Final Report

ARTC STANDARD GAUGE RAIL NETWORK DORC

AUSTRALIAN RAIL TRACK CORPORATION LTD

Sydney
February, 2001

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BOOZ·ALLEN & HAMILTON

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1 INTRODUCTION

1.1 Background

The Australian Rail Track Corporation Ltd. (ARTC) engaged Booz·Allen & Hamilton to determine the depreciated optimised replacement cost (DORC) of the current ARTC rail network. This report describes the scope, approach and results of the DORC analysis.

Broadly, the sections of the ARTC network included in the study are:

- Adelaide to Parkeston
- Adelaide to Melbourne
- Adelaide Metropolitan
- Port Augusta to Whyalla
- Crystal Brook to Broken Hill
- Melbourne to Wodonga
- Melbourne Metropolitan.

1.2 Establishing the DORC value

The approach we used in establishing the DORC value is illustrated in Figure 1 below.

The philosophy underlying calculating the DORC is discussed in detail in Appendix 2.

The ARTC network under study was divided into pricing segments matching those adopted by the ARTC. The Adelaide-Parkeston pricing segment was further subdivided due to the length of the segment. The pricing segment codes and geographical names are shown in Table 1.

Figure 1 Approach

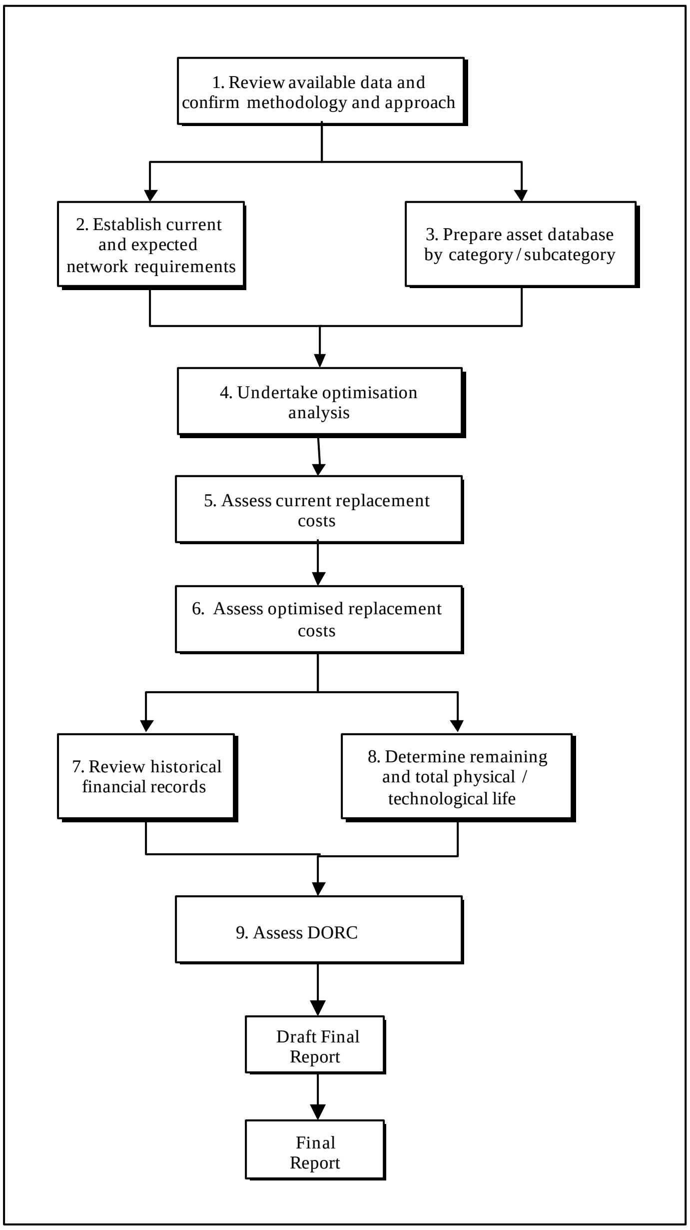


Table 1 Pricing Segments

PRICING SEGMENT CODE	GEOGRAPHICAL NAME
1	Adelaide to Parkeston, subdivided into
1.1	Dry Creek (inclusive) to Crystal Brook
1.2	Crystal Brook (inclusive) to Port Augusta
1.3	Port Augusta (inclusive) to Tarcoola
1.4	Tarcoola (inclusive) to Parkeston (inclusive)
2	Crystal Brook to Broken Hill (Kanandah) (inclusive)
3	Dry Creek to Melbourne (Spencer Street) (inclusive)
4	Dry Creek to Adelaide Outer Harbour (inclusive)
5	Melbourne (Tottenham) to Wodonga (inclusive)
6	Port Augusta (Spencer Junction) to Whyalla (inclusive)
7	Melbourne (Appleton Dock Junction) to Melbourne (Appleton Dock) (inclusive)

While the ARTC currently controls the infrastructure between Tarcoola and Alice Springs, determining the DORC of this section of the network is not included in this study. ARTC will soon lease this section of the network to the Asia Pacific Transport Consortium as part of the arrangements for development of the Alice Springs to Darwin Railway. Under the lease terms, the Asia Pacific Transport Consortium assume responsibility for the ongoing maintenance and management of the railway between Tarcoola and Alice Springs, effectively excising the railway from the rest of the ARTC network.

The brief was to determine the DORC by way of a desktop study using information provided by the ARTC. No field inspection was done to verify the accuracy or otherwise of this information.

1.3 Structure of the Report

The Report is structured to reflect the key work steps in the assignment. There are six further sections:

- Section 2 Establishing the DORC value
- Section 3 Existing and expected rail network requirements
- Section 4 Optimised stand alone rail network
- Section 5 Replacement costs
- Section 6 Condition Assessment
- Section 7 Final DORC values.

2 EXISTING AND EXPECTED RAIL NETWORK REQUIREMENTS

2.1 Forecast Rail Task

ARTC provided Revenue Growth Forecasts from 2001 to 2006 for use in estimating the future rail task. These are listed in Table 3. Revenue Growth Forecasts were provided by Operations Segment and by ARTC Business Segment within each Operations Segment. These match the segment codes shown in Table 1 and train details shown in Table 2. Loop length allowances are detailed later in Table 5.

Table 2 Train Characteristics

ARTC BUSINESS SEGMENT	MAX. TRAIN SPEED (KM/H)	MAX. AXLE LOAD (T)
Passenger Super Premium	130	20
Freight or Passenger Premium	115	20
Freight High	110	21
Freight Standard	80	23

2.2 Historical Rail Task

Many asset types have lives which can be measured in gross tonnes. For example, a certain rail size may be quoted as having a life of 600 million gross tonnes (MGT), meaning that the rail is considered to require replacement when it has carried 600 MGT of traffic.

Calculating remaining asset life in years for such assets requires knowledge of the asset life, the asset life already consumed and the expected usage over future years. Unfortunately, there is no reliable data available on the gross tonnes already carried by the ARTC network from initial construction of the network to now. The assumption was made that the historical level of traffic is the same as the forecast level of traffic for this year. The level of traffic for this year was forecast by reducing ARTC's traffic forecasts for 2001 by 3%, the approximate long-term traffic growth figure assumed by ARTC in their traffic forecasts.

