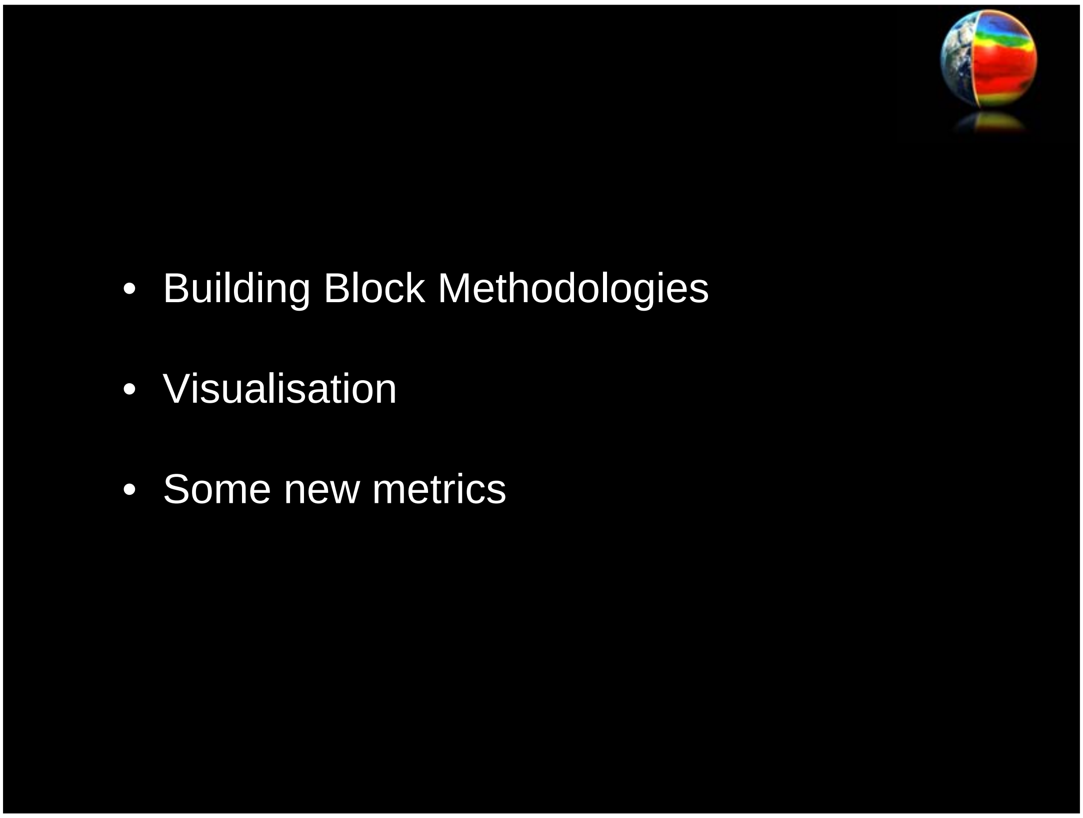
High Density Seating #s	6 car trains	696
	8 car trains	940
	10 car trains	1184

Cars per train	Pk Hr Seated capacity (high density)	135% Pk Hr capacity Seated (high density) with standing	fleet car numbers	availability fleet car numbers/ service configuration 95%
6	10,440	14,094	72	76
8	14,100	19,035	96	101
10	17,760	23,976	120	126
8	18,800	25,380	128	135
10	23,680	31,968	160	168

[redacted]



Identifying option characteristics



Use the sustainability requirements but assess the city wide sustainability performance change.

Use building block methods of transport planning to provide the analytical basis and traceability to the levers that drive sustainability.

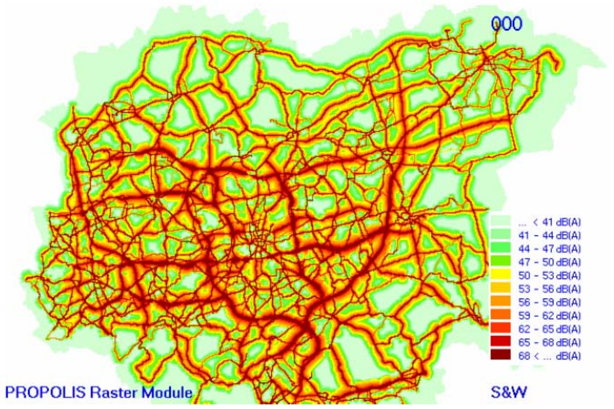


Figure 3.24 Traffic noise in Dortmund region

(source: Spiekermann and Wegener, 2003, p. 14; http://www.ltcon.fi/propolis , Jan 2005)

