



NETWORK PLANNING PRINCIPLES

THE UNIVERSITY OF SYDNEY
BUSINESS SCHOOL

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OUTLINE

1. Objectives and purpose of network planning
2. The role of Economics in Network Planning
3. Principles of planning
4. Issues in planning

Network Planning Principles 2

OBJECTIVES AND PURPOSES 1



1. OBJECTIVES AND PURPOSE OF PLANNING

- › Outline
- › Defining the nature and scope of network planning tasks and measuring its success
- › Impacts on urban structure – transport and land use
- › Institutional issues and their impact on 'success'
- › Network success factors

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CONTEXT

DEFINE SCOPE OF NETWORK PLANNING

- › Partly defined by the institutional set-up
- › Partly determined by mode
- › BUT VERY important
- › Define the area of study
- › Define the aspirations for level of service
- › Understand how existing resources contribute to different goals
- › Recognise that planning in the short, medium and long-term have different issues

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DEFINING THE NETWORK PLANNING TASKS

- › Specify goals and objectives
 - Allow public transport operators to provide services that customers are willing to pay for
 - Support social policy
 - Provide efficient transport
 - Contribute to a sustainable city

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DEFINE THE INDICATORS OF SUCCESS

- › Monitoring change necessary for good decision making and management
- › Key indicators needed at the planning stage so that evaluation is targeted

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IMPACT ON URBAN STRUCTURE

- › Public transport networks do influence land use structure and vice versa
 - eg proposed metro and the building up of densities around proposed stations
 - Developments can drive the need for new public transport links
- › These need to be positively considered so that land use and public transport strategy reinforce each other


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IMPACT ON URBAN STRUCTURE

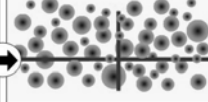
Transit & Land Use: Weak Strategy

If you haven't made transit a convenient means of travel among key regional centers and destinations...



If transit systems are unable to provide superior connectivity among a core set of points, they are unlikely to shape the future growth of that region.

Don't expect transit to shape urban growth, as the auto will remain the defining transportation mode.



Source: David Hensher, June 18-19 2008 BITRE Colloquium Canberra

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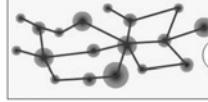
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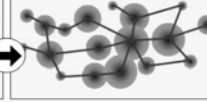
IMPACT ON URBAN STRUCTURE

Transit & Land Use: Strong Strategy

If you figure out a way to hook your principle centers together as directly, rapidly, and frequently as possible...



...then transit can begin to shape urban growth, given the usefulness of that system to its region.



Source: David Hensher, June 18-19 2008 BITRE Colloquium Canberra

Cities that develop strategies to connect their component parts as quickly as possible create truly useful transit systems—and markets tend to respond to such usefulness.

© 2008 by The Author Group. Designing Effective Transit to Organize Frameworks for Transit Systems Development 17

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INSTITUTIONAL ISSUES

- › Public transport framework does make a difference in terms of its regulatory features
- › Choice of institutional framework does have an impact on costs
- › Network planning is most important in the public service approach
- › The co-ordination of the bodies involved will determine the success of the planning outcome

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MARKET COMPETITION

Market competition is not a goal in itself but a means to achieve some other benefits

Advantages	Disadvantages
Can result in better service to the market, in accordance with the demand.	Is likely to result in large differences in service levels between areas and corridors: A concentration of services to strong, well established markets to/from the city centre, where competition from the car is weakest, due to congestion, few and restricted parking spaces etc. Weak coverage by public transport in large areas with heavy car use.
Efficiency in the production of services due to the competition between operators.	Many operators in the same market often lead to complex and almost incomprehensible network of lines and services.
More focus on the development of new products and services	May lead to proprietary information and ticketing systems and strongly segmented marketing and branding, even to the extent that users pay more for the service than they have to.
	Excess capacity and overproduction as a result of several parallel services, without taking advantage of economies of scale, with low profitability as a consequence.
	The flexibility and market adjustments lead to a less stable service that weakens the basis for the development of heavy infrastructure

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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COORDINATED PLANNING

Advantages

It is possible to develop an integrated network as a full attractive and understandable travel alternative to car use

May exploit economies of scale when designing an integrated network, in the scheduling of routes and in the choice between different means of public transport.

