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RAIL PATRONAGE MANAGEMENT – effectiveness in practice, and new theoretical frames

Chris Hale
Phil Charles
University of Queensland, Centre for Transport Strategy
Brisbane, Australia

ABSTRACT
The paper discusses the emerging discipline of rail demand management or "demand smoothing".

Many passenger rail systems have lacked active management of passenger demand levels for an extended period now. This has perhaps often resulted in excessively peak-loaded rail systems that struggle to deal with overcrowding during morning and afternoon commutes, while carrying unviable levels of patronage outside of commute markets and periods. Rail demand management is re-emerging as an important discipline in which passenger demand levels are actively managed, in order to deliver "smoother" patronage levels across the day and week.

Potential areas of strategy and action include: better tracking and management of passenger flows; efficient pricing structures including peak surcharges; other encouragements to off-peak travel including customer outreach; and "responsive and responsible" network planning, service and infrastructure measures on the supply-side. In the European approach, mass transit passenger demand is generally quite actively managed. By contrast, a less interventionist and active approach seems to prevail in some New World systems (in the USA or Australia for example). Contrasting approaches are explored in the paper.

Findings from UQ's recent extended research efforts in rail demand management are summarized, then broadened into recommendations for rail operators and transit agencies seeking to develop a more up-to-date, effective approach to passenger demand levels. Practical measures and approaches for delivering "smoother" demand levels are identified.

Keywords: *rail demand management; mass transit; passenger rail economics; rail benchmarking; peak period*

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Note on sources of information and referencing of data in the paper:
Please refer to the *Bibliography and Source Notes* section (part 6) for detailed discussion on the use of published sources, direct information-provision from rail agency staff, and occasional use of researcher's best estimates in delivering the key performance indicators discussed below.

1. INTRODUCTION – structure of paper

The following paper reviews demand management from the perspective of outcomes, practice and performance within a cluster of international mass transit systems. The first part of the analysis provides an overview of the systems, through a benchmarking of basic parameters.

In Section 3, we then reprise the context and motivation of the research, along with a brief discussion of the approaches and methods employed to undertake the research and analysis.

Then in Section 4, we review the manner in which different agencies within the cluster define their peak and off-peak periods, while asking the initial question of whether particular agencies have a differential pricing structure in place. A key metric of "peak-to-base ratio" is then compared, before a discussion of some of the better analytical tools being employed from among the cluster of rail agencies.

Section 5 takes a closer look at the pricing structures and mechanisms in place across the agencies – as pricing is considered to be a foundation element of demand management.

In Section 6 an attempt is made to benchmark agencies based on peak-to-base ratio performance, and with respect to cross-comparison of certain metrics that should offer insight into outcomes and contributing factors. It should be noted that isolation of particular variables has not been attempted – the analysis remains largely at the strategic and thematic levels.

In Section 7, the idea of demand management as a passenger rail industry field of practice is discussed - and we place this emerging concept within the framework of a range of broader changes and developments taking place in the industry and in its management approaches. Section 8 offers final recommendations.

2. OVERVIEW OF 10-SYSTEM BENCHMARKING ANALYSIS

An important component of this research has been the collation of key performance indicators (KPIs) relevant to demand management from a selection of major rail systems. These systems are all in the mid-to-large city category, with New Jersey (at a state-wide NJ Transit-served 8 million plus) and Hong Kong (at around 7 million residents) the largest urban areas in the listing. It was felt that this cut-off was effective in avoiding comparisons between *much larger* networks and cities like Tokyo, New York Subway, or London Underground (as examples), while still allowing inferences to be drawn from some systems at an "upper-end" of a recognisable scale or continuum.

The benchmarking of these nine systems was felt to offer an effective insight into current key performance indicators among a grouping of reasonably "like" agencies – but readers will need to acknowledge that this is not an attempt to suggest that conditions in the various cities and networks are "the same".

Table 1. Selected mid-size networks - approximate passenger demand, operating ratio, in context

Agency	*Daily passengers (approx)*	*No. of stations*	*Network length km (approx)*	*Operating Ratio[1] (approx)*	*Metro population served (million)[2]*
Hong Kong MTR	4.4 million	85	175	190%	7
Munich MVV	2 million	245	540	70%	5
Singapore SMRT	1.72 million	51	90	126%	5
Sydney CityRail	1,000,000	300+	1,600	30%	4.5 to 5
Washington DC Metro	750,000 weekdays	89	170	76–80%	5
Melbourne Metro	585,000	200	830	29%	4
San Francisco Bay Area BART	362,000	43	170	73%	4-4.5
New Jersey NJT	270,000	162	860	36%	8+
Perth -Transperth	200,000	67	173	37.5%	1.7
Brisbane QR CityTrain	170,000	143	382	30%	3

Clearly Singapore, Hong Kong and Munich represent cities with *highly-networked* rail systems featuring frequent transfer opportunities, and highly or relatively *urbanised* land use conditions (perhaps with some level of debate-ability around this last density-based aspect in Munich's). The remaining cities tend to have more "*radial* and *suburban*" passenger systems and built environment conditions by comparison. By "radial" we mean an emphasis on just a few centrally-located morning destination stations, and relatively few inter-line transfer opportunities. Within this exercise we did not have the space or resources to sufficiently develop the metrics on networking and rate of interchange at our various systems in the cluster. But even without clear metrics to delineate exactly the extent and nature of networking in each system listed here, this issue creates a key point of curiosity for the analysis. The relative performance of our presumed "urban/networked" versus "suburban/radial" systems, as well as relative performance within those groupings is of great interest. The relative strength of certain KPI outcomes among the suburban/radial systems as a sub-group is likely to generate debate and attention from planners and other interested parties. By "performance" we primarily mean a "smooth" demand paradigm on the peak-to-base ratio, and strong outcomes on the leading financial indicator of operating ratio.

