PRACTICE REVIEWS IN PEAK PERIOD RAIL NETWORK MANAGEMENT: MUNICH & WASHINGTON DC

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ABSTRACT

The paper reviews current rail peak demand management approaches in Munich and the Washington DC metropolitan areas, through a practice review approach.

Munich and the Washington DC metropolitan area offer two different approaches 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 the Washington DC metropolitan area, the Metro rail system links activity centres in the District of Columbia with suburban jurisdictions in Maryland and Virginia. The Metro system, as a late twentieth-century rail network, is seen as a leader for US transit in terms of scale, the quality of network design and planning, and popularity with riders. Lessons drawn from DC Metro on rail demand management approaches are indicative of best-practice in the USA at present.

In Munich, the U-Bahn is a new-generation metro-style urban rail network, which is complemented by the more suburban oriented "S-Bahn" - of a longer-distance, more radial-style configuration. Munich's transport planners are proactive in their tracking of passenger flows and their actioning of a variety of measures that have produced "smooth" passenger flows that avoid the "excessive peaks" of many other major rail systems. This is perhaps partially a contributor to the strong overall financial outcomes for mass transit in Munich. In addition, the network characteristics of the Munich rail systems are notable, in that there are a substantial number of popular destination/origin stations, and the system is not over-reliant on a small number of major inner city stations.

From these case study examples of established and emerging practice, suggestions are drawn for strategic options to assist transport agencies and rail operators in addressing peak demand issues through a more managed and structured approach.

Keywords: passenger rail; demand; demand management; mass transit planning; WMATA; Munich; MVV; U-Bahn; DC Metro

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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 practices and approaches, the analysis is structured to review the following key areas in rail demand management:

1. Describing the peak period and its challenges
2. The configuration of the two rail networks and the role of network layout in rail congestion
3. Fare structures and ticketing

This analysis frame is primarily derived from the literature review of Hale and Charles (2009a) and has also been applied in an earlier practice review that covered the San Francisco Bay Area and Sydney (published as Hale and Charles 2009b). The first step is to characterise peak period demand-related issues and problems in the passenger rail network. Reviewing the network configuration of a particular rail system then assists in understanding the impact of pressure points and corridors or stations of heavy demand. Fare structures and pricing approaches are logical points of interest in demand management, as is the question of whether current pricing regimes account for key components in the cost structure of service provision. Ticketing technologies are a related issue, and any move toward more "efficient" yet inherently complex pricing structures is difficult in the absence of facilitative ticketing systems.

This paper was written to analyse practices based primarily on public domain material, with assistance from key contacts in Munich's *MVV* and the Washington DC metropolitan area's *WMATA* agency.

METHOD AND MOTIVATION

The research discussion that follows represents a case study component of a larger research program conducted during 2009 and 2010. This industry-sponsored exercise reflects a need for information explaining potential responses to pressures that are currently being faced with growing peak period demand in the "big three" Australian urban rail systems – Sydney, Melbourne and Brisbane – and to a lesser degree Perth. The two case studies discussed here, Munich and Washington DC, were chosen because they were seen to offer reasonably innovative examples in current and evolving practice, as well as being familiar to the researcher and offering good availability of information. These two systems, plus the previous case study locations (San Francisco and Sydney), the other big Australian systems, and certain Asian networks (Hong Kong and Singapore) emerged as a viable "cluster" of networks from a research perspective. While the systems are reasonably diverse, it was judged that they are generally serving "mid-sized" cities (2 million to 7 million) rather than being "true megacities" (like Tokyo, Paris, London or New York – possibly with apologies to Hong Kong). As networks handling roughly between a few hundred thousand to several million passengers a day, they offer insights into effective practice network management that should be "generally transferable", rather than specifically or directly so. A range of themes and issues presented themselves as "shared discussion points" among this cluster set – including current issues in ticketing technology, fare structure, service levels, ridership growth, network development, a desire for integration with urban morphology and land use, and more. Extended discussion of the usefulness and rationale for this cluster analysis is offered in Hale & Charles (2010). The basic research method has been "read, visit, enquire, analyse, and discuss". Relevant background and planning documentation has been thoroughly consulted. The systems have been visited for fieldwork on several occasions – allowing a reasonable level of familiarity with on-the-ground conditions. Analysis of key metrics (identified initially in Hale & Charles 2009a) was performed – with much of the information gathered through questionnaire or direct enquiry to agency planners. Significant follow-up discussion with agency staff followed during drafting of this paper.

MUNICH 1. DESCRIBING THE PEAK PERIOD

To understand issues and challenges currently being faced in Munich in managing and smoothing passenger loadings, this section reviews the definitions and descriptors of the "peak period" in use. Issues related to 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

Transport stakeholders and publications in Munich do not provide clear indications of when "official" peak periods take place. The most basic descriptor in reasonably common usage revolves around the morning period between 6am and 9am during which holders of certain travel passes (particularly concession style passes) are unable to use their ticket (MVV 2009). Notably, there does not seem to be a similar period of "concession holder exclusion" during afternoon times in which heavy commuter travel would normally be expected. The overall lack of definition and clarity in terms of official nomination of peak periods may be in-line with the phenomenon of Munich as a system in which "peakiness" is notably less pronounced (at a 35/65 peak/off-peak patronage split[2]) compared to other systems internationally (particularly in the New World, where peaky demand paradigms are generally highly pronounced). MVV planner Bernhard Fink has suggested that during the periods of 6am – 9am, and 4pm – 6pm, increased demand levels are generally observable throughout the network.

Station demand challenges

There are a number of inner-city and inner-suburban stations in Munich that are experiencing very high or notable levels of daily usage. In the central and inner city these include (City of Munich July 2005, appendix 1):

Marienplatz (at the centrally-located city hall plaza):	170,000 passengers
Hauptbahnhoff ("main station" offering long-distance transit connections):	160,000
Ostbahnhoff (the "eastern station"):	92,000
Karlsplatz (at the western edge of the old city retail district):	80,000
Rosenheimer Platz:	52,000
Isartor (at the eatern edge of the old city retail district):	47,000

Graphic 1: Marienplatz Station. December 2007, C Hale.

In inner and middle suburbs, a handful of stations handle levels of daily patronage that would be considered very high for a suburban location in most major rail networks internationally. In fact

2 Provided by MVV staff, current at May 2010

Munich's rail system is in-part notable for the high levels of patronage at a range of suburban stations. Selected examples include:

Pasing	56,000
Laim	36,000
Donnersbergerbrücke	33,000
Giesing	17,000

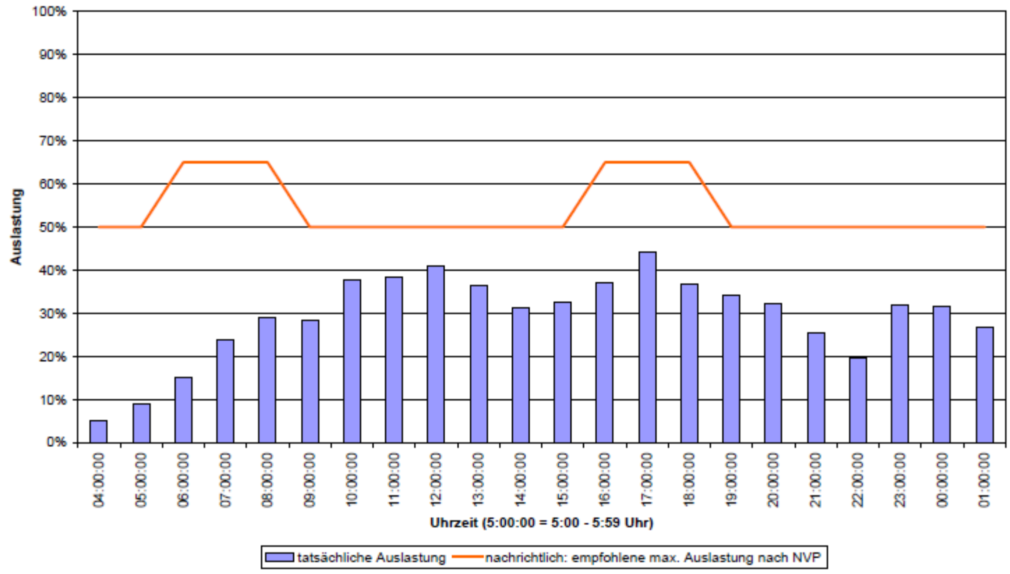
Of the inner-city stations, both Marienplatz and the Hauptbahnhoff are handling levels of patronage that are sufficiently challenging for serious long-term redevelopments or station duplication options to have been raised (City of Munich July 2005). In the case of Marienplatz, an option has been put forward that would effectively provide a new station within walking distance of the existing central plaza Marienplatz station, situated on the proposed new "second trunk corridor". In the case of the Hauptbahnhoff "main station", levels of passenger demand at this key interchange between international, intercity, regional, S-Bahn, U-Bahn, light rail and bus transit are sufficient to have led to an international architecture design competition for a station replacement that was awarded during 2004 (DB 2004). Although due to the perceived scale of the project, and its relationship to other highly complex rail infrastructure expansion proposals (the "second trunk" included), the Hauptbahhoff redevelopment has not been implemented subsequent to the design competition.

