North – South Corridor Strategy

9 February 2005

INTRODUCTION

On 5 September 2004, the Australian Rail Track Corporation (ARTC) commenced a 60 year lease of the NSW interstate and Hunter Valley rail lines. ARTC previously controlled the interstate rail network within the area bounded by Albury on the NSW / Victoria border, Kalgoorlie in Western Australia and Broken Hill in wesern NSW. The commencement of the NSW lease consolidated control of the majority of the interstate rail network under ARTC

In 2002, ARTC developed a detailed infrastructure investment program for the NSW network in the context of the lease proposal to NSW. This investment program was worth $872 million including complementary investment on the Melbourne – Albury corridor.

Subsequently, the Commonwealth made available $450 million to ARTC to invest in the network, with a focus on the NSW North Coast. The Commonwealth has made a further $550 million available for rail freight projects through Auslink, of which $110 million is available for works to improve freight access through Sydney.

It is now 3 years since ARTC's NSW investment program was developed and it needed to be reviewed and revised in light of subsequent developments. Similarly, while an indicative scope of works was developed for the $450 million, there was also a need to subject it to rigorous analysis, to optimise the scope of works in the context of the available funding and an improved understanding of business needs.

The review and revision process fell naturally into two parts:

- Understanding the needs of ARTC’s major customers and the freight market they service.
- Understanding how best ARTC can improve its service to these customers, within known and likely funding limits.

In relation to the first of these, a discussion paper was provided to major customers and followed-up with meetings. Discussions covered a range of issues, including:

- predictions of market growth
- factors that will make a material difference to rail’s competitiveness with road
- outcomes operators and the market require with respect to transit time, reliability, capacity, yield, pathing etc to achieve predicted rail market growth
- how operators will address issues such as rolling stock availability, terminal capacity and operation, and other issues that will affect the achievement of market growth

In parallel with this market evaluation, an extensive review was carried out of the existing infrastructure and operating patterns on the Melbourne – Sydney – Brisbane corridor to define the current situation and provide a datum by which improvements could be gauged. The effects of staged improvements that can reasonably be undertaken within the known development budgets for the next 10 years have then been analysed to see what kind of service can reasonably be offered to customers by 2010 and 2015.

Looking further into the future, there are a large number of projects, mainly deviations on the North Coast line that have been considered in the past to further reduce transit times,.

This report sets out the analysis undertaken of improvement options and integrates the outcomes into a future train plan designed to deliver substantial improvements in transit time, reliability, capacity and above and below rail yield.

OPERATIONAL OBJECTIVES

ARTC has four key objectives it is pursuing to improve the performance of rail freight on the North-South corridor:

- Reduction of bare transit times to facilitate commercially efficient Melbourne – Sydney –Brisbane transits
- Improvements in the reliability of transit times to provide train operators with certainty of achievable transit times
- Increase in actual line capacity to accommodate projected medium term rail traffic growth
- Reduced above-rail operating costs, and an acceptable yield for ARTC, from an upgraded North-South corridor

Most analytical work on potential infrastructure improvements carried out over the last five years has been undertaken on the premise that the reduction of achievable transit times to a level where overnight transits between adjacent capital cities would be in the public interest by encouraging a long term containment, if not reduction, in long distance road freight movements. It appears that freight train operators may take a more sanguine view that until they see physical evidence of usable transit time reductions they would prefer to pursue longer distance (ie Melbourne-Brisbane), in preference to shorter distance (ie Melbourne-Sydney or Sydney-Brisbane) journeys because they are more competitive with road with fewer risks. Of particular interest is also the ability to achieved significant improvements in asset utilization on the Melbourne – Brisbane corridor by reducing the cycle time from 96 to 72 hours.

Reliability - that is the extent to which actual transit times vary - is probably the more immediate concern for train operators. Reliability should be measured in terms of the amount of delay over bare transit times that train operators would experience when running between termini. Actual transit times then become the sum of the bare transit times plus a realistic estimate of the amount of delay that particular train services could expect to receive. Therefore, if reliability is to be improved average delay needs to be reduced, either as experienced by particular services or by the train flow as a whole. Delay, particularly in single track territory, generally accrues when trains cannot run free because their paths are obstructed by conflicting trains. Delay in double track territory is more likely to occur when there is a disparity between the running times of particular trains and those of their predecessors. The specific issue in the North-South corridor is the very high level of delay experienced by current train flows, particularly on the NSW North Coast.

Line capacity and reliability are related to each other because an increase in line capacity should lead to a reduction in delay and therefore an improvement in reliability. Those railway operations which prize reliability will often provide nominally excess capacity to buy reductions in delay. Line capacity, which is what a track provider sells, has to meet the dual requirements of being sufficient to keep the growth in system delay in check and of being sufficient for projected medium term traffic levels.

Yield is specifically the track provider's concern. When a track provider is faced with capital constraints, which is normally the situation, there is clearly a need to achieve the best outcome in terms of a mix of bare transit time reduction, delay reduction/reliability improvement and capacity increase. All classes of project that address one or more of these improvement measures need examination and those measures which deliver the best bare or actual transit time returns for the least cost in decreasing order of effectiveness selected until the capital improvement budget is allocated.

In the light of the above discussion the following strategy was adopted to pursue ARTC's aims:

- Identify and analyse infrastructure improvements to target bare transit times of 24 hours between Melbourne and Brisbane and efficient overnight transits between Melbourne and Sydney and Sydney and Brisbane.

- Provide single track capacity to efficiently handle the most optimistic projections of North-South rail traffic in the medium term (by and large double track capacity in automatically signalled territory comfortably exceeds projected traffic levels).
- Develop a theoretical train plan to validate the performance outcomes once all of the infrastructure improvements are implemented.

Because of the uncertainty about the form of future train plans, a flexible infrastructure strategy was developed which would be capable of handling different patterns of train flows, for example, both fleeted and regularised train movements. Furthermore, the infrastructure would still have to perform efficiently as transit time improvements were brought online because these transit time reductions would displace the crossing zones between northbound and southbound train flows.

The scope of projects identified to achieve these performance outcomes was:

- Eliminating train speed impediments such as the Wagga Viaducts and the Murrumbidgee River crossing at Wagga, the Murray River crossing at Albury and the slow transit through Wodonga
- Applying more aggressive track geometry standards
- Commissioning high yielding alignment deviations
- Progressive loop lengthening and regularisation of sectional running times in single track territory
- Matching the spacing of crossing loops in single track territory to localised levels of traffic
- Eliminating discontinuities in double track sectional clearance times through the conversion of remaining double line manual block to automatic signalling
- Providing refuging opportunities in double track territory to cater for transit time disparities between different classes of trains

THE STUDY AND METHODOLOGY

Involvement

The work recorded in this report has been undertaken by TMG International (TMG). They have been assisted by BT contractors (BT), who have provided detailed costing information in relation to all the improvement projects considered, and Samrom who have provided operational input. Some analytical input and cost information has been developed internally by ARTC.

Methodology

The concept of service to customers has been considered in relation to:

- Transit time
- Capacity
- Reliability

Projects that improve these aspects of the corridor operation have been selected on the basis of cost effectiveness. Transit time is reduced by raising the average speed of trains and/or reducing the total distance traveled.

Speed is raised by:

- Increasing super-elevation and increasing cant deficiency on existing curves,
- Increasing curve radii (curve easing),
- Removing the need for temporary speed restrictions.

Distance is reduced by:

- Constructing deviations, or new sections of track, which by virtue of their better alignment will also normally increase average speed.

Reliability is improved:

- By providing more opportunities for passing and overtaking – loops and refuges – at appropriate locations.

The options available to make these changes have been reviewed and train diagrams prepared to show how selected works improve these chosen indicators of service to customers.

Sources of Information

The following sources have been used to provide information about projects that can be implemented to improve customer service. A full list is provided in the References section of the report. Most of the reports included estimates of project costs, but inevitably they were prepared at different times and involved different assumptions and so are not strictly comparable. To overcome this problem BT has re-calculated the costs of all projects using a similar basis and late-2004 dollars so that comparisons are meaningful.

Reference	Subject	Date
1	Sydney-Newcastle Corridor: Investigation of High Speed Train Services. Preliminary Evaluation Phase.	Oct 1999
2	Sydney-Melbourne-Sydney Reduction of Superfreighter Transit Times. (Project 12)	Oct 1999
3	Sydney-Newcastle Rail Upgrade Project. Feasibility Study-Stage 2 – Detailed Evaluation. Evaluation of Alignment Options DRAFT	Feb 2000
4	Action for Transport 2010. Sydney-Newcastle Rail Project. Review of Freight Opportunities.	Apr 2000
5	Sydney-Melbourne-Sydney Superfreighter Corridor Improvements. (Project 11)	Apr 2000

6	Fassifern to Hexham Rail Corridor Planning, Land Use and Alignment Study.	May 2000
7	Interstate Rail Network Study. Improvements in Superfreighter Performance: Sydney-Brisbane and Melbourne – Sydney Corridors. Final Report	Jan 2001
8	Interstate Rail Network Audit Final Report (and Summary Report)	Apr 2001
9	Bowning to Cootamundra Deviation Report	~Dec 1999

Project Identification

The numerous deviation projects that have been identified in the background reports have all been given different names and at times identification numbers. In order to bring some consistency to this process, all projects have been re-named in this study using:

- V to indicate Victoria
- S to indicate the Main South line in NSW
- N to indicate the North Coast line in NSW

followed by a number which represents the round kilometre of the centre of the project on the current chainage system. As an example N159 is the Fassifern to Hexham deviation on the North Coast line in NSW.

General Assumptions

The following assumptions have been made in order to undertake the operational analyses:

- Design Train - the design train was hauled by 3 x NR locomotives, was 1500m long, had a trailing load of 3900 t and a maximum speed of 115 km/h.

- Speed Restrictions – there are currently numerous temporary speed restrictions on the Melbourne – Sydney – Brisbane corridor. In carrying out the analysis of train operations it has been assumed that these can all be lifted with appropriate maintenance over the next 5 years. As a result the train diagrams provided assume that trains can run at the maximum speed around each of the existing curves to appropriate track geometry standards, if they are able to attain it. This is discussed in more detail elsewhere.

- Loops and Refuges – are of varying lengths and unevenly distributed along the entire corridor. It has been assumed that for all future works minimum loop/refuge length will be 1650m. The philosophy of loop location is addressed elsewhere.

- Sydney Transit – no attempt has been made to analyse freight train movements in the Sydney – Broadmeadow corridor. Designated RailCorp freight paths shown in the draft 2008 CityRail timetable have been adhered to for journeys in either direction between Chullora and Broadmeadow.

- Increased Superelevation and Cant Deficiency – is an ARTC initiative to increase speed on curves and hence reduce transit times. Analysis has been undertaken assuming it is possible, but no attempt has been made to determine possible negative effects of this initiative which could include increased maintenance costs for both track and trains. The cost associated with these increases is assumed to be related only to the cost of converting to full face concrete sleepers on relevant curves, re-profiling the track and incidental costs of implementation. Costs in relation to this item have been provided by ARTC and not BT.

