

THE REGIONAL FAST RAIL PROJECT - A TECHNICAL FOCUS

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ABSTRACT

The Regional Fast Rail project delivered the greatest revitalisation of regional rail in Victoria in over 120 years. The project involved the upgrading of track, signals, level crossings, trains, and safety systems across four rail corridors – Ballarat, Bendigo, Geelong and Traralgon. The integrated Thiess ALSTOM Joint Venture (TAJV) worked to a performance-based design and construct contract including signalling on the Geelong corridor and Ballarat corridor. The project scope included the design and construction of upgraded rail infrastructure necessary for the new V/Locity 160km/h trains to achieve the mandated run times.

TAJV set a new benchmark in the delivery of the Ballarat and Geelong rail lines. Where lengthy and disruptive line closures were expected over a number of years, TAJV brought about a paradigm shift in the approach to the delivery of this multidiscipline project. An innovative delivery methodology resulted in a series of short, sequenced rail shuts. Record levels of construction work were achieved within the shuts and thousands of rail commuters were successfully bussed during the shut-downs over the four year construction period.

The project required the management of a large and intricate web of competing and changing stakeholder groups over four years. The client, the Victorian Department of Infrastructure (DOI), regularly requested scope changes to ensure the needs of the track owners, safety authorities, road and rail authorities, land owners and rail passengers were met. Despite a 30% change in the project scope following contract award, TAJV delivered both rail corridors on time and achieved satisfactory completion of the performance and reliability requirements for the project.

Over 1.5+ million man hours were expended on the project without major incident. TAJV safely inducted over 900 staff on both rail corridors, all of whom worked successfully beside live rail for the life of the project. The long linear nature of the two rail corridors meant that multiple environmental biosites needed careful management. TAJV completed the works without adverse affect to any biosite and the project team restored the heritage listed Portland Flat Road Bridge.

As at January 2006, commuters on the Geelong line could travel to and from Melbourne within the target time of 45 minutes. Commuters on the Ballarat line can now travel to and from Melbourne in the target 64 minutes. The integrated and innovative approach of the Thiess ALSTOM Joint Venture has established the benchmark for the successful delivery of rail projects in Australia.

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INTRODUCTION

The Regional Fast Rail (RFR) project involved the design and construction of new and upgraded rail and signalling infrastructure on both the Geelong (70 kms of dual track) and Ballarat (100 kms of single track) rail corridors.

The project delivered the greatest upgrade of regional rail in over 120 years in Victoria. The broad scope involved not only the renewal and upgrading of the track, signalling safety systems and train control, but also included the requirement for new trains and station renewals.

The project was designed to bring regional and metropolitan communities closer – to enhance economic and social opportunities, via the provision of a faster and more reliable regional rail service between Melbourne and the regional centres.

One of the government's key requirements was the delivery of improved run times for the new V/Locity trains along the upgraded Ballarat and Geelong rail corridors. The performance-based Design and Construct contract was set by the client, the Department of Infrastructure (DOI), and based on the performance modelling of the new country rolling stock.

PROJECT SCOPE

The Thiess ALSTOM Joint Venture (TAJV) had to achieve a run time from Werribee to Geelong of 19 minutes, so that passengers could get between Geelong and Melbourne in 45 minutes, regardless of direction.

TAJV had to achieve a run time from Sunshine to Ballarat of 47 minutes, so that passengers could get between Ballarat and Melbourne in 64 minutes, regardless of direction.

TAJV used the latest international technology with the SIMMU++ train simulation package, to develop the optimum track alignment and signalling aspect sequences to achieve the required run times while maintaining the density of trains on the corridor. The scope included the upgrading of track, level crossings, new and innovative signalling systems, a new centralised train control system and the design and construction of two of Australia's largest rail bridges as well as the 8.2km Bungaree deviation.

