1-1-2014

Building a railway for the 21st century: bringing high speed rail a step closer

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Abstract

High Speed Rail (HSR) operating at maximum speeds of above 250km/h with electric passenger trains are now operational in at least 11 countries. As the feasibility of building an Australian East Coast HSR network between Melbourne, Sydney and Brisbane is once again being examined, governments at Federal, State and Local levels need to develop complementary transport infrastructure and services to ensure the long-term financial and operational success of HSR. The lengthy time frame currently envisaged for completing the first stage of an Australian East Coast HSR network by 2035 provides a 20-year window for improving and upgrading urban and regional rail systems to make them 'HSR ready'. This paper explores an incremental approach to providing a HSR network that will allow progressive enhancements rather than the currently recommended 'big bang' approach and identify changes required to produce a healthy intercity rail network to complement a successful HSR network.

Keywords

closer, 21st, step, railway, building, rail, speed, high, bringing, century

Disciplines

Engineering | Science and Technology Studies

Publication Details

Michell, M., Martin, S. & Laird, P. (2014). Building a railway for the 21st century: bringing high speed rail a step closer. Conference on Railway Excellence, Proceedings (pp. 612-621). Australia: Railway Technical Society of Australasia.

BUILDING A RAILWAY FOR THE 21ST CENTURY: BRINGING HIGH SPEED RAIL A STEP CLOSER

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SUMMARY

High Speed Rail (HSR) operating at maximum speeds of above 250km/h with electric passenger trains are now operational in at least 11 countries. As the feasibility of building an Australian East Coast HSR network between Melbourne, Sydney and Brisbane is once again being examined, governments at Federal, State and Local levels need to develop complementary transport infrastructure and services to ensure the long-term financial and operational success of HSR.

The lengthy time frame currently envisaged for completing the first stage of an Australian East Coast HSR network by 2035 provides a 20-year window for improving and upgrading urban and regional rail systems to make them 'HSR ready'. This paper explores an incremental approach to providing a HSR network that will allow progressive enhancements rather than the currently recommended 'big bang' approach and identify changes required to produce a healthy intercity rail network to complement a successful HSR network.

INTRODUCTION

The International Union of Railways (UIC) (1) notes that High Speed Rail (HSR) involves electric passenger trains using steel wheels on steel rails. Based on the HSR prototype pioneered by Japan's *Tokaido Shinkansen* in 1964, HSR generally requires dedicated rights of way, purpose-built rolling stock and in-cab signalling.

While UIC notes (1, 2) there is no single definition of HSR, if it is defined as offering train journeys at top speeds of more than 250 km/h, at least 11 countries currently operate HSR, including Japan, South Korea, Taiwan, China, France, Italy, Spain, Germany, Britain, Turkey and Belgium. If HSR is defined as including trains operating at maximum speeds of between 200km/h and 250km/h (1), then a number of other countries join the high speed rail league, including United States, Netherlands and Switzerland.

Of course there are many countries where maximum speeds of 160 km/h or higher are operated – Medium Speed Rail (MSR) – but the key issue is the consistency of operation at higher speeds rather than the nominal train capability. Many countries operate trains at MSR standard including countries without HSR systems, such as Australia, that operate some medium and long-distance passenger services in the MSR range of maximum speeds.

In the definition of HSR and MSR the maximum speeds quoted need to be achievable over the majority if not all the line length to qualify – unlike most of Australia's existing fastest trains which are largely limited to quite sedate speeds over much of their journeys from excessively tight radius curves.

SETTING THE SCENE

The benefits of HSR for new and existing rail users including faster transit times (city centre to city centre), higher service frequencies and span of hours, comfort, reliability, price and safety are well documented. Environmental benefits such as higher energy efficiency than air or road transport (with lower greenhouse gas emissions) and reduced social and environmental externalities from transport such as road accidents, pollution, climate change and noise (1).

A key issue for HSR is the impact it can have on demography and the spatial relationships between home, work and leisure. In France, SNCF has noted that 95% of users of the TGV network are 'regular' travellers. Over recent decades, the TGV has become part of everyday life for many French.

Japanese and European experience indicates HSR operates most effectively between city pairs 100-600km apart (3). On routes of up to 500km HSR is claimed to capture between 80-90 per cent of traffic and on routes up to 800km, 50 per cent of traffic (4). Research from France, UK and Sweden indicates that travel time rather than distance between city pairs is the key factor to success of HSR/MSR, with 2-3 hour journey times over longer distances identified as critical to facilitating rail as

a time-competitive travel mode over larger areas, encouraging greater economic development, particularly in regional cities (5, 6).

The history of Australian settlement and the primacy of its capital cities means population is concentrated in the east coast capital cities of Brisbane, Sydney, Canberra and Melbourne (7), an issue largely determined by the proximity to sea transport and legacies of the Colonial era and Federation. Regional cities are by and large relatively small which is largely a function of the inadequacy of inland transport and its lack of connectivity in the 19th and 20th centuries.