- Freight Terminals – it is an inherent assumption that freight terminals are able to receive trains when they arrive and dispatch them on the return journey when required by the proposed timetable. No account has been taken of the inter-modal terminal proposed for Newcastle.

- Fleeting of Trains and Long Crossing Loops - ARTC has expressed a desire to construct long sections (up to 50 km) of duplicated track, so that freight trains can be operated in fleets. There is no reason why such practices cannot be adopted, provided there is capacity for such fleets to pass through the Sydney Metropolitan and Interurban Railways. However, interurban and provincial passenger train services in the NSW Southern Highlands, the NSW Central Coast and in Newcastle and the Lower Hunter Valley appear to constrain path availability to two trains per hour in each direction outside the Sydney commuter peak periods. Furthermore, individual freight customers appear to want to spread their own train flows out in order to make best use of current or projected freight terminals. Therefore, in this study a strategy of seeking to reduce and regularise the spacing of long enough refuges and crossing loops to cater for perceived capacity and reliability objectives has been pursued.

Analysis

Analysis of transit times and operational constraints has been carried out using the MTRAIN[1] train performance modelling system and the SKETCH[2] timetable and infrastructure planning system.

The former model was used to establish the travel time impacts of various infrastructure projects ranging from changing track geometry standards through to the commissioning of worthy alignment deviations. The latter model was used to explore the interactions between infrastructure provision, for example, the number of running lines and/or the provision of long enough refuges or crossing loops spaced to efficiently separate following and opposing train flows and the out-turn line capacity.

[1] MTRAIN is a proprietary train performance and signal simulation tool owned by TMG International
[2] SKETCH is a proprietary timetable and infrastructure planning tool owned by TMG International

Deviations

TMG used past reports and unofficial analysis of options by various interested individuals to identify the range of deviation options available on the North-South corridor.

In all, 146 deviation options were identified. The projects are generally identified in appendix 1.

TMG analysed the benefit of these deviation proposals on a time saved basis. M-Train was used to model the transit time savings from each of the proposals. Transit time savings were analysed on two basis:

- As individual stand-alone projects and
- As a part of a group of deviations.

Individual projects usually perform better as part of a group of projects as they allows trains to maintain a constant higher speed.

BT contractors then costed each of the projects using estimated construction quantities and current (late 2004) unit rates.

Projects were then able to be ranked on a cost per minute saved basis. In recognition of the synergies from running a series of projects together to maintain a consistent train speed, projects were grouped for final analysis. This was done on the basis that where the cost per minute saved was less for a project on a stand-alone basis than the cost per minute saved for adjacent projects on a grouped basis it was treated as a stand-alone project. Otherwise it was incorporated into a group of projects so as to optimise the transit time saving.

A list of all deviation projects with their cost, time savings and cost per minute saved is at appendix 2.

The full list of deviation projects with their grouping and ranking is at appendix 3. The total estimated cost of all of the identified projects is $5.5 billion. The following table shows the highest ranking deviation projects up to a value of $1 billion.

Project	FROM		TO		Cost ($m)	Time Saving (mins)	$m / min Saved	Cumulative Cost ($m)	Cumulative Time Saving (mins)	Cumulative $m / min Saved
	Name	km	Name	km						
N573 - N591	Nambucca Heads (Station)	565.081	Bonville (Station)	596.494	$39.43	8.81	$4.48	$39.43	8.81	$4.48
N401	Taree (Dawson River)	383.300	Johns River	417.801	$76.41	12.53	$6.10	$115.84	21.34	$5.43
N379	Taree North Bypass	375.000		382.900	$20.11	3.19	$6.30	$135.95	24.53	$5.54
N528 - N559	Tamban (Station)	520.558	Nambucca Heads (Station)	565.081	$117.54	17.49	$6.72	$253.48	42.02	$6.03
N495 - N512	Kundabung	487.197	Tamban (Station)	520.558	$71.67	10.13	$7.07	$325.15	52.15	$6.23
N159	Fassifern	142.31	Hexham	175.530	$123.48	16.53	$7.47	$448.63	68.68	$6.53
S386	Demondrille	391.500	Cunningar	380.920	$48.60	6.25	$7.78	$497.23	74.93	$6.64
N433 - N457	Rossglen (Syd. Side)	439.096	Telegraph Point (Not station)	474.000	$85.64	10.77	$7.95	$582.87	85.70	$6.80
N223	Hexham	176.480	Stroud Road	270.000	$361.33	43.00	$8.40	$944.20	128.70	$7.34
S343	Binalong	350.750	Bowning	334.500	$60.07	7.09	$8.47	$1,004.27	135.79	$7.40

As shown in the table, the best performing deviation has a cost per minute saved of $4.48 million with the next best a jump to $6.1 million and then a progressive increase in the cost per minute saved. The cost per minute saved is up to approximately $8.5 m by the time the total value of projects reaches $1 billion.

Increasing Train Speed

A review has been undertaken of opportunities to increase train speed to achieve the minimum possible transit time within the constraints of the track geometry of the existing railway.

These opportunities arise from two areas:
- Increasing superelevation and cant deficiency, thereby allowing trains to travel faster on the existing geometry.
- Identifying and eliminating speed restrictions dictated by factors other than track geometry. Typically these include condition related speed restrictions on track and structures, sighting distances issues and optimising the position of speed boards.

These issues have previously been addressed in detail in the Project 12, Project 11 and Interstate Audit studies and most of the necessary works were incorporated in the NSW Lease business case. This study has reviewed and validated the prospective time savings identified in those previous studies.

Superelevation and Cant Deficiency

Superlevation (also known as cant) describes the relative positioning of the high and low rail's on a curve. Superelevation has two primary purposes:
- To increase the speed that a train can pass through a curve by directing the centrifugal force of the vehicle into the track and
- To reduce friction at the wheel / rail interface by reducing the distance differential that the high and low wheels need to travel through the curve.

For a given level of superelevation there is an equilibrium speed of the train. This is the speed at which the direction of the centrifugal force exactly matches the superelevation of the curve.

If a train is travelling faster than the equilibrium speed, this creates a cant deficiency. That is, there is a deficiency in the level of superelevation or cant relative to the equilibrium speed. If the train is travelling slower than the equilibrium speed there is a cant surplus.

Current train speeds in curves in NSW are based on the following criteria:

- Maximum superelevation = 125mm (140mm on concrete sleepered track)
- Maximum cant deficiency = 75 mm (110 mm for the XPT)
- Maximum rate of change of superelevation = 55mm/sec

Different standards for superelevation and cant deficiency are applied around the world with relatively little research providing the foundation for the selected standards. In Britain for example, the maximum superelavtion is 150mm, with an absolute maximum of 200mm and a typical superelevation deficiency of 110mm with 150mm for selected vehicles.

Previous studies have proposed increasing the track geometry standards for appropriate freight vehicles to:
- Maximum superelevation = 140mm
- Maximum superelevation deficiency = 110mm
- Maximum rate of change of superelevation = 55mm/sec

Adopting these standards is contingent on:
- Provision of concrete sleepers, or as a minimum a sleeper/rail connection with resilient fastenings,
- A ballast profile to standard with the ballast in clean condition,
- No significant vertical or horizontal alignment irregularities,
- Continuous welding of the rails,

- Suitable vehicle (and particularly wheel) maintenance,
- Wheel/rail profiles matched by grinding,
- Level crossing sighting times to standard,
- Adequate signal braking distances,
- Clearance to structures and track centres to standard.

Non-Geometry Related Restrictions

Non-geometry related restrictions have previously been identified as follows:

- Casino-Greenbank CTC
  The Casino-Greenbank section currently operates on an electric staff system. This requires all trains to stop and manually exchange staff instruments. The delay at each location is approximately 5 minutes.

- Signal braking distance
  With a shift to longer and heavier trains which take further to stop, the signal spacing at some locations is inadequate to allow a train to stop between a caution indication and a stop indication. To address this problem, some signals have a speed restriction on them to limit train speed to the level necessary to stop in the available distance. This includes much of the Sydney metropolitan area. The problem will be exacerbated if increased cant deficiency and superelevation is introduced as train speeds on the approach to signals will be higher.

- Temporary speed restrictions
  The Melbourne-Brisbane corridor has traditionally had a number of long-standing temporary speed restriction on it due to track and structure condition. While these have declined in recent years, the opportunity still exists to improve transit time by eliminating the remaining long-standing restrictions. A particular example is the Murrumbidgee River Bridge which due to the length of the viaducts and bridge structure, and the low speed, imposes a particularly severe time penalty on the corridor.

- Permanent speed restrictions through yards
  Traditionally speed restrictions were placed on yard areas in recognition of the dangers of high speed operation through areas where ground staff were operating. Due to the speed restriction, track in these areas was often maintained to a lower standard than required for high speed running. Despite the almost complete elimination of yard operations, many of these speed restrictions and the lower standard track remain. The opportunity exists to eliminate these restrictions subject to upgrading of the yard.

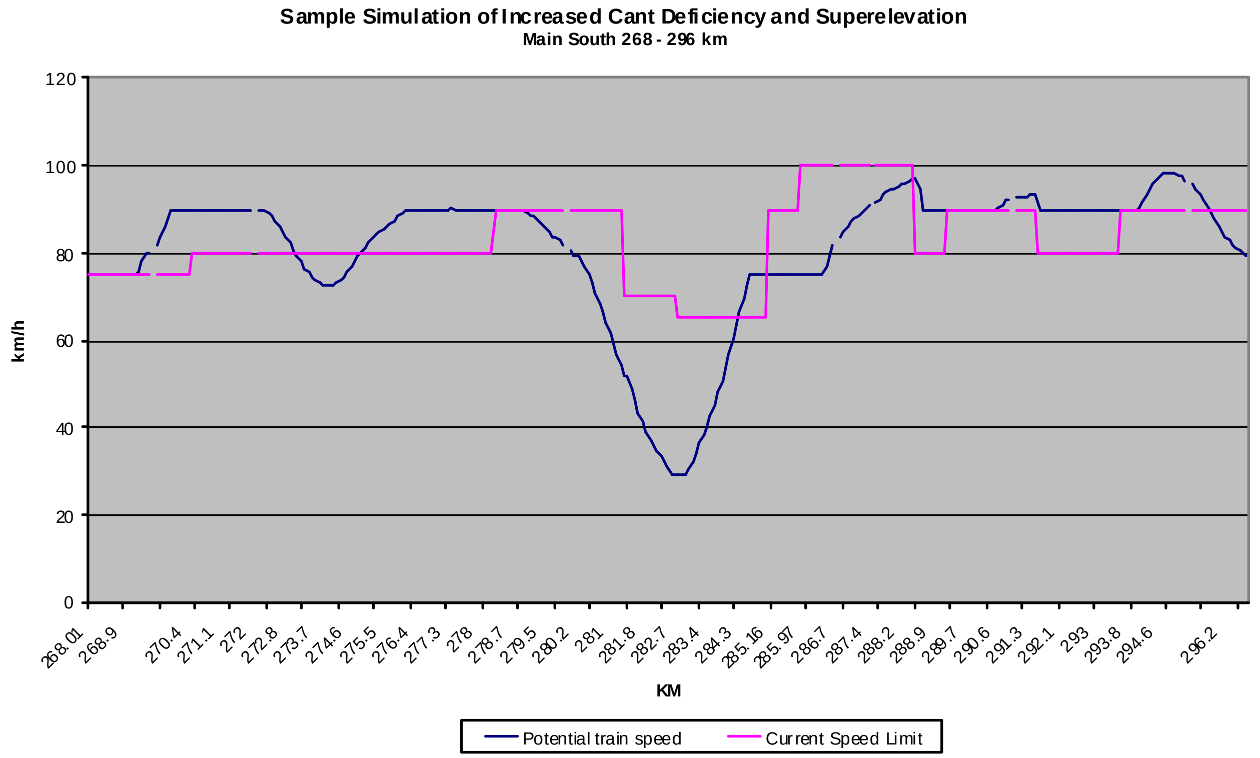
- Signal and level crossing sighting distances
  In various locations there are speed restrictions imposed due to either the difficulty of train drivers sighting a signal at sufficient distance, or vehicle drivers sighting a train at sufficient distance at a level crossing. These sighting distance problems are directly related to train speed and require remedial works to improve sighting times. Increasing train speed will increase the number of locations where sighting is an issue and will require remediation.