Table 3 Forecast Traffic Volume on ARTC Network in Gross Tonnes

	CORRIDOR, SECTORS	2000	2001	2002	2003	2004	2005	2006	5 YEAR AVE
1.1	Dry Creek (inc.) to Crystal Brook	7,472,593	7,696,771	7,732,231	7,889,562	8,050,512	8,240,328	8,435,091	8,007,416
1.2	Crystal Brook (inc.) to Port Augusta	8,945,801	9,214,175	9,385,210	9,559,591	9,737,384	9,950,444	10,168,488	9,669,215
1.3	Port Augusta (inc.) to Tarcoola	7,628,784	7,857,648	8,007,711	8,160,784	8,316,930	8,507,161	8,701,987	8,258,704
1.4	Tarcoola (inc.) to Parkeston (inc.)	7,027,415	7,238,237	7,394,290	7,554,125	7,717,835	7,885,516	8,057,267	7,641,212
2	Crystal Brook to Broken Hill (inc.)	4,499,026	4,633,997	4,668,927	4,766,515	4,866,518	4,969,006	5,074,051	4,829,836
3	Dry Creek to SA Border (inc.)	10,347,994	10,658,434	10,598,753	10,862,871	11,134,240	11,413,078	11,699,607	11,061,164
3	SA Border to Spencer Street (Melbourne) (inc.)	11,573,641	11,920,850	12,244,259	12,592,995	12,949,809	13,317,747	13,697,182	12,787,140
4	Dry Creek to Adelaide Outer Harbour (inc.)	2,942,804	3,031,088	2,828,497	2,907,842	2,990,242	3,075,818	3,164,695	2,999,697
5	Tottenham (Melbourne) to Wodonga (inc.)	6,508,755	6,704,018	6,891,735	7,081,422	7,138,085	7,197,015	7,258,382	7,045,110
6	Spencer Junction (Port Augusta) to Whyalla (inc.)	1,671,310	1,721,449	1,747,065	1,773,065	1,799,456	1,826,242	1,853,430	1,786,785
7	Appleton Dock Junction to Appleton Dock (Melbourne) (inc.)	2,411,003	2,483,333	2,566,389	2,652,879	2,742,989	2,836,914	2,934,865	2,702,895

3 OPTIMISED RAIL NETWORK

3.1 Approach to Optimisation

Producing a fully optimised network layout normally requires extensive analysis of traffic requirements and detailed computer simulation of the network operation. Such a rigorous approach has not been possible within the timeframe available to carry out this DORC. Given the relatively simple nature of ARTC's network, the optimisation process was essentially limited to reviewing the number and placement of crossing loops and associated train control systems, plus reviewing the track structure required for present and future traffic.

3.2 Maximum Capacity Considerations

It is understood that ARTC currently meets its performance criteria for the percentage of "Healthy" trains which achieve their timetabled transit time (95%). A significant number of trains typically run in packs to suit the requirements of the end users, thus creating peaks in the traffic. During these peak periods, ARTC are still able to provide paths with reasonable transit times to the suit the current operators' requirements. However, in the event that extra paths are requested by operators, it is becoming increasingly difficult for ARTC to find additional paths with reasonable transit times around the peak hours. When paths are identified, they often have significantly longer transit times as the additional trains have to wait for others to cross. This implies that the current network configuration is reasonably well matched to the demand (for the purposes of this DORC valuation).

3.3 Optimised Track Infrastructure

Track configuration was optimised taking into account the forecast train numbers likely to use each segment over the next five years. Some areas require more crossing loops, particularly across the Nullarbor. In other areas optimisation resulted in short loops being eliminated, or extended: the western line through Victoria is an example. The optimised loop arrangement would result in approximately equally spaced loops to enhance train operations.

Given current and projected traffic levels, the one (and only) section of double track, located in the vicinity of Coonamia on the Trans Australian Railway would be replaced with a revised layout for the Crystal Brook to Coonamia area.

The assumption made in optimising the track infrastructure is that the only track infrastructure required for ARTC's operations is main line and crossing loops. Where there are additional tracks and sidings coming off the main line or crossing loops in the current network configuration, the assumption is that ARTC will own the turnout connecting the additional tracks to the main line or crossing loop and that the connecting track (and subsequent turnouts) will be owned by another party.

The resulting optimised track layout is shown on the drawing entitled "ARTC DORC Network Schematic" in Appendix 1.

In developing replacement costs, "modern equivalent form" configuration applies. For example, much of the ARTC network utilises rail of 47 kg/m section size. Although this rail section size is adequate for current traffic and projected future traffic over the next five years, it is recognised that this rail section size is no longer produced in Australia and 50 kg/m rail (modern equivalent form) has been chosen as the replacement rail. Sleeper centres have not been changed as it is believed that the current sleeper centres are adequate for current traffic and projected future traffic over the next five years.

A more detailed discussion of issues affecting the choice of replacement assets is contained in Appendix 2.

3.4 Optimised Safeworking Systems

Modern replacements for the existing safe working systems are assumed to be used, and methods of safeworking are assumed to remain the same. It has been noted that the current level of train order activity undertaken by the Train Controllers for Parkeston – Port Augusta segment is relatively high and sometimes results in delays to trains during peak periods. Whilst there is a strong operational case for the application of a more sophisticated safeworking system, the current service offering provided is only manual trains orders and this situation is likely to exist for much of the next five years.

3.5 Optimised Communications Systems

Modern replacements for the existing communications systems are assumed to be used, and the basic technology in use and the principles of operation is assumed to remain the same.

Whilst there is a strong operational case for the application of a more sophisticated communications systems including satellite and fibre optic, the current service offering provided is predominantly based upon the use of radio and leased lines and this situation is likely to exist for much of the next five years.

4 REPLACEMENT COSTS

Replacement costs are calculated from asset configuration information and unit rates developed for each type of asset. Some unit rates were developed from first principles by Booz·Allen & Hamilton and some unit rates were developed by Connell Wagner in previous work for the ARTC. The approach used for each asset type is discussed in more detail below.

To account for the remoteness of much of ARTC's assets from major population centres, a "location factor" has been adopted to increase the unit rates for asset replacement dependant upon where the assets are located. The location factors used are shown in Table 4 below.

Table 4 Location Factors

SEGMENT	LOCATION FACTOR
1.1 Dry Creek (inc.) to Crystal Brook	1
1.2 Crystal Brook (inc.) to Port Augusta	1.03
1.3 Port Augusta (inc.) to Tarcoola	1.06
1.4 Tarcoola (inc.) to Parkeston (inc.)	1.08
2 Crystal Brook to Broken Hill (inc.)	1.05
3 Dry Creek to SA Border (inc.)	1.02
3 SA Border to Spencer Street (Melbourne) (inc.)	1.03
4 Dry Creek to Adelaide Outer Harbour (inc.)	1
5 Tottenham (Melbourne) to Wodonga (inc.)	1.02
6 Spencer Junction (Port Augusta) to Whyalla (inc.)	1.03
7 Appleton Dock Junction to Appleton Dock (Melbourne) (inc.)	1

Unit rates referred to in the following sections are rates before application of a location factor.

4.1 Track

Track includes rail, sleepers, fastenings and ballast. Track currently forming part of ARTC's network is not homogeneous in structure. A review of the available data on track structure shows that rail section varies between 80 lb/yard on the Port Augusta to Whyalla line to 60 kg/m on parts of the line between Melbourne and Wodonga. Similarly, while concrete sleepers predominate there are sections of timber sleepers in Victoria.

