RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Rail Industry Safety and Standards Board (RISSB)

Assessment of interoperability issues from the proposed introduction of new train control systems

v1.0, September 2019

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palazzirail

New systems present an interoperability issue that must be addressed, for the good of the industry and the nation

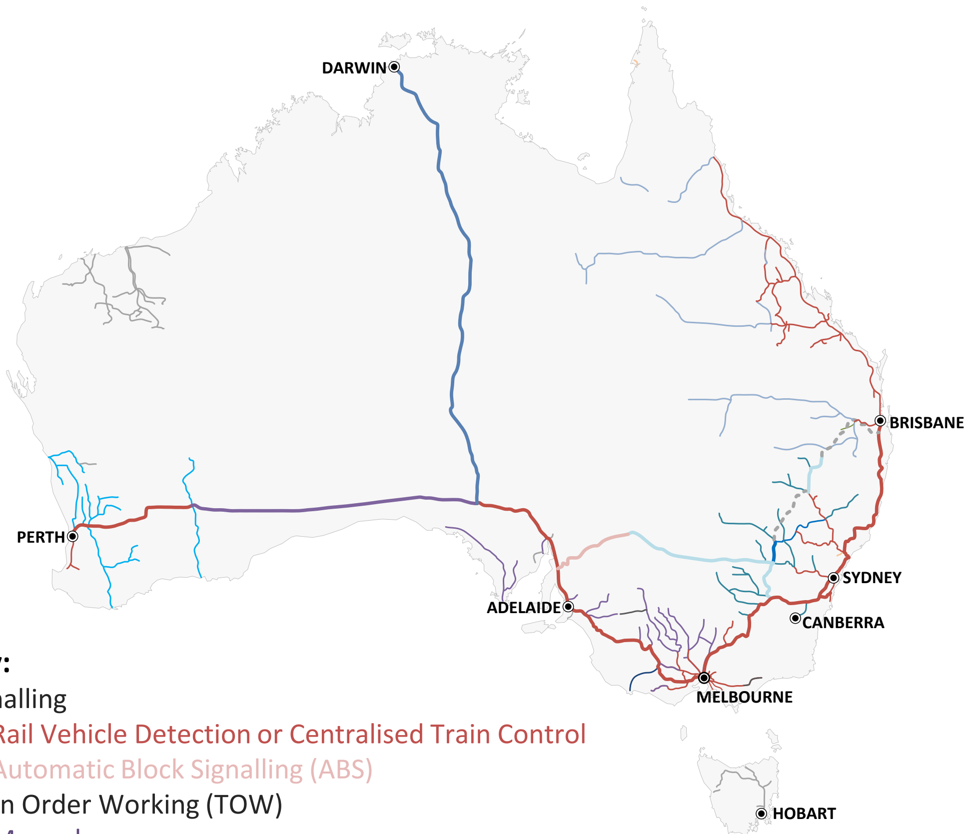
The issue

- A number of railways are moving to adopt new network control systems in order to maximise the value (capacity, efficiency, safety) of their rail asset. A key characteristic of these new systems is the need for both trackside and onboard components.
- Because of the integrated nature of rail operations across Australia, greatest efficiency of the network will be achieved with cooperation and integration between rail operators and rail network owners/managers, and between adjacent rail networks.
- An integrated approach to network control systems across Australia has the potential to provide many benefits to the rail industry generally, to individual businesses involved in the rail industry, and to the economy. Conversely, a disjointed approach will have consequences that will last for many years, including higher costs and lower competitiveness for rail transport.

What is an interoperability assessment and what is its scope?

- RISSB has produced AS 7666 Train Protection and Control Interoperability to assist network managers in the adoption of new technology whilst not creating inefficiencies and costs for operators who use the networks.
- AS 7666 calls for the proponents who seek to introduce new systems to undertake an assessment on whether there will be operating impacts on users of the network or on adjoining networks. It requires definition of the geographic and operating impact and the development of a plan to minimise the impact.
- Normally the interoperability assessment would be done by a proponent for the network it manages. However, given the interconnectedness of the national rail system RISSB has decided undertake this interoperability assessment to ensure the complete impact of new systems is understood.
- This assessment focuses on the connected elements of the national rail network, including:
  - the Defined Interstate Rail Network (DIRN) and the networks that support the DIRN (such as urban networks in Sydney);
  - regional networks that connect to the DIRN or use urban networks to access ports;
  - coal networks that also have other users; and
  - long distance passenger trains that use all of these networks.
- The assessment excludes stand alone networks such as Tasmania, the Pilbara iron ore lines (which are leaders in the use of these new systems), and the Sydney Metro.

The current diversity of 'historic' train control systems adds cost to rail operations, and constrains capacity and performance



Key:

Signalling

- Rail Vehicle Detection or Centralised Train Control
- Automatic Block Signalling (ABS)

Train Order Working (TOW)

- Manual
- WestCad
- Ansaldo STS Train Order System (TOS)
- Phoenix Train Order System (PTOS)
- Direct Traffic Control (DTC)
- Train Management and Control System (TMACS) with voice transmission
- TMACS with data transmission

Staff and Ticket (S&T)

Out of scope

Systems in use (within the scope of this assessment)**:**

1. At least 10 different signalling and train control systems are in used across Australia.
2. Within the 10 different systems each state or jurisdiction typically has its own distinct safeworking rules – meaning that there are more than 17 distinct safeworking systems in use.

Current issues:

Gaps in safety for trains (lack of speed or end of authority enforcement) and track workers (procedural nature of track work authority process).

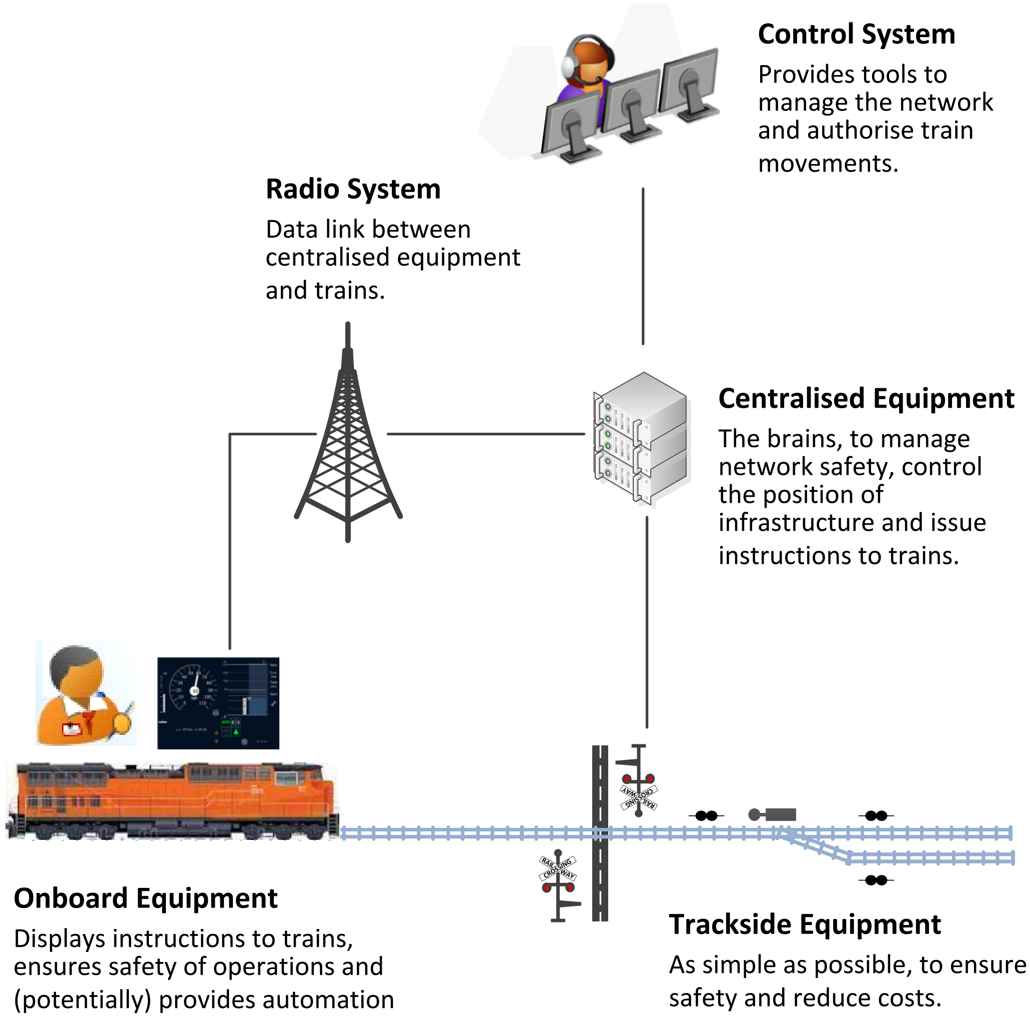
The number of systems in use creates a burden in management, competencies, etc.

Much of the existing signalling and train control equipment is approaching life expiry and replacement will be very expensive.

Current systems constrain network capacity and do not permit network optimisation.

New systems use modern technology to enhance safety and capacity, and reduce costs.

- Existing train control systems focus around complex and expensive trackside infrastructure, whilst being reliant on the driver to ensure safety of train operations.
- New train control systems differ from those currently in use in a number of significant ways:
  1. Systems include both Centralised and Onboard components, which must communicate with each other.
  2. Systems are dependant on a data radio link.
  3. Systems aim to simplify trackside equipment.
- Compared to current systems, the new systems provide:
  - Enhanced safety of train operations and for track workers;
  - Better network management tools, including better capacity (ability to have more trains use the same track);
  - Lower costs, due to less trackside equipment;
  - Opportunity for further enhancements, including semi and full automation of train movements.



Different networks require systems that are aligned with their business needs

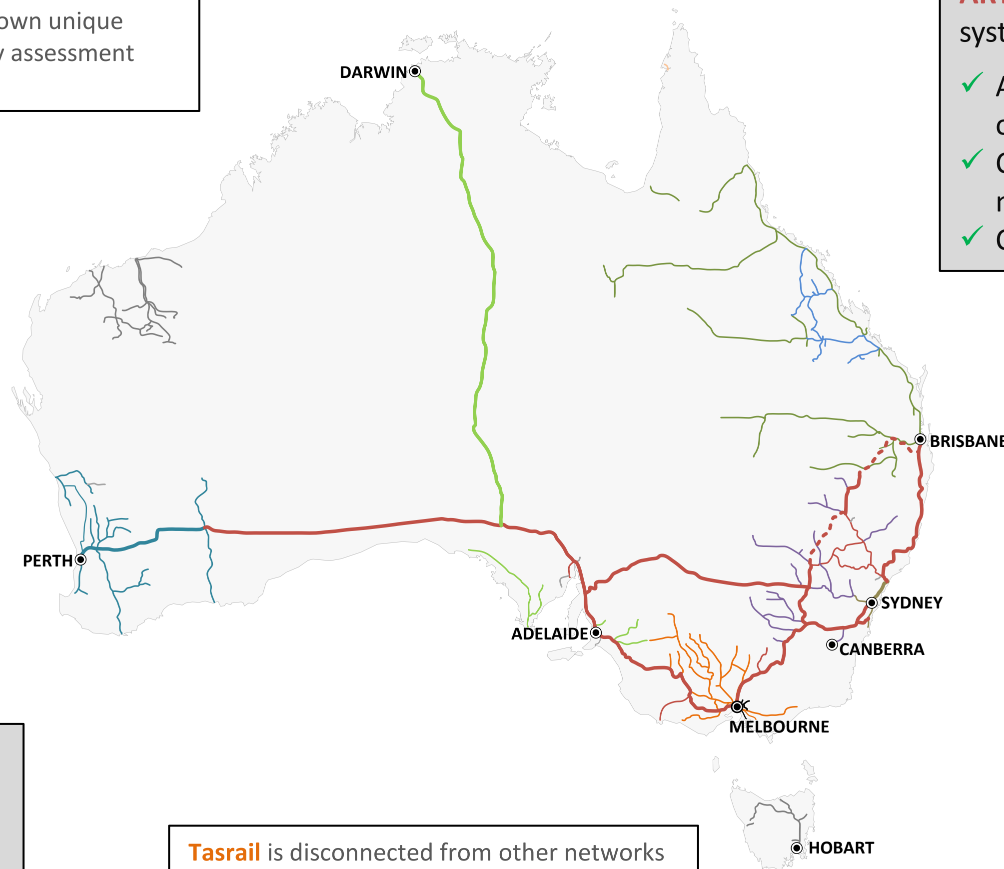
The **Pilbara railways** are disconnected from other networks in Australia and have their own unique operating needs. This interoperability assessment does not apply to these railways.

The Defined Interstate Rail Network, which includes components managed by **ARTC**, **GWA** and **Arc Infrastructure**, requires systems that typically:

- ✓ Are suited to long railways
- ✓ Optimise movements on a single- or double-track railway
- ✓ Are robust to power and communications outages

Regional networks, such as those managed by **VicTrack**, **John Holland Rail**, **Queensland Rail** and **Arc Infrastructure**, require systems that typically:

- ✓ Focus on simplicity,
- ✓ Optimise movements on a single track railway
- ✓ Minimise costs.



Tasrail is disconnected from other networks in Australia and thus has no interoperability problems. However, as a small network it may benefit from economies of scale as a result of a mainland interoperability strategy.

Coal network, managed by **ARTC** and **Aurizon,** require systems that typically:

- ✓ Are suited to a dense operating environment
- ✓ Can apply to single, double or multiple track areas
- ✓ Can work over long distances

Urban networks, such as in **PERTH**, **ADELAIDE**, **MELBOURNE**, **SYDNEY** and **BRISBANE**, require systems that typically:

- ✓ Are suited to dense operating environments,
- ✓ Optimise passenger train movements
- ✓ Provide high infrastructure reliability and availability.

Four system alternatives are under active development in railways across Australia

Railway Type	Metro	Suburban	Coal	Interstate	Regional

Typical Characteristics

Train frequency	High ↔	Low
Corridor length	Relatively short ↔	Relatively long
Stopping frequency	High ↔	Low
Traffic and journey variability	Low ↔	High
Interfaces	Few ↔	Many

Selected Network Control Systems

CBTC (Metro)
ETCS L2 (Metro to Coal)
ATMS (Coal to Regional)
Enhanced TOW (Interstate to Regional)

Communication-Based Train Control (CBTC) is the de-facto standard system for high capacity metro lines.

- ✓ Ideally for an isolated, self-contained railway.
- ✓ Offers high levels of automation.
- ✓ Designed to optimise passenger train operations.
- ✓ Specific solutions from individual suppliers, that do not interface.

E.g. Sydney Metro
Melbourne Metro

European Train Control System Level 2 was developed to facilitate interoperability across Europe but is now global.

- ✓ Different suppliers working to common specifications.
- ✓ Accommodates variety in traffic types and operations.
- ✓ Can be enhanced with automation.

E.g. Sydney Trains
Queensland Rail (SEQ)

Advanced Train Management System (ATMS) is being developed by ARTC specifically for it's railway conditions.

- ✓ Single supplier but open interfaces.
- ✓ Designed to optimise long distance railways, at a low cost.
- ✓ Robust to cope with remote environments.