"*Although radial trip-making still predominates, …the trend in Munich is toward more crosstown travel*." (Cervero 1998, p216)

Train capacity management
Another notable aspect of demand management practice and system-wide service provision in Munich is the willingness to provide rail capacity that is by-and-large *in excess* of demand levels. This approach may at first seem unusual or counter-intuitive to transit practitioners in Australia or the United States, for example, but is in-fact based on the implementation of firmly-established transit planning principles. Key transit planning sources such as Vuchic (2006; 2007) refer to the need for a benchmarking of demand at 80% of offered capacity, while the TCRP (1996; 2003) refer to the need for "loading diversity factors" as buffers to non-optimised loading and passenger flows. The summary of these "best practice" theories would be to suggest that rail agencies should offer capacity in excess of demand, perhaps adopting an approach in which demand is averaged at around 80% of capacity at most. This approach would allow for a capacity buffer in the system in order to allow non-disruptive responses to inevitable system breakdowns, for regular but difficult-to-predict surges in passenger numbers for particular services, and for the inevitability of non-optimal loading of trains. It also allows for high levels of passenger comfort overall (most longer-distance travellers can obtain a seat) and provides a capacity margin that can be available for takeup by new passengers who may not have previously travelled by rail. Without a capacity buffer in the order of 20% or thereabouts, rail systems are invariably overburdened, overcrowded, uncomfortable and less reliable – and this is the case in many US or Australian networks, particularly those (Sydney, Brisbane, Melbourne for example) that have seen strong ongoing patronage growth in recent years that has exhausted all spare capacity (Hale & Charles 2009a; 2009b). Notably, the Munich network *actually features a capacity buffer* such as those familiar to New World planners only through textbooks and reference reports (Vuchic 2006; TCRP 1996; TCRP 2003), as a firmly-established and successful operating and planning paradigm. In other words, Munich is notable for having planned to avoid train capacity problems and overcrowding, and having achieved that outcome – delivering system reliability, high levels of passenger comfort, and the ability to continue to attract new passengers over time while avoiding "unforeseen" problems of overcrowding.

The policy in question is the so-called "*empholene maximum Auslastung*" or "mandated demand/capacity ceiling" (in approximate translation) (City of Munich 2005, appendix 6). This equates to the red line on the graph presented below. Notably; a) this maximum is rarely attained, and b) the ceiling is set very low (at demand levels of between 50% of off-peak and 65% of total peak capacity) – presumably in order to deliver high passenger comfort levels and the other benefits of operating below capacity as set out above. This practice in Munich occurs in a system which is seeing strong overall financial performance.

Graphic 2: U3/U6 corridor, Universität to Odeonsplatz Stations section city-bound. Demand and supply analysis. March 2005. Courtesy MVV.



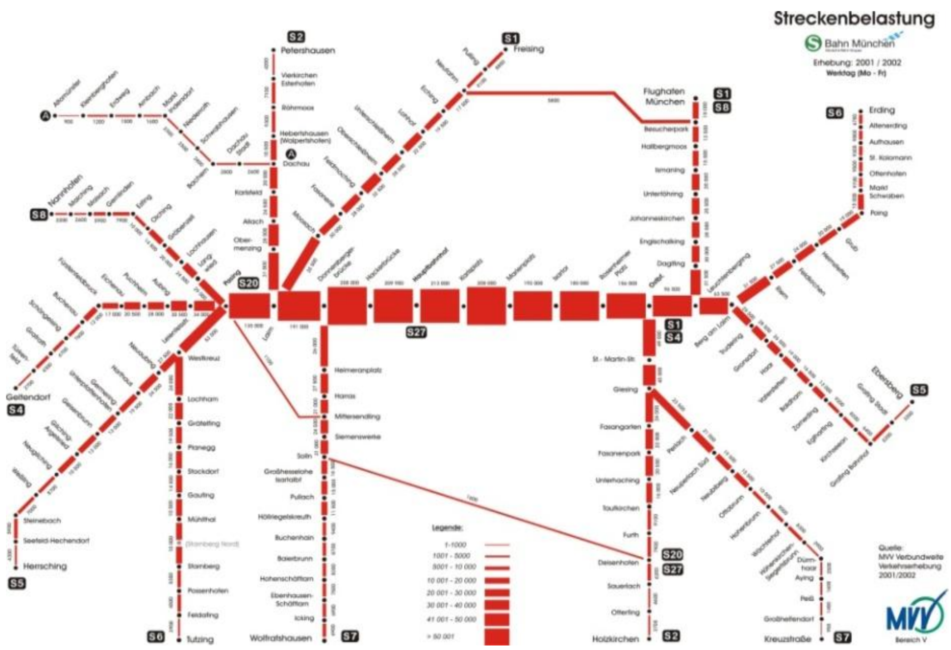
Line capacity

Overall, Munich's highly advanced rail networks facilitate effective line speeds and the ability to move large numbers of trains over a given line during a given period. To provide an example, most corridors see frequencies of between 2 and 5 minutes at some point during weekdays. With 2 minute headways seen as a benchmark internationally for train movements, it is interesting to note that the recent program of capacity improvements for the S-Bahn network (the so-called "266 million Euro program") sought to more firmly establish the capability to deliver frequencies of 30 trains per hour along individual lines running through the central trunk corridor (the east-west "Stammstrecke"). But a word of warning was sounded by transport planners that (in translation): "…*once this program is fully implemented, the capacity level of the central corridor cannot be increased further*…" (City of Munich 2005, p5). The report goes on to suggest that catering to increased passenger demand beyond this capacity benchmark will require the development and construction of a "second trunk corridor". Although the 2005 Nahverkehrsplan (translation: *Public Transport Plan*) nominated an opening date of 2010 at a cost of some 1 billion Euros (City of Munich 2005, p56), it does not appear that work on the second corridor has progressed at the rate that was initially projected… with an opening date for the second trunk not firmly established, and full scale construction yet to begin at time of publishing. MVV planner Bernhard Fink suggests: "*Because of the decision of the Free State of Bavaria not to pursue the maglev line between Hauptbahnhoff and the airport, the planning of the second trunk tunnel had to be adapted. Because of this, the original time-line for the second trunk could not be met. Now, the second trunk will likely be delivered with another underground station -"Ostbahnhof". Because of this, it is will also be possible to provide an express S-bahn link to the airport. The planning of the second trunk tunnel is divided into three sections: For the first section between Laim and Karlsplatz, all the necessary planning papers have been* *arranged. For the second section (with the station Marienhof), the planning is already done. For the third section (Isar-Leuchtenbergring), the planning will be finished as soon as possible. The aim is to finish the second tunnel by the year 2018, when possibly the Winter Olympic Games will take place in Munich. Beginning of work for the second trunk tunnel could be around 2011*."

System capacity constraints
The notable attribute of the current central corridor configuration is the convergence of some 5 or 6 individual S-Bahn lines though the main east-west section between Laim and Ostbahnhoff stations. In some parts the central corridor offers as many tracks in each direction, but the corridor is also carrying heavy levels of intercity and regional rail travel. So the convergance of lines in conjunction with the attractiveness of many central corridor stations as passenger destinations and origins seems to be combining to bring about problematic levels of demand – even with respect to the high carrying capacities and strong frequencies available in the corridor. The demand capacity challenges of the core east-west trunk were already established 10 years ago or more (Cervero 1998, p220). As such, the emerging need for a second east-west trunk corridor and potential redevelopments or duplications of stations such as the Hauptbahnhoff and Marienplatz seem to be reinforcing the rail demand management axiom that converging lines in centrally located positions with strong intermodally-linked stations are the main sources, causes and locations of problematic levels of passenger demand.

Tracking and management of problems
Among other leading attributes, Munich is notable for the quality and insight of its capacity/demand tracking and analysis. This should be at least partly attributable to the clearly articulated and highly regulated backing for mass transit performance standards in Munich and throughout the Free State of Bavaria (City of Munich July 2005, p17-19).