Recent evidence in Victoria, following on from the Regional Fast Rail program of a decade or so ago, is that frequent and relatively fast rail services will encourage significant regional population growth in the area covered by one to two hours' travelling time. Extrapolating this experience, along with evidence from elsewhere, suggests that HSR has the ability to shift the population and economy of Australia's East Coast from highly centralised to be more evenly distributed along new linear growth corridors between the major cities.

Even if HSR promotes shorter commuting times to and from capital cities, thus supporting their primacy in the economy, the collateral gains in freight handling and transport is likely to engender a greater role in manufacturing and processing in regional locations. To this extent the creation of an Australian HSR network needs to be aware of the non-passenger rail issues that are of relevance to the regions through which the HSR passes.

Since the first railways in the 19th Century, it was recognised railways function as a 'machine ensemble', with infrastructure, rolling stock and service levels as indivisible elements of the machine ensemble that, when the elements are manipulated separately or collectively can increase its overall efficiency (8).

The machine ensemble of the railway can be adapted in a range of ways that support HSR. A number of models based on Asian and European experience of HSR are available for adaptation into an Australian HSR system, spanning a range of options and combinations of Rights-of-Way (ROWs) and rolling stock technologies (3, 4, 9):

1. **Dedicated HSR**

   High-speed corridors utilising dedicated tracks on rights-of-way fully segregated from road and other rail traffic, capable of speeds of up to 350km/h. Japan's *Shinkansen* network is an example of dedicated HSR infrastructure. This is most appropriate where major population centres and intermediate cities are distances (≤4 hours travel time), supportive of frequent HSR services.

2. **Mixed HSR**

   This model includes the French TGV system that uses a network of dedicated HSR lines; with trains also using suitable 'classic' lines that extend the reach of HSR into larger catchment areas. French TGV trains are dual voltage as a matter of course with four voltage variants able to run across international borders, giving these trains far wider reach than just the French HSR network. This model requires extensive electrification, which is unlikely in an Australian context.

3. **Fully Mixed Rail**

   This model is exemplified by Germany's rail network covered by ICE trains, with most tracks on the rail network compatible with all HSR and conventional passenger and freight trains. The more evenly distributed population of Germany means there are fewer large population centres but more significant intermediate centres. The Germans have hybridised so that high speed trains (ICE in Germany) are able to achieve considerably better than normal train times between a very wide range of city pairs while at the same time providing some speed advantage to conventional passenger and freight trains.

4. **Tilting HSR**

   A variation of HSR rolling stock involves trains using tilt technology to run at higher speeds around curves, reducing the capital cost of high speed track alignment or allowing higher train speeds (or both). Swedish (X2000) and Italian (*Pendolino*) high-speed trains, along with Amtrak's *Acela* trains running at top speeds of 200-250km/h on conventional ROWs. Diesel and Electric tilt trains also run in Australia at speeds of up to 160km/h on upgraded narrow gauge corridors in Queensland (4, 9), but their overall average speeds are unspectacular by international standards.

Most HSR rolling stock is based on conventional trains, albeit with distributed power over a number of axles and significantly higher installed power than for 'normal' trains. All pure HSR trains are electrically powered with high-voltage overhead transmission systems and are designed to run at speeds as high as 380 km/h (although 350 km/h is the highest speed used in commercial service).

Early HSR trains such as Japan's *Shinkansen*, France's TGV and Germany's early ICE's utilise dedicated power units at each end, but with component miniaturisation and improved power technology the trend is now to passenger trains utilising distributed power, such as the later series

German ICE and the French designed AVE trains. Some diesel-electric trains achieve low-end HSR 'threshold' speeds of around 200km/h, most notably the British Intercity 125 train (4).

Maglev trains are a peculiar variant on the high-speed theme. However, they are unlikely to challenge conventional wheel-rail technology in the time line involved in the local East Coast HSR proposal.

A BRIEF HISTORY OF HSR IN AUSTRALIA

The history of Australian HSR is one of many proposals and concepts period between 1981 and 2013. While the 'early' period of Australian HSR proposals from 1981 to 1997 has been covered elsewhere (10, 11), a short chronology of later proposals is provided below.

1998: The Speedrail consortium was invited to prepare and submit a "proved up bid" for a Sydney-Canberra HSR route, conditional on it being at "no net cost to the tax payer." While publicly available information on the bid is limited, the 270km link was costed at $4.8 billion with the public sector's required contribution being reportedly over of $1 billion (12). Lack of political support by the Howard Government saw the Speedrail proposal lapse.