3. MOTIVATION AND METHOD

This research was part of a wider exercise funded by Australian rail operators. The driving motivation from an industry point of view, in summary, has been the need to identify new options and potential solutions for peak period overcrowding as a result of strong ongoing passenger growth for several years now in the larger Australian rail systems (Sydney, Melbourne, Brisbane and Perth).

[1] Operating ratio (%) = (farebox revenues + other non-subsidy revenues) / (total non-capital costs)
[2] Indicative only

In addition to their perceived cross-relevance as “medium to large” advanced rail systems serving “medium-sized to larger” metropolitan populations, the systems here are all familiar to the researcher from 4 years of repeated fieldwork visits. In each of the cases listed throughout this paper, multiple field research investigations have taken place, agency planning documents have been scrutinized, and some level of interaction has occurred with agency planning staff or local experts in recent years. Hence, a level of “analysis filtered by direct experience” was possible. The initial data-gathering was performed by questionnaire covering key metrics, as well as demand-management processes and policies – and this was informed by cross-referencing to available reports and public realm information. Many of the agencies were willing to be involved in further follow-up and discussion on the topic and their approaches – and the impression was gained that the demand management topic or theme is a key emerging interest for the majority of the systems grouped here within the cluster. The listed agencies were therefore to a large extent chosen on the basis of availability of data from agency staff and/or published information. In further iterations of this research, there may be opportunities to bring in performance indicators from other agencies but at this stage these listed agencies offered a strong mix of relevance and availability of info.

4. TRACKING AND MANAGEMENT OF PASSENGER FLOWS

The tracking and description of actual passenger flows in a rail system is a foundation for active and effective management of those flows. This section reviews some basic KPIs on this topic, as well as providing examples of practice encountered.

Definitions of “peak and off-peak periods”

An initial point of interest in reviewing the approaches at different networks was to identify the accepted definitions of “peak” and “off-peak” periods in active usage.

Table 2. Peak/off-peak definitions for selected mid-size networks

Agency	Peak pricing regime in place?	Main descriptors used for peak/off peak periods **(based on convention, observed passenger demand levels, or pricing structure, etc)**
Hong Kong MTR	No	“morning peak, evening peak, peak of the peak, non-peak"
Singapore SMRT	Yes	n.a.
Munich MVV	Yes	6am - 9am mornings. 4pm - 6pm afternoons
Washington DC Metro	Yes	WMATA tracks demand in 15 minute increments. Ticket structure based around morning peak “before 9.30am” and between 3.00pm and 7pm afternoons
Sydney CityRail	Yes	7am - 9.30am mornings. 4pm - 6.30pm afternoons
San Francisco Bay Area BART	No	n.a.
New Jersey NJT	Yes	Depending on corridor, peak period is three hours (6-9am, 4-7pm). *Peak hour* also is used in *scheduling*
Perth Transperth	Yes	Peak periods “generally” 7am – 9am, 3.30 – 6pm
Brisbane CityTrain	Yes	6 – 9am mornings, 3.30 to 6.30pm afternoons

It is important to note here that we are not always necessarily referring to the peak/off-peak periods utilised in fare structures. Many agencies and cities seem to have different definitions of what their "peak period" means and when it occurs. Table 2 is an attempt to summarise these descriptions, whereas in a later section the question of ticketing-based definitions will be addressed more directly. At this stage we are also interested in the basic question of whether the benchmarked networks have a peak pricing regime in place or not.

The variety of definitions indicates that there are different meanings attached to the phrase "peak period" and its "off-peak" counterpart. During early-stage research, and on compilation of the information provided from the ten systems, the question of "non-standard definitions" for the peak and off-peak was considered an issue worth canvassing relatively thoroughly. For the most part the "simple definitions" we might be looking for are absent, and only a more nuanced engagement with definitions, practices and observed travel patterns can yield a richness of information that assists the practitioner or theorist to understand "what the peak period is, and what it means".

While ticket-price and timing-based definitions are common, agencies are also referring to "peak periods" that extend far beyond the ticket/time definition in use. As one example, Munich encourages pensioners and students to travel after 9.30am (this is MVV's only peak price mechanism), but refers internally to a morning period of 6am – 9am (3 hours) and an afternoon peak of 4pm to 6pm (2 hours). Further complexity can be considered in Munich's case when we recognise that "peak times" are not necessarily based entirely on observed passenger flows. Munich's well-balanced rail network does not see the "peakiness" of other systems (refer to figure 3 in this paper for further context), so the three morning hours and two afternoon hours referred to by planners relate more to *the timing of "traditional white-collar commuter travel*" rather than to observed exaggerated passenger flows (see also Hale & Charles 2010 for extended discussion).

In Hong Kong's case, MTR planners have offered us a richly descriptive vocabulary in which there are 5 basic periods under examination. These are the morning and afternoon peaks respectively, plus the "peak within the peak" that occurs twice daily. All other periods are described as "non-peak" and these descriptions exist in a system with no ticket price-based descriptors or designations. In other words, these are MTR planning "shorthand" for the passenger demand phenomenon that are observable in the Hong Kong system. Notably too, the MTR planners reserve the right to not define these terms via specific clock-based periods. The descriptors are attached primarily to actual passenger volumes, with the timing of those flows a next-step consideration based on observation.