Our approach to calculating unit rates for replacement of the track is to adopt a standard track cross-section with the following attributes:

- Rail size: 50 kg / m
- Sleeper type: Concrete, with resilient fasteners
- Sleeper spacing: 685 mm
- Ballast depth: 200 mm under the sleeper
- Ballast shoulder: 250 mm

Based on these attributes, the unit rates for track replacement is $422,000 per kilometre, before any distance weighting is applied. The overall unit rate after weighting for distance by applying location factors is $455,000 per kilometre.

The quantity of track to be replaced is calculated from our optimised track layout (see Appendix 1). The quantity of track replaced is summarised in Table 5 below:

Table 5 Quantities Of Track To Be Replaced

SECTION	TRACK LENGTH	NUMBER OF CROSSING LOOPS
1.1 Dry Creek (inclusive) to Crystal Brook	182 km	9 at 1,800 m long
1.2 Crystal Brook (inclusive) to Port Augusta	114 km	10 at 1,800 m long
1.3 Port Augusta (inclusive) to Tarcoola	412.5 km	13 at 1,800 m long
1.4 Tarcoola (inclusive) to Parkeston	1,283 km	34 at 1,800 m long
2 Crystal Brook to Broken Hill (inclusive)	372 km	13 at 1,800 m long
3 Dry Creek (Adelaide) to SA Border	319 km	14 at 1,500 m long
3 SA Border to Spencer Street (Melbourne)	528.5 km	21 at 1,500 m long
4 Dry Creek (Adelaide) to Outer Harbour (Adelaide)	19.3 km	0 (assumed)
5 Tottenham (Melbourne) to Wodonga	307.1 km	17 at 1,500 m long
6 Spencer Junction (Port Augusta) to Whyalla	73 km	1 at 1,800 m long
7 Appleton Dock Junction to Appleton Dock (Melbourne)	2.3 km	0 (assumed)

4.2 Turnouts

Turnouts may be classified into primary and secondary turnouts. Primary turnouts are those that connect directly to the ARTC main line, for example turnouts at each end of a crossing loop or turnouts connecting private sidings to the main line. Secondary turnouts are those that connect to non main line track, for example turnouts to sidings and yards from crossing loops.

Our analysis of information provided by ARTC shows the following split between Primary and Secondary Turnouts:

Table 6 Primary and Secondary Turnouts

SEGMENT	PRIMARY	SECONDARY
1.1 Creek (inclusive) to Crystal Brook	21	13
1.2 Crystal Brook (inclusive) to Port Augusta	15	6
1.3 Port Augusta (inclusive) to Tarcoola	24	16
1.4 Tarcoola (inclusive) to Parkeston	65	54
2 Crystal Brook to Broken Hill (inclusive)	26	26
3Adelaide to SA Border	36	29
3 SA Border to Spencer Street	79	10
4 Adelaide to Outer Harbour	0	3
5 Tottenham to Wodonga	45	25
6 Port Augusta to Whyalla	2	0
7 Appleton Dock Junction to Appleton Dock	0	4
Total	**313**	**186**

Our approach to calculating unit rates for replacing turnouts is to standardise turnouts based on the primary and secondary classification outlined above. Primary turnouts will generally be required to support more traffic at higher speeds than secondary turnouts. Two standard turnout configurations have been adopted for the ARTC network, based upon, and generally following, existing configuration:

- Primary turnouts are turnouts with rail bound manganese crossings and concrete or timber bearers, and cost $134,220 per unit to supply and install
- Secondary turnouts are turnouts with fabricated rail crossings and timber bearers and cost $121,115 per unit to supply and install.

These average weighted costs has been developed dominated by the characteristics of:

- Concrete bearers, tangential switches, rail bound manganese frogs, resilient fasteners, 50 kg/m rail, and
- Timber bearers, flexible heel switch, rail bound manganese frogs, resilient fasteners and plates, 50 kg/m rail standard carbon

Typical secondary turnouts are based on:

- Timber bearers, flexible heel, rail fabricated frogs, resilient fasteners and plates, 50 kg/m rail

These costs exclude switch motors, which are included in the signalling costs.

4.3 Structures

Structures include underbridges and culverts. Overbridges and footbridges are excluded from calculation of replacement cost of ARTC's assets. ARTC are assumed not to own and to not be responsible for maintenance of these bridges.

In previous asset valuation work for ARTC, Connell Wagner developed unit rates for replacement of structures within South Australia and Western Australia. These rates were increased by 10% to allow for inflation between 1996 and today and applied to ARTC structures in South Australia, Western Australia and Victoria.

The resulting unit rates are shown in Table 7 and Table 8.

Table 7 Unit Rates for Bridges

CONNELL WAGNER CATEGORY	COST ($/M SPAN)	TYPICAL SPAN (M)	EXAMPLE STRUCTURE TYPE
1	9,900	0-4	Concrete Ballast Top / Tall Rail Deck Culvert
2	19,800	20-30	Steel Girder Bridge
3	9,900	4-10	Prestressed Concrete Deck
4	6,600	0-4	Rail Deck Culvert (Replace with Box Culvert)
5	13,200	4-8	Transoms on Steel Girder
6	14,300	10	Concrete Deck with Steel Girders and Trestles
7	16,500	10-16	Concrete Deck with Steel Girders and Concrete Piers
8	Not Valued		Footbridge
Overbridge	Not Valued		
Tunnel	18,920/12675		Double/Single bore

Table 8 Unit Rates for Culverts

TYPE	COST ($/M LENGTH)		NOTES
	A	B	
Pipe Culvert	330	660	Rate A applies up to 0.6 m diameter. Rate B applies above 0.6 m diameter.
Rail Deck Culvert	1,650		This is a per square metre rate.
Armco	880	1,320	Rate A applies up to 1.0 m diameter. Rate B applies above 1.0 m diameter.
Box Culvert	1,650		This is a per square metre rate.
Pedestrian Subway	Not Valued	Not Valued	
Arch Culvert	1,650		This is a per square metre rate.

Connell Wagner's structures database was used as the database for structures in South Australia and Western Australia. The Sinclair Knight Merz CEDRIC database was used as the database for structures in Victoria.

As at 12 December 2000, the data from CEDRIC supplied by ARTC / Sinclair Knight Merz only encompassed bridges and structures between Melbourne and Wodonga. A pro-rata calculation based on route kilometres and bridge and structure data from the Connell Wagner database between Adelaide and the Victorian border was used to account for these bridges and structures. (The pro-rata calculation excluded the major bridge over the Murray in the Connell Wagner database as its inclusion would have skewed the resultant calculation due to the large value of this bridge.)

4.4 Earthworks

Earthwork cuttings and embankments are required to provide for the support of track. Data from Connell Wagner's track database ("Track.xls") was used to deduce earthworks volumes for South Australia and Western Australia and data from ARTC's databases "ARTCN-E12.db2.mdb" and "ARTC'S-W14.db1.mdb" was used to deduce earthworks volumes for Victoria.

Connell Wagner's database provides cut and fill volumes for each of the ARTC pricing segments. We have used these volumes directly in our calculations of earthworks quantities. The ARTC databases provide length of cut and fill areas but do not provide volumes of cut and fill. The following assumptions relating to the calculated volumes for earthworks in Victoria were made:

- Average cut volume is 12.375 m^3 / m, based on a 6 m wide base, average depth of 1.5 m and batter slopes of 1:1.5

- Average fill volume is 11.25 m^3 / m, based on a 6 m wide top, average height of 1.5 m and batter slopes of 1:1.

