Engineering Plan
Signalling and Control Systems

PL S 44000

Signalling and Control Systems Strategy

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Plan

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Document control

Version	Date	Author/ Prin. Eng.	Summary of change
1.0	1 July 2016	David Smit	Initial Issue

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Executive Summary

This document forms a high level strategy for Signalling and Control Systems (S&CS) in Sydney Trains to align with the strategies, plans and other documents produced within Sydney Trains, Transport for NSW and the NSW Government to deliver Sydney Rail's Future. To demonstrate alignment with these strategies it has been developed with the same key TfNSW and Sydney Trains high level business requirements.

Key strategic principles:

- Use a risk-based approach to innovation, encouraging the use of new technology on the network, while balancing the risk associated with untried or highly customised systems;
- Align project designs to the high level business requirements to facilitate the delivery of Sydney's Rail Future and meet the operational needs of Sydney Trains without 'gold-plating';
- Utilise a whole of life integrated systems approach to provide best value for money over the life of the system. This will involve balancing capex and opex costs, and just as importantly, balancing the risks introduced with specific asset technologies against the benefits they introduce for an integrated system;
- Encourage better use of condition monitoring to support maintenance optimisation, improved asset reliability and ultimately reduce system downtime and time working in the danger zone;
- Learn from international experience. Encourage the cross acceptance and use of internationally recognised products and systems with well-established support networks and system upgrade paths;
- Follow a systems engineering and progressive assurance approach to design and implementation. This encourages good requirements definition and continuous alignment of design with the business requirements;
- Apply consistent Reliability, Availability, Maintainability and Safety (RAMS) analysis to designs and technology selection;
- Encourage the use of tailored off-the shelf systems in preference to bespoke or highly customised systems; and
- Ensure that the key technology elements of this S&CS Strategy are embedded in the governance for project development alongside the requirement for ASA standards compliance.

Summary of the key strategies:

People

- Competence frameworks, standards and requirements will continue to be developed to provide consistent competence management across Sydney Trains and industry, providing a more flexible workforce and easier cross-acceptance of competence between organisations;
- Sufficient work will be retained in-house to maintain Sydney Trains' core engineering competency and capability, with the majority of work volume supported through collaboration with industry within the AEO framework developed by the ASA; and
- Coaching, mentoring and leadership training will be supported to develop high performance teams with a more agile and customer focused culture.

Process

- A system engineering approach and progressive assurance will be core to the delivery of designs and technology that deliver high reliability and availability and also meet operational needs;
- Internal processes will be reviewed and updated to encourage innovation while balancing the needs to meet RAMS, minimise whole of life cost and provide more efficiency in equipment selection and type approval; and
- Design, testing and maintenance processes will be reviewed to improve efficiency, reduce cost and ensure processes are proportionate to the safety risks and operational criticality of the systems involved.

Technology

- TfNSW has endorsed ETCS Level 2 as the preferred rail systems solution for the Sydney Trains network. New signalling projects and equipment selection will need to be ETCS Level 2 compatible. Obsolete and incompatible systems will be replaced as part of asset management MPM planning;
- Advanced axle counters with intelligent reset capability and more resilient degraded mode operations will replace track circuits as the preferred train detection technology. This will provide significant benefits in reliability, availability and safety, as well as providing significantly lower lifecycle costs. Axle counters have also been endorsed as part of the TfNSW ETCS Level 2 rail systems strategy;
- Point systems that remove the need for high cost and high maintenance air system operation will support the safety and reliability demands of the future network. Air systems are no longer supported as part of the long-term technology roadmap and will be progressively decommissioned with the introduction of ETCS Level 2;
- Obsolete train control technology such as push-button panels will initially be replaced by the in-house ATRICS system and progressively centralised within the new Rail Operations Centre (ROC). At a subsequent phase of ROC development, more advanced Traffic Management System (TMS) functionality will be required for Sydney Trains operations. A future TfNSW technology roadmap will determine the extent to which this involves ATRICS and/or a separate TMS, and define interface requirements with ETCS Level 2 deployment; and
- The use of condition monitoring and remote diagnostics will provide opportunities for new cost-risk optimised maintenance regimes, improved fault rectification times, and the potential for reduced danger zone working for field staff.

A technology roadmap for these strategies is provided in Appendix A.

Key Risks to delivering the Strategy

- Ensuring that the S&CS Strategy is embedded in the development of new schemes so that projects are aligned with this strategy in addition to being compliant with ASA standards.
- Ensuring that Network Rules and Operational Procedures are aligned with the changes that will be introduced with new technologies, as reluctance to make changes to the existing processes could result in costly, inefficient, suboptimal solutions being implemented for the long term.
- Ensuring that there is early commitment and oversight of the implementation of this strategy is required to ensure that projects do not continue with the existing systems and processes to meet deadlines and de-risk their projects.

1 Introduction

1.1 Purpose

This document forms a high level strategy for Signalling and Control Systems (S&CS) in Sydney Trains to align with the strategies, plans and other documents produced within Sydney Trains, Transport for NSW and the NSW Government.

It is intended to ensure both alignment with other agencies in the transport cluster and continued compliance with legislative requirements as a rail operator.

1.2 Background

The Current Asset Standards Authority documents pertaining to strategies for S&CS derive from a RailCorp S&CS Strategy document dated September 2010, produced by the then Chief Engineer Signals and Control Systems.

There has been a period of significant changes between 2010 and now, including a major restructure of the heavy rail transport, resulting in the functions of RailCorp being split into three new bodies; Transport for New South Wales (TfNSW), Sydney Trains and New South Wales Trains. Changes in government have resulted in a sharper focus on infrastructure projects and a need to deliver higher efficiencies and faster results to remain competitive.

Central to these changes has been a desire for long term planning and transparency of process to provide confidence of continuity to public and private industry. Key documents are at a government level, “State Priorities” (previously “NSW 2021”) and the “Long Term Transport Master Plan”, provides plans for modernising Sydney’s rail network in response to population growth, changing customer preferences and economic, social and environmental sustainability of public transport services in Sydney. At the cluster level TfNSW has produced “Sydney’s Rail Future” and the “Rail Systems Strategy”. These two documents detail a 5-stage strategy to deliver the network improvements set out in Figure 2. They are also currently developing a Medium Term Rail Development Plan.

Figure 1 – Hierarchy of NSW Transport Strategy

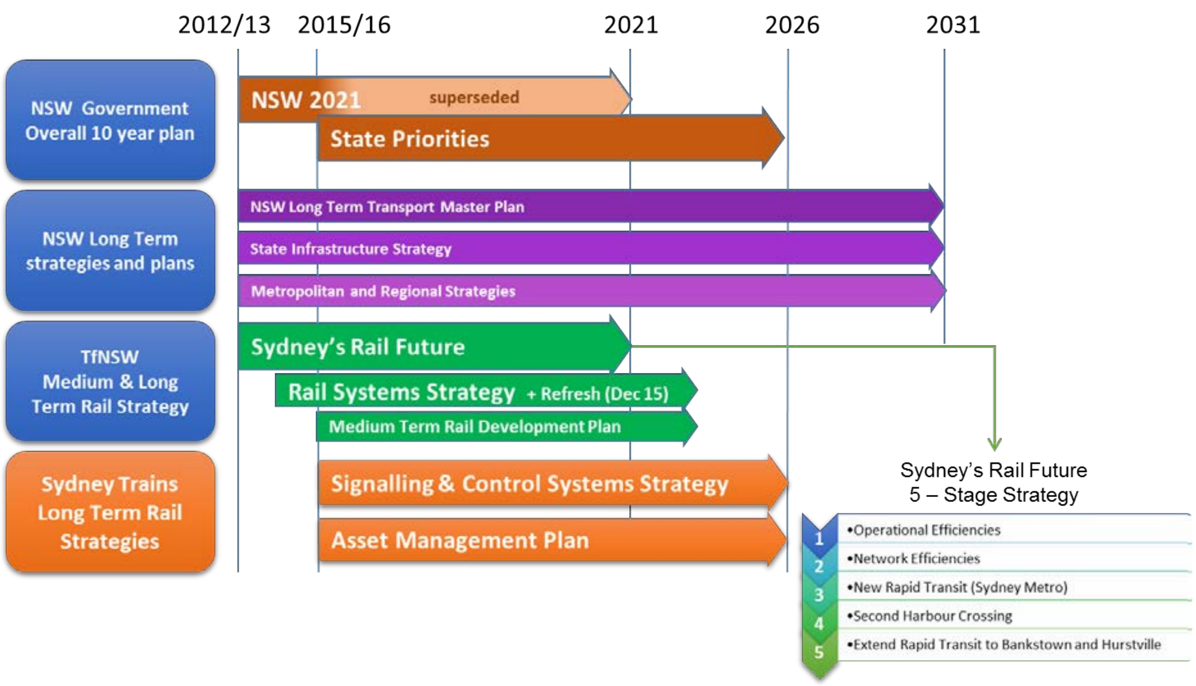
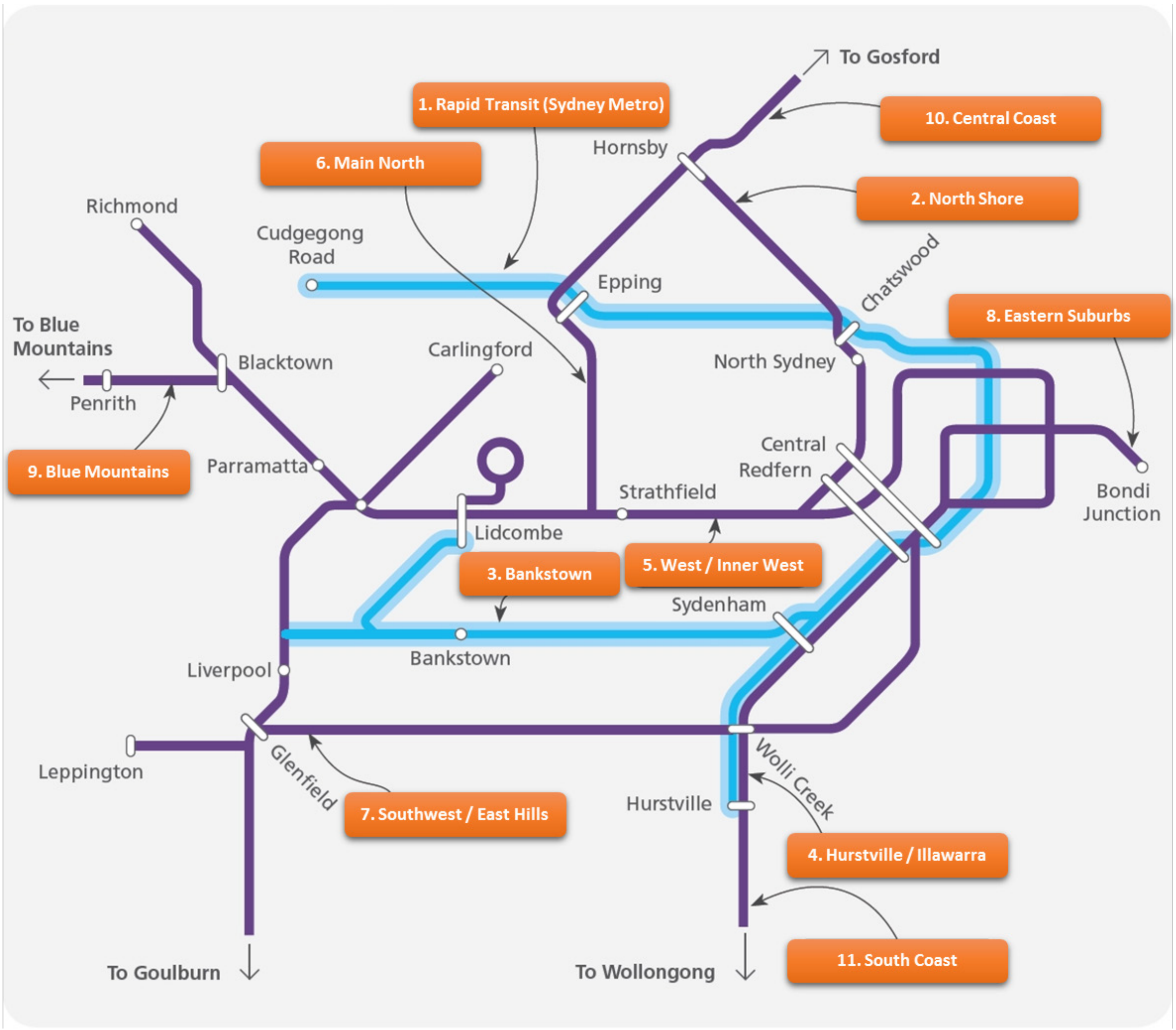