Existing visualisation methods using GIS and graphical displays illustrate the value of visual metrics in communicating urban dynamic outcomes and sustainability performance. Visualisation using GIS techniques is proving to be effective in displaying complex information in a simple but meaningful way

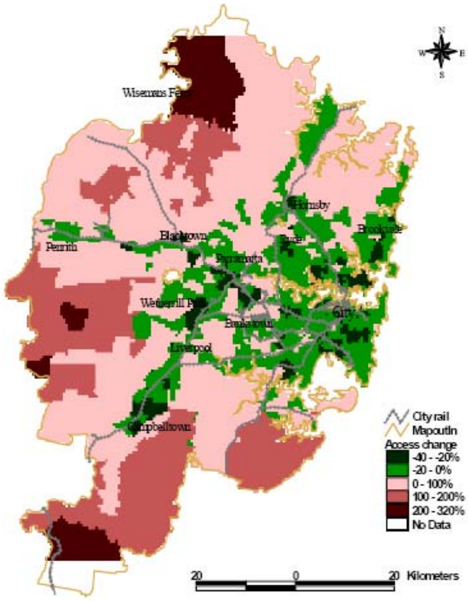
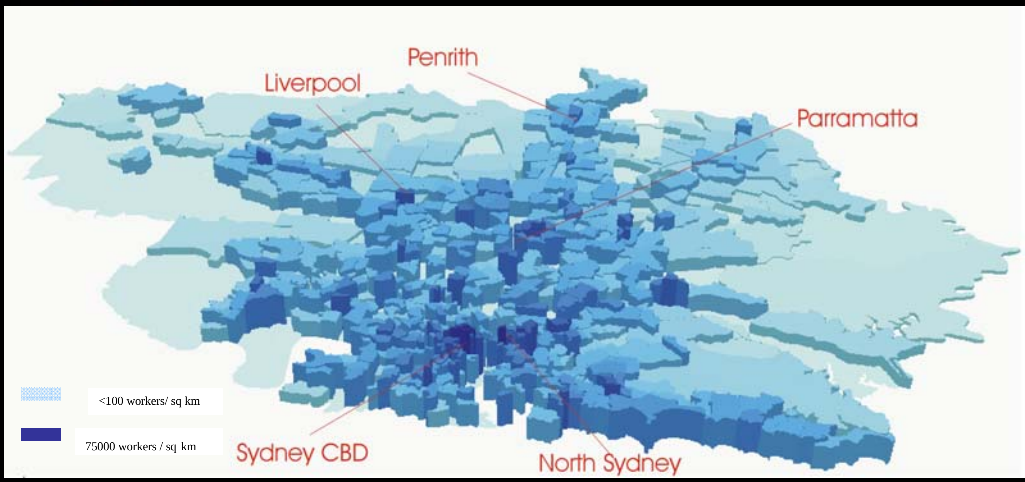


Figure 3.12 Percentage Change in Residential Accessibility Employment Sydney 1981-96



