THE PILBARA INFRASTRUCTURE PTY LTD

COMPUTER SIMULATION MODELLING
OF
RIO TINTO'S PILBARA RAIL NETWORK

Document No: 27-521.01
January 2008

SIMULATION MODELLING
SERVICES PTY LTD

Contents

Page

1 INTRODUCTION

The Pilbara Infrastructure Pty Ltd (TPI) is seeking declaration under Part IIIA of the ***Trade Practices Act 1974*** of the rail track infrastructure in the Pilbara controlled and operated by entities associated with Rio Tinto Limited (Rio)***.***

TPI recognise that computer simulation modelling is a tool which will help all parties concerned with this matter to better understand the capacity of the rail network. Accordingly, Simulation Modelling Services Pty Ltd (SMS), management consultants of Newcastle, NSW have been engaged by TPI to undertake modelling of the rail network.

1.1 Modelling Requirements

TPI wish to understand what is the maximum capacity of 11 nominated parts of the Rio rail network. The network modelled is shown schematically in Figure 1 below.

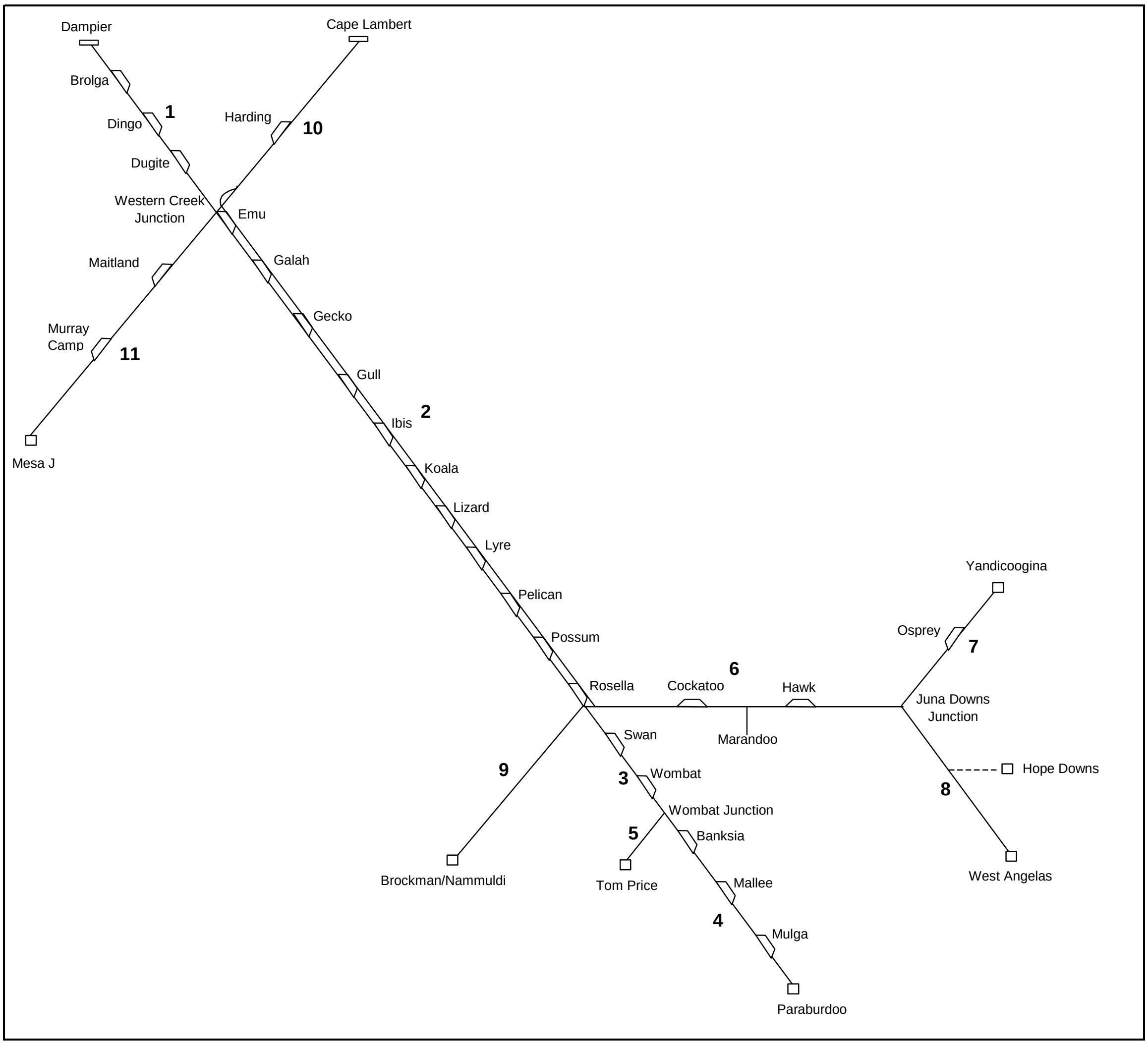
This network diagram was prepared from information provided by TPI for the purpose of this report, based on its understanding of the Rio rail network. Further details of network configuration as TPI understands it are contained in Table 1.