Information from the New Jersey Institute of Technology is also suggesting that New Jersey Transit uses a "timetable-based" definition of peak and off-peak – depending on offered level-of-service or frequency/headway. In other words – their "peak period" is taken to be the periods during which higher frequency of service is offered (typically at peak period headways of under 10 minutes for most lines in the NJ Transit context). This may seem "obvious" at first, but it is worth drawing out that this is *yet another* descriptor (not mentioned by other informants, but also inherent in the approach out of Melbourne) that analysts and practitioners need to keep in mind. This also alerts us to be cautious about how much we attribute peak demand to "demand of itself" as opposed to the idea that passengers are travelling during periods in which they know service levels encountered will be sufficiently convenient to make peak travel a more reliable option when compared to travelling during off-peak when waits may be longer and connections less readily available.

And finally, WMATA planners have suggested that their observance of passenger flows is based on *15 minute increments* for the purpose of detailed analysis. This descriptor of the analytical frames in use is important because it alerts interested parties to the need for a "finely graduated" analysis of passenger demand levels at particular locations or corridors. Part of dealing with and responding effectively to the "peak within the peak" phenomenon is having analytical frameworks in place that allow for more specific analysis than the 2 – 4 hour periods that notionally span increased demand levels in the morning and evening.

Peak to Base Ratio

A review of the literature confirmed the use of the "peak to base ratio" (Vuchic 2006; TCRP 2003a; TCRP 1996) as a potential leading key performance indicator for the "peakiness" of a rail network. This is variously presented as either a true ratio (as a single figure), but apparently more commonly as two percentages totalling to 100, in which the number of trips during peak periods is the numerator, and the number of trips during the off-peak is the denominator. Table 3 summarises the results of our information-gathering, drawing from figures provided by agencies, or calculated from data in published reports, or estimated from related info in Melbourne's case. For the purposes of this research effort, the peak-to-base ratio is considered a leading indicator of the "smoothness" of passenger demand, and hence the "performance" of agencies in delivering a balanced passenger demand outcome. Readers should understand that this is not a "perfect" measure, as it is provided by agencies themselves, via methods and definitions that will vary between agencies. The 'peak period' definition itself tends to *flex* according to observed passenger flows – so a *longer* peak period (for example) will not necessarily be reflected as a variation in peak-to-base ratio. The research process has, however, presented this still reasonably unfamiliar metric as being of genuine interest as demand management develops into a coherent field of network management practice in coming years. The benefits of working with and developing a somewhat unfamiliar metric, which has shifting definitions, are seen to outweigh any drawbacks. The researchers also feel that info presented in the table below is reasonably illustrative of network conditions.

Table 3. Peak to Base Ratio for selected mid-size networks

Agency	*Peak to Base Ratio*[3]
Hong Kong MTR	30/70
Munich MVV	35/65
San Francisco Bay Area BART	57/43
Transperth	58/42
Sydney CityRail	61/39
New Jersey NJT	62/38
Washington DC Metro	65/35
Melbourne Metro*	70/30
Brisbane QR CityTrain	72/28

*Melbourne indicative only – researcher's best estimate from available info

Table 3 offers an insight into the regularity with which a roughly 60/40 peak/off-peak ridership split seems to present itself as a recurring benchmark. "High performing" systems that are spreading ridership quite effectively across the standard work day include Hong Kong (with some 70% of journeys taken during the off-peak) and Munich's MVV which has around 65% of journeys during non-peak periods. BART is perhaps notable for a reasonably "balanced"

[3] Peak to base ratio = (percentage of all trips during peak) / (percentage of all trips in non-peak)

ratio of journeys apportioned between the two periods, as are the figures from Perth (perhaps unexpectedly).

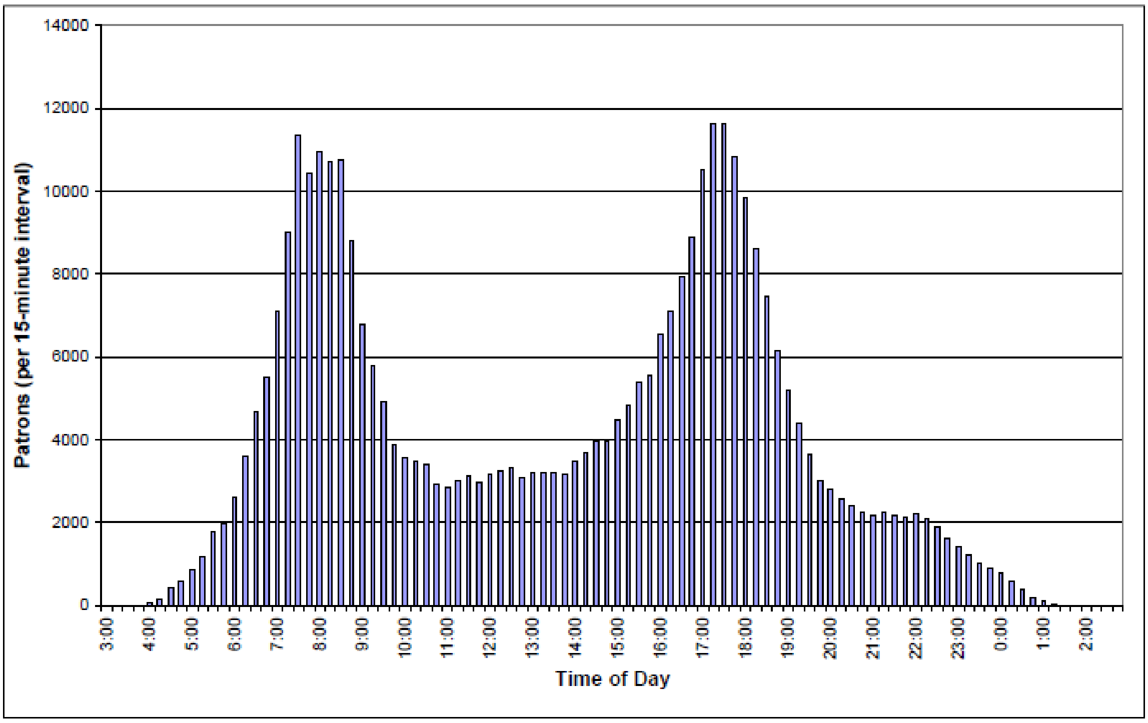
Examples of effective practice in tracking and analysis of demand and capacity