E.g. ARTC

Enhanced Train Order Working (eTOW) is a progressive improvement of traditional systems, using technology to improve capacity and safety.

- ✓ Focus on simplicity and low cost.
- ✓ Enhancements can be added onto the base system, as required.
- ✓ Multiple suppliers progressing different initiatives.

E.g. John Holland Rail (NSW regional network)

Further information: Slides 30-37

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Characteristics of system alternatives

Characteristic	CBTC	ETCS L2	ATMS	Enhanced TOW
Natural fit for	Isolated, high density metro lines	High capacity suburban and interurban lines	Long distance interstate corridors	Regional lines
Capacity	High – Very High	High	Moderate	Low - Moderate
Suitable for trains	Metro	Suburban, regional, freight	Freight, regional	Freight, regional
Suppliers	Multiple	Multiple	Single	Multiple
Standards	Common standard, proprietary implementation	Common standard, interoperable	Proprietary	Proprietary
Onboard system	Specific	Specific but interoperable	Specific	Non-specific
Communications System	Wi-Fi / LTE	GSM-R / GPRS	Designed for 4G and satellite, as used on the ARTC network	Variable, including satellite
Proven interoperability arrangements	Retain signals for non-fitted trains	Dual fit trackside, interfaced onboard, retain signals for non-fitted trains	Retain signals for non-fitted trains	Interfaced onboard
Other possible interoperability arrangements	None		Dual fit trackside, interfaced onboard	None required

Interoperability may pose an issue for all trains crossing network boundaries, including freight and passenger trains

- Interstate trains use the ARTC network, as well as one or more additional networks, depending on the route. This includes urban networks such as Sydney.
- Intrastate trains typically use regional networks, part of the interstate network, and may also enter urban areas.
- **Long distance passenger trains are perhaps worst affected -** The iconic Indian Pacific passenger train traverses networks managed by Sydney Trains, John Holland Rail, ARTC, Arc Infrastructure and Public Transport Authority WA – 5 networks in total.

Some example routes:

Interstate freight

Sydney to Perth

Melbourne to Brisbane (via coast)

Adelaide to Darwin

Intra-state freight

West Wyalong to Port Kembla (NSW)

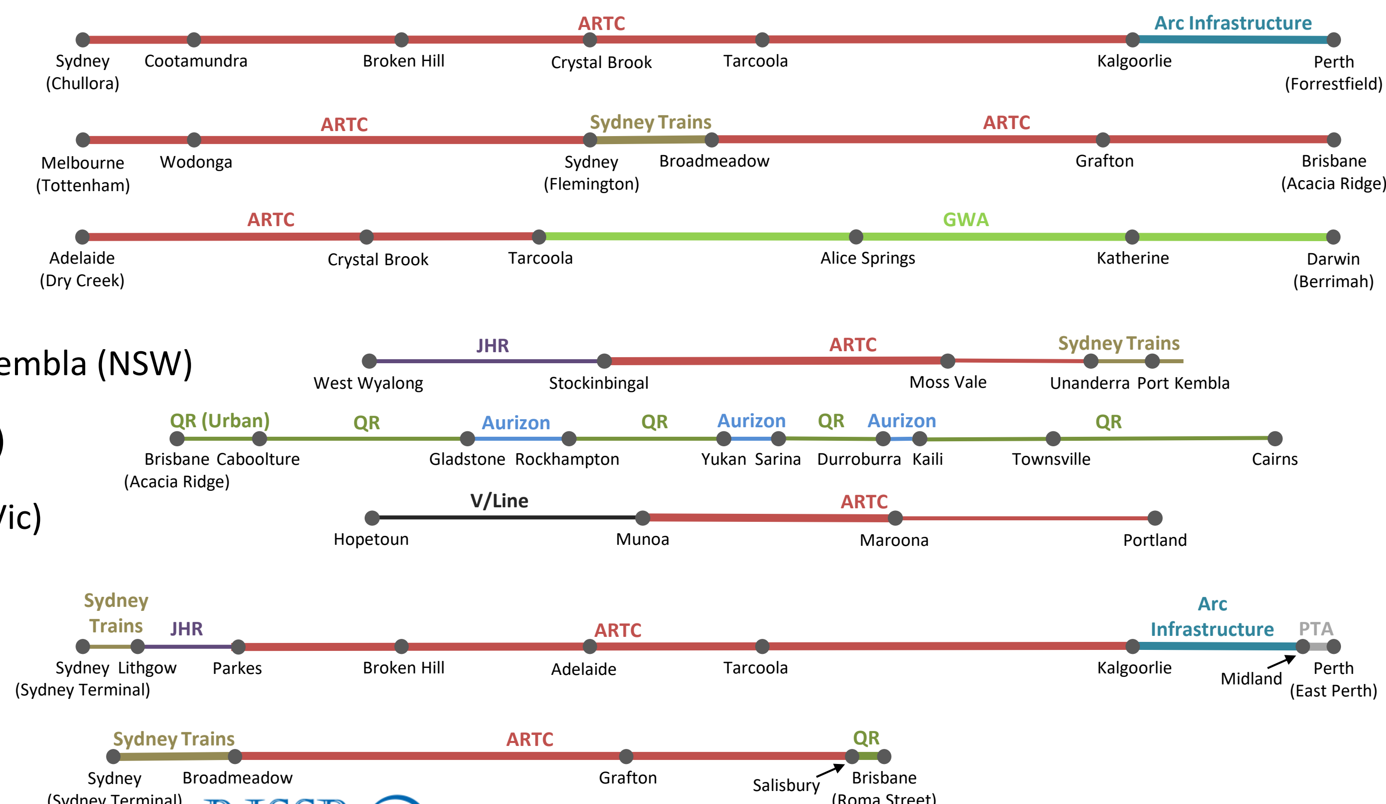
Brisbane to Cairns (QLD)

Hopetoun to Portland (Vic)

Passenger

Sydney to Perth (Indian Pacific)

Sydney to Brisbane



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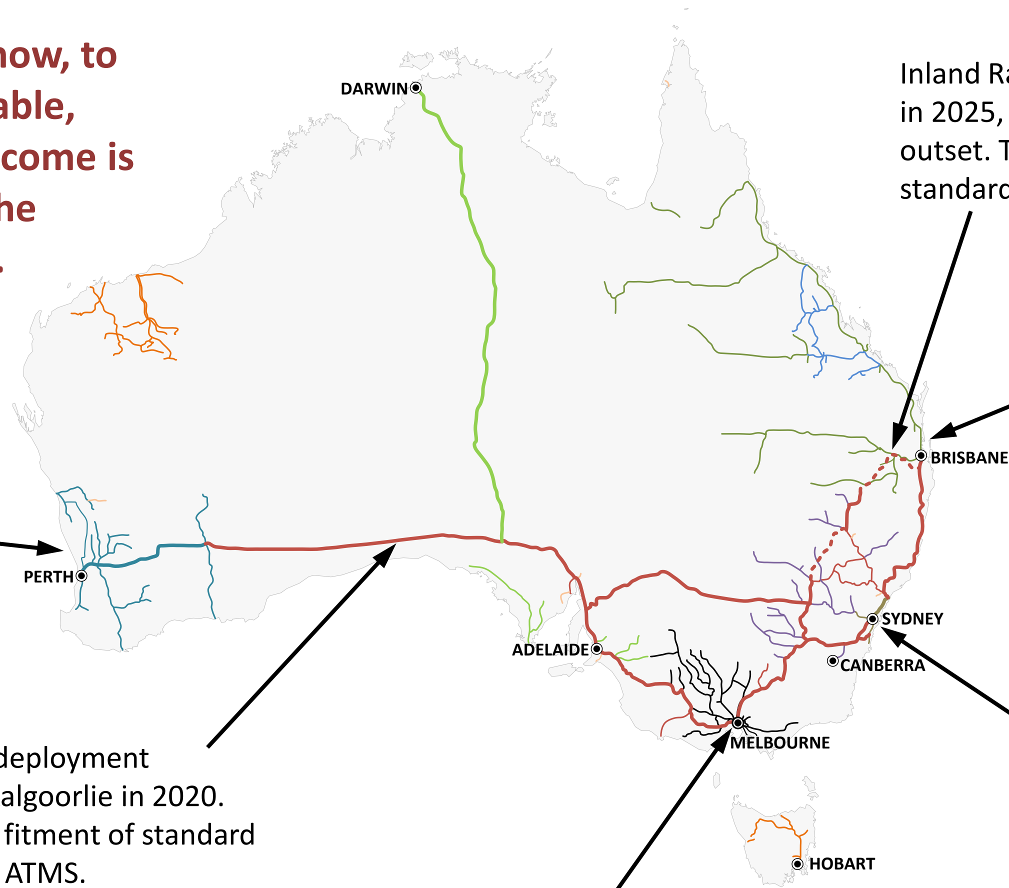
Based on current deployment planning, interoperability issues will emerge around 2024-2025

Work must start now, to ensure an acceptable, interoperable outcome is achieved across the national network.



Inland Rail will commence operation in 2025, using ATMS from the outset. This may impact both standard and narrow gauge trains.

Transport and Main Roads is planning to implement ETCS in central Brisbane in conjunction with Cross River Rail, from 2024. This will impact long distance passenger trains operating to Roma Street.

PTA is planning CBTC deployment across the Perth network in the 2020s. This will impact long distance passenger trains from Perth.

Transport for NSW is implementing ETCS on the Sydney Trains network from 2022. The first areas that impact on long distance trains will be commissioned in 2024/25

ARTC is planning ATMS deployment between Tarcoola and Kalgoorlie in 2020. This will commence the fitment of standard gauge locomotives with ATMS.

CBTC will be deployed in Melbourne as part of the Metro Tunnel Project in 2024. This will impact broad gauge freight from the east of Melbourne. The approach for train on Melbourne's west, including those interacting with standard gauge trains, is yet to be determined.

A good outcome meets allows each rail business (above- and below-rail) to meet their needs within a coherent national framework

Effective — Provides the required functionality for efficient rail operations

Upgradeable — Systems must be supported, and must provides a pathway to further enhancements / integration with other systems .

Safe — **The Rail Safety Act requires safety risks to be reduced So Far As Is Reasonably Practicable.**

Scalable — One or multiple systems that can be cost-effectively applied across all types of railways in a seamless way, i.e. suburban, coal, interstate and regional.

Harmonised — Harmonising of safeworking systems across state boundaries, wherever one signalling and control system is used, the same safeworking rules are applied.

Interoperable — Each train fleet can operate over the required network(s) with only one onboard system for network control purposes.

Options for interoperability between systems

Interoperable trackside			Interoperable onboard		
Dual fit trackside	**Interfaced trackside**	**Retain signals**	**Dual fit onboard**	**Interfaced onboard**	**Portable onboard**
Complete fitment of both systems trackside, with one interlocking dominant. Each trackside system communicates with its specific onboard.	One system fitted trackside, but is able to send messages to either onboard unit.	Only one system fitted trackside, communicates to one onboard solution only. Signals provided to allow the passage of trains with other onboard units.	Complete fitment of both systems onboard. The appropriate onboard system is active depending on the trackside system.	One system fitted onboard, but is able to receive messages from either trackside system.	Trains fitted with a primary onboard system. Simple onboard system used to receive message from non-fitted system, to allow passage of train.
Pros					
More straightforward trackside interface between systems. Both systems provide enhanced safety.	Both systems provide enhanced safety.	Potentially the option with lowest deployment risk. May be a useful transition stage.	More straightforward onboard interface between systems. Both systems provide enhanced safety.	Can streamline onboard requirements and simplify arrangements for drivers.	May provide a relatively simple and cost effective interoperability option. May be a fall-back arrangement in the longer term.
Cons					
Dual fit of systems can be costly for network owners. Potential differences in safeworking capability between systems.	Interface between systems may be complicated and difficult to achieve.	Costly for network owners. Safety benefit not available to trains using signals. Capacity benefits from new systems not realised	Onboard space is often at a premium. Human factors issues with switching between systems. Costly for operators.	Interface between systems may be complicated and difficult to achieve.	Likely to involve operational restrictions when using portable. Difficult to achieve safety benefits.

Benefits to operators and network managers

Above rail operator	Below rail network manager
Benefits of new train control systems generally	
Improve safety of operations	Improve safety of operations Improve safety for network maintenance
Reduce costs by: • Savings in fuel and brake use	Reduce costs by: • Minimising the amount of trackside equipment
Enable future enhancements: • Additional enhancements such as Driver Advisory Systems, semi-automation	Improve network capacity Improve efficiency of network management
Additional benefits of interoperability and harmonisation	
• Improved safety as a consistent and considered national solution is achieved, minimising the risk of confusion between systems leading to error.	
• Reduce costs of equipment, including capital and ongoing costs. • Reduced down-time in fitting and maintaining multiple systems.	• Ability to share development cost for new systems. • Greater ability to piggy-back off initiatives by other networks.
• Reduced costs of workforce training and competence management.	• Reduced costs of workforce training and competence management.
• Rail is more competitive against other transport modes.	• Better outcomes for customers (i.e. operators).
• Economic benefits to the nation with greater productivity of the rail transport offering.	

ICE Radio: an interoperability success story

To support the implementation of the National Train Communications System (NTCS), and to ensure efficient rail operations on the DIRN, ARTC sponsored the development of ICE, In-Cab Communications Equipment. The system is now in use across the DIRN, as well as in adjoining networks such as the NSW and Victorian regional networks.

Single driver's console

Single enclosure with multiple voice and data channels

GSM-R | Satellite | UHF (analog, digital) | 3G (UTMS, HSDPA) | Other?

ICE provides a single system on a locomotive that can communicate through multiple channel options, depending on the solution appropriate to the operations. ICE was initially equipped with systems relevant at the time of fitment, however is able to be upgraded and expanded to accommodate future radio systems as they are deployed.

ICE provided benefits to both network owners and operators, in upfront and ongoing cost savings, as well as reducing training durations and downtime of locomotives for fitment and maintenance.

The ICE commercial model may also represent a starting point for future interoperability initiatives, where initial equipment was provided free-issue to operators, with the proviso that operators manage and maintain the units in the longer term.

Refer to http://www.base2.com.au/Mobile-Communications/ice-radio.html

Barriers and opportunities

Technological

Barriers

- Technical complexity in developing an interoperability solution.
- Issues with interfacing to proprietary systems
- Existing system choices have pedigree from different areas / conform to different standards.
- Lack of value in developing independent national standards.

Opportunities

- Develop an interoperability framework for Australia, in consultation with industry.
- Use open interfaces, where they exist.
- Leverage off international developments as far as possible, e.g. adopt international standards for passage of data.

Commercial

Barriers

- Cost of developing an interoperability solution may be significant, and tends to fall on individual operators / network managers when it is actually an industry-wide issue.
- Cost of fitment of locomotives may be substantial, plus disruption to business during the process.
- IP issues with individual systems result in challenges to create an interface.

Opportunities

- Goodwill of industry – the problem is understood and, with appropriate commercial support, these barriers may be overcome.

Safety

Barriers

- Some necessary steps may arguably provide a perceived lower level of safety
- Traditional safety approach can be unrealistic to commercial realities.

Opportunities

- A better understanding of the SFAIRP framework, and a realistic consideration of what is 'reasonably practicable,' will enable a broader range of possibilities to be considered.