Simulation

TMG undertook a simulation of the entire corridor using M-Train to identify those locations where there would be significant benefit from an increase in superelevation and cant deficiency. Benefit arises where the potential speed of the train with the higher superelevation and cant deficiency parameters exceeds the current speed limit.

Typically benefit arises for curves toward the bottom of downgrades, where train speed has built up, and on the lower part of upgrades, before the train loses momentum. There is frequently little benefit in increasing speeds through curves toward the tops of grades as the potential speed of the train is less than current track geometry standards permit. Indeed, increasing the superelevation at these locations is undesirable as a train travelling at less than the equilibrium speed will place increased pressure on the low-side rail, increasing wear.

The sample chart below is illustrative of the outputs. Between approximately 270 km and 274 km the train speed with increased superelevation and cant deficiency is substantially above the current speed limit, though still constrained by the higher speed limit. In contrast, there is no benefit from increased cant deficiency and superelevation between 279 km and 285 km where the train speed falls below the current speed limit and is unconstrained..



The NSW Lease business case did not fully address the potential for time savings from increasing superelevation and cant deficiency. As noted above, it is highly desirable that concrete be installed on curves to be subject to the higher track forces arising from the changed standards. The business case did not provide for any additional concrete sleepering to facilitate the change to the higher standards.

The analysis indicates that there is substantial additional potential for transit time reduction by concrete sleepering selected curves on the Main South. Due to the relatively gentle gradients and extensive number of curves on the North Coast, the analysis suggests that there is benefit in concrete sleepering all curves on this line.

It should also be noted that by basing speed on the prevailing track geometry, the simulation also implicitly models the elimination of the other non-geometry related restrictions. The NSW Lease business case provided for most of these restrictions to be addressed. Investment associated with increasing train speed through increased cant deficiency and superlevation will also need to address additional areas where signal and level crossing sighting distances become an issue.

OPERATIONAL ANALYSIS

Introduction

There are two issues affecting the adequacy of railway infrastructure on the North-South Corridor between Melbourne and Brisbane:

i) the pattern of future traffic;
ii) the most appropriate plan of infrastructure improvements.

TMG modelled a nominal 2015 traffic pattern which reflects a high-end forecast of potential volume. Users include:

i) CityRail, as the operator of NSW Southern Highlands provincial commuter passenger services;
ii) Countrylink, as the operator of NSW long distance passenger services between Sydney, Canberra, Griffith and Melbourne;
iii) V/Line Passenger, as the operator of Victorian intrastate passenger services between Melbourne and Albury;
iv) Pacific National, as the major operator of intrastate and interstate freight services; and
v) PPL, QRN, SCT, etc, as the minor operators of intrastate and interstate freight services.

These train service patterns, particularly those of the interstate passenger and freight train operators, probably pose the greatest problem when determining future infrastructure needs. These services are expected to concentrate in particular time windows yet they also have to take into account the practicalities of terminal operation, whereby the rate of receipt and despatch of freight trains will depend upon different terminal configurations (which are outside the scope of this work).

Melbourne - Sydney

Roughly half the North-South Corridor between Sydney and Melbourne is double track. This track configuration largely eliminates conflicts between opposing train movements. However, it still has to deal with conflicts between following train movements. The early completion of automatic signalling will assist in this matter. However, there will still be a need to provide strategically located opportunities to refuge and/or overtake trains. Such opportunities have been factored into the following infrastructure assessments.

The bigger problem is expected to be encountered in the single track remainder of the corridor. There will be a need to provide:

i) sufficient capacity for future traffic;
ii) adequate flexibility to be able to accommodate flighted and/or regular train movements; and
iii) as low as practicable delays to the movement of trains to improve the reliability of the whole train flow.

With these issues in mind we have thus explored a range of infrastructure alternatives south of Junee, the current limit of double track in the corridor. In principle, we need to equalise the sectional running times between those crossing loops capable of refuging 1500 metres trains. These limiting sectional running times should reflect the likely headways between following trains and the sectional clearance times between opposing trains. The limiting sectional running times should be no more than 30 minutes and preferably less, eg 15-20 minutes, in order to accommodate flighted train movements as well as expediting the passage of opposing train flows as is expected to occur between Cootamundra and Albury.

After consultation with ARTC, TMG adopted a common pattern of loop lengthening in NSW in order to provide limiting 15-20 minute sectional running times for intermodal trains while accepting constraints on the ability to lengthen the crossing loop at Wagga Wagga. Thus, we have chosen to lengthen Harefield, Bomen, Uranquinty and Culcairn to accommodate 1500 metres trains to complement the existing long loops at Yerong Creek, Gerogery and Albury. We have also assumed that Junee will be able to stage long freight trains entering and leaving the double track.

The more problematical section is the abutting Victorian NESG. This stretch of railway has irregularly spaced crossing loops but more uniformly spaced intermediate signals so that it is ideally configured for fleeted traffic running successively northbound and then southbound. While this is certainly the current pattern of standard gauge traffic it is not expected to be the future pattern whereby it is expected that interstate traffic can be expected to spread out over the whole of a working day and over which formerly broad gauge traffic can be expected to be overlaid.

With this future traffic is mind we conducted a number of SKETCH infrastructure experiments in Victoria (all with the same crossing loop configuration in NSW) with the previously discussed nominal 2015 traffic pattern, ie:

i) the existing pattern of lengthened loops in Victoria, ie Tottenham (10 km via IG), Somerton (22 km), Wallan (47 km), Seymour (101 km), Longwood (137 km), Violet Town (170 km), Glenrowan (219 km) and Chiltern (272 km) [Case L];

ii) a modified pattern of lengthen loops in Victoria, in addition to the above crossing loops, ie Tullamarine (23 km via IG), Donnybrook (34 km), Broadford (74 km), Benalla (196 km) plus a new loop near Springhurst (252 km) [Case M];

iii) lengthening all loops in Victoria, ie addition to the above loops also McIntyre (16 km via IG), Tallarook (89 km), Alumatta (232 km) and Wodonga (298 km), but excluding the new loop near Springhurst [Case N];

iv) all long loops plus division of the Seymour – Longwood, Longwood – Violet Town and Alumatta – Chiltern sections with new long loops at Avenel (119 km), Euroa (154 km) and Springhurst (252 km) [Case O];

v) all long loops plus provision of 15-20 kilometre "passing lanes" from Seymour (101 km) to Avenel (119 km), from Euroa (154 km) to Violet Town (170 km) and Alumatta (232 km) to Springhurst (252 km) [Case P}; and

vi) duplication between Seymour (101 km) and Wodonga (298 km) [Case Q].

In all cases, since the above traffic scenario assumed the incorporation of former broad gauge traffic (assumed to be three weekday pairs of Down and Up intrastate passenger trains between Spencer Street and Albury plus two pairs of Down and Up freight trains between Melbourne and northeastern Victoria), it was assumed that passenger stops could be made at Seymour, Avenel, Euroa, Balmattum, Violet Town, Benalla, Glenrowan, Wangaratta, Springhurst, Chiltern, Barnawartha, Wodonga and Albury.

The revised nominal 2015 traffic pattern incorporated 43555 train minutes for 142 trains and 22659 train minutes for 35 intermodal trains (including those only running between Chullora and Cootamundra) in the 24 hours between 1200 on a Wednesday and 1200 on a Thursday. Table 1 summarises the total delays for all trains and just intermodal trains under near optimal timetable resolution for each of the above cases.

Delay Category	**Case L Train minutes**	**Case M Train minutes**	**Case N Train Minutes**	**Case O Train minutes**	**Case P Train minutes**	**Case Q Train minutes**
Average All Trains	**4404 (10.1%)**	**2731 (6.3%)**	**2563 (5.9%)**	**1947 (4.5%)**	**1701 (3.9%)**	**1357 3.1%)**
Best All Trains	**2970 (6.8%)**	**2240 (5.1%)**	**2241 (5.1%)**	**1715 (3.9%)**	**1472 (3.4%)**	**1214 (2.8%)**
Best I'modal Trains	**1881 (8.3%)**	**1201 (5.3%)**	**1179 (5.2%)**	**883 (3.9%)**	**720 (3.2%)**	**624 (2.8%)**

It can be seen that these best rates of delay reduction occur as the existing NESG crossing loops are all lengthened to accommodate 1500 metres trains after which the three longest sections are divided by new long crossing loops. The substitution of "passing lanes" for these new crossing loops offers a further modest improvement, but at expected cost levels the reduction in delay minutes performs better than the best ranking deviation projects. Accordingly it is preferred as the optimum scope of works. Duplication for 197 kilometres between Seymour and Wodonga then only yields a minor improvement.

The train graph produced for the preferred scope, Option P, is attached at appendix 4.

Sydney - Brisbane

Only one fifth of the North-South Corridor between Sydney and Brisbane is double track. This track configuration largely eliminates conflicts between opposing train movements. However, it still has to deal with conflicts between following train movements. This is exacerbated by the intense Central Coast commuter passenger traffic between Sydney, Gosford, Wyong, Morisset and Newcastle, followed by the busy Newcastle District provincial passenger traffic between Newcastle, Maitland and Dungog. While there are infrastructure alternatives these have not yet been developed into a firm plan. In the meantime, RailCorp is working on providing two guaranteed freight train paths per hour in each direction outside the Sydney commuter peak periods.

Nevertheless, with four-fifths of the corridor single track the immediate infrastructure problems will lie there, on the NSW North Coast Line. There will be a need to provide:

iv) sufficient capacity for future traffic;
v) adequate flexibility to be able to accommodate flighted and/or regular train movements; and
vi) as low as practicable delays to the movement of trains to improve the reliability of the whole train flow.

With these issues in mind we thus explored a range of infrastructure alternatives north of Maitland and Telarah, the current limit of double track in the corridor. Because of the currently slow running times throughout the North Coast Railway we adopted a number of infrastructure projects which were expressly intended to reduce running times without direct regard for line capacity. These projects included the conversion of Electric Train Staff safeworking to Centralised Traffic Control, changes to track geometry to raise the speeds of trains around curves and selected deviations. Their nett effect should be to reduce bare running times between Telarah and Acacia Ridge by two hours.