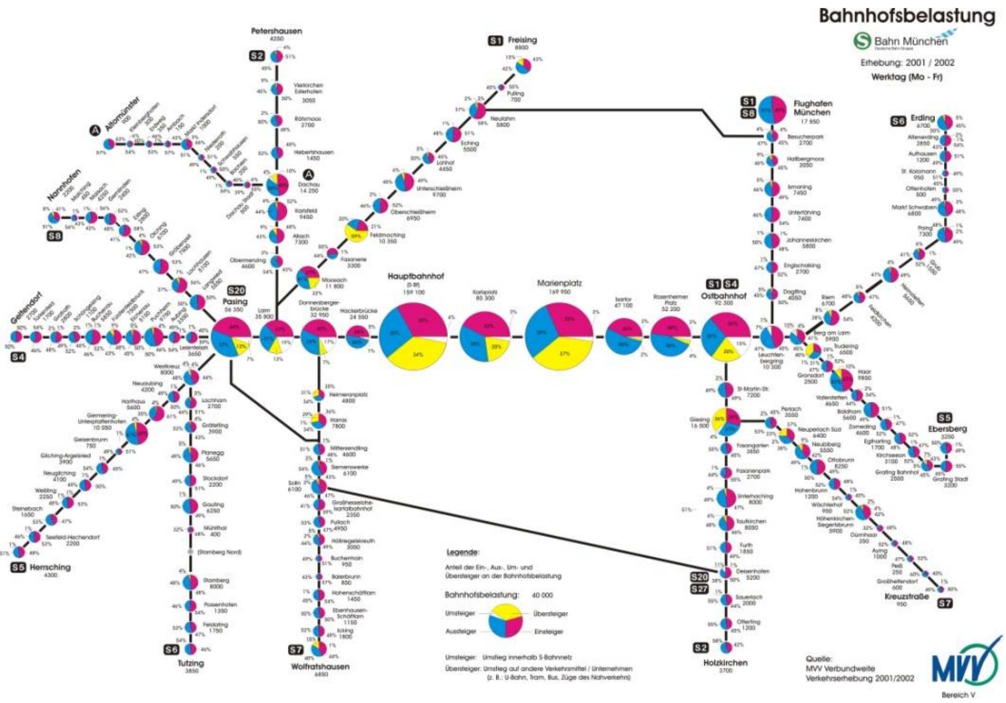
Graphic 3: Munich S-Bahn System, demand analysis 2002. Courtesy MVV.



Analyses such as those in *Graphic 3* above indicate that on individual rail lines, whether U-bahn or S-Bahn (as pictured), Munich's transport planners are actively tracking demand and capacity over time and able to present that information in a manner that is both accessible and informative. Although graphical representations such as those above may at first seem somewhat mundane, it is worth remembering that very few agencies internationally are matching this standard of ongoing analysis and making it available for public release.

As indicated by the visual representation below (*Graphic 4*), Munich is also actively tracking supply and demand at individual stations throughout the network. This graphic represents total passenger numbers at each station during workdays, and splits the count into origin/boarding passengers (pink), alightings (blue), and transfers (yellow and white according to mode). Once again the simplicity and effectiveness of these visual representations tend to underplay the difficulty that other agencies around the world seem to have presenting information in an accessible manner, and making the analysis available to stakeholders and the public.

Graphic 4: Munich S-Bahn System, station patronage analysis 2001. Courtesy MVV.



MUNICH 2. THE RAIL NETWORK's ROLE IN TRAVEL-GENERATION & CONGESTION

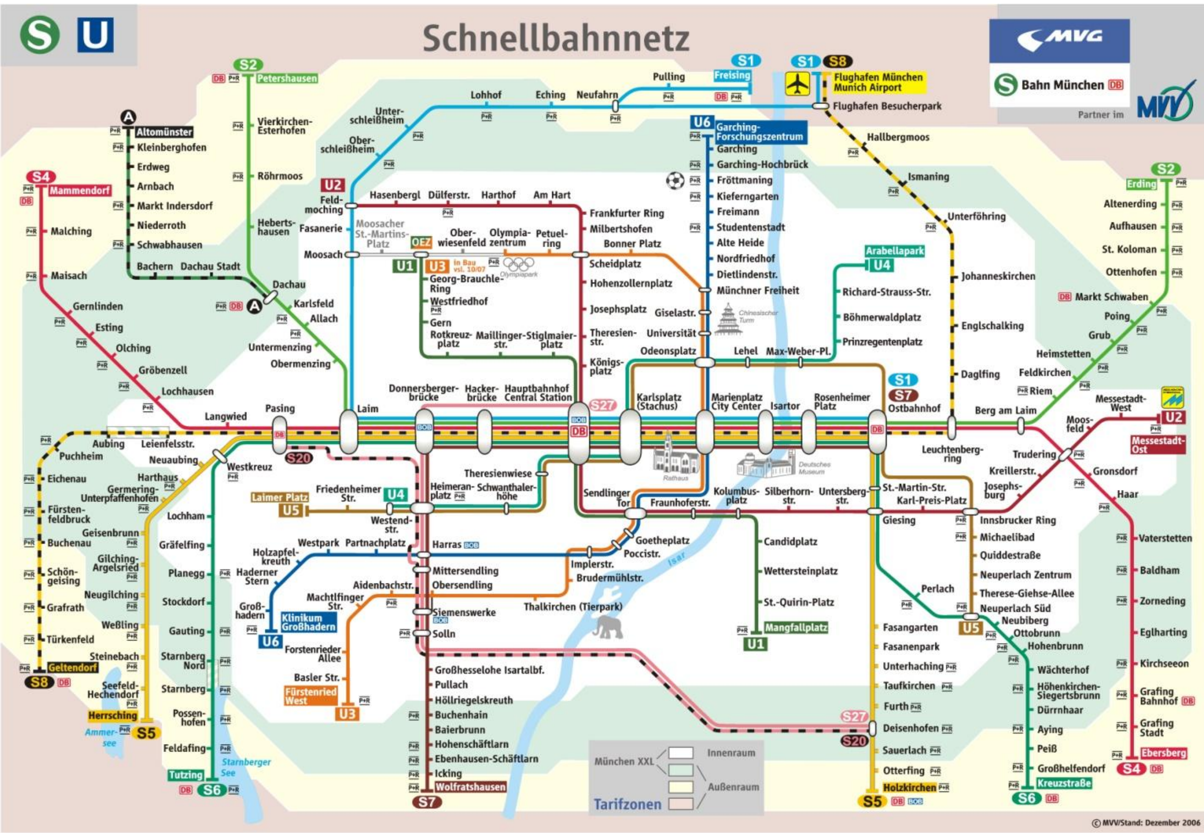
It is important to see rail networks as evolving infrastructures, rather than as a constant set of corridors, lines and stations. By understanding network configuration, we can begin to identify where and why constraints and pressure points have emerged, and may begin to understand the benefits of a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

Network Configuration

"*Thus the trend is clearly away from the traditional commuter-oriented suburban railways and toward multifunctional regional rail systems, which are better suited to the present more decentralized, multifocal cities than are their nineteenth-century predecessors.*"
(Vuchic 2007, p35)

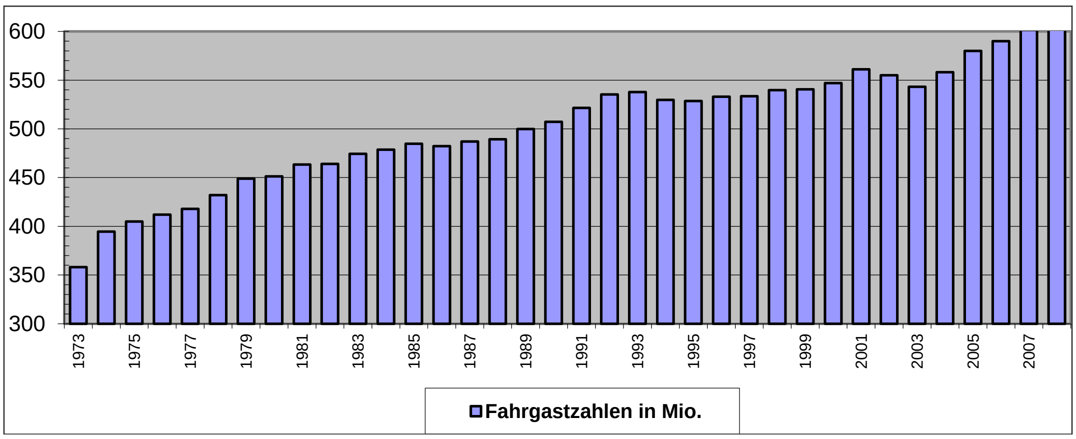
Over the past 35 or more years since the 1972 Olympic Games, Munich has actively developed and expanded its heavy rail system into a highly polycentric, grid style layout (Cervero 1998, p219). As a network element, the S-Bahn tends to provide both an east-west core trunk and a radial schema beyond the inner city and into the suburbs. Complementing this, the U-Bahn system is decidedly and deliberately "grid-style", and is oriented more toward serving north-south travel. The combination of these two primary network elements is highly effective – and both the conception and implementation program that has led to these outcomes should be commended.