Operational

Barriers

- Widely varying operational needs of different rail networks
- Different safeworking cultures across different railways
- Coordinated organisational changes required across industry

Opportunities

- Can use this transition to move to a harmonised national system, eliminating the legacies of the past.
- Will provide greater efficiencies for rail and a robust platform for future productivity growth.

Further information: Slides 49-51

Appendix

Appendix overview

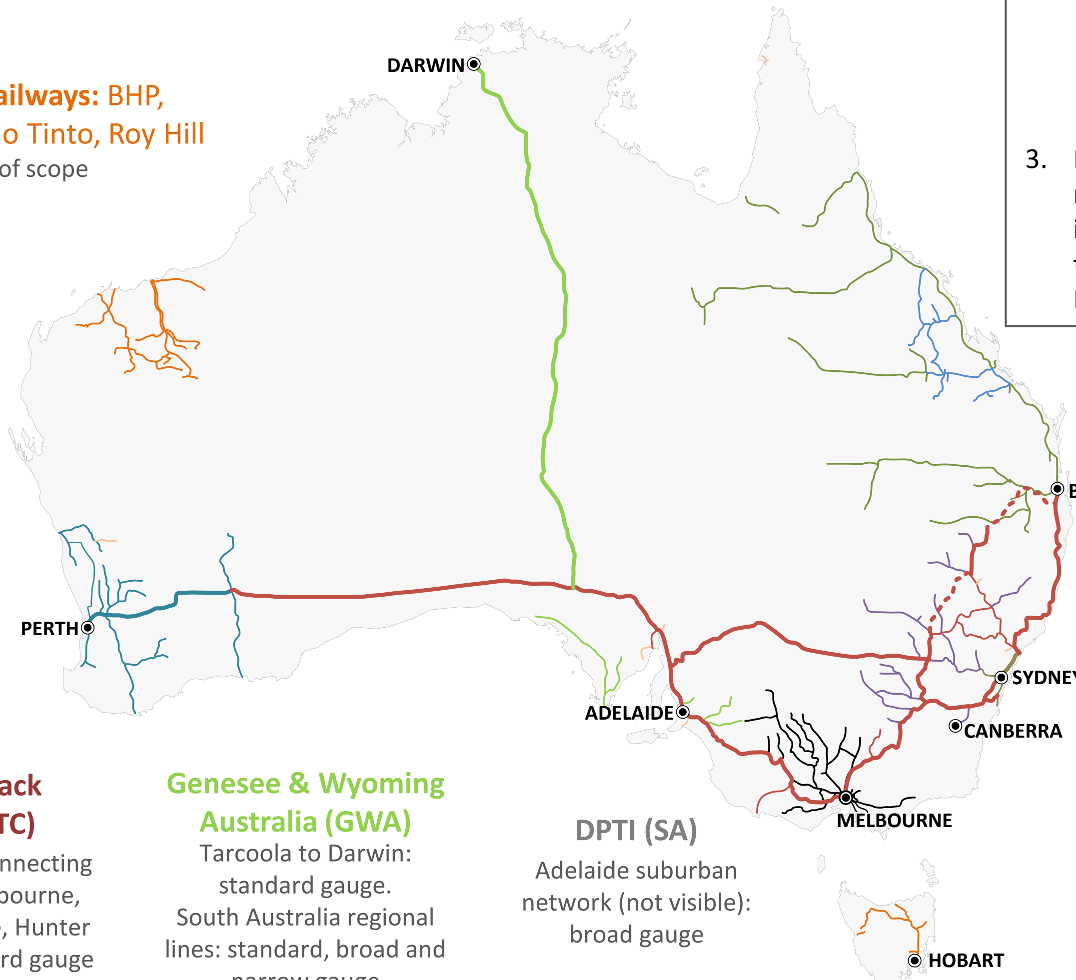
1. Operational requirements
   - National overview
   - Freight
   - Urban passenger
2. Survey findings
3. Network control systems landscape
   - Current network control systems landscape
   - Planned network control systems
4. Interoperability assessment

Rail operations across Australia

Networks and network management

Key Points:

1. The interconnected national rail network is owned and managed by more than 11 different parties, including government and private entities.
2. The national rail network includes:
   - Interstate main lines
   - Coal lines
   - Regional lines
   - Suburban lines
   - Metro lines
3. Broad, narrow and standard gauge networks remain. There is limited interworking between these networks through dual gauge track, in Melbourne Brisbane, Adelaide and Perth.



Aurizon
Central Queensland coal lines: narrow gauge

Pilbara Railways: BHP, Fortescue, Rio Tinto, Roy Hill
Out of scope

Arc Infrastructure
Main line connecting Kalgoorlie and Perth: standard and dual gauge
West Australian regional lines: narrow and standard gauge

PTA (WA)
Perth suburban network (not visible): narrow gauge

Australian Rail Track Corporation (ARTC)
Interstate main lines connecting Brisbane, Sydney, Melbourne, Adelaide and Kalgoorlie, Hunter Valley coal lines: standard gauge

Genesee & Wyoming Australia (GWA)
Tarcoola to Darwin: standard gauge.
South Australia regional lines: standard, broad and narrow gauge

DPTI (SA)
Adelaide suburban network (not visible): broad gauge

Tasrail
Out of scope

Queensland Rail (QR)
Brisbane suburban area, Queensland North Coast and regional lines: narrow gauge

John Holland Rail (JHR)
NSW regional lines: standard gauge

Sydney Trains
Sydney suburban area and NSW south coast: standard gauge

DoT Victoria
Melbourne suburban network, Victoria regional lines: broad gauge

Data from Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2018, *Trainline 6, Statistical Report,* Canberra ACT.

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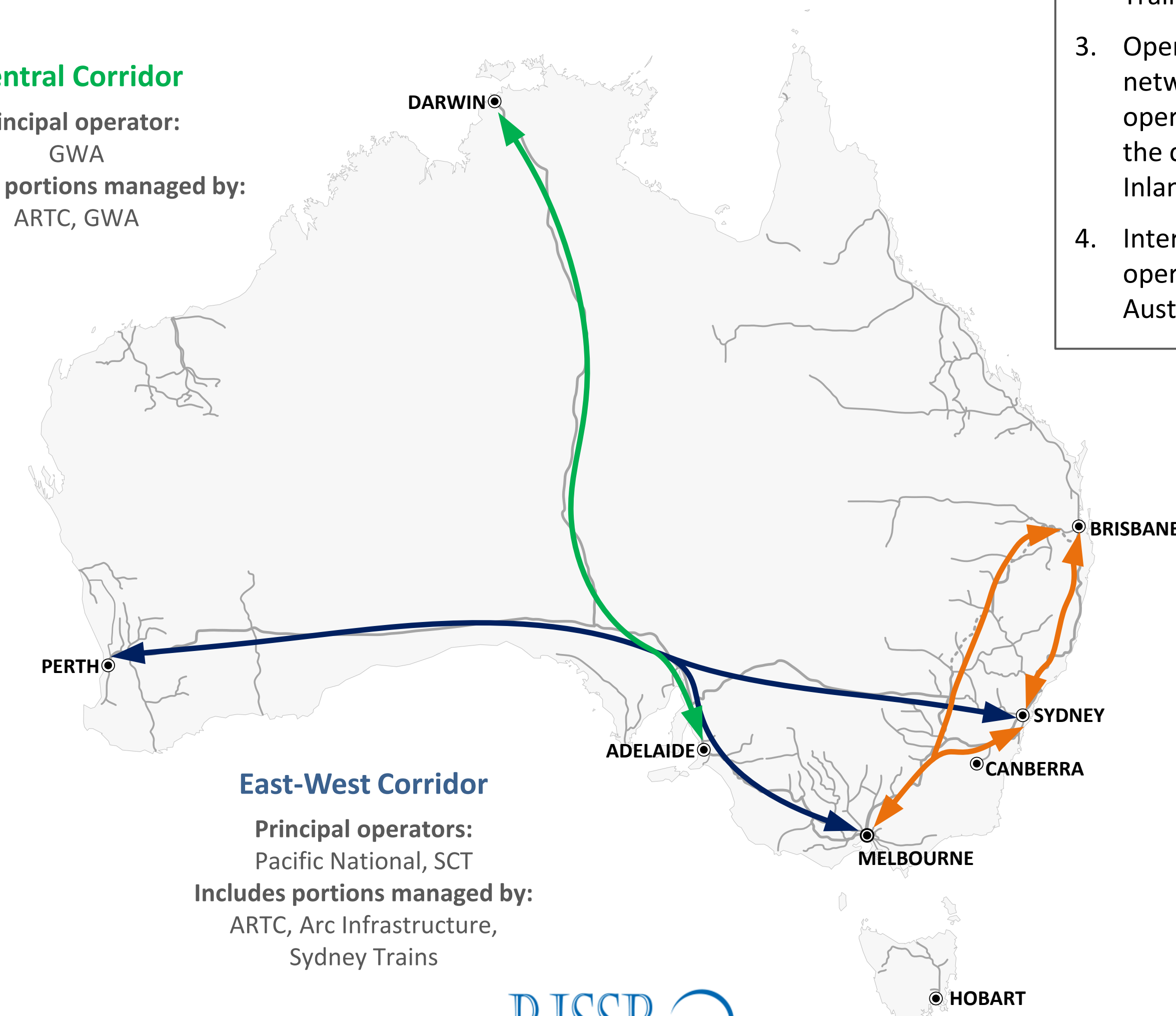
Rail operations across Australia

Primary routes and operators: interstate freight

Key Points:

1. Interstate operations are dominated by 4 above-rail operators – Pacific National, GWA, SCT and Qube.
2. Interstate operations use 4 different rail networks. These include ARTC, Arc Infrastructure and GWA as well as Sydney Trains.
3. Operations on the Queensland narrow gauge network are largely distinct from interstate operations. This will change to a degree with the completion of the Melbourne – Brisbane Inland Rail corridor.
4. Interstate operations exist alongside intrastate operations in New South Wales, Victoria, South Australia and Western Australia.



Central Corridor

Principal operator:
GWA
Includes portions managed by:
ARTC, GWA

East-West Corridor

Principal operators:
Pacific National, SCT
Includes portions managed by:
ARTC, Arc Infrastructure,
Sydney Trains

East-Coast North –South Corridor

Principal operators:
Pacific National, SCT
Includes portions managed by:
ARTC, Sydney Trains

Data from Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2018, *Trainline 6, Statistical Report,* Canberra ACT.

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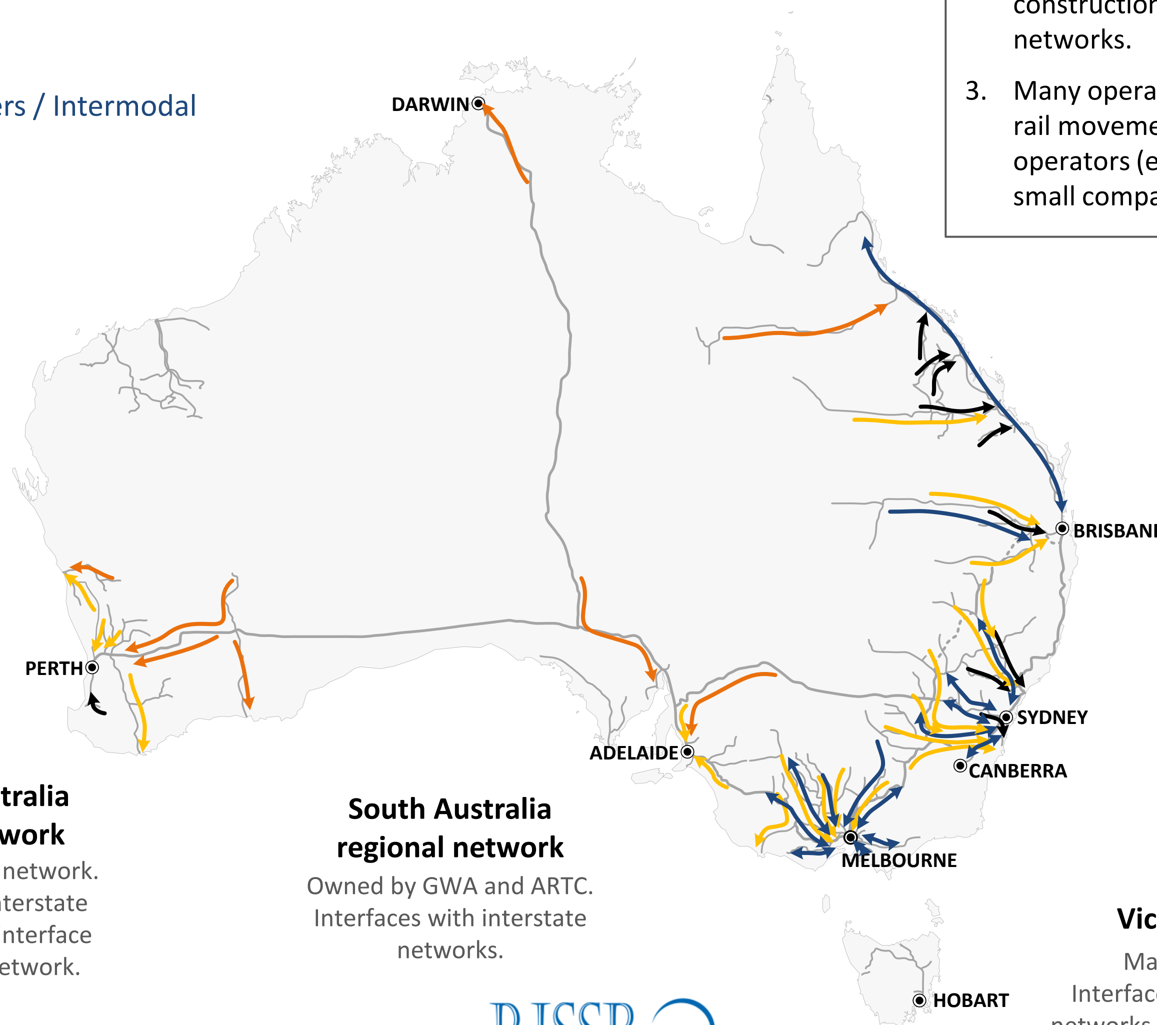
Rail operations across Australia

Primary routes and operators: intrastate freight

Key to freight flows:

- Grain
- Coal
- Minerals
- Containers / Intermodal



Key Points:

1. Operations on regional networks also use the interstate network as well as (in some instances) suburban networks.
2. Intrastate operations in each state are reasonably distinct from adjacent states. Key interactions are between NSW and Vic networks, as well as (with construction of Inland Rail) between the NSW and Qld networks.
3. Many operating companies are involved in intrastate rail movements in each jurisdiction. This includes large operators (e.g.. interstate operators) as well as many small companies.

Queensland regional and coal network

Owned by QR and Aurizon.
Interfaces with suburban network' Limited interface with interstate network although this will be established with Inland Rail

NSW regional and coal network

Managed by JHR and ARTC.
Interfaces with interstate and suburban networks, traffic from southern NSW to Victoria. Links to Queensland network will be established with Inland Rail

Western Australia regional network

Arc Infrastructure network.
Interfaces with interstate network, limited interface with suburban network.

South Australia regional network

Owned by GWA and ARTC.
Interfaces with interstate networks.