SIGNALLING AND TRAIN CONTROL

REQUIREMENTS FOR CHANGE

The increase of maximum line speed from 130 km/h to 160 km/h required a change to the signalling system to account for the increased braking distance and the need for drivers to sight signals at a greater distance. The signalling system that existed on the line was a mixture of equipment installed over the past 80 years including:

- Pre-first world war mechanical signalling with semaphore signal arms and rod operated points
- 1950's relay interlockings with open aerial conductors
- Various 1980's remote control systems (SCADA) for small parts of the corridor

Prior to the project, the control of the signalling on both corridors was performed by localised signal boxes - each operator controlling a limited area of the corridor using simple unit lever panels and mechanical manual lever frames. Train control was

performed at Melbourne via hand drawn graphs and a telephone to the operator in the local signal boxes. The increase in speed and train density meant that this antiquated system needed to be upgraded with a whole of corridor system to provide increased train visibility and control.

SIGNAL SIGHTING

The signalling planning process included the necessary procedure of determining the placement of signals so that they are visible to the drivers and positioned so that there is sufficient margin to allow drivers and trains to react and bring their train safely under control. This process involved the temporary placement of trial signals for observation under various conditions and also relied heavily upon the experience of senior drivers. All signals were sighted and the placement agreed between all parties before the signalling system was installed.

All signals were replaced with LED signal light units which have improved visibility and provided a longer life cycle than incandescent lamps.

LEVEL CROSSING CHALLENGES / INNOVATIONS

TAJV was also responsible for designing, constructing and commissioning the upgraded level crossings. Works had to be progressed amidst operating trains and road users requiring extensive road detours and community relations management. The level crossing protection on both corridors was upgraded on the basis of a risk analysis. The levels of upgrade available were:

- Flashing light protection
- Full boom barrier protection
- Pedestrian gates crossings

Integration of the level crossings into the signalling system was required and the train control system was utilised for remote monitoring.

TAJV delivered an innovation for level crossing road surfaces by introducing new rubber panels, a first in Australia,

TRAIN CONTROL CHALLENGES / INNOVATIONS

Prior to the RFR upgrade, the Train Controller had no real-time information regarding the position of trains. He/she relied on telephone messages from the local operator to manage the corridor. On conclusion of the works the new Train Control and Monitoring System (TCMS) included;

- A Regional Train Control System (at Geelong and Ballarat) that provides improved operational control of the corridors and increased train visibility.
- A Central Monitoring System (at Melbourne) that provides real time information about the position of trains and the condition of the infrastructure on both corridors for the Train Controllers
- A Fault Management System (at Melbourne) that provides remote monitoring and alarm management of all active signalling equipment including level crossings

The heart of the TCMS is the Regional Control System (RCS) SigView, a 'Point and Click' Graphical User Interface (GUI) based train control system run on a 'commercial off the shelf' PC operating system.

Real time displays show the train location and the status of the signalling equipment across a number of LCD monitors and it includes a large feature set from individual commands to automatic route setting.

Dual servers are used for redundancy and all events are logged and backed up for fault finding and maintenance. With its introduction at Ballarat and Geelong, the multiple local signal boxes were rationalized into one regional control centre with a single operator.

The Central Monitoring System (CMS) allows the Train Controller at Pacific National's headquarters in Melbourne to see real time information about the position of trains and the status of the signalling equipment on both corridors. Where as before the train controller relied on verbal information, the CMS displays now allow the operator to make appropriate decisions and minimize delays on the corridor by predicting the future conflicts between trains.

The Fault Management System (FMS) includes the same functionality as the CMS with an additional suite of maintenance and fault finding tools including a Replay Facility and a text based Event Recorder.

The Replay Facility allows a graphical play back of the event logs to show the status of the signalling equipment can be in real time, slow motion or at a high speed. The replay has been used to investigate faults and incidents on the system to determine the cause and thus allow steps to prevent recurrence of the incident.