1981 to 2001 change in employment density

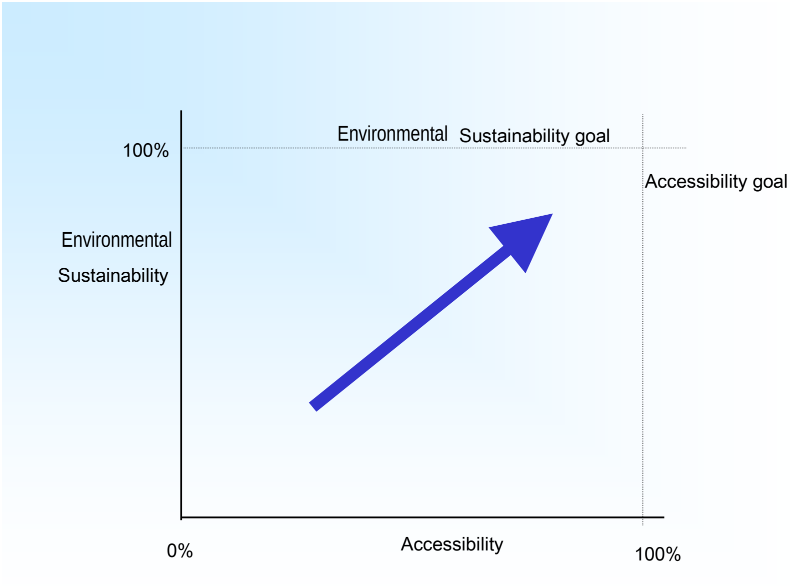
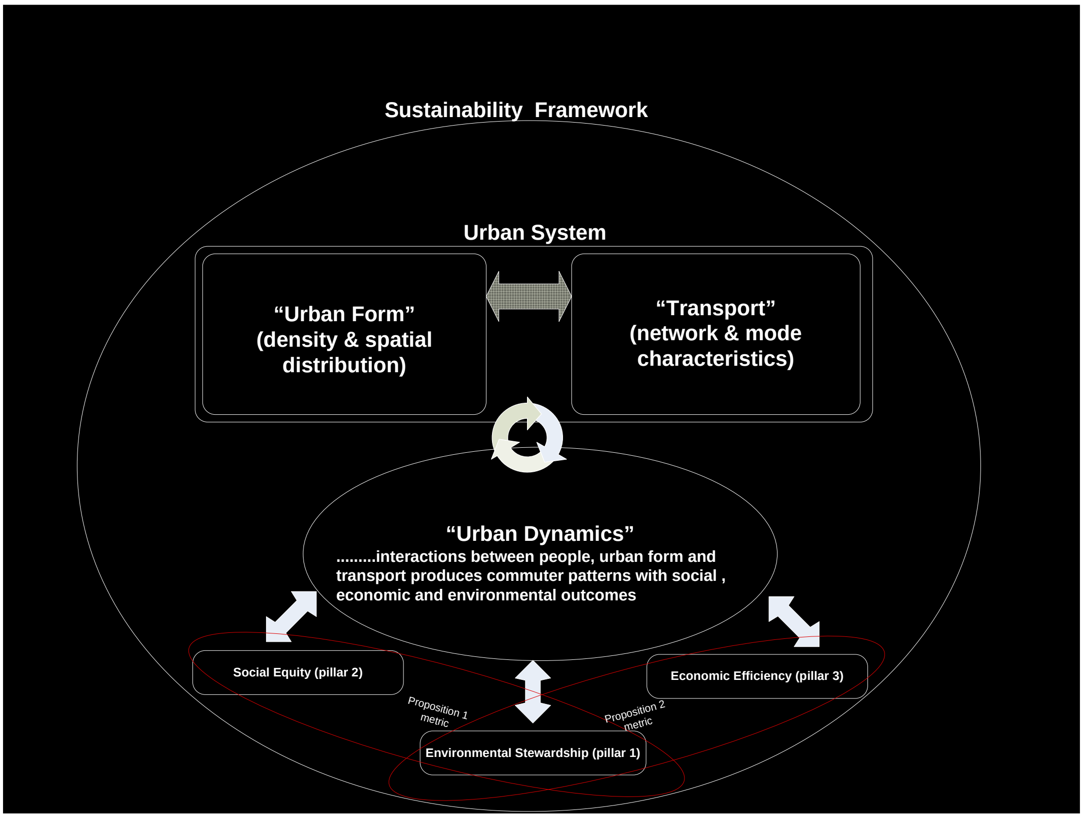


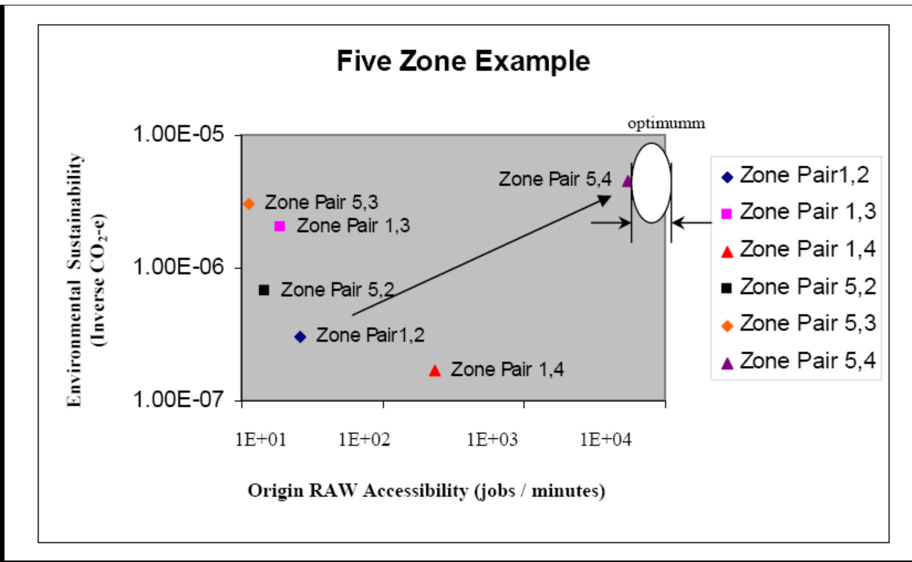
Figure 4.2 Environmental sustainability - accessibility space