2000: The Australian Government instead commissioned a two-stage East Coast Very High Speed Train (ECVHST) Scoping Study, with Stage One released in December 2001 (13). That study found that overall, total benefits exceeded total costs. Despite this, in March 2002 it was announced Stage Two would not proceed (11).

2010: A report on HSR released by the CRC for Rail Innovation concluded the time was right to carry out an in-depth study of HSR in Australia (14). The report identified extensive economic, social and environmental benefits, recommending corridor reservation to preserve future options alongside incremental approaches to HSR. In August 2010, the Australian Government announced a two-stage HSR study.

2011: The Australian Government released the Stage One HSR report, with quoted construction costs of between $61 and $108 billion to build over 1600 km of track between Melbourne and Brisbane via Canberra and Sydney (15).

2013: The Australian Government released the Stage Two HSR report, examining financial feasibility, identifying alignments, refining patronage and cost estimates and investigating financing options. The report determined a 1748km route between Melbourne, Sydney and Brisbane and a spur line to Canberra. Upper range cost estimates were $50 billion for a Sydney-Canberra-Melbourne route and $64 billion for a Sydney-Brisbane route. Construction would not start until 2027 (16), indicating a low priority on the part of the consultants. Serious questions about the firmness of the route and its costings have been raised, but political indifference to HSR seems to consign this proposal to the archives.

The change of government at the 2013 Federal election has left a question mark over the future of HSR in Australia. Facing such uncertainty, it is timely and appropriate for all levels of government and the rail industry to consider alternative options for upgrading existing lines for higher average operating speeds and provide capacity to run MSR passenger trains and faster freight trains.

AUSTRALIA'S FASTEST TRAINS

It has been 15 years since Queensland Rail's (QR) electric tilt train set a new Australian railway speed record, reaching a notionally HSR-level top speed of 210km/h near Bundaberg on 23 May 1999 (17). While that speed record remains unbroken, significant investment in new and upgraded track and rolling stock since 1999 has increased average train speeds, particularly on interurban and regional rail routes, particularly in Victoria.

During the 1990s, the Queensland government invested significantly in its Main Line Upgrade (MLU) project, an extensive program of curve straightening, track deviations and reconstructions along the North Coast Line from Brisbane to Cairns. This project enabled the introduction in 1998 of the electric Tilt Train between Brisbane and Rockhampton, one of Australia's fastest, covering the 639.8km route in seven hours (average speed 91.4km/h). Since then, travel times have been extended and average speeds decreased, but the 11.00 northbound Electric Tilt Train still remains one of Australia's faster passenger rail services with an average speed of 86.3km/h.

For interurban rail, Western Australia's Perth-Mandurah line set new standards upon its completion in 2007. The route's direct alignment, lack of level crossings and lengthy distances between stations allows full advantage to be taken of the rolling stock's 130km/h top speed in reducing journey times. Limited stop AM and PM peak services between Perth and Mandurah run to 10-minute headways, covering the 72km route in 49 minutes at average speeds of 88.2km/h. The line is highly successful, carrying 70,000 passengers a day (more than five times the patronage of the bus service it replaced), reaching 2021 patronage levels a decade ahead of schedule (18).

The Victorian government's significant investment in the Regional Fast Rail (RFR) project on four Victorian regional rail lines (Ballarat, Bendigo, Geelong and the Latrobe Valley) between 2002 and 2006 increased average train speeds,

reduced travel times and improved service frequencies between Melbourne and regional Victorian cities. The travelling public responded to this improvement in rail services with a 45% increase in V/Line patronage over pre-RFR levels in the first three years of operation (19).

With new DMU rolling stock travelling at top speeds of 160km/h, average speeds have increased dramatically on all lines to around 85km/h, particularly on the Ballarat and Bendigo lines. Certain limited stop AM and PM peak 'Flagship' services have faster schedules, with PM peak Flagships on the Ballarat and Bendigo lines are among Australia's fastest, reaching average speeds of 101.9 km/h and 102km/h respectively.

It is notable that none of the trains described in the foregoing are located along the Melbourne–Canberra-Sydney–Brisbane lines. If anything, the schedules and speeds of existing trains on these lines are such that a no change policy in regard to these trains will inevitably result in their demise before any HSR replacement is likely to be built.

Average speeds for Australia's fastest passenger trains are significantly below the 145km/h minimum threshold for MSR services and are more akin to what the US Federal Railroad Administration calls 'Emerging/Feeder Routes' (20). These routes and lines provide a foundation for faster passenger rail services in Australia. They also serve as reminders of what can be achieved on corridors where average speeds are lower still, such as the Sydney-Wollongong (54 km/h) and Sydney-Newcastle (65 km/h) corridors in NSW.

OVERSEAS PERSPECTIVES ON MSR

International experience of upgrading existing lines to a standard capable of supporting either high-speed and medium-speed passenger services or a mixture of HSR, MSR and freight services is particularly relevant to the Australian context. A brief synopsis of developments in key countries is provided below.

