Ebor Route Planning - Example Use Case

Modelling the Ebor Route – a new long distance rail line concept

Introduction

This use case describes the modelling of a concept option for a new long-distance rail line in Australia. The modelling is to illustrate a methodology for using Traxim to support early-stage feasibility analysis and benefit appraisal.

The Australian Government is progressing “Inland Rail”, a 1,600km freight rail line, now under construction. It will connect Melbourne and Brisbane via regional Victoria, New South Wales and Queensland, and offer a materially shorter route that bypasses the congested Sydney metropolitan area.

The broad corridor for Inland Rail was selected through an options assessment process undertaken in 2006, the “North-South Rail Corridor Study”. That study overlooked a prima facie viable potential route that utilised more of the existing network and created a contiguous Melbourne – Brisbane route by adding a new line connecting the “Main North” rail line near Armidale, with the “North Coast” rail line south of Grafton, cresting the Great Dividing Range in the vicinity of the town of Ebor.

This use case describes the modelling of a concept alignment on this alternative corridor, and compares it to both the selected Inland Rail alignment, and the existing Coastal Route, as a high-level “what could have been” comparison. While the primary focus is on describing the use of Traxim, it will provide sufficient detail on the background and specifics of the scenario to place the Traxim modelling in context.

Note that what was originally referred to as the “Inland Route” has been branded as “Inland Rail” for the purposes of the construction phase. This paper will reference both the route and the current project, and as such will use both terms as appropriate in the context.

Background

The Australian government and rail industry have a long-standing desire to create a new, shorter, rail corridor for Melbourne – Brisbane intermodal freight that would also bypass the choke point created by the Sydney commuter network. Such an alignment would also benefit Brisbane – Adelaide and Brisbane – Perth intermodal freight.

Two further considerations for the project at the time of route selection were:

- The prospects for the West Moreton coal industry, which, notwithstanding good awareness of climate change at the time, and the need for wind-down of fossil fuel use, were considered promising.
- Potential benefit to the agricultural industry in South-West Queensland and North-West NSW, particularly grain and cotton exports.

While successive Australian Governments have strongly promoted the project and made firm commitments to its delivery, progress has been markedly slower than originally forecast due to extensive design and approval challenges. Cost estimates have also increased by orders of magnitude.

At the same time:

- The prospects of the West Moreton coal industry have dimmed as global action on climate change has accelerated, and
- Due to changes in the structure of the economy, interstate intermodal freight volumes have grown more modestly than the historical rates assumed in the studies at the time.

Both of these eventualities will have reduced the forecast economic benefit, as will have the significant increase in cost.

Within this context, the Ebor Route option offers an interesting case study.

Figure 1 places the corridor options in context. The translucent pink corridor between Melbourne and Narromine is common to both the Inland and Ebor routes. The selected Inland Rail route then continues in translucent purple, while the Ebor Route heads more easterly in translucent green.

Greenfields sections of Inland Rail are shown in solid purple, while the greenfields section of the Ebor Route is in solid green.