We then turned our attention to measures expressly intended to address line capacity and the reduction of delay (necessary for the promotion of reliability). Traffic conditions on the Lower North Coast, between Telarah and Craven, are atypical of the rest of the railway. This is because Newcastle District provincial passenger trains and export and power generation coal trains easily double even future train flows. The solution would be to lengthen all the crossing loops between Telarah and Craven (ie Telarah, Mindaribba, Paterson*, Kilbride, Wallarobba* Dungog, Monkerai and Stroud Road*) to refuge 1500 metres trains. The marked crossing loops are already sufficiently long, thus five additional crossing loops would have to be lengthened over what is currently in place.

We then had the alternative of either selectively lengthening the remaining crossing loops between Craven and Acacia Ridge to provide long crossing loops 25-30 minutes apart for intermodal trains or to lengthen all crossing loops.

The selective lengthening would require long loops at Berrico, Bulliac*, Mt George, Killawarra*, Taree*, Melinga, Johns River*, Kerewong, Telegraph Point*, Kempsey*, Eungai*, Nambucca Heads*, Raleigh, Boambee Beach*, Coramba, Kungala*, Braunstone, Kyarran, Lawrence Road*, Rappville*, a new loop at Namoona, Kyogle*, Loadstone, Glenapp*, a new loop at Tamrookum, Bromelton*, Greenbank and Acacia Ridge*. The marked crossing loops are already sufficiently long, thus twelve additional crossing loops would have to be lengthened over what is currently in place. Melinga was required to reduce sectional running time between Taree and Johns River. On the other hand, it was thought that Grafton might be too difficult to lengthen so that Braunstone and Kyarran were proposed in its place. Similarly, it was thought that Casino might be too to lengthen so that Namoona was to be constructed in its stead.

The global loop lengthening would require Craven, Gloucester, Bundook, Wingham, Kendall, Wauchope, Kundabung, Tamban, Macksville, Bonville, Landrigans, Nana Glen, Glenreagh, Camira Creek and Leeville to be additionally lengthened: a total of fifteen additional loops.

With future traffic is mind we thus conducted two SKETCH infrastructure experiments along the NSW North Coast Railway to test the operational impact of these alternative loop lengthening scenarios, ie:

vii) global loop lengthening south of Craven and selective loop lengthening north of Craven, as outlined above [Case L]; and

viii) global loop lengthening between Telarah and Acacia Ridge, as outlined above [Case M].

The revised nominal 2015 traffic pattern incorporated 32455 train minutes for 151 trains and 19515 train minutes for 26 intermodal trains in the 24 hours between 1200 on a Wednesday and 1200 on a Thursday. Table 1 summarises the total delays for all trains and just intermodal trains under near optimal timetable resolution for each of the above cases.

TABLE 1: SUMMARY OF REVISED SKETCH NSW NORTH COAST INFRASTRUCTURE SIMULATIONS

Delay Category	Case L Train minutes	Case M Train minutes
Average All Trains	**2442 (7.5%)**	**2084 (6.4%)**
Best All Trains	**2041 (6.3%)**	**1759 (5.4%)**
Best Intermodal Trains	**1493 (7.2%)**	**1183 (6.1%)**

It can be seen that global loop lengthening only slightly improves the operational results so that selective loop lengthening should deliver acceptable reliability as well as a two hour bare transit time reduction.

The train graph produced for the preferred scope, Option L, is attached at appendix 4.

Conclusions

The key conclusions of the analysis are:

- Increasing train speed through increased superelevation and cant deficiency performs very well on a cost per minute saved basis and should be a high priority. Implementation of higher train speeds also requires a number of consequential works to be completed.

- Loop lengthening works also perform very highly in terms of cost per minute saved. The optimum scope of works is:
    a. Lengthen all loops on the North Coast between Maitland and Weismantels.
    b. Lengthen selected loops north of Wesimantels to give a maximum section running time of around 35 minutes.
    c. Lengthen all loops between Melbourne and Seymour.
    d. Provide 3 sections of double track between Seymour and Albury (with a total distance of around 45 km).
    e. Lengthen selected loops to Junee.
    f. Provide a limited number of additional refuging facilities between Junee and Sydney, preferable in conjunction with resignalling schemes.

- The highest ranking deviation works are well justified once the gains from increased trains speeds and an optimized loop configuration have been achieved.

REFERENCES

1 "Sydney-Newcastle Corridor: Investigation of High Speed Train Services Preliminary Evaluation Phase For SRA." Arup-TMG, October 1999.

2 "Sydney-Melbourne-Sydney Reduction of Superfreighter Transit Times." (Project 12) Prepared for RAC by Rail Personnel Ltd, October 1999. (Attachments 3 to 6 omitted)

3 "Sydney-Newcastle Rail Upgrade Project. Feasibility Study-Stage 2 – Detailed Evaluation. Evaluation of Alignment Options DRAFT" Prepared for SRA and RAC by Arup-TMG, February 2000. (Subsequently superseded by Connell Wagner Report of which no copy was available during the study.)

4 "Action for Transport 2010. Sydney-Newcastle Rail Project. Review of Freight Opportunities." Prepared for RAC by Ove Arup & Partners, April 2000.

5 "Sydney-Melbourne-Sydney Superfreighter Corridor Improvements." (Project 11) Prepared for RAC and ARTC, by Rail Personnel Limited, April 2000

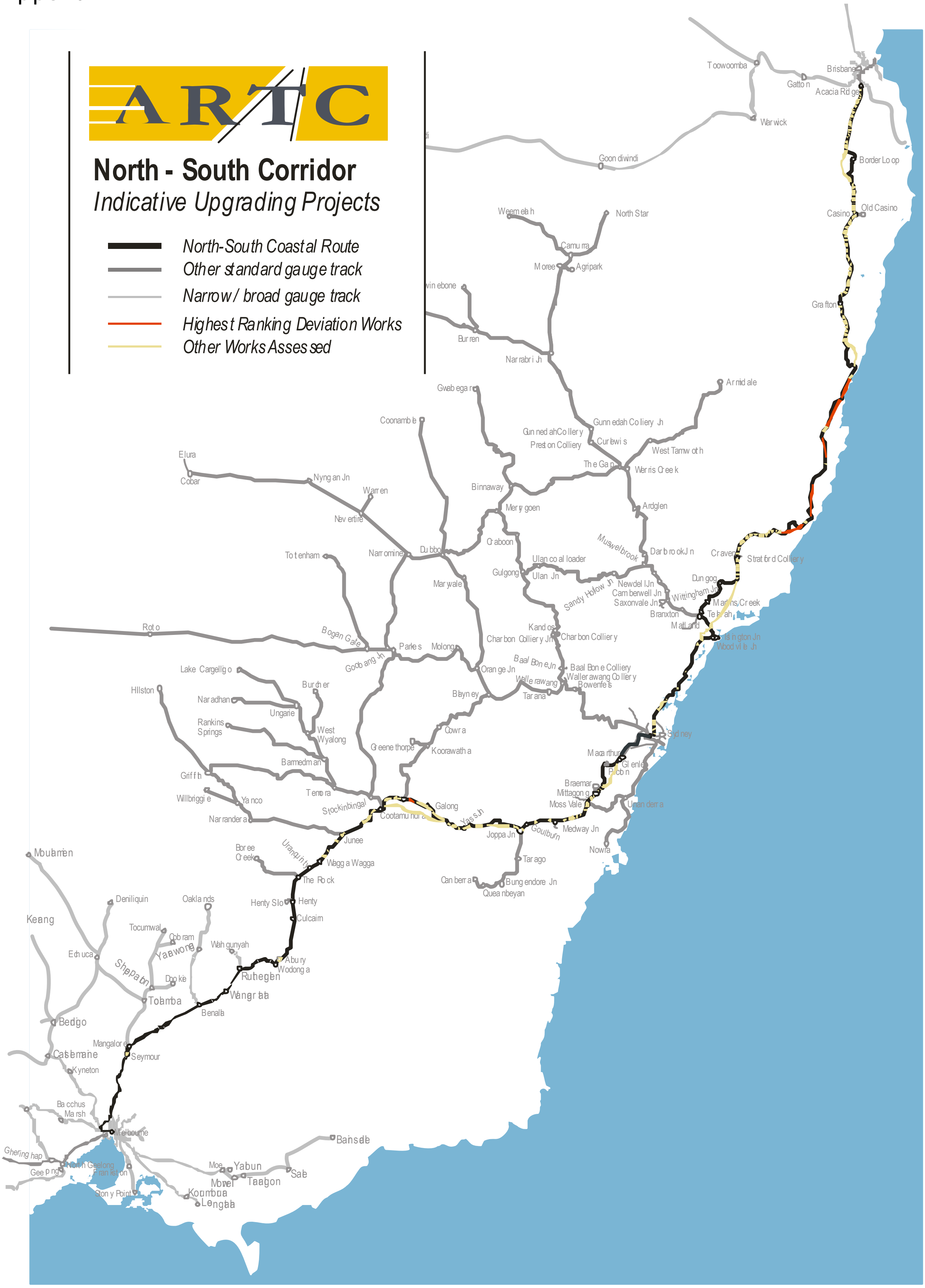
6 "Fassifern to Hexham Rail Corridor Planning, Land Use and Alignment Study." Prepared for RAC by Ove Arup & Partners, May 2000

7 "Interstate Rail Network Study. Improvements in Superfreighter Performance: Sydney-Brisbane and Melbourne – Sydney Corridors Final Report" Prepared for ARTC by Maunsell McIntyre, Revision A January 2001.

8 "Interstate Rail Network Audit Final Report (and Summary Report)." Prepared for ARTC by Booz Allen Hamilton, April 2001

9 "Bowning to Cootamundra Deviation Report." (Original study undertaken for RAC by the University of Wollongong using a SPIRT grant.)