Figure 2 – Sydney's Rail Network Improvement Options



Given the extent of changes in the transformation from RailCorp to Sydney Trains, the Signalling and Control Systems Strategy (September 2010) has been refreshed and updated. It now also includes strategies covering people, process and technology, and introduces the Advanced Train Control Migration System (AMS), deployment of ETCS Level 2 and introduction of the Rail Operations Centre (ROC). Where there are significant differences from the previous S&CS strategy, these are identified and reported in the individual sections.

In the development of this document, a large number of key principles were derived from an S&CS strategy workshop with approximately 40 participants from Sydney Trains and TfNSW, including key S&CS personnel and stakeholders from the Sydney Trains Maintenance Directorate (which covers Engineering and System Integrity, Asset Management, Network Maintenance, Major Works), the Operations Directorate, and the Asset Standards Authority (ASA). The full outputs from this workshop have been published separately as a Sydney Trains Customer Central report.

1.3 Scope

The scope of this document is to provide a strategy for S&CS within Sydney Trains that will drive decisions throughout the business and has been divided into the following three areas:

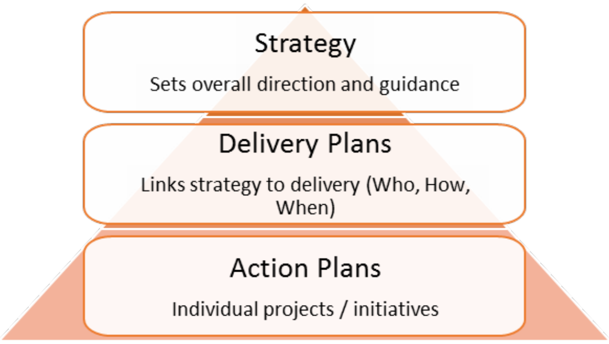
- People – This area addresses the strategy for resource planning, competence management, organisation structure, culture, outsourcing, etc.

- Process – This area addresses the strategy for design, (including integration between the signalling and control system elements), configuration management (design documents and data), introducing new equipment (type approval and assurance), acceptance and assurance of external works, etc.

- Technology – This area addresses the strategy for equipment selection and procurement, obsolescence management, system architecture, condition monitoring, etc. This area forms the basis of a technology roadmap for managing and upgrading conventional S&CS technologies, as well as the technology change associated with the proposed TfNSW 'Sydney's Rail Future' introduction of ETCS Level 2.

1.4 Application

This document provides guidance for all personnel working in the TfNSW cluster (in particular, Sydney Trains and ASA), and for organisations working with TfNSW, on the strategy for Signalling and Control Systems on Sydney Trains' infrastructure.



It is anticipated that a suite of delivery plans will provide the detail on how areas of the strategy will be delivered, e.g. deployment of axle counters, upskilling of maintenance staff, embedding changes in scheme development etc. These will provide a structured path to be managed and resourced and ensure the strategy is delivered. A number of these plans already exist and will require reviewing and possibly updating at their next refresh to align with the strategy.

The strategy itself does not include any mandatory requirements. However, it is expected that any mandatory requirements included within Sydney Trains standards and procedures will be aligned with this strategy document and managed by a suitable plan.

1.5 Reference documents

1. 'Signals & Control Systems Strategy', RailCorp, September 2010.
2. 'NSW 2021', Department of Premier and Cabinet, September 2011.
3. 'State Priorities', Department of Premier and Cabinet, September 2015.
4. 'Long Term Transport Master Plan', TfNSW, December 2012.
5. 'Sydney's Rail Future', TfNSW, June 2012.
6. 'Rail Systems Strategy', TfNSW, December 2013.
7. 'Rail Systems Strategy Refresh', TfNSW, November 2015.
8. Signalling and Control Systems Strategy Session, Sydney Trains Customer Central report, September 2014.
9. 'Advanced Train Control Migration System (AMS) Concept of Operations', November 2015.
10. 'Climate Change Risk Assessment and Adaptation Management Plan', Sydney Trains, October 2015.
11. 'Sydney Trains Control Centres Lightning and Surge Protection Study', Sydney Trains, September 2015.
12. 'Maintenance Directorate Signals & Control Systems Asset Management Plan', November 2015.

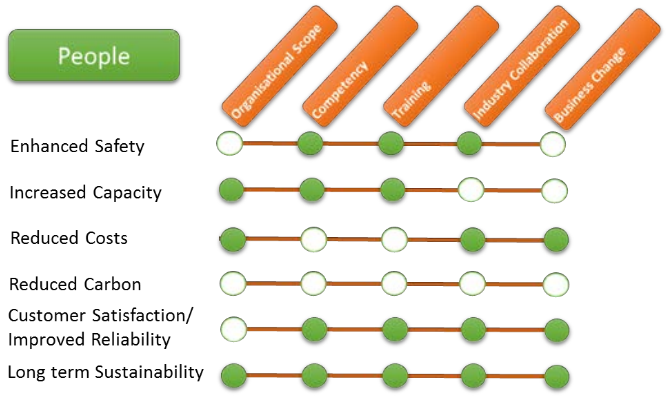
1.6 Terms and definitions

The following definitions apply in this document:

AEO	Authorised Engineering Organisation
AMS	Advanced Train Control Migration System – Sydney Trains implementation of elements of ETCS Level 1 to deliver a SFAIRP alternative to a standard ETCS Level 1 solution, as part of the migration to ETCS Level 2.
ARS	Automatic Route Setting
ASA	Asset Standards Authority
ASB	Absolute Signal Blocking
ATCS	Advanced Train Control System - Sydney Trains implementation of ETCS and related systems as part of TfNSW's 'Sydney's Rail Future'.
ATO	Automatic Train Operation
ATP	Automatic Train Protection - This term is used within this document to refer to the generic function and associated principles, and not the specific application of ETCS Level 1 ATP technology in Sydney.
ATRICS	Advanced Train Running Information Control System
CBI	Computer Based Interlocking
CBTC	Communications Based Train Control
COC	Certified Office Copy
DRS	Disaster Recovery Site
ETCS	European Train Control System - This term is used to refer to all standard forms of ETCS, with different forms or 'levels' of ETCS distinguished by specific additional terms, including: 'Level 1 Limited Supervision', 'AMS', 'Level 1', 'Level 2', 'Level 2 without Signals' and 'Level 2 with ATO'.
ITSR	Independent Transport Safety Regulator
MPM	Major Periodic Maintenance
NWRL	North West Rail Link
OCDN	Operations Critical Data Network
OEM	Original Equipment Manufacturer
ONSR	Office of National Rail Safety Regulator
RAMS	Reliability, Availability, Maintainability and Safety
RBC	Radio Block Centre
RIM	Rail Infrastructure Manager
RISSB	Rail Industry Safety and Standards Board
ROC	Rail Operations Centre
S&CS	Signalling and Control Systems
SFAIRP	So Far As Is Reasonably Practicable
TMS	Traffic Management System
TfNSW	Transport for New South Wales

2 People

This area addresses the strategy to enable the workforce to meet the Sydney Trains and TfNSW high level business requirements.



Of highest priority is the continued monitoring of core skills to ensure Sydney Trains has the capability to execute the legislative duties as a Rail Infrastructure Manager (RIM). Central to this strategy is the development of a competency framework to assure the workforce remains competent to deliver the business requirements, and the functional alignment of the Signalling and Control Systems division around the asset lifecycle.

The long term strategy is to reduce the work undertaken by Sydney Trains while still maintaining a core competency and capability across the asset lifecycle. Collaborative working with industry will support additional work and upskilling of internal and external workforces.

Retention of a core capability within Sydney Trains will be achieved through the creation of clear pathways for staff progression and, where required, a skill procurement strategy that balances developing skills internally with recruitment of advanced skills from industry.