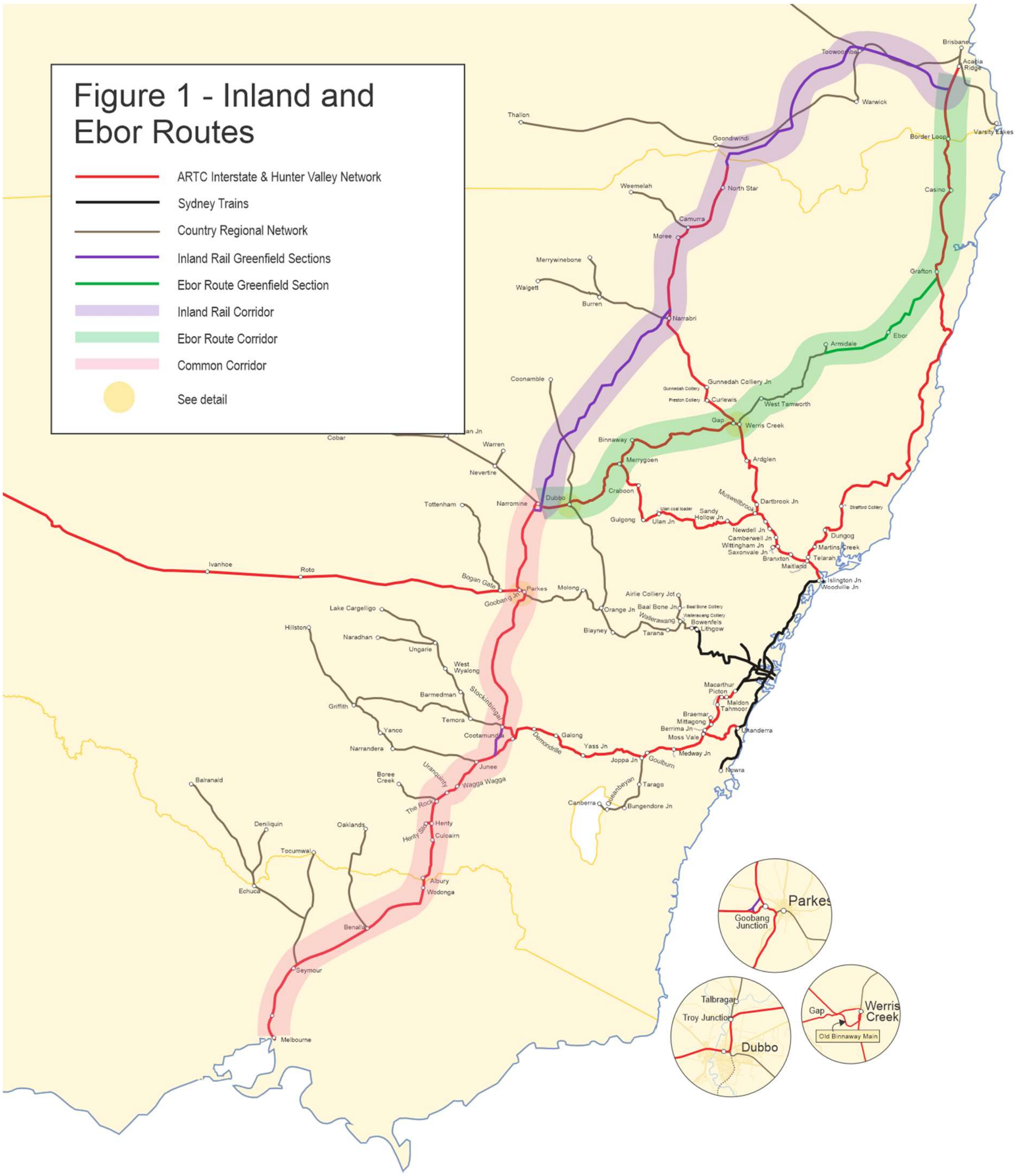
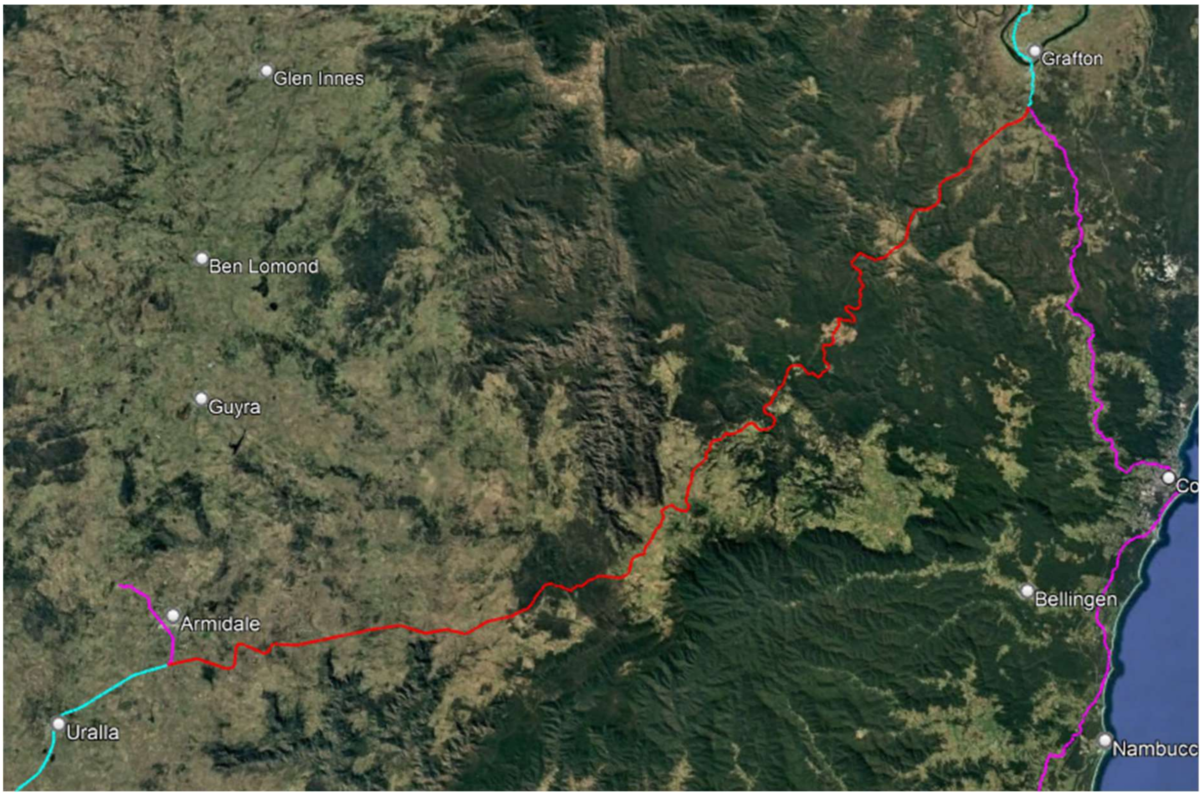


Figure 1 - Inland and Ebor Routes

A concept alignment for the greenfields section of the Ebor route has been developed using the path creation and elevation profile tools in Google Earth. This is shown in more detail in red in Figure 2.

Figure 2 – Concept Alignment for Greenfields Section of the Ebor Route



It is important to emphasise that the Ebor Route option has significant challenges. Elevation falls from 1330 m in the vicinity of Ebor to 235 m in the Nymboida Valley, a straight-line distance of 56 km. This would require a continuous grade of 1 in 50. In practice, this grade can be reduced by creating a longer rail distance. At the same time, terrain challenges and managing construction cost may mean that some sections of the alignment would have needed to be steeper than 1 in 50.

For comparison, the Inland Rail alignment needs to grapple with a fall from 630 m at the edge of the Toowoomba Range, to 160 m in the vicinity of Helidon, a straight-line distance of 18 km. This would be a continuous 1 in 38 (2.6%) gradient. In practice, the Toowoomba Range Tunnel has allowed this to be eased to something like 1 in 64 (1.6%).