Can form the basis for long term planning of infrastructure and land use.


Disadvantages

There is a risk of developing an inefficient monopoly of planning with weak market orientation and too little focus on efficient operations and service product development. There is also the possibility of ignoring the transfer penalty perceived by passengers.

May create a system with inherent cross subsidy so that it is difficult to identify which routes are viable in their own right.

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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INSTITUTIONAL ISSUES

SUCCESS FACTORS

- › Regional organisation
- › Supporting policy
 - Complementary policies which reinforce the underlying transport policies in their achievement of modal shift.
- › Successful co-ordination between land-use policies and transport policies in recognition of their conjoint spatial attributes.
- › Funding

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INSTITUTIONAL ISSUES – FUNDING

City	Population (000)	Subsidy per head of population (£)	Public Transport Investment per head of population (£)	Single Fare (£)
Madrid	5600	54	5	0.65
Barcelona	4228	17	1	0.65
Copenhagen	1800	111	5	1.00
Helsinki	1200	71	40	1.50
Stockholm	1500	141	100	1.20
London	7000	29	43	2.00
Munich	2500	72	200	1.20
Zurich	1200	125	17	1.50
Edinburgh/Lothians	700	59	21	1.30

Source: Adapted from Colin Buchanan and Partners (2003) – in Hitrans BPG 2

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NETWORK SUCCESS FACTORS


- › Networks that perform well are characterised by
 - Stability required for public transport system to influence urban development and create more sustainable transport patterns
 - Robust and simple structure
 - Serving all citizens

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THE ROLE OF ECONOMICS AND ITS IMPACT ON NETWORK PLANNING 2



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THE ROLE OF ECONOMICS

- › Economics is fundamentally about allocation of resources
- › Individual decisions v Government decisions
- › Government responsibilities
- › Individual responsibilities

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NETWORKS, SYSTEMS AND ACCESSIBILITY

- › Commitment to networks and systems (not 'projects' or 'corridors')
 - Importance of network effect
- › Transport provides accessibility



Source: <http://mappery.com/isp-of/Melbourne-Australia-Public-Transportation-Map>

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PUBLIC TRANSPORT OBJECTIVES

- › Public transport policy objectives are multidimensional
 - Economic aspects
 - Environmental sustainability
 - Social aspects
- › Public transport quantitatively more difficult to provide in rural areas
 - Density
 - Diverse purposes and viability

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PUBLIC TRANSPORT USE

- › Evidence
 - the 'forget the timetable' **frequency**
 - journey times
 - parking




Source: <http://selic.com.au/living-in-sydney/>

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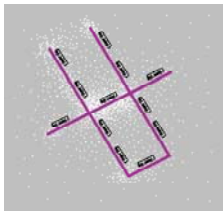
WHAT SORT OF PUBLIC TRANSPORT?

COVERAGE VERSUS FREQUENCY TRADE-OFF

Coverage



Frequency



... but when it's presented this way, they see why it's a tradeoff.
Source: Dr Jarrett Walker

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NETWORKS, OBJECTIVES AND PERFORMANCE

Objectives met through frequency


- › Patronage growth
- › Financial
 - Fare return
- › Environmental impact reduction
 - from reduced private vehicle trips.
 - Reduced emissions.

Objectives met through coverage

- › Social Inclusion
- › "Equity"
 - Entitlement to a public service.
 - "We pay taxes too"
- › Redistributive aims

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ANALYSIS OF NETWORKS



- › Analysis of key corridors giving constraints to the network is imperative
- › Understanding how key corridors add to the network
- › Improving corridors which contribute to the network effect

Source: Draft NSW Long Term Transport Master Plan, 2012, p.84

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PRINCIPLES OF NETWORK PLANNING 3

PRINCIPLES OF NETWORK PLANNING

OUTLINE

- › Good Characteristics
- › Why Network Planning focuses on buses
- › Corridors
- › Frequency
- › Simplicity
- › Responding to demand
- › Network effects
- › Interchange
- › Low density – Flexible Transport Services
- › Success and failure

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GOOD CHARACTERISTICS

- › Stability required for public transport system to influence urban development and create more sustainable transport patterns
- › Robust and simple structure
- › Serving all citizens