Of the agencies reviewed, special attention can be focused on some of the tools and techniques of system demand analysis utilised by MVV in Munich, WMATA in Washington DC, and to some degree at BART in San Francisco. These analysis examples were chosen for their descriptive power and usefulness as potential analysis tools for other rail agencies.

BART – basic passenger demand analysis

Figure 1 shows passenger demand in the BART system. This most basic of graphic analytical tools for tracking system-wide passenger demand flows should be part of the standard armoury applied to these issues by rail agencies. Notably, regularly production and publication of this type of analysis is still not a mainstream outcome among major rail systems. In the absence of open publication of this type of analysis, both internal and external stakeholders would potentially lack information and understanding.

Figure 1: BART daily system ridership (15 minute intervals)

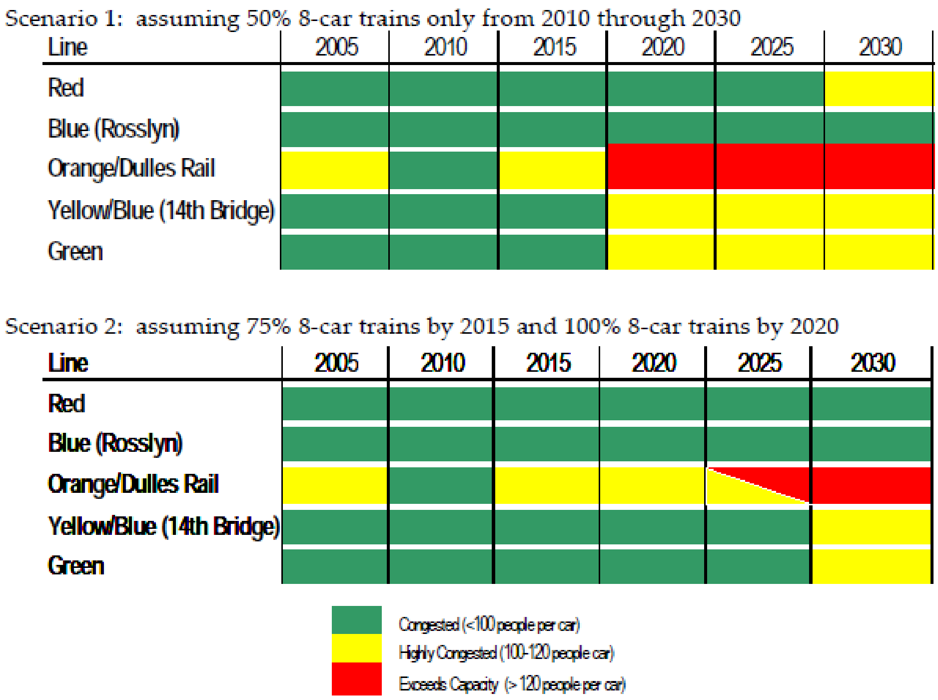


Source: Nelson-Nygaard (2009)

WMATA – conditions of congestion according to line and time horizon

Figure 2 (following page) shows the time horizon for the emergence of problematic levels of on-train congestion in the different lines of the DC Metro system. This graphic approach should be worthy of replication by other agencies because it clearly summarises congestion-related problems and offers a planning horizon during which appropriate responses can be formulated.

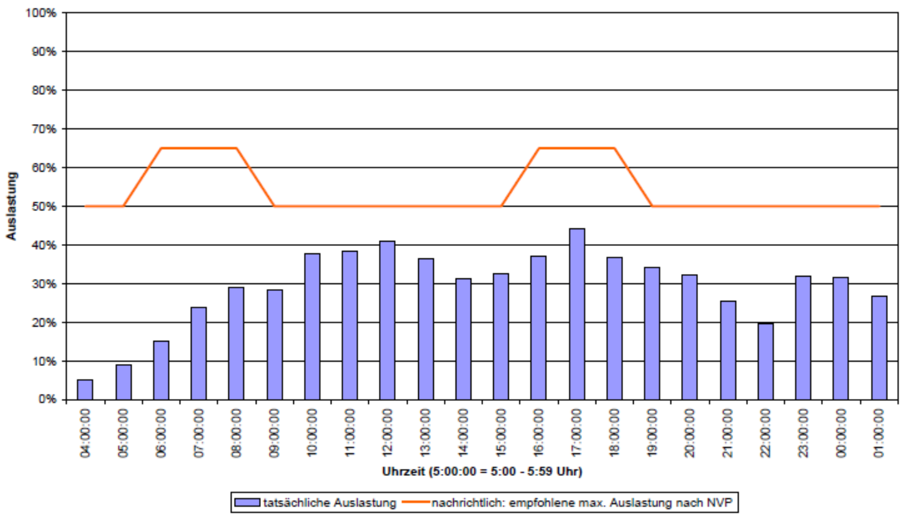
Figure 2: DC Metro System capacity at maximum load segments 2005 – 2030, am peak hour



