PRACTICE REVIEWS IN PEAK PERIOD RAIL NETWORK MANAGEMENT: SYDNEY & SAN FRANCISCO BAY AREA

32nd Australasian Transport Research Forum (ATRF), Auckland New Zealand, 2009

Chris Hale and Phil Charles[1], Centre for Transport Strategy
The University of Queensland, Brisbane, Australia

Abstract

The paper reviews current rail peak demand management approaches in Sydney and San Francisco through a practice review approach.

Sydney and the San Francisco Bay Area offer two cases in the management of rail passenger demand in peak periods and beyond. By reviewing a range of strategies in use and under consideration, a broader picture emerges of the potential options and solutions available.

In Sydney, certain lines are facing challenging peak-period scenarios, in which the rail system is severely overcrowded and perhaps unable to deliver greater capacity without major infrastructure upgrades. The paper reviews the state of practice in Sydney - tracking the peak demand problem and considering the management, pricing and communication strategies that are currently in place and emerging.

In San Francisco, similar scenarios of peak-capacity are faced, with infrastructure bottlenecks at critical locations and potential operational constraints on the horizon in a region with a growing population.

From these case study examples, suggestions are drawn for a suite of strategy options to assist transport agencies and rail operators to address peak demand issues through a managed and structured approach.

Keywords: transport planning, rail demand management, peak period, crowding, mass transit capacity, Sydney, San Francisco, BART

Acknowledgement: *This paper was produced under Project No R1.107 Urban Rail Demand Management Strategies funded by the CRC for Rail Innovation (established and supported under the Australian Government's Cooperative Research Centres program). The authors would also like to thank staff members from RailCorp and BART for their assistance. The paper is undertaken as an independent review, and the views expressed are those of the authors*.

INTRODUCTION

This paper reviews current and emerging practice in the management of passenger loadings in two major suburban/metropolitan passenger rail systems, both of which are symbols of rail transit in their respective countries. In seeking to understand the practices and approaches, the analysis is structured to review the following key areas in rail demand management:

a. Describing the peak period and its problems
b. The configuration of the two rail networks and the role of network layout in rail congestion
c. Fare structures and ticketing

This analysis frame is primarily derived from the literature review of Hale and Charles (2009).

By looking into the manner in which the peak period is described, we begin to understand the way transit agencies and other related stakeholders are approaching the issue of passenger demand variability over time. The next step is to then characterise the nature of peak period demand-related problems currently encountered in the rail network.

Reviewing the network configuration of a particular rail system assists in understanding how particular pressure points and corridors or stations of heavy demand relate to the wider network. We can also begin to understand whether the current passenger rail network may be a contributing factor to excessive passenger loadings and other challenges being experienced, and possibly then identify cost-effective solutions in planning, service-provision and network expansion to address current problems.

---

[1] Chris Hale is a researcher and Professor Phil Charles is Director of the Centre for Transport Strategy, School of Civil Engineering, The University of Queensland

Fare structures and pricing approaches are logical points of interest in a demand management approach, and classic economic theories point to the need for "efficient pricing" in transit service provision. The extent that current pricing regimes are accounting for key components in the cost structure of service provision is of interest. Fare structures and their logic are reviewed here. Ticketing technologies are a related issue and there can be no move toward "efficient" (yet inherently complex) pricing structures in the absence of ticketing systems that allow this to occur. The paper briefly reviews the manner in which prevailing ticketing technologies may be aiding or hindering potential moves toward more effective fare structures.

This paper was written as an attempt to analyse practice based on readily available information – most of which was public domain material, with assistance from key contacts in Sydney's RailCorp and San Francisco's Bay Area Rapid Transit (BART). Any limitations on analysis or gaps in understanding of peak period and demand management practice in these systems reflects the availability of information on this topic. The paper represents early-stage research in this field.

SYDNEY 1. DESCRIBING THE PEAK PERIOD

To understand issues and challenges currently being faced in Sydney in managing passenger loadings, this section reviews the definitions and descriptors of the "peak period" in use. Problems of station and train capacity, as well as capacity constraints in the system as a whole are discussed along with the way capacity issues are tracked and managed.

Definitions and descriptors in use

There are a variety of definitions used to portray the time-span of peak periods in Sydney. Recent research for RailCorp into peak period management has used the following descriptors for daily demand levels (TNS 2008a 2008b):

Pre-morning peak	4am – 7.15am
Morning peak	7.15am – 9.15am
Post morning peak	9.15am – 10.15am
Off peak daytime	10.15 – ?
Pre evening peak	not clearly specified
Evening peak	4pm – 6.30pm
Post evening peak	6.30pm onward

A number of RailCorp documents use different time-based descriptors and naming conventions for peak periods (including a confusion between 7.15 and 7.45 as the beginning of the morning peak). In ticketing terms, the "off-peak" period for the purposes of customer ticket selection is defined as 9am to 4pm[2].

IPART made pricing determinations for tickets referring to 7.00am to 9.30am and 4.00 to 6.30pm peak periods, and have also provided a variety of other "peak period" definitions, including referring at times to the "peak hour" and elsewhere to the two "peak periods" of 6.00 to 9.00am and 4.00 to 6.00pm (IPART, 2008).

The Transport Data Centre (2003) defined the peak as *"…train trips arriving at their destination between 6.00am and 9.30am or departing between 3.00pm and 6.30pm on an average weekday."*

Formalising the definitions for the peak and other periods may be a simple, yet important step that could be taken in the interests of effective analysis and as a foundation response for peak period management.

Station capacity problems

Without commenting on the actual capacity of particular stations in the Sydney network, a review of relative passenger loadings at CBD stations provides an indication of the locations which are experiencing peak period challenges. Doggett et al (2004) identified that three CBD stations; *Central, Town Hall and Wynyard*, are carrying 23%, 25% and 24% of all CBD-bound morning passengers respectively and handle similar levels of patronage in the afternoon peak. The primary reasons behind the concentration of passengers into these three locations seems to be:

- convenience according to their dominant positions on the rail approaches to the CBD, and

[2] www.cityrail.info/fares/day_tickets accessed June 2009

- quality of pedestrian access and relative proximity to popular CBD work destinations

By contrast, other CBD stations seem to suffer from a poor position in the network relative to preferred destinations or origins. Research by Doggett et al identified that Sydney's CBD stations are dominated by walking as the preferred access and egress mode, and that convenience of access or egress is a determining factor in station choice. It seems that *position* in the CBD and on the rail network is leading to heavy loadings in particular locations, but a potential opportunity to balance out passenger loadings at CBD stations may lie in *targeting pedestrian infrastructure* to reposition the pedestrian convenience and relative attractiveness of less trafficked stations.

"*Long term strategic rail demand forecasting in Sydney has ... suggested that the Sydney Rail system is unlikely to be able to accommodate forecast patronage growth for the year 2021 without additional rail capacity through the Sydney CBD.*" (Doggett et al 2004, p3) Along with other aspects of capacity-expansion and demand management, re-addressing the role of particular CBD stations, both overloaded and underutilised, seems to be an essential step in facing future challenges related to passenger growth.