Appendix 1


ARTC
North - South Corridor
Indicative Upgrading Projects
North-South Coastal Route
Other standard gauge track
Narrow / broad gauge track
Highest Ranking Deviation Works
Other Works Assessed
Toowoomba
Brisbane
Gatton
Acacia Rdge
Warwick
Border Loop
Goondiwindi
Casino
Old Casino
Weemelah
North Star
Camurra
Moree
Agripark
Grafton
Burren
Narrabri Jn
Armidale
Gwabegar
Coonamble
Gunnedah Colliery Jn
Gunnedah Colliery
Preston Colliery
Curlewis
West Tamworth
The Gap
Werris Creek
Elura
Cobar
Nyngan Jn
Warren
Binnaway
Merrygoen
Ardglen
Nevertire
Craboon
Musvelbrook
Dartbrook Jn
Craven
Stratford Colliery
Tottenham
Narromine
Dubbo
Ulan coal loader
Gulgong
Ulan Jn
Dungog
Maryvale
Sandy Hollow Jn
Newdell Jn
Camberwell Jn
Saxonvale Jn
Wittingham Jn
Martins Creek
Branxton
Telarah
Maitland
Roto
Bogan Gate
Kandos
Charbon Colliery Jn
Charbon Colliery
Parkes
Molong
Goobang Jn
Lake Cargelligo
Orange Jn
Baal Bone Jn
Baal Bone Colliery
Wallerawang
Wallerawang Colliery
Bowenfels
Burcher
Hillston
Naradhan
Blayney
Tarana
Ungarie
Rankins Springs
West Wyalong
Cowra
Greenethorpe
Koorawatha
Sydney
Barmedman
Macarthur
Glenlee
Picton
Griffith
Temora
Braemar
Mittagong
Moss Vale
Willbriggie
Yanco
Stockinbingal
Galong
Narrandera
Cootamundra
Yass Jn
Unanderra
Goulburn
Junee
Medway Jn
Joppa Jn
Boree Creek
Uranquinty
Wagga Wagga
Nowra
Tarago
The Rock
Canberra
Bungendore Jn
Queanbeyan
Moulamein
Deniliquin
Oaklands
Henty
Culcairn
Kerang
Tocumwal
Cobram
Yarrawonga
Wahgunyah
Echuca
Shepparton
Albury
Wodonga
Rutherglen
Dookie
Wangaratta
Tolamba
Benalla
Bendigo
Mangalore
Seymour
Castlemaine
Kyneton
Bacchus Marsh
Melbourne
Bairnsdale
Geelong
North Geelong
Moe
Yallourn
Sale
Traralgon
Morwell
Korumburra
Leongatha