Source: WMATA 2008

MVV – the mandated demand/capacity ceiling
Figure 3 is an example from Munich's U-Bahn system. Of interest to practitioners and other systems will be: (a) the tracking of hourly demand in blue columns; (b) the fact that this particular U-Bahn line has a "peak" during the late morning (probably partly as a result of its serving a university catchment); and (c) the "mandated demand/capacity ceiling" the red line which would trigger a planning response if it were exceeded by average demand. This *demand/capacity ceiling* is a key innovation coming out of Munich.

Figure 3: U3/U6 corridor, Universität to Odeonsplatz Stations section city-bound. Demand and supply analysis. March 2005.



Source: Courtesy City of Munich 2005

5. PRICING STRUCTURES

Information was also sought from the agencies regarding any peak/off-peak fare structures they have in place.

Table 4. Peak/off-peak pricing structure - selected mid-size networks

Agency	*Peak pricing?*	*Basic description of pricing structure*
Hong Kong MTR	No	n.a.
Singapore SMRT	Yes (but "soft")	Sing10c discount to adults and senior citizens arriving downtown before 7.30am.
Munich MVV	Yes (but "soft")	Certain tickets and passes which are only valid for use after 9am and before 3pm are cheaper (around 75% of full fare). These pass products appear to be primarily marketed at students and pensioners.
Washington DC Metro	Yes	Reduced fares after 9.30 am weekdays and outside of the afternoon 3pm - 7pm peak weekdays. Typical discount example would be for a short journey (under 3 miles) that costs $1.65 during peak times, and $1.35 in the off-peak (a differential of some 22%)
Sydney CityRail	Yes	Save approx 30% for travel after 9.00am Monday to Friday, or any time on weekends and public holidays.
San Francisco Bay Area BART	No	n.a.
New Jersey NJT	Yes	Off peak varies between 50-75% of peak price. Ticket-based definitions: am peak 0600-0900, pm peak 1600-1900
Perth Transperth	Yes (but "soft")	Certain concession tickets available for use only between 9.00am and 3.30pm on weekdays, and certain classes of "All day tickets" not valid until *after* 9am.
Melbourne Metro	Yes	"Early bird" ticket offers free travel for arrivals prior to 7am
Brisbane CityTrain	Yes	"Off peak daily" tickets valid between 9am and 3.30pm, and after 7pm - at around 25% discount. Single trip tickets generally 9% discount for off-peak travel.

Common to many of the pricing structures is a discount for trips outside a defined morning peak. In terms of concepts of "optimal" fare structures, it is perhaps surprising that a number of agencies are not explicitly differentiating between journeys *early* in the morning peak period, as opposed to those closer to 9am. Munich, New Jersey, Washington DC, Perth and Sydney appear to be in this category – they offer an "off-peak" incentive, but there appears to be a lack of subtlety in attracting passengers to travel earlier in the morning (prior to 7.30am for example) rather than in the 8am – 9am "rush" period during which system capacity problems are generally triggered. At time of writing, it was reported that the WMATA board were considering a peak-of-the-peak surcharge proposal (Thomson 2010).

Hong Kong MTR and BART (San Francisco Bay Area) are notable for having no peak/off-peak pricing structure in place. This is an interesting outcome – as the two are otherwise seen as being very advanced passenger rail systems, with strong planning and financial performance (and smooth demand profiles for that matter). It appears that BART has recently been discussing this option, but no decision has been made.

Munich, Perth and Singapore all appear to be targeting concession holders (pensioners, the unemployed and students) as likely adopters of non-peak travel. But Singapore's apparent 10c discount for pre 7.30 am travel by concession holders appears to be surprisingly small when we consider standard price-elasticities for rail travel are generally estimated at around 0.3 (see Litman 2007) or on an absolute basis.

Melbourne is alone among this reference cluster in having *free* travel available in the morning for passengers arriving at their destination prior to 7am. On a range of network planning principles, not least the need for agencies to make every effort to generate a reasonable level of fare revenue and maintain a strong overall financial position, transport planners might ordinarily be wary of "free" travel as a demand-smoothing measure. Indeed Melbourne is performing below other agencies on key metrics such as farebox recovery or operating ratio, and it appears that a strong argument could be made that this "giveaway" approach is under-resourcing an already financially strained system. On the other hand, an interesting (though debatable) argument has been made by Currie (2009) that on the balance of net economic costs and benefits, the trial of free early bird travel has been a qualified success in Melbourne. As an aside, it might be noted that in Australian rail systems, contractual or incentive-based linkages between passenger demand levels and operator revenues have become somewhat unclear, and some commentators have suggested that "no party is responsible" ultimately for issues such as effective management of passenger demand (Mees 2010).