Customer research by TNS (2008b) identified that a majority of surveyed passengers see *platform crowding* as a significant problem in the Sydney network – with 39% of all surveyed passengers suggesting it was a "very big problem" and another 27% categorising this as a "big problem". Overall 73% of all surveyed passengers described platform crowding during peak periods in negative terms, and as a "problem" to some degree or other. Other sources have also pointed out that crowding is an identified issue of importance to passengers (IPART 2008).

Train capacity problems

CityRail works to a benchmark of *135% of official seating capacity* as a definition for undesirable levels of crowding. The *acceptable* level of overcrowding instances against this benchmark is for only 5% of peak trains to be carrying passengers beyond this level. It was observed that CityRail is currently not performing against this self-imposed target (IPART, 2008).

Customer research by TNS (2008b) identified that surveyed passengers were seeing the experience of *crowding on trains* in Sydney in strongly negative terms. Some 53% of all respondents replied that train crowding during the peak was a "very big problem", with an additional 37% painting the issue in negative terms (either as a "problem" or a "big problem").

Since 2004, peak period conditions on the CityRail network have seen an ongoing and steady upward trend in crowding. At this stage is appears clear that CityRail is not able to meet benchmarks and standards on tolerable crowding – with between 13 to 16% of peak services overcrowded. Focus group exercises run by IPART have also identified crowding on trains as a major issue among stakeholders that significantly contributes to perceptions of "poor service" in the CityRail network (IPART 2008).

Overall crowding on trains is a significant issue for CityRail and for rail travellers in Sydney – as well as for the broader community, as service provision in mass transit is a key component of overall urban liveability. If significant numbers of workers, commuters and other travellers are experiencing overcrowded trains, this is seen as a distinct negative for quality of life. High levels of crowding are problematic in mass transit provision terms. Identified problems can include: deterioration in reliability of services, inability to cater to new passengers, poor image for the system/agency, strains on existing infrastructure, and safety-related issues.

System capacity constraints

Brooker and Moore summarise the constraints currently faced by the Sydney commuter rail system after a number of consecutive years of patronage growth: "*On most lines leading into the Sydney CBD, the high level of crowding of peak hour train services, which is now typically 100-150% seated capacity…, combined with the limited time for which passengers are prepared to stand while travelling on trains, means that effective growth in peak hour rail passenger travel is now only possible from areas within "standing commuter" travel distance from the Sydney CBD*." (Brooker and Moore, 2008 p9) The problems associated with existing and emerging system-wide capacity constraints were also identified by IPART (2008, p8), who put forward a view that patronage growth "...*will moderate over the determination period due to uncertainties surrounding growth in CBD employment and CityRail's future capacity constraints*."

Line capacity

Slow travel speeds are quoted by IPART (2008) as an identifiable problem, and it might be surmised from this issue that a combination of older technologies and approaches in the interface between tracks, rolling stock, operating regimes and signalling systems are contributing to the capacity constraints of the Sydney system. Any moves to address and improve system capacity will need to look at moving more trains over the same infrastructure. This generally involves using advanced technology, especially in signalling, but also through operational approaches to allow running at higher speeds which aids the provision of greater capacity along specific lines.

Tracking and managing of problems

Overall, Sydney has a rail system which is reasonably heavily oriented toward peak period travel to the CBD. In 2003, some 61% of *all* passenger rail travel occurred during the weekday peak periods, according to the Transport Data Centre (2003).

IPART (2008) identified a need to provide greater specificity for performance standards in the CityRail network, noting that while a variety of important performance characteristics are tracked and monitored, these standards are not currently part of the funding relationship between CityRail and the NSW Ministry of Transport, and there is no public reporting of performance on a range of measures. It is generally recognised that reporting openly on performance against accepted standards is a key component of moving toward better service outcomes and toward improved effectiveness.

IPART suggest that a lack of clear service standards results in a "status quo" outcome on service-provision aspects, including crowding and capacity and there is also the potential for standards to *deteriorate* under current arrangements. New service standards and reporting recommended by IPART include capacity and crowding benchmarks. (IPART, 2008)

IPART suggests that the potential for continued strong growth in patronage would lead to "…*less need for fare increases*". "…*In general, a higher patronage growth forecast will lead to lower fare increases, because the revenue requirement can be recovered from a higher number of ticket sales*" (IPART 2008, p84). This raises a number of issues: (a) it does not account for any need to move CityRail into a stronger operating ratio position over time; (b) assumes no significant improvement in service levels to meet greater demand (which effectively equates to a deterioration in service standards); and (c) does not address the reality that meeting peak demand levels in an already-strained system will most likely require expensive infrastructure-based measures and initiatives (placing greater demand on financial resources).

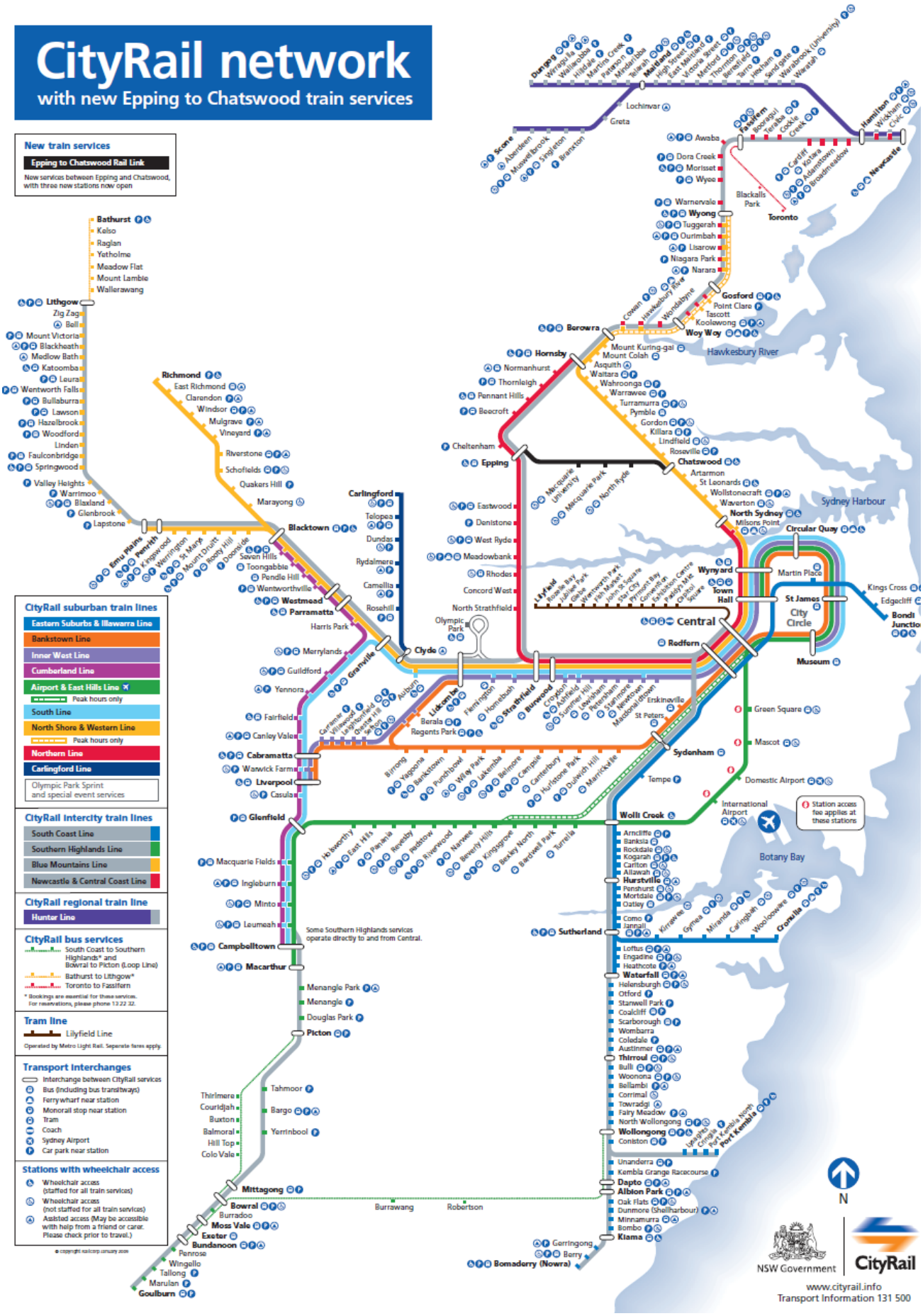
While CityRail tracks peak-period demand and related issues, their public reporting might be improved, which may lead to better management of the issues over time. It also seems that pricing of tickets and the overall business/subsidy structure of CityRail needs to be re-oriented from the current position that "crowding is OK, because we squeeze more revenue out of the existing system". This thought process is common in Australian, Asian and North American cities, but not accepted in European cities, where successful rail management involves *avoidance* of overcrowding and a clear understanding that overcrowding represents service *deterioration,* which is not beneficial to mass transit outcomes overall.