Graphic 5: Munich Heavy Rail Network. Courtesy MVV.



Compared to many international rail systems, the polycentric multi-directional layout of the Munich systems provide ample opportunity to avoid the excessive peakiness inherent in so many radially configured networks. This outcome is reflected in "balanced" passenger demand paradigms in which some 65% of travel occurs during non-peak periods[3].

Graphic 6: Munich Heavy Rail Riderhsip 1973 - 2008. Courtesy MVV.



3 Figure provided by MVV staff

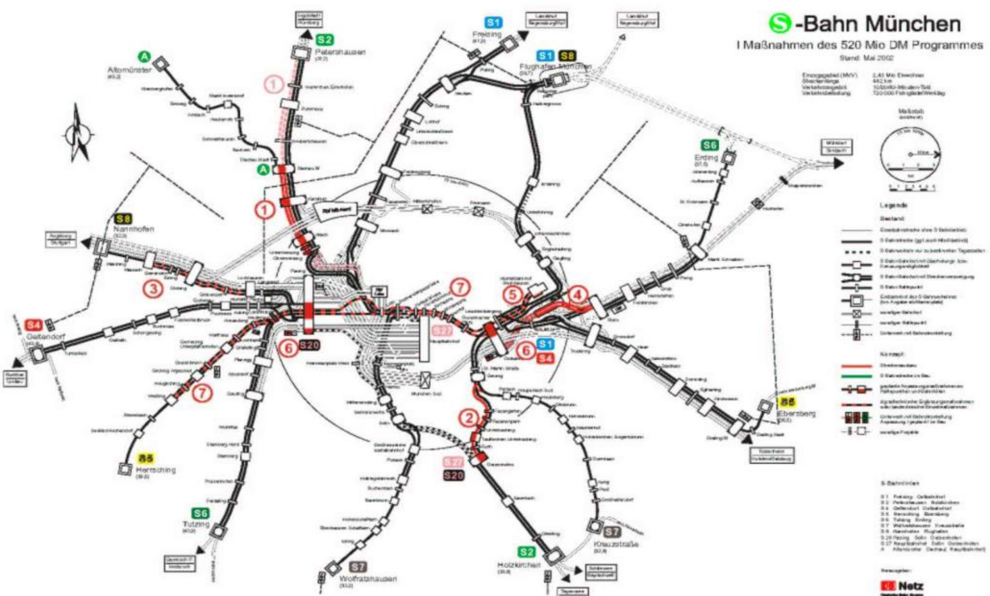
Planning Responsiveness
"*Greater Munich has pursued a balanced approach to linking transit and urban development.*" (Cervero 1998, p213)

The Munich system's impressive and steady growth in ridership over time has been complemented, underpinned and guided by a posture of responsive and proactive planning which is closely linked to implementation programs for corridor expansion, and growth in station numbers in both the U-Bahn and S-Bahn systems (Cervero 1998). *Graphic 6* above describes this steady and ongoing growth in passenger numbers.

Graphic 7 below indicates the posture of active expansion and investment that was in place for the 1998 – 2004 planning horizon in the S-Bahn network.

Where to from here?
Key projects in the current phase of planning appear to revolve around the question of implementation for the "second trunk corridor". This project will take place in the context of major urban development activity at the western end of the corridor, in the 4 or 5 stations situated between the Hauptbahnhoff and Pasing stations (Hale 2009). In this sense, the integration of urban planning and mass transit infrastructure programs in Munich seems to be facilitating a situation where development and passenger demand growth are targeted to inner and middle suburban areas that already see strong service provision, but which are also currently in need of capacity expansion. This appears to be an effective approach to handling the common problem of infrastructure and service delivery "step functions" for rail transit. Planners and operators are able to move with greater certainty because urban planning, housing and commercial development activity is supportive of and targeted toward the corridor in which major transit capacity expansion needs to occur. This strategy is doubly effective because the mix of commercial and residential development involved in the Central Corridor should also be able to anchor a multi-directional travel generation paradigm. Rather than reinforcing any CBD-oriented peak commute tendencies, the urban planning outcomes of the integrated Central Corridor effort seem to be leading toward the creation of CBD-alternative centres of travel generation (Hale 2009).

Graphic 7: Munich S-Bahn Development Program 1998 - 2004. Courtesy MVV.



MUNICH 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.

Farebox recovery
The farebox recovery ratio (ratio of ticket revenues to running costs) for MVV is estimated at around 70%[4] which is very strong compared to a range of international cities and systems. This scenario maintains some level of state subsidy, but allows significant financial independence for MVV as an agency – which appears to go hand-in-hand with an innovative organisational culture for planning and system development.

Pricing Structure
The fare structures of the Munich system have long been noted for their complexity (Pucher & Kurth 1996, p286; Cervero 1998, p225). A large array of ticket and pass-based options is offered to customers. As an example, there are at least 7 mainstream branded ticket options available to passengers (City of Munich, April 2004).

The distance-based aspect of fare structure is founded on 16 distinct "rings" across four travel zones (MVV 2009, p20). This structure allows for both travel within each zone on tickets bought for that purpose, as well as offering fine graduation in pricing of distance travelled where applicable. There is also the option of ticket products valid for either the "inner area" (8 rings) or "outer area" (12 rings). Notable from a congestion-pricing point of view is the time-based validity of various discount ticket or pass products. For many of these products, travel during the traditional morning peak period (basically taken to be 6am to 9am in Munich) is not included in the purchase price. So in this sense, many of the discounted ticket/pass options are actually "non-peak" travel options. The target markets for these products appear to be pensioners and students – market segments that are both price-sensitive, and perhaps more readily able to adopt non-peak travel routines.

How does pricing relate to revenues and costs?
Munich provides an important touchstone case study in the ongoing discussion regarding the appropriate balance between simplicity in fare structures as a passenger-attraction measure on the one hand, as against the reality that close and efficient linkages between travel choice and service-provision on the other hand will invariably demand greater complexity – particularly in attributes such as the pricing of distance travelled. While the balance of opinion for many years appeared to be in favour of greater simplicity, the research program represented by this paper has re-established a case for complexity (Hale & Charles 2009a) as have other sources very recently (eg Van Vuuren 2002; Hofker et al 2009). Greater impetus for this viewpoint seems to be closely linked to the emergence of smart card ticketing technologies at the same time as robust peak ridership growth is experienced in many rail networks.

Munich's case is more complex – largely because the "time-based" congestion-related argument for greater price differentiation may not be as compelling as it is in other cities for the simple reason that Munich is already achieving a less "peaky" demand profile. This may in part be due to the encouragement of non-peak travel by students and pensioners, but is probably also intertwined with a range of other factors (polycentricity and highly "networked" system paradigms in particular).

[4] Using 2009 estimates provided by MVV staff

In summary, Munich's two primary mechanisms for linking revenue and service-provision cost are the highly graduated distance-based structure (Cervero 1998, p225), in combination with the encouragement to non-peak travel for "non white-collar, non-CBD commute" market segments. While the principles and mechanisms are obvious, the actual economic relationship between journey choice and cost of ticketing is not clearly articulated in the public realm.

MVV planner Bernhard Fink suggests: "*The decisions on tariff structure at the MVV are always done with input from the political authorities and shareholders of the MVV, and with local transport suppliers. They have very particular interests. The tariff should offer a maximum of cost-effectiveness on the one hand, and on the other hand the tariff must be "social" and "fair" and easy to understand. This is our main priority, but beside this we have the following ticket-policies: In general, we always try to convert single-trip users of public transport into all-day users. For this we have special offers for tickets that are valid for a week, month or year.*
We also try to make a balanced and full utilisation of rolling stock resources through the whole day and week by making special offers to induce travel outside the rush hour – including; tickets that are only valid after 9:00 a.m., the banning of taking bicycles on trains during the peak period, and special offers for leisure oriented tickets that are only valid on weekends."