Unit rates for bulk earthworks were derived from consultation with industry, and are \$11.50 per m^3 for cut and \$5.75 per m^3 for fill. These rates allow for design, procurement, project management and coordination. In addition to the bulk rate, there is a unit rate allowance of \$20.00 per linear metre for drainage and clearing, including provision for access roads.

4.5 Signalling, Train Control and Safeworking

Signalling and train control equipment includes signals, interlockings and signage required to provide for safe passage of trains over the ARTC network. There are several different signalling and train control systems in use on the ARTC system at present, including CTC and ASW systems.

Our approach to replacement of these systems is generally to replace the existing system on a fit-for-purpose, modern equivalent form, basis. The systems used are shown in Table 9:

Table 9 Replacement Safeworking System and Signalling Equipment

SEGMENT	SAFEWORKING SYSTEM & SIGNALLING EQUIPMENT
Parkeston to Coonamia, Crystal Brook to Broken Hill and Port Augusta to Whyalla	Verbal Train Order Working, incorporating • Self restoring points for two stop crosses at crossing loops • Approach controlled warning signals at crossing loops • Interlocking for crossing loops • Train Radio
Coonamia to Dry Creek, Dry Creek to Melbourne, Tottenham to Wodonga, Dry Creek to Outer Harbour and Appleton Dock Junction to Appleton Dock	Full CTC with Train Radio

The unit rates adopted for replacement signalling, train control and safeworking systems are shown in Table 10:

Table 10 Unit Rates for Replacement Signalling, Train Control and Safeworking Systems

SYSTEM ELEMENT	UNIT RATE FOR CTC TERRITORY	UNIT RATE FOR TOW TERRITORY
Loop	$928,000 per loop, + 10% for power. Rate per loop includes: • 6 signals; • 4 track circuits; • 2 interlockings; • 2 point machines; • local radio; • OCC telemetry; • 2 location cases.	$692,000 per loop, + 10% for power. Rate per loop includes: • 4 signals; • 2 track circuits; • 2 interlockings; • 2 point machines; • local radio; • OCC telemetry; • 2 location cases.
Single Line Section	$80,000 + N x $12,000 + (N-3) x $35,000, + 10% for power. (N = number of track circuits) Rate per section includes: • 4 signals; • 1 track circuit every 4km; • N-3 location cases.	$50,000 Rate per section includes: • 2 signals; • local radio.
Control Centre Equipment	$10,000,000	

4.6 Communications

Communications systems are the fixed infrastructure required to allow train controllers to communicate with train drivers and maintenance staff and to facilitate telemetry between the control centre and trackside signalling systems.

In general, ARTC provides communications systems via equipment owned by ARTC and equipment leased from an external communications carrier (e.g. Telstra leased lines).Only ARTC owned equipment is accounted for in this DORC analysis.

All communications equipment is assumed to be replaced like for like in its current location, although it is recognised that there are some areas of poor communications coverage with the existing systems.

Communications assets are valued as shown in Table 11:

Table 11 Unit Rates for Communications Assets

SYSTEM ELEMENT	UNIT RATE
Radio Base Station or Sub-Comparator	$250,000 per unit
Control Centre Equipment	$400,000
Fibre Optic Communications Backbone	$25,000 per km

4.7 Fences and Level Crossings

It is normal practice to provide fencing along a railway to prevent animals and unauthorised persons gaining access to the infrastructure. For the purposes of this evaluation, it is assumed that fences are provided on one side of single lines, at a cost of $15,000 per kilometre. This one side only assumption is intended to cover those areas of track having no fencing through to two-sided man proof fencing required in urban areas.

There are many level crossings where roads cross ARTC track. The Sinclair Knight Merz numbers of level crossings are used for the ARTC network in Victoria. For the ARTC network outside Victoria, it is assumed that level crossings are provided on average every four kilometres on main lines only.

The unit rate for level crossings is $12,700 per crossing.

5 CONDITION ASSESSMENT

Three major sources for asset condition information are used: track recording car data, previous asset condition work done by Connell Wagner and previous asset condition work done by Sinclair Knight Merz.

Connell Wagner conducted a condition assessment for track located in South Australia and Western Australia in 1997 as part of their valuation of ARTC's assets. In turn, their condition assessment was based on work undertaken by the former Australian National Railways in 1990. Sinclair Knight Merz conducted a condition assessment of assets in Victoria in early 2000. Their work included condition information provided by ARTC and ARTC's maintenance contractor ABB.

The asset condition data from the two previous studies is calculated in two different ways. Connell Wagner primarily use asset age as an indicator of condition while Sinclair Knight Merz use condition inspection data, maintenance history, fault history and other information in addition to asset age. Usage of the condition data is described below for each major asset group.

5.1 Track

The major components of the track asset are rail, sleepers and ballast.

Track recording car (TRC) data has provided an essential input to the condition assessment for rail, sleepers and, especially, ballast.

Rail

The assessment of life consumed is based upon two factors: tonnage carried and impact geometry.

Tonnage carried

From the Connell Wagner work, calculated weighted rail age was calculated for each different rail section for each different ARTC pricing segment in South Australia and Western Australia. The rail age is weighted by the length of rail with that age. The weighted average rail age for each rail section size in the pricing segment was then calculated. Multiplying the weighted rail age by the estimated current rail traffic in millions of gross tonnes per annum gives the estimated number of tonnes carried by the rail since it was installed. This was then expressed as a percentage of estimated rail life in tonnes and the result reported as the consumed life of the rail.

The rail lives used are shown in Table 12:

Table 12 Rail Life

RAIL SECTION SIZE	LIFE IN MGT WITH RAIL MANAGEMENT
40 kg / m (80 lb / yard)	300
47 kg / m (94 lb / yard)	600
53 kg / m (107 lb / yard)	750
60 kg / m (standard carbon)	900
60 kg / m (head hardened)	1,200

From the Sinclair Knight Merz work, the weighted average rail condition was calculated for each different ARTC pricing segment in Victoria. This was based on the Sinclair Knight Merz calculated rail condition figures, which are expressed on a 0 to 100 scale (poor to good condition). The weighted average condition was then expressed as a percentage and adopted as the condition of the rail.

Impact geometry

For a variety of reasons rail suffers extra wear plus surface and internal damage as a consequence of uneven alignment. Figure 2 (not ARTC track) illustrates a variation in vertical alignment of rail that gives rise to extra dynamic loading on track.

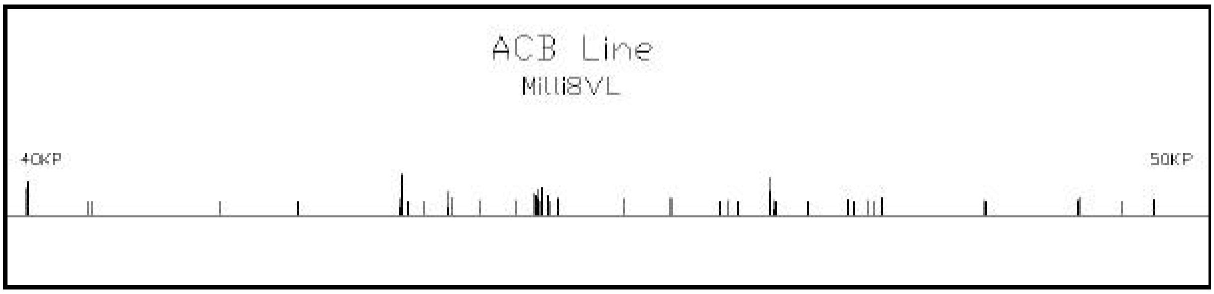
Figure 2 Example of Vertical Alignment Defect

Wheel / rail profiles are designed to contain contact stresses within the limits of the materials of both wheel and rail. Dynamics such as are generated by uneven rail longitudinal profiles are not accommodated when rail is loaded to material limits. Hence occurrences such as a weld peak as shown above, or weld dips, or poor track leading to overloading of the rail foot and consequent bending of the rail section, cause rail deterioration (and detrimental affects upon the rest of the track structure).