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NATURE OF THE NETWORK

- › Different modes
- › Different lines

Need to be integrated into

- › Single, user-friendly travel network giving
 - a stable and simple network of lines with fix-scheduled services and frequencies
 - a flexible, demand-responsive service catering for all other public transport services

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THE NETWORK FACTOR

- › Relationship between
 - Lines
 - Waiting time
 - Transfers

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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SQUARESVILLE – THE IDEAL CASE

Adapted from Mees' (2000)

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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THE CITY DOES NOT NEED TO BE 'SQUARE'

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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THE CITY DOES NOT NEED TO BE 'SQUARE'

village Eg station

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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WHY NETWORK PLANNING FOCUSES ON BUSES

- › In the short-term, the rail system is fixed.
 - Can change the timetable
 - Can change frequency and stopping patterns
 - But cannot change the route
- › For urban areas, in the short-term, bus provides the flexibility to meet changing or new 'needs' of accessibility
- › Principles thus relate to network planning for buses

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TWO APPROACHES TO NETWORK PLANNING

- › Tailor made approach
 - Fit the needs of different users
 - Fit the needs of different times of day
- › Ready-made approach
 - Same network but varying frequency
 - Seamless public transport easier with this approach

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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CORRIDORS

- › Concentrate resources on corridors – and use timetable co-ordination to increase the frequency as density increases.
- › Frequencies need to be good (London estimates 12 minute frequency leads to 'forget the timetable')
- › No advantage from super-high frequency – better to start a new corridor or introduce limited stop

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CORRIDORS = CONCENTRATING RESOURCES

Before
Two low frequency lines that run in the vicinity of each other

After
... replaced by one line with doubled frequency.

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY SIMPLICITY

› One section-one line

Network principle "Direct connections - no transfer"

Network principle "One section - one line"

6 lines
6 timetables

2 lines
2 timetables

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY SIMPLICITY

Minimise the number of routes

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY SIMPLICITY SAVES MONEY

Index for the operational cost for serving an urban district

Cost Index	Route Type	Characteristics
100%	Yes	Straight line, with few, but centrally located stops
150-250%	Avoid	Bending line, with many stops at short intervals
250-400%	Avoid	Ring lines with many stops on the border of the area to be served

Rational and direct routes are important for the economics of public transport operations as well as for the attractiveness of the system.
(Adapted from Kommunikationsdepartementet 1975.)

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY SIMPLICITY

Who would understand this?

?

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UNIVERSITY OF SYDNEY FREQUENCY

› Three classes of frequency (TRRL 2004)

- Forget the timetable
- Fixed minute timetable
- Service on demand only

› Not a lot of evidence as to what the frequency boundaries are ...

- Between 1 and 2: 6-12 departures/hr (London)
- Between 2 and 3: hourly (Norway)

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UNIVERSITY OF SYDNEY NETWORK PLANNING AND FREQUENCY

- › Forget the timetable – important to have equal intervals
- › Fixed minute – challenge is to keep to timetable
- › Service level 3 – more flexible approach needed (to discuss later)

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FREQUENCIES AGAIN...

- › Is there an optimum frequency?
 - Empirically 6-12 departures/hour in peak for medium size cities
 - Diminishing returns from more than this
 - If average wait time = ½ interval between departures, headways > 5-10 minutes gives long wait & transfer times check timetable before departure
 - Shorter headways cost more to run but no significant reduction in waiting times

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THE EFFECT OF FREQUENCY....

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USE TIMETABLES TO ADVANTAGE...

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ADJUSTING FREQUENCY

ADJUSTING FREQUENCY FOR DEMAND VARIATIONS

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ADJUSTING FREQUENCY

ADJUSTING FREQUENCY FOR DEMAND VARIATION

The use of frequency as a tool for flexible service adjustments

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RESPONDING TO DEMAND

- › When capacity constraints from constant headway, should you increase frequency or change network?
 - Headways of 2 mins in many big cities at peak giving vehicle on vehicle congestion
 - Often used strategy is to spread out stops but this makes
 - System more complicated
 - Interchange more of a penalty
- › Should consider new routes that release pressure and provide alternative travel destinations – but must not forget the network effect

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UNIVERSITY OF SYDNEY NETWORK EFFECTS

JOIN NODES TO EXTEND COVERAGE

Suburbs
Inner city
City centre

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY THE NETWORK EFFECT

Low frequency network
Network with some high frequency lines or sections
High frequency network: Network effect