sustainability metrics, using visualisations in “environmental sustainability – accessibility space” were generated. These visualisations display a social spatial equity form of accessibility in a metric indicating the accessibility to jobs for workers from their place of residence. Visualisations for measures of environmental sustainability and economic efficiency focused accessibility (the first and third pillars of sustainability) were also produced.

The metrics have been developed based on the concept of a sustainability goal in “environmental sustainability – accessibility space”. Figure 4 illustrates this spatial concept and the idealised performance goal. A city’s transport related sustainability performance can be quantified and visualised in a detailed but simple manner by collectively plotting in this space the points for different locations in the city. Each of these points represents the environmental sustainability and accessibility performance for a specific origin and destination location pairing. For a city divided into travel zones, each origin and destination zone pair has an environmental sustainability characteristic and an accessibility characteristic.

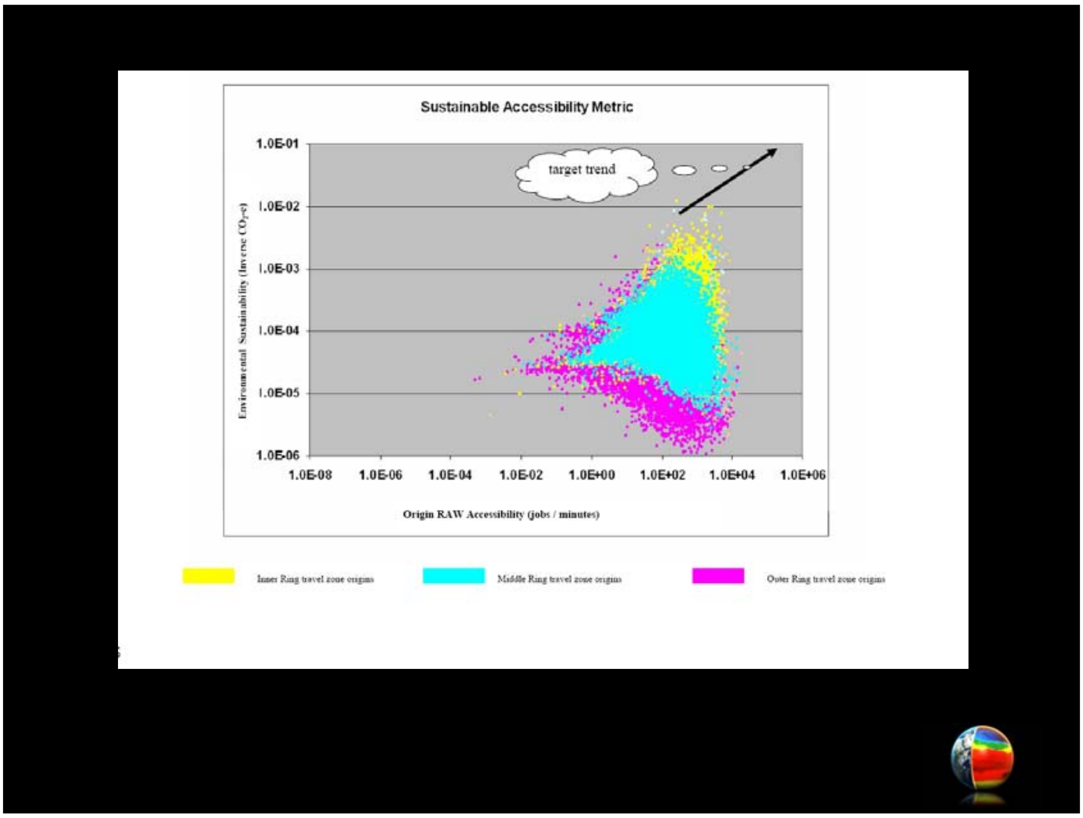


Shows interaction between system elements