Appendix 2

Melbourne - Brisbane Deviations Options - Project Information

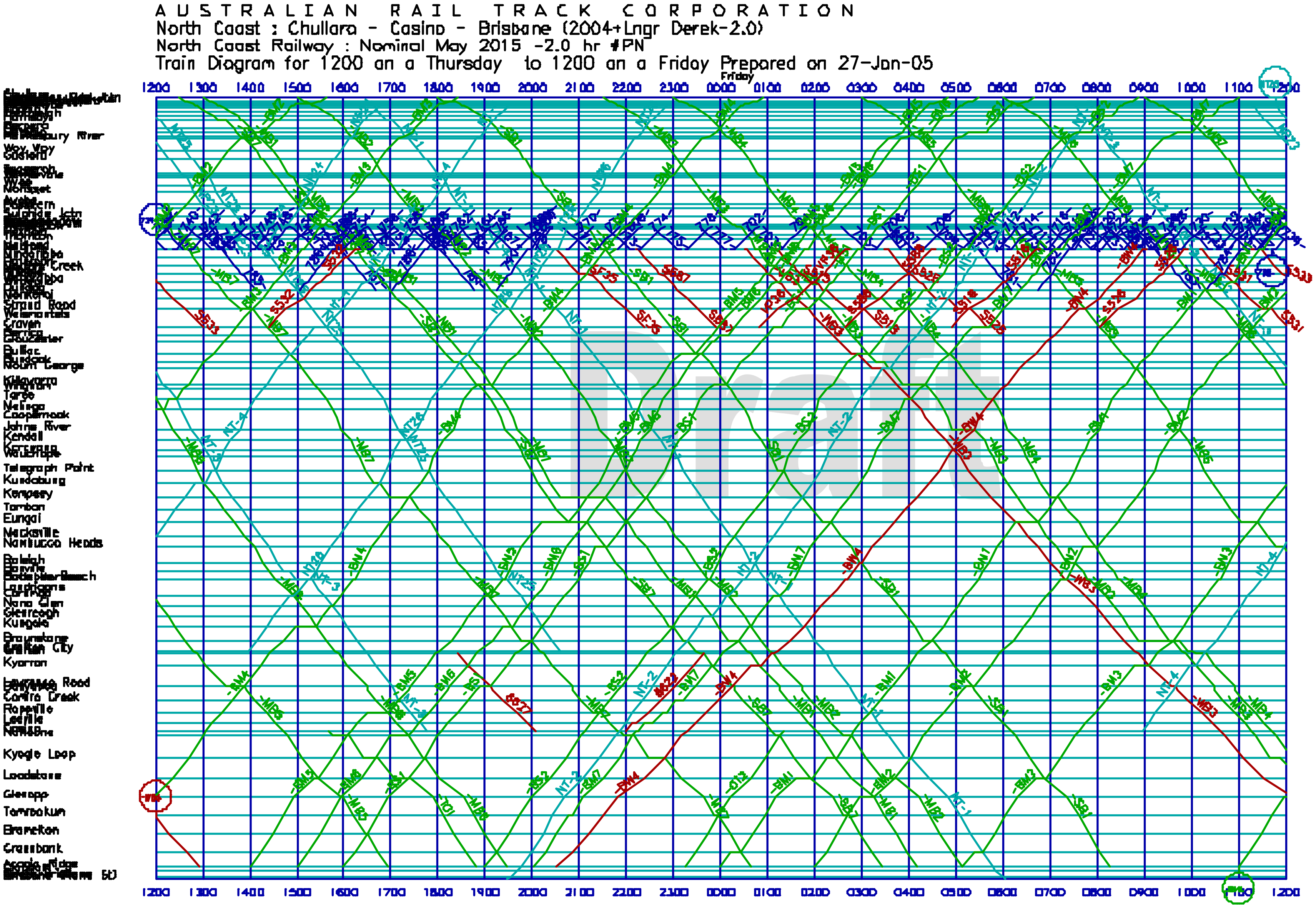
Project Number		Project Group	FROM Name	FROM km	TO Name	TO km	PROJECT DETAILS Cost $M	New Length (km)	Cost per km $M	DEVIATION LENGTH (Km) Existing (if different from calculated)	Distance saved	TRAVEL TIMES Existing (mins)	Proposed time(mins) Individually	Proposed time(mins) Inline	Timesaved (mins) Individually	Timesaved (mins) In line	Cost/time saved ($M/min) Individually	Cost/time saved ($M/min) In line
MELBOURNE																		
V 98		V98	Seymour	97.550		99.020	$3.26	1.000	$3.26		0.47	110	0.83	0.83	0.27	0.27	$1208	$12.08
V 300		V300	Wodonga Bypass	296670		303000	$21.95	5.000	$4.39		1.33	678	3.50	3.50	3.28	3.28	$669	$6.69
S 649		S649	Murray River bridge	649500		648500	$20.18				1.00	097	0.48	0.48	0.49	0.49	$4119	$41.19
ALBURY																		
S 647		S647	Albury curve easing	648500		644500	$17.08				4.00	501	2.19	2.19	2.82	2.82	$606	$6.06
S 519		S519	Wagga South(inc Murrumbidgee Bridge)	522230	Bomen	515800	$22.94				6.43	1247	3.45	3.45	9.02	9.02	$254	$2.54
S 513		S513	Bomen curve easing	515500		511000	$13.80				4.50	455	3.04	3.04	1.51	1.51	$914	$9.14
S 507		S507	Shepherds	507580		507200	$3.90				0.38	021	0.19	0.19	0.02	0.02	$19477	$194.77
S 490		S490	Harefeld curve easing	490690		489380	$21.63				1.31	150	1.47	1.47	0.03	0.03	$72084	$720.84
S 452		S452	Bethungra (UP Only)	456040	Frampton	447700	$99.92	6.550	$15.26		1.79	727	6.43	6.43	0.84	0.84	$11895	$118.95
S 439		S439	Frampton	445530	Cootamundra South	433400	$66.44	8.700	$7.64		3.43	1293	8.03	8.03	4.90	4.90	$1356	$13.56
COOTAMUNDRA																		
S 382		S381	Cootamundra North	428230	Bowning	333450	$763.58	78.080	$9.78		16.70	10659	68.30	68.30	38.29	38.29	$1994	$19.94
S 416		S416	Morrisons Hill	421580	Jindalee	411000	$49.98	9.400	$5.32		1.18	1158	10.05	10.01	1.53	1.57	$3267	$31.84
S 405		S405	Walenbeen	407830	Nubba	401640	$23.64	5.990	$3.95		0.20	574	4.56	4.55	1.18	1.19	$2003	$19.87
S 396		S396	Nubba	399150	Demondrille	392650	$29.94	8.000	$3.74		-150	624	4.14	4.13	2.10	2.11	$1425	$14.19
S 386		S386	Demondrille	391500	Cunningar	380920	$48.60	8.000	$6.07		2.58	1595	9.70	9.68	6.25	6.27	$778	$7.75
S		S	Alternative to S382				-											
S 365		S365	Cunningar	375220	Binalong	355750	$120.98	18.250	$6.63		1.22	2066	14.38	14.38	6.28	6.28	$1926	$19.26
S 343		S343	Binalong	350750	Bowning	334500	$60.07	12.800	$4.69		3.45	1588	8.79	8.78	7.09	7.10	$847	$8.46
S 331		S331	Bowning curve easing	331600		329550	$42.82	2.000	$21.41		0.05	138	1.43	1.39	-005	-001	-$856.30	-$4281.50
S 326		S326	Bowning	328900	Yass Junction	322100	$43.43	9.450	$4.60		-265	627	4.03	3.81	2.24	2.46	$1939	$17.66
S 320		S320	Yass Junction West curve easing	321150		319800	$8.06	1.200	$6.71		0.15	098	0.98	0.83	0.00	0.15	#DIV/0	$53.70
S 317		S317	Yass Junction East curve easing	317800		315250	$17.98	2.550	$7.05		0.00	179	1.96	1.96	-017	-017	-$105.79	-$10579
S 305		S305	Coolalie(Mundanoon Tunnel)	309550	Jerrawa	300000	$53.41	6.650	$8.03		2.90	1315	11.38	8.17	1.77	4.98	$3017	$10.72
S 272		S272	Jerrawa	297000	Breadalbane	247000	$196.23	36.250	$5.41		13.75	4579	28.13	26.58	17.66	19.21	$1111	$10.21
S 231		S231 - S229	Yarra	231670	Joppa Junction	230490	$4.45				1.18	069	0.71	0.62	-002	0.07	-$222.40	$63.54
S 229		S231 - S229	Joppa Junction	230490	Goulburn	227540	$28.20				2.95	205	1.97	1.74	0.08	0.31	$35255	$90.98
GOULBURN																		
S 214		S214	Wolondilly#2	212770		215050	$32.06				2.28	147	1.42	1.26	0.05	0.21	$64116	$152.66
S 192		S192	Medway	193270	Marulan	190470	$21.09				2.80	181	1.73	1.23	0.08	0.58	$26360	$36.36
S 183		S183 - S179	Talong	183110	Wingello	182190	$12.98				0.92	057	0.53	0.48	0.04	0.09	$32447	$144.21
S 179		S183 - S179	Wingello	181020		177300	$41.73				3.72	293	3.51	2.78	-058	0.15	-$71.95	$278.19
S 170		S170		170540	Penrose	168470	$33.57				2.07	140	1.26	1.13	0.14	0.27	$23977	$124.32
S 165		S165	Penrose	165600	Bundanoon	164100	$14.81				1.50	088	0.88	0.77	0.00	0.11	$000	$134.66
S 152		S152	Werai	153580	Exeter	151000	$34.25				2.58	327	3.03	1.75	0.24	1.52	$14270	$22.53
S 138		S138 - S130	Burradoo	138080	Bowral	137380	$8.39				0.70	049	0.46	0.43	0.03	0.06	$27969	$139.85
S 136		S138 - S130	Bowral	136090		135380	$4.96				0.71	074	0.73	0.70	0.01	0.04	$49572	$123.93
S 133		S138 - S130	Bowral	134750	Mittagong	132000	$21.65				2.75	253	4.17	2.33	-164	0.20	-$13.20	$108.25
S 130		S138 - S130	Mittagong Junction	130250		129300	$13.69				0.95	080	0.83	0.67	-003	0.13	-$456.37	$105.32
S 128		S128	Mittagong	128210	Aylmerton	126880	$10.12				1.33	123	1.10	1.00	0.13	0.23	$7784	$44.00
S 97		S97	Aylmerton	126600	Menangle	68.000	$563.75	39.540	$14.26		19.06	5591	37.75	37.75	18.16	18.16	$3104	$31.04
SYDNEY																		
N 88		N159	Fassifern	142313	Hexham	175530	$123.48				33.22	4875	32.22		16.53	16.53	$747	$7.47
HEXHAM																		
N 224		N223	Hexham	176480	Stroud Road	270000	$361.33	68.000	$5.31		25.52	8381	40.81	39.97	43.00	43.84	$840	$8.24
N 271		N271 - N284	Johnson Creek Deviation	270000		271604	$9.50	1.500	$6.33		0.10	140	1.23	0.84	0.17	0.56	$5586	$16.96
N 273		N271 - N284	CoalShaft Creek Deviation	271916		275237	$30.83	2.500	$12.33		0.82	333	2.73	1.58	0.60	1.75	$5138	$17.62
N 276		N271 - N284	South Weismantels Curve Easing	275900		276400	$5.09	0.700	$7.28		-020	103	1.15	0.73	-012	0.30	-$42.46	$16.98
N 280		N271 - N284	Weismantels Deviation	276900		282704	$26.67	5.000	$5.33		0.80	483	4.38	3.22	0.45	1.61	$5926	$16.56
N 284		N271 - N284	Tereel Road Deviation	282860		284169	$6.85	1.300	$5.27		0.01	168	1.67	1.09	0.01	0.59	$68472	$11.61
N 288		N288 - N293	Craven Deviation	285019		290086	$28.38	4.840	$5.86		0.23	679	6.56	4.05	0.23	2.74	$12337	$10.36
N 293		N288 - N293	Upper Avon Curve Easing	291900		293200	$6.29	1.300	$4.84		0.00	303	2.81	2.39	0.22	0.64	$2860	$9.83
N 299		N299 - N338	Avon River Deviation	296184		301500	$29.87	5.100	$5.86		0.22	555	5.18	4.23	0.37	1.32	$8072	$22.63
N 305		N299 - N338	South Gloucester Deviation	301665		308620	$32.39	6.140	$5.28		0.81	650	5.33	4.39	1.17	2.11	$2769	$15.35
N 313		N299 - N338	Barrington River Bypass	309631		316391	$64.16	6.200	$10.35		0.56	597	4.84	3.92	1.13	2.05	$5678	$31.30
N 320		N299 - N338	Buliac Pinnacle Deviation	316713		323840	$97.35	6.150	$15.83		0.98	744	5.35	3.76	2.09	3.68	$4658	$26.45
N 326		N299 - N338	Wirradgurie Deviation	324024		328531	$47.18	4.180	$11.29		0.33	413	3.49	2.45	0.64	1.68	$7372	$28.09
N 332		N299 - N338	Doon Aye Deviation	328871		334142	$58.08	4.540	$12.79		0.73	613	4.43	3.08	1.70	3.05	$3417	$19.04
N 338		N299 - N338	Manning River Crossing	334401		341563	$69.48	6.200	$11.21		0.96	709	5.48	3.58	1.61	3.51	$4316	$19.80
N 346		N346 - N363	Charity Creek Deviation	342000		350147	$39.10	6.570	$5.95		1.58	727	5.95	4.02	1.32	3.25	$2962	$12.03
N 354		N346 - N363	Kilawarra Creek Deviation	350000		358355	$31.06	4.150	$7.49		4.21	717	5.27	3.16	1.90	4.01	$1635	$7.75
N 363		N346 - N363	West Wingham Deviation	359600		365844	$28.28	5.470	$5.17		0.77	692	5.61	4.97	1.31	1.95	$2159	$14.50
N 371		N371	Wingham East Deviation	368611		373928	$29.44	5.410	$5.44		-009	527	5.03	4.83	0.24	0.44	$12267	$66.91
N 376		N376	West Taree Deviation	375017		377773	$16.18	2.450	$6.60		0.31	327	2.73	2.41	0.54	0.86	$2995	$18.81
TAREE																		
N 379		N379	Taree North Bypass	375000		382900	$20.11	5.000	$4.02		2.90	831	5.12		3.19	3.19	$630	$6.30
N 401		N401	Taree (Dawson River)	383300	Johns River	417801	$76.41	26.500	$2.88		8.00	2915	16.62	15.31	12.53	13.84	$610	$5.52
N 423	A	N423	Johns River (Station)	417801	Rossglen	427200	$27.36	1.900	$14.40		0.00	789	6.26	4.82	1.63	3.07	$1678	$8.91
N 423	A	N423	Part RAC02 notpart of CE1	417801		427200		7.180	$0.00		0.32							
N 434		N433 - N457	Rossglen (Syd. Side)	427200	Herons Creek (Station)	439096	$39.70	9.000	$4.41		2.90	1023	6.1	4.82	4.13	5.41	$961	$7.34
N 457		N433 - N457	Herons Creek (Station)	439096	Telegraph Point (Not station)	474000	$45.94	12.250	$3.75		1.08	2804	23.9	22.68	4.14	5.36	$1110	$8.57
N 481		N481	Yarrabee Park	480792	Mingaletta	482154	$2.54	1.280	$1.98		0.08	085	0.79	0.7	0.06	0.15	$4231	$16.92
N 495		N495 - N512	Kundabung	487197	Kempsey (Station)	503572	$38.10	15.730	$2.42		0.65	1458	11.87	9.14	2.71	5.44	$1406	$7.00
N 512		N495 - N512	Kempsey (Station)	503572	Tamban (Station)	520558	$33.57	11.300	$2.97		1.40	1324	10.41	8.55	2.83	4.69	$1186	$7.16
N 528		N528 - N559	Tamban (Station)	520558	Eungai (Station)	534556	$44.91	11.880	$3.78		2.12	1270	8.68	6.88	4.02	5.82	$1117	$7.72
N 542		N528 - N559	Eungai (Station)	534556	Macksville (Station)	552417	$46.69	16.650	$2.80		1.21	1566	11.22	9.36	4.44	6.30	$1051	$7.41
N 559		N528 - N559	Macksville (Station)	552417	Nambucca Heads (Station)	565081	$25.95	11.600	$2.24		1.06	1193	8.86	6.56	3.07	5.37	$845	$4.83
N 573		N573 - N591	Nambuccaheads (Station)	565081	Urunga(Station)	580918	$20.53	15.590	$1.32		0.25	1305	10.01	8.42	3.04	4.63	$675	$4.43
N 584		N573 - N591	Urunga(Station)	580918	Raleigh (Station)	586454	$4.63	2.500	$1.85		0.00	430	3.8	2.94	0.50	1.36	$927	$3.41
N 591		N573 - N591	Raleigh (Station)	586454	Bonville (Station)	596494	$14.26	9.300	$1.53		0.74	888	8.42	6.06	0.46	2.82	$3101	$5.06
COFFS HARBOUR																		
N 629		N628	Coffs Harbour - Nana Glen Deviation	610700		644340	$162.75	24.950	$6.52		8.69	3382	20.81	17.03	13.01	16.79	$1251	$9.69
N 649		N649 - N691	Glenreagh Deviation	644340		654270	$60.16	8.880	$6.77		1.05	832	6.27	5.00	2.05	3.32	$2935	$18.12
N 657		N649 - N691	Sherwood Deviation No 1	654400		658670	$21.38	4.200	$5.09		0.07	332	3.39	2.48	-007	0.84	-$305.49	$25.46
N 661		N649 - N691	Sherwood Deviation No 2	658710		663010	$17.66	3.850	$4.59		0.45	362	2.89	2.26	0.73	1.36	$2419	$12.98
N 667		N649 - N691	Dundoo Creek Deviation	663490		670040	$24.82	6.250	$3.97		0.30	533	4.13	3.63	1.20	1.70	$2069	$14.60
N 671		N649 - N691	Qwyarigo Curve Easing	670400		670900	$1.41	0.500	$2.83		0.00	064	0.67	0.52	-003	0.12	-$47.10	$11.78
N 673		N649 - N691	Lanitza Deviation	671370		674810	$14.80	3.130	$4.73		0.31	305	2.77	2.33	0.28	0.72	$5284	$20.55
N 676		N649 - N691	Poison Creek Curve Easing	675400		677300	$3.78	1.870	$2.02		0.03	172	1.62	1.44	0.10	0.28	$3776	$13.49
N 684		N649 - N691	Braunstone Deviation	678820		687000	$30.15	7.320	$4.12		0.86	787	6.21	5.97	1.66	1.90	$1817	$15.87
N 691		N649 - N691	South Grafton Deviation	687720		693700	$38.60	5.860	$6.59		0.12	751	6.29	6.18	1.22	1.33	$3164	$29.02
N 705		N705 - N714	Grafton Exit	704250		706400	$10.74	2.050	$5.24		0.10	199	1.96	1.25	0.03	0.74	$35805	$14.52
N 710		N705 - N714	Koolkhan Deviation	706640		712380	$18.01	5.000	$3.60		0.74	518	4.39	3.31	0.79	1.87	$2280	$9.63
N 714		N705 - N714	Southgate Deviation	712620		714580	$3.47	1.930	$1.80		0.03	191	1.86	1.26	0.05	0.65	$6947	$5.34
N 721		N721 - N763	Warragai Creek Deviation	714880		727280	$40.74	11.750	$3.47		0.65	1170	8.77	6.96	2.93	4.74	$1390	$8.59
N 731		N721 - N763	Lawrence Road Southern Extension	727760		733950	$27.55	5.710	$4.82		0.48	598	5.80	3.65	0.18	2.33	$15304	$11.82
N 738		N721 - N763	Lawrence Road Curve Easing	736100		740350	$4.56	3.860	$1.18		0.39	584	6.67	4.46	-083	1.38	-$5.50	$3.31
N 746		N721 - N763	Banyabba Deviation	740700		751200	$42.47	9.800	$4.33		0.70	917	6.93	6.02	2.24	3.15	$1896	$13.48
N 756		N721 - N763	Camira Creek Deviation	751670		759770	$33.82	7.460	$4.53		0.64	722	5.48	4.42	1.74	2.80	$1944	$12.08
N 763		N721 - N763	Ampdale Deviation	761840		764550	$9.94	2.400	$4.14		0.31	386	3.23	2.51	0.63	1.35	$1578	$7.37
N 766		N766 - N799	Selection Flat Regrade	765140		767320	$10.07	2.060	$4.89		0.12	206	1.90	1.42	0.16	0.64	$6293	$15.73
N 770		N766 - N799	Clearfield Deviation	768700		772000	$18.10	2.060	$8.79		1.24	343	2.99	2.38	0.44	1.05	$4113	$17.24
N 775		N766 - N799	Myrtle Creek Curve Easing	774880		775620	$6.75	0.740	$9.13		0.00	252	2.43	1.97	0.09	0.55	$7504	$12.28
N 780		N766 - N799	Rappville Deviation	775980		783450	$17.28	6.620	$2.61		0.85	578	4.94	3.96	0.84	1.82	$2057	$9.49
N 784		N766 - N799	Sandy Creek Curve Easing No 1	783660		783880	$3.20	0.220	$14.56		0.00	032	0.31	0.22	0.01	0.10	$32032	$32.03
N 785		N766 - N799	Sandy Creek Curve Easing No 2	784520		785200	$6.37	0.680	$9.37		0.00	095	0.93	0.72	0.02	0.23	$31869	$27.71
N 786		N766 - N799	Coombell Deviation	785650		787300	$5.70	1.630	$3.50		0.02	153	1.45	1.17	0.08	0.36	$7126	$15.84
N 792		N766 - N799	Branch Creek Deviation	789960		793100	$6.90	3.140	$2.20		0.00	401	3.89	3.34	0.12	0.67	$5748	$10.30
N 794		N766 - N799	Leeville Curve Easing	793580		794300	$4.96	0.720	$6.89		0.00	081	0.78	0.67	0.03	0.14	$16543	$35.45
N 799		N766 - N799	South Casino Deviation	795200		803280	$28.16	7.440	$3.79		0.64	668	5.70	5.15	0.98	1.53	$2874	$18.41
CASINO																		
N 808		N808 - N816	North Casino Deviation	807000		808740	$7.76	1.560	$4.98		0.18	152	1.35	1.2	0.17	0.32	$4567	$24.26
N 811		N808 - N816	Summerdowns Curve Easing	810000		810920	$3.62	0.900	$4.02		0.02	173	1.64	1.42	0.09	0.31	$4025	$11.69
N 812		N808 - N816	Summerdowns North Curve easing	811520		811800	$0.82	0.280	$2.93		0.00	064	0.63	0.51	0.01	0.13	$8207	$6.31
N 813		N808 - N816	Woodlands Dip Curve Easing	812290		813400	$9.69	1.070	$9.06		0.04	121	1.13	0.88	0.08	0.33	$12118	$29.38
N 816		N808 - N816	Fairy Hill Deviation	814020		818360	$11.33	4.160	$2.72		0.18	391	3.46	2.72	0.45	1.19	$2517	$9.52
N 822		N822 - N841	Baraimal Curve Easing	821500		822320	$2.61	0.820	$3.18		0.00	293	2.86	2.19	0.07	0.74	$3725	$3.52
N 825		N822 - N841	Studders Lane Deviation	823850		825590	$5.51	1.670	$3.30		0.07	275	2.47	1.76	0.28	0.99	$1968	$5.57
N 827		N822 - N841	South Kyogle Curve Easing	827100		827500	$5.76	0.500	$11.51		-010	165	1.52	1.04	0.13	0.61	$4428	$9.44
N 832		N822 - N841	Kyogle Deviation	827900		836000	$56.88	7.400	$7.69		0.70	807	6.13	4.35	1.94	3.72	$2932	$15.29
N 838		N822 - N841	Greenwood Lagoon Curve Easing	837970		838660	$1.83	0.690	$2.66		0.00	22	2.1	1.45	0.10	0.75	$1834	$2.45
N 841		N822 - N841	Kilgra Deviation	839460		842600	$21.08	2.840	$7.42		0.30	316	2.74	2.02	0.42	1.14	$5019	$18.49
N 866		N866	Border Crossing Deviation	844490		886900	$311.46	30.190	$10.32		12.22	4847	28.39	23.33	20.08	25.14	$1551	$12.39
N 890		N890 - N902	Glenapp Deviation	887440		892360	$26.73	4.160	$6.43		0.76	503	5.65	3.13	-062	1.90	-$43.11	$14.07
N 893		N890 - N902	New Year Creek Curve Easing	892880		893800	$2.51	0.860	$2.92		0.06	126	1.31	0.78	-005	0.48	-$50.14	$5.22
N 898		N890 - N902	Logan River Deviation	895000		901140	$36.91	5.330	$6.93		0.81	647	5.4	3.81	1.07	2.66	$3450	$13.88
N 902		N890 - N902	Ugly Creek Curve Easing	901500		902750	$10.13	1.250	$8.11		0.00	124	1.21	0.88	0.03	0.36	$33772	$28.14
N 904		N904 - N923	Tamrookum Creek Deviation	903060		905400	$18.74	2.260	$8.29		0.08	189	1.78	1.49	0.11	0.40	$17038	$46.86
N 906		N904 - N923	Tamrookum Curve Easing No 1	905860		907000	$4.59	1.140	$4.03		0.00	104	0.99	0.87	0.05	0.17	$9182	$27.00
N 908		N904 - N923	Tamrookum Curve Easing No 2	907500		908800	$3.35	1.230	$2.72		0.07	111	1.08	0.98	0.03	0.13	$11159	$25.75
N 910		N904 - N923	Tamrookum Curve Easing No 3	909780		910300	$3.10	0.520	$5.96		0.00	092	0.91	0.84	0.01	0.08	$30989	$38.74
N 912		N904 - N923	Round Mountain South Curve Easing	911120		913460	$5.73	2.340	$2.45		0.00	192	1.86	1.72	0.06	0.20	$9558	$28.67
N 915		N904 - N923	Round Mountain Road Curve Easing	914500		915940	$2.69	1.440	$1.87		0.00	153	1.51	1.37	0.02	0.16	$13474	$16.84
N 918		N904 - N923	Sandy Creek Road Curve Easing	916430		919350	$5.39	2.920	$1.85		0.00	209	2.04	1.85	0.05	0.24	$10787	$22.47
N 923		N904 - N923	Sandy Creek Deviation	921880		924230	$17.25	2.200	$7.84		0.15	31	2.88	2.64	0.22	0.46	$7839	$37.49
N 926		N926 - N945	Bromelton Deviation	924700		926940	$10.83	2.220	$4.88		0.02	206	2.08	1.76	-002	0.30	-$541.28	$36.09
N 929		N926 - N945	Allan Creek Deviation	927600		929780	$18.11	2.000	$9.06		0.18	203	1.9	1.62	0.13	0.41	$13934	$44.18
N 935		N926 - N945	Saville Road Deviation	932000		938100	$18.29	6.100	$3.00		0.00	525	5.16	4.56	0.09	0.69	$20325	$26.51
N 939		N926 - N945	Teviot Brook South Deviation	938500		940000	$3.63	1.500	$2.42		0.00	124	1.22	1.03	0.02	0.21	$18143	$17.28
N 945		N926 - N945	Teviot Brook North Deviation	940600		949790	$38.66	9.190	$4.21		0.00	637	6.15	5.51	0.22	0.86	$17571	$44.95
N 951		N951 - N956	Olson Road Curve Easing	950950		951460	$1.67	0.510	$3.27		0.00	107	1.05	0.92	0.02	0.15	$8326	$11.10
N 953		N951 - N956	Oxley Creek Divide Deviation	951740		954700	$7.87	2.860	$2.75		0.10	22	2.16	1.8	0.04	0.40	$19685	$19.69
N 956		N951 - N956	Greenbank Curve Easing	955640		955900	$1.35	0.260	$5.18		0.00	088	0.9	0.79	-002	0.09	-$67.35	$14.97
N 959		N959 - N970	Greenbank North Deviation	957250		961740	$10.00	4.460	$2.24		0.03	422	4.01	3.73	0.21	0.49	$4761	$20.41
N 964		N959 - N970	Brown Plains Deviation	962060		966280	$12.33	4.130	$2.99		0.09	338	3.75	2.98	-037	0.40	-$33.32	$30.83
N 968		N959 - N970	Larapinta Curve Easing	967180		968350	$5.12	1.170	$4.38		0.00	135	1.35	1.18	0.00	0.17	-	$30.12
N 970		N959 - N970	Beaudesert Road Deviation	968690		972180	$10.92	3.210	$3.40		0.28	307	2.83	2.61	0.24	0.46	$4551	$23.75
BRISBANE																		