2.1 Strategic Principles (People)

- Collaboration with industry to provide additional capacity and support the development of skills and competencies to align with 'whole of life' thinking and the asset lifecycle;

- Strengthen cross discipline collaboration, sharing of resources and alignment of processes within the Engineering and System Integrity division, including opportunities for parallel and aligned career paths;

- Competency system capable of capturing product knowledge, supported by contracted Through Life Support agreements;

- Standardisation and cross-acceptance of competencies across the rail industry, including specification of generic, domain and product competencies, and increased awareness and recognition of competencies from other industries and engineering bodies;

- Stronger emphasis on 'soft' competencies such as leadership, management and communication to align with NSW government competencies;

- Strong succession planning to facilitate knowledge transfer and availability of strong candidates; and

- Shorter product support cycles require a balance between retaining existing knowledge and skills, and the rapid reskilling of staff to keep up with changes.

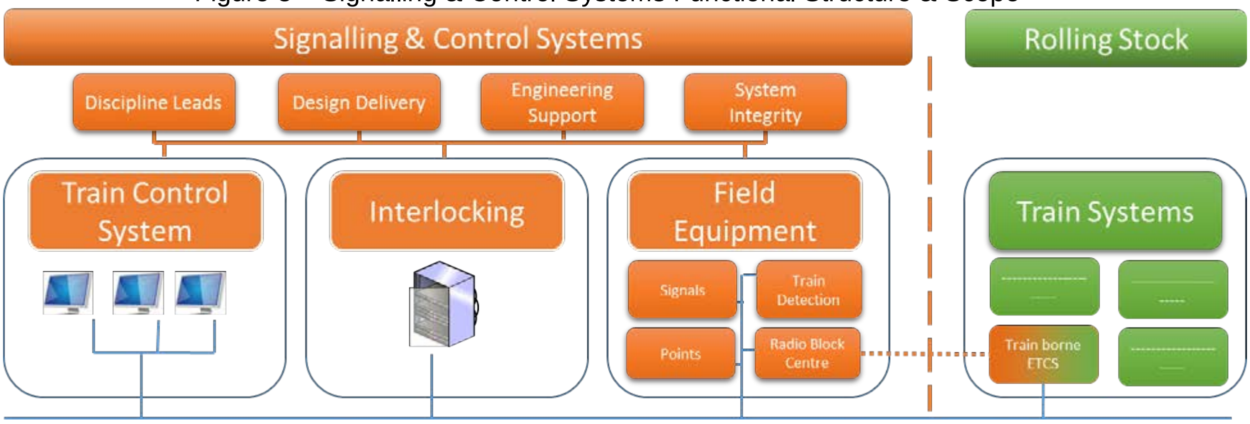
2.2 Strategy Details (People)

2.2.1 Organisation Scope

The Sydney Trains organisational structure has brought the Signalling and Control Systems disciplines closer together with an emphasis on increased collaboration. Co-locating these two groups will allow the integration of design processes, deliver greater consistency, and encourage the transfer of knowledge, skills and ideas while at the same time allowing more efficient use of common resources.

Alignment of the S&CS Division into a functional structure will better support all stages of the asset lifecycle across all the assets and systems within the scope of S&CS. A functional structure is also expected to foster a culture with greater focus on delivery and value adding throughout the lifecycle.

Figure 3 – Signalling & Control Systems Functional Structure & Scope



Discipline Leads

- Delegated engineering authority
- Discipline specific approvals
- Discipline specific strategy

Engineering support

- Equipment technical support and investigations
- Reliability analysis and improvements
- Technology introduction and type approval

Design delivery

- Scheme development / concept design
- Detailed design

System Integrity

- Incident Investigations
- Standards compliance

The organisation structure is expected to have clear career progression paths and support succession planning within the Division.

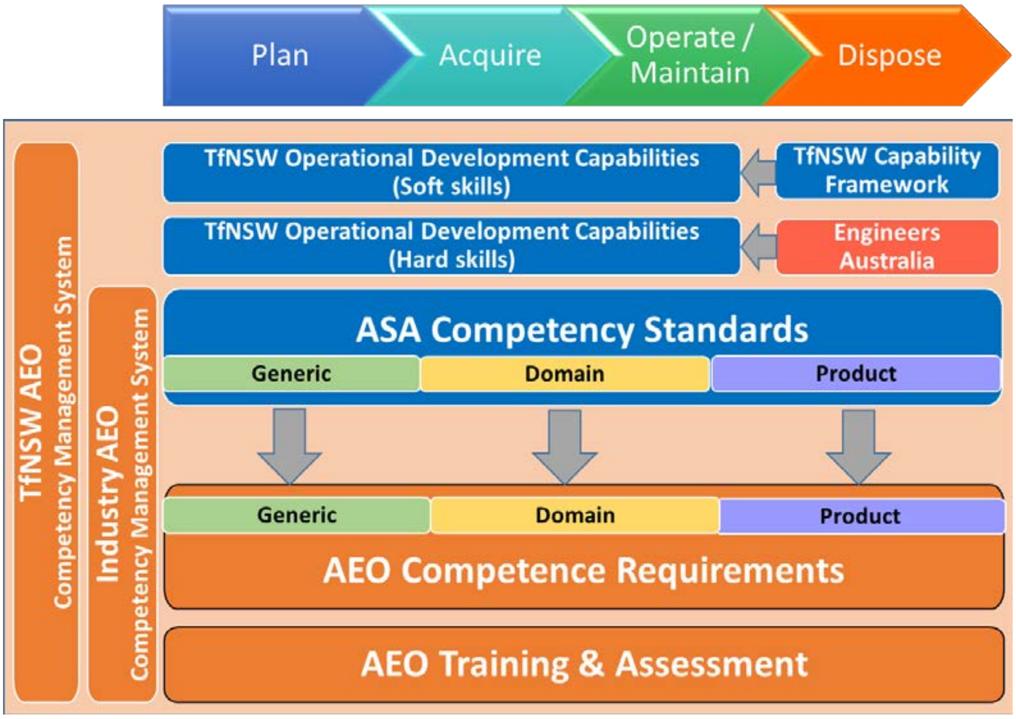
Work has already commenced on the development of the new S&CS organisation structure and the level of resources needed to support this strategy. Initial planning has suggested that co-located teams and a functional structure will enable S&CS to adequately support the strategy.

2.2.2 Competency

It is the intent of S&CS to develop the right level of internal resource capability and competency across all stages of the asset lifecycle, including adequate safety and systems assurance capability. Parallel and aligned career paths will be developed and formalised to ensure an appropriate cross pollination of capabilities between related disciplines and provide diverse opportunities for career progression.

Sufficient work will be retained within Sydney Trains to maintain an internal capability and competency. The existing competence management system will take into account both the asset lifecycle and range of employees working on the network. This will cover the training of new staff such as apprentices and graduates, refresher training of existing staff, and specification of contractor competency where 'domain-specific' knowledge and skills is required.

Figure 4 – Competency Framework Concept



A key element of the competence management system will be capturing product knowledge as new systems are brought onto the network. Supporting this is an expectation for supply agreements to have provision for internal staff to be embedded with the supplier or the supplier to embed individuals within S&CS for specific project delivery works. This will allow S&CS to gain or retain the necessary competence to support future works, gain experience on products installed and maintained by third parties, and provide contingency against supplier ceasing support for legacy products or going out of business. Encouraging suppliers to support this philosophy will be through the ability for them to take on the additional workload and the provision of more Through Life Support contracts.

The technology strategy will also see a shift towards more software and communications based technology that will require a very different skill set to the legacy electro-mechanical systems. Field technicians will need to become more knowledgeable on data transmission, networks and operational/IT systems, and be able to use specialised diagnostic equipment during maintenance and fault finding.

The TfNSW competency framework has introduced many ‘soft’ skills, aligning with the NSW Government competencies. These skills are highly transferrable and assist in creating a more agile and flexible workforce. S&CS will continue to work with TfNSW to ensure alignment with TfNSW competency framework and ensure the TfNSW framework aligns with the skills needed by a future network.

2.2.3 Training

Sydney Trains is shifting from being a formal training provider to more of a training developer and facilitator working with both TfNSW and industry. Formal training facilities are now held by TfNSW who provide training across the whole transport cluster. S&CS will continue to provide maintenance and design support for the S&CS simulated training environment at the Curtin Training facility to ensure it remains a relevant and up to date training asset.

There will be a step change in the technology deployed on the network over the coming years. This combined with shorter asset lifecycles will require a training capability that can rapidly upskill the workforce on novel technologies before they are brought into use on the Sydney Trains network. To achieve this Sydney Trains will need industry support in the development of suitable training material and potentially deliver training on new systems to manage the ‘wave’ of training needed in the early days of a new system.

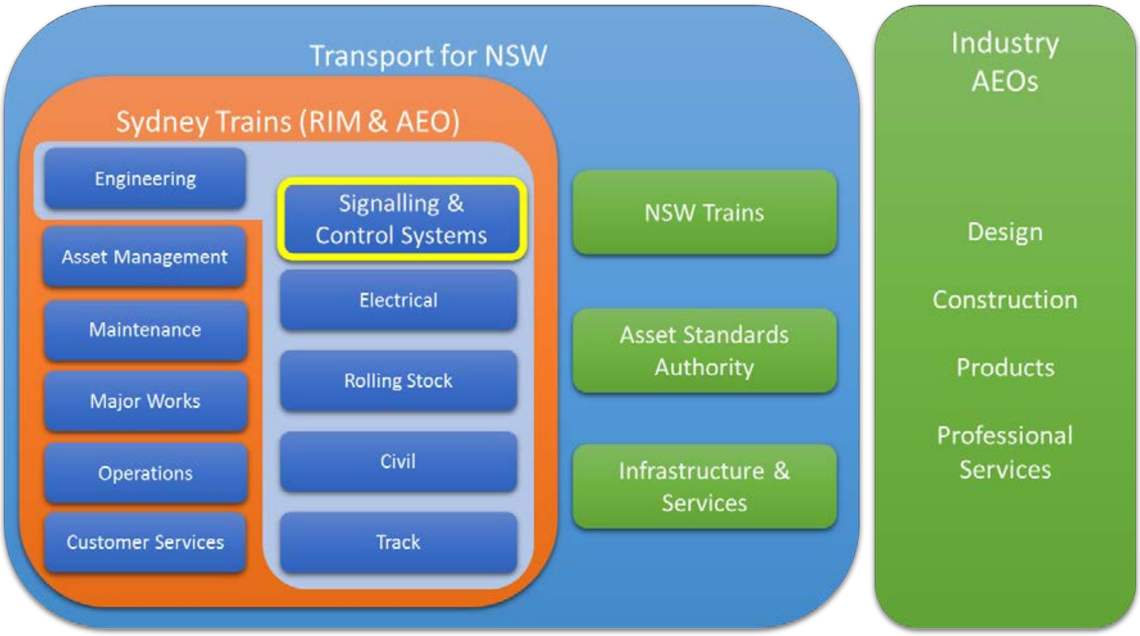
Succession planning within Sydney Trains will become an essential part of training plans and staff professional development. It will also help in retaining skilled staff in an environment with highly transferable skills. While obsolete systems remain in place, skills on these systems will need to be retained. Priority planning is needed for those skilled staff likely to retire with no clear successors.