EUROPE

Germany: Germany has a widely dispersed but quite dense population such that the normal radial rail network concept is replaced by a dispersed 'spider web' network. Germany's high-speed rail program has included construction of extensive new HSR alignments with top speeds of 250-300km/h, alongside upgrading many existing mainline tracks to speeds of up to 200 km/h as a continuation of earlier rail improvement efforts. (21). Average speeds on upgraded parts of the network are at the lower end of the HSR spectrum (240-255km/h), while construction costs for Germany's 'Fully Mixed' network are higher than 'Dedicated' or 'Mixed' HSR lines. However, it is concluded Germany's HSR model spreads the benefits of increased average train speeds across both passenger and freight trains, generating wider economic growth and development (22).

United Kingdom: During the late-1960s and early 1970s, the then British Railways developed two new MSR rolling stock designs to increase speeds on existing routes without building new high-speed lines. BR's two designs were the diesel-powered InterCity 125 (IC125) and the electric-powered Advanced Passenger Train (APT), capable of top speeds at the boundaries between MSR and HSR: the IC125 reaching 200km/h and the APT capable of 250km/h (5). Both trains were designed to operate on long-distance regional corridors between 300km and 650km between London and Swansea, Edinburgh and Glasgow. Although the APT never reached revenue service, its successors the IC225 and *Pendolino* tilting trains regularly run at 225km/h in normal service on Britain's East and West Coast Main Lines.

Switzerland: The Swiss Federal Railways' (SBB) *Bahn2000* strategy is guided by its motto of "not as fast as possible but as fast as necessary". Speed is seen not as an end in itself, but a means to reduce time-critical distances for customers (5). SBB chooses to invest in customer-focused infrastructure upgrades providing regular frequencies, consistent travel times and multi-modal connections from international and national HSR and MSR services to regional and local trains and other public transport modes (23). SBB's investment in new rolling stock, deviations and resignalling between Switzerland's largest city (Zurich) and its capital (Berne) provides an attractive customer offering of frequent services, and reduced journey times (from 69 minutes to 56 minutes) at speeds of up to 200 km/h (5, 21).

Sweden: The Swedish State Railways introduced the locally designed and built X2000 tilt train in the late 1980s to increase passenger train speeds on Sweden's mainline network. The X2000 offered top speeds of 200km/h, increasing average operating speeds by up to 30% with only minimal upgrades to track infrastructure (6). Initially introduced on the Stockholm-Gothenburg corridor in 1990, the X2000 reduced journey times by one hour (to 2 hours 45 minutes) and raised average speeds from 85km/h to 120km/h. As part of a long-term investment by the Sweden's government in the rail network, average speeds of 160km/h were attained on suitably upgraded track from the late 1990s (6, 24). As a result, the X2000 increased rail's market share on the Stockholm-Gothenburg corridor from 42% to 57%, competing with airlines on journeys up to 400km (6).

The X2000 train was demonstrated in Australia (and also the US) between Sydney and Canberra (25) in the mid-1990s to assess its potential for speeding up services on existing routes.

NORTH AMERICA

United States: Despite its role as a 19th and 20th Century railway innovator, the United States' interest in HSR has largely occurred in reaction to foreign success. The main US HSR investment has taking place on the 'Fully Mixed' Northeast Corridor (NEC) between Boston, New York and Washington DC. In the late 1960s, trains reached HSR threshold speeds of 175km/h in regular service on tracks shared between long-distance passenger, commuter and freight trains. In 2000 Amtrak introduced tilting Acela trains operating at top speeds of 240km/h on the NEC, but are constrained to average speeds of around 140km/h (21). Bringing the NEC to full HSR standard with maximum speeds of 350 km/h has been priced in Amtrak's latest capital investment plan at around US$151 billion between 2012 and 2040 (26).

As a response to the Global Financial Crisis and the rapid growth of China's HSR network, the US Government allocated over US$8 billion for planning and investment in HSR and MSR projects (22). Of this, almost US$7 billion was allocated in 2010 for HSR (240km/h) construction in California and Florida and projects raising passenger rail services up to MSR (175km/h) speeds in Illinois, Ohio and Wisconsin (27). Over $3 billion in funding was later rejected by newly elected Governors in Florida, Wisconsin and Ohio, leaving the central California HSR project and upgrading Chicago to St Louis to MSR standards (27, 28).

In Illinois, $1.5 billion of State and Federal government investment will raise maximum speeds on most of the 455km Chicago-St Louis corridor from 126km/h to 175km/h by 2017. When completed, travel times will reduce by one hour (to 4½ hours), while investment in new rolling stock will allow faster, more frequent services to run on a corridor already featuring strong patronage growth (29). A typically American characteristic of this corridor is that it remains largely owned by a freight railway and is shared with freight trains.