Ticketing technology
One of the most curious aspects of public transport in both Munich and Germany appears to be the maintenance of older ticketing technology approaches at the same time as enlightened outcomes are achieved such as; excellent overall levels of service, quality of station design and rolling stock, and effectiveness in network planning and network expansion. Anecdotally, the phenomenon of older ticket technologies has been linked to a German desire to establish a national non-proprietorial smart card technology suite – an aim which appears to be making only limited progress so far. But field work research undertaken in recent years repeatedly presented ticketing technologies and systems as the "Achilles heal" of public transport in Munich, and in Germany more broadly. At the same time that Munich maintains a highly complex fare structure, the system is reliant on paper tickets – which are inherently only practical in the context of a simplified fare structure. Equally the ticket purchase options themselves appear unwieldy – involving a choice between either long queues for face-to-face service, or using a vending machine system that takes notes for reasonably high-priced tickets (€10 or more being a common charge), while only returning change in piles of heavy coin.

Where to from here?
Overall, the Munich fare structure must be assumed to be reasonably effective, given evidence of strong financial outcomes, balanced peak/off-peak passenger demand paradigms, and high levels of graduation in terms of the cost of tickets with regard to distance travelled. Less clear are the exact linkages between ticket price and cost of service provision, as well as question marks over the future of ticketing technologies in this otherwise most advanced of rail systems. The former may or may not be an area of concern for MVV and Munich's transport stakeholders, but the latter looms as an issue that will likely emerge more strongly in coming years.

MUNICH 4. SUMMARY OF STATE OF PRACTICE

Munich has established itself over a 30 year plus time horizon as one of the leading public transport cities in the world. This has been achieved through an "apex guiding principle" of *strong ongoing efforts at ridership cultivation* (City of Munich, October 2006). This principle seems to have informed robust efforts in network planning, infrastructure expansion, close linkages between land use and transport enhancement, and the creation of fare structures that are nominally complex, but which seem to effectively incorporate economic principles such as incentives to off-peak travel and graduation of price based on distance travelled.

These strong outcomes are also clearly founded on an excellent analytical base as an informer of quality planning. Examples of effective practice include the extent of integrated planning *documents* published in Munich (eg- City of Munich 2005; City of Munich November 2006; City of Munich March 2006), as well as the effectiveness of communication on key concepts such as system supply/demand (as per the graphic examples included in this paper – but many other instances are in place).

Equally – we should pay attention to Munich's implementation of "mandated demand/capacity ceilings" which provide a buffer of capacity at least 35% in excess of average demand levels. This real-world implementation of textbook mass transit planning principles means that customer comfort levels are high, system reliability is strong, and the network always has the spare capacity and space available to attract new riders. All this is achieved within a framework of strong financial outcomes for the transit system.

In rail planning, prominent attention should be focused on integrated land use/transit approaches as a tool for achieving balanced passenger demand outcomes. This is clearly the case in Munich's long term efforts toward developing a polycentric metropolitan region in which most major rail stations are linked to particular land uses in the surrounding area and hence to particular travel generation paradigms. Linkages to and from universities, retail areas, residential districts, airports, sporting stadia and new development zones are all excellent. There is a "Hauptbahnhoff" major station and a prominent downtown retail district, but much of the employment is Munich is dispersed effectively throughout key rail-served locations in the inner and middle suburbs. This linkage between land use, travel generation and balanced transit ridership outcomes perhaps stands out as Munich's leading contribution to informing other cities and rail agencies of new directions in policy and planning.

WASHINGTON DC 1. DESCRIBING THE PEAK PERIOD

The Washington Metropolitan Area Rapid Transit Agency (WMATA) is a suburban/metropolitan integrated rail and bus transit agency, which is by far the most significant transit operator in its area – but not the only operator. WMATA operates under the generic "Metro" branding for its urban/metro rail services. For the purposes of this report, "WMATA" will refer to the agency and its decisions, while "Metro" or "DC Metro" will be used to designate the heavy rail service itself. WMATA has traditionally been a strong analyser and reporter on demand and capacity related issues – and recent strong ridership growth in conjunction with capacity constraints has renewed this focus.

Definitions and descriptors in use
Metro pricing structures revolve around a defined morning peak fare that runs from opening through to 9.30 am, and an evening peak fare from 3pm till 7pm, although WMATA prefers to refer to these as "regular fare" hours and the remaining periods as "reduced fare" periods (WMATA 2010, p32). In other locations, WMATA refers to the idea of a "peak hour" (8am to 9am) as a period of clearly-observable increased demand. The agency also refers at times to the "peak 15 minutes"…, a descriptor which is applied for analysis to capture the peak within the peak. Elsewhere, there is reference to more clearly-defined peak periods based on observed ridership flows: "*On weekdays, the period of maximum ridership lasts for about 75 minutes in the morning peak period and about 90 minutes in the afternoon peak period.*" (WMATA 2006, p11)

Graphic 8: DC Metro system map. Courtesy WMATA.

Station capacity challenges

Station capacity constraints and other capacity-related issues in DC Metro tend to be situated in what is referred to as the "system core" - centred on the three major centrally-located interchange stations; Metro Centre, Gallery Place-Chinatown, and L'Enfant Plaza. In addition, nearby stations such as Union Station, Dupont Circle and others are very high-patronage locations and tend to be included in the "system core" designation. An indicative tally of daily ridership at selected high-volume stations might include (WMATA April 2008, p30):

Union Station	64,000 passengers (all figures approx)
Metro Centre	52,000
Farrugut West	50,000
Dupont Circle	46,000
L'Enfant Plaza	43,000
Gallery Place	38,000

Capacity challenges for DC Metro have been discussed in the context of likely scenarios of ongoing passenger growth throughout the system over coming decades (WMATA April 2008). These scenarios and assumptions are probably realistic, or even somewhat conservative given that funding constraints appear to be preventing a full-engagement with ridership cultivation through system expansion (Puentes 2004). An interesting aspect of the growth-related scenario is WMATA's identification of the inter-related issues of "high transfer volumes" at certain stations, alongside looming challenges for passenger movements through facility elements such as fare gates and escalators at these high volume stations (WMATA April 2008). This is a somewhat novel but important lesson for other agencies from the WMATA approach – the agency seems to be clearly identifying passenger growth challenges, but also able to identify the location and nature of the issues that passenger growth brings. A summary of projected transfer volume growth at selected stations is tabulated below, drawing on and summarising from WMATA figures (WMATA April 2008, p33):

Graphic 9. DC Metro Peak Transfer Volumes

Station	Transfer lines	2005 AM peak hour transferring passengers	PM peak hour 2005	AM peak hour 2030	PM Peak Hour 2030	Total projected growth to 2030 during peak periods%
Metro Centre	Blue, orange, red	10,300	9,900	15,100	14,700	48
Gallery Place - Chinatown	Yellow, green, red	9,700	9,500	12,600	12,900	33
L'Enfant Plaza	Blue, orange, yellow, green	7,000	6,500	13,200	12,800	93
Fort Totten	Red, green	1,200	1,100	1,700	1,600	40
Rosslyn	Blue, orange	1,050	1,100	2,800	2,900	168

Another interesting aspect for WMATA's analysis of its station capacity challenges is its clear focus on the issue of station access – with constraints in access via park and ride, feeder buses and even walking and cycling all looming as a challenging planning issue to be addressed in coming years as passenger growth continues (WMATA April 2008).

Train capacity problems

"*Between 2000 and 2006 Metrorail's annual ridership increased from 163 million riders to approximately 199.9 million, an average annual growth rate of 3.38%*" (WMATA April 2008, p8)

The overall growth challenges for DC Metro are expected to impact on both the loadings of individual trains and the entire fleet management program for WMATA in the coming decade and more. Current fleet is configured to offer roughly a 50/50 split between seated and standing capacity within cars (WMATA 2006, p4). In terms of overall car loadings (which could conceivably be around 150-160 passengers per car in a full crush-load scenario), WMATA has been seeking to benchmark 120 people per car as a maximum peak loading factor – with the obvious intent to maintain heavy loadings, while still buffering some amount of additional capacity into the system (WMATA 2006, p12). "*Experience following the opening of the Branch Avenue section of the Green Line taught us that an average of 120 passengers per car is the point where customers will refuse to board a train and will be left behind on the platform. Passenger demand and our ability to accommodate those demands become unmanageable beyond a peak hour average of 120 passengers per car*." (WMATA 2006, p12)

Current loading standards are defined thus (WMATA 2006, p12):

"*Peak Primary Standard: Not to exceed 120 passengers per car (ppc) average of all trains passing the maximum load point in the peak direction in the peak one hour on each line.*

Peak Secondary Standard: Not to exceed 140 ppc for the peak half-hour or 155 ppc on any single train passing the maximum load point on each line during the peak period."