S&CS will ensure that team training is not restricted solely to technical and equipment training, but include appropriate mix of coaching, mentoring, and leadership skills development. This will also support the TfNSW competency framework.

2.2.4 Industry Collaboration

The new structure of Transport for NSW will see increasing involvement of external parties (other transport clusters and agencies and private industry) in delivering new work across the Sydney Trains network. Unlike these external parties, Sydney Trains will be required to balance its duties as a Rail Infrastructure Manager (RIM) with the objectives of the government and TfNSW in creating separate transport agencies and AEOs (refer to section 3.2.1 ‘Engineering Authority’). Both of these objectives will need Sydney Trains to work more collaboratively with external parties.

Figure 5 – Organisational and Industry Interfaces with S&CS



The initial focus will be on developing standardised competence requirements for external parties to allow more effective delivery and collaboration by industry. This will be achieved through a mixed approach including business partnerships, bringing external contractors in for internal projects, as well as releasing Sydney Trains resources to work with external parties. Industry participation will be encouraged by providing continuity of work for external parties to promote industry confidence in the benefits in developing their own workforces.

S&CS will support the ASA to work with all its key stakeholders in setting standards that align with international industries and foster development and innovation while keeping safety paramount. Sydney Trains' close collaboration with other transport agencies will also support the efficient delivery of cross agency practices like competency frameworks, procurement strategies, etc.

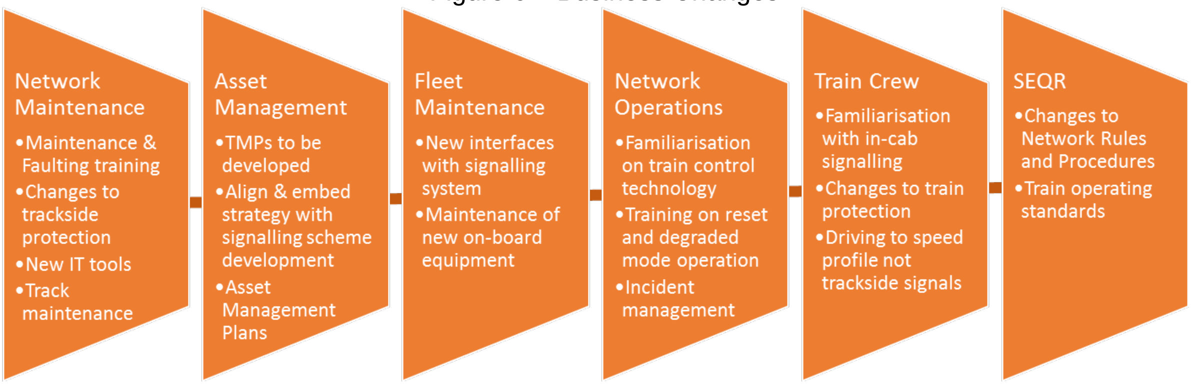
Growing a culture of transparency and shared purpose will continue to be important with events such as contractor technical forums providing an important platform for networking and sharing across the industry. Industry forums run and managed by Sydney Trains will support rail safety workers employed across all stages of the system lifecycle and form an integral part of licensing requirements to ensure the currency of domain knowledge.

A structured approach 'value add' will be used to determine attendance at conferences and interstate events to ensure that these are more closely aligned with the requirements of the competence framework. These conferences provide unique opportunities to review international practices and lessons learnt from project delivery and investigation of incidents, which can then be included in Sydney Trains forums alongside internal project and incident experiences.

2.2.5 Business Change

Change Management will form a significant part of introducing new technology and process changes. In order to efficiently deliver Sydney's Rail Future many of these will see major changes. Paramount to introducing these changes, will be the need to work closely with the other divisions of Sydney Trains and for the organisation to be flexible in adopting change rather than having to adapt 'off-the-shelf' systems to meet existing practices.

Figure 6 – Business Changes



The scale and breadth of the areas within Sydney Trains affected by the introduction of new technology and processes is partly highlighted in Figure 5. Organising and managing this will become more of a Sydney Trains business change rather than just an S&CS change. Further details on the impact, changes and the support needed from other divisions within Sydney Trains and TfNSW cluster organisation is covered in Section 5.

2.3 'People' Differences from Previous RailCorp Strategy

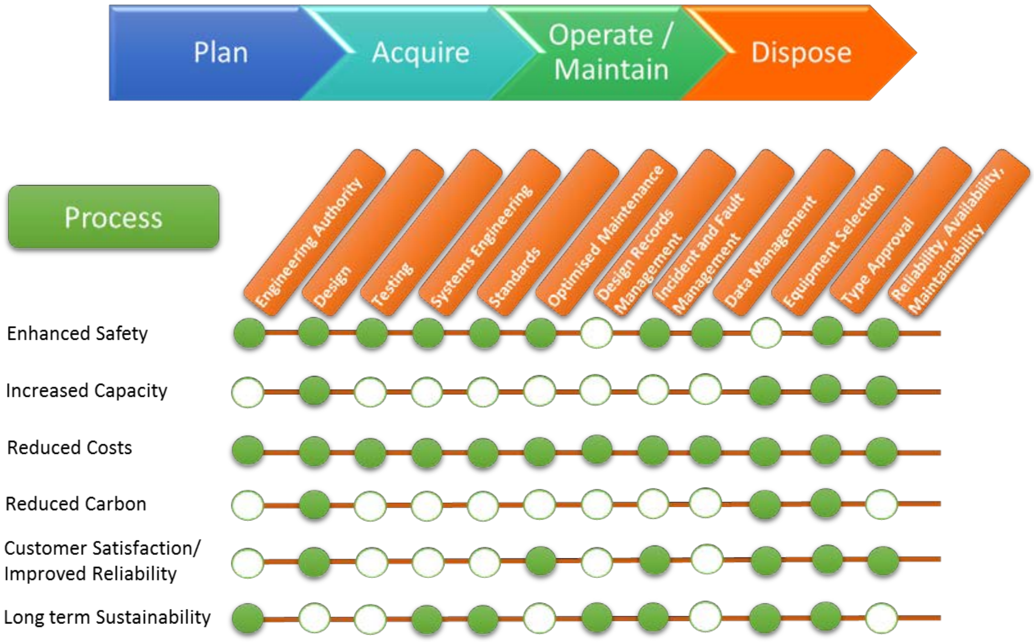
The key differences from the previous RailCorp strategy are:

- Realignment of competence management systems to support the new AEO structure within industry;
- Standardisation of competencies within generic, domain and product areas to facilitate cross-acceptance of competence across the rail industry;
- Improved collaboration with industry to support the volume of project work required for Sydney's Rail Future and Rail Systems Strategy; and
- Organisational restructure to a functional framework to better align across Sydney Trains divisions and throughout the system lifecycle.

3 Process

This area addresses the strategy for the review and development of S&CS processes across the asset life cycle to meet Sydney Trains' and TfNSW's business requirements and align with ASA standards.

Figure 7 – Sydney Trains' asset lifecycle



A comprehensive suite of processes is needed to support a Systems Engineering approach and on-going progressive systems assurance. This will introduce improved requirements development and through-life requirements management. This will improve the effectiveness of activities across the system lifecycle, from clear traceability between business requirements and design, through to clarity and efficiency in the definition of maintenance requirements.

In general, the overall strategy for processes is to provide: consistency in the completion of tasks; reduced burden on training needs; traceability for decision making; and improved risk management in an environment of considerable technology change.

3.1 Strategic Principles (Process)

- Sydney Trains remains accountable for maintaining and complying with its processes and procedures to meet its obligations as a RIM and AEO and ensure compliance with ASA Standards;
- Sydney Trains remains accountable for the assurance and acceptance of 3rd party designs and engineering works to assure the on-going integrity of the network;
- Automate and streamline processes to reduce timeframes and resource requirements for lifecycle activities, including design, testing, commissioning and maintenance;
- Encourage the use of existing, well established and demonstrated processes, collaborating with industry to develop common processes where possible;
- Enhance workers safety though minimising time in the danger zone;

- Support industry collaboration in innovation and more efficient introduction of new technologies, without compromising system safety or integrity;
- Business rules to align with industry/national/international standards for equipment rather than modifying standard equipment to suit existing business rules; and
- Designs must be ‘constructable’ and meet legal obligations for ‘safety-in-design’.

3.2 Strategy Details (Processes)

3.2.1 Engineering Authority

Engineering authority will be reviewed with the goal of delegating authority and empowering the workforce. This is expected to remove ‘bottlenecks’ in processes and reduce the dependency on a small pool of individuals. To achieve this, new or updated processes will be developed alongside new competency requirements to support the new delegations.

In addition to Engineering Authority changes within Sydney Trains, the new TfNSW structure has introduced Authorised Engineering Organisations (AEOs) and delivery of projects managed by external parties. Sydney Trains now has much less control over projects and changes to the network, especially signalling works. However, Sydney Trains as a Rail Infrastructure Manager (RIM) is still required to maintain and assure the on-going integrity of the delivered projects. Mitigating potential risks associated with these new interfaces will require large changes to existing internal processes. This has already commenced with the development of processes accommodating interfaces with AEOs and links to TfNSW configuration management processes e.g. Configuration Control Boards, etc.