It is also worth noting that the elevation gain for the Ebor Route is more than double the elevation gain for the Inland Route. This will necessarily have a direct impact on energy consumption and / or average speed independent of any other features of the alignment.

An interesting consideration in this context though is the future of rail propulsion. The solution for decarbonisation of rail transport, particularly long-distance freight, remains unclear. However, it is reasonable to assume that rail freight will need to be decarbonised, and that the steady progress of renewable energy will ultimately lower the cost of energy, potentially significantly. The different characteristics of electric propulsion mean that gradient isn't likely to be as big a consideration in a future where battery storage is significant, either as a direct source of power or as an intermediate step between hydrogen and the electric propulsion motors, as peak energy delivery is only limited by the traction motors, not the diesel engine power output.

This is an important consideration in comparing the Ebor Route with Inland Rail. The existing network that would be used as part of the Ebor Route already has grades of approximately 1 in 40 (2.5%) for northbound trains between Tamworth and Armidale. While an option would be to construct deviations to ease this grade, the assumption has instead been made that future energy solutions will reduce the disbenefit of these steeper grades. While this doesn't automatically mean that 1 in 40 is also the appropriate maximum southbound grade, it is worth noting that more freight travels north than south. As such, the 1 in 40 northbound grade will determine the peak power requirements. This means that (on average) there will be more than adequate power available for southbound trains if the ruling gradient is 1 in 40.

Hence, in developing a concept alignment for modelling purposes, 1 in 40 has been treated as acceptable as the design limit in both directions. In practice it's been possible to keep the grade somewhat below this, closer to 1 in 45.

Inter-related with the gradient issues is that, at this very rough concept level, limited consideration has been given to the scale of earthworks. While the concept alignment has been developed to follow terrain contours, no consideration has been given to cut and fill balancing, or the length of any bridges or tunnels required. Optimisations around these design elements may increase the route length and effective ruling grade, though this is unlikely to significantly change any broad conclusions around route performance.

Coming back to the market issues, it is important to emphasise that the Ebor Route offers no benefit to either the West Moreton coal or SW Queensland / NW NSW agricultural industries. Prima facie, the only traffic that would make use of the greenfields section of the route would be interstate intermodal freight. The decline in the fortunes of coal makes this mute for that benefit stream. With regard to agriculture, while the Ebor Route would see the loss of those potential benefits, the relatively small volumes mean that the loss of the benefit stream would make limited difference to the economic case.

Methodology Overview

The purpose of this use case is to describe the use of Traxim to help support early-stage economic (or commercial) analysis of project options. The key outputs of the operational modelling required to feed an economic modelling exercise are:

- Transit time (as an input to both modal shift analysis, and train operating cost estimates),
- Train configuration and fuel consumption (as inputs into train operating costs), and
- Number of crossing loops (as an input to the capital cost estimate).

Inland Rail has, in theory, been optimised to maximise its economic benefit. It logically follows therefore that to provide a foundation for a considered comparison, the Ebor Route modelling should likewise seek to optimise its economic benefit rather than attempting to maintain like-for-like with the Inland Rail operating assumptions. This is, however, a substantial undertaking requiring a sophisticated and iterative parallel economic modelling exercise. Hence for the purposes of this paper, pragmatic assumptions have been made about what an approximately optimised solution would be.

Step 1 of the methodology is to model raw (ie assuming no dwell) transit time. Step 2 is to model the network with forecast train numbers at time intervals to understand capacity and scheduled (ie with deconflicting dwell) transit times.

To add context to the comparison, the existing Coastal Route has also been modelled. This option has been modelled as-is. That is, no optimisations have been applied. The consequences of this are discussed in the relevant sections.

Although the corridor end points are nominally Tottenham and Acacia Ridge, there is an expectation that the Acacia Ridge terminal lacks the capacity to accommodate the growth associated with Inland Rail, and also that it lacks the ability to expand to do so, and that a new terminal will therefore be required to meet future growth. Terminal options have been considered at Ebenezer and Bromelton. Rail operator SCT already has a terminal at Bromelton. As the Ebor route would not require construction of that part of the line needed to get to Ebenezer, Acacia Ridge and Bromelton have been used as the nominal corridor end points in Brisbane for the purpose of this analysis. Also, Dynon has been treated as the nominal Melbourne end point notwithstanding that Tottenham was the original nominal location.

Finally, the Government set a target for Inland Rail to achieve a 24-hour Melbourne – Brisbane transit time for an “express” service. It is not clear that this 24-hour transit time has any logical or analytical foundation, but this analysis will reference this benchmark.

Train Configuration

Context

This section will consider the issues around determining an optimised train configuration for the Ebor Route, and an appropriate train configuration for modelling the coastal route.

Inland Rail assumed two base train configurations for the dominant intermodal traffic: an express configuration, and a standard configuration. Both trains are nominally 1800 m long, double-stacked, and 4456 tonnes trailing weight. The express train is assumed to be hauled by 3 x Cv40-9i (NR class) 4000 hp DC traction locomotives giving a power to weight ratio of 2.7 hp / tonne. The standard train is assumed to be hauled by 2 x GT46C-ACe 4400 hp AC traction locomotives (first introduced in Australia as the SCT class) giving 2.0 hp / tonne.

Train Length

Train length for Inland Rail has been set at 1800m to align with the maximum train length used across most of the current interstate network. This train length is already built into the common section infrastructure.