Brisbane is notable for having introduced a highly-standardised peak/off-peak structure in conjunction with ongoing efforts to cement smart cards as the preferred ticketing option. For single journeys, a standard price discount of 9% is now in place in Brisbane for off-peak trips.

An overall impression or interpretation of the fare structures in place among the reference cluster is that the *full engagement* of available fare structure-based incentives for travel in less crowded periods is not yet mainstream practice. There were a wide range of options observed, but few agencies appear to be combining all or most of the available measures and techniques into a coherent price structure incentivised toward smoother or more balanced passenger demand levels across the day and week. A full review of options and techniques in a search for coherent incentive mechanisms is likely to become a relatively common program for international agencies to undertake in coming years – given the infrastructure and other costs involved in non-optimised fare structures, and the opportunities offered by intelligent pricing structures in the context of now-widespread smart card use (Hale & Charles 2009a; Streeting & Charles 2006).

6. CATEGORISING NETWORKS – broad inferences from demand management-related Key Performance Indicators

The final benchmarking analysis is based on cross-referencing of financial outcomes on the one hand, and effectiveness in delivering "smooth" demand paradigms on the other. No attempt is made here to isolate variables or establish causality. "Operating cost per passenger trip served" is presented as a relatively "new" or unfamiliar metric, which appears to offer some promise with respect to demand management-related performance analysis. It is calculated as a function of annual system-wide operating costs divided by annual passenger trips. The authors feel this metric may have some advantages over others such as 'cost per passenger km', in that the adjustment for distance in this more familiar metric may be adjusting-out cost inefficiencies involved in catering primarily to longer-distance journeys.

Mobilising operating ratios in this context provides a cross-reference of the basic demand profile of different agencies (via peak-to-base ratio) against the leading indicator of their financial performance. It had been surmised that a "smoother" demand profile would be a more economically efficient use of resources employed (all things being equal). While there are no-doubt a wide variety of factors beyond demand balance contributing to outcomes on the operating ratio metric, we are interested at this stage in whether the benchmark dispels or confirms the logic of "smooth-demand networks as financially more robust". There is also a wider hypothesis in play questioning whether smooth demand profiles may partially be a result of better, more effective management approaches, in simple terms. Once again, this initial benchmarking analysis may begin to allow us to determine whether this 'efficient management hypothesis' is worth pursuing further. Interested parties must be willing to make *inferences* in this form of strategic analysis, and be prepared to pursue this line of research as an 'emerging new topic' in rail management. The authors are not able to present 'solutions' beyond the recommendation of *pursuit of the topic*, and *willingness to analyse performance.*

Table 5: KPIs: "peakier" verses "smoother" systems - selected mid-size networks

Agency	***Peak to base ratio***	***Operating Ratio (Approx)***	***Operating cost per passenger trip served ($US)***
Hong Kong MTR	**30/70**	**190%**	**$0.52**
Munich MVV	**35/65**	**70%**	**$2.50***
Singapore SMRT	**n.a.**	**126%**	**$1.00**
San Francisco Bay BART	**57/43**	**73%**	**$4.21**
Transperth	**58/42**	**37.5%**	**$5.70**
Sydney CityRail	**61/39**	**45%**	**$6.50**
New Jersey NJT	**62/38**	**40%**	**$6.36**
Washington DC Metro	**65/35**	**76% - 80%**	**$3.40**
Melbourne Metro	**70/30***	**29%**	**$3.45**
Brisbane QR CityTrain	**72/28**	**30%**	**$10.50**

* Melbourne indicative only - researcher's best estimate from incomplete but related data/info

At this point the initial interest in the attributes and outcomes of different 'types' of rail systems becomes a topic of discussion again. We can observe a clear distinction in performance among the 'urban/networked' systems compared to the "suburban/radial" types. But 'star performers' emerge from out of the ranks of the 'suburban/radials' – and this was a key area of interest and motivation for performing this research in the first instance.

Of the 'handicapped' suburban/radials, San Francisco Bay Area's BART service stands out for higher-level performance in delivering relatively 'smooth' or 'balanced' passenger flows and robust financial performance. For this reason, BART is placed in the top tier of radial networks. Among those in the remainder of the suburban/radial systems there is a clear distinction in performance between Sydney, New Jersey and Washington DC on the one hand (with their more balanced demand levels and stronger financial performance), against the performance of both Melbourne and Brisbane – whose overall level of effectiveness in delivering balanced passenger movements appears inter-related to their lack of financial performance. This places Melbourne's "early bird" free travel experiment in a poor light. Perth could be described as a 'surprise packet' on the performance outcome detailed here.

In summary, Hong Kong, Munich MVV, Singapore MRT, and San Francisco Bay Area's BART all appear to be *generally* performing better on both operating ratio and peak-to-base compared to the other systems in the cluster analysis. Although it is difficult to establish causality as such, the researchers would like to venture a series of potential explanatory factors. The first of these is an impression that these leading agencies are *well-managed* and progressive. While this is not to denigrate the other agencies, the authors feel that operating ratio tends to be a function of *management* (of itself), as much as any other explanatory possibility. Here the "good management – strong financial performance – smooth demand" axis, while complicated, is certainly not *disproven* as a hypothesis. Of the remaining agencies, WMATA is also considered to be an agency offering 'up-to-date network management style'. The inclusion of 'operating cost per passenger served' offers another angle on this discussion. Once again, causality is unclear (and not necessarily sought), but there remains an impression from theory, from common sense, and from the benchmarking above that a 'smooth' demand paradigm must surely be a cost-recovery or economic efficiency benefit for agencies.

