STRATEGIES FOR SYSTEM CAPACITY ENHANCEMENT

By

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Introduction

Underlying the proposed upgrading of many city's rail system is the objective of utilizing the assets of the existing rail system to greater and better effect that they are currently. Demand for major transport corridor travel is forecast to increase and a significant portion of that increase is required to be carried via rail transportation. As usually the sole future provider of this type of service, Government through its agencies must develop an effective strategy to deal with such growth. In this section, the broad strategies available to deal with growth are canvassed.

As the purpose of a passenger railway is to shift people from place to place, the ultimate relevant measure of railway capacity is passengers per hour transported rather trains per hour, though the latter is a appropriate interim measure for considering the performance of certain system elements such as signalling.

It should be further recognised that rail corridors are obviously not necessarily homogeneous along their length neither in terms of their capacity to transport people nor in terms of the capacity demanded of them throughout their length. While demand tends to increase continuously, capacity increases in a step wise fashion. This applies in two dimensions Firstly, along each corridor demand as measured by passengers on board progressively increases towards a city's CBD while capacity can only increase in steps by virtue of, for example the number of trains operating or the number of tracks available. Secondly, the demand for rail travel over the metropolis increases (or decreases) continuously whereas total system capacity to move passengers is increased in major increments as new rail lines are added into the system. However, in a metropolitan system there are practical limits to the way capacity can be increased. For example, it is generally impractical on a metropolitan railway to increase the number of cars per train part way along a corridor.

In the section which follows, the broad options for managing capacity on the system are outlined followed by discussion of the general parameters which influence the ability of the system to deliver passengers. These broad options include:

- Manipulative or 'Political Will' Solutions;
- Managerial Solutions;
- Operational Solutions;
- Infrastructural Improvements;
- Alternative Modes;
- Tactical Solutions;
- Strategic Solutions.

These solutions are most commonly thought of in circumstances where capacity is constrained rather than where new additional infrastructure can be built.

Options for Managing Capacity

Manipulative or 'Political Will' Solutions

Governments generally have powers which, in theory at least, could prevent such growth in overall long haul corridor transportation demand from taking place in the first place. That is by restricting urban development and population growth in places which might lead increased demand on the rail system with the objective of capping demand for rail transportation to the level which an existing railway is able to provide with the current infrastructure, operating system and organization. Such powers are normally held by the Government and City Councils through various pieces of legislation concerned with regional and CBD planning.

The success, however, of governmental intervention in influencing such demand over the longer term, even in centrally planned economies, is poor, with such demand being driven relentlessly by market forces. If travel patterns in a city follow those elsewhere then there would be a shift to public transport modes and in particular rail as urban intensification takes place along rail corridors.

Therefore, there appears to be little likelihood that such powers that do exist would be used in any event by government to actively diminish demand for rail transportation task although realisation of different futures for corridor urban and CBD development could significantly alter the scale of the task.

Given the cost of new infrastructure and the likely absence of political will solutions to diminish demand for rail transport obtaining the maximum performance from the assets already in existence assumes a yet higher imperative.

Policy will in any event potentially be the converse – that is to use political will solutions to promote regional growth strategy along transport corridors and .in the form of travel demand management to actively promote corridor travellers to switch from car mode to public transport.

Managerial Solutions

Within the context of an existing operating system there are several ways in which the managers of the system can respond to increasing demand. Some examples follow.

One obvious way is to adjust prices for the service to keep demand at the level which can be accommodated without further investment. This is a classical response in a market economy but not one which is generally considered appropriate by government where a public sector monopoly exists. However, often state based (and even privatised) rail agencies do not have much ability to manage demand by pricing as the cost of rail travel is a matter which is politically controlled.

Another way is to allow the standard of service to decline, for example by ensuring that every train operates at 'crush' capacity. It is unlikely that this approach would be favoured by users who would express such dissatisfaction through the political process.

Re-timetabling may allow capacity to be assigned to provide it when it is needed most. This generally results in a less frequent level of service for lower demand stations, which is then interpreted as a decline in the standard of service by users.

Management of demand could also be attempted such that the peak demand passenger volume is spread over a longer period. To achieve this may require incentives in the form of fare differentials during the overall peak period to encourage users to travel earlier or later. This approach has been used to encourage non-peak usage. but may be difficult to implement with, say, a 3 hour peak period.

Operational Solutions

There are numerous elements of an operating railway system which have a bearing on the capacity of a passenger rail system as is outlined below Currently, for example, Sydney Trains in NSW believes it is impractical to reliably operate the system beyond 20 trains per hour per track, (and in places 18 trains /hour) although historically the system has operated at higher levels.

For example, improvements to signalling systems and track conditions may possibly enable higher capacities than current to be achieved within the rail network, since other factors are essentially fixed for the existing system.

On discrete sections of the RER in Paris, however automated train control systems allow up to 30 trains an hour to reliably operate.

Infrastructural Improvements

Depending upon which part of the overall system is constrained, there may existing the possibility of achieving the required increase in capacity by making discrete improvements to selected elements of the system.

For example, congestion at stations could possibly be relieved by remodelling of the station to facilitate the movement of passengers on and off trains and generally through the station's concourses, ramps and stairs. This may yield better utilisation of existing levels of train service reducing the need for additional trains.

Track congestion may be able to be alleviated by new localised construction such as:

- Provision of additional tracks;
- Provision of new crossovers to permit rebalancing of capacity;
- Augmentation of existing flyovers to enable greater shifting of traffic from side to side of existing track work;
- Introduction of grade separations to removing conflicting train movements;

The purpose of such localised improvements is to enhance the performance of the existing system as economically as possible.

Alternative Modes

In addition to using various forms of rail based alternatives, the possibility is often raised of using non-rail based modes to performing an equivalent function. Obviously, adoption of a non-rail mode automatically introduces the requirement for passenger interchanging. It also usually involves the utilisation of corridor space which might other wise be allocated to rail.

Alternative modes can take a wide form and range from low capacity modes, e.g. taxis to high capacity modes such buses and yet higher modes such as light rail rapid transit.

Alternative modes generally will generally only find application in shorter and more densely populated corridors and effectively be an infilling of the major transport corridors modes.

Tactical Solutions

For the purpose of this study, a tactical solution is considered to be one which is a major response to providing more capacity in a specific region of the system, but which does not greatly change the nature of the way the system operates overall.

Thus, tactical solutions are typically regarded as "battlefield" actions which attempt to solve particular problems directly and do not attempt to deal with the problem in a wider context which could result in the problem being removed altogether.

Strategic Solutions

Strategic solutions are considered to be solutions which in contrast to tactical solutions, result in fundamental changes to the whole system such that major but localized problems are alleviated indirectly -for example, new regional railways which change the pattern of flows between sources of passenger growth and their destinations.

Strategic solutions not only have the capacity to deal with system problems by changing the structure of the system, but also have the potential to change the patterns of flow such that the way the system is used also changes, for example by facilitating new travel paths and inducing new demand for rail travel.

Good examples of strategic solutions in Sydney are the Airport Rail Link and the Parramatta Rail Link, both of which contribute to alleviation of capacity constraints in parts of the existing system while opening up a range of entirely new ways to operate the system and travel opportunities for users.

A wholly new rail corridor in Sydney would be a strategic solution - if it both provided a new pathway into the CBD for existing passengers thereby freeing up capacity on other corridors and also creating new rail travel opportunities.

A generalized model for passenger delivery capacity of railways

The passengers able to be delivered by a city's rail system is a complex function of the city's geography, population characteristics, the physical characteristics of the rail system and the operational characteristics of the railway system

This can be described in parametric form as in the relationship which follows. Each of the parameters is commonly used to benchmark the performance of cities and railways in them as described elsewhere in this report.

Passengers delivered = fn {A*B*C*D*E} where:

A= {City Area * (Corridors/City Area)* (Tracks/Corridor}

B= {(Trains/Track) * (Cars/train)}

C= {(Passenger seated capacity/car)*(Total Passengers per car in peak hour/Passenger capacity per car)}

D= {(All day Passengers/Passengers per peak hour) *(Corridor Rail Passengers per peak hour/Total Corridor Travellers)}

E= {(Corridor Travellers/Corridor population)*(Corridor Population/Corridor Area)}

This is not intended to necessarily be a formal mathematical equation – though it can – but to illustrate those parameters which influence the ability of a rail system top deliver passengers and to form a paradigm for considering the question of asset utilisation. These can be grouped into four main areas:

City Geographic Structure Characteristics

These parameters reflect both the degree to which railways have been invested in as a means of providing mass passengers transportation and the degree to which the current and future residents of that city enjoy a legacy of assets from the past.

- Corridors/City Area– the number of corridors, their density and their spatial distribution in the city obviously determines the accessibility of rail to the travelling public;
- Tracks/Corridor – the surface corridor held by railway owners is the major network asset not the infrastructure upon it in the case of an existing railway. The ability to insert additional tracks easily is obviously a major source of capacity expansion.

Railway System Characteristics

These parameters are at the core of this study. They reflect not only the engineering capacity limitations but also the operating limitations and opportunities. That is to say utilization of the existing assets is governed not only by absolute engineering factors but also by the manner in which the system is run by its operators and is used by its patrons:

Trains/track is a complex function of, inter alia:

- railway geometry;
- system complexity (e.g. flat junctions)
- signalling and control;
- power systems; track condition;
- station spacing; car design;
- station dwell times;
- stopping patterns;

Dwell times themselves will be influenced by station design and passenger management within stations. Practical limitations are typically set on the number of trains per track per hour than are operated to ensure that the system operates without delays, operates to the timetable and meets all required safety considerations.

Railway Vehicle Characteristics

Railway systems are not just the assets below rail and not just the vehicles above but a complexity of both. Unlike most road vehicles, rail vehicles are designed and built closely to their planned duty conditions. The following parameters measure the performance of the rail vehicles

- Cars/train – the ability to lengthen and shorten trains is one of rail's major advantages in managing capacity requirements. However, practical limitations exist in terms of existing station length for lengthening trains to gain system capacity
- Passenger capacity /car – rolling stock design can vary widely and both the capacity to transport passengers and the relative attractiveness of rail to passengers is affected by this ratio;
- Total Passengers per car in peak hour/Passenger capacity per car – this ratio reflects the service offered by the rail operator to its passengers. A limit on crowding beyond seated capacity will be set both for safety and for comfort reasons;

The design of rail vehicles also has a crucial bearing on station dwell times as a result of their inherent door loading and unloading rates.

Mode Attractiveness

This group of parameters reflect the attractiveness of rail as a mode of transport

- All day Passengers/Passengers per peak hour – this ratio reflects the daily distribution of passengers and given transport agencies tendency to plan for peak periods the peak hour forecasts and actual passengers per peak hour data is often more available than all day data.
- Corridor Rail Passengers per peak hour/Total Corridor Travellers per peak hour – this ratio reflects the mode split between rail and other modes of travel in the corridor – clearly this may be different in different corridors reflecting the relative attractiveness of rail viz. a viz. other modes

Population density and travel behaviour

This group of parameters reflect the way population is distributed within the city and the populace's overall degree of travel along that corridor.

- Corridor Travellers/Corridor population – this ratio reflects the propensity of corridor residents to travel in the corridor and obviously may vary from corridor to corridor;
- Corridor Population/Corridor Area – this ratio reflects the density of the city along the particular corridor, which may vary from corridor to corridor and fact vary along the length of the corridor itself.

These parameters are relevant to the overall nature of a rail system that a city has. Rail is not a “random access” transport device that permits a very high degree of mobility and degrees of freedom. It is a high capacity bulk transport system servicing concentrated populations along very specific linear corridors, generally with diffuse origins and highly concentrated major destinations in the morning peak and vice versa in the evening peak for journeys to and from places of employment and education.

Spreadsheet model

Using the basic parameters as described above the following simple spreadsheet model can be constructed to estimate the delivery capacity of rail corridors in a city.

While this many not tell an experienced rail planner a great deal, it is valuable a as device to assist decision makers understand the many complexities and factors which bear on the ability of a rail service to provide the level of service they are seeking to deliver to customers.

An important issue for any city is the manner in which rail serves or does not serve its populus by virtue of there being a rail corridor in sufficient proximity. The number of corridors per head of population is therefore a key parameter as is their special distribution.

Key Points

- The ultimate relevant measure of railway capacity is people moved per hour rather than trains per hour though the latter is a component of achieving the former;
- Capacity generally is provided in a stepwise fashion both in terms of quantum and in terms of timing;
- Theoretical maximum capacity is a given section of rail corridor generally is tempered by practical considerations which may occur outside that section;
- There is a range of options to manage and/or enhance capacity – from discouraging patronage growth via limitations of employment growth to building more railways. This study is mostly concerned with options which extract the maximum perform from assets that exist.
- The passengers able to be delivered by a rail system is a complex function of the city’s geography, the population characteristics and the physical and operational characteristics of the railway system itself;
- A simple model can be valuable in assisting decision makers to understand the complexities and decisions that must be made in planning a rail operation. More importantly the effect of having an adequate number of rail corridors to serve the city can be explored.

Brisbane Rail Network Upgrade - Generalised Rail Corridor Capacity Model

Data

Population	1.6	Operating Hours/weekday	16
Number of Actual CBD access Corridors	6	Operating Hours/weekend day	16
Tracks per Corridor (avg)	2	Av Weeks "normal operation" per year	50
Max Track Capacity	20	Av. Trains per peak hour	20
Cars per train	6	Av. Trains per non-peak hour	2
Seats per car	80	Av. Trains per weekend hour	2
Peak Crush Factor	1.1	No of peak hours	2
Off Peak Crush Factor	0.4	Weekly/Weekday Service Factor	5.9
Seats Turnover Factor	1	Weekly to Yearly Service Factor	0.96

No. of Required Corridors	**7.0**	**Week day Train Services Provided per track**	**68.0**

Annual Passenger Delivery Capacity of Rail =

City Size		Penetration of Rail per Million head of Population		Corridor Capacity	
Population	X	No. Corridors / Population	X	Tracks / Corridors	X
1.60		3.75		2	

94,450,447

Daily Track Capacity		Train Size		Train Capacity		Average Crush Factor	
Max Trains/day / Track	X	Cars / Train	X	Seats / Car	X	Seated +Standing / Seats	X
320		6		80		0.812	

Seat Turnover Factor		Daily Track Capacity Utilisation Factor		Weekly/Daily Service Factor		Annual Service Weeks
Times Seat Occupied per trip	X	Total Trains per day Operated / Max Trains/Day	X	Total Weekly Trains / Total Weekday Trains	X	Equivalent "Normal" Weeks Per Year Operated
1		21%		5.9		50