However, for historical reasons, the North Coast line between the junction for the Ebor Route and Brisbane is only built to a 1500 m maximum length. To operate at 1800 m, the following existing loops would need to be extended to achieve a nominal 1850 m minimum loop length: Grafton (386 m, currently only 1464m), Kyarran (150m), Rappville (70m), Namoona (150m), Kyogle (179m), Glenapp (160m), and Tamrookum (250m). These extension projects are not necessarily straightforward given the challenging terrain, but given the modest scope it seems prima facie reasonable to assume 1800 m as the train length. This maintains train length consistency with Inland Rail.

For the purposes of modelling the existing coastal route, it has been assumed that train length would remain at 1500 m. This will necessarily mean that more trains are required to move the same volume of freight. The consequences of this assumption are discussed further below.

Double Stacking

Double stacking on the Ebor Route would be more difficult to achieve than on the Inland Route as more of the route is existing track which would require retrofitting to achieve the increased clearances. This would be reasonably straightforward on Narromine – Werris Creek, and only a little harder between Werris Creek and the junction for the greenfields section just south of Armidale. However, the North Coast line between Grafton and Brisbane has some difficult barriers, particularly in the topographically challenging area around the NSW / Queensland border, which includes a number of tunnels. The major bridge across the Clarence River at Grafton would also be expensive and difficult to address.

One option would be to assume trains are single stack only. This would mean less freight was carried on each train, which would require a recalculation of train numbers. This may be an appropriate optimisation, especially noting that double-stacking north of Kagaru (34 km south of Acacia Ridge) has previously been ruled-out for political reasons. However, it reduces the directness of comparability between the Inland and Ebor routes. Hence, the option of simply assuming double-stacking on the Ebor route has been adopted.

A key consideration in this regard is the extent of tunnelling that would be required on the Ebor Route. Inland Rail requires a tunnel of around 6 km and whether to build it to double-stack clearance is a threshold decision. If tunnels could be largely avoided in the detailed design of an Ebor Route alignment, the marginal cost of building the greenfields section to double-stack clearance could be inconsequential. This would have created an option to optimise investment into the future by not undertaking the double-stack clearance works on the existing sections of the route until volumes warranted it.

There is no realistic possibility of introducing double-stacking on the existing coastal route. As already noted in regard to train length, this would consequently mean that more trains would be required for the same freight task.

Locomotive Configuration

Notwithstanding the steeper ruling gradients in both directions on the Ebor Route compared to the Inland Route, the nominal Inland Rail locomotive configuration provides adequate power, other than for one very short grade between Tamworth and Armidale.

However, the significantly greater elevation gain on the Ebor route, and the high number of speed constraining curves on both the existing sections, and in the concept design of the greenfields section, mean that average speed on the Ebor Route will necessarily be significantly slower than on the Inland Route.

This can be mitigated to some extent by increasing the number of locomotives. This will have a direct impact on operating cost due to both the increased capital (for the additional locomotive) and increased fuel consumption and locomotive maintenance costs. As previously noted though, as rail propulsion technology evolves to remove fossil fuels, these costs may decline significantly.

One approach would have been to assume the necessary grade easing to allow the Inland Rail locomotive configuration to be used on the Ebor Route. However, preliminary analysis of the Ebor route indicated that the threshold 24-hour transit time was unlikely to be achievable with the Inland Rail locomotive configuration. Hence, the modelling has assumed that one additional locomotive is added to both nominal train configurations.

For the coastal corridor, a simplifying assumption has been made that the nominal train configuration remains at 4456 tonnes notwithstanding that as a single-stack, 1500m train, this train weight is unrealistic given average domestic container weights. The same locomotive configurations have been used as for the Ebor route option, as the Inland Rail configuration stalls on the Cowan Bank to the north of Sydney. While this train configuration is not achievable in practice, the way to look at it is that the train configuration is describing a power to weight ratio rather than a specific train. It is this power to weight ratio that determines train performance and train operating costs.

To be clear, the consequence of this approach is that the power to weight ratio of the nominal trains for the Coastal route and Ebor route options are directly comparable, though they are both more highly powered than Inland Rail trains and hence would have increased capital and operating costs.

Simulating Raw Transit Time

Base network

Modelling a network in Traxim requires two key elements: a data string for the track alignment expressed in latitude, longitude and elevation, and; details of the track configuration expressed as nodes (turnouts or intermediate signals) and links between nodes. The existing Australian standard gauge network, including Inland Rail, had already been set-up in Traxim.

Creating the Ebor Route

As already noted, the Ebor Route alignment was created using the path creation and elevation profile tools in Google Earth. In the absence of access to sophisticated track design software tools, or engaging a team of engineers, creation of the alignment has been purely a judgement, and trial and error, process. As such, the alignment is, at best, a rough approximation of what could be achieved.

The broad route passes through very challenging terrain, with significant elevation changes over short distances. Extensive curvature has therefore been required to both follow the terrain contours, and to extend the length of the line to keep gradient acceptable between ridge saddles and valley bottoms.

The Traxim User Manual includes a detailed description of how to create a track alignment string using free publicly available tools. In short, a path created in Google Earth can be exported to give latitude and longitude. These coordinates can then be fed into a free online website that will generate the elevation for the given coordinates, all of which is exportable to a csv file editable in Excel, which is the basic format for input into Traxim.

Given the complex terrain, it has then been necessary to adjust the elevation to ensure that it meets the target gradient limits. While gradient averaging across the length of the train automatically smooths the alignment to some extent, it was necessary in this case to force longer lengths of track into implicit cuttings and embankments.