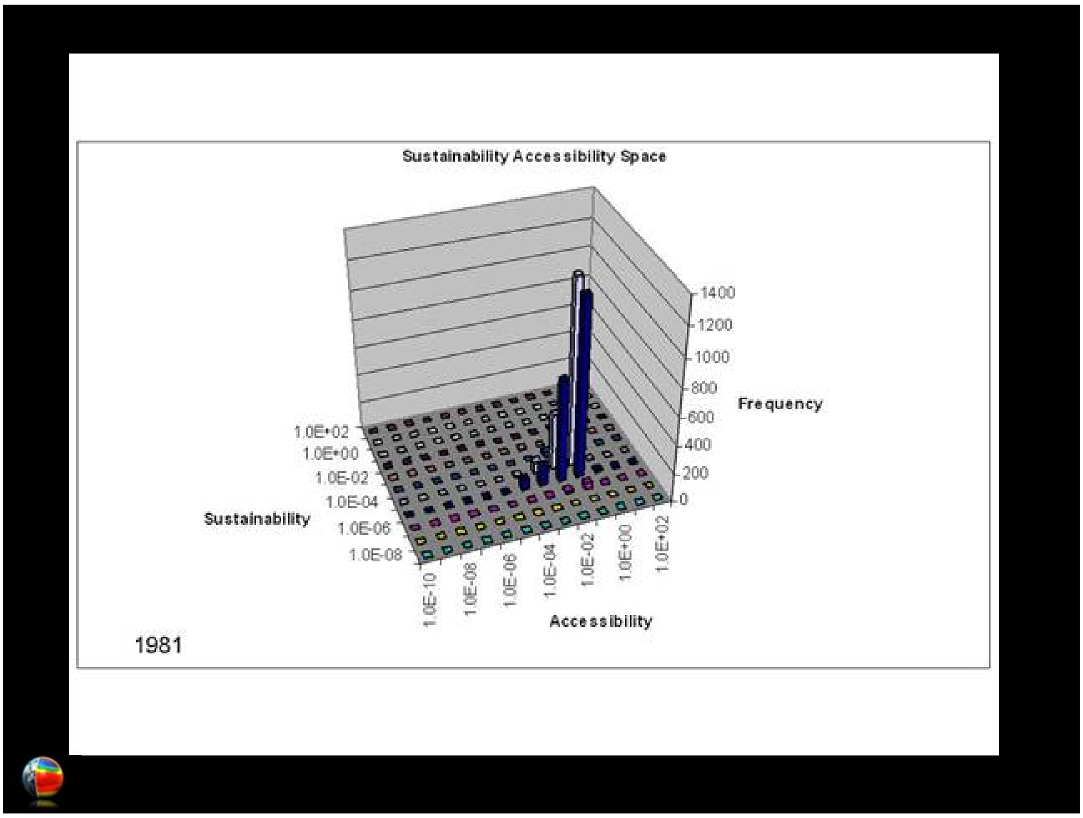


- Notes:
- Origin RAW Accessibility is defined as the accessibility to jobs at a destination zone (TZj) from an origin zone (TZi) calculated by dividing the total attractions from all origin zones to TZj by the transport impedance from TZi to TZj. Units are workers/ minutes, where workers are a proxy for jobs.
- Environmental sustainability measure is defined as the inverse of CO_2 emissions from the total JTW trips between zone pairs, including an allocation of emissions from manufacture of vehicle and road infrastructure. This is calculated as a sum of the carbon dioxide equivalent (CO_2-e) per unit trip km at the average speed with the shortest path trip length and number of trips. The carbon dioxide equivalent (CO_2-e) is calculated as the sum of the quantity of greenhouse gas and the Global Warming Potential Index (AGO,2005,Appendix 3)
- Figure 5 Environmental sustainability (Pillar1) – “Raw” accessibility (Pillar3) scatter plot visualisation

The simple five zone example provides the fundamentals of the concept. The scatter plot shown shows the sustainability performance against the desirable trend in sustainability. A shift to the top right hand corner and a limited spread in accessibility is identified as the theorised optimum.