The awkward point behind WMATA's detailed discussion and elaboration on train loading issues seems to be an impression that these problematic loading levels are *already quite common* throughout the system, especially at key locations and corridors. In fact, WMATA discusses the 120 ppc benchmark in terms of an "objective" of "reducing" its average loadings below this level – implying sustained passenger loadings beyond this point as common already (WMATA 2006, p12). In this context, WMATA's projections for ongoing ridership growth would appear to be a major challenge. Much of the planned response revolves around increasing the proportion of the fleet operating as 8 car sets into the future – but an impression remains that the challenges of train overcrowding are only just beginning for the agency.

Line capacity constraints

"*Current Metrorail passenger demand requires headways of two to three minutes in downtown areas in peak periods*." (WMATA 2006, p9)

DC Metro's relatively new, late 20th century rail network is configured to operate with "…state of the art automatic train control…" (WMATA 2006, p4) and it seems that current arrangements probably allow highly efficient train movements that come close to international headway benchmarks at just on or over every 2 minutes. With a high-performing system already in place, there appears to be little room for capacity expansion through improved headways on individual lines – and with ongoing passenger growth expected it appears that a difficult period looms ahead for WMATA planners.

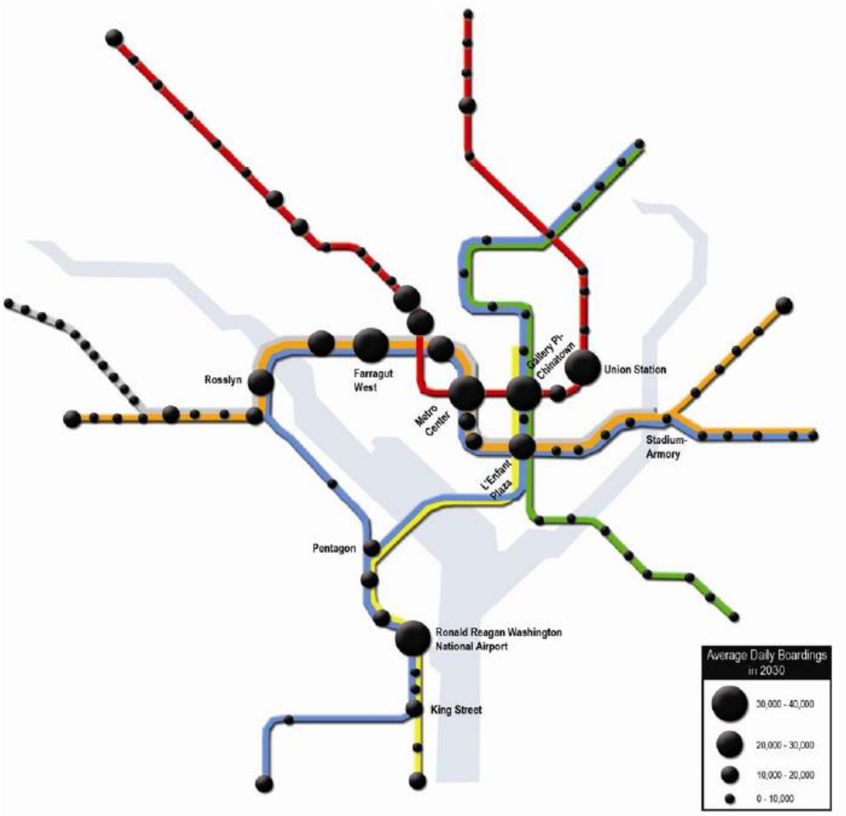
Tracking of peaking and planning for future demand

"*Of the 2030 average daily ridership, 50 percent will be within the core, 12 percent in non core areas of the District, 19 percent in non-core areas of Maryland, and 19 percent in non core areas of Virginia. Within the system core, Metrorail ridership on all the lines will remain strong, reaching 365,000 trips daily by 2030. Outside the system core, ridership will experience faster growth than the growth inside the core, indicating a continuing trend of job and population growth in suburbs and an increasing demand for transit service outside the system core*. …*The systemwide peaking pattern in 2030 is expected to be similar to that of 2005. Approximately 60 percent of daily ridership will occur during the AM and PM peak periods. The AM peak hour Metrorail trips to non core areas will grow faster than the core, suggesting an increasing demand for reverse commuting on Metrorail during the peak period. Stations located within the system core will remain top destinations of rush hour trips totalling 75,100, the majority of which are work trips*." (WMATA April 2008, p3)

Both the range of analytical tools and approaches used by WMATA, and the quality and openness of reporting on these topics and issues are to be commended. Graphic 10 below provides an interesting insight into both the challenges that are presenting themselves for DC Metro, as well as the ability to utilise innovative communication mechanisms to clarify potential scenarios (WMATA April 2008, p 36).

Overall, WMATA is highly active and effective at tracking and reporting on challenges and issues with regard to capacity/demand trade-offs that are occurring. Of particular interest for other rail agencies may be the phenomenon described above, in which non-central locations provide heavy ridership growth into the future – holding the prospect of significant counter-balancing passenger flows. This "counterbalancing" outcome is something of a holy grail for major rail systems – offering the prospect of significant ridership and revenue growth without the need to offer more peak-direction capacity (Hale & Charles 2008a). In fact, some of the capacity required for "reverse commute" travel patterns may already be in place in the form of underutilised outward-journeys for runs that currently cater mostly to inward-bound commutes.

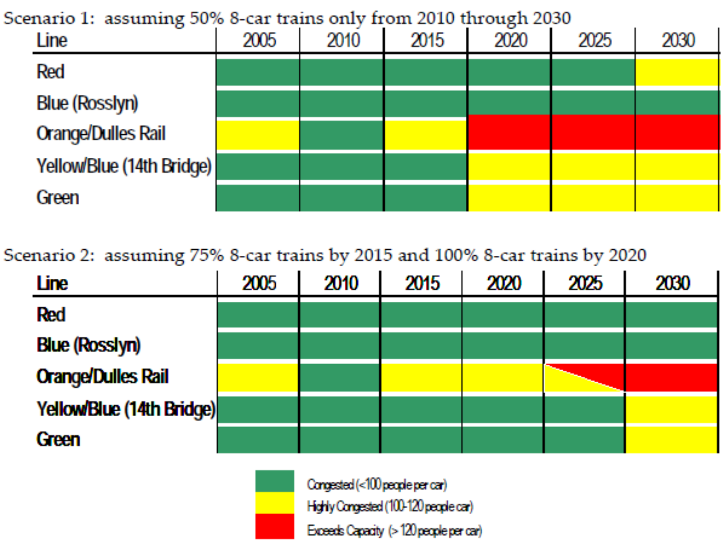
Graphic 10: Projected average daily boardings 2030
Reproduced courtesy of WMATA



System & corridor capacity constraints

As alluded to in Graphic 11, the corridors that are emerging as the likely locations of problematic capacity constraints are readily identifiable. They include the orange line (especially with regard to the planned extension from that corridor into Dulles Airport) and the yellow, blue and green lines - especially beyond 2025/2030.

Graphic 11: System capacity at maximum load segments 2005 – 2030, am peak hour
Reproduced courtesy of WMATA



WASHINGTON DC 2. THE RAIL NETWORK's ROLE IN TRAVEL GENERATION & CONGESTION

DC Metro has long been acknowledged for the innovative attributes of network design that were delivered through its establishment and development as an entirely "new generation" network through the 1960s into the late 20th century (Schrag 2006). Notably, DC combines both metro/subway elements and extensive at-grade alignments, while also offering a combination of radial elements and a networked system core. Further, the use of individual lines as tangential and cross-town travel paths is somewhat innovative – and holds promise for improving "reverse-commute" options. It also means that DC Metro has no terminus stations in central locations, and hence the problematic in-out nature of train movements in so many older-generation systems is avoided.

Planning Responsiveness

Once again, DC Metro's status as a "new generation" network means that its particular planning circumstances are relatively uncommon. Planning and system expansion programs have been more or less ongoing for around 40 years now. System expansion is set to continue somewhat through the Dulles Airport extension and other programs that will offer around a dozen new stations through till 2030. But at the same time, WMATA currently faces significant challenges in the adaptation of organisational posture from a "first generation" (1960 to 1990s) phase into a "second generation" phase replete with typical challenges such as major rolling stock fleet replacement and maintenance cycles, and a maturing of the network in terms of saturation of available capacity (without radical change or major new initiatives currently avoided in planning documents). Like many systems in the USA (and elsewhere for that matter) it has often been commented that DC Metro is constrained in terms of its network planning and development posture by financial limitations. In particular, the reliance on annual appropriation funding, has been singled out, along with a more general "lack of dedicated funds" from WMATA's various financial stakeholders (Puentes 2004).