Canada: In Canada as in Australia, HSR has also been the subject of a number of government supported studies, particularly in the 1200-km Quebec City-Windsor corridor, which comprises about two thirds of Canada's population and between 85% and 90% of VIA Rail's passenger traffic volume (30). The most recent study in 2011 examined two cases for HSR in the Quebec City-Windsor corridor: with DMU trains operating at 200km/h and EMU trains operating at 300km/h. The cost range for HSR on the complete corridor ranged from C$18.9 billion for the DMU option to C$21.3 billion for the EMU option take 14 years to implement after gaining approval (31).

In the absence of a decision to proceed with HSR on this corridor, the Canadian Government has invested C$923 million in upgrading track, rolling stock and stations between Windsor and Montreal. These improvements, progressively delivered between 2008 and 2014 have augmented capacity on the corridor, increased speeds, reduced transit times and increased frequencies for VIA Rail passenger services, with additional benefits for rail freight operations (32).

FASTER TRAINS FOR AUSTRALIA

To date, Australian HSR studies have only examined 'Exclusive HSR' options with dedicated track and trains. Incremental options such as 'mixed HSR' or MSR have not been considered. A culture of rail-based travel for all but short-haul regional and metropolitan trips is in danger of extinction on Australia's East Coast in the foreseeable future. If this eventuates, it will make the 'big bang' development of a long distance HSR virtually impossible to implement, for political and other reasons.

It is the authors' opinion that major incremental improvements to existing Australian mainline rail corridors could provide infrastructure of a sufficiently high standard at an earlier date and for a price significantly lower than full HSR. Such a process would increase average operating speeds and reduce travel times for both passenger and freight trains. These improvements would be designed with longer-term requirements for full HSR in mind. Achieving a bankable HSR project, growing from existing MSR routes or corridors is far more likely to go ahead than a high cost 'greenfields' HSR proposal.

CANDIDATE CITIES FOR MSR UPGRADING

Australia's geography and population distribution, particularly the concentration of over 60% of the population in its five biggest cities (Sydney, Melbourne, Brisbane, Perth and Adelaide) means there are few existing mid-sized regional cities available as parts of a city pair for upgraded passenger rail services, particularly in or near the one to two hour intercity travel time band deemed critical for successful MSR services (5, 33).

Candidate cities with a population above 50,000, existing rail connections to a state capital and rail travel times that could be successfully lowered to less than 3 hours for all services by upgrading its rail connection to MSR standards are listed in Table 1 below.

The cities in Table 1 comprise 2.94 million people (over 12% of Australia's population) and represent many of the major non-capital cities comprising Australia's urban mega-regions of Greater Melbourne, Greater Sydney and Southeast Queensland. Populations of these regional cities are expected to grow further as Australia's population increases to 27.2 million people in 2026, some 30% above 2007 levels (34).

NSW	
Newcastle-Maitland	420,850
Canberra-Queanbeyan	412,049
Central Coast	317,517
Wollongong	282,843
VIC	
Geelong	179,689
Ballarat	95,240
Bendigo	88,827
Albury-Wodonga	84,983
Moe-Morwell-Traralgon	57,574
QLD	
Gold Coast-Tweed Heads	592,839
Sunshine Coast	286,497
Toowoomba	110,085
WA	
Bunbury	70,132

Table 1: 2012 Population data for MSR candidate regional cities (35)

From a demographic perspective, there is scope to enhance the speed, frequency and reliability of passenger rail services on a number of these regional routes, which, in the medium to long term would enable them to feed into an Eastern Australian HSR spine between Melbourne, Sydney and Brisbane.

Victoria

Victoria's RFR project has already provided a range of benefits for regional passenger rail services. Significant investment by the Australian and Victorian governments in Regional Rail Link (RRL) will provide further benefits, particularly for the Ballarat, Bendigo and Geelong lines. Once RRL is complete, these three lines will be largely separated from the suburban railway system, which should allow some of the padding in V/Line timetables to be removed.

The Victorian Government's new planning strategy also supports increased population growth in Victoria's regional cities as part of managing the state's long-term population growth (36).

While potential for further MSR upgrading remains in Victoria, many of the easier wins have been taken and future gains in speeds and reduced travel times will be limited and increasingly costly. In planning future upgrades to the V/Line interurban network, the initial travel time targets for 'Flagship' services in the original RFR feasibility study should become travel time targets for express services, with faster travel times than now for stopping services (37).

Ballarat (117 km): Achieving 60-minute travel times for express trains and 70-minute times for stopping trains on the Ballarat line would require improved rolling stock (either conventional or tilting), duplication from Deer Park West to the growing peri-urban communities at Melton (and possibly Bacchus Marsh), increased level crossing protection or grade separations and increased sections of double track or duplication between Bacchus Marsh and Ballarat to increase capacity in both directions and to raise average trains speeds to 114km/h for expresses and 97.5 km/h for stopping trains, faster than nearly all services currently operating on the line.