Although AEOs are accountable for the engineering authority around the work that they deliver, there is a need to ensure that industry understands the obligations of Sydney Trains as a RIM and the extent to which this has to be reflected in the level of stakeholder engagement.

3.2.2 Design

The design and assurance of complex safety integrity (SIL rated) systems is an expensive and time consuming process. In order to deliver cost improvements and faster design delivery timeframes, without compromising safety, the following areas of design will need to be reviewed and improved:

- Clear separation of critical and non-safety critical elements to allow cost effective systems and design processes to be utilised for the less critical aspects;
- Minimising and simplifying, by design, the safety critical elements;
- Minimising the level of customised data in the safety critical modules;
- Alignment of design review requirements with the criticality of the design;
- Procedures and processes to be streamlined and aligned with new competences and sign-off authorities to reduce the existing bottle-necks;
- Automated checking tools to minimise the human element where possible;
- Modular designs to reduce design timeframes and cost, and ultimately introduce modular construction techniques further reducing time and cost;

- Consistency in asset identification and location description across all disciplines.

Taking a Systems Engineering approach, described in Section 3.2.4, will be a key step towards addressing and improving many of these design processes. It will also prevent excessive workload and 'gold-plating', where design and product selection are far in excess of the original business requirements.

Methodologies and tools that introduce greater consistency in design development will be encouraged. These help reduce the risk of errors, reduce timeframes, and remove a lot of the subjective decision making that again can introduce a level of excessive complication in designs.

Further efficiencies and consistency in design techniques will be achieved through the integration of the design processes from the signalling and the control system groups, previously two separate divisions. Aligning and combining these processes will simplify engagements with industry, reduce the number of competency requirements and generally streamline the work within S&CS.

Sydney Trains needs to introduce more formal 'safety-in-design' processes as part of its legal obligations and ensure that these are an integral part of the design process.

Within the areas of signal design there is a need to improve the level of 'constructability' in design, e.g. more formal designs for equipment racks and cable routes.

3.2.3 Testing

A key challenge for industry is to reduce the time and the cost of testing new signalling and control systems while maintaining at least the same level of system integrity. There is also a need to reduce the impact of commissionings on the operational railway, driving a need for testing practices to accommodate shorter duration possessions, testing during live operation and smaller more frequent upgrades.

Whether it is Factory Acceptance Testing prior to installation or Site Acceptance Testing following installation, potential areas to be explored include:

- Developing processes to determine which tests are critical and which could be performed using sampling techniques;
- Automating tests;
- Modular testing of systems and interfaces to reduce wholescale system testing;
- Combined test plans to accommodate multiple parties and avoid duplication of workload.

Historically, testing control systems would involve multiple parties independently testing the system against each of their own system requirements. In addition to introducing duplication and extended timeframes, there is also extra time and potential risk from the resulting correspondence between the parties to address and close out any identified issues. A Systems Engineering approach will encourage progressive testing and assurance against a suite of stakeholder agreed requirements. Combining this with wider use of modelling and simulations to test individual systems and stages of a project will further support the reduction in project delivery times and more importantly impact on the operational railway and customer.

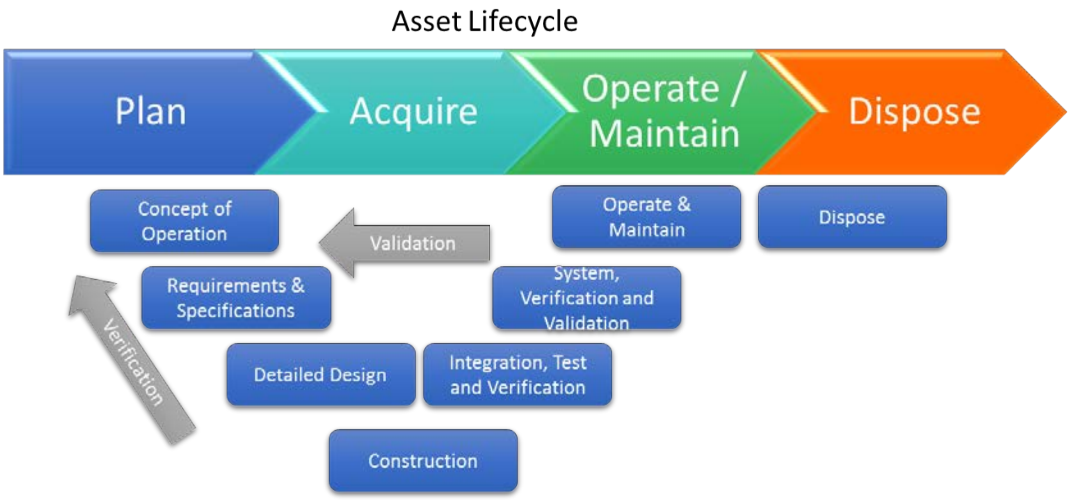
3.2.4 Systems Engineering

Aligning processes with the Systems Engineering approach taken by the TfNSW Asset Standards Authority and described in AS/NZS ISO/IEC 15288 will be key to driving innovation in:

- Requirements Management
- Design and Testing processes
- Product / System selection
- System and Safety Assurance
- Verification and Validation

An initial step will be the creation of an S&CS system/process model; mapping the functional organisation structure to the typical asset lifecycle. This will be followed by the mapping and development of new processes to align with the Systems Engineering 'V' model concept.

Figure 8 – Simplified Systems Engineering 'V' model



Implementation of this new approach will be a step change for engineering within Sydney Trains. To support the change management aspect of this strategy, a systems engineering approach will be embedded within the competency management system being developed.

3.2.5 Standards

The new TfNSW structure has seen most standards transfer from what was previously RailCorp to the ASA and an increased alignment with national standards produced by RISSB.

The transfer of standards to the ASA has introduced an issue for Sydney Trains in that many of them contained both requirements and procedural descriptions, which is no longer appropriate. These procedural descriptions must be separated from the standards and the new ASA custodian. The AEOs including Sydney Trains should be left to develop their own processes and procedures and introduce efficiencies and alignments with their own organisation structures while still complying with the relevant standards whether held by the ASA or other governing body.

Where there is a conflict between introducing innovation and efficiency and compliance with ASA standards, Sydney Trains should actively investigate opportunities for concessions with the ASA.

Sydney Trains S&CS is expected to be a stakeholder along with other key industry AEOs in the development of new transport standards. Standards developed by the ASA are expected to deliver the desired cross-industry standardisation without becoming unnecessarily restrictive and detailed, thus providing stakeholders with an amount of flexibility.

New technologies are being introduced that require the development of standards not previously addressed by RailCorp and now require cross-industry alignment, for example:

- The wide spread use of axle counters may require changes to standards around broken rail management, traction return through the rails, engineering reset protocols, failure recovery, etc.; and
- Increased use of communication networks combined with an increased risk of hacking with malicious intent to disrupt operations requires guidance or standards on system security, encryption and protocols to manage the risk.

3.2.6 Optimised Maintenance

There are opportunities for efficiencies in moving away from scheduled maintenance to more performance based maintenance regimes. To support this move, the establishment of processes around condition monitoring equipment and an overhaul of maintenance processes will be required.

Standardisation of maintenance tasks and frequencies for asset types across the network are expected to be replaced with new optimised tasks and frequencies that are more aligned with the operational risks and performance requirements of the network.

To achieve the required performance and maintenance efficiencies it is also likely that maintenance will move from simple time based intervals to usage or condition based criteria where appropriate. Processes and systems will be needed to adequately manage varying maintenance interventions and assure the quality of information driving those interventions.

3.2.7 Design Records Management

The current internal design records management processes are not suitable for an environment where multiple internal and external parties could be modifying the same documents with limited or no transparency. Previously this was managed through a process where all signal designs were verified and approved by the RailCorp Chief Signalling Engineer. With the introduction of AEOs who can verify and approve their own designs, new processes are needed to manage these new and novel risks.

The long timeframes between project commissioning and issuing ‘as built’ design documentation will not be acceptable as we move towards more frequent updates. Streamlining of processes is needed to ensure up-to-date design documentation is available as soon as possible and ready for use by field staff or the next project.

New processes and a new records management team within S&CS is already being developed out of the previous RailCorp documentation section to support these improvements through the provision of:

- A one-stop shop for accessing PDFs and CAD (MicroStation) files
- Formalised process for booking out drawings

- Interim as-built maintenance copies
- Parallel design process

3.2.8 Incident and Fault Management

In line with legislative requirements as a RIM, incident investigations will remain a core process for Sydney Trains. Increased activity of external parties on the network will likely increase the occurrence of investigations that involve external parties. Investigation processes will need refining to reflect the challenges these investigations may present including:

- External pressures on investigation timeframes;
- Agreement on investigation conclusions; and
- Agreement on recommendations and where actions are assigned, including where applicable to external organisations.

New processes will introduce a greater commercial focus when evaluating the recommendations from an investigation. Robust processes will be required to evaluate the recommendations and agree the priority or feasibility in delivering them on a cost and risk basis.

These issues may require changes to the role of external bodies with the possibility of the Independent Transport Safety Regulator (ITSR) and Office of the National Rail Safety Regulator (ONSR) being involved with lower level investigations and acting as mediators in disputes.

No Fault Found and self-rectification still form a significant proportion of reported faults. Current initiatives to conduct more detailed investigations conflict with the need for less track access, and less work in the danger zone. Assets allowing remote access to diagnostic and historical information will significantly improve investigations and ultimately reduce time in the danger zone.

The facility within many modern software based systems to make minor configuration changes on site needs to be reviewed to ensure that the risks are managed appropriately within 'safeworking' procedures.

3.2.9 Data Management

With an ever increasing amount of computer based systems and associated data being deployed around the network, the role and importance of data management should not be underestimated.

Access to up-to-date data within a centralised multidisciplinary tool will be needed by various stakeholders to efficiently undertake their roles. Field staff will be expected to replace failed equipment containing local geographical data with the need for a risk based approach to the level of testing required.

Data configuration management tools will be necessary to ensure consistency in the data across disciplines (e.g. geographical descriptors), manage changes and control versions for release. Data files need to be managed, issued and tracked with the level of rigour associated with the criticality of the data. This will be particularly important where for example 3rd line maintenance support establishes a data change, which in turn could trigger configuration processes and design reviews.