Victoria regional network

Managed by V/Line and ARTC.
Interfaces with interstate and suburban networks, some traffic from southern NSW.

Data from Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2018, *Trainline 6, Statistical Report,* Canberra ACT.

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Rail operations across Australia

Primary routes and operators: interstate and regional passenger

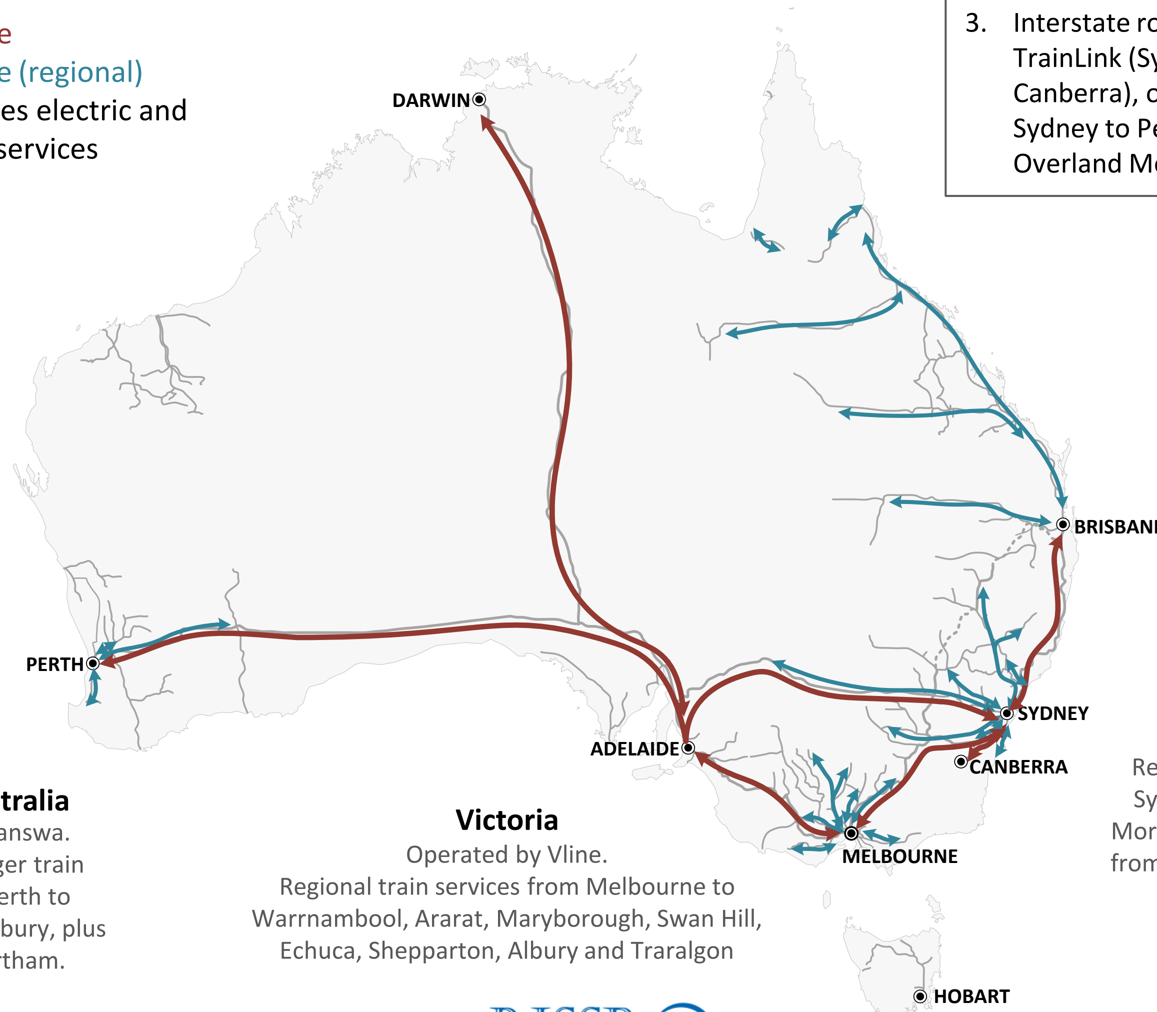
Key to passenger train routes:

- Interstate
- Intrastate (regional)

Map excludes electric and interurban services

Key Points:

1. Passenger services follow similar routes to freight, only using a subset of the intrastate routes available.
2. Intrastate routes are mostly operated by state government transport entities.
3. Interstate routes are either operated by NSW TrainLink (Sydney to Melbourne, Brisbane or Canberra), or by Great Southern Rail (Indian Pacific Sydney to Perth, The Ghan Adelaide to Darwin, or the Overland Melbourne to Adelaide)



Queensland

Operated by Queensland Rail.
Regional passenger train services from Brisbane to Roma, Longreach and Cairns. Also services from Townsville to Mt Isa, Cairns to Forsyth and Croydon to Normanton.

NSW

Operated by NSW TrainLInk.
Regional passenger train services from Sydney to Griffith, Broken Hill, Dubbo, Moree, Armidale and Nowra. Also services from Campbelltown to Goulburn and from Newcastle to Scone and Dungog.

Western Australia

Operated by Transwa.
Regional passenger train services from Perth to Kalgoorlie and Bunbury, plus Midland to Northam.

Victoria

Operated by Vline.
Regional train services from Melbourne to Warrnambool, Ararat, Maryborough, Swan Hill, Echuca, Shepparton, Albury and Traralgon

Data from Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2018, *Trainline 6, Statistical Report,* Canberra ACT, also railmaps.com.au

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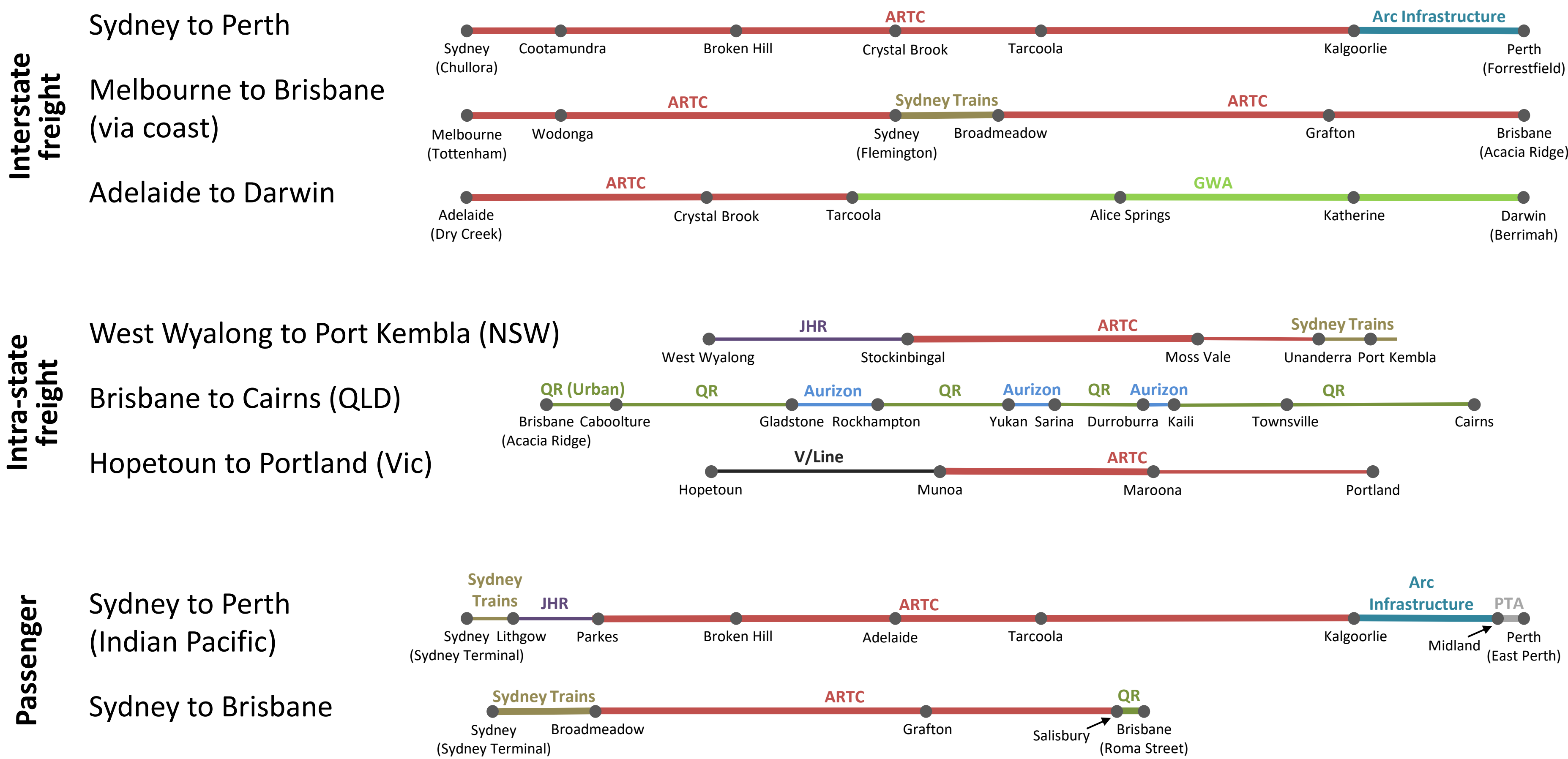
Some example routes

Key Points:

1. The selected routes are typical of interstate and intrastate freight routes across Australia. They have been selected to illustrate the mix of network owners in typical journeys, as well as the connections between the interstate and intrastate networks.



Key:
Colour indicates network owner
Thick line indicates interstate network
Thin line indicates regional / intrastate network

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Issues with current systems landscape

A recent survey of selected above and below-rail entities collected data and to identify and collate outcomes that must be achieved from future network control systems.

Issues identified relating to current systems and systems status are provided below:

Above rail operator	Below rail network manager
Gaps in safety for trains (lack of speed or end of authority enforcement) and track workers (procedural nature of track work authority process)	
Many signalling and safeworking systems are in use across Australia, creating a burden in management, maintenance of systems and competencies, etc.	
Current approaches may result in a need for multiple onboard systems – including multiple radio systems.	Much existing signalling equipment is approaching life expiry. Replacement of these systems like-for-like will be very expensive.
	A number of control systems in use around Australia are aged and are now unsupported or difficult to support.
	Current systems constrain network capacity and do not permit network optimisation.

Desired outcomes from future systems

Outcomes desired from future network control systems are provided below:

<table>
<tr><th>Above rail operator</th><th>Below rail network manager</th></tr>
<tr><td>Improve safety of operations</td><td>Improve safety of operations
Improve safety for network maintenance</td></tr>
<tr><td>Reduce costs by:
• Minimising the number of safeworking systems in use
• Minimising the amount of equipment required in locomotives
• Savings in fuel and brake use</td><td>Reduce costs by:
• Minimising the amount of trackside equipment
• Minimising the number of safeworking systems in use</td></tr>
<tr><td></td><td>Improve network capacity
Improve efficiency of network management</td></tr>
<tr><td>Enable future enhancements:
• Additional enhancements such as Driver Advisory Systems
• Potential move to improved crewing arrangements and semi-automation</td><td></td></tr>
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Signalling and train control systems in use across Australia

	WA	SA	NT	Vic	NSW	Qld
CTC/RVD	✓	✓		✓	✓	✓
ABS		✓				
Manual TOW		✓		✓		
WestCad TOW		✓	✓			
TOS	✓					
PTOS				✓	✓	
DTC						✓
TMACS / voice					✓	
TMACS / data					✓	
S&T				✓		

Key:

Signalling
- Rail Vehicle Detection or Centralised Train Control
- Automatic Block Signalling (ABS)

Train Order Working (TOW)
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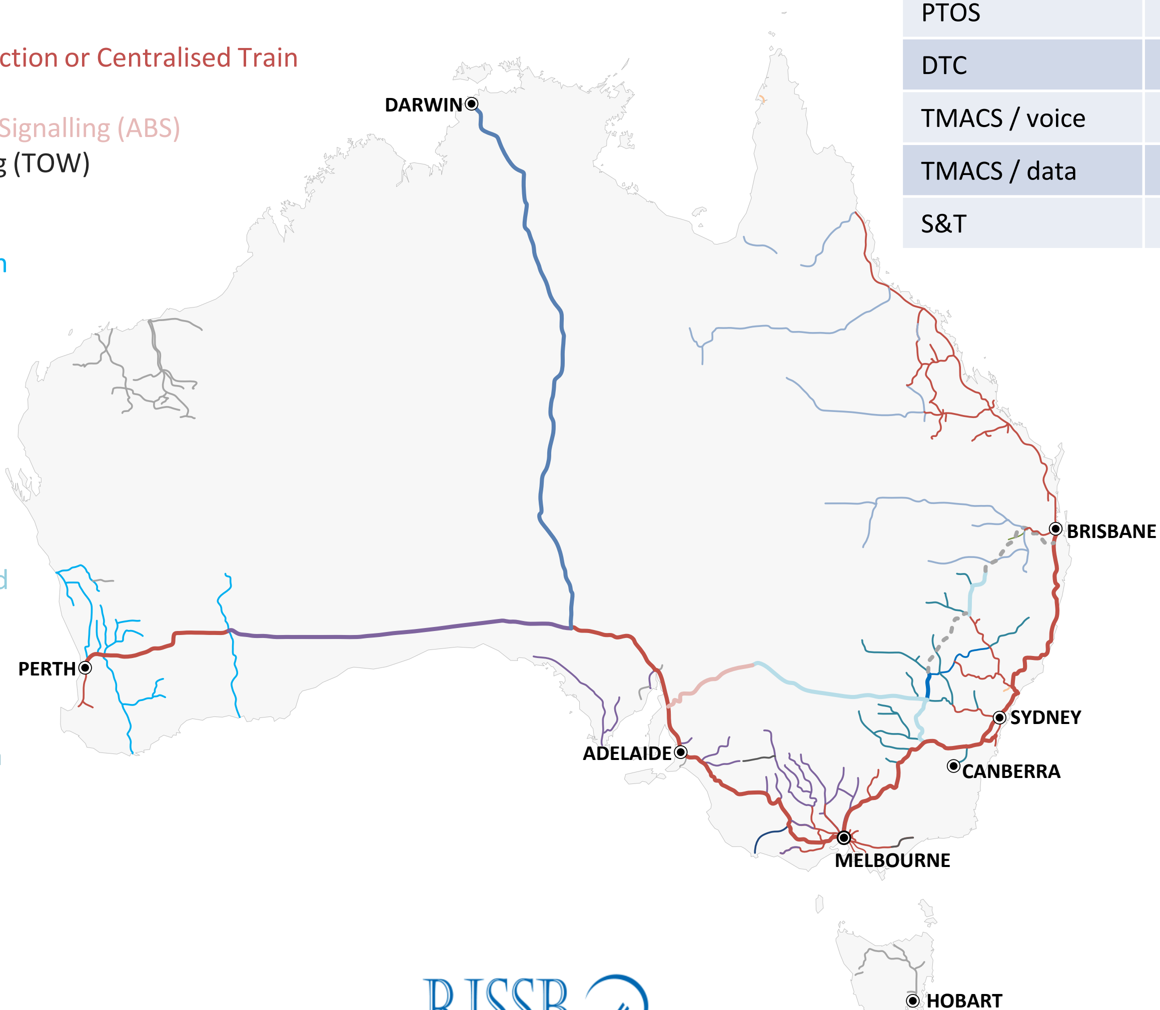
Staff and Ticket (S&T)

Out of scope



Key Points:

1. At least 10 different signalling and train control systems are in used across Australia; these are primarily variants of signalling and train order working. Some corridors in regional Victoria still retain Staff and Ticket working.
2. Within the 10 different systems each state or jurisdiction typically has its own distinct safeworking rules – meaning that there are more than 17 distinct safeworking systems in use across Australia.