Other potential explanatory factors might include issues such as: population and employment density; network poly-centricity; ridership habit and hence sheer passenger numbers and revenue opportunity; and 'compact scale' of network (although this potentially presents counter-veiling challenges in catering to higher service intensity). All of these factors, however, also represent network management and development *opportunities*, rather than being purely 'handicapping' factors. Hence repeated efforts at interpretation seem to lead the analyst back to the 'better management' hypothesis time and again.

Overall the recommendation, simple as it is, would be for each and every agency to make the best of their conditions, and aspire to move into a higher benchmarking category based on improvements in performance through operational and planning innovation. Potentially this could be pursued through efforts such as fare structure revisions, demand-balancing TOD, and other sustained efforts to balance-out demand levels. The aim for Sydney, New Jersey and Washington DC should be to attain levels of performance closer to those of the top 4. Melbourne and Brisbane must clearly endeavour to identify strategies and mechanisms to lift themselves above their current level of performance. Recent projections from Washington DC's Metro network (for example) suggest that the system will see a 'balancing-out' of demand over time via strong growth in 'suburban-to-suburban' travel patterns over time (WMATA 2008, esp p33), and this could be surmised as a result of effective planning and management efforts over a sustained period.

7. DEMAND MANAGEMENT WITHIN A NEW PARADIGM FOR RAIL NETWORKS

The final endeavour of this paper is to link the observed performance of the nine benchmarked agencies with a version of good practice, and with other new ideas that emerged out of investigations undertaken in related research (e.g.- Hale & Charles 2009a; 2009b; & 2010), and eventually with a broader concept of how demand management fits with emerging trends toward improvement of management and economic practice in rail transit internationally. It appears from our broader research outcomes that effective demand management is not about addressing one single issue or area if interest – but multiple fronts and options must be pursued, many of which go against the grain of entrenched practices.

Demand management basics

Through the literature review (Hale & Charles 2009a) a number of key options were established for agencies attempting to address passenger demand, and deliver "smoother" passenger flows. These included:

- Increasing capacity during the peak through intelligent operational planning, rolling stock changes, and then infrastructure responses as something of a last resort. In this sense, supply-side and capacity-oriented strategies are part of any demand management response, but greater emphasis should initially be afforded to lower-cost management and pricing options
- Differential pricing with the aim of shifting trips – potentially through increases in peak prices as well as decreases in the off-peak
- Improved off-peak service levels with the aim of shifting trips (also: TNS 2008a)
- Shifting station choice away from overloaded stations
- Developing a wider set of peak destinations over time
- Communication-based measures (refer also to: TNS 2008a; TNS 2008b)

The recommendations from Hale and Charles (2009a) suggested that agencies address *all* of the above options to some degree or other. It was also suggested more broadly that "…*a posture of 'active management' of demand will be required of rail transit agencies into the future*". The benchmarking analysis undertaken for this paper has generally supported these earlier findings and inferences.

Examples of effective practice

From the two practice review papers (Hale & Charles 2009b & 2010) which addressed current practice and emergent issues in Sydney and the San Francisco Bay Area, and Munich and the Washington DC metropolitan area respectively, a series of good-practice options and examples have also been drawn – and the value of these potential actions appears to have been sustained by the broader agency cluster benchmarking analysis in this paper. These approaches and issues included:

- Sydney's interest in gauging customer-readiness to travel in non-peak periods

- The independent recommendation (not yet adopted) for Sydney's CityRail to widen peak/off-peak price differentials to 50% (IPART 2008)
- BART's concentration on rolling stock as a capacity-expansion option
- BART's emergent success in developing non-commute travel through transit oriented development exercises that reposition park and ride dominated stations into more active travel generation outcomes
- The option in both San Francisco (the "Second Transbay Tube"), and Sydney to spread downtown destination options by expanding network elements, and creating new stations in central locations (although Sydney subsequently cancelled its centrally-located Metro project). Brisbane's "Cross River" project presents another current example
- Munich's example of a system which has maintained a finely graduated distance-based fare structure
- Munich's encouragement of non-peak travel by concession holders (and perhaps Perth too)
- Outstanding "network" outcomes in Munich that reduce system peakiness
- WMATA's success over time in using TOD to leverage "counter flow" travel to non-central locations
- WMATA's identification of station access as a significant capacity-related issue
- Strong analysis and communication on capacity and demand challenges – particularly the example of Munich's use of effective visual communication tools, and WMATA's dedication to open publication of demand/capacity analysis and other planning documents

A further recommendation for interested rail agencies and planners is that improving exchange of information, and greater readiness to adopt good practice established in other locations, should become more common in future. Benchmarking provides an early insight into the idea that while individual transit systems are unique, all transit systems do share similar goals and performance metrics, and each must strive to maximise their performance in demand management, ridership maximization, and financial outcomes.

Demand management as part of a bigger picture

Better demand management should go hand in hand with better performance on a range of key metrics, but also with a wider set of initiatives and planning approaches aimed at repositioning rail mass transit to deal with the challenges of a new century. Many of the aims and techniques of enlightened mass transit management have already been identified by a range of sources (e.g.- Banister 2002; Bratzel 1999; Cervero 1998; Cervero 1990; City of Munich 2005 & 2006; Hofker et al 2009; LTA 2008; TCRP 2003a; 2003b & 1996; Vuchic 2006 & 2007; WMATA 2008).