Finally, Traxim has an optional function to automatically calculate curve radius and apply an appropriate speed limit given user defined limits for superelevation and cant deficiency. While speed limits can also be entered manually into the Traxim scenario using the Speedboards file, in this case the automated curve speed limiting feature was used. Assumed superelevation was set at 120 mm, and cant deficiency at 75 mm.

Raw Transit Time Simulation Process

A Train Plan input file was then created incorporating each of the benchmark train configurations, that is, the express and standard trains operating between Dynon and both Acacia Ridge and Bromelton, in each direction.

This was then run through the Traxim scenario validation process for each of the Inland, Ebor and Coastal routes. This generates a csv output giving key performance statistics for each train, including transit time and power consumed. Note that this is for a raw, unconflicted transit: no dwells are included in this output.

As well as power consumed, statistics on the amount of time spent braking and idling are generated. These were used in conjunction with power generated to estimate fuel consumption.

Traxim also estimates the amount of energy generated by dynamic braking. Diesel locomotives typically vent this to the atmosphere as heat, but in a future where batteries are a feature of the propulsion system, it could instead be recycled.

Raw Transit Time Simulation Results

Table 1 shows the key performance outputs.

Table 1 - Average raw MB transit time

	Dynon - Acacia Ridge						Dynon - Bromelton				
	Transit time (hours)	Average Speed	Power KWh	Recoverable braking KWh	Fuel Consumption		Transit time (hours)	Average Speed	Power KWh	Recoverable braking KWh	Fuel Consumption
Average of Directions											
Coastal											
Express (4 x NR | 3.6 hp/t)	26.57	64.0	154	39	43,197		25.99	65.5	150	38	42,140
Standard (3 x SCT | 3.0 hp/t)	27.44	62.0	141	37	39,582		26.85	63.4	138	36	38,631
Inland											
Express (3 x NR | 2.7 hp/t)	19.25	88.4	122	9	34,289		19.10	89.1	121	9	33,817
Standard (2 x SCT | 2.0 hp/t)	20.90	81.4	110	10	30,770		20.73	82.1	108	10	30,375
Ebor											
Express (4 x NR | 3.6 hp/t)	23.02	73.9	149	38	41,794		22.44	75.8	145	37	40,738
Standard (3 x SCT | 3.0 hp/t)	24.13	70.5	137	35	38,374		23.53	72.3	134	34	37,426
Difference: Inland v Coastal											
Express	- 7.32	24.3	- 32	- 30	- 8,908		- 6.89	23.6	- 30	- 29	- 8,323
Standard	- 6.54	19.4	- 31	- 28	- 8,811		- 6.12	18.7	- 29	- 27	- 8,256
Difference: Ebor v Coastal											
Express	- 3.55	9.9	- 4.9	- 0.7	- 1,403		- 3.55	10.4	- 4.9	- 0.7	- 1,402
Standard	- 3.31	8.5	- 4.2	- 2.6	- 1,207		- 3.31	8.9	- 4.2	- 2.6	- 1,205
Difference: Ebor v Inland											
Express	3.77	- 14.5	27	29	7,505		3.34	- 13.3	25	28	6,921
Standard	3.23	- 10.9	27	25	7,604		2.80	- 9.8	25	24	7,051

Comment

Modelling of the raw transit times shows that the Ebor route offers around half of the transit time saving of Inland Rail relative to the Coastal route.

Given the increased height gain and additional locomotives, it only offers a modest reduction in fuel consumption relative to the Coastal route, and substantially less than the Inland route does. However, it is worth noting that the regenerative energy generated approximately balances out the higher power requirement. That is, if the energy currently lost in braking was recovered by batteries, the Ebor route energy requirement would be roughly the same as the Inland route's.

Modelling Scheduled Transit Time

Creating the Train Plans

For this simulation exercise, two sets of train plans were required. Firstly, a set of trains that would use the new routes being analysed. Secondly, an assumed background train scenario to properly simulate interactions between trains on those parts of the existing network used by the first set of trains.

For the background trains, a train plan was created from the current ARTC master train plans. This covered all of the trains using the network east of Goobang Junction (inclusive) and Tottenham (inclusive), but excluded Hunter Valley coal trains, given that these are only peripherally relevant but impose a very high simulation load. Note that passenger trains on the Sydney Trains network were also excluded. Modest growth in Melbourne – Sydney, Sydney – Brisbane, and Sydney – Perth intermodal train numbers was added. This background train scenario was then treated as common to the three network scenarios to be simulated.

The starting point for the trains to operate via the new routes was a nominal train plan reflecting the train numbers assumed in the original Inland Rail program business case.

However, as already noted, coal was assumed to be a significant contributor to the traffic task on Inland Rail. It would now be unreasonable to assume that there will be significant, if any, coal traffic at the opening time of Inland Rail, or that it's construction will stimulate the opening of new mines. Hence, all West Moreton coal traffic was excluded.

As previously mentioned, evidence suggests that growth in the base interstate freight volumes, that is, freight carried by both road and rail, has been slower than assumed in the Inland Rail business case. To the extent that intermodal rail volumes are therefore unlikely to achieve the traffic forecasts, this is of less significance – the volumes can be assumed to be achieved at some point in time even if that is quite a few years later than was originally projected. Hence, intermodal train numbers have been maintained at the program business case level in the nominal year, with that nominal year really representing a number of trains rather than a specific point in time.