Control and Indication data is gathered in the field through a variety of local interface equipment including point to point logic controllers, radio based remote terminal units and a direct interface into the vital signalling computers. The data is collected and processed at a dual multiplexer computer located at the main field control room, before being processed to the operator SigView via a fibre optic network.

SIGNALLING CHALLENGES / INNOVATIONS

The signalling required the installation of new signalling conduits, cables and equipment boxes which were installed along the length of both corridors and which was used to connect the 232 signals, 76 motor operated points, 484 train detectors, 18 sets of automatic pedestrian gates and 62 actively protected level road crossings.

Supply

The TAJV team were presented with significant challenges with regards to the sourcing, assembly and installation of the signalling system along the two corridors.

Componentry for the new system had to be sourced from multiple locations, assembled and tested on site, within the confines of the project timelines.

Location equipment boxes containing the equipment used to operate the signalling system had to be wired for a specific location. The boxes were manufactured in Victoria and NSW and shipped to site in a fully tested condition – this process was carefully planned with regard to the overall project timelines.

After the boxes were erected on site they were connected to the Fibre Optic and Copper cables that were installed along the rail corridor and ultimately connected to the line side equipment.

Train Protection and Warning System

As part of the safety case to introduce 160 Km / hr train running, a new system was required that enforced the restrictive signal aspects to the train braking system.

The solution was the TPWS (Train Protection Warning System), together with the signalling system it provides a warning to train drivers at junctions, sidings and crossing loops to enable them to control the speed of their train, to prevent collisions and over speeding.

The TPWS system measures the speed of trains as they approach a restrictive or stop signal, and in the event that the driver does not adequately control the speed of the train, the (TPWS) automatically applies the brakes at a sufficient distance to stop the train.

The TPWS formed the critical part for the safety case of the signalling design to be accepted by the regulator and was another first in Australia.

Solid State Interlocking System

The signalling system was based upon the computer based Solid State Interlocking System (SSI), which was installed for the first time in Australia with vital fibre optic communication links driving the field signalling equipment.

The SSI operates on a triplicated computer system with the ability for each processor to compare its outputs with the other processors and if a difference is detected the system will fail the faulty processor and continue as long as two processors produce the same output.

The software design was carried out in Australia and was subject to a rigorous checking process followed by a full office simulation where each train movement and each operation was tested to ensure that the system installed was both safe and functional.

The Optic Data Link Interface Units (ODLIU) were designed and manufactured in Australia and provide a direct FO interface between the trackside SSI data link modules and the dark FO cable with no changes required to the SSI system.

The Train Protection and Warning System (TPWS) was integrated into the SSI system both at the hardware interface and at the software data structure level. This was another first in Australia.

SIGNALLING AND TRAIN CONTROL CHANGES SUMMARY

Signalling Upgrade for the Geelong Corridor

Werribee to Geelong	Before	After
Control Centres (Signal Boxes)	4	1
LED Signals (colour light type)	Nil	120
Track Circuits	209	234
Motor points	21	51
Automatic Pedestrian Gates	Nil	9
Boom Barrier crossings	10	12
Flashing Light Crossings	Nil	Nil
Route length	40.3km	40.3km

Signalling Upgrade for the Ballarat Corridor

Sunshine to Ballarat	Before	After
Control Centres (Signal Boxes)	3	1
LED Signals (colour light type)	Nil	112
Track Circuits	215	250
Motor points	13	25
Automatic Pedestrian Gates	Nil	9
Boom Barrier crossings	9	32
Flashing Light Crossings	21	18
Route length	105.3Km	100.3Km

BUNGAREE DEVIATION CHALLENGES

The Bungaree Deviation is an 8.2 km section of new rail alignment designed to eliminate a number of small radius curves and low track speed on the existing alignment.

TAJV designed the deviation for the maximum permitted speed of 160km/h to achieve the required run time between Sunshine and Ballarat.