SYDNEY 2. THE CURRENT RAIL NETWORK AND ITS ROLE IN CONGESTION

It is important to see rail networks as evolving infrastructures, rather than as a constant set of corridors, lines and stations. By understanding the network configuration, we can begin to identify where and why constraints and pressure points have emerged, and may even begin to understand how a planning approach that responds to emerging challenges can assist in overcoming issues.

Network Configuration

Sydney has evolved a *radial* passenger rail network – focussed on the central business district as the dominant destination and origin and offering limited opportunities and attractiveness for rail journeys that do not involve a journey to the CBD, or a transfer at a central location.



Picture: CityRail network, courtesy CityRail

With around eight suburban lines converging into the CBD at Central station, Sydney offers only limited transfer opportunities in middle and suburban areas, and does not offer "grid-style" network elements or a completed orbital circulation element at this stage.

The CBD remains the destination and origin of choice, the key travel generator for rail. While significant loadings occur in secondary centres such as Parramatta and the North Sydney area, overall the metropolitan region has not developed into a polycentric schema – and this land-use outcome is reflected in the relatively constrained set of rail corridors in current operation.

In the CBD, three stations dominate passenger numbers, and the "loop" in central areas (comprising Central, Town Hall, Wynyard, St James and Museum stations) is not necessarily providing a balanced "passenger spreading" role. The radial nature of Sydney's rail network is probably influenced by the dominance of rail as a commute mode to central city locations. "*Over half of CBD commute journeys are undertaken by CityRail*." (IPART, 2008 p87)

Planning Responsiveness

The Sydney system is currently scrambling to catch-up on recent rates of passenger growth, with all of the current capacity-increasing measures under implementation likely to be exhausted by around 2012 (IPART 2008).

Australian cities and their rail networks have been notable for their planning stasis over recent decades and it appeared that expansion of rail networks and infrastructure was off the agenda throughout Australia during most of the 1980s and 1990s. Sydney can be seen as an exception, having opened new lines during the 1990s and early 2000's – in the Airport and Epping-to-Chatswood lines respectively. The new suburban Epping to Chatswood link is part of an emerging "orbital" network component. It perhaps represents a strong case that work has already commenced toward beginning to address the "CBD-centric" nature of Sydney's existing network. Similarly, while the Airport line terminates in the city, the connection to the airport as a significant non-CBD travel generator in its own right is a worthwhile step toward a more polycentric network layout and travel-generation paradigm.

Equally, the sustained emphasis on planning and development of alternative centres such as North Sydney and Parramatta has been reasonably successful over time and has added important travel *generators* to the rail system. Perhaps these initiatives provide clues for future demand-balancing efforts in the long-term regional planning paradigm. A series of recent proposals for "metro" style inner-urban lines also offers the possibility of a future in which Sydney's important inner suburbs are more effectively served with mass transit infrastructure.

Less clear is the path toward relief for Central, Wynyard and Town Hall as the overloaded city centre stations. No proposals are evident which specifically address the issue of passenger concentrations and capacity issues in these three locations – either in the form of new lines and stations in central areas to relieve pressure, nor in the form of substantial design efforts and works to improve the capacity of existing facilities.

In summary, Sydney has positioned itself as a leader in Australia in terms of relatively high levels of travel by urban rail, and through contemporary efforts and planning activities oriented toward corridor expansions and improved network diversity. But at this stage, the specific problems of CBD capacity and "funnelling effects" into a limited set of centrally-located station choices both remain as issues to be addressed in ongoing planning and infrastructure development.

Where to from here?

IPART (2008) suggests that 80% of all capital investment is being targeted toward meeting peak demand pressures. A more proactive approach may see a shift away from catering to peak period pressures in existing corridors through capacity enhancement, in favour of building new corridors and travel options that take pressure off current choke-points and overloaded network components. The Epping to Chatswood link is an example.

IPART suggests that moves toward a more responsive and proactive planning and network development posture are ultimately predicated on establishment of more efficient fare structures:

> *"A cost-reflective temporal structure should encourage prudent investment in the network because it should create a more transparent link between increases in peak fares, and capital expenditure incurred by CityRail to expand the capacity of the network to meet peak demand." (IPART, 2008 p121)*

SYDNEY 3. FARE STRUCTURES & TICKETING

A key component of delivering efficient services in public infrastructure is the extent to which pricing structures reflect the cost of service provision, balance levels of demand with available supply, and provide clear pricing signals that encourage realistic choices from customers and service-providers. Choices that do not overburden a network or system.

Farebox recovery

The farebox recovery ratio (ratio of ticket revenues to running costs) for CityRail is estimated at around 24%[3], which is low compared to high-performing international cities and systems. This scenario presumes a high level of dependency on state subsidies, and allows limited opportunity to plan boldly for new infrastructure, network development and service improvements.