As a general rule, a change in angle of 8 milliradians (mrad) and over will cause deterioration, and at 14mrad, considerable damage will develop. Further, it is extremely difficult to remove these longitudinal profile defects, though the ARTC does bend rail straight and grind smooth the result, all in order to minimise the consequences of dynamic loading upon other-than-straight rail.

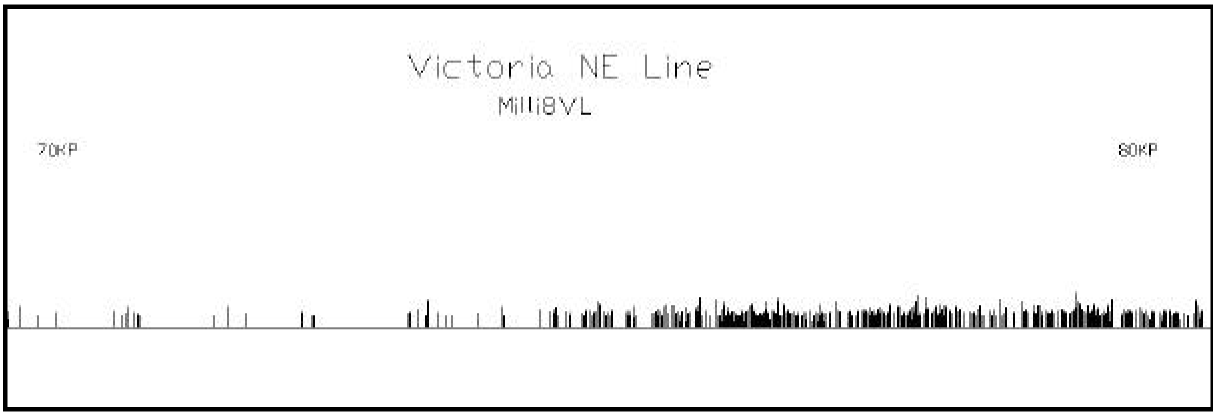
However, as shown in the two illustrations below, there are considerable lengths of track that have uneven longitudinal profiles. The Adelaide to Crystal Brook example illustrated in Figure 3 shows a relatively good section of track. The spikes show those locations where 8mrad or more rail profile irregularity was found in the TRC data, (left rail only):

Figure 3 Rail Profile Irregularity: Good Track



By comparison, the Victoria North East line illustrated in Figure 4 is in substantially poorer condition:

Figure 4 Rail Profile Irregularity: Poor Track



Other parts of the ARTC network fell between. For example, 910km to 1000km on the Trans line was found to be similar to the ACB illustration in Figure 3 above, while 1400km to 1500km was found to be little better than the Victoria NE line.

The TRC data was analysed to identify changes in longitudinal profile and utilised these readings to determine which sections rail are experiencing life reduction due to impact. Rail was considered to be crippled, and consequently life expired in impact terms, when 14mrad or above was identified. Lesser changes in profile were treated as having proportionately lesser life consumed in impact terms. Th results were then added to the depreciation due to tonnage carried.

Sleepers

Assessment of sleeper life consumed is based upon age, as discussed below.

From the Connell Wagner work, a similar approach was adopted to calculating the age-based condition of sleepers to that outlined for rail tonnage carried above. As the majority of the ARTC network comprises concrete sleepers, a uniform life of 50 years for sleepers was adopted.

From the Sinclair Knight Merz work, a similar approach was adopted to calculating the age-based condition of sleepers to that outlined for rail tonnage carried above.

Ballast

The Connell Wagner asset condition work contained data describing the condition of ballast for each pricing segment for the ARTC network in South Australia and Western Australia. The condition is expressed as a percentage, and the assumption is that this is the percentage of "good" ballast.

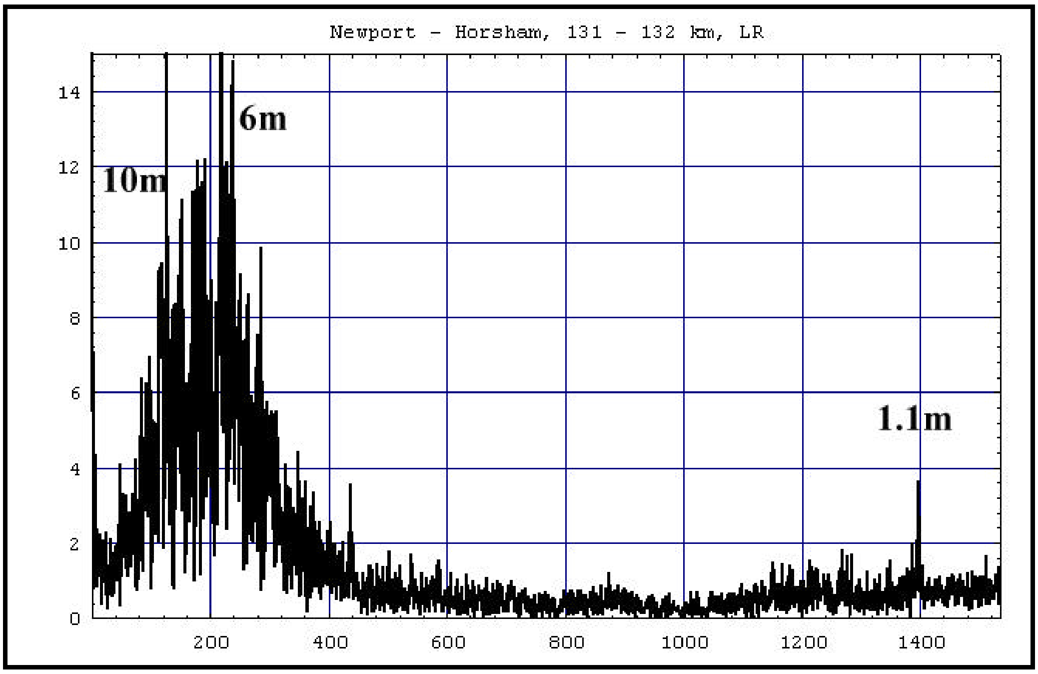
Based on Booz·Allen's knowledge of ARTC's network and historical maintenance practices, the percentages quoted by Connell Wagner seem high. Likely ballast condition was therefore calculated on the basis of TRC data. The approach to calculating ballast condition is outlined below. (For consistency, ballast condition derived from TRC data was also adopted for the ARTC network in Victoria.)

TRC records were analysed to identify track profiles characteristic of poor ballast condition and used the results for assessment of life consumption.

The background to this approach is that bogies and vehicles interact with track in fairly easily identifiable ways. Of immediate relevance, pitch and bounce create a feature commonly known as cyclic top when below-sleeper support is poor. This interaction is readily definable in wavelength terms, given a knowledge of vehicle and bogie masses, spring rates and geometry. It is a particularly applicable indicator when the rail and sleeper type is consistent and hence the prime variable in support conditions lies below the base of the sleeper. Fast Fourier Transform analysis techniques were used to identify characteristic wavelengths in the TRC Top data, and these were checked for correlation with bogie dynamics.