Those tracks are:

1. Dampier to Emu;
2. Emu to Rosella;
3. Rosella to Wombat Junction;
4. Wombat Junction to Paraburdoo;
5. Wombat Junction to Tom Price;
6. Rosella to Juna Downs Junction;
7. Juna Downs Junction to Yandicoogina;
8. Juna Downs Junction to West Angelas;
9. Rosella to Brockman/Nammuldi;
10. Cape Lambert to Western Creek;
11. Western Creek to Mesa J.

Further, SMS was asked to explore the impact of fully duplicating the track from Western Creek Junction to Cape Lambert.

Figure 1 – Rio Rail Network



2 THE COMPUTER MODEL

2.1 Simulation Software

An animated computer simulation model has been constructed using the Arena simulation system from Rockwell Automation of the US.

Arena is a modern, powerful, sophisticated, general purpose modelling system. World-wide it is the most used software tool for simulating mining, materials handling and logistics systems.

2.2 Model Logic

The computer model simulates trains moving up and down the rail line connecting the various locations on the rail network.

It includes the placement of sidings at appropriate distances along the track where a train may wait as necessary for the next section to be available for its use. The model also accommodates duplication of parts of the line as necessary.

Only one train may occupy any section of track at any time. As a train moves along the track from siding to siding, it will stop and wait, as necessary, until the next section of track which it requires to access is free.

Loaded trains, moving towards the coast are given priority. Unless their passage is blocked by a breakdown or by rail maintenance activities, they will travel the entire length of the line without needing to stop.

Empty trains on the other hand, heading away from the coast will stop and wait as necessary at sidings.

Where the scenario being modelled includes duplication of a section, then while both tracks are in service, one will be reserved for loaded trains and one for empty trains.

Trains will take an appropriate length of time to traverse each section depending on whether they are empty or loaded. They will also take additional time to draw to a stop at a siding and to commence moving again from stationary.

Train movements are interrupted from time to time by both planned and unplanned rail maintenance activities and by the random breakdown of trains in mid-section.

Each of these events blocks the appropriate section to traffic in both directions. In those scenarios where the section affected is duplicated, then the model will allow movements in both directions on the parallel line for the duration of the outage.

The loading and dumping of trains is not modelled. Rather, for the purposes of assessing the absolute capacity of each portion of the network, it is assumed that there are always loaded trains waiting to enter the track and similarly that there are always empty trains waiting to return.

In real life, the scheduling of such a rail system usually revolves around one of two philosophies (or variations upon one or other). These are:

- the use of regular, scheduled departure times or ***slots***. A train ready to depart will await the next slot. If a slot is missed ie there is no train available to occupy it then usually the opportunity will be lost;
- run-when-ready. This involves a more ad hoc mode of operation with trains taking more-or-less the earliest opportunity to depart once ready to proceed.

Given that the objective of this exercise is to assess the capacity of components of the network, the run-when-ready concept cannot apply. Accordingly, the philosophy embodied in the computer model is the use of regular departure slots for loaded trains with empty trains taking every opportunity to enter the track, between the arrival of loaded trains. Departure slots for loaded trains are lost as maintenance, etc causes interruptions.