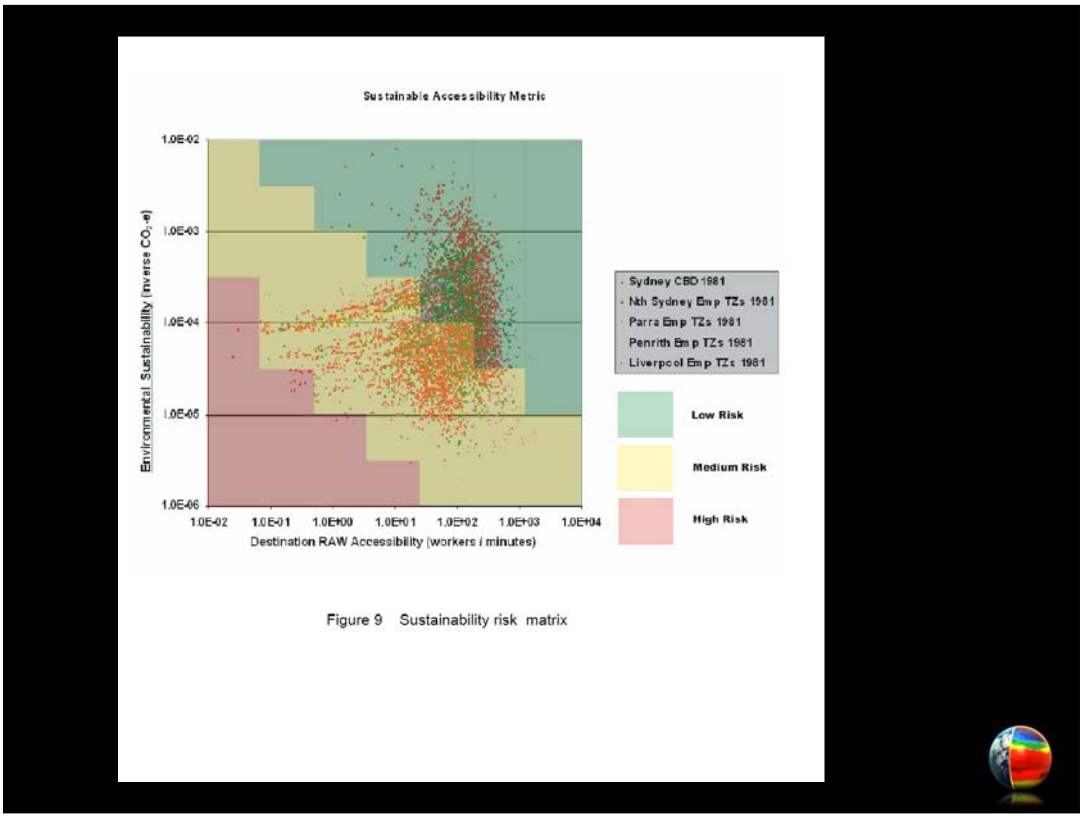


Each of these visualisations provide insight into the position, spread and internal frequency trends for a city's urban sustainability pillars of environmental stewardship, social equity and economic efficiency.



To give a greater degree of visualisation of the data sets, the "environmental sustainability – accessibility space" was divided into a grid and plotted as a prism map with the frequency in "environmental sustainability – accessibility space"

Through these three dimensional visualisations of the data sets, a number of additional differences between each set become visible.



These metrics can also be applied in a way that expresses sustainability performance in terms of sustainability risk. High risk where sustainability performance is poor, indicated by low metric values. Low risk where sustainability performance is satisfactory, indicated by a higher metric value, above a community accepted minimum target.

The grid concept can be likened to a risk matrix allowing each zone pair to be assigned a sustainability risk rating (Figure 9). This sustainability risk rating can then be plotted onto geographic space using geographic information system (GIS) thematic mapping. Figures 10, 11&12 illustrate some examples of visualisations in geographic space.