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Types of network control systems in use

Parameter	Signalling / CTC	Train Order Working	Token (Staff and ticket)
Used in / Examples	High density lines, esp. interstate and coal lines	Regional networks, some interstate corridors	Regional Vic network (legacy system)
Controller support	Signalling control system	Depends on the specific solution adopted.	Nil
Authority transmission	By lineside signal	Transmission via radio, either voice or data	Token
Train location	Track circuit / axle counter	Depends on the specific solution adopted.	Nil
Amount of trackside infrastructure	High	Low	Low
Onboard equipment	Nil	Depends on the specific solution adopted.	Nil

Refer to next slide

Current network control systems landscape

The many forms of Train Order Working in use throughout Australia

Manual train order working
E.g. V/Line network

- Controller uses paper train graphs
- Train positioning through driver reporting
- Authority transmission by read-out/read-back
- Points manually worked by driver
- Onboard equipment limited to radio system

Safety Enhancements		Examples: Tarcoola - Kalgoorlie	WestCad TOW (GWA)	DTC (QR & Aurizon networks)	PTOS (ARTC network)	TMACS (JHG network)
Computer assist to controller Reduces risk of controller error	Requires control centre equipment.		✓	✓	✓	✓
Independent train position reporting using e.g.. GPS Reduces risk of lack of situational awareness	GPS is available through ICE radio. Requires integration into system.				✓	✓
Data transmission of authority Improves efficiency of authority transmission process Reduces risk of communications error	Data transmission is possible using ICE radio. Requires in-cab screen, e.g. ICE or DTC onboard.			~		✓
Electronic train graph Improves controller efficiency	Requires control centre equipment.					✓
Auto-normalising of points **Setting of points on train approach** **Remote control of points** Improves operational efficiency	Requires motorised points plus potentially other enhancement e.g. ICAPS.	✓	✓	✓	✓	✓
Operational Enhancements						

Notes:
DTC uses a code-based system to enhance verbal read-out/read-back.
ICAPS is installed on the Tarcoola to Kalgoorlie section, to permit setting of points by the driver on approach. A similar system is in use between Tarcoola and Darwin,

Comparison with the desired outcomes

Issue		Signalling / CTC	cTOW with data transmission	cTOW with voice transmission	Train Order Working	Token (Staff and ticket)
Safety	Prevention of control errors	YES	YES	YES	NO	YES
	Speed / authority enforcement	NO	NO	NO	NO	NO
	Possession controls	NO	YES	YES	NO	NO
	Independent position reports	YES	YES	YES	NO	NO
	Miscommunications controls	YES	YES	Depends *	NO	YES
Operations	No unnecessary stops / starts	YES	YES	YES	Depends *	NO
	Efficient crossing movements	YES	Depends *	Depends *	Depends *	NO
	Efficient authority transmission	YES	YES	Depends *	NO	NO
Cost	Level of trackside equipment	HIGH	LOW	LOW	LOW	LOW
	Onboard equipment	NO	YES	Depends *	NO	NO

Notes:

cTOW = Computer-assisted Train Order Working

'Depends' indicates where the option may meet the objective or may not, based on the specific solution adopted in any given instance – see previous slide for examples.

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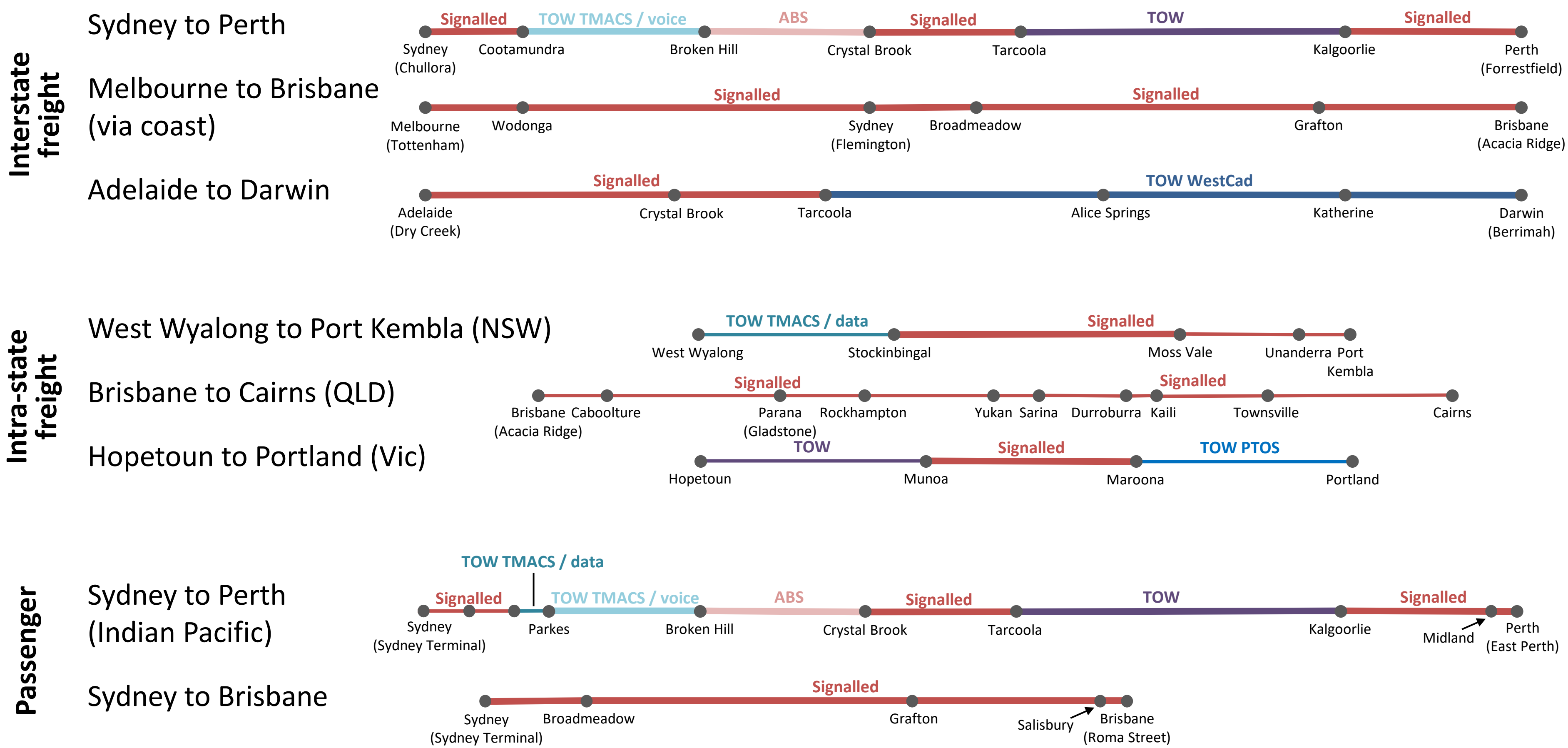
Existing control systems on the example routes



Key:
Colour indicates existing control system
Thick line indicates interstate network
Thin line indicates regional / intrastate network

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Radio systems in use and planned across Australia

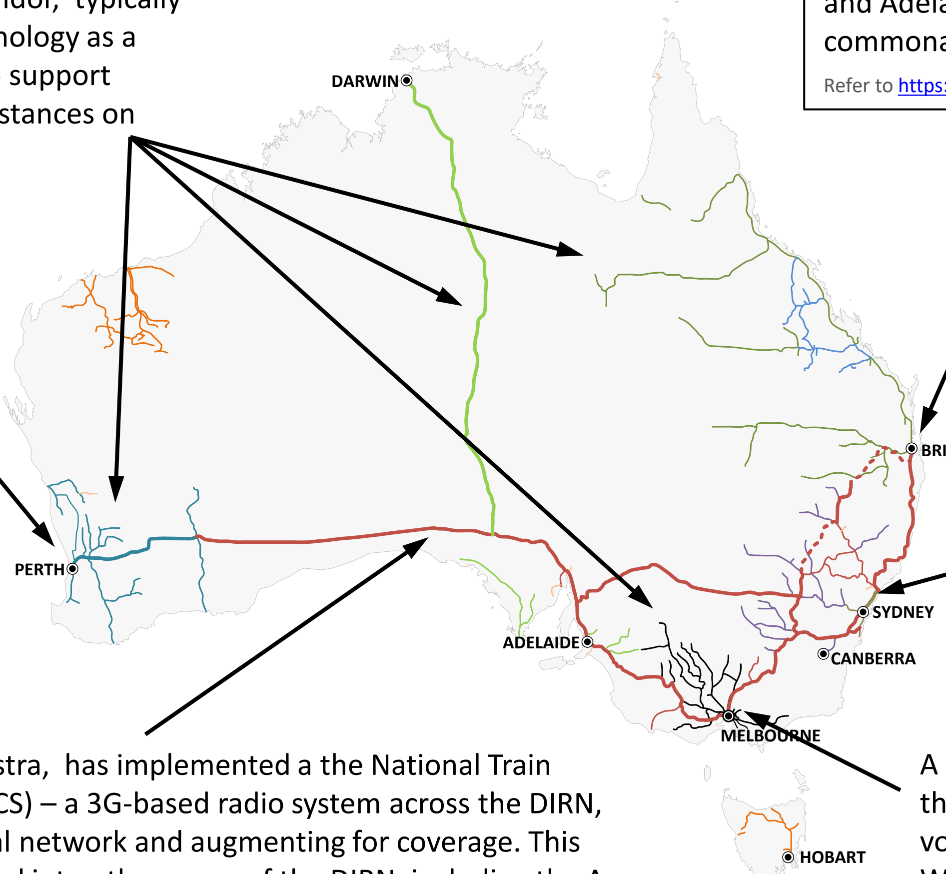
A characteristic of the new systems is a reliance on robust control-to-train communications. This issue is being addressed in different ways by railways across Australia.

The 1800MHz band was secured for use by railways in Melbourne, Brisbane, Sydney, Perth and Adelaide. This provides some level of commonality for operators and suppliers.

Refer to https://www.ara.net.au/key-issues/telecommunications

Regional networks, including the Tarcoola to Darwin corridor, typically use satellite radio technology as a cost-effective means to support operations over long distances on lightly used corridors.

PTA is implementing a new radio system for the Perth network, using 4G/LTE technology. The system is planned to be operational in 2022, and will support the forthcoming CBTC train control system



TMR/QR is implementing GSM-R on the SEQ rail network, as part of the cross River Rail / ETCS Inner city initiative. This will support ETCS L2 operations as well as provide voice communications.

Transport for NSW commissioned a GSM-R network across the Sydney network in 2016, providing voice communications. This network is being augmented to support ETCS Level 2.

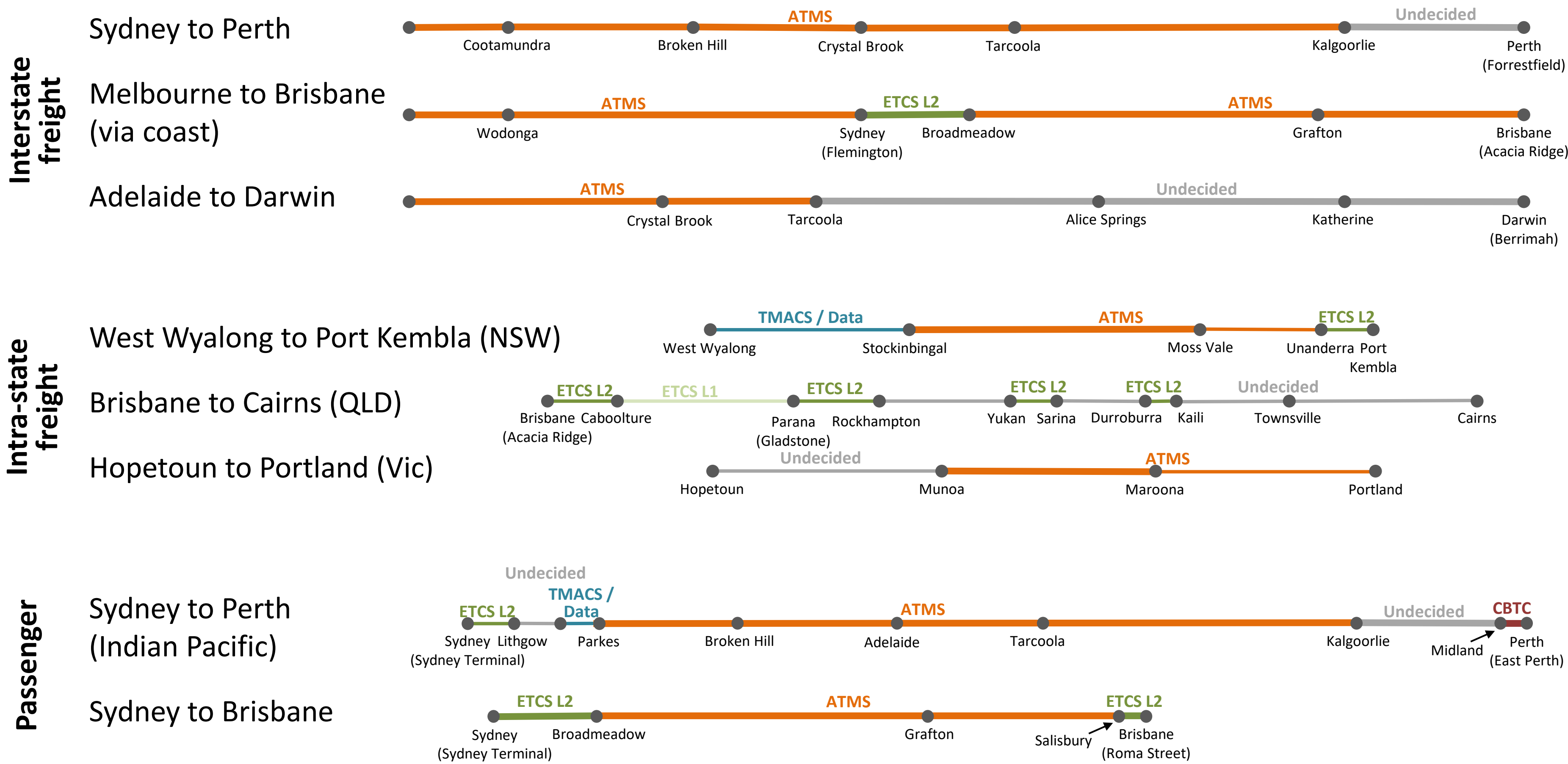
ARTC, in partnership with Telstra, has implemented a the National Train Communications System (NTCS) – a 3G-based radio system across the DIRN, making use of the commercial network and augmenting for coverage. This system has also been extended into other areas of the DIRN, including the Arc Infrastructure corridor from Kalgoorlie to Perth.