Appendix 3

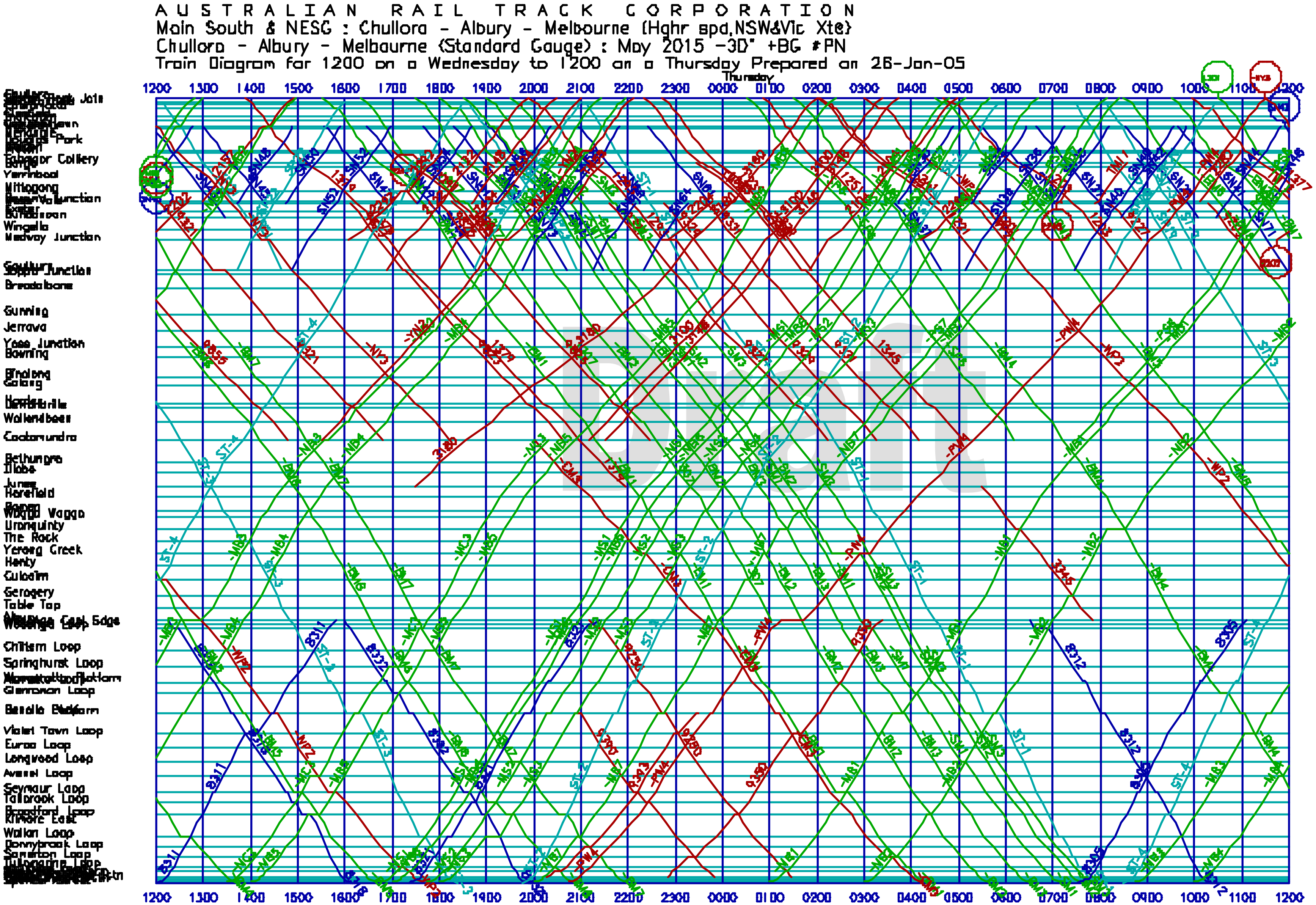
Melbourne - Brisbane Deviations Options - Ranking