New responses to peak overcrowding could reasonably be expected to revolve around offering improved services and expanded infrastructure while *seeking greater revenue from peak period passengers*, who generally have the willingness and ability to pay extra for improved services. This potential path could assist in meeting current and futures issues, while making few new demands on the level of government subsidy.

Pricing Structure

Fare structures in Sydney are primarily determined by distance and time of day.

> *"IPART maintains its preliminary view that a distance-based fare structure comprising a flat flag-fall charge and a variable distance charge is most appropriate for CityRail. It considers that this structure is the most cost reflective option. The flag-fall charge can be set to reflect the fixed costs of providing the CityRail network, and the distance-based charge can be set to reflect the variable costs of providing the services. This means that the overall fare for a particular trip is closely tied to the costs of providing that trip." (IPART 2008, p112)*

On the issue of time-of day pricing, IPART determined:

> *".. that return distance-based tickets that are purchased for use in the off-peak period will be discounted at 50 per cent, and that these tickets may be used on any regular CityRail service in the off-peak period, with valid usage times limited to services that are scheduled to arrive at Central before 7 am or after 9.30 am; to depart Central before 4 pm and after 6.30 pm; on the weekend or public holidays." (IPART 2008, p108)*

IPART's rationale behind the determination indicates:

> *"…the fare structure should:*
> - *better reflect the extent to which demand for peak-period services to and from the CBD is driving the need for investment in additional capacity to alleviate congestion*
> - *better reflect the significant excess capacity on the CityRail network during off peak periods (such as weekends) and on some parts of the CityRail network during peak periods."* (IPART 2008, p119)

The most significant outcome of the recent review process for the CityRail fare structure seems to have been the move toward a standardised 50% discount or differential for off-peak travel compared to peak prices. This widens the gap between peak and off-peak ticket prices from the previous 30% differential, and is achieved through a combination of increases in peak ticket prices, plus discounting off-peak fares. All of this is undertaken within a "revenue positive" fare revision process that also incorporated a greater emphasis on efficient pricing of distance travelled (IPART 2008).

It is worth noting that the pricing of various travel options through CityRail fare structures is reasonably complex and suggests that electronic ticketing could play a role in delivering better ease-of-use at the same time that efficiencies through highly differentiated fare structures are being pursued.

---

[3] Using 2007/08 forecasts in IPART (2008) around $605m was contributed through CityRail farebox revenues, with approximately $2.5b in operating costs (includes some level of capital-related costs)

How does pricing relate to revenues and costs?

IPART nominate expected 2008/09 fare revenue at around 28% of costs and while it has been suggested that the level of subsidy for CityRail is determined by an objective assessment of the broader economic value of CityRail to the community (IPART, 2008), the overall impression is that the subsidy is simply the "left-over" costs that fare revenues do not cover.

CityRail's fare structures seem to be in a transition phase, toward more rational and commercial approaches to revenues, costs and fares. Certainly there seems to be little support at the moment for increasing fares substantially to fundamentally reposition the financial profile and operating ratio of the business, or as a strong tool to address peak period crowding, or for funding peak-related pressures for expanded capacity. Concern for a range of community impacts and political challenges are seen as constraints toward a full evolution in the funding model, with IPART taking an initial view that a robust fare increase of around 20% over three years was warranted, but in the end settling for a 12% determination after encountering stakeholder resistance (IPART 2008).

Determining Fares

> *"...IPART has determined that CityRail's annual revenue requirement should include efficient operating costs, a return of capital or depreciation, a return on capital and a return on working capital." (IPART 2008, p32)*

IPART has determined to include some capital costs in structuring revenue/ticket pricing levels and the overall financial model in place.

> *"Creating a transparent link between the size of CityRail's revenue requirement and the level of fares* (is important)*. For example, once IPART decides what share of the revenue requirement is to be funded through fares, any increase in this revenue requirement due to an increase in operating or capital expenditure by CityRail will lead to an increase in fares. This link should signal to stakeholders that service improvements involving significant capital investment (such as extending the network or upgrading rolling-stock) are likely to entail significant fare increases. These increases can then be taken into account in assessing any proposed service improvement projects." (IPART 2008, p35)*

One notable point of departure from the move toward more rational and efficient pricing is the determination to continue supporting discounts for regular passengers purchasing weekly or other extended-period passes (IPART 2008).

Ticketing technologies

IPART's fare structure determinations refer to the looming introduction of smart-card ticketing in Sydney, and the current pricing determination has been couched in terms of its relevance and applicability when smart cards are introduced (IPART 2008).

There are a number of carry-over issues where paper ticketing seems to be limiting the application of efficient and equitable fare structures in the interim period prior to the mooted introduction of smart cards. One example is the "TravelPass" suite of products, which allow and encourage complex multi-modal journeys for pass holders. The restrictions of paper ticketing mean that encouragement of integrated journeys requires an all-modes unlimited-travel pass. Such tickets are unable to incorporate efficient charges based on distance travelled and other considerations. IPART has determined to retain these ticket products until such point as smart cards supersede the limitations and constraints that paper tickets place on multi-modal transit travel (IPART 2008).

Where to from here?

Overall, Sydney appears to be a network undergoing a transition to a future where principles of efficient pricing play a much greater role over time – and more transparent links are in place between fare determinations, revenues, costs, patronage and demands for service expansion and improvement. IPART have also made wide-ranging recommendations toward improving the governance, accountability and quality of reporting for CityRail. These measures are suggested to include stronger analysis of key performance metrics, including those related to patronage levels and the customer experience.

> *"IPART has made a draft decision to recommend that service standards be incorporated into the regulatory framework … between RailCorp and the Minister for Transport, so it*

becomes an effective service agreement. …This includes (among other things) the following recommendations:

- *… clearly specify performance targets for both the quantity and quality of service CityRail is required to provide*
- *the Government monitor and evaluate CityRail's performance in meeting these targets." (IPART, 2008 p22)*

Ideally, standards, monitoring and evaluation should incorporate tracking and responsiveness on demand-related issues like overcrowding on trains, stations, and the overall system.

SYDNEY 4. SUMMARY OF STATE OF PRACTICE

CityRail is a lead industry partner in the CRC for Rail Innovation project on Urban Rail Demand Management Strategies aiming to scope out the scale and nature of crowding and other peak period problems experienced by passengers, and looking at strategic options that may be available in the realm of demand management.

Customer survey-based investigations into passenger perceptions and needs in peak period travel were undertaken during 2008 (TNS 2008a, 2008b). This demonstrates a determination at CityRail to come to grips with these issues and challenges. A brief summary of issues identified through those investigations include (TNS 2008a):

- The strong role of "routine" in maintaining passenger's choices to continue peak-period travel. There are narrow daily windows in which passengers generally travel
- Currently only limited incentives or momentum for passengers to begin travelling in non-peak periods more often
- Workplace inflexibility as a significant barrier to change
- A handful of potential enablers and opportunities to generate beneficial change in travel behaviour are available
- Speed and frequency of train services strongly identified as a potential enabler
- More integrated multi-modal connections as an enabler
- The need for strong efforts in communication on behalf of CityRail to elicit change
- The idea that a *combination* of mutually-reinforcing initiatives is likely to be more effective

In summary, CityRail currently faces significant pressures on peak demand levels and crowding problems. Potential options for CityRail include continuing efforts toward establishing a more responsive planning posture. Increased monitoring and tracking of key demand/supply/capacity metrics may assist in directing effective responses to travel demand pressures. Continued evolution toward a more differentiated and efficient fare structure also needs to be considered, and may hold the potential for fare structures that provide opportunities for increasing fare revenues – which would assist in addressing financial constraints. Options to shift passenger's choice of CBD station may or not be workable. And finally, increased efforts in researching and identifying demand management approaches and techniques seems to provide a way forward, along with continued engagement in understanding the customer experience of peak period travel.