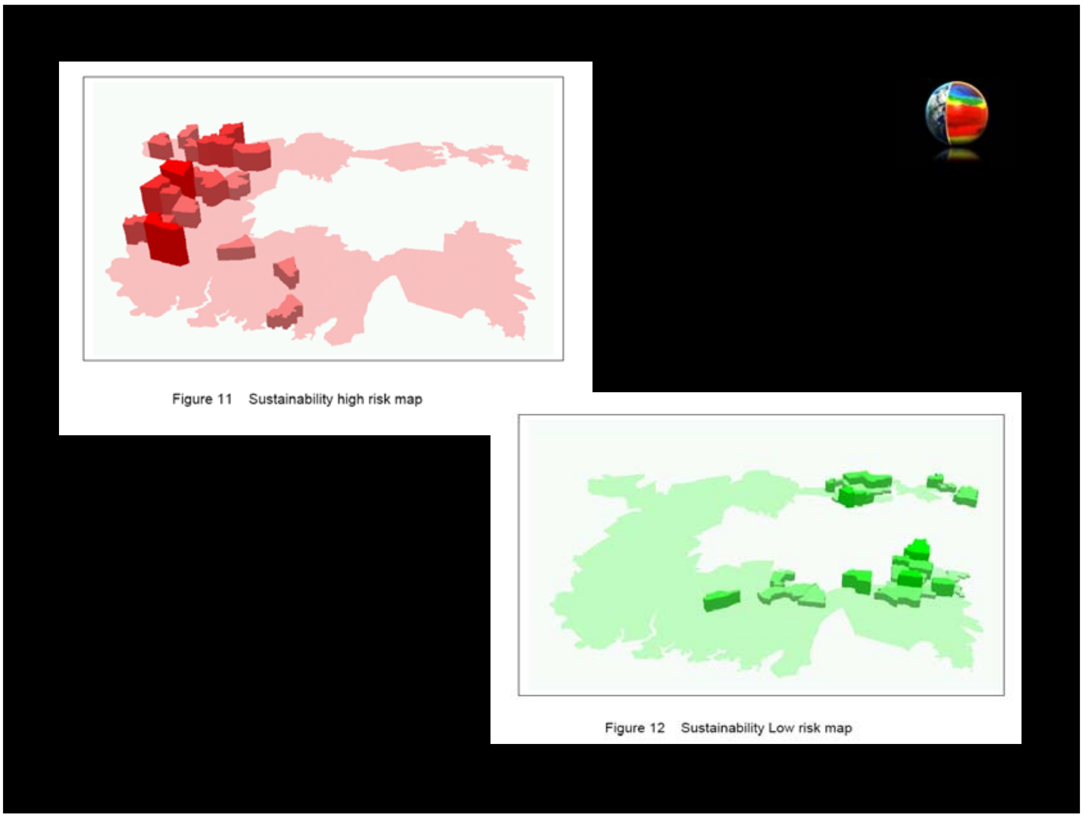


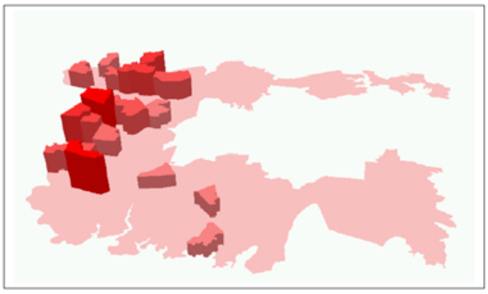
Figure 11 Sustainability high risk map

Figure 12 Sustainability Low risk map

For community and decision makers these visual differences give a simple snapshot of overall sustainability performance, for each scenario being considered. Change the scenario, use the building block techniques and produce a new metric plot to see the sustainability effect. Stakeholders can see measurable change for their communities in relation to sustainability goals. The process provides another dimension to visioning and sustainability strategy development by adding the means by which community can measure and judge one infrastructure and urban form scenario with another.

Choice of boundaries between low, medium and high risk of unsustainability needs discussion and may vary from city to city. For example, what are the points in environmental sustainability – accessibility space that moves a community from a low risk to a medium risk of being unsustainable? In the case of a city system with current scenario of transport & urban form a baseline assessment can be made.

An important aspect of the metric methodologies is their analytical basis. All visualisations have traceability back through the algorithms to the source inputs. This is a particular strength when checking results, making scenarios changes and applying different planning instruments. A particular strength of using the sustainability framework and the metrics demonstrated is that they are derived from data sets that have been commonly used by planners for many years. These are commonplace amongst transport and city planning departments. With these inputs and the assistance of readily available GIS/T software, all of the urban dynamics and sustainability metrics are able to be derived. The sustainability framework enables the holistic picture of sustainability to be maintained during the assessment process.