So while system expansion over the previous 25+ years has been nothing short of spectacular, the interested observer may envisage serious challenges looming for DC Metro. Current planning documents (eg WMATA 2006; WMATA April 2008) do indeed speak of a range of capacity expansion options. They include; the Dulles airport expansion; station system and capacity improvements for both internal environments and access capacity; the "blue and orange line splits"; and evolution toward primarily 8 car fleet. But as indicated by graphic 11, this suite of capacity-expansion efforts becomes increasingly exhausted from 2015 onward. The Station Access & Capacity Study (WMATA April 2008) suggests that this "Constrained Long Range Plan" has only been partially approved by the board of directors. In addition, while ongoing growth of around 3% is projected based mainly on population growth, this projection is predicated on two key assumptions – one is "no more new lines beyond the Constrained Plan", and the other is "no mode share shift in favour of transit". Both of these assumptions may well reflect current commercial constraints and realities for DC Metro. But in the context of strong projected metropolitan population growth and the potential for issues like fuel price and carbon caps to impact favourably on transit mode share, key assumptions of this nature appear to be somewhat problematic to the independent observer (see Puentes 2004).

Network Configuration

Returning to the issue of network configuration, we see both positives and drawbacks in current configuration. The interchange-friendly central core, based around Metro Centre, Gallery Place and L'Enfant Plaza stations appears to have been workable during the development phases of DC Metro's development and ridership growth. But clearly, the model of focusing on these three core stations has now reached the end of its usefulness in terms of capacity saturation

(WMATA April 2008), and despite investments in station capacity the scenario can only become more problematic as time goes on. On the other hand, there are several elements of network configuration that only now seem to be coming into their own. Attributes such as the emphasis on suburban transit oriented development, and the cultivation of multiple non-core major activity centres are beginning now to look like highly prescient initial concepts that have been supported very effectively though ongoing multi-stakeholder efforts over time. These efforts seem to be fulfilling themselves with respect to the strong projected ridership development at non-core morning destinations. "*Stations located within the system core will remain top destinations of rush hour trips totaling 75,100, the majority of which will be work trips. Outside the system core, three areas are on the way to becoming major employment centers: between Waterfront and Congress Heights on the Green Line, between the Pentagon and Potomac Yard on the Blue and Yellow Lines, and on the Orange Line inside Arlington. These areas are likely to receive almost doubled increase in AM peak hour trips: 108 percent on the Green Line segment, 85 percent on the Blue/Yellow Line segment, and 108 percent on the Orange Line segment*." (WMATA April 2008, p31)**.**

This scenario is amply demonstrated in the table below (graphic 12), especially via the figures for projected ridership growth in the "inside to outside" (13% growth) and "outside to outside" markets (a highly noteworthy 46% growth projection):

Graphic 12: AM peak hour ridership growth 2005 – 2030
Reproduced courtesy of WMATA

	2030			% Change: 2005-2030		
Destination (To) / Origin (From)	Entire System	Inside Core	Outside Core	Entire System	Inside Core	Outside Core
Entire Metrorail System	117,800	75,100	42,700	35%	33%	39%
Inside System Core	17,200	10,600	6,600	12%	12%	13%
Outside System Core	100,600	64,600	36,000	40%	37%	46%

Where to from here?
"*Overall, peak hour growth is forecasted to be 35 percent between 2005 and 2030. This is less than the 42 percent growth projected for daily trips, indicating higher growth in the off peak period*." (WMATA April 2008, p31)

There are strengths and weaknesses discernible in WMATA's current planning situation. On the one hand, the prospective emergence of strong counter-flow "reverse commute" travel paradigms offers the possibility of significant amounts of "painless" ridership growth. But at the same time, peak ridership growth in peak directions is also set to grow significantly (by around 30%), and this appears to be a difficult scenario given the saturation of the three main centrally-located transfer stations, and of certain corridors. Equally, while overall ridership growth projections appear positive for DC Metro, the constrained financial position of WMATA appears to be holding back planning of anything but the most obligatory of system extensions, precisely at a time when recent and future metropolitan population and employment growth is so robust and favourable for bold planning initiatives. In not addressing the key capital funding challenges of the system, WMATA's board appears likely to forgo the opportunity to capture greater mode shares and the possibility to use regional growth to underpin viable "next generation" expansion of the Metro network. A vision for next-generation expansion could potentially see DC Metro evolve from "one of the better mass transit systems in the USA" toward genuinely being established among the top handful of systems worldwide.

Land use relationships and transit oriented development need to be singled out as outstanding achievements of DC Metro and local government and other stakeholders. Not only the Rosslyn-Ballston corridor, but a range of other locations have seen effective cultivation of TOD over extended periods (TCRP 2004, ch12) – to the benefit of overall ridership but also the composition and relative weighting of inward/outbound peak journeys. TOD efforts and their positive spin-offs are set to continue.

Further commentary on network configuration is also warranted. The paradigm of a highly interchange-friendly core in combination with tangential lines extending into suburban areas seems to have been a winning approach during the first generation of DC Metro maturity. But at this point in time, the future workability of those same aspects of system configuration is suddenly open to question. Without attempting to describe an off-the-cuff series of network development options for DC Metro, it appears that efforts toward identifying both radial/suburban extensions apart from the Dulles corridor, and core capacity-enhancing new lines in central locations, will probably *both* become increasingly necessary aspects of the planning mix through the coming 5-10 year cycle. Thankfully, WMATA's established culture of planning excellence should stand it in good stead for rising to these emerging challenges.

Finally, it should be noted that with regard to configuration-based demand/capacity challenges both established and emerging, *all available* non-infrastructure, management-based approaches at WMATA's potential disposal will need to be re-canvassed. These will be further discussed below, and in the conclusions to this section on DC Metro.

WASHINGTON DC 3. FARE STRUCTURES & TICKETING

WMATA runs DC Metro under a basic peak/off-peak pricing regime. Metro is also one of the early-adopters of smart card ticketing in the US market. Overall though, fare structures and ticketing seem to be presenting themselves as new areas of further opportunity when compared against the current emphasis on infrastructure expansion-based responses to growth.

Financial position and current issues
Planning and infrastructure futures for DC Metro have been discussed by both internal and external commentators in the context of the uncertain funding cycle in which Metro finds itself (Puentes 2004; WMATA April 2008; WMATA 2006). While the agency performs reasonably well on leading metrics such as the operating ratio, with a rail-only ratio of around 75 – 80%[5], considerable attention has been focused on the problematic issue of DC Metro's funding cycle.

"…WMATA receives no dedicated stream of revenue each year for capital or operational costs. Instead, WMATA is uniquely dependent on annual operating subsidies from its member jurisdictions as well as revenue it generates internally from passenger fares, advertising, and parking." (Puentes 2004, p1)

The financial constraints for WMATA appear to be emerging strongly at the same time as ridership growth, ongoing growth in population catchments served, and the issue of system capital replacement requirements as the DC Metro enters its fourth decade of operations (Puentes 2004; WMATA April 2008; WMATA 2006). Once again, it appears that DC Metro's infrastructure expansion options are constrained due to the overall financial situation. At the same time, it could be suggested that recent WMATA planning documents and reports, while effective and based on strong analysis, have been heavily infrastructure-oriented, while potential management and/or strategy-based responses such as nuanced variations in pricing

[5] Information provided by WMATA staff, January 2010

mechanisms received little attention. Reportedly though, a board-level proposal for peak-of-peak pricing differentials was being raised at time of writing as part of the FY2011 budget proposal (Thomson 2010).

Pricing Structure
DC Metro operates with a relatively straight-forward pricing structure that places a higher price on the "boarding fare" for peak periods (before 9.30am and between 3pm and 7pm). There are essentially three distance-based price bands which are also varied according to time of day (ie the distance-based price bands vary between the peak and the off-peak). Without describing the full fare structure in detail, a straight-forward 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%).

How does pricing relate to revenues and costs?
Interestingly, Metro caps its fares at $4.50 – suggesting that linkages between the marginal cost of service provision and ticket prices diminish as journey distances increase.

"*The rail formulas also have two components: base rail and "max fare." The base allocation reflects three equally weighted elements—population density, number of rail stations, and ridership—intended to reflect the benefits that jurisdictions would receive by having Metrorail service. The max fare allocation adjusts for the fact that WMATA's fare structure results in diminishing returns for longer trips*." (Puentes 2004, p12)

In terms of theories of efficient pricing (Hale & Charles 2009a) this "maximum fare" structure can be seen as a non-equitable and non-efficient outcome. Puentes alludes to this above, while stating the issue in a somewhat confusing manner – rather than "adjusting for" diminishing marginal revenues, the fare structure probably "exacerbates" these diminishing returns to the agency when catering to longer-distance journeys.