The computer model has been constructed in a suitably flexible form so that the specification of the particular portion of the rail network being modelled at any time and the parameters pertaining to it, are supplied as data.

3 MODEL ASSUMPTIONS AND DATA

The following information has been provided by TPI for the purposes of this study.

3.1 Track Layout

The layout of the rail network as modelled is shown schematically in Figure 1. There is full duplication of the line between Emu and Rosella.

Empty and loaded train travel times and the lengths of sections of track and of sidings used in the model are shown in Table 1.

It is assumed that a train coming to a halt adds 3 minutes to its journey time. Similarly, starting from stationary adds 5 minutes to the travel time to the next location.

Table 1 – Network Data

From	To	Travel Time (min)		Distance	Siding(a)
Emu to Dampier		**Loaded**	**Empty**	**(km)**	**(km)**
Emu	Dugite	16	15	13.4	2.8
Dugite	Dingo	24	21	20.9	2.8
Dingo	Brolga	18	14	16.3	2.6
Brolga	Dampier	22	22	18.8	
Rosella to Emu					
Rosella	Possum	20	20	18.9	4.7
Possum	Pelican	24	22	14.4	2.9
Pelican	Lyre	22	20	17.6	2.8
Lyre	Lizard	20	20	17.4	3.8
Lizard	Koala	22	21	20.9	2.7
Koala	Ibis	14	13	13.2	2.7
Ibis	Gull	24	21	21	0.1
Gull	Gecko	10	8	7.6	0.3
Gecko	Galah	16	25	12.9	
Galah	Emu	9	8	5.3	1.5
Wombat Junction to Rosella					
Wombat Junction	Wombat	7	7	3.2	2.5
Wombat	Swan	6	10	5.4	2.5
Swan	Rosella	22	18	18.9	2.7
Paraburdoo to Wombat Junction					
Paraburdoo	Mulga	36	20	25.4	2.7
Mulga	Mallee	37	20	19.8	2.7
Mallee	Banksia	44	22	24.7	2.5
Banksia	Wombat Junction	41	21	23.1	
Tom Price to Wombat Junction					
Tom Price	Wombat Junction	5	5	6.9	
Juna Downs Junction to Rosella					
Juna Downs Junction	Hawk	40	25	11.5	2.7
Hawk	Marandoo	60	40	46.6	
Marandoo	Cockatoo	30	25	26.4	2.7
Cockatoo	Rosella	25	20	21.8	2.7
Yandicoogina to Juna Downs Junction					
Yandicoogina	Osprey	70	35	37	2.5
Osprey	Juna Downs Junction	35	20	45.5	
West Angelas to Juna Downs Junction					
West Angelas	Juna Downs Junction	55	50	55	
Brockman/Nammuldi to Rosella					
Brockman/Nammuldi	Rosella	40	35	39.7	2.7
Western Creek to Cape Lambert					
Western Creek	Harding	26	25	77	2.5
Harding	Cape Lambert	30	30	42	
Mesa J - Western Creek					
Mesa J	Murray Camp	90	50	65.7	2.1
Murray Camp	Maitland	50	35	37.7	2.7
Maitland	Western Creek	20	36	19.2	

Notes: (a) Siding located at the "To" location

3.2 Mine Tonnages

Table 2 sets out an estimate of the current annual production from Rio entities' Pilbara mines. These tonnages are used for the purpose of proportionally scaling up the maintenance activities (discussed below) as the tonnage modelled increases. These tonnages were provided by TPI based upon its estimates of the amounts of iron ore produced annually at the mines listed in Table 2.

Table 2 – Mine Tonnages

Mine - Port	Tonnage (Mt/y)
Tom Price - Dampier	24.5
Paraburdoo - Dampier	17.5
Yandicoogina - Dampier	31.5
Brockman/Nammuldi - Dampier	11.4
Marandoo - Dampier	13.1
Mesa J - Cape Lambert	26.7
West Angelas - Cape Lambert	25.3
Total	150.0

Each train emanating from Tom Price, Paraburdoo, Yandicoogina, Brockman/Nammuldi, Marandoo and West Angelas carries 24,000t of iron ore. Those from Mesa J carry 15,600t of iron ore.