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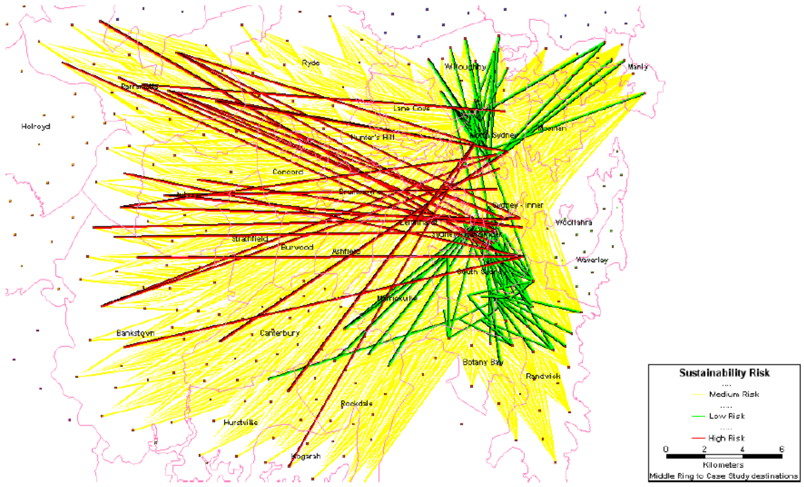
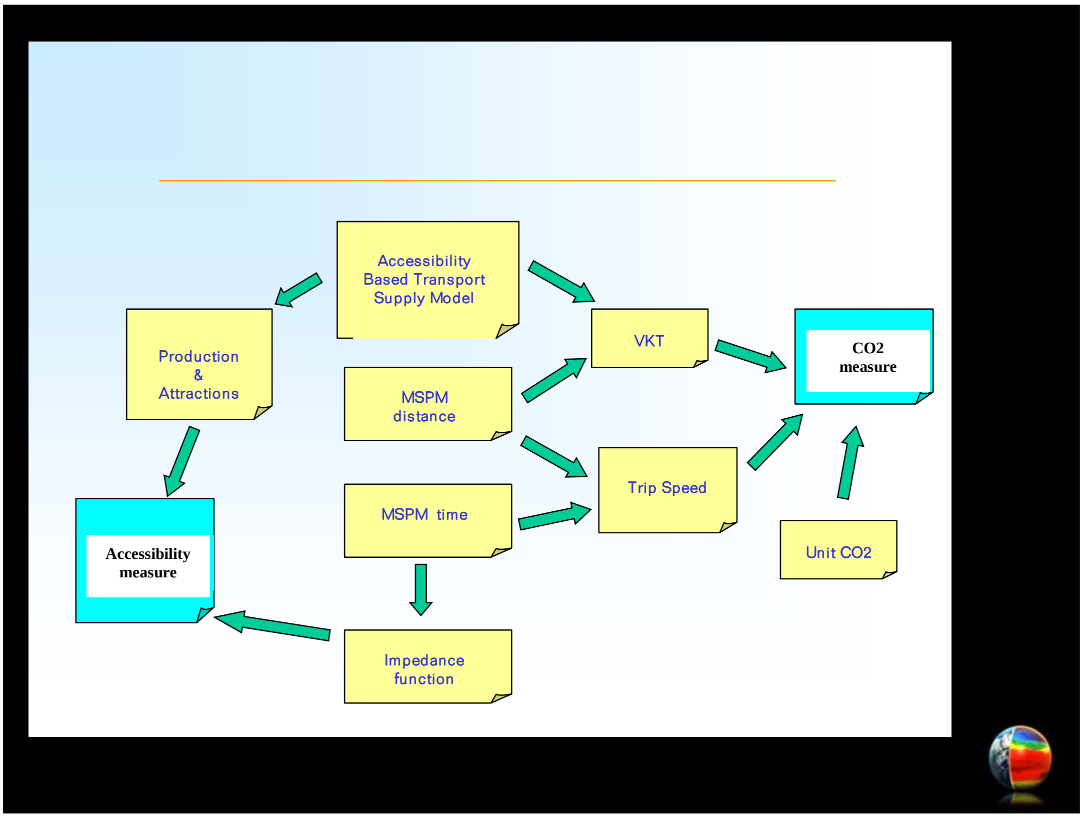


Figure 10 Sustainability risk GIS plot

Optioneering of changes in transport & urban form puts forward different possibilities for a cities future. This assessment methodology enables these scenario options to be assessed for change in sustainability performance over the system as it exists now. Not only can the snapshots of performance with current demands be made, but also as is done in traditional planning, the projected performance with projected demands.

The sustainability assessment of various transport and urban form options is therefore seen as a valuable tool for comparing the relative performance where the variables are transport and urban system characteristics, urban dynamics associated with demand choices people make in place of living, where they work, relax, shop and visit and how and when they choose to travel. These variables we are familiar with. However, climate change adds another dimension with constraints and feedback effects to each of these variables which have not previously been assumed to occur.



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