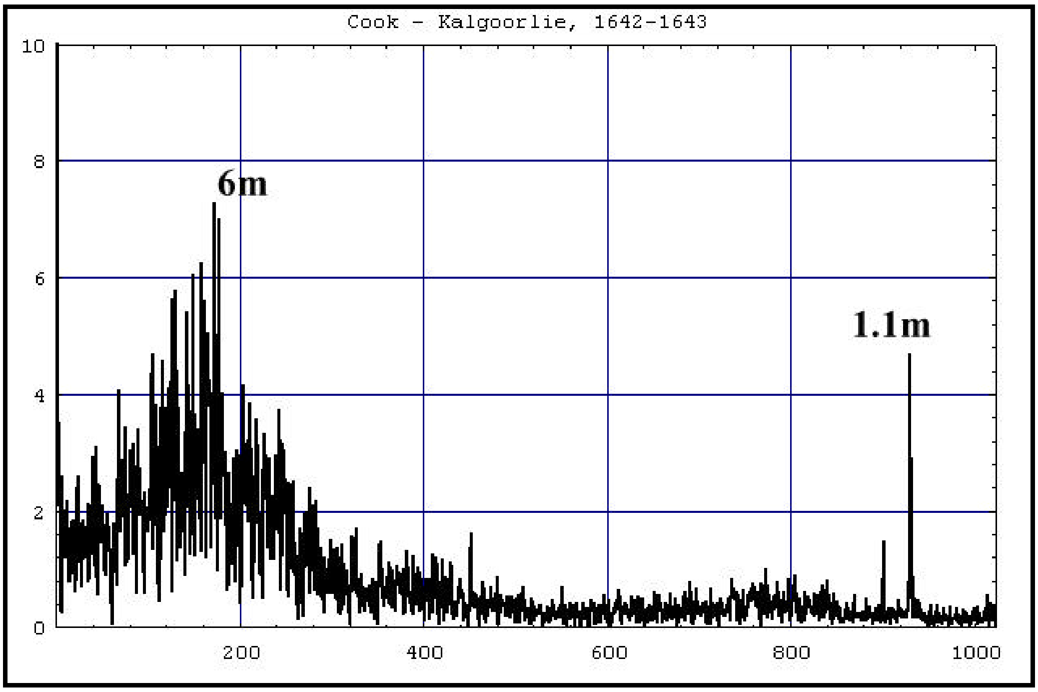
The illustration in Figure 5 below shows that 5-10m wavelength cyclic top is common-place, but also that there are quite significant sections of track having 1.1m and, to a lesser degree, 2.5m, wavelength forms.

Figure 5 Cyclic Top Between Newport and Horsham



The short wavelength feature on parts of the Trans line is extraordinary, as illustrated in Figure 6:

Figure 6 Cyclic Top Between Cook and Rawlinna



Once wavelengths associated with vehicles and "soft" track were identified, the TRC database was searched to determine the extent of track having poor support in each segment. The results were used to characterise ballast condition.

Applying the results of the condition assessment to the replacement values of the track asset provides the DORC shown in Table 13:

Table 13 ORC and DORC for Track

CODE	SEGMENT	ORC ($M)	PERCENT CONSUMED	DORC ($M)
1.1	Dry Creek(inc) to Crystal Brook	84.5	40	50.4
1.2	Crystal Brook (inc) to Port Augusta	54.8	39	33.4
1.3	Port Augusta (inc) to Tarcoola	198.2	45	108.5
1.4	Tarcoola (inc) to Parkeston (inc)	627.3	41	370.1
2	Crystal Brook to Broken Hill (Kanandah)	179.2	30	126.2
3	Dry Creek (Adelaide) to SA Border (inc)	152.6	56	66.8
3	SA Border to Spencer Street (Melbourne) (inc)	254.0	38	157.4
4	Dry Creek (Adelaide) to Outer Harbour (Adelaide)	8.9	25	6.7
5	Tottenham (Melbourne) to Albury (inc)	148.0	54	68.0
6	Spencer Junction (Port Augusta) to Whyalla (inc)	33.4	38	20.8
7	Appleton Dock Junction to Appleton Dock (Melbourne) (inc)	1.5	0	1.5

5.2 Turnouts

In the absence of data on turnout condition from the Connell Wagner work, it is assumed that the condition of turnouts in South Australia and Western Australia are the same as the overall condition of the track in the pricing segment.

The Sinclair Knight Merz condition data was used for turnout condition in Victoria.

Applying the results of the condition assessment to the replacement values of the track asset provides the DORC shown in Table 14:

Table 14 ORC and DORC for Turnouts

CODE	SEGMENT	ORC ($M)	PERCENT CONSUMED	DORC ($M)
1.1	Dry Creek(inc) to Crystal Brook	4.4	40%	2.6
1.2	Crystal Brook (inc) to Port Augusta	3.0	39%	1.8
1.3	Port Augusta (inc) to Tarcoola	5.4	45%	3.0
1.4	Tarcoola (inc) to Parkeston (inc)	16.1	41%	9.5
2	Crystal Brook to Broken Hill (Kanandah)	6.9	29%	4.9
3	Dry Creek (Adelaide) to SA Border (inc)	9.2	56%	4.0
3	SA Border to Spencer Street (Melbourne) (inc)	12.6	24%	9.6
4	Dry Creek (Adelaide) to Outer Harbour (Adelaide)	0.4	23%	0.3
5	Tottenham (Melbourne) to Albury (inc)	9.6	23%	7.4
6	Spencer Junction (Port Augusta) to Whyalla (inc)	0.3	37%	0.2
7	Appleton Dock Junction to Appleton Dock (Melbourne) (inc)	0.5	0%	0.5

5.3 Structures

It is assumed that the condition of structures is a function of their age, and a nominal 100 year life is assumed for all structures.

The Connell Wagner work contains a "Good, Fair, Poor" condition rating for structures. This rating was used to modify the age and therefore remaining life of structures such that a "good" structure is given 15% more remaining life than a "fair" structure of the same age, and a "poor" structure is given 15% less remaining life than a "fair" structure or the same age. A "fair" structure is given the remaining life calculated from its age without modification.

In the absence of other information, all structures in Victoria are given a "fair" condition rating and the remaining life is calculated from the structure age without modification.

In the event that a structure is in excess of 100 years old it is given a nominal remaining life of 10 years, i.e. 10% of its full life, to reflect the fact that it is still in service and therefore has some value.

5.4 Earthworks

Earthworks are assumed to be a perpetual asset in that given appropriate maintenance they do not "wear out" due to the passage of trains or time. For the purposes of this analysis, earthworks are assigned a depreciated value according to their age relative to a nominal life of 100 years. Where earthworks are over 50 years old, they are capped at a depreciated value of 50% of their replacement value.

5.5 Signalling, Train Control and Safeworking

Signalling, train control and safeworking assets are assumed to have an economic life of 30 years, and a depreciated value was assigned to these assets in proportion to their remaining life based on their current age. In the event that an asset is in excess of 30 years old it is given a nominal remaining life of 3 years, i.e. 10% of its full life, to reflect the fact that it is still in service and therefore has some value.

5.6 Communications

Communications assets are assumed to have an economic life of 15 years for radio equipment and 20 years for cabled communications backbone systems.A depreciated value was assigned to these assets in proportion to their remaining life based on their current age. In the event that an asset's age is in excess of its economic life, it is given a nominal remaining life of 10% of its economic life to reflect the fact that it is still in service and therefore has some value.