The construction deviation included the following:

- 8.2 km in length from Sullivans Road in Millbrook to Torpeys Road in Dunnstown
- 380,000 m³ of cut to fill earthworks including
 - 80,000m³ of rock from the 14m deep Cut 7
 - 6 km long haul road from cut to fill transporting fill material over Lal Lal Creek and Moorabool River
- Construction of 4 road over rail bridges
 - Sullivans Road (16m span) including the demolition of the existing road over rail bridge
 - Spread Eagle Road (12.5m span)
 - Peerewerrh Road (12.5m span)
 - Old Melbourne Road (18.5m span)
- Construction of 2 rail over bridges (some of the largest rail bridges in Australia)
 - Moorabool Bridge
 - Maximum height: approximately 27m above ground
 - Length: 270m; 10 spans of 27m
 - Weight of largest pier: 25tonne
 - Weight of beams for lifts: 62tonne. Beams lifted by a single crane
 - Over 150tonne of steelwork in piers
 - 900m³ of in-situ concrete (excluding precast units)
 - Lal Lal Bridge
 - Maximum height: approximately 40m above ground
 - Length: 363m; 11 spans of 33m
 - Weight of largest pier: 82tonne

- Weight of beams for lifts: 76tonne. Beams dual lifted
- Over 500tonne of steelwork in piers
- 1650m³ of in-situ concrete (excluding precast units)
- Construction of 8.2 km of new rail track using concrete sleepers and 60kg/m rail with 60kg/m, 1 in 15 tangential turnouts on concrete bearers at each end of the deviation to connect into the existing alignment. There is no intermediate crossing work or at grade road crossings on the length of the deviation.
- A new signalling system was designed and constructed for the deviation that allowed train movements on the deviation in both directions and train movements on the existing loop line through Bungaree. The signalling system allowed both passing movements (with trains travelling in opposite directions) and overtaking movements (with trains travelling in the same direction) without the need to stop either train. The signalling system was completely integrated with the signalling on the remainder of the corridor and was remotely controlled from the Regional Control Centre at Ballarat.

The design and construction of the Bungaree Deviation proved to be one of the most significant challenges facing the TAJV team. Although it was a green field site and the work was able to be planned and programmed away from the frenetic construction activity that was necessary to achieve completion of the infrastructure upgrades during the programmed main line shut downs, there were a number of unique engineering problems to solve. These issues included:

- Finalisation of the rail alignment to minimise the impact on the local farming community. There was significant opposition from the local community to the deviation.
- Design and construction of the deep cuts that bisected underground aquifers and the solutions that will ensure the track structure is not adversely affected by rising water table.
- Programming the works around the normal wet and cold weather conditions typical of this part of Victoria.
- The design and construction of the Moorabool River and Lal Lal Creek bridges to minimise the amount of site works. The design and construction of these bridges was “game breaking” innovation.

INNOVATION IN THE RAIL BRIDGES

The construction of the Moorabool River and Lal Lal Creek bridges on the Bungaree Deviation included many innovative design and construction solutions. The challenge for the design team was to develop an innovative design that would minimise the on-site works and therefore minimise risk for the construction phase of the project. The design and construction methodology included the following objectives:

- Minimise work at heights
- Prefabricate and preassemble as much as possible
- Include access systems in the prefabrication
- Assemble as much on the ground as possible
- Use physical handrails rather than fall arrest systems

The adverse weather conditions expected during the construction period and the difficult site access resulted in detailed planning of the logistics for getting loads into site, the delivery and storage of beams and the sizes of cranes and lifting positions. During the design phase the following alternatives were investigated using cost comparisons and risk assessments:

- Launched superstructure or beams
- Concrete or steel piers
- Super T or steel beams
- Number of spans
- Position of piers

During this process the following design – constructability interfaces were considered in detail:

- Rock Anchor to spread footing base
- Steel Pier to foundation
- Steel Pier to Precast Concrete Crosshead
- Precast Concrete Crosshead to Super T beam
- Beam to precast ballast wall

Following this detail evaluation a number of innovative design solutions were developed.