Bendigo (162 km): Achieving regular 80-minute travel times for expresses and 90-minute times for stopping services requires additional work to separate V/Line trains from suburban trains between Sunshine and Sunbury, full or partial restoration of double track north of Kyneton and increased level crossing protection or grade separations enroute along with new conventional or tilting rolling stock to ensure express trains operate at average speeds of at least 121km/h and 108km/h for all-stops services (38).

New South Wales

Newcastle (168 km): It has long been recognised the track between Hornsby and Newcastle is due for realignment. This section is now one of the busier sections of double track railway in Australia, albeit from frequent passenger trains rather than freight trains. A mixture of stopping and semi fast trains, with peak hour enhancement, currently delivers the fastest rail travel time on the 168km route from Sydney to Newcastle at a little over 2½ hours with an average speed of 65km/h.

The NSW Government's *Long-Term Strategic Plan for Rail* (the 2001 Christie Report) envisaged construction of a high-speed route between Hornsby and Woy Woy and realignments north to Newcastle being completed between 2015 and 2021 (39). In practical fact, a more limited scope of work to build out isolated restrictive curves, some limited realignment and provision of more functional passing and overtaking capacity at a relatively modest 'best practice' cost would reduce semi-fast trains to 2 hours or better between Sydney and Broadmeadow (162 km). Complex engineering, high construction costs and unrealistic expectations seem to have consigned the earlier 2001 plans to the archives, along with any interest in looking at simpler and lower cost alternative ways of achieving faster transit times.

Wollongong (82 km): The Christie Report identified the importance of bypassing the current, geologically unstable rail alignment along the

Illawarra escarpment with a new, tunnelled alignment between Waterfall and Thirroul of around 14km in length. If constructed, this tunnel shortens the Sydney-Wollongong railway line by approximately 18km, enabling travel times and faster average speeds than the existing fastest trains currently on the corridor. To maximise the value of such investment, a range of projects were identified as necessary to create capacity for faster, more frequent interurban services in the Sydney suburban area (39). None of these progressed beyond the Christie Report's recommendations: if anything, interurban capacity on suburban tracks has been reduced since 2001.

Queensland

Gold Coast (89 km): Trains capable of 130km/h top speeds already operate on the Gold Coast line between Brisbane Airport and Varsity Lakes at 30 minute intervals off peak and as little as 8 minutes in the peak. The *SEQ 2031* planning strategy envisages extension of the Gold Coast line to the Gold Coast Airport at Coolangatta, with an objective that "for most passengers, rail transport will be quicker and more reliable than driving a car." (40) Provision for an extension is already made in a shared road/rail corridor along a section of the Pacific Highway.

Sunshine Coast (109 km): Planning provision (with corridor protection) has been made for a branch line from Beerwah to Maroochydore, along with extension of duplication and realignment from Beerburrum, to Landsborough and Nambour similar to the Caboolture-Beerburrum duplication.

Toowoomba (127 km): After almost a decade of studies on the Brisbane-Toowoomba corridor, a high-quality rail route (with a minimum 2200m curvature) between Grandchester and Gowrie was protected by Queensland Transport in 2004. This route would service Inland Railway inter-modal, Surat Basin coal, grain and regional freight that is currently severely constrained by gauge and the existing 1865 railway's constrained alignment. Passenger trains would gain collateral benefits of achieving a roughly 90-minute journey time between Toowoomba and Brisbane via Ipswich.

Freight developments will determine if and when an MSR quality rail service could be provided but at this stage the stars are looking more likely to align than at any time in the recent past.

Western Australia

For many years, Western Australia was home of Australia's fastest train, the *Prospector*, a train that still maintains high average speeds. During the late 1980s, Friday night's eastbound *Prospector* was Australia's fastest train, covering the 655km route from East Perth to Kalgoorlie in six hours, at a still-unequalled average speed of 109.2km/h.

Bunbury (181 km): WA's other regional rail service, the Perth-Bunbury *Australind* train is relatively sedate, with an average speed of 76km/h, albeit on narrow gauge. In 2010, the WA Government commissioned GHD to define a preferred route for an MSR corridor between Perth and Bunbury suitable for trains operating at speeds of up to 200km/h while minimising, social and environmental impacts. The corridor would partially utilise the Mandurah line's alignment, then use a new alignment in the Kwinana Freeway and Forrest Highway corridors. Using 160km/h trains, transit times between Perth and Bunbury were modelled at 91 minutes: a 54 minute (or 37%) reduction in travel time from the current 145 minutes, with further savings possible using 200km/h rolling stock (41).