While it is common to see variations in fare structure across different rail agencies as being "peculiar" to that location and the operating and planning environment in which it is situated, it is probably fair comment to suggest that DC Metro has a non-optimal fare structure with regard to distance-based pricing components at the very least. Equally, while a peak fare surcharge of around 20% for many journeys is in place, this structure needs to be measured against its effectiveness in re-directing peak journeys into less heavily trafficked timeslots in the context of a network that is generally seen to be operating at or beyond capacity during peak times (especially during the 8am – 9am peak hour). At the same time, transport planners are now questioning whether a simple peak/off-peak structure is effective enough in dealing with actual passenger demand levels – with finer pricing graduations seen to be a possible option with future potential (Hofker et al 2009; Hale & Charles 2009a & 2009b). Patronage can surely peak within a rush *hour*, so the basic question emerges as to whether encouraging passengers to shift into slightly earlier timeslots is a viable option. In DC Metro's case there is currently no encouragement for passengers to travel at 7.30am (for example) rather than at an 8.30am "rush" time slot. Finer graduation of fares is probably an option worth considering for DC Metro. An independent observer might suggest that significant attention should be accorded to DC Metro's fare structure in coming years as a cost-effective alternative to infrastructure expansion scenarios that appear unable of themselves to fully meet anticipated demand.

Ticketing technologies
DC Metro passengers are the heaviest users of the regional smart card system branded "SmarTrip". Early implementation of smart cards in the DC metropolitan area is seen as another of the "best practice" attributes that place DC Metro in a position of leadership among US mass transit networks. Current advantages for SmarTrip users revolve more around the convenience aspects of smart ticketing, and there are no substantial incentives in place to use SmarTrip rather than the magnetic stripe stored value ticket options that remain popular with Metro riders.

With respect to potential evolution of fare structures, it may be possible that the retention of the magnetic stripe ticketing options for DC Metro users holds back the option of generational change in fare structure. DC Metro fare structures would appear to be somewhat basic – this is probably the result of the previous phase of mass transit pricing practices in which "simplified" fare structures were considered useful tools for creating ease-of-use and attracting passengers. Although recently, some discussion has emerged as to whether simplification of fare structures is effective practice on equity grounds and in terms of agency financial outcomes, while the role of paper and magnetic ticketing technologies has been questioned in terms of their potential to constrain the full evolution of fare structures that smart cards might cater to (Hale & Charles 2008). In this context, DC Metro appears to be entering into another interesting phase of system evolution – it is not out of the question that magnetic stripe ticketing options could be removed from operation, while a contemporaneous examining of the issue of diminishing marginal returns for longer distance trips could also produce pressure for wholesale fare structure revisions in the context of constrained financial resources and heavy passenger demand. Once again, these issues appeared to be raised at board level at time of writing.

WASHINGTON DC 4. SUMMARY OF STATE-OF-PRACTICE

DC Metro appears to be a system that is grappling with a classic "generational change" paradigm, which is closely linked to the maturing of the system after around 35 years of operation, this extends across areas like rolling stock fleet, ticketing technology, capacity expansion, fare structure and pricing, planning, and funding. The key challenge for WMATA lies in maximising Metro's capture of new passenger markets in a context of expanding regional employment and population, while at the same time ensuring that passenger growth is managed effectively, and that any tendencies toward "peaky" demand profiles are mitigated in order to take pressure off overloaded stations and corridors. A number of key lessons present themselves for other agencies seeking to learn from Metro's planning approach. Firstly, the long-term emphasis on transit oriented development and the creation of a multi-centric metropolitan travel generation landscape appear now to be bearing fruit at a time of competing pressures on the network. DC Metro's projected growth in "reverse commute" and non-radial travel markets over coming decades appears to be positioning the system well for overall service-planning and financial outcomes.

Secondly, the initial network configurational ideas for DC Metro appear to have been robust concepts for the long term. Rather than developing an overly-radial network concept, important elements of circulation and multi-centricity were planned-in from the outset. This means that DC Metro sees a handful of high-volume stations in the central or core areas, rather than being overwhelmed by directing too much traffic at a single "central" destination.

Thirdly, DC Metro's fare structures and ticketing technologies are close to the edge of best practice. While emerging concepts such as "smart card-only systems" and "finely graduated fare structures" are not yet in place at Metro, the system is well-positioned to transition into new-generation fare and ticketing concepts and structures for the 21st century.

The final element that needs to be commended in the DC Metro approach is the extent, quality and openness of reporting on key planning, system capacity and analytical questions. DC Metro makes most major planning documents and reports available through its website – and this provides broad access toward understanding the challenges and issues the network if facing. In the fields of analysis, reporting and open publication, DC Metro and WMATA benefit from the strong emphasis placed on these issues in the US transit industry generally, but distinguish themselves as an enlightened and proactive agency by the robustness of forward-analysis and the ready identification of problems and challenges for the benefit of all stakeholders.

SUMMARY OF DEMAND-RESPONSIVE OPTIONS

The current state of practice in Munich and Washington DC is highly relevant and important for other agencies seeking to establish strong practice principles, and to learn about the different approaches that are in place at major rail agencies in the international context. A summary of the main demand management options that these major rail systems have in place includes:

- The cultivation of polycentric passenger movements and networked system configurations
- Increasing capacity through improved, systems, rolling stock, and infrastructure
- Differential pricing including peak surcharges
- Munich offers an example of a highly-graduated distance-based fare structure
- Targeting of concession fare travellers (in Munich's case) as a group that are willing and able to accept price incentives to chose non-peak travel options
- Developing a wider set of peak destinations over time through long-term efforts in transit oriented development
- A focus on station access (in DC Metro's case) as a mainstream component of capacity/demand outcomes
- The importance of actively tracking and managing demand and capacity and of reporting openly on these topics
- MVV offers a wealth of visually-sophisticated communication tools for analysing and discussing system demand and capacity

Both DC Metro and Munich MVV's rail systems are performing very well from the point of view of key metrics such as operating ratio. They share a somewhat common heritage as contemporary late 20th century rail networks. While Munich's network developed at a slightly later stage, both systems have benefited from a "clean slate" approach that has emphasised strong non-radial elements and corridors. In this sense the two agencies have "historic" advantages that other agencies (such as the Australian networks with their early 20th century radial legacy) do not have. It is important for any rail system contemplating new challenges in demand and capacity to engage with the lessons of these two most important European and US systems. At the same time, the looming generational legacies of the two systems are similar. Munich faces the massive cost of a "second trunk corridor", while DC Metro sees heavy passenger loadings into its core stations – especially the three main centrally-located stations which are already notionally beyond capacity during the peak.

Graphic 13: Marienplatz station – Mezzanine level. June 2008, C Hale.

The full extent of pricing and fare structure-based mechanisms for smoothing demand perhaps remains to be fully optimised. While they both have a fairly basic (but differing) peak surcharging mechanism in place, the graduation of surcharging according to passenger demand could be improved. While in DC Metro's case, the question of efficient pricing of longer-distance journeys is probably set to raise itself as an issue in the context of parallel challenges in system capacity and financial constraints. Munich's offer of cheaper non-peak travel to concession product holders (essentially students and pensioners) is somewhat unique and worthy of attention. At face value, this could be interpreted as a win/win scenario – in that peak congestion is mitigated, while the concession holders are offered a cost effective travel option. But in both the DC and Munich cases, peak/off-peak structures are very basic overall at present.

A somewhat unique contribution from DC Metro might be its targeting of station access capacity as a relevant issue. While enlightened transport planners would understand the connection between access capacity and demand levels, few agencies have made the link as closely and explicitly as WMATA, while planning efforts themselves from WMATA on this topic are quite sophisticated and at the level of international best practice.

And finally, the general emphasis on analysis and reporting in both cases is very strong. Munich's planning efforts take place within the framework of a planning cycle that also addresses land use and a range of other issues alongside public transport in companion reports. DC Metro's analysis of most issues in its planning documents is strong, but the particular attention afforded to capacity/demand at the corridor and station levels, including analysis of transfer volumes, is well-developed and provides strong future direction.

Broader Implications

It appears that demand management, capacity-planning and demand-smoothing are now asserting themselves as important considerations for major rail agencies internationally. The two case studies outlined here offer a range of options, but ultimately best results will be delivered in particularly locations and cities through a willingness to adopt a responsive and active posture on network planning, pricing, service-provision and infrastructure. Increasingly, it is expected that performance on a range of fronts will be improved among those agencies and operators willing to engage with the full range of potential options, with the examples of the better systems worldwide, and with the idea of demand management as a component in a broader concept of renewal in rail network management practice.

Graphic 15: U-Street Metro station, District of Columbia. November 2008, C Hale.

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