The techniques of demand management are a core component of a larger range of issues including: the overall management approach and organisational culture at agencies; the adoption of *explicit aims* for passenger growth and system improvement over time; technical advances and the delivery of efficient engineering outcomes; better station design and better station access planning and infrastructure; as well as implementation of new ticketing technologies and efficient fare structures.

These aspects of delivering a modern passenger rail system and others are outlined in Table 6, drawing from the literature (as referenced in the paragraph above) and from experience and findings emerging out of this research program. In this conceptualisation we see "new and emergent best practice" set against "old" or "entrenched" paradigms and ways of thinking. In some cases for some agencies, the emergent paradigm has already been encountered and adopted, while other agencies will find themselves remaining in an "old" paradigm on certain topics. More complex is the addressing of some "old" practices that were previously seen as "best-practice". Pass products and simplified fare structures are a case in point… While they were necessary and desirable prior to the advent of smart cards, their usefulness and relevance is now rapidly diminishing, and maintaining simplistic fare structures in a context of overcrowding and constrained resources no longer makes sense in most cases.

Table 6. Changing Paradigms in major rail systems

Traditional paradigm	***Emergent/new paradigm***
Falling or stagnant rail patronage	Robust ridership growth
Static rail network planning & development	Ongoing planning and expansion to grow passenger markets
Rail travel as inferior to car	Rail travel superior to car
Public transport as social support for low-income travellers	Heavy use of mass transit by white collar CBD workers
Subsidy to rail to encourage people out of cars	New financial realism in all transport funding
Ideologies of free market competition applied to public transport	Practical approaches to transit economics and planning. De-emphasis of politics and unproven ideology and theory
Rail ticket pricing as social policy	Rail pricing understood within reality of constrained government funding resources for transport
Focus on conditions of rail industry employees and managers	Focus on improvement of rail customer experience
Paper tickets & magnetic stripes	Smart cards
Integrated all-modes passes	Pricing according to journey – "user pays". No discount travel passes available for use during peak periods or in heavily loaded locations within the network
Simplification of fares	Increasing complexity in fares, related to actual cost of journey based on distance, time, location
Peak and off peak. "Coarse" graduation in fares.	Spike, peak, shoulder, off-peak. "Fine" graduation of fares related to observed passenger demand levels
Crowded trains in peak periods said to be "good" for revenues	Understanding that overly peak-loaded systems are inefficient and wasteful
Infrastructure expansion resources allocated to meet peak period demand	Infrastructure development intended to lessen the "peakiness" of the system by developing non-radial travel options and enhancing the non-radial elements of the network
Reactive planning posture	Proactive planning
Limited or controlled access to key data, information and planning documents.	Openness on challenges of transit systems. Open project & planning processes. Open publication of analysis
Bureaucratic culture in transit agencies	Professional, knowledge-oriented culture
Limited analysis and reporting on demand/capacity trends and issues	Detailed and effective reporting and analysis of demand/capacity

The recommendation is for agencies and planners to undertake conscious efforts to move from old to new approaches wherever possible and as soon as possible – as this will hopefully lead to better outcomes on key metrics, better service-delivery for passengers, and improved financial performance. "New" approaches to demand management will be part of a broad effort to reposition rail as the leading urban transport mode for the 21st century.

8. SUMMARY AND FINAL RECOMMENDATIONS

This research effort sought to engage with different practices and options provided by a variety of medium to large sized rail agencies as they deal with passenger growth, especially during peak periods. This research has been oriented toward "identifying valid questions and issues" in demand management as a strategic and management-based pursuit – rather than seeking to isolate variables, or offer "answers" through abstracted modelling.

We feel that two reasonably unfamiliar metrics that were discussed in this paper should offer new frontiers for agencies seeking to better understand passenger demand conditions and pressures on their systems. These metrics include:

- The peak-to-base ratio
- Operating cost per passenger

It was also suggested that any cross-comparison of performance on the basis of these metrics should refer back to the leading financial indicator of the *operating ratio*. More broadly, the researcher's feel that there is great merit in moving toward cross-benchmarking of performance in different rail networks, and drawing out areas of strong or innovative practice in place at particular agencies.

A further effort, not extensively stated so far, has been to move away from the idea of 'density' as the *only* causal factor of note in the demand and financial outcomes of major rail agencies worldwide. New perspectives on a more nuanced role for density have emerged recently from Mees (2010). An overarching concern here was to place demand management research in the network planning-oriented tradition of Cervero (1998), rather than the density-focused research paradigm of Newman & Kenworthy (1999). While residential or population density may well have been an interesting metric to include in our benchmarking, it has been judged that this focus tends to draw attention away from the highly important planning, management, and strategy aspects of rail networks. Density is not always destiny for rail.

Picture: Hong Kong MTR train – off peak. C Hale, 2008.

Notes on sources of information
The key performance indicators in the paper have come from two main sources – public domain documents and direct agency information provision. Certain rail transit agencies provided direct input on current level of performance according to the KPIs addressed here, and the authors would like to provide particular thanks to staff at; Hong Kong MTR, Washington DC Metro/WMATA, Munich MVV, RailCorp in Sydney, Transperth (Perth), and New Jersey Institute of Technology (Jerry Lutin) for the New Jersey Transit data.

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