CASE STUDY: SYDNEY – CANBERRA

The Sydney–Canberra route provides an ideal Australian demonstration project for a true intercity MSR corridor providing both improved passenger and freight services. In terms of length (around 270km) and potential transit times (two to three hours), it hits a 'sweet spot' that maximises rail's ability to successfully compete with road and air transport between Australia's largest city and its national capital. Unlike the commuter rail networks radiating out of Melbourne, Sydney or Brisbane, the Sydney-Canberra route is a true intercity route.

For approximately $3.5 billion, around one-fifth the cost of a HSR route (estimated at $18 billion dollars), the railway from Sydney to Canberra would be rebuilt shorter (from 330km to 260km) and faster to accommodate passenger trains operating at top speeds of 200km/h while allowing freight trains to achieve shorter transit times within existing train speed limitations.

An important goal of such an MSR demonstration project would be cutting almost two hours off the current Sydney-Canberra rail journey time to achieve an initial 2½-hour journey time with an ultimate goal of 2 hours city-to-city. This would be a vast improvement on the current average journey time of 4 hours and 10 minutes, which is uncompetitive in absolute terms with the frequent 3½-hour bus service, and significantly better than the 3 hour 25 minute journey time achieved during the 1995 demonstration runs of the X2000.

Incidental benefits could also include travel time savings of up to 75 minutes for Sydney-Melbourne interstate freight and passenger trains, while leaving bypassed sections of the existing route available for local passenger and regional bulk freight trains.

Sydney-Canberra MSR could be developed on an incremental basis, working from the 'outside in' to increase speeds and reduce travel times outside the Sydney metropolitan area first before tackling

the more complicated and costly metropolitan infrastructure improvements that would support suburban and regional passenger and freight trains. An MSR demonstration project could be delivered in three main stages with progressive speeding up of passenger (and freight) services as each new section of infrastructure comes on line.

The three segments of the demonstration project are as follows:

1. Canberra to Moss Vale – a section requiring some curve straightening and a modest amount of new track into a new North Canberra rail terminal,
2. Moss Vale to Campbelltown – involving an ascent of 600 metres from the Cumberland Plain to the Southern Highlands through reasonably difficult terrain, and;
3. Campbelltown to Central – which is made more difficult by traversing a largely built up area with heavy suburban rail traffic.

All new works would as far as possible be built to HSR standards for horizontal and vertical curvature, track spacings and running line infrastructure such as turnouts. Wherever new alignments are to be built, level crossings would be avoided, while on retained sections of existing track, level crossings would either be grade separated or given higher levels of protection, based on the nature of the road, traffic volumes and terrain at each location.

A key aspect of the new route between (North) Canberra and Goulburn would be to provide a new branch off a realigned Main Southern line alignment, shortening the route and creating synergies with the main Sydney-Melbourne and Sydney-Broken Hill (via Cootamundra) lines. The new Canberra branch would be less than half the length of the existing branch (from Joppa Junction) and would also reduce the Melbourne–Canberra rail distance by over 100 km.

Early delivery of the Canberra–Moss Vale section would provide a quick demonstration of the worth of MSR, by increasing speeds and reducing travel times between Sydney and Canberra, while supporting and encouraging extension of the MSR route toward Sydney. An incremental approach is appropriate and similar to the staged HSR delivery methodology recommended by the former Australian Government's HSR Advisory Group in August 2013.

The route for Stage 1 of the MSR demonstration project linking Canberra on a new alignment to Goulburn would basically entail a new, improved alignment between Goulburn and Yass with a spur line from Yass to North Canberra. There are several alignment options but all would achieve the same basic result. It would also be highly desirable to connect the Canberra spur from North Canberra to the Airport allowing air–rail interchange to become part of the MSR business plan. The ACT Government's Canberra Spatial Plan already contains planning protection for a HSR alignment to Canberra Airport using the Majura Parkway corridor (16). Using this corridor for MSR (engineered to HSR standards) should help reduce land acquisition costs considerably. Conservative costings of the line from Yass to Civic via the Airport (including two new stations) would be in the vicinity of $1.2B based on a cost of around $10M per km with added contingency for putting the section from Canberra Airport to Civic into a tunnelled alignment.

Stage 2 would tackle the construction of a new MSR alignment between Campbelltown and Moss Vale. The new alignment would provide both a significant reduction in route length and travel time savings for Sydney-Canberra passenger trains and interstate freight and passenger trains. One such proposed alignment, the 'Wentworth Route', was identified by ARUP/TMG in a 1995 report to State Rail on Sydney–Canberra high-speed rail options was outlined ARTC's 2001 track audit (42).

The Wentworth Route would reduce the length of this section by 26km and save up to 53 minutes in freight train travel time. Time savings for an appropriately powered diesel multiple unit MSR passenger train with a 200km/h top speed would be higher, in the vicinity of 70 minutes for a non-stop journey. Based on the quoted price of $478M (2000 dollars), this section would now cost approximately $814M to build in 2013 dollars (43).