A GSM-R network is in place across the Melbourne network, providing voice communications. A separate Wi-Fi network is being deployed to support the CBTC system that is being provided for Metro Tunnel.

Network control systems planned

Railway	Current Systems	Planned systems
ARTC	Lineside signalling Train order working PTOS Train Order Working	Advanced Train Management System (ATMS)
Aurizon	Lineside signalling	ETCS Level 2
Arc Infrastructure	Lineside signalling Train order working	Targeting to implement single Train Control System for both signalled and Train Order territory within 2 years. Monitoring the market for suitable cab signalling solutions in the longer term.
Country Regional Network (NSW)	Lineside signalling TMACS Train Order Working, with data transmission	TMACS Train Order Working, with data transmission and enhancements, inc. electronic track worker authorities and authority enforcement.
DPTI (SA)	Lineside Signalling with ETCS Level 1	No committed program as yet
Genesee & Wyoming	Train order working	Exploring a range of GPS based electronic train control systems which will interface with the ICE radios installed in the standard gauge locomotive fleet.
Queensland Rail	Lineside signalling with ATP Direct Traffic Control (DTC)	ETCS Level 2 (Brisbane Suburban area) ETCS Level 1 (North Coast Line)
PTA (WA)	Lineside Signalling with ATP	Communications Based Train Control (CBTC)
Transport for NSW	Lineside signalling	ETCS Level 1 (Limited Supervision) ETCS Level 2 (longer term)
Transport for Victoria	Lineside Signalling	Communications Based Train Control (CBTC)
VicTrack	Lineside signalling with TPWS Train Order Working Staff and Ticket	No committed program as yet

Planned control systems on the example routes



Key:
Colour indicates proposed future control system, where known, or 'undecided' where no plan has been announced.
Thick line indicates interstate network
Thin line indicates regional / intrastate network

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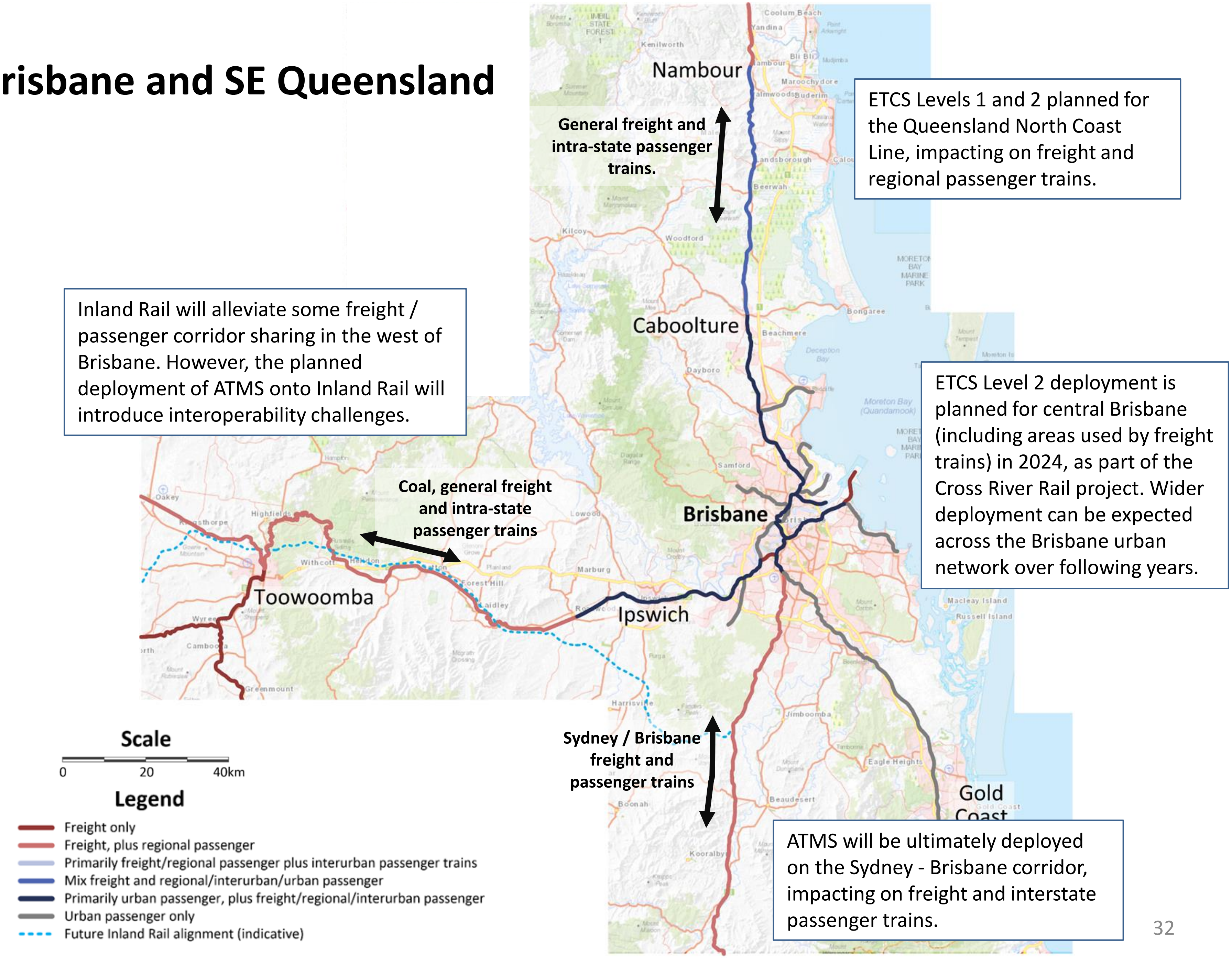
Brisbane and SE Queensland



Sydney and surrounds

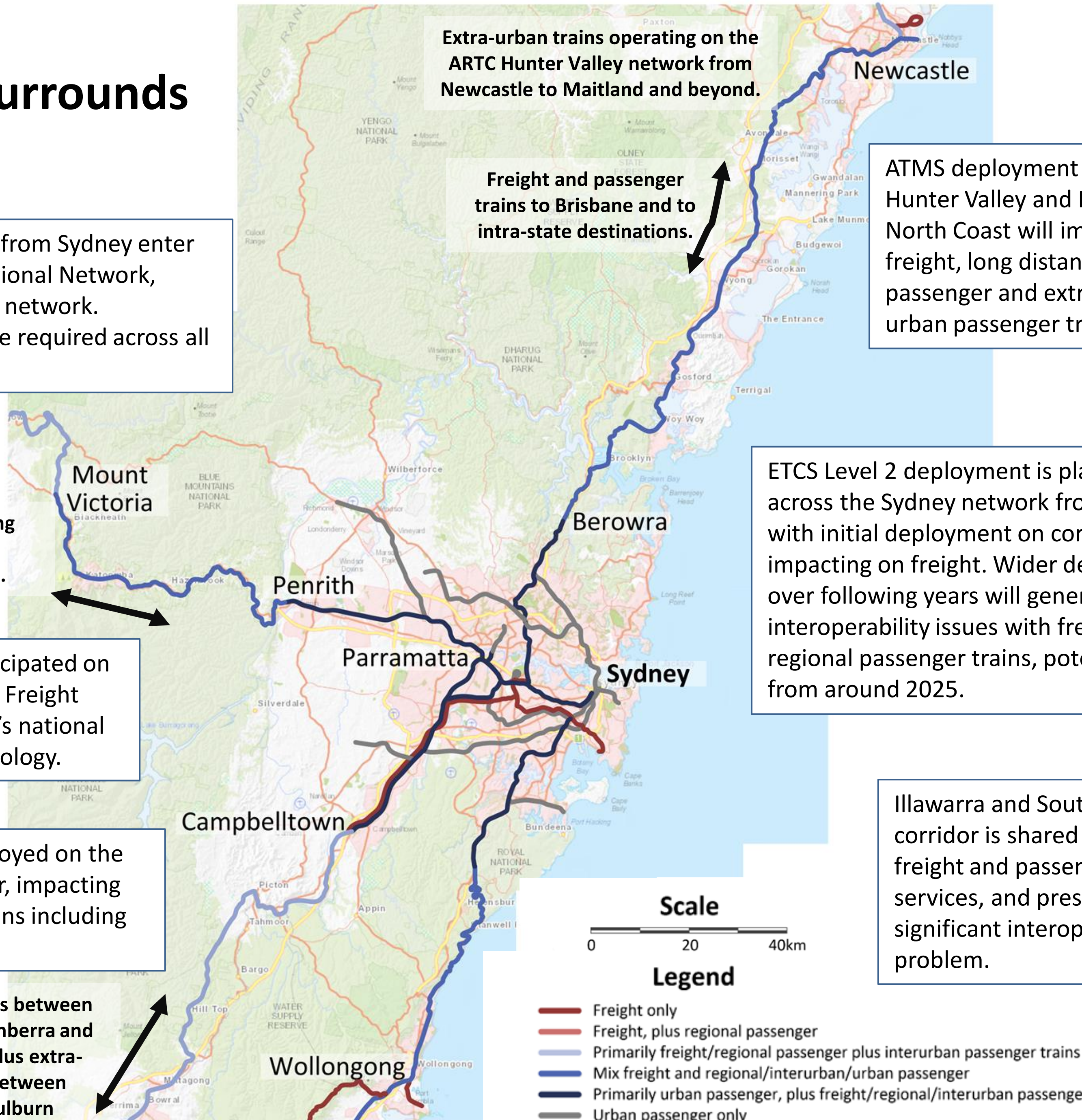
Trains travelling west from Sydney enter the NSW Country Regional Network, followed by the ARTC network. Interoperability will be required across all three networks.

Coal, general freight and long distance passenger trains, including the Indian Pacific.

ATMS deployment is anticipated on the Sydney Metropolitan Freight Network as part of ARTC's national deployment of the technology.

ATMS will be ultimately deployed on the Sydney – Melbourne corridor, impacting on freight and passenger trains including extra-urban trains.

Freight and passenger trains between Sydney and Melbourne, Canberra and intra-state destinations, plus extra-urban trains operating between Campbelltown and Goulburn



Extra-urban trains operating on the ARTC Hunter Valley network from Newcastle to Maitland and beyond.

Freight and passenger trains to Brisbane and to intra-state destinations.

ATMS deployment in the Hunter Valley and NSW North Coast will impact on freight, long distance passenger and extra-urban passenger trains.

ETCS Level 2 deployment is planned across the Sydney network from 2022, with initial deployment on corridors not impacting on freight. Wider deployment over following years will generate interoperability issues with freight and regional passenger trains, potentially from around 2025.

Illawarra and South Coast corridor is shared between freight and passenger services, and presents a significant interoperability problem.

Melbourne

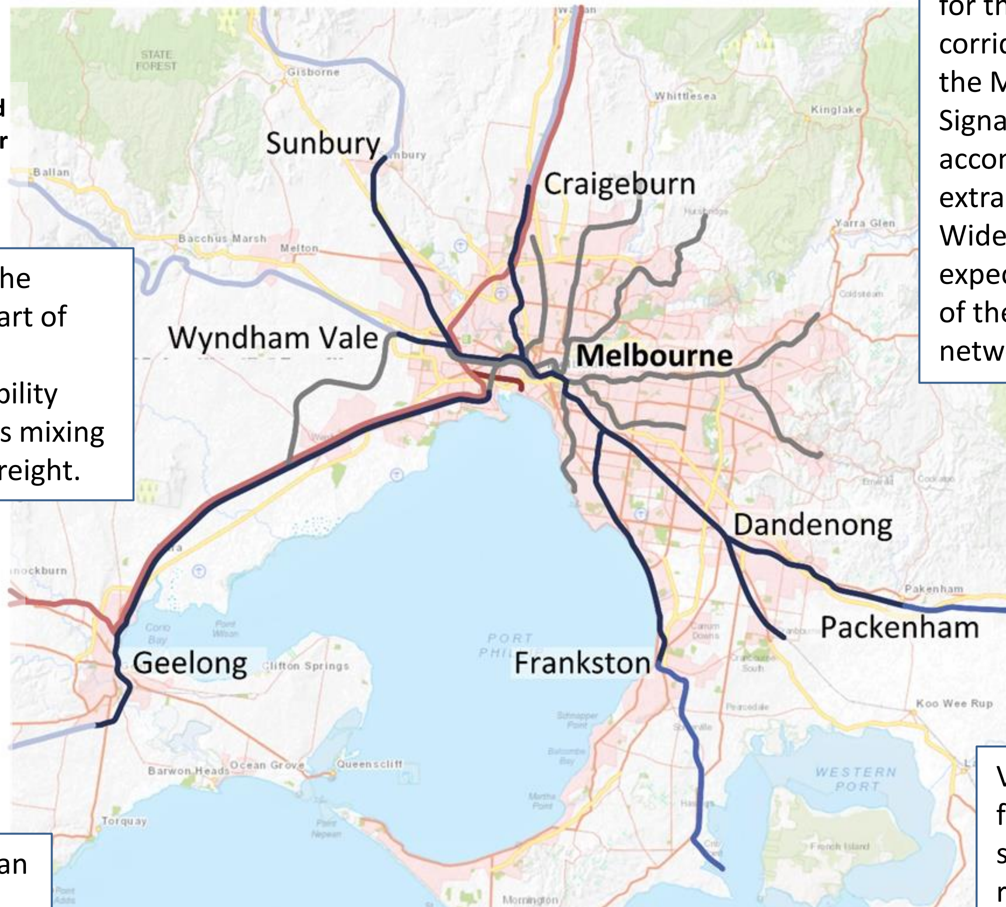
Intra-state freight and extra-urban passenger services to Bendigo.

Freight and passenger trains between Melbourne and Sydney, and intra-state destinations.

CBTC deployment is planned for the Sunbury to Dandenong corridor in 2024, as part of the Metro Tunnel Project. Signals will be retained to accommodate freight and extra-urban passenger trains. Wider deployment can be expected across other areas of the Melbourne urban network over following years.

Intra-state freight and extra-urban passenger services to Ballarat.

ATMS deployment is anticipated on the standard gauge freight corridors as part of ARTC's national deployment of the technology. This presents interoperability issues where dual gauge lines permits mixing of interstate freight with intra-state freight.



Freight and passenger trains between Melbourne and Adelaide, and intra-state destinations.

Freight and extra-urban passenger services to Gippsland.

Intra-state freight and extra-urban passenger services.

VicTrack has not yet finalised a technology selection for the Victorian regional network.

Intra-state freight and extra-urban passenger trains use both the Melbourne urban network as well as the Victorian regional rail network. Interoperability will be required across these networks.