The provision of data production and simulation tools for use by Sydney Trains will form part of Through Life Support contracts with suppliers. These will allow Sydney Trains to undertake changes as part of routine maintenance and even provide 3rd line support as more issues are resolved through data changes.

3.2.10 Equipment Selection

Selection of S&CS equipment for projects is generally based on a list of type approved equipment and project specific requirements, all in isolation of wider network or business strategies. Strategic oversight is therefore required to ensure the S&CS strategy is considered in the development of project scopes.

Establishing an adequate governance process to ensure projects align with the technology strategy is seen as one of the key risks in delivering this strategy (refer to section 5).

3.2.11 Type Approval

At the time of production of this strategy there is an ongoing review and update of processes around the selection and type approval of equipment being undertaken by ASA in collaboration with Sydney Trains. These processes will:

- ensure there is an actual need for a product (considering existing products and future use for the product);
- consider the whole of asset lifecycle (including disposal);
- evaluate Reliability, Availability, Maintainability and Safety (RAMS); and
- avoid personal prejudices or agendas.

It is intended to change the type approval process to emphasise more supplier/industry/AEO involvement, shifting the role of Sydney Trains from conducting the testing and reporting on new equipment, to approving supplier/industry/AEO produced reports. This will require engagement with industry and the ASA to encourage innovation and facilitate easier and faster delivery of type approvals. Key to this process change will be a shift from project sponsored type approvals which can often discourage innovation due to time, cost and risk pressures and move towards a strategic Sydney Trains and ASA sponsored approach.

Key issues to be addressed for an updated type approval process include:

- Balancing the risk of innovation and proven technologies;
- Aligning the level of review with the criticality of the equipment, potentially introducing a tiered type approval system with defined requirements for assessments of complex, vital, non-vital and support systems; and
- Simplification of cross acceptance to encourage the use of proven systems widely used elsewhere.

To support the overall technology strategy, type approval reviews of industry proven, off-the shelf systems with large installation bases will be undertaken to ensure that priority is given over new untried systems. In-house research into product improvements and new systems on the market will be encouraged. However, in-house system development will become the exception rather than the rule.

3.2.12 Reliability, Availability, Maintainability (RAM)

RAM optimisation of the rail network is becoming a fundamental part of technology selection, renewal and upgrade decisions. TfNSW's high level strategy documents define future capacity requirements, train service frequencies and wider business requirements from which RAM targets can be derived. Development of a RAM hierarchy will guide S&CS and other rail suppliers towards the level of performance required from the various signalling and control systems to deliver Sydney's Rail Future.

Simulation and modelling tools are widely available to calculate the performance of assets, systems and designs. It is expected these will be incorporated into a robust RAM framework to allow consistent analysis and comparisons of competing technologies and system designs. Optimised solutions that meet the defined RAM targets can be implemented without excessive 'gold plating'.

There will be a balance between the engineering RAM aspects of the system and the flexibility required by Network Operations. Complex systems that provide extensive flexibility for the Operator can also introduce additional failure points, increased maintenance costs, and can end up self-perpetuating the need for more flexibility.

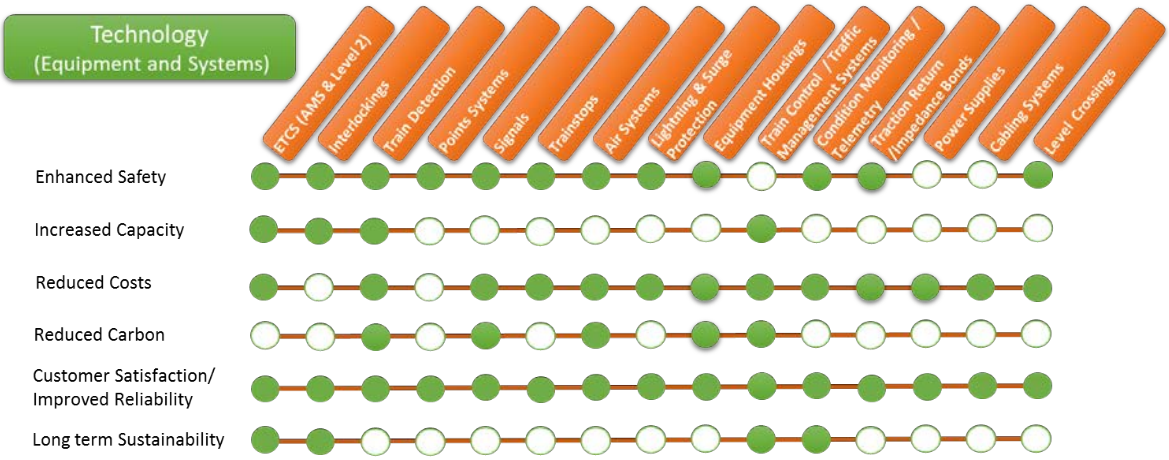
Providing an appropriate level of flexibility and/or redundancy to manage these operational perturbations, system failures, maintenance needs while keeping costs down is always a significant challenge. However, the development of an appropriate RAM model should provide strong support to project decisions and improve the resilience of projects against costly changes and scope creep brought on by external pressures.

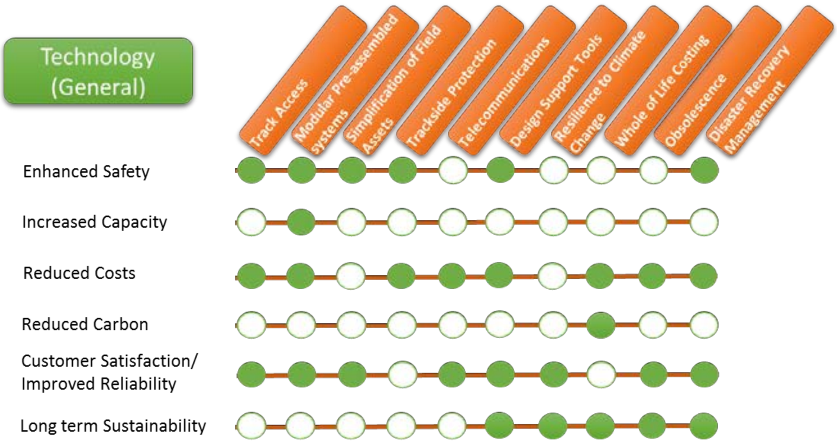
3.3 'Process' Differences from Previous RailCorp Strategy

- Systems engineering approach across all engineering life cycle activities;
- A need for new assurance processes to support an increase in externally delivered AEO works;
- A refinement of processes to be proportionate to risks and complexity;
- More standard processes aligned with industry standards and supported by industry collaboration;
- Designs must be demonstrably 'constructable' and meet legal obligations for 'safety-in-design';
- Design records management aligned with the need for multiple parties undertaking parallel design activities;
- Improved ability to cross accept type approval between railway organisations, and a disconnection of type approval from the isolated perspective of individual project sponsorship;
- More integration between signalling and control systems processes to reflect changing systems, technologies and interdependencies; and
- Improved data management tools and processes to support a significant increase in software based systems and configuration items.

4 Technology

This section addresses the strategy for specific equipment types and systems on the Sydney Trains network as well as the more general engineering aspects of technology such as obsolescence management and disaster recovery.





4.1 Strategic Principles (Technology)

The following strategic principles for signalling and control systems align with the TfNSW Rail Systems Strategy [Ref 6].

- New signalling projects and equipment selection will need to be ETCS Level 2 compatible. Obsolete and incompatible systems will be replaced as part of asset management MPM planning;
- Increased network capacity and customer demands will require a step change in asset/system reliability and availability that can only be achieved through changes in technology, and not through altering existing systems;
- "Off-the-shelf" products with no customisation and minimal configuration are preferred. The use of bespoke products and in-house development shall be avoided wherever possible;
- Reduce the overall need to access the operating railway and in particular the 'danger zone', to improve network availability and improve safety e.g. through the reduction and consolidation of assets in the danger zone;

- Technology is to be used to provide engineering rather than procedural controls for safe working in the Danger Zone;
- Advanced axle counters with intelligent reset capability and more resilient degraded mode operations will replace track circuits as the preferred train detection technology;
- Point systems that remove the need for high cost and high maintenance air system operation will support the safety and reliability demands of the future network;
- Air systems are no longer supported as part of the long-term technology roadmap and will be progressively decommissioned with the removal of trainstops as part of the introduction of ETCS Level 2;
- Obsolete train control technology such as push-button panels will be replaced by the in-house ATRICS system and progressively centralised within the new Rail Operations Centre (ROC);
- Traffic Management System (TMS) will align with a TfNSW strategy which defines the interdependencies between control of the existing Sydney Trains (ATRICS) network and the requirements associated with the introduction of ETCS Level 2;
- The use of condition monitoring and remote diagnostics will provide opportunities for new cost-risk optimised maintenance regimes, improved fault rectification times, and the potential for reduced danger zone working for field staff;
- Technology selection shall be cognisant of the pace of communications technology. Deployment of short-medium term projects should consider the potential for future wireless communication and the ability to locate systems away from the rail corridor;
- Introduce systems that can be deployed and allow future upgrades without impacting network operations; and
- Minimise the disruption of major disasters caused by system failure, extreme weather, or terrorist activities.

4.2 Strategy Details (Equipment and Systems)

This section addresses the strategy for specific equipment types and systems on the Sydney Trains network, i.e. points systems, signals, train detection, interlockings, train control systems etc. It provides a renewed focus on delivering operational objectives to align with TfNSW and Sydney Trains key strategic principles and business requirements, and facilitate the delivery of the high level S&CS technology roadmap presented in Appendix A.