	Project	FROM		TO		Cost ($m)	Time Saving (mins)	$m / min Saved	Cumulative Cost ($m)	Cumulative Time Saving (mins)	Cumulative $m / min Saved
		Name	km	Name	km						
N	N573 - N591	Nambucca Heads (Station)	565.081	Bonville (Station)	596.494	$39.43	8.81	$4.48	$39.43	8.81	$4.48
N	N401	Taree (Dawson River)	383.300	Johns River	417.801	$76.41	12.53	$6.10	$115.84	21.34	$5.43
N	N379	Taree North Bypass	375.000		382.900	$20.11	3.19	$6.30	$135.95	24.53	$5.54
N	N528 - N559	Tamban (Station)	520.558	Nambucca Heads (Station)	565.081	$117.54	17.49	$6.72	$253.48	42.02	$6.03
N	N495 - N512	Kundabung	487.197	Tamban (Station)	520.558	$71.67	10.13	$7.07	$325.15	52.15	$6.23
N	N159	Fassifern	142.31	Hexham	175.530	$123.48	16.53	$7.47	$448.63	68.68	$6.53
S	S386	Demondrille	391.500	Cunningar	380.920	$48.60	6.25	$7.78	$497.23	74.93	$6.64
N	N433 - N457	Rossglen (Syd. Side)	439.096	Telegraph Point (Not station)	474.000	$85.64	10.77	$7.95	$582.87	85.70	$6.80
N	N223	Hexham	176.480	Stroud Road	270.000	$361.33	43.00	$8.40	$944.20	128.70	$7.34
S	S343	Binalong	350.750	Bowning	334.500	$60.07	7.09	$8.47	$1,004.27	135.79	$7.40
S	S513	Bomen curve easing	515.500		511.000	$13.80	1.51	$9.14	$1,018.07	137.30	$7.41
N	N705 - N714	Grafton Exit	704.250	Southgate	714.580	$32.22	3.26	$9.88	$1,050.29	140.56	$7.47
N	N721 - N763	Warragai Creek	714.880	Ampdale	764.550	$159.08	15.75	$10.10	$1,209.38	156.31	$7.74
N	N288 - N293	Craven	285.019	Upper Avon	293.200	$34.67	3.38	$10.26	$1,244.05	159.69	$7.79
N	N346 - N363	Charity Creek	342.000	West Wingham	365.844	$98.45	9.21	$10.69	$1,342.49	168.90	$7.95
S	S272	Jerrawa	297.000	Breadalbane	247.000	$196.23	17.66	$11.11	$1,538.72	186.56	$8.25
N	N822 - N841	Baraimal	821.500	Kilgra	842.600	$93.67	7.95	$11.78	$1,632.39	194.51	$8.39
V	V98	Seymour	97.550		99.020	$3.26	0.27	$12.08	$1,635.65	194.78	$8.40
N	N628	Coffs Harbour - Nana Glen D	610.700		644.340	$162.75	13.01	$12.51	$1,798.40	207.79	$8.65
S	S439	Frampton	445.530	Cootamundra South	433.400	$66.44	4.90	$13.56	$1,864.84	212.69	$8.77
N	N890 - N902	Glenapp	887.440	Ugly Creek	902.750	$76.28	5.40	$14.13	$1,941.12	218.09	$8.90
S	S396	Nubba	399.150	Demondrille	392.650	$29.94	2.10	$14.25	$1,971.05	220.19	$8.95
N	N808 - N816	North Casino	807.000	Fairy Hill	818.360	$33.23	2.28	$14.57	$2,004.28	222.47	$9.01
N	N766 - N799	Selection Flat Regrade	765.140	South Casino	803.280	$107.50	7.09	$15.16	$2,111.78	229.56	$9.20
N	N866	Border Crossing Deviation	844.490		886.900	$311.46	20.08	$15.51	$2,423.24	249.64	$9.71
N	N271 - N284	Johnson Creek	270.000	Tereel Road	284.169	$78.93	4.81	$16.41	$2,502.17	254.45	$9.83
N	N423	Johns River (Station)	417.801	Rossglen	427.200	$27.36	1.63	$16.78	$2,529.53	256.08	$9.88
N	N951 - N956	Olson Road	950.950	Greenbank	955.900	$10.89	0.64	$17.01	$2,540.42	256.72	$9.90
N	N649 - N691	Glenreagh	644.340	South Grafton	693.700	$212.76	11.57	$18.39	$2,753.18	268.29	$10.26
S	S365	Cunningar	375.220	Binalong	355.750	$120.98	6.28	$19.26	$2,874.16	274.57	$10.47
S	S326	Bowning	328.900	Yass Junction	322.100	$43.43	2.24	$19.39	$2,917.60	276.81	$10.54
S	S381	Cootamundra North	428.230	Bowning	333.450	$763.58	38.29	$19.94	$3,681.17	315.10	$11.68
S	S405	Wallenbeen	407.830	Nubba	401.640	$23.64	1.18	$20.03	$3,704.81	316.28	$11.71
N	N299 - N338	Avon River	296.184	Manning River	341.563	$398.53	17.40	$22.90	$4,103.34	333.68	$12.30
N	N959 - N970	Greenbank North	957.250	Beaudesert Road	972.180	$38.37	1.52	$25.24	$4,141.71	335.20	$12.36
N	N376	West Taree Deviation	375.017		377.773	$16.18	0.54	$29.95	$4,157.89	335.74	$12.38
S	S305	Coolalie (Mundanoon Tunnel	309.550	Jerrawa	300.000	$53.41	1.77	$30.17	$4,211.30	337.51	$12.48
S	S97	Aylmerton	126.300	Menangle	68.000	$563.75	18.16	$31.04	$4,775.05	355.67	$13.43
S	S416	Morrisons Hill	421.580	Jindalee	411.000	$49.98	1.53	$32.67	$4,825.03	357.20	$13.51
N	N904 - N923	Tamrookum Creek	887.440	Sandy Creek	924.230	$60.85	1.84	$33.07	$4,885.88	359.04	$13.61
N	N926 - N945	Bromelton	924.700	Teviot Brook North	949.790	$89.52	2.47	$36.24	$4,975.40	361.51	$13.76
S	S649	Murray River bridge	649.500		648.500	$20.18	0.49	$41.19	$4,995.58	362.00	$13.80
S	S128	Mittagong	128.210	Aylmerton	126.880	$10.12	0.13	$77.84	$5,005.70	362.13	$13.82
S	S231 - S229	Yarra	231.670	Goulburn	227.540	$32.65	0.38	$85.93	$5,038.35	362.51	$13.90
S	S138 - S130	Burradoo	138.080	Mittagong Junction	228.540	$48.69	0.43	$113.23	$5,087.04	362.94	$14.02
S	S452	Bethungra	456.040	Frampton	229.540	$99.92	0.84	$118.95	$5,186.96	363.78	$14.26
N	N371	Wingham East Deviation	368.611		230.540	$29.44	0.44	$66.91	$5,216.40	364.22	$14.32
S	S152	Werai	153.580	Exeter	231.540	$34.25	1.52	$22.53	$5,250.65	365.74	$14.36
S	S507	Shepherds	507.580		232.540	$3.90	0.02	$194.77	$5,254.54	365.76	$14.37
S	S183 - S179	Tallong	183.110	Wingello	233.540	$54.71	0.24	$227.95	$5,309.25	366.00	$14.51
S	S170		170.540	Penrose	234.540	$33.57	0.27	$124.32	$5,342.82	366.27	$14.59
S	S192	Medway	193.270	Marulan	235.540	$21.09	0.58	$36.36	$5,363.91	366.85	$14.62
S	S214	Wollondilly #2	212.770		236.540	$32.06	0.21	$152.66	$5,395.97	367.06	$14.70
S	S490	Harefield curve easing	490.690		237.540	$21.63	0.03	$720.84	$5,417.59	367.09	$14.76
S	S165	Penrose	165.600	Bundanoon	238.540	$14.81	0.11	$134.66	$5,432.40	367.20	$14.79
S	S320	Yass Junction West curve ea	321.150		239.540	$8.06	0.15	$53.70	$5,440.46	367.35	$14.81
S	S331	Bowning curve easing	331.600		240.540	$42.82	- 0.01	-$4,281.50	$5,483.27	367.34	$14.93
S	S317	Yass Junction East curve ea	317.800		241.540	$17.98	- 0.17	-$105.79	$5,501.26	367.17	$14.98

Appendix 4 - SYDNEY-BRISBANE 24-HOUR TRAIN DIAGRAM FOR NOMINAL 2015 TRAFFIC


AUSTRALIAN RAIL TRACK CORPORATION
North Coast : Chullora - Casino - Brisbane (2004+Lngr Derek-2.0)
North Coast Railway : Nominal May 2015 -2.0 hr #PN
Train Diagram for 1200 on a Thursday to 1200 on a Friday Prepared on 27-Jan-05
Draft

MELBOURNE – SYDNEY 24-HOUR TRAIN DIAGRAM FOR REVISED NOMINAL 2015 TRAFFIC


A U S T R A L I A N   R A I L   T R A C K   C O R P O R A T I O N
Main South & NESG : Chullora - Albury - Melbourne (Hghr spd,NSW&Vic Xte)
Chullora - Albury - Melbourne (Standard Gauge) : May 2015 -3D" +BG #PN
Train Diagram for 1200 on a Wednesday to 1200 on a Thursday Prepared on 26-Jan-05
Thursday
1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 0000 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200
Tahmoor Colliery
Yerrinbool
Mittagong
Wingello
Medway Junction
Breadalbane
Gunning
Jerrawa
Yass Junction
Bowning
Binalong
Galong
Wallendbeen
Cootamundra
Bethungra
Junee
Harefield
Wagga Wagga
Uranquinty
The Rock
Yerong Creek
Henty
Culcairn
Gerogery
Table Top
Chiltern Loop
Springhurst Loop
Glenrowan Loop
Benalla Platform
Violet Town Loop
Euroa Loop
Longwood Loop
Avenel Loop
Seymour Loop
Tallarook Loop
Broadford Loop
Kilmore East
Wallan Loop
Donnybrook Loop
Somerton Loop
Draft