Picture: the new Macquarie University Station, Sydney. C Hale, April 2009.

BAY AREA 1. DESCRIBING THE PEAK PERIOD

The San Francisco Bay Area Rapid Transit agency (BART) is a suburban/metro rail system, which is the most significant mass transit operator in its metropolitan area. BART has recently begun consideration of demand management as a potential tool in facing ridership growth. The following analysis is mainly drawn from BART publications, but also drew on discussion with BART staff, and includes quotes from senior BART staff members on key issues. These were provided expressly for the purpose of this paper.

Definitions and descriptors in use

BART's "Question and Answer" article on new demand management research and initiatives commented on observed ridership flows and related problems: "*Our ridership has a very large, narrow peak that lasts for about a 30 to 90 minute window in both the mornings and evenings."* (BART 2008a) The BART (2007) annual report refers alternatively to a "…*Six hour peak period (three hours a.m. and three hours p.m.)…"* The report does not specify the actual hours during which the peak occurs. As BART is not operating under a peak/off-peak pricing regime, there is no "official ticketing definition" of the peak period in place.

Station capacity problems

The two stations most commonly identified as facing problematic levels of crowding are the downtown San Francisco stations Montgomery and Embarcadero (BART Sep 2008). Val Menotti, a senior planner at BART has suggested that: "*The three issues BART examines for station capacity are a) platforms, b) vertical circulation, and c) fare gates. The constraints on the first two for CBD stations are the cost drivers. Vertical circulation constraints are typically during the AM peak, while platform constraints are typically during the PM peak*."

BART documents seem to imply that these issues are not restricted only to Montgomery and Embarcadero alone (Sep 2008). BART monitors station loadings and makes the information available to interested stakeholders and members of the public through its website. The system's most popular or heavily-loaded stations according to weekday exits are (BART 2008a):

Embarcadero	36,000 exits
Montgomery Street	34,000
Powell Street	28,000
Civic Centre	20,000
Balboa Park	14,000
12th Street Oakland	13,000
Berkeley Downtown	12,000

Perhaps predictably, the top four heavily-loaded stations are in "city" locations (in downtown San Francisco), while a handful of locations outside San Francisco County also carry reasonably heavy daily loadings (including "East Bay" locations such as Oakland and Berkeley). The top four locations seem to be spreading a downtown patronage load of some 120,000 daily exits in an effective and balanced manner. But current discussion is suggesting that the top three are all handling levels of patronage, especially during peak periods, that may be increasingly problematic moving forward with respect to the designed passenger-handling capacities of these stations.

Train capacity problems

BART has identified the configurations of existing trains in its fleet as worthy of attention in responding to recent and ongoing passenger growth. Proposed responses include modifying the internal layout of existing trains, as well as specifying greater passenger capacities in new trains yet-to-be delivered (BART 2008a, 2009b). "*We are in the process of modifying the interior arrangement of cars. The modifications will increase the number of persons who can board by more than 10 percent. We are also preparing specifications and seeking funding to replace and expand our rail car fleet, which is a multi-year effort"* (BART 2008a). An update on this effort suggested BART is moving forward with a $US3.4billion rolling stock replacement program over 10 years and more. "*Goals of the project include accommodating projected growth in ridership while increasing reliability, ensuring rider comfort and minimizing impact on the environment*" (BART 2009b). This effort seems to be focusing on the carrying capacity of individual trains, the

efficiency of passenger loading, as well as the total number of trains in the fleet – especially considering a handful of corridor extensions have been proposed. Under the "project" section of the BART website[4], "*New Rail Car Opportunities, Goals, Challenges*…" are discussed, including the points that:

> *"Perhaps the greatest challenge facing the next generation of BART rail cars is the projected increase in ridership. Forecasts show that the next rail cars will need to handle over 500,000 daily riders - more than double the ridership during most of the 1990's. Ridership patterns are also evolving."*
>
> *"BART's success in attracting riders hinges not only on expanding capacity, but on prioritizing the comfort, convenience, and security of its passengers. Adding a third door to speed boarding and alleviate platform congestion is one way the new rail cars will be re-designed to accommodate more riders. New seating arrangements will explore ways to carry more people and make it more comfortable for both standing and seated passengers."*

BART planner Val Menotti has reiterated that: "For the new fleet, BART is *exploring* three-door cars in order to expedite boarding and alighting and reduce station dwell times."

Line capacity constraints

BART is a relatively new system overall – and trains are running on reasonably high-performance below-rail infrastructure that facilitates maximum speeds of around 80kph. The network is managed using modern train control systems that should facilitate efficient spacing of trains. At this stage it would seem that the speed and spacing of trains along individual lines are probably close to optimised and should not represent a *major* immediate system constraint, nor are these likely to be areas where opportunity for improved performance is particularly compelling.

> *"The mainline Train Control System (TCS) has benefited from recent reinvestment by replacing original subsystems of SORS (Sequential Occupancy Release System), ATO (Automatic Train Operations), and an ongoing program to replace the relay based interlocking equipment with microprocessor equipment. However, the underlying original track circuit and speed control system is beyond its expected life of 30 years. This essential, safety-critical system is identified for replacement within the next six years. Vehicle Automatic Train Control (VATC) receives critical speed commands from the wayside equipment controlling train speed and stopping. This system was developed by in-house staff and has been modified several times over its life. The equipment is beyond its useful life and re-engineering work has begun to bring it to current standards and to improve its performance." (BART Sep2007, p5-12)*

Val Menotti of BART has suggested: "*In the medium- to long-term, BART is moving towards upgrading the train control system to accommodate additional throughput*." While management of line capacity seems to be basically under control, the fact that multiple BART lines are often running on single tracks seems to be a reasonably likely source of capacity constraint however.

System & corridor capacity constraints

"Many of the constraints are in the busy Transbay corridor…" (BART 2008a)

The possibility of looming pressure on the capacity ceiling of the "Transbay Tube" underwater connection between San Francisco County stations ("the city") and Oakland-side destinations ("East Bay") is the most significant capacity-related issue behind current efforts at developing rail demand management frameworks and approaches. It appears unlikely that the tube, with a single track serving each direction, could accommodate significant increases in service frequency beyond the current 15 minute standard peak headway on each line – given that the tube is carrying traffic from four individual BART lines (Richmond-Daly City/Millbrae; Pittsburg/Bay Point – SFO; Dublin/Pleasanton – Daly City/Millbrae; and Fremont – Daly City).