4.2.1 European Train Control System (AMS and Level 2)

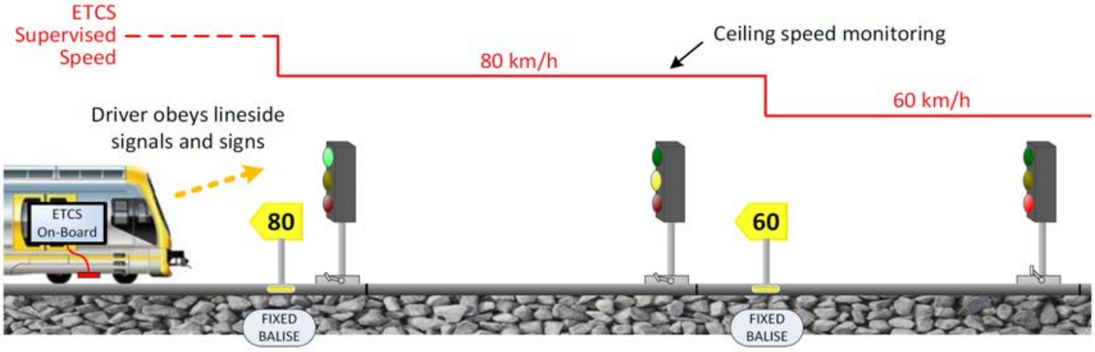
To meet the requirements of Sydney's Rail Future in enhancing safety, increasing capacity, reducing costs and providing high service reliability for customers, TfNSW has recommended ETCS Level 2 (or higher) as the preferred future signalling solution for the Sydney Trains network.

ETCS has three levels of operation: Level 0 (L0), Level 1 (L1) and Level 2 (L2). Sydney Trains is currently deploying the Advanced Train Control Migration System (AMS), a variation of ETCS L1 with a migration path to ETCS L2. A summary description of AMS and ETCS L2 deployment are included in the following sections.

4.2.1.1 Advanced Train Control Migration System

The Advanced Train Control Migration System (AMS) is based on ETCS L1 and addresses the safety recommendations from the Waterfall Special Commission of Inquiry report by supervising the train speed in relation to the allowable track speed. Trainstops, where already fitted, will continue to provide protection against SPADs. Where mainline signals are not currently protected by an existing mechanical trainstop, an (electronic) ETCS trainstop will be provided.

Figure 9 – Advanced Train Control Migration System



The simplified version of ETCS L1 was chosen to provide a cost effective solution in meeting the Waterfall recommendations and to provide a migration pathway to ETCS L2 through the fitment of ETCS on-board systems.

AMS will enforce line speed supervision (using fixed (passive) balises), and provide protection from the following hazards (using controlled balises and lineside equipment units (LEUs)):

- The approaches to turnouts deemed as high risk;
- High-risk deficient overlaps;
- Specific hazards within the overlap such as catch points and level crossings;
- Mainline signals not currently protected by a mechanical trainstop; and
- All main line buffer stop locations.

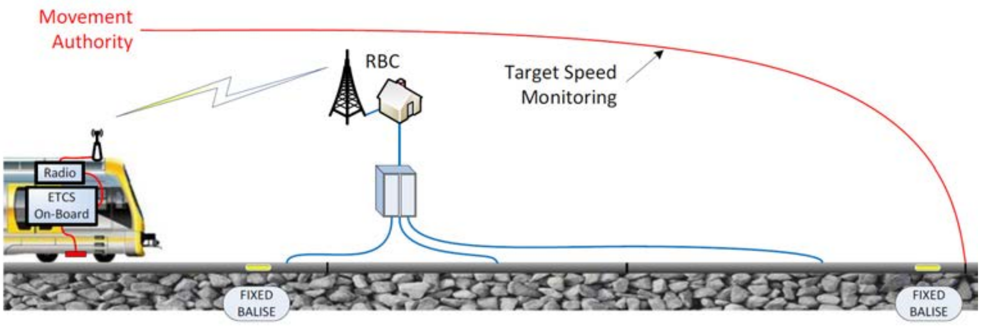
AMS will be rolled out progressively across the Sydney Trains network and rolling stock fleets with completion expected by 2019.

A detailed description of AMS is provided in the TfNSW “Advanced Train Control Migration System Concept of Operations” [Ref 7].

4.2.1.2 ETCS L2

As discussed in the earlier sections, ETCS L2 is the preferred signalling solution to be implemented on the Sydney Trains network. It uses radio to communicate with the train alongside conventional train detection inputs (e.g. track circuits or axle counters), and provides the necessary movement authority and maximum speed information (in-cab signalling) to the driver. This removes the need for trackside signals (where all trains operating on the line are ETCS fitted).

Figure 10 – ETCS L2

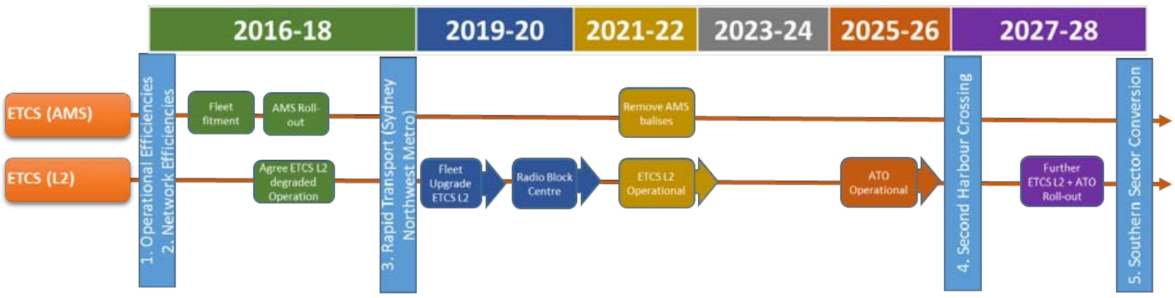


Under ETCS Level 2, controlled balises and LEU equipment will become redundant, being replaced with Radio Block Centres (RBCs) and the fitment of a secondary antenna on the train to receive movement authority.

In parallel with the technological aspects of delivering this new signalling system, a number of people and process issues need to be considered and resolved, including:

- Worksite protection arrangements for track workers;
- The use of temporary speed boards; and
- Recovery from degraded operation and loss of train location information.

A pilot deployment of ETCS L2 is anticipated to be operational by 2022 with a long term goal of an implementation of ETCS L2 with Automatic Train Operation by 2026.



4.2.2 Interlockings

To meet the increasing capacity demands of the Sydney Trains network, the TfNSW Rail Systems Strategy has recommended the implementation of ETCS L2 across the network. The Sydney Trains' interlocking strategy takes account of these high level business objectives through the selection of ETCS L2 compatible interlockings.

Mechanical Interlocking

Many of the mechanical interlockings are over a century old and effectively life expired. Some are in poor condition, have limited or non-existent spare parts and cannot be modified or expanded. The knowledge to maintain, repair and operate them is in decline, all of which will lead to ever increasing risks associated with reliability and asset integrity. It is therefore a priority to replace all mechanical interlockings.

Relay Interlocking

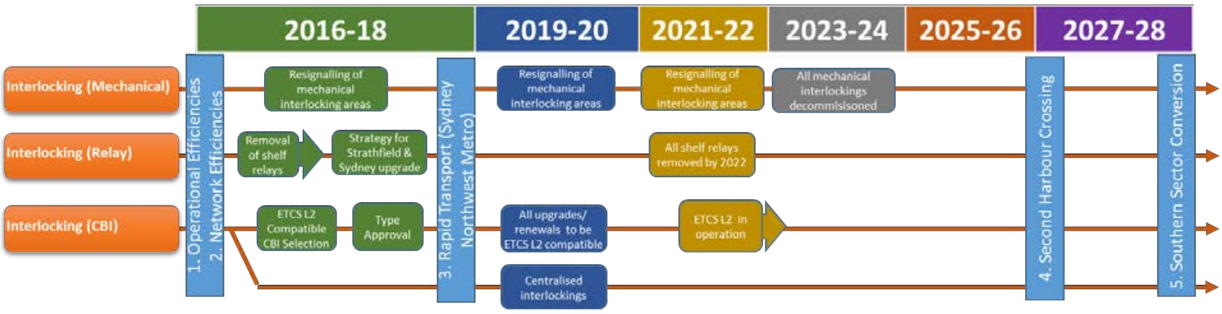
Relay Interlockings are located throughout the network with major installations at Sydney, Strathfield, Sydenham and Wollongong Control Centres. Many of these interlockings are nearing life expiry and at some locations use obsolete shelf relays which are costly to maintain. Planned re-signalling projects will see all shelf relays removed by 2022.

Of particular importance is the upgrade of the two biggest relay interlockings at Sydney and Strathfield signal boxes. Upgrading these to ETCS L2 compatible Computer Based Interlocking is critical to improving capacity, reliability and maintaining alignment with the TfNSW Rail Systems Strategy.

Computer Based Interlocking

Compatibility of the existing CBI systems with the preferred long term ETCS L2 solution is variable throughout the network. Although all are suitable for remote control, some early versions of CBI, including SSI and Westrace Mk1, are not compatible with ETCS L2 as they do not have the capability to interface with Radio Block Centres. Selection and type approval of suitable ETCS L2 compatible interlockings to replace these early interlockings is needed to meet MPM and capacity requirements.

The specific configuration of interlocking control boundaries (sectorised, line based, geographically based, etc.) will need to be developed in line with Sydney Trains' operational and performance requirements. Improved communications technology and security will be required to remove the need for interlockings to be geographically located near the assets they control.



4.2.3 Train Detection

The short term train detection strategy centres on the use of two audio frequency jointless types (UM71 and TI21) and one impulse (HVI). Digital upgrades of the UM71 and TI21 track circuits are the preferred replacement of other track circuit styles no longer supported, while HVI remains the preferred option across points and high risk track circuits where infrequent track use or contamination occurs.

Microtrax coded track circuits have recently been implemented at Kiama – Bomaderry as a pilot implementation, but the resulting performance has not been satisfactory, and the associated track sections have since been supplemented with the installation of axle counters. As a result, Microtrax track circuits are not recommended for wider deployment.

Other track circuit types currently used on the network but no longer supported include:

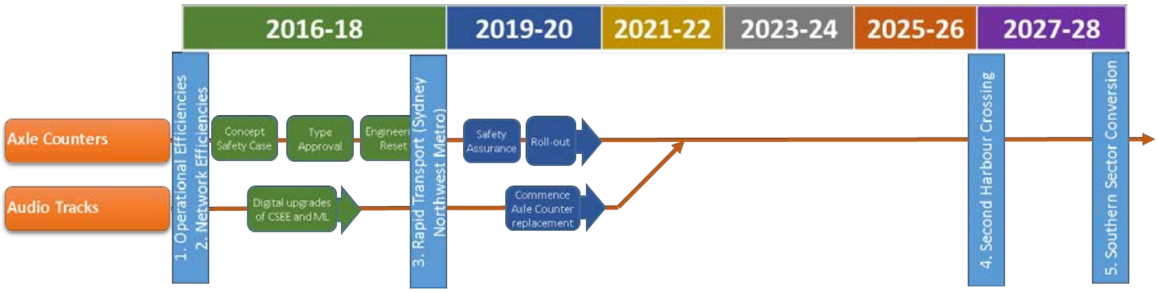
- 50Hz AC double and single rail configurations
- Westinghouse FS2600
- Westinghouse FS2500 (Analogue Audio Frequency)

In the medium-term, more advanced train detection technologies (e.g. axle counters) are needed to allow new signalling to be installed as an overlay without disturbing the existing track circuits, reducing the number of possessions required during resignalling works.