Ideally a station would be located close to the current Campbelltown station (for interchange purposes) while a 'parkway' type station in the Mittagong–Moss Vale area would provide for the nearer Southern Highlands. The existing railway would still serve local passenger and freight traffic.

Stage 3 would provide the most formidable barrier in developing a route through the Sydney suburban network from near Campbelltown to Central Station. There are two realistic options that present themselves: a surface route from the Sydney 'Steam' station (platforms 1 – 15) to the East Hills line; or, an 'underground' route via the Airport to the East Hills line. Both would require improved flat junctions and at least one grade separated junction, along with an interchange platform at Wolli Creek or Turrella on the surface route for traffic to and from Sydney Airport.

The Airport option would activate the unused Platforms 26 and 27 at Central Station as a dedicated MSR station with a short, tunnelled section (about 1.5km in length) to join up with the Airport line once underground. This would give direct access to Domestic and International Airport stations and the existing link through Wolli Creek to the East Hills line. As is the case with Canberra,

access to Sydney Airport would be a critical factor in ensuring the financial attractiveness and viability of a Sydney-Canberra MSR route.

With either option, the MSR corridor would use the existing quadruplicated track from Wolli Creek Junction to Revesby and require approximately 27km of new track from Revesby to Macarthur. Based on a cost of $28M per km (2010 dollars) for new heavy rail lines inclusive of any land acquisition, services relocation and a small length of new tunnel it would require around $840M (2013 dollars) to create a fast MSR exit from Sydney via the Airport and East Hills lines (43).

It is noted that a suitable combination of Stages 1 and 2 have the potential to achieve transit times of around 2½ hours. A program of metropolitan works could deliver a transit time not too far off the Speedrail HSR target transit time of 84 minutes between Sydney's Central Station and Canberra.

MSR TRAINS

In the initial stage trains running on the upgraded railway would be some form of diesel technology - possibly an upgraded XPT-type train or Diesel Tilt Train. A maximum speed of at least 200 km/h would be required along with the ability to sustain full power at reasonable speeds during the ascent of the Southern Highlands. Modern diesel technology can provide significantly higher power than that in the XPT power units without any weight increase and with lower exhaust emissions.

In the longer term the line would need to be electrified (at high voltage AC rather than the traditional low voltage DC) as a precursor to HSR trains and at that stage higher speeds and faster travel times would become the order of the day. These trains would have a capability of 300 km/h or thereabouts even if they were initially limited to lower speeds. Both the electric trains and electric infrastructure would need to be compatible with the future HSR and may well become a secondary service offering on such a line when it is built.

CONCLUSION

High Speed Rail is approaching its 50th birthday. From a start in 1964 in Japan, it spread to France and progressively most of Western Europe and is now appearing in countries that were until recently classified as third world. Since 1984, Australia has undertaken a number of studies, but has never had the political will to carry HSR forward into reality. In the meantime, a long overdue upgrading of the alignment and capacity of existing main lines, most notably in NSW, has languished.

This paper has proposed a middle ground approach to achieving faster passenger rail transit times. Collateral benefits for freight trains would be an advantage. Routes such as Sydney – Newcastle and Sydney – Canberra have barely improved over a long period of time. The former at least now has high frequency but is no faster than the better trains in steam days. Canberra has had around an hour cut from its rail transit time over a period of 60 years, but with very poor frequency. Since then, bus travel times on the now fully-upgraded highway have been halved and they are now both noticeably faster than trains and operating at much higher frequencies.

The authors are proposing a concept of medium speed (by world standards) mixed traffic upgrades on suitable candidate sections of railway that might in time become part of the proposed East Coast HSR line. The objective of the incremental approach would be to achieve near term door to door transit times better than other forms of land transport, to not only benefit passenger travel but to enable improvement to freight operations in terms of transit times and operating costs. Such projects would capture the imagination of the public, who have to a large extent lost sight of rail as an alternative, and could provide a leader to eventual upgrading to full HSR standards.

As the French, in their admirable way, have shown HSR can be built in stages with classic lines used to access locations beyond the main HSR route. Even if this involves bi-mode technology during the transition period it would be an affordable and achievable way of implementing HSR without having to wait for $114 billion to be in the till. Furthermore, if we are to continue the debate on HSR, as seems likely, an early start to carefully planned medium speed upgrades in key areas would seem to be an expedient alternative.

ACKNOWLEDGEMENTS

The authors thank the Railway Technical Society of Australasia and the conference organisers for the opportunity to present the paper along with their respective organizations and an unknown referee for comments. However, the views expressed in this paper remain those of the authors and are not necessarily shared by any of the above organisations.

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