Legend

- Freight only
- Freight, plus regional passenger
- Primarily freight/regional passenger plus interurban passenger trains
- Mix freight and regional/interurban/urban passenger
- Primarily urban passenger, plus freight/regional/interurban passenger
- Urban passenger only

Scale

0 20 40km

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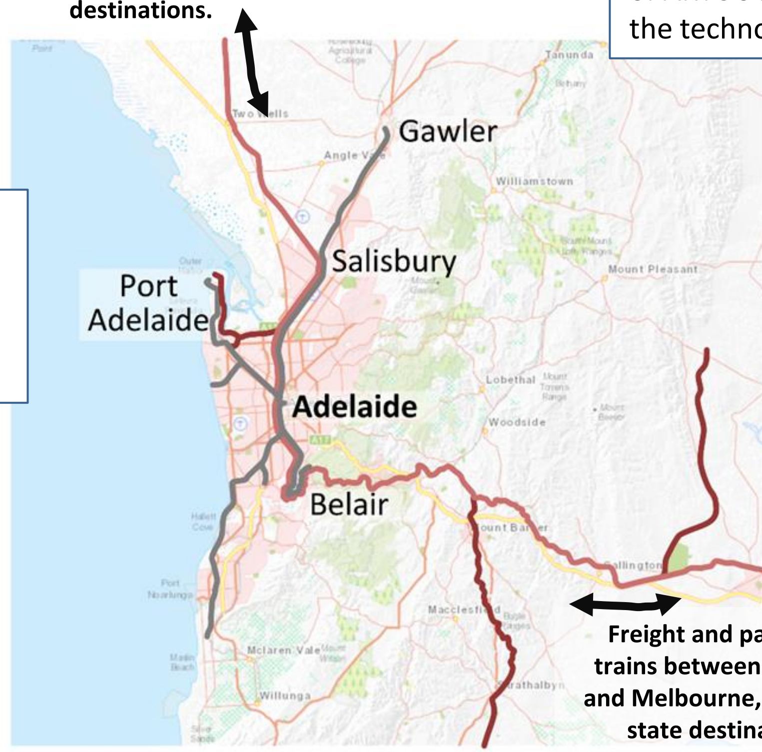
Adelaide

Freight and passenger trains between Adelaide and Perth, Darwin and Sydney, and intra-state destinations.

ATMS deployment is anticipated on the standard gauge freight corridors into and through Adelaide, as part of ARTC's national deployment of the technology.

ETCS Level 1 has been deployed across the Adelaide urban network. Deployment of ETCS Level 2 may follow in future years, although no plans have been announced.



Progressive works across the Adelaide rail network, plus the closure of many branch lines, has mean that the urban and freight / long distance networks are now fully separated. Interoperability issues will be minimal.

Freight and passenger trains between Adelaide and Melbourne, and intra-state destinations.

Legend

- Freight only
- Freight, plus regional passenger
- Primarily freight/regional passenger plus interurban passenger trains
- Mix freight and regional/interurban/urban passenger
- Primarily urban passenger, plus freight/regional/interurban passenger
- Urban passenger only

Scale

0 20 40km

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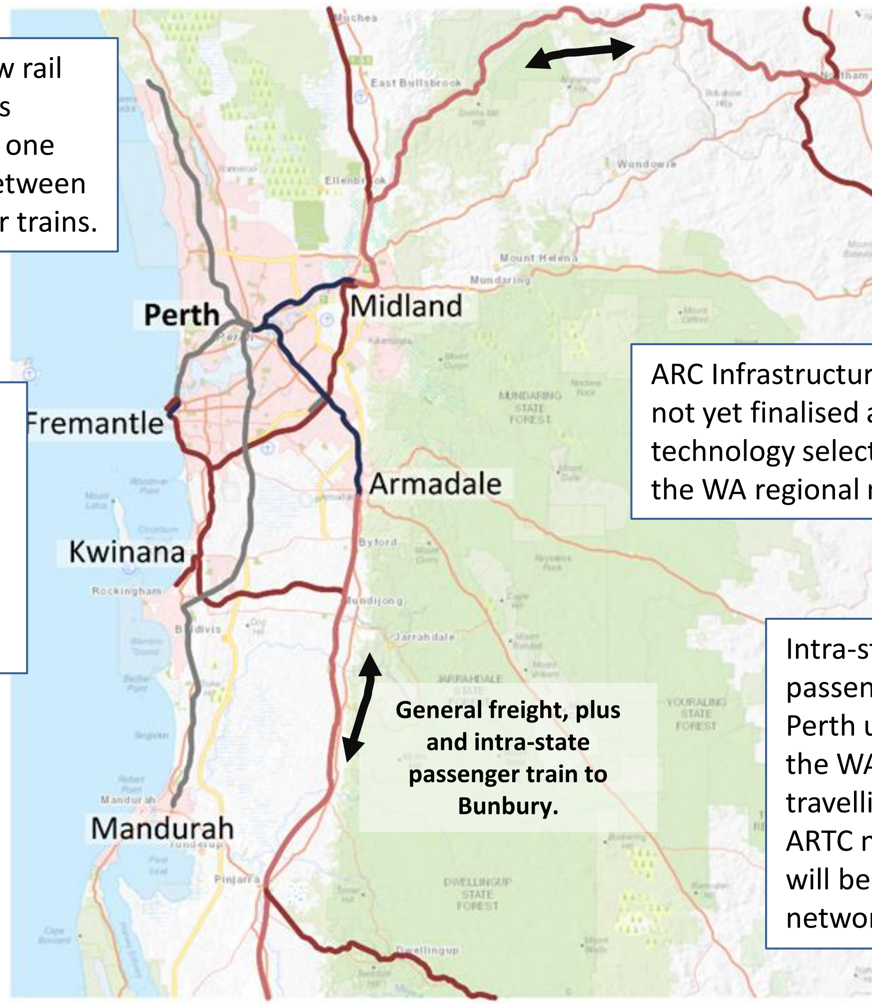
Perth

Freight and passenger trains between Perth and Adelaide, Melbourne and Sydney, and intra-state destinations. This includes the Indian Pacific passenger train.

Construction of a new rail bridge at Fremantle is planned to eliminate one existing constraint between freight and passenger trains.



CBTC has been selected as the preferred technology for the Perth urban network, with deployment planned for the 2020s. Signals will be retained to accommodate unfitted trains, including long distance passenger

ARC Infrastructure has not yet finalised a technology selection for the WA regional network.

General freight, plus and intra-state passenger train to Bunbury.

Intra-state freight and extra-urban passenger trains use both the Perth urban network as well as the WA regional network and, if travelling towards Adelaide, the ARTC network. Interoperability will be required across these networks.

Scale

0 20 40km

Legend

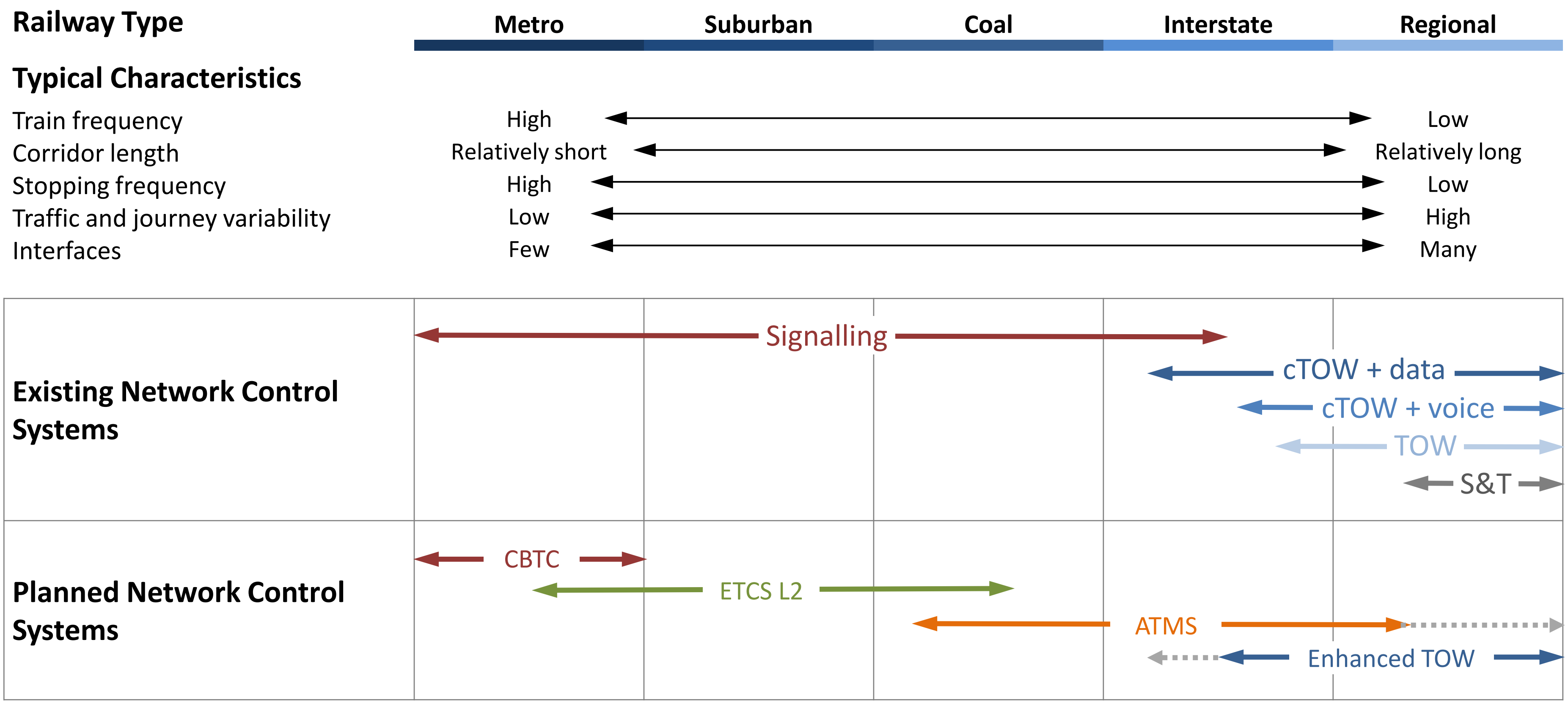
- Freight only
- Freight, plus regional passenger
- Primarily freight/regional passenger plus interurban passenger trains
- Mix freight and regional/interurban/urban passenger
- Primarily urban passenger, plus freight/regional/interurban passenger
- Urban passenger only

Summary of current and planned network control systems

Railway Type: Metro — Suburban — Coal — Interstate — Regional

Typical Characteristics

Characteristic		
Train frequency	High	Low
Corridor length	Relatively short	Relatively long
Stopping frequency	High	Low
Traffic and journey variability	Low	High
Interfaces	Few	Many



Notes:

For planned systems – solid line indicates breadth of currently planned scope. Grey dotted line indicates potential wider application with enhancement.

Communications Based Train Control (CBTC)

What is it?

CBTC refers to a class of train control systems developed in accordance with the IEEE 1474 standard. These systems have been specifically developed for high density metro operations and are highly specialised to this task.

These systems use high-resolution train location determination, continuous and high-capacity bidirectional train-to-wayside data communications; and trainborne and wayside processors capable of implementing Automatic Train Protection (ATP) functions, as well as optional Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) functions. CBTC applications include systems with drivers through to fully automated systems.

CBTC systems have been developed by individual companies with no view to interoperability between systems. CBTC systems are optimised for a single type of rolling stock, performing a consistent task. Worldwide experience has demonstrated difficulty in adapting CBTC to work with freight and main line operations, particularly with trains of variable length and performance.

Use in Australia

The first use of CBTC in Australia was on the fully automated Sydney Metro corridor from Rouse Hill to Chatswood. This system will be extended through further metro projects in Sydney.

CBTC has been chosen for use on the Melbourne suburban network and is being initially deployed on the Sunbury to Dandenong corridor by the Melbourne Metro Tunnel Project. This broad gauge network is also used by some broad gauge freight, as well as regional passenger trains. Lineside signals are being retained to allow the continued operation of non-urban traffic.

CBTC has also been selected for the Perth suburban network. Portions of this network are shared with the standard gauge Indian Pacific train, as well as regional passenger trains. Retention of lineside signals is likely to be necessary to accommodate these trains.

Characteristic	CBTC
Natural fit for	Isolated, high density metro lines
Capacity	High – Very High
Suitable for trains	Metro
Suppliers	Multiple
Standards	Common standard, proprietary implementation
Onboard system	Specific
Communications System	Wi-fi / LTE
Proven interoperability arrangements	Retain signals for non-fitted trains
Other possible interoperability arrangements	None

Refer to https://en.wikipedia.org/wiki/Communications-based_train_control

European Train Control System (ETCS)

What is it?

ETCS is an initiative of the European Union to provide interoperability of systems across different countries and types of networks. A single onboard unit can be used to interface with multiple trackside variants. ETCS systems have been functioning on rail networks in a number of countries in Europe for more than ten (10) years. ETCS systems continue to be deployed in both European and other countries, including South Korea, China, New Zealand and Australia.

ETCS has been developed in levels, to provide flexibility in deployment:

- ETCS Level 1 provides a safety enhancement to railways equipped with lineside signals, and can be used as a transitional step to higher levels of ETCS.
- ETCS Level 2 provides full in-cab signalling and hence allows removal of lineside signals. As well as safety enhancements, Level 2 allows simplified infrastructure and control optimisation.
- ETCS Level 3 is not yet available, but will provide further optimisation of railway operations,

Use in Australia

ETCS Level 1 has been deployed in the Adelaide urban network, and in deployment across the Sydney Trains network. Both these applications are to provide a safety enhancement to the current systems using lineside signals. ETCS Level 1 is also being applied in the Queensland Rail North Coast line, again augmenting the existing signalling system.

ETCS Level 2 is under deployment in several areas, including the Sydney network (through the Digital Systems Program) and Brisbane (through the Cross River Rail project), as well as on the Aurizon network in central Queensland. This system has been selected for these railways as it is suitable for more densely trafficked networks, is able to be fitted to different types of traffic and it provides options for interoperability.

Characteristic	ETCS L2
Natural fit for	High capacity suburban and interurban lines
Capacity	High
Suitable for trains	Suburban, regional, freight
Suppliers	Multiple
Standards	Common standard, interoperable
Onboard system	Specific but interoperable
Communications System	GSM-R / GPRS
Proven interoperability arrangements	Dual fit trackside, interfaced onboard, retain signals for non-fitted trains
Other possible interoperability arrangements	Not necessary

Refer to https://en.wikipedia.org/wiki/European_Train_Control_System

Advanced Train Management System (ATMS)

What is it?

ATMS is a communications based safeworking system that has been developed by ARTC. The system is being specifically tailored to meet the needs of a long distance and geographically spread network. The system:

- Replaces trackside signalling with in-locomotive displays of authorities to drivers
- Provides precise location of trains (both front and rear)
- Provides enforcement of authorities on each locomotive if a train is at risk of exceeding its authority; and
- Provides points setting and automatic route clearance functionality

ATMS combines computerised blocks to manage train movements, with trainborne technology that can apply the trains brakes to prevent an unsafe circumstance occurring. This will enable more capacity by allowing trains to run closer together, and will reduce the cost of rail operations by minimising infrastructure and improving operational efficiency. The system also offers numerous safety benefits including reducing the risk of train collision and providing greater visibility to drivers of the route ahead.

Use in Australia

A Proof of Concept demonstration of ATMS was conducted in 2013. Implementation Stage 1 is now underway, which will deploy ATMS on the corridor from Port Augusta to Whyalla. This will enable ATMS to be proven before wider roll-out on the ARTC network.