It is generally considered that there is only a minority of the freight market that is transit time sensitive, with a larger share price sensitive. Operating the express train will inevitably be costlier. When only a few trains a day are operating, it generally follows that only a proportion of the freight on an express train will be time sensitive. The whole train obviously needs to operate to an express configuration though, even if a considerable amount of the freight doesn't need the faster transit time. Reflecting this, it has been assumed that there are a fixed number of express trains, which are common to all years, and that as volumes grow an increased share of the freight on the express trains becomes time sensitive. All of the increase in train numbers over time is therefore assumed to be in standard trains.

The resulting train plan has then been used for the three scenarios. The only difference is that there are a number of additional grain and import / export container services in the Inland route train plan that are excluded from the Ebor route and Coastal route plans.

It should be noted that as the three routes have different performance outcomes, they will generate different amounts of mode shift. Hence, for any given year the amount of intermodal rail freight demand will differ between routes, even though the train numbers as modelled are the same. Again, the best way to think about this is that the nominal year is for reference purposes only and that the transit time performance of a scenario really attaches to an assumed number of trains rather than a point in time.

This is also the best way to think about the previously discussed issue that the nominal coastal route train configuration isn't operatioally feasible. Although a 1500m single-stack train doesn't carry the same amount of freight, what is really being modelled is a number of trains and a power to weight ratio. In a project where the economics were being modelled, the approach would be to use the estimated rail freight demand to calculate a number of trains required with a given train configuration, which then identifies the relevant train plan scenario to use for performance purposes.

Crossing Loops on the Ebor Route

Inland Rail is a largely single-track corridor. The sections of double track within the working definition of Inland Rail are common to both the Inland and Ebor routes, so are assumed to be neutral for the purposes of this analysis.

Being a single-track line, a critical question for determining both performance and construction cost is "how many loops should be built".

The scope of the current project was developed to accommodate a nominal 2040 task, though loops in some places are more closely spaced than is strictly required for capacity. This in part reflects an expectation that there will be significant peaking in path demand, and that the peak in each direction will need to cross around the midpoint of the route, creating congestion.

Also, as previously discussed, it would be unreasonable to in this analysis include coal volumes as forecast in the business case. Accordingly, the Inland Rail scope of loops significantly exceeds what is strictly required for capacity, though it is potentially still appropriate to maximise economic benefit, since loop frequency is a key factor in transit time.

There are only a few loops on the sections of the existing network being incorporated into the Ebor route (that is, between Narromine and Armidale), none of which are suitable for 1800 m trains. As already noted, crossing loops on the North Coast line are generally built for a 1500m maximum train length.

The number and location of loops on Narromine – Armidale has been developed using an iterative approach having regard to the 24-hour transit time target, terrain, existing infrastructure, and a principle of approximately equalising loop spacing on an average section running time basis.

Traxim generates an output file listing the node arrival and departure times for nominated nodes on a train's route. A rough approximation of loop locations was generated as a first step, and all crossing loop end points were flagged as nominated nodes. A first iteration of a timetable output was then generated and Excel used to calculate section times as an average of directions and, by extension, capacity utilisation.

It is worth noting here that, as a deconflicted timetable was used, the average section time and capacity are both calculated including train deceleration and acceleration arising from trains executing crosses. Hence, to the extent that there is peaking inherent in the timetable and this causes relative congestion in certain areas, this will translate into increased section times. It is also important to be aware that using this methodology, section times will be influenced by the number of trains in the timetable scenario. In this case, train numbers, and growth in train numbers, are largely homogeneous across the sections being analysed. However, in a scenario where sections on a network have train numbers growing at different rates, the specifics of the train plan to be used for determining loop locations can be important.

Also note that moving a loop location in Traxim is as simple as entering a new kilometrage for the node characteristics using the Network Editor. In this modelling exercise, the turnaround time to generate a new timetable output and update the Excel analysis was around 5 minutes, making it quick and simple to hypothesise a new set of loop configurations and test the consequent performance.

Scheduled Transit Time Simulation Results

Table 2 shows the results of the modelling of scheduled transit time. 25 perturbed timetables were generated for each year of each scenario and performance metrics averaged. Note that capacity on the coastal route, specifically on the section between Newcastle and Taree, was exhausted beyond 2035. Hence the 2040 Coastal route scenario wasn't modelled.

Table 2 - Total transit time

Average of all MB trains (Dynon - Acacia Ridge / Bromelton)	Total Distance	Total Deconflicting Dwell	Total Transit Time	Average Speed	Dynon - Acacia Ridge: Average Transit Time	Dynon - Acacia Ridge: Average Dwell	Dynon - Bromelton: Average Transit Time	Dynon - Bromelton: Average Dwell
	Coastal							
Express								
2025	51,534	5,605	49,406	62.6	30.45	3.45	29.72	3.37
2030	51,340	6,210	49,973	61.6	30.91	3.84	30.17	3.75
2035	51,164	8,434	52,251	58.8	32.43	5.23	31.65	5.11
2040	n/a	n/a	n/a	n/a	n/a	n/a		
Standard								
2025	26,404	5,076	28,550	55.5	34.34	6.10	33.51	5.96
2030	59,335	10,669	62,814	56.7	33.62	5.71	32.81	5.57
2035	110,603	31,286	130,510	50.8	37.47	8.98	36.57	8.77
2040	n/a	n/a	n/a	n/a	n/a	n/a		
	Inland							
Express								
2025	47,318	2,082	35,546	79.9	21.30	1.25	21.03	1.23
2030	47,318	2,176	35,696	79.5	21.39	1.30	21.12	1.29
2035	47,315	2,342	35,958	78.9	21.55	1.40	21.28	1.39
2040	47,304	2,615	36,304	78.2	21.76	1.57	21.49	1.55
Standard								
2025	23,706	2,349	20,821	68.3	24.91	2.81	24.59	2.77
2030	52,826	6,705	48,064	65.9	25.80	3.60	25.47	3.55
2035	73,288	9,904	67,632	65.0	26.17	3.83	25.84	3.78
2040	93,186	13,494	87,245	64.1	26.55	4.11	26.21	4.05
	Ebor							
Express								
2025	49,026	2,340	41,047	71.7	24.43	1.39	23.79	1.36
2030	48,998	2,725	41,498	70.8	24.72	1.62	24.07	1.58
2035	48,954	3,237	42,069	69.8	25.08	1.93	24.42	1.88
2040	48,861	4,471	43,313	67.7	25.87	2.67	25.19	2.60
Standard								
2025	24,602	2,543	23,089	63.9	27.39	3.02	26.67	2.94
2030	56,361	6,492	53,607	63.1	27.76	3.36	27.03	3.27
2035	106,529	14,413	106,569	60.0	29.19	3.95	28.43	3.84
2040	136,526	24,452	143,127	57.2	30.59	5.23	29.79	5.09