3.3 Interruptions

Five different categories of interruption to train running are explicitly modelled. Each occurrence of one of these interruptions stops rail movements along the section of track in which it occurs – a "section" being the length of track running between two defined locations eg Dampier to Brolga.

All rail maintenance activities are assumed to be dependent on the tonnage passing over a given section of rail track. Therefore, the model distributes the incidence of maintenance events across all sections on the network in proportion to their length and tonnes carried.

Although on occasions multiple (different) activities may occur coincidentally at the same time in different locations across the network, the simulation model will not allow more than one such event in any section at any time.

3.3.1 Major Planned Maintenance

This occurs approximately every 25 days, so that it will be carried out on each section once every three years. The model randomly chooses which section is affected on each occurrence, as discussed above.

It takes the section out of service for 24 hours.

3.3.2 Rail Defect Repairs

This category is assumed to accommodate the repair of eg hairline cracks which may be detected by surveying. At 150 Mt/y these events are assumed to occur on average once per fortnight. They will take out a randomly chosen section of track somewhere on the entire network for between 2 and 12 hours.

The simulation model will create these events at the nominal interval +/- 25%. The frequency will be scaled according to the tonnage being carried and the length of the track under consideration. It will then choose the section to which the event applies.

It will then randomly choose a duration for the current instance, somewhere between 2 and 12 hours.

3.3.3 Random Unplanned Maintenance

These events are assumed to include all other factors requiring maintenance eg switch gear/communications/signalling problems, objects on the line, storm damage, etc. They are assumed to occur on average 5 times per fortnight across the network.

They are modelled in the same fashion as rail defects above but the duration is assumed to be 4 hours +/- 25%.

3.3.4 Rail Grinding

One or two (depending on the scenario being modelled) grinding units move up and down the network servicing one section daily. This activity takes place at an average of 5 km/h with the distances being drawn from Table 1 above.

Scenarios were modelled assuming that one grinding unit services the entire network ie that each section is serviced once every 44 days. Alternate scenarios were also modelled which assumed two grinding units in operation servicing each section on the network once every 30 days.

3.3.5 Train Breakdowns

It is assumed that these events occur on average 40 times per year at 150 Mt/y, somewhere across the entire network. Again, the frequency is scaled up and distributed depending on the tonnage being carried.

These events block the section for 12 hours +/- 25%.

3.4 Cyclones

It is assumed that there will be 10 days of inactivity on the entire network each year due to the presence of cyclones.

This interruption is not modelled explicitly – rather it is taken into account when reporting the long-term average daily movements up and down the track.

4 MODELLING RESULTS

4.1 Use of the Model

The simulation model is used as a ***what if*** tool to explore likely performance under a range of operating conditions.

Using the model to analyse each scenario involves initially setting up the data pertaining to that particular scenario. This data includes the track layout under consideration ie travel times, distances, etc plus information on which sections are duplicated. It also includes the parameters which describe the various maintenance activities, cyclone interruption, etc.

The simulation model is then run and the results assessed.

For each section of the network being modelled, the process involves running the simulation model many times over, adjusting those parameters which define the scheduling of loaded train movements. The part of the track under consideration is assumed to be operating at capacity when the number of movements of empty trains matches the achieved delivery of loaded trains, ie the number of movements in each direction is in balance.

Every scenario is simulated for a period of 3 years. This ensures that there is sufficient account taken of the "random" events occurring in the model so that the long-term average number of train movements reported by it for the case under consideration is a reasonable reflection of likely performance of the real-life system operating under the same conditions.

4.2 Results – Existing Infrastructure

In this manner, we have modelled each of the nominated tracks (as listed in Section 1.1) with the existing infrastructure as described in Section 3 above to determine its maximum capacity.