ARTC plans the roll out of ATMS in stages across the Defined Interstate Rail Network. Implementation Stage 2 is planned for the corridor from Tarcoola to Kalgoorlie. ATMS will also be deployed onto the new-build sections of Inland Rail, as well as progressively onto the other portions of the corridor.

Characteristic	ATMS
Natural fit for	Long distance interstate corridors
Capacity	Moderate
Suitable for trains	Freight, regional
Suppliers	Single
Standards	Proprietary
Onboard system	Specific
Communications System	Designed for ARTC network
Proven interoperability arrangements	Retain signals for non-fitted trains
Other possible interoperability arrangements	Dual fit trackside, interfaced onboard

Refer to https://www.artc.com.au/projects/atms/

Enhanced Train Order Working (eTOW)

What is it?

Enhanced Train Order Working (eTOW) is a concept that builds on the principles of Train Order Working already in place in existing safeworking systems, to enhance safety, capacity and efficiency. eTOW is hence a class of systems, rather than a specific product.

At its most basic, Train Order Working consists of a controller issuing instructions (orders) to drivers. These instructions are recorded by drivers on a form, then acted upon. Safety is maintained through tools provided to the controller (such as a train graph) to plan and manage movements, by strict adherence to safeworking rules and by rigorous communication protocols to ensure clarity. Train Order Working as been used on the most remote lines across Australia for many years, as it provides a simple, cheap and effective means of managing low volumes of rail traffic.

TOW can be enhanced in may ways, through the provision of computer support to controllers, transmission of orders via data rather than voice, and through enhancing infrastructure arrangements to improve efficiency of train movements.

Use in Australia

eTOW is already in use in several networks in Australia, with a number of different systems being developed to varying degrees as highlighted previously in this documents,.

One example is the TMACS system in use on the NSW Country Regional Network and on parts of the ARTC NSW network. TMACS provides safety enhancements by integrating GPS location monitoring of train movements and provides an electronic train graph. Data transmission of authorities has been developed and implemented on the JHR network, with train authorities being displayed on an existing screen in the locomotive cabin. This means that additional onboard equipment is not required to support TMACS. Data transmission of track work authorities has also been implemented.

Characteristic	Enhanced TOW
Natural fit for	Regional lines
Capacity	Low - Moderate
Suitable for trains	Freight, regional
Suppliers	Multiple
Standards	Proprietary
Onboard system	Non-specific
Communications System	Variable, including satellite
Proven interoperability arrangements	Interfaced onboard
Other possible interoperability arrangements	None required

Planned network control systems

Improving safety for train movements

	System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
En-hanced	Predictive enforcement	Onboard system monitors speed and end of authority and intervenes if necessary – **requires safety-related onboard unit**.	Not yet in use in interstate / regional Australia	Provided	Provided	Provided	Not planned (see note)
Safety	Reactive enforcement	Onboard system reacts to the train exceeding authority limit and can raise alarm or apply brakes. No speed enforcement.	Electronically assisted TOW systems.	Not necessary	Not necessary	Not necessary	Possible enhance-ment
	Control-centre alarms	Alarms are generated in the control centre if a train exceeds authority limit. No speed enforcement.	Many electronically assisted TOW systems.	Not necessary	Not necessary	Provided	Provided
Basic	No enforcement	No link between authority limit / speed and train braking system.	Almost universally the situation across Australia	Not necessary	Not necessary	Not necessary	Not necessary

Notes:

Enhanced TOW = Computer-assisted Train Order Working plus data transmission of authorities plus further enhancements such as in-cab enforcement of authority limits. This is intended to reflect a general category of system, although the data present is for the TMACS system as deployed / under development for JHR.

Predictive enforcement of speed and authority limits would require the interfacing of enhanced TOW to an onboard safety system.

Planned network control systems

Improving safety for track workers

	System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
En-hanced	**Enforced possessions**	Work on track authorities are interlocked with other authorities and enforced through onboard ATP – **requires safety-related onboard unit**.	Not yet in use in interstate / regional Australia	**Provided**	**Provided**	**Provided**	Not yet planned
Safety	**Interlocked possessions**	Work on track authorities are authorised with security codes and are interlocked with other authorities.	Electronically assisted TOW systems.	Not necessary	Not necessary	Backup option	**Provided**
Basic	**Procedural possessions**	Work on track authorities are established using procedural means.	Manual TOW systems, staff and ticket.	Not necessary	Not necessary	Not necessary	Not necessary

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Improving capacity

High

Capacity

Low

System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
High density operations	Closely-spaced blocks to optimise capacity on a double or multiple track corridor areas.	Necessary in suburban networks to accommodate passenger traffic.	Yes	Yes	Yes	Not possible
Fleeting movements on double track	Permits closely following movements on a double track corridor, made up of two unidirectional tracks.	Normal operation on a double track corridor	Yes	Yes	Yes	Not practical
Fleeting movements on single line	Permits closely following movements on a single track corridor.	Currently requires a block point to be established	Not normally used for single lines	Yes	Yes	Yes, requires a block point to be established
Single-line working	Manages occupation of single track between crossing loops, with one train permitted at a time.	Normal approach on single track corridors	Not normally used for single lines	Yes	Yes	Yes

Improving efficiency of crossing movements

High

Cost

Efficiency

Low

System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
Motorised with remote control	Points are remotely operated by controller.	Crossing loops	**Default**	**Default**	**Default for crossing loops**	Possible
Motorised with approach control	Points are locally operated by train crew on approach (e.g. ICAPS), auto-normalise on departure.	Crossing loops	Not possible	Not normally used	Possible	**Option for loops**
Motorised with pushbutton	Points are locally operated by train crew or others, auto-normalise on departure.	Crossing loops	Not possible	Not normally used	Possible	**Option for loops**
Interlocked and detected	Confirms position of points to crew on approach, points are locally operated by train crew or others.	Low density lines, sidings (e.g. wheat sidings)	Not possible	Possible	**Default for sidings**	Not used or planned
Interlocked, local indication	Requires driver to confirm position of points on approach, points are locally operated by train crew or others.	Low density lines, sidings (e.g. wheat sidings)	Not possible	Not normally used	Possible	**Default for sidings**
Non-interlocked	Locally controlled by shunter or train crew, not appropriate for through traffic.	Line termini, shunting yards	Not possible	Not normally used	Not normally used	Not normally used

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Improving efficiency of control

High ↑ Efficiency ↑ Low

System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
Optimisation of network management	Electronic train graph has predictive functions to identify and resolve conflicts and to optimise train movements.	In use in dense operations, not yet in use in interstate / regional Australia	**Provided**	**Provided**	With ANCO	Possible enhance-ment
Electronic train graph	Controller uses electronic train graph to plans train movement, which is integral to the control system.	Widely used	**Provided**	**Provided**	With ANCO	**Provided**
Paper train graph	Controller plans train movements manually, then executes them using the control system.	Widely used	Not necessary	Not necessary	**Provided**	Not necessary
No control	Entire corridor is locked out for each train, using key staff, blocking or similar.	Terminal corridors with only 1 train	Not normally used	Not normally used	Not normally used	Not normally used

Notes:

For ATMS, the possible enhancements to provide electronic graphing and network optimisation would be achieved through linking the system to ANCO (ARTC Network Control Optimisation), under development for the Hunter Valley network.

Improving efficiency of communications

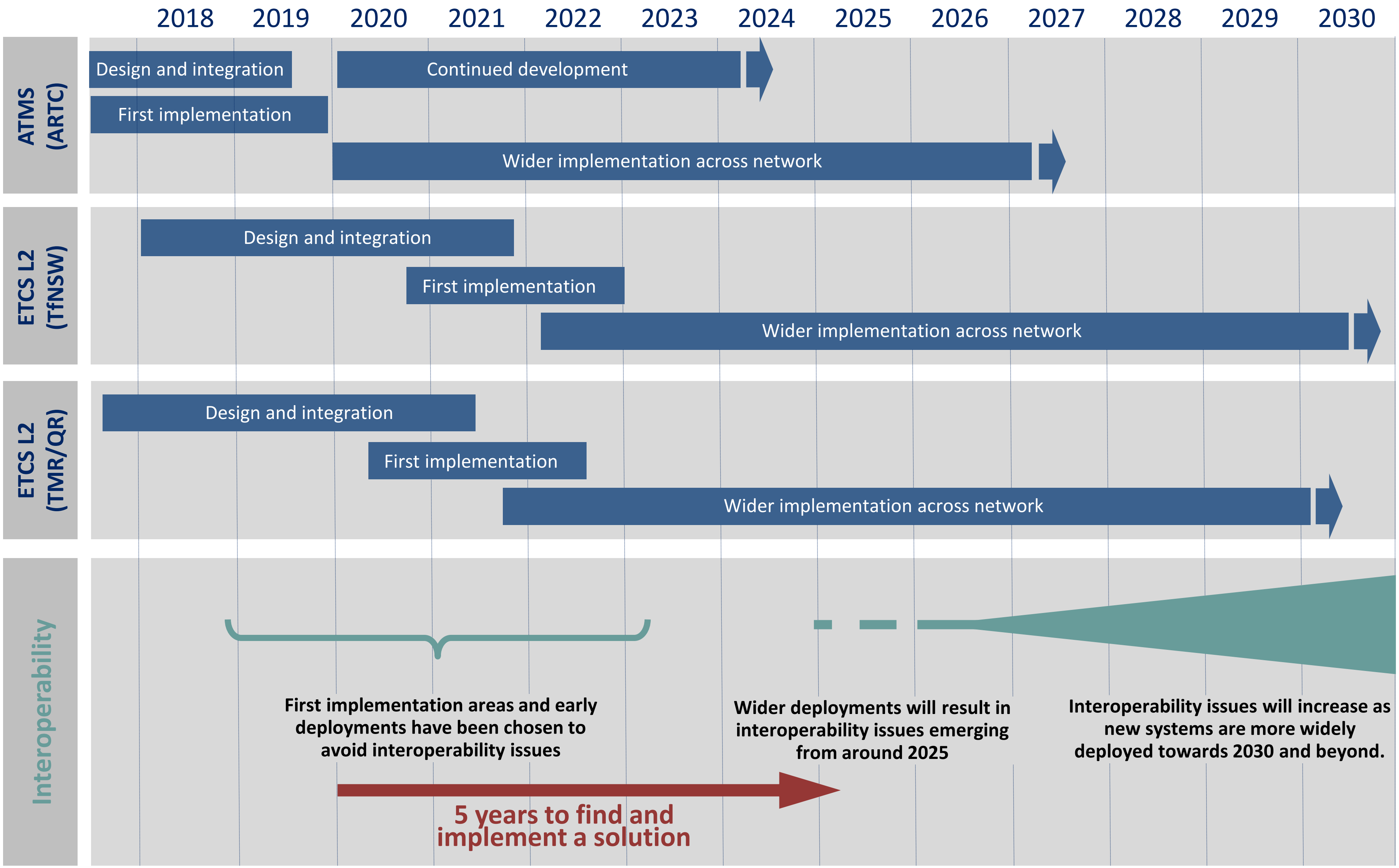
High

Efficiency

Low

System	Features	Use	CBTC	ETCS L2	ATMS	eTOW
Integration with higher functions	Onboard data is combined with other data for additional driver information, e.g. Driver Advisory System (DAS) or Automatic Train Operation (ATO).	Not yet in use in interstate / regional Australia	Provided	Possible enhance-ment	Possible enhance-ment	Possible enhance-ment
Data to onboard unit	Authorities are transmitted to the cab using data radio, processed by an in-cab unit and displayed on a DMI.	Not yet in use in interstate / regional Australia	Provided	Provided	Provided	Possible enhance-ment
Data to in-cab	Authorities are transmitted to the cab using data radio and displayed on an in-cab screen.	Used in data TOW to speed the process of transmission	Not necessary	Not necessary	Not necessary	Provided
Voice to in-cab	Authorities are transmitted to the cab using voice radio, with a read-out / read-back protocol.	Widely used for TOW	Not necessary	Not necessary	Backup option	Backup option
Voice to lineside	Train stops to enable crew to use lineside telephone or similar.	Staff and Ticket	Not necessary	Not necessary	Not necessary	Not necessary

Indicative timing of key initiatives with interoperability impacts



Notes: Timings shown are indicative only, based on publically available data.

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Can ‘good’ be achieved with current systems and developments?

A ‘good’ outcome would be Safe, Effective, Upgradeable, Scalable, Interoperable and Harmonised.

Assuming:

1. All announced initiatives are progressed as planned, and
2. Networks that have not yet identified a direction adopt one of the systems under development.

Issue	Comments	
Safe	Current developments address, or provide pathways to address, current gaps in safety including speed and end of authority enforcement and trackside worker safety	✓
Effective	The combination of systems under development provides functionality that spans the range of requirements from regional to suburban networks.	✓
Upgradeable	Each of the systems planned for deployment is supported and able to be upgraded. Whilst ATMS is upgradeable, the initial small deployment base may influence the cost of upgrades as costs are borne by relatively few entities.	✓
Scalable	The combination of options under development appears to have the breadth of functionality to cost-effectively meet the needs of different types of railways	✓
Interoperable	CBTC, ATMS and ETCS use different onboard equipment. TMACS uses the ICE radio screen for display of authorities, which is common across the standard gauge fleet. Signals may be retained to provide interoperability as a transition stage.	Work to be done
Harmonised	Adopting a new system provides the ability to move to harmonised safeworking systems, however this has not yet been achieved	Work to be done

Potential issues with the current systems trajectory

Potential for multiple onboard systems

- Need to achieve interoperability between ETCS and ATMS
- Need to accommodate a number of different radio systems

Potential for no rationalisation of safeworking systems

- Several railways have not yet decided on a systems approach
- Harmonising of safeworking systems across state boundaries will still be necessary

Key initiatives are not yet proven

- Unlike other alternatives, ATMS is not yet proven, and remains in final stages of development
- Only one initiative is being actively pursued for enhanced TOW. Enforcement with enhanced TOW remains in development, and would likely only be reactive.

Potential for missed opportunities

- Developing locally may mean international initiatives are unavailable
- Developing locally may increase risk of product with stranded, unfunded development paths
- No clear path to enhanced functionality e.g. Driver Advisory Systems, energy / fuel conservation systems, semi-automated and automated operations

Elements of harmonisation

Currently:

- 10 different systems of working, and 17 different variants of system in each state,
    - creates inefficiencies, adds costs and creates barriers to entry to the rail industry.

Harmonisation of new systems will mean:

Practically (as far as possible):

- One set of rules for each system, applied wherever it is deployed
- Principles and infrastructure are transferrable between implementations
- Common interfaces to users (e.g. lineside indications to drivers are consistent across all implementations, driver interfaces are consistent),

Benefits would include:

- Transferability of skills of users, providing greater opportunities for workers and a greater resource base for companies
- Transferability of suppliers, providing market competition and reducing system and equipment costs
- Reduced costs to acquire and maintain competencies
- Reduced costs for infrastructure and system element
- Reduced barriers to entry to market

But it will take:

- Concerted effort during the development phase, to align rules and approaches
- Leadership and goodwill

This applies to:

- **ATMS**, ensuring a harmonised approach to deployments across the ARTC network and on all other networks where this technology is deployed
- **ETCS Level 2**, where possible, achieving harmonisation between Sydney and Brisbane deployments, and providing a baseline for any further decisions to use this technology.

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