Equally, the station capacity pressures faced at downtown San Francisco locations like Embarcadero, Powell and Montgomery are not only due to their popularity as travel destinations and origins. These stations are handling trains from the four individual lines listed above, and

[4] www.bart.gov accessed June 2009

generally see a train arriving regularly at intervals of between 3 to 5 minutes throughout the peak period. Clearly there is limited opportunity to increase throughput of fully-loaded trains at these important stations beyond current levels without significant infrastructure, systems and operational changes of a longer-term nature.

Tracking and managing of problems

Overall, taking 2007 as an exemplar year, some 57% of all patronage was for peak period journeys (BART 2007). "System utilisation" is listed at only 31% – providing some insight into the overall inefficiencies of heavily commute-oriented railway networks. In BART's case, low overall utilisation of the system seems to be present even at a time when clear signs of peak period capacity constraint are emerging. This points to the dichotomy at the heart of peak-loaded networks.

With an eye to the longer term, BART has a view that crowding and other peak period demand problems will continue to grow. BART is beginning to articulate the idea that demand management is to be increasingly important in future, due to ridership growth pressures such as "…*gas prices, freeway congestion, auto tolling, the need to reduce greenhouse gas emissions, and regional growth*." (BART 2008a). By naming these sources of future demand growth, BART distinguishes itself from other transit agencies internationally and in the United States, who often seem to be adopting a stance that lacks preparedness – on the basis that passenger growth "may or may not occur".

BAY AREA 2. THE CURRENT RAIL NETWORK AND ITS ROLE IN CONGESTION

The BART system consists of three or four primary corridors – with the major constraint of the underwater Transbay Tube a salient feature of network layout. It seems that the layout of the system is a partial contributor to the capacity constraints currently faced.

Planning Responsiveness

"*As part of the Strategic Plan update, the BART Board and staff are now working on BART's vision for the next 50 years in the context of the Regional Rail Plan, which is also being developed to define a rail plan for the broader Bay Area region. BART is currently developing a "Metro" vision that focuses on increasing capacity, metro-like frequency of service, and increased coverage, for example, through infill stations*." (BART Sep2007, p1-4)

During April 2009, BART's Board of Directors resolved to push ahead with a major program of system expansion, including the "Contra Costa" expansion, and the implementation of a people-mover style connection from BART to Oakland airport (BART 2009a). Consideration is also being given to an extension of the Dublin/Pleasanton line. A major extension of the south eastern BART corridors beyond Fremont has been mooted – with a relatively minor extension from Fremont to Warm Springs as an initial stage, to be followed by extension of BART via the East Bay corridors to San Jose and Santa Clara, as well as other Silicon Valley destinations along the way (VTA, 2008). It has been suggested that this project is likely to proceed subject to environmental clearances during 2010, and will utilise the existing Union Pacific railway alignment.

In addition, a range of options for integrating BART's system with the proposed California High Speed Rail (CAHSR)[5] stations and corridors have been raised, with San Francisco and San Jose emerging as likely future inter-modal stations. This would project a future for BART as a metropolitan system supporting and integrating effectively with a major regional/intercity high-performance rail tier. This possibility represents a paradigm change in the nature of the future network.

Potential Transbay Tube duplication is under discussion and consideration, without extensive formal planning being pursued in the public domain at this time. Overall, it appears BART is emerging from an extended period subsequent to the initial development and construction phases of the system during the 1970s and 1980s, after which only limited attention was given to potential extensions and network expansion.

[5] www.cahighspeedrail.ca.gov

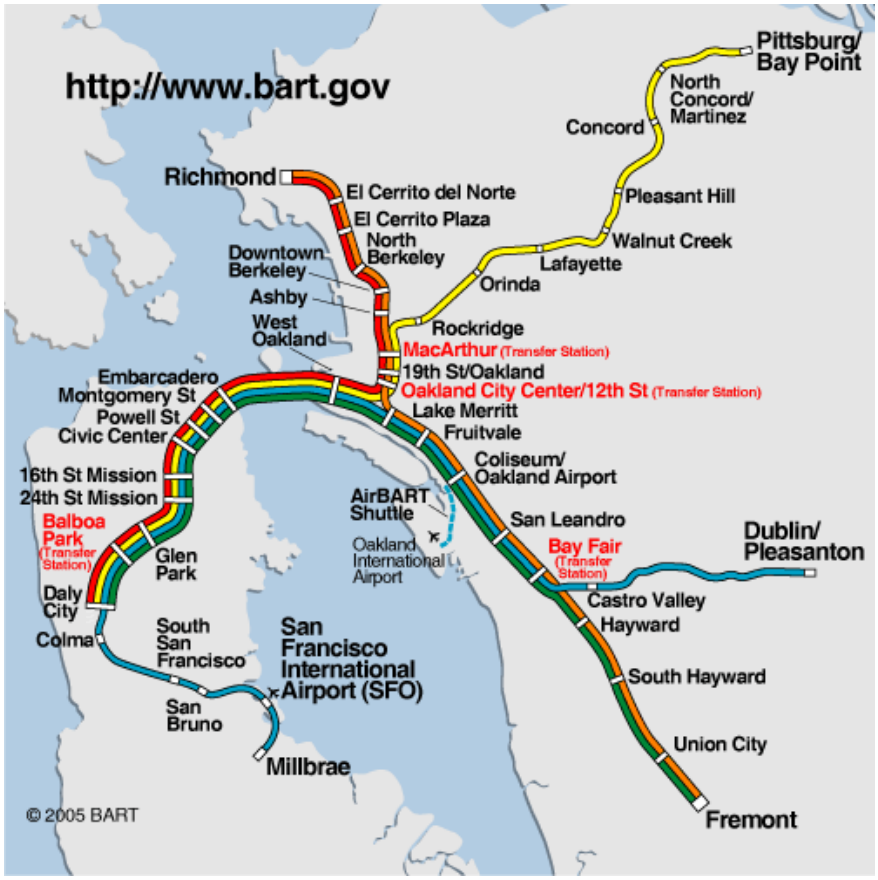
On the other hand, the central San Francisco and East Bay-City capacity issues are yet to be addressed in public through network expansion concepts that might relieve the "funnelling" effects that these corridors and locations seem to involve. Additionally, it is not clear the extent to which these identified areas of constraint will be further pressured or compromised by proposed line extensions elsewhere in the BART system – extensions that would appear to be logical sources of further patronage growth and increased peak period pressures if ridership remains primarily in a peak period commute paradigm.

Network Configuration

The historic network layout of BART seems to have been premised by-and-large on a commuter market, connecting residents of non-city locations with downtown San Francisco. Facilitating commuting or other travel market connections to Oakland and Berkeley seems to have been a secondary, but important additional priority in the initial network concept.