5.7 Fences and Level Crossings

The Sinclair Knight Merz figures were used for condition of level crossings for the ARTC network in Victoria. We have assumed that all fences, and level crossings outside Victoria, are 50% life consumed.

6 FINAL DORC VALUES

The final replacement cost and depreciated, optimised replacement cost values for the ARTC network are shown in Table 15:

Table 15 Final Replacement and DORC Values (Millions of Dollars)

Sector	Segment	Track		Earthworks		Structures		Signals and Train Control		Communications		Totals		Dep'n
		ORC	DORC	ORC	DORC	ORC	DORC	ORC	DORC	ORC	DORC	ORC	DORC	
1.1	Dry Creek(inc.) to Crystal Brook	84.5	50.4	12.2	6.1	19.9	4.2	12.2	6.1	1.8	0.6	130.5	67.3	48%
1.2	Crystal Brook (inc.) to Port Augusta	54.8	33.4	6.9	3.4	10.4	5.8	5.8	2.9	0.8	0.3	78.6	45.8	42%
1.3	Port Augusta (inc.) to Tarcoola	198.2	108.5	46.8	23.4	21.6	6.0	11.2	5.6	4.1	1.6	281.9	145.1	49%
1.4	Tarcoola (inc.) to Parkeston (inc.)	627.3	370.1	124.0	62.0	14.3	3.3	29.9	15.0	9.2	3.1	804.7	453.6	44%
2	Crystal Brook to Broken Hill (Kanandah)	179.2	126.2	47.5	33.2	27.5	19.3	11.1	5.5	1.6	1.2	266.8	185.5	30%
3	Dry Creek (Adelaide) to SA Border (inc.)	152.6	66.8	25.4	12.7	65.3	29.2	19.8	9.9	0.3	0.2	263.4	118.8	55%
3	SA Border to Spencer Street (Melbourne) (inc.)	254.0	157.4	35.4	17.7	Inc. in above	Inc. in above	30.9	21.8	6.4	2.2	326.7	199.1	39%
4	Dry Creek (Adelaide) to Outer Harbour (Adelaide)	8.9	6.7	0.8	0.4	NA	NA	0.2	0.1	0.4	0.2	10.2	7.4	28%
5	Tottenham (Melbourne) to Albury (inc.)	148.0	68.0	11.8	5.9	96.2	53.8	23.1	11.0	5.4	1.8	284.4	140.5	51%
6	Spencer Junction (Port Augusta) to Whyalla (inc.)	33.4	20.8	8.1	5.7	12.7	10.4	0.8	0.4	0.0	0.0	55.0	37.3	32%
7	Appleton Dock Junction to Appleton Dock (Melbourne) (inc.)	1.5	1.5	0.1	0.1	NA	NA	0.1	0.1	0.4	0.4	2.1	2.0	5%
	Control Centre							10	5			10	5	
	TOTALS	$1,742.4	$1,009.8	$318.9	$170.7	$267.9	$132.0	$155.2	$83.3	$30.2	$11.5	$2,514.5	$1,407.3	**44%**

APPENDIX 1: ARTC DORC NETWORK SCHEMATIC

APPENDIX 2: DORC UNDERLYING PHILOSOPHY

UNDERLYING PHILOSOPHY
CALCULATION OF DORC FOR ARTC's RAIL NETWORK

Introduction

Booz·Allen & Hamilton has been retained by the ARTC to develop a Depreciated Optimised Replacement Cost methodology to support ARTC's Access Undertaking. The methodology is to be acceptable to the Australian Competition and Consumer Commission (ACCC).

The Access Undertaking will describe, amongst other things, the terms and conditions on which the ARTC will provide access to third parties. The ACCC is required to assess the Undertaking against criteria 44ZZA of the Trade Practices Act (TPA). Once accepted, the Undertaking becomes binding on the ARTC and other participants in the access regime.

The relevance of a DORC valuation to the Undertaking is in its relationship to pricing. The TPA is not prescriptive as to how prices for access are to be determined, indeed it favours commercial negotiation. In accepting the Undertaking, however, the ACCC will want to be satisfied that prices are reasonable and do not include monopoly rent[1]. The monopoly rent test (which is a price or revenue 'ceiling test') generally applied is that the infrastructure provider should not earn more than a reasonable risk-adjusted return on the value of assets employed. DORC is a generally accepted method of valuing assets in such a context.

Definition of DORC

The DORC is the replacement cost of an 'optimised system', less accumulated depreciation.

Booz·Allen's interpretation of the DORC is to base the replacement cost valuation on the replacement cost of existing assets with the optimisation reflecting only the elimination of redundant assets (gold-plating) and potential cost savings from new technologies (e.g. updates in communications/signalling technologies). It does not incorporate any increase in performance standards.

ARTC have argued that the 'optimised' system for the interstate rail network should reflect the higher standards established in the ATC performance targets. Existing assets would not be replaced on a like-for-like basis and any contemporary replacement decision would incorporate the higher performance assets available in the market today. Indeed, many of the existing assets (e.g. 47kg rail) are no longer available. The 'optimal' network will not reflect what is on the ground today but what one would design for the market today incorporating modern assets and technologies.

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[1] *The 44ZZA criteria do not specifically refer to excluding monopoly rents although regulators have interpreted this requirement given they are required to take account of the public interest, including the public interest in having competition in markets, and the interests of the persons wanting access to the service.*

Regulatory practice

DORC is applied to establish the regulated cost base against which reasonable prices can be determined. Regulators will try and ensure that as far as possible regulated outcomes reflect competitive market outcomes.

IPART in its review of the NSW rail access regime, has argued in the context of DORC that "an optimised system is a reconfigured system using modern technology designed to serve the current load with current technology, with some allowances for growth"[2]. Further "this method excludes any unused or under utilised assets and allows for potential cost savings that may have resulted from technological improvement"[3]. The latter point relates to the use of *modern equivalent asset* methodology. While it is conceivable modern equivalent assets could be more expensive, this is generally not the norm.

NSW Treasury Policy Guidelines state "It is stressed that optimisation for valuation purposes is not concerned with improving the system from its current state. The system must never be valued as better than it is, whether in terms of capacity or other standards. Optimisation leads only to reductions in the replacement costs of network system assets"[4].

The DORC is a method of valuing *existing* assets. It is therefore based on the functionality and service performance of existing assets, not on functionality and service performance of assets not yet in place, even though the existing assets would not be replaced on a like-for-like basis. If the replacement assets being valued generate higher functionality and performance than those in place, an adjustment to the replacement values is required. The best way to illustrate this point is by example:

In a competitive market for rail infrastructure, an infrastructure owner could not reasonably expect to charge a user more than the cost of the user building their own line (often called the bypass cost). In the case of the regulated asset, there may be many practical reasons why a new line could not be built, but regulators will want to ensure that the price outcome for an access seeker is no worse than the bypass cost.

If the user was to build a new line, it would no doubt be based on the most modern assets and technologies and reflect the service and performance standards required by the user to best compete in its market place both currently and into the future. If the existing line, for historical reasons, reflected a lower standard, it is not reasonable to expect that in a competitive market, the owner of the existing line could charge the user the same as it would cost the user to build the bypass line. They would have to offer a substantially lower price which reflected the lower functionality and performance of the existing asset. In regulating access to the existing line, regulators

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2 *IPART, "Aspects of the NSW Rail Access Regime", Final Report April 1999, p34*

3 *op-cit, p34*

4 *NSW Treasury, "Policy Guidelines for Valuation of Network Assets of Electricity Network Businesses", Technical paper, December 1995 p26*

would therefore seek to ensure that the asset value was appropriately adjusted to reflect the reduced standard.