Table 3 shows the capacities so determined:

- ***Track*** - the relevant portion of the rail network;
- ***Rio Tonnage (Mt/y)*** – the estimated total current tonnage over that track taking into account all of the current mines whose trains use it (derived from the tonnages shown in Table 2);
- ***Modelled Capacity Av. Trains/day*** - the long-term average number of movements per day (in both directions) which the simulation model indicates are achievable on this track;
- ***Modelled Capacity Tonnage (Mt/y)*** – the annual tonnage represented by this number of movements, calculated by applying the relevant train size (15,600t from Mesa J, 24,000t from all other mines);
- ***Surplus Capacity Tonnage (Mt/y)*** – the tonnage by which the modelled capacity exceeds TPI's estimate of Rio current usage;
- ***Surplus Capacity %*** - surplus capacity as a percentage of modelled capacity.

For these scenarios, rail grinding occurs in each section every 44 days.

Table 3 – Modelling Results (44 day Rail Grinding Cycle)

Track	Rio Tonnage (Mt/y)	Modelled Capacity		Surplus Capacity	
		Av. Trains/day	Tonnage (Mt/y)	Tonnage (Mt/y)	%
1. Dampier - Emu	98.0	22.5	197	99.0	50
2. Emu - Rosella	123.3	39.9	345	221.7	64
3. Rosella - Wombat Junction	42.0	30.4	266	224.0	84
4. Wombat Junction - Paraburdoo	17.5	17.0	149	131.5	88
5. Wombat Junction - Tom Price	24.5	55.3	485	460.5	95
6. Rosella - Juna Downs Junction	69.9	11.6	102	32.1	31
7. Juna Downs Junction - Yandicoogina	31.5	11.7	103	71.5	69
8. Juna Downs Junction - West Angelas	25.3	11.8	103	77.7	75
9. Rosella - Brockman/Nammuldi	11.4	16.9	148	136.6	92
10. Cape Lambert - Western Creek	52.0	18.7	149	97.0	65
11. Western Creek - Mesa J	26.7	8.9	50	23.3	47

Note that the capacity shown for the Rosella to Juna Downs Junction line assumes that there is a siding located at Marandoo to allow trains to pass.

Also, the capacity shown for the Cape Lambert to Western Creek line assumes that all additional traffic is in terms of 24,000t trains from West Angelas ie that the tonnage out of Mesa J remains at the base load of 26.7 Mt/y.

Similarly, Table 4 shows the consequences of increasing the frequency of rail grinding in each section from once every 44 days to once every 30 days.

Table 4 – Modelling Results (30 day Rail Grinding Cycle)

Track	Rio Tonnage (Mt/y)	Modelled Capacity		Surplus Capacity	
		Av. Trains/day	Tonnage (Mt/y)	Tonnage (Mt/y)	%
1. Dampier - Emu	98.0	21.4	188	90.0	48
2. Emu - Rosella	123.3	41.0	359	235.7	66
3. Rosella - Wombat Junction	42.0	29.5	259	217.0	84
4. Wombat Junction - Paraburdoo	17.5	16.6	146	128.5	88
5. Wombat Junction - Tom Price	24.5	55.1	483	458.5	95
6. Rosella - Juna Downs Junction	69.9	11.4	100	30.1	30
7. Juna Downs Junction - Yandicoogina	31.5	11.4	100	68.5	69
8. Juna Downs Junction - West Angelas	25.3	11.6	102	76.7	75
9. Rosella - Brockman/Nammuldi	11.4	16.8	147	135.6	92
10. Cape Lambert - Western Creek	52.0	18.2	145	93.0	64
11. Western Creek - Mesa J	26.7	8.7	50	23.3	47

4.3 Results – Additional Track Duplication

Table 5 presents the results of a scenario which assumes that the track between Western Creek and Cape Lambert is duplicated. It shows that the capacity of this line increases from 145 Mt/y to 325 Mt/y.

For this scenario, rail grinding was assumed to happen in each section every 30 days.

Table 5 – Modelling Results (Additional Infrastructure)

Track	Rio Tonnage (Mt/y)	Modelled Capacity		Surplus Capacity	
		Av. Trains/day	Tonnage (Mt/y)	Tonnage (Mt/y)	%
Duplicated Western Creek-Cape Lambert	52.0	38.8	325	273.0	84

Again the modelled capacity shown assumes that there is no increase in tonnage from Mesa J (via smaller 15,600t trains).

Simulation Modelling Services Pty Ltd