Axle counter technologies can also provide a step change in system reliability through automated system recovery, resilience to contaminated rails, ability to duplicate heads for extra redundancy near critical junctions, and be configured to provide more resilient degraded mode operations to maintain network capacity under fault conditions. Energy consumption is expected to be much lower than traditional track circuits, partly from the removing the continuous current draw along the length of the line, but also from the removal of impedance bonds and associated cabling and connection resistances.

Key issues surrounding loss of broken rail detection, procedures for system resets will also need to be reviewed and addressed.

Selection of specific train detection products will consider RAMS and whole of life costs along with other general aspects discussed within this Strategy, including reduced access requirements and placement of maintainable equipment outside the danger zone'.



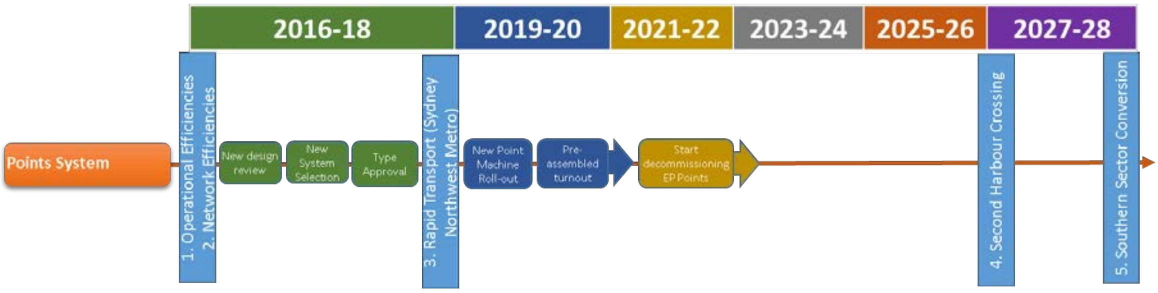
4.2.4 Points Systems

The strategy for point systems focuses on achieving a step change in reliability and availability to meet increasing network and customer demands. This requires an initial rationalisation of the asset base and use of risk based tools to reduce the number of complex layouts that provide operational flexibility that is not cost effective.

There is a need to phase out mechanical and air powered points and move towards electric powered point systems capable of driving all types of turnouts, and supported as off-the–shelf solutions from recognised international suppliers with an existing large installation base.

Also required is greater use of modular pre-assembled designs with in-bearer and on-bearer style arrangements to allow tamping and mechanised track maintenance without disconnection of equipment and accommodate reduced track access and fewer possession windows.

In line with the general technology strategy, developments of point machines are expected to have 'plug and play' line replaceable units to reduce track access time during faulting and maintenance activities. In-built condition monitoring and diagnostic capability should also be considered to support future optimised maintenance strategies and assist in remote fault diagnosis. To achieve improvements in reliability the additional functionality must not come at a cost to system availability and additional hands-on maintenance.



4.2.5 Signals

The current strategy for signals is to continue the replacement of incandescent signals on the network with LED signal designs and wherever possible rationalise layouts that provide operational flexibility that is not cost effective. LEDs require less maintenance (reducing working at height safety issues), provide improved sighting for drivers (reducing the risk of signals passed at danger SPAD) and offer improved reliability and lower energy consumption.

In areas where the implementation of ETCS L2 is initially planned, the LED upgrade programme will be scaled down as the number of signals are rationalised or removed depending on the need for fall-back arrangements under degraded mode operation. All trains (including freight) operating on the line will need to be fitted with ETCS L2 in-cab signalling before the removal of all signals could proceed.

Opportunities to service the asset from the ground and possibly maintain from outside the danger zone should be considered.

The remaining mechanical signals will be replaced as mechanical interlockings are upgraded.

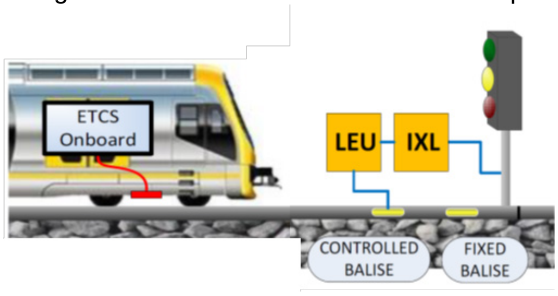
4.2.6 Trainstops

Trainstops will remain the primary method of control for Signals Passed at Danger (SPAD) until ETCS L2 is fully implemented across the network and rolling stock (including freight). The on-board ETCS L2 will then monitor the speed of the rolling stock and automatically apply braking to prevent a SPAD, removing the requirement for trainstops.

As ETCS L2 is implemented, the removal of trainstops will provide adequate spares for the remaining areas until full ETCS L2 across the network is completed.

Where mainline signals already lack a physical trainstop, the AMS technology discussed previoulsy will provide an electronic trainstop. These utilise a controlled balise connected to the signal interlocking to report the status of the signal to the on-board ETCS equipment.

Figure 11 – ETCS L1 Electronic Trainstop



4.2.7 Air Systems

The long term signalling strategy removes the need for an air supply system including compressors, dryers, auto-drains and air main. Many air driven assets such as electro-pneumatic trainstops and points will gradually be replaced with ETCS L2 train protection technology and electric powered point machines.

In the interim, upgrades and replacement of aged existing air systems may still be required to ensure adequate asset life until deployment of ETCS L2. If an opportunity arises to decommission air systems on a project even earlier, through the replacement of point systems with electrical equivalents, this shall be encouraged.

4.2.8 Lightning and Surge Protection

Addressing 'climate change resilience' is a requirement of the TfNSW Long Term Master Plan [4]. With an expected increase in both frequency and severity of extreme weather events, greater protection of modern signalling and control equipment against lightning and accompanying electrical surges is needed.

Power surges from electricity providers switching power during storms will be reduced through the fitment of more localised UPS systems. Small capacity battery backups will provide clean supplies and easily manage short duration switching anomalies being detected more frequently by modern signalling equipment. RAM analysis will be used to determine suitable UPS configurations to deploy.

Fitment of surge protection devices to address power surges at trackside equipment locations shall be rolled-out as standard. Automatic or remote reset functionality will also be a key requirement to avoid site visits and excessive downtime. Standards on cable separation and a greater use of fibre optics and other influencing factors surrounding lightning and power surges shall be reviewed and updated where required.

4.2.9 Equipment Housings

The long term strategy to consolidate assets and move towards the use of fibre optic and radio based communication is expected to reduce the number of trackside equipment housings. This in turn will allow the provision of larger walk-in housings to provide the equipment and workers suitable protection from the environment.

Centralised equipment can allow for more cost effective solutions for UPS systems and air conditioning to provide suitable environments for modern electronic systems. Housing designs will need to consider the fitment of more electronics in the future for the likes of condition monitoring, higher capacity communication requirements and further consolidation of sites. The configuration of UPS and air conditioning systems, expected to be incorporated at the sites, will need to consider typical failure response times, available system monitoring, redundancy etc. in determining optimum design requirements.

New technologies will allow more convenient locations to be selected for equipment housings (e.g. station areas). These bring additional benefits in the form of easier access to power, site access without the need to enter the rail corridor, and improved security of both equipment and workforce.

4.2.10 Train Control Systems

A new Rail Operation Centre (ROC) will be completed late 2017 and consolidate control of the entire rail network. Signal boxes will progressively be migrated into the ROC along with all other network operation functions.

Figure 12 – Rail Operation Centre (artist impression)

Technology will be used to deliver efficiencies in the ROC allowing optimisation of train controllers to manage different geographical areas, including:

- Automatic Route Setting
- Automatic Train Regulation
- Digital Train Radio System
- Degraded mode operation
- Centralised alarm and condition status

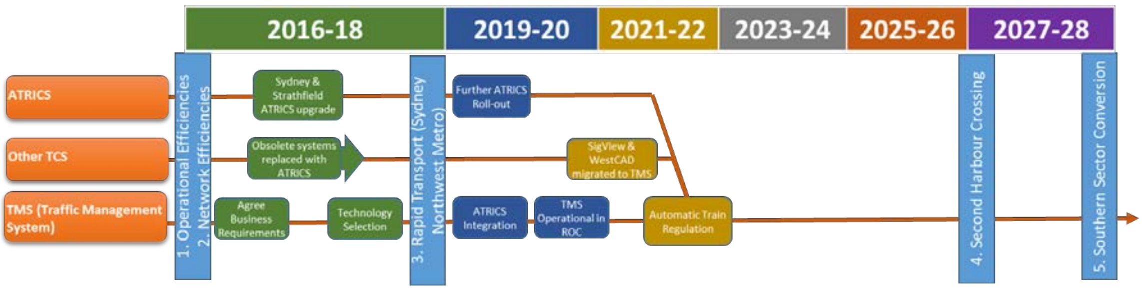
The rationalisation of signal boxes and train control will see systems no longer supported and life expired e.g. push button panels and some computer based systems being replaced with the in-house ATRICS system. Other systems such as SigView and WestCAD are expected to continue to be supported by their manufacturers or other third party support until control is replaced with ATRICS and migrated to the ROC.

The Train Control System in the ROC will initially be ATRICS migrated from various locations on the network. As ETCS L2 is gradually deployed, an Advanced Train Control Traffic Management System (TMS) will be deployed incorporating a variety of new functions to support the train controllers and further enhance traffic management.

If a TMS solution needs to be implemented in the ROC prior to the introduction of ETCS Level 2, the exact architecture and configuration of the TMS and extent to which ATRICS needs to be interfaced/retained will need to be determined in