Advice from IPART[5] is that a regulator may consider including in DORC higher mandated standards which impose costs on the service provider but do not involve an increase in capacity or value to the user. An example might be higher environmental standards in electricity generation. The treatment of the higher standards in DORC will ultimately depend on the particular circumstances. For instance, consider the valuation of car engines where all new car engines are required to carry more costly environmental equipment. It is reasonable to accept that the replacement cost should reflect the cost of the new equipment for the purposes of valuing the existing asset (even though the existing asset does not carry the environmental equipment). This would be true provided there was no obligation to replace the existing car engine before it was life expired (as far as the user is concerned, it has the same service potential as an asset carrying the new environmental equipment of the same age and serviceability). If the new equipment provided some upgraded capability or standard of value to the user, some adjustment to the value of the existing asset would be required.

A railway analogy to raised environmental standards in electricity might be higher safety standards than previously existed. To the extent public policy directs higher safety standards be implemented, then a case could be made for including the costs in the present DORC, notwithstanding the fact the higher standard assets have yet to be invested. If the higher safety standards (e.g. upgraded train control) provided additional capacity or transit times, some adjustment to the existing asset value would be required.

The regulated asset value is not independent of maintenance and operations costs. Regulators will be concerned with consistency of the overall package. For instance, if current life cycle replacement decisions favour a high capital cost, low maintenance cost asset, yet existing assets are predominately older higher maintenance cost assets, it would be inappropriate to charge users the higher costs of the modern replacement asset and the higher maintenance cost of the older existing asset. An adjustment to the capital cost would be required to deliver a competitive market outcome. For instance, consider modern high capacity fuel efficient locomotives compared with older less reliable and less efficient locomotives. In a competitive market, the value of the existing assets will reflect their functionality and performance compared to the newer asset - beyond the difference in age (e.g. if there were 2 identical assets and one was half life expired, the difference in value is likely to reflect the difference in age. If the older asset was more costly to run and more costly to maintain, the difference in value would go beyond the difference in age).

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5 *Personal contact, 27th Nov 2000*

Higher actual performance than design standards

The ARTC have argued that they are currently achieving a higher 'operating' performance from their assets than traditionally accepted engineering practice. The higher standards come at a cost of a higher maintenance effort but because maintenance expenditure is efficient and because of advances in infrastructure husbandry, the additional maintenance costs incurred are only marginal and the higher performance outcome justifies the approach. Normally one could also expect a reduced life of the asset because of the more intense usage above the design standards, but advice from ARTC is that the maintenance effort is such that the remaining life of the assets is not being materially reduced.

It is reasonable to base the DORC on the cost of the assets which would be used to replicate the current performance of the assets. In practice, these assets might be of a higher standard than currently on the ground (say 50kg rail rather than 47kg rail) but in such cases, the assets would carry with them a reduced maintenance cost (than 47kg operating at the higher standard). To ensure overall consistency in the regulated cost base, some adjustments to actual maintenance costs will be necessary.

Future demand

It is generally accepted that a DORC valuation should include an allowance for future demand. Booz Allen have interpreted this requirement narrowly as only including an allowance for growth. The justification for allowing for growth in a regulated asset base is that even in competitive markets, future demand is not known with certainty and a certain amount of excess capacity is 'normal', particularly when investment decisions involve a significant time lag. To only allow the infrastructure provider to recover the costs of capacity actually in use at any point in time would be particularly harsh and could potentially discourage investment. Regulators therefore allow the infrastructure owner to recover the costs of investing 'ahead of demand' even though current demand may not make full use of the capacity. In NSW, IPART allows 5 years of growth to be considered in the DORC valuation.

ARTC argue that future demand also takes into account future demand for higher performance standards, presumably because the competitive environment will require continued improvement in performance over time. In a regulatory context, it is difficult to justify charging users for enhanced performance before they can actually enjoy the improved standards (and before they have an enhanced ability to pay the higher charges).

Brownfields Vs greenfields

The brief requires the DORC valuation to address the options of a 'brownfields' calculation of the DORC, i.e. construction that occurs around the existing community infrastructure compared with 'greenfields', i.e. railway construction across an area devoid of an community development. Typically, brownfields valuations include the costs of surface restoration and other surface diversions.

For most of ARTC's network, the impact of community development on replacement cost is largely irrelevant. The urban areas will be the exception. In the recent DORC assessment of RAC's Hunter Valley coal network, earthworks, tunnels and culverts were excluded from the DORC valuation. Any distinction therefore between brownfields and greenfields largely disappeared.

One issue is the assumption of whether replacement occurs under traffic. Replacement under traffic can add significantly to the cost because of the possible need to build diversions and because of the impact on labour and equipment productivity. An assumption of no traffic (i.e. exclusive access for construction) has been applied in the RAC DORC because of the structure of the charges (periodic renewals are expensed). It could be argued that the no traffic situation is also more consistent with a bypass interpretation of the ceiling test (although a bypass test might take into account surface restoration type costs associated with a brownfields valuation).

ARTC similarly expenses major period renewals (MPM). Care needs to be taken to avoid double counting, i.e. charging customers for the renewals (as an expense) and then raising capital charges following the renewals because of the higher standard of the asset. There is no easy answer to this issue. With MPM expensed, the quandary is how to determine appropriate depreciation (return of capital) and return on investment (return on capital) charges.

Given railway tracks are generally maintained to a steady-state standard, our preferred approach is to assume that the depreciation covering the decline in asset value from 'new' to the present steady state standard has already been charged to the customer (and returned to the investor). The value of invested capital outstanding is represented by the current written down value of the assets and it is this value which should be multiplied by the rate of return to determine the return **on** capital. Because MPM is expensed and the customer is paying for the up-keep of the asset at the steady state standard, depreciation will be zero[6].

Summary

In our view, if the calculation of DORC for ARTC's network is to satisfy the ACCC, it must reflect the functionality and performance standards of the existing infrastructure. The replacement cost assumptions may reflect a higher standard of infrastructure than currently in place (if this is the optimal investment decision) but in such cases, adjustment to maintenance costs will be required to ensure consistency in the overall regulated cost base.

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6 *The outstanding value of the assets will presumably need to be returned to the investor at some point in the future (implying depreciation > 0), but because it is probably safe to assume that the interstate rail infrastructure assets will be maintained in perpetuity, it is difficult to justify charging both MPM and depreciation.*

The only basis for including higher future standards in the present DORC might be if the increased standards reflect changed public policy which imposes higher costs on the industry (e.g. environmental standards or safety).

In the ARTC context, it is unlikely the ceiling test will be a binding constraint on pricing. Freight rates are set by the market and competition from road and sea transport, and consequently this ultimately sets the maximum price able to be charged for access. The net income potential of the interstate network, expressed as a present value, is likely to be substantially less than a DORC value of assets.

It is difficult to see how the interpretation and valuation of DORC is likely to have any real effect on actual pricing or investment. Any future investment by ARTC will be added to the regulated asset base and depreciated. The cost of investment to raise standards will be allowed into the optimised asset base once the raised standards are in place (and users' ability to pay higher charges is enhanced).