Little chance of attracting car users
Some car users are attracted on radial journeys
Public transport can become a realistic alternative for many car users, even with low complementary measures such as parking restrictions

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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UNIVERSITY OF SYDNEY NETWORK EFFECTS ARE IMPORTANT

- › If the frequency is high, walking further will not have a big impact on combined walk and wait time
- › Having good frequency only on a small part of the network does not get people out of cars
- › Having links radially and cross city with good frequency and interchange can speed up journeys

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UNIVERSITY OF SYDNEY WALKING, WAITING AND FREQUENCY

Walking time

0 m 0 min
200 m 2.5 min
400 m 5 min
600 m 7.5 min
800 m 10 min

Departures per hour

Walking and waiting time

Source: G. Neilson, TOI, Oslo

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UNIVERSITY OF SYDNEY INTERCHANGES

- › Accept interchanges are needed
- › Simple networks will need interchanges between
 - Lines operated by the same mode
 - Lines operated by different modes
- › Accepting interchange means that services do not need to concentrate on "direct journeys" for all – allows greater coverage. The planning skill is to maximise the number of direct journeys by knowing what passengers want
- › Interchange allows the best of the mode to be exploited and transfer to another mode when better

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UNIVERSITY OF SYDNEY INTERCHANGE CAN RELEASE RESOURCES

Common section
18 departures per hour, at every 3.3 minutes

Branch
3 departures per hour, at every 20 minutes

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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INTERCHANGE CAN RELEASE RESOURCES

8 departures per hour, at every 7.5 minutes

Branch 6 departures per hour, at every 10 minutes

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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TRANSFERS AND INTERCHANGES

- › Minimise the cost of interchange
 - Ensure timetable co-ordination
 - Present route information accessibly
 - Remove fare penalties
 - Create short and easily understood interchanges
- › Empirical evidence
 - Higher levels of transfer associated with higher public transport modal shares – the benefit of the network effect eg Arlanda, Sweden

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AREAS OF LOW DENSITY AND DEMAND

- › Alternative strategies are needed
 - Use the 'hub and spoke' approach of airlines to co-ordinate arrival and departure times
 - Use flexible transport when demand will not support use of bigger vehicles

Source: G.Neilson, TOI, Oslo

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FAILURE AND SUCCESS

The difference between failure and success

Route alignment – the difference between failure and success is demonstrated by the comparison of bus line 651 in Melbourne with line 60 in Toronto. (Adapted from Mees 2000)

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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VERY EASY TO DO!

Source: Public Transport – planning the networks. Hitrans Best Practice Guide 2

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ISSUES IN NETWORK PLANNING

4

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ISSUES IN NETWORK PLANNING

OUTLINE

- › Timeframes
- › Understanding demand

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TIMEFRAMES

	Short term < 1 year	Medium term 2-5 years	Long term 6-25 years
General	Budget planning	Audit and monitoring analysis	Urban and regional structural planning
Semi-detailed	Fares policy	Mode choice decisions	Transport studies investment planning
Detailed	Crew and vehicle scheduling	Network planning (Route choice analysis)	
	Operational short term planning		
		Strategic long term planning	

Source: Public Transport – planning the networks, Hitrans Best Practice Guide 2

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UNDERSTANDING DEMAND

- › Clarify the user requirements and preferences. The travelling public want good service
 - Good information
 - Good access
 - Good reliability
 - Good security
 - Low price
 - Short journey time
- › Network design and its presentation to the travelling public does have impacts on patronage and on system effectiveness – this is a growing area of research

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UNDERSTANDING DEMAND

- › Take account of urban structure in locating demand – density, existing infrastructure and networks. Need to recognise that it works 'both ways'
- › Recognise the role of transfers and interchange points and connections to wider networks
- › Remember that different topography can cause constraints
- › The institutional arrangements – the history, the politics, also act as constraints as to what can be done.

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UNDERSTANDING DEMAND

Remember that the journey on vehicle is a small part of public transport travel and the traveller is concerned with the whole

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    graph LR
      Start --> Travel[Travel to stop]
      Travel --> Wait
      Wait --> Board[Board vehicle]
      Board --> InVehicle[In vehicle travel]
      InVehicle --> Alight
      Alight --> Finish[Finish Journey]
    
```

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