Comment

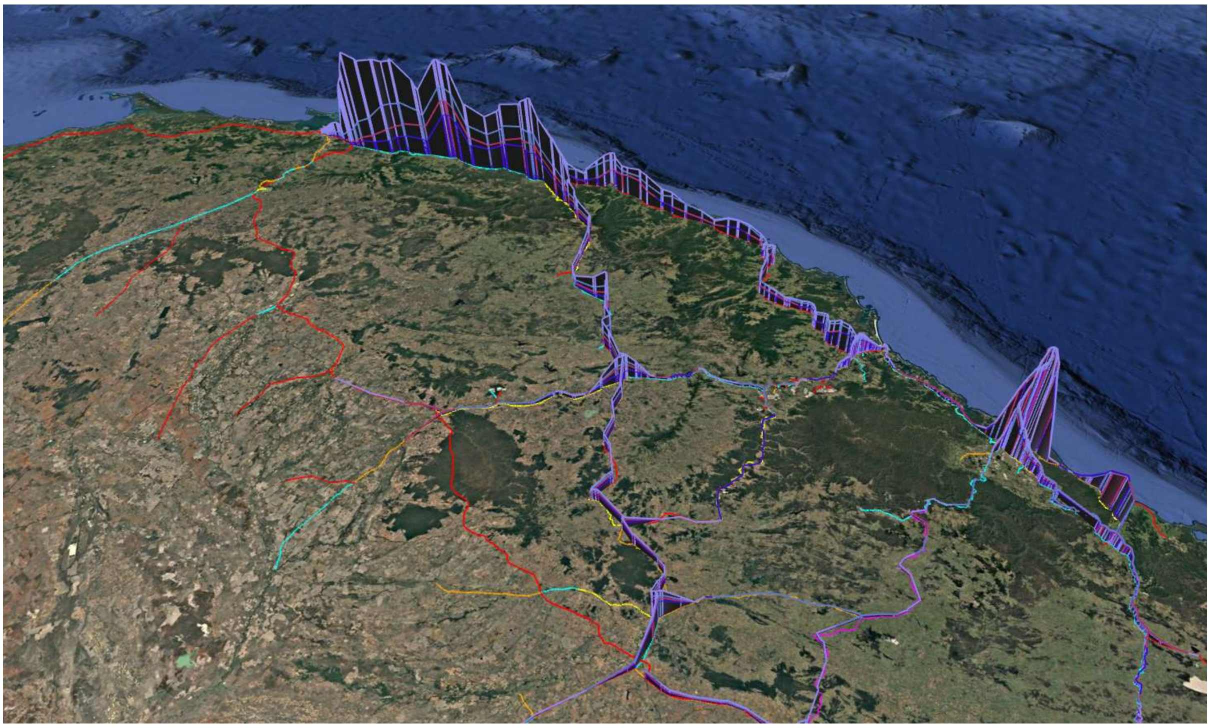
Figure 3 shows a comparison of the transit time savings achieved by the Inland and Ebor routes relative to the Coastal route for traffic volumes in the years 2025, 2030, and 2035. As previously noted, capacity on the Coastal route is exhausted after 2035, so no comparison is available.

Consistent with the results of the raw transit time analysis, the Ebor route offers less transit time saving than the Inland route. However, because dwell isn't pro rata with raw transit time, the proportional reduction in the saving is less. That is, the advantage of the Inland route relative to the Ebor route is lesser when looking at scheduled transit time. Ebor route transit time savings range between 65% and 80% of the equivalent saving the Inland route achieves against the Coastal route.

The Ebor route doesn't quite achieve the benchmark 24-hour transit time for the express service to Acacia Ridge, though it does to Bromelton at 2025 train numbers. It should be noted that the modelling uses a relative priority for the express services. Since the number of express services is assumed to remain constant over time while the number of standard services increases, it would be possible to still achieve the 2025 express service transit times in future years by increasing their level of priority, at the expense of increased overall delay.

Alternatively, additional loops could reduce crossing dwell. Traxim generates a kml file of delay by location that helps visualise the incidence of delay. Figure 4 shows delay on the Ebor route for 2025 in dark blue, 2030 in red, 2035 in light blue and 2040 in lavender.