Many of the suburban East Bay stations are heavily commuter-oriented in that they were initially established with large parking lots adjacent to each station. Many stations seem to have been premised mainly on park and ride commuters as the target market. Clearly, this combination of commuter-focus, with a related lack of local activities, may have constrained many BART stations to a one-dimensional role as a morning peak origin and then an afternoon peak destination. In this sense, it might be ventured that the park and ride/commute focus of many BART stations is a possible contributor to exaggeratedly peak-loaded travel patterns.

The recent extension of BART to San Francisco International Airport (SFO), which was opened in 2003, grew the system further south from San Francisco, playing an important role by adding another potential major non-city travel origin and destination. On the basis of recent daily ridership figures though, it seems that SFO may not be living up to its full ridership-generation potential as yet (with just some 5,000 exits on average for weekdays in 2008).



Picture: BART system map, courtesy BART.

Where to from here?

"Ultimately, the long-term solution to these crowding problems will be more BART service, including expanding the fleet, offering more frequent service, a second Transbay Tube and new stations." (BART 2008a)

The network is set to enter an expansion and growth phase, while at this stage still retaining the single Transbay Tube/Central San Francisco core *corridor* that seems to be both the cause and location of much of the peak-period congestion. Attention to developing secondary centres and their stations as more significant origins and destinations may be an important part of smoothing demand levels over the average workday.

The San Francisco airport (SFO) is one location that could benefit from targeted attention at cultivating greater patronage, hopefully growing as another major counter-balancing origin-destination that anchors the network outside of San Francisco City proper. Equally, East Bay locations such as Berkeley, and the stations in Oakland, could see ridership growth over time – but *dedicated efforts* at underpinning their role as major employment centres would offer another important counter-balancing opportunity. At the same time, greater efforts in marketing and passenger market cultivation for these destinations from BART as an agency could reap non-San Francisco ridership benefits in a metropolitan region that remains tied to the private vehicle as the preferred form of transport overall. The extension of BART on the East Bay side to Silicon Valley destinations and San Jose also presents itself as a major counter-balancing passenger market opportunity – perhaps the most significant of the potential growth origins and destinations in BART's metropolitan area.

And finally, the major efforts being undertaken throughout the system to convert park and ride dominated stations through transit oriented development into livelier locations with a more holistic role as travel origins and destinations should result in some load-balancing. This program may need to be tempered with analysis of the likely impacts of emphasising residential versus employment uses in balancing passenger loadings. A recent major study on Bay Area transit oriented development opportunities and implications concluded that: "*Land use intensification holds the greatest potential for building off peak ridership, especially during the midday period. TOD offers BART the opportunity to build all day and off peak ridership which takes advantage of capacity in the existing BART system without imposing additional costs on the system*". (Arup et al 2006, p5)

BAY AREA 3. FARE STRUCTURES & TICKETING

At this stage, BART is working under a somewhat simplified fare structure, rather than with a "full spectrum" of priced-based demand management tools. BART remains among the family of significant systems worldwide that does not have a time-of-day fare structure with peak surcharges in place.

Fare structures, financial position and current issues

During early-to-mid 2009, it was identified that BART was facing a funding shortfall that needed to be addressed. Interestingly, despite contemporaneous discussion of peak period congestion issues, the price-increase proposals focused on boosting the "base fare", rather than on targeting peak periods or problematic corridors for increased differential pricing (BART 2009c). A range of other revenue-generation options have been canvassed and implemented, including parking charge increases, and surcharges on journeys to the airport. As such, a wide variety of options have come under consideration – but *peak pricing and related concepts did not emerge as strong possibilities at this stage*. This is despite the earlier identification of the potential for peak surcharges as a pricing efficiency mechanism (BART 2003). This suggests that although peak period management is a recognised and acknowledged need in the Bay Area, the analysis and tools for demand management-based pricing have not yet progressed to the stage that options such as increasingly differentiated fare structures are ready for application at BART.

In terms of basic metrics such as the farebox recovery ratio, a figure based on interpretation from the most recent publically available forecast (BART 2009) would be around 61%. This represents a considerably stronger outcome than many other comparable agencies in the US and Australia are achieving and perhaps comparable in performance to some well-managed European agencies. On this metric, the financial strains outlined above are put in context – BART is an agency with a reasonable level of control over its own revenue-generation destiny,

and is not beholden to government subsidy to the extent of Sydney (as one example). On the other hand, recent discussions surrounding the mid-2009 fare increases at BART suggest that the ability to derive additional incremental revenue through government subsidy is limited and that BART's use of hypothecated sales tax revenues is problematic during a period of recession in which sales tax receipts have fallen.

> *"The large deficit is due mostly to one of the steepest declines of sales tax revenues in BART's history, elimination of state funds for transit and declining ridership because of job losses in the region." (BART 2009c)*

Pricing Structure

BART operates under a relatively straightforward fare structure established on the foundation of a "base fare", plus increments for distance. Although there is a distance-based fare structure in place, it is not clear that this is founded on explicit analysis of the actual cost of particular station-to-station journey legs.

Another notable fare structure attribute is the surcharge pricing on trips to the airport. In this sense, there is some pre-existing incorporation of "choice of line" in the pricing structure, although the structure does not place a surcharge price on notable corridors experiencing demand pressure such as the TransBay crossing. As previously discussed, time of travel is not incorporated into the current fare structure, nor is the "choice" of entrance/egress station (which in BART's case is a substantial demand management issue).

How does pricing relate to revenues and costs?

As early as March 2003, BART was acknowledging the possible need to move toward the principle of closer relationships between ticket prices and the cost of service provision for individual journeys. Among the "goals" of its financial stability, goal 4 is to: "*Provide a fare and fee structure that is tied to the cost of providing service, optimizes use of the BART system, and provides BART customers with convenience, ease of use, and a good value for the money*." Under "fares and revenues" BART would increasingly provide consideration to: "*A peak premium, at some point in the future when ridership is growing, tied to the need to optimize off-peak system use and to fund core system capacity improvements*." (BART 2003) So far, there have been no major revisions to the fare structure of BART tickets to include peak surcharges.

Ticketing technologies

BART is currently using smart cards under the "EZ Rider" brand, along with magnetic-stripe stored value cards (which are also available for single-trip fares). Individual traditional "paper tickets" are no longer part of the range of ticketing options available for BART users. EZ Rider also offers a payment option for use of BART park and ride facilities. As yet, there is no regional integrated smart card option in place in the Bay Area. A regional integrated card has been raised as an option – and is expected to replace the EZ Rider cards at some point, but implementation timing is not clear at present.

The extent to which the current ticketing arrangements would be able to handle a fare structure involving time-of-day and other peak pricing differentials is not clear. There seems to be no reason why the EZ Rider or widespread stored-value magnetic stripe tickets would not be able to handle greater differentiation in fares or peak surcharges. On the other hand, these fare revisions have not yet been introduced, and it could be speculated that the unresolved question of the move toward a regional smart card system could be one factor contributing to continuation of the fare structure status quo. It is also quite possible that current BART research and efforts toward establishing a strategic framework for managing peak period demand may be logical first steps in a progression toward greater fare differentiation that has not yet unfolded.