Foundation design was targeted to suit the range of geotechnical conditions found during detailed investigations at the 2 sites.

- At Moorabool River 2 foundation types were used:
 - Bored piles that encountered a confined aquifer that required a dewatering solution.
 - Spread footings with rock anchors. The rock anchors were used to resist wind loads, which cause overturning moments.
- At Lal Lal Creek a broad range of foundations types were adopted due to the variation in the ground conditions. These included:
 - Spread Footings with rock anchors
 - Driven piles with pre-bored holes
 - Driven piles
 - CFA Piles where soft silts above the dense sands would cave in during excavation. Bored piles would have required bentonite or casing to stabilise the ground, which was expensive and environmentally unacceptable because of likely run-off into the creek.
 - Bored piles
- Connection details for the pier to foundation connection
 - Preassembled HD cage delivered to site in one piece weighing up to 1tonne. Each pier base and HD cage a unique size
 - Locating bolts incorporated in the cage to enable the steel pier to be located easily
 - Oversized base plate hole used again to ease locating the steel pier
 - Use of a template to match drill the base plate and anchor plate

- Innovative concrete core fill to the bottom 1.5m of the steel pier and to form a plug connection to the pile cap. This eliminated the need for a second internal row of HD bolts for the pier
- Steel Wind Tower columns adopted for the bridge piers
 - Fabricated by Keppel Prince in Portland
 - Lal Lal piers rolled from 32mm plate with a maximum length of 38m and maximum weight of 82 tonnes. Base diameter up to 4.5m tapering down to 1.5m at the top
 - Moorabool piers rolled from 20 – 25mm plate with a maximum length of 25m and maximum weight of 25 tonnes
 - All the piers were transported to site in one section including the platforms and access systems to enable piers to be erected straight off the truck.
- Precast concrete crossheads weighing 27 tonne were lifted onto each steel pier. Permanent access platforms were installed on the crossheads on the ground prior to final erection.
- Super T precast concrete beams were used ranging from 62 tonne-76 tonne and lengths from 27m – 33m. There are 3 beams for each span. All beams were fitted out on the ground prior to lifting into final position. The fit out included the installation of ballast walls incorporating permanent hand rails, drainage system and temporary handrails around lifting points. Additional lifting clutches were incorporated to take into account the change in centre of gravity due to the beam fit out.

The use of very large steel columns, precast beams, and crossheads required detailed planning for each lift. Mobile cranes were used for all the lifts and special attention was placed on prepared detailed engineering solutions for all lifts including access roads and the provision of piled support systems and embankment strengthening works for the crane positions.

CONCLUSION

The signalling and control system was seamlessly integrated with the existing signalling at the corridor boundaries. The signalling and train control system was installed complete with the following innovations;

- Train Protection and Warning System (TPWS) system to enforce train speed
- New FO based Solid State Interlocking (SSI) system enforcing speed proving of all restrictive signal aspects
- An improved real time Train Control System providing whole of corridor visibility at Ballarat, Geelong and Melbourne, including automated signalling controls, fault monitoring and management tools

The design and construction of the Bungaree Deviation and in particular the construction of the major bridges proved to be one of the most significant challenges that faced the TAJV team. The major risks of working at height, the weather constructing through the winter months, remote access and ground conditions, were meticulously planned and designed in detail such that the bridges were delivered safely, on time and below budget. The planning and execution of the bridge

construction was described as 'the most professional observed for such work' by Client review.

As a legacy the access system incorporated into the design not only enabled a safe system for the bridge erection but also access for maintenance inspection of these remote bridges without the need for expensive access equipment.

The rail infrastructure and rolling stock upgrade allowed the following increase in the number of train services and reduced travel time;

- 91 more services per week for the Ballarat Line
- 38 more services per week for the Geelong Line
- 24 minutes reduction in travel time for the Ballarat Line
- 13 minutes reduction in travel time for the Geelong Line
- 30% patronage increase across both corridors