Figure 4 – Ebor Route Delay by Location by Year



It is immediately apparent that in all years there is significant delay being incurred on the Grafton – Brisbane section of the North Coast line. As previously noted, a decision was taken to assume that all 1500m loops on this section were extended to 1800m. However, the scale of delay suggests that there may be a case for additional new or extended loops on this section, which would potentially reduce delay significantly. This would be an optimisation for a more detailed economic assessment.

It is also important to note that the Coastal route modelling doesn't address the complexity of operations between North Strathfield and Broadmeadow where there is a high volume of commuter passenger services operating to a fixed interval timetable that get absolute priority over freight. Freight pathing in this environment is very rigid, and this inevitably induces additional delay, even in the master planning process. The morning and afternoon commuter peaks also sterilise capacity, which creates additional congestion across the balance of the day. The potential time saving of both the Inland and Ebor routes relative to the coastal route is therefore understated.

On a technical note, it would normally be expected that as train numbers increase, dwell should increase. However, the complex interplay of train departure times, consists, and priority, means that there can be anomalies. The data in Table 2 has a such an anomaly, with the standard train on the coastal route incurring less delay in 2030 than in 2025. This anomaly isn't an error - total weighted delay for all trains in the scenario (which isn't reported) is logically consistent between years. The apparently counter-intuitive result is simply an artifact of the high levels of complexity in train interactions.

A Comment on Reliability

Reliability is an important consideration for optimising the competitiveness of a rail service offering, particularly in the intermodal market.

In this context there are two key principles that should guide thinking on reliability.

First, the reliability of the rail infrastructure will be a direct function of the standards to which it is built and maintained. As this paper has commented, the Ebor Route uses much more of the existing network. It could reasonably be assumed that it will therefore have worse infrastructure reliability. The extent to which it is worse will ultimately depend on the extent of upgrading of the existing line sections.

Second, it is worth recognising that most unreliability is due to matters outside of the track owner's control. This includes delays caused weather, animals and people. Most delay though is due to above rail operators.

When the network is disrupted, its ability to recover is fundamentally a function of the amount of optimisation build into the timetable. To the extent that the master timetable is optimised to minimise delay beyond what the network control system can achieve in real time, it would be expected that delay will deteriorate. To the extent that there is recovery built into the timetable and dwells are not highly optimised, the network is likely to recover some of the lost time.

It is difficult, if not impossible, to quantify the extent to which Traxim is optimising. It uses a "greedy" algorithmic approach, which does aim to locally optimise, but it does not aim to optimise across a corridor. Using the average results of a population of timetables with a perturbed train plan should also reduce the risk of statistical outliers.

Ultimately, the only way to align the theoretical modelling with the real-world outcome would be to use the same algorithm for both the timetable planning and the live run. In this case, any delay would be neutral. That is, on average, trains would neither recover nor further deteriorate unless recovery time was built into the timetable, though this assumes that the performance metric and the basis of algorithmic decision making is to minimise priority weighted transit time for the network as a whole. To the extent that there is departure from this principle, for instance by giving healthy or on-time trains priority over unhealthy / late trains, it is not possible to forecast reliability levels.

Summary of Pros and Cons of the Ebor Route Against the Inland Route

Advantages of Inland Route	Advantages of Ebor Route
Shorter by 49 km to Acacia Ridge, and 25 km to Bromelton. Faster raw transit time by 3h 46m minutes to Acacia Ridge, and 3h 21m minutes to Bromelton for an express service, and 3h 14m / 2h 48m for a standard service. Similar, though reduced, savings in scheduled transit time (ie 1.5 – 3.5 hours).	Reduced greenfields construction – 197 km versus 588 km. Fewer new loops required – 21 versus 31. Potential option to defer a decision on double- stacking until economically justified. Option to defer upgrading of existing sections until economically justified. Option to ease gradients in the future if

Reduced fuel consumption in the order of 20% to 25%, though future propulsion technology with regenerative braking may largely negate this. Provides benefit to south-west Queensland and north-west NSW agricultural freight. No further upgrading of existing lines against 477 km of upgrading for the Ebor Route (184 km of existing Inland route sections requiring upgrading have already been completed). Better ruling gradient of 1 in 64 versus 1 in 40, allowing one less loco on both train types. No further loop extensions required against 7 for Ebor Route. Potential to contribute toward the introduction of Toowoomba passenger services. No extra scope to achieve double-stacking (Scope for Ebor Route is undefined, but considerable).	economically justified.

In summary, the current Inland Rail route is superior to the Ebor route on every operational dimension. The Ebor route could, however, be considered to have had the potential to meet the minimum operational objectives of the Inland Rail project, and to have offered a large proportion of the transit time saving relative to the Inland route. Importantly, it would have achieved this with around one-third of the length of greenfields construction. The complexity of construction of the greenfields section of the Ebor route would have been very high though, and hence would have been unlikely to be deliverable for one-third of the cost of Inland Rail. Nonetheless, savings could have been substantial. As previously noted, a full assessment of the relative merits of the two routes is only possible in the context of a full economic appraisal.

Conclusion

In this use case, Traxim has been deployed to analyse a new rail route concept.

Traxim was used to:

- Simulate raw transit times.
- Estimate energy consumption.
- Determine an appropriate scope of crossing loops.
- Generate a population of timetables to determine total transit time.

Traxim's ability to work with a simple Google Earth generated track centreline, drag and drop infrastructure configuration editing, and automatic curve speed limiting, allows the scenario development process to be greatly accelerated.

How the Ebor route fully compares to the Inland route would require a full economic appraisal. This use case shows how Traxim can be used to efficiently and validly generate the critical operational inputs to such a business case.