BAY AREA 4. SUMMARY OF STATE-OF-PRACTICE

BART is currently addressing rail congestion problems through a major study into demand management. The aims of this study are:

- *"To identify and analyze strategies to manage transit demand and evaluate whether they're applicable for BART*
- *To evaluate public acceptance of those strategies*
- *To quantify impact of the strategies, and consider their potential to generate revenue to relieve unfunded capacity constraint" (BART 2008a)*

The discussion article posted on BART's website alludes to price-based responses as a starting point, in the context of "…*insufficient state and federal transportation funding to meet public demand*" …and with acknowledgment to similar studies and efforts undertaken in Washington DC and New Jersey. Val Menotti of BART has pointed to a September 2008 board discussion which raised travel demand management in the contexts of (in paraphrase): managing peak demand; encouraging travel to regional centres and in the off-peak; seeking to defer capital investments through demand management in order to better fund other capital priorities; and considering peak-related revenue generation in order to meet identified capital needs. Menotti points out that there has also been early-stage analysis of potential configurations for the new Transbay Tube, and its interface with the BART network on both sides of the Bay in the context of "medium and longer term core capacity". Options such as a new downtown line - as an extension of the Transbay crossing, but separated from the Emarcadero to Civic Centre corridor - may well be investigated in greater depth at some later stage. Overall, BART sources such as Mr Menotti are suggesting that longer-term TOD-related counter-balancing plans are reasonably well advanced at this point. Sources are suggesting that potentially transformative infrastructure and capacity-based responses are recognised, but at an early and sensitive stage at present.

It may be that BART's current demand management research phase needs time for completion before the planning and analysis is in place for more engaged discussion on the use of pricing options such as peak-differentiated fares.

Picture: Civic Centre BART Station, downtown San Francisco. C Hale, November 2008

SUMMARY OF OPTIONS PROVIDED BY SYDNEY AND SAN FRANCISCO CASE STUDIES

The current state of practice in Sydney and San Francisco points to a range of demand management options for rail systems. Even if all these options are not yet in place, they have at least been identified as worthy of further attention. A summary of the main demand management options that these major rail systems have identified includes:

- Increasing capacity through improved infrastructure, systems and rolling stock
- Differential pricing including peak surcharges
- Encouraging a shift of station choice away from overloaded stations
- Developing a wider set of peak destinations over time
- The importance of actively tracking and managing demand

While Sydney has the advantage of an independent ticket price regulator to analyse and negotiate its fare structure needs, BART does not – and is required to manage this difficult process and engage with major stakeholders on pricing without independent intervention. While this seems to be a distinct advantage for Sydney and has led to the introduction of greater differentiation in fare structures via a version of peak-period pricing, it has not yet translated into better overall financial outcomes for the network – with BART significantly outperforming Sydney on key metrics including the farebox ratio.

Sydney has recently engaged in a major effort to determine the view of its passengers regarding the experience of peak period travel, along with attempts to identify the opportunities and barriers toward shifting patronage into off-peak periods wherever possible. This is an enlightened step and should be an important indicator to other agencies and systems dealing with peak period demand pressures.

BART has targeted rolling stock changes and reconfigurations to boost overall capacity on trains as a potential measure, whereas Sydney has a fleet of large double-decked multiple units

which probably already comes close to the maximum potential capacity of the system in rolling stock terms. There seems to be limited opportunity for CityRail in this area of capacity-response, but it is an obvious area of opportunity for many transit systems.

Both systems have to contend with "funnelling effects" that have produced robust demand levels at key CBD stations. While both cities have a number of CBD station options to cater to passenger travel needs, the most conveniently located of these stations are facing excessive levels of demand at present. Rethinking the network layout and CBD station options seems to be a logical but potentially expensive response for major rail systems facing peak period pressures. In simple terms, the clear indication from both cities is that network layout and station options *are key issues* in meeting and managing demand for rail services over time.

The broader outcome and the key recommendation from the case studies is that "active management" of demand and peak period conditions on major rail networks is emerging as a necessity. A more active posture of demand management throughout individual days and over the week offers the opportunity that networks can achieve "smoother" demand profiles with fewer peak period pressures. When this is achieved it seems logical that rail systems will also be attaining a more effective and efficient utilisation of system capacity.

Rail agencies that adopt effective demand management processes should also be delivering a better, more attractive experience to riders, and improving their relationship with their customers. Demand management appears ready to emerge as a key tool in the strategic armoury of major rail systems around the world.

BIBLIOGRAPHY

Arup (December 2006) *Access BART – Final report* San Francisco CA: Arup (authors and publishers).

BART (2003) *Financial Stability – implementation plan to be developed* Oakland CA: San Francisco Bay Area Rapid Transit, 27 March 2003.

BART (2007) *Annual Report* Oakland, CA: San Francisco Bay Area Rapid Transit

BART (September 2007) *Fiscal Year 2008 – Short-Range Transit Plan & Capital Improvement Program* Oakland, CA: San Francisco Bay Area Rapid Transit

BART (2008a) *BART looks at ideas to handle growing,* Oakland CA: San Francisco Bay Area Rapid Transit, 18 September 2008

BART (2008b) *Fiscal Year 2009 Budget,* Oakland, CA: San Francisco Bay Area Rapid Transit

BART (2009a) *BART moves forward with $1billion in extension projects,* Oakland CA: San Francisco Bay Area Rapid Transit, 27 April 2009

BART (2009b) *Rail cars of the future – check out early concepts and give feedback,* Oakland CA: San Francisco Bay Area Rapid Transit, 7 May 2009

BART (2009c) *More options for dealing with budget deficit to be considered at BART Board meeting,* Oakland CA: San Francisco Bay Area Rapid Transit, 15 May 2009

Brooker, T and Moore, S (2008) *Recent developments in rail passenger travel demand and transit oriented development in Sydney.* Australian Transport Research Forum 2008

Doggett, M Douglas, N and McGregor, G (2004) *The spatial profile of trips within the Sydney CBD.* Australian Transport Research Forum 2004

Hale, C and Charles, P (2009) *Managing Peak Demand for Passenger Rail: a literature review*, 32nd Australasian Transport Research Forum (ATRF), Auckland New Zealand, 2009 (under review)

IPART (2008) *Review of CityRail Fares 2009-2012. Draft report and draft determinations*: Sydney: Independent Pricing & Regulatory Tribunal of New South Wales, October 2008.

TNS Social Research (TNS) (2008a) *Peak to off-peak – encouraging the shift.* Report for CityRail, Sydney, April 2008

TNS Social Research (TNS) (2008b) *SmartSaver trial evaluation – report of findings.* Report for CityRail, Sydney, October 2008

TPDC (2003) *Train Users in Sydney.* Department of Infrastructure, Planning and Natural Resources, Transport and Population Data Centre of NSW, Sydney

VTA (2008) *Fact Sheet – BART to Silicon Valley*. Santa Clara CA: Santa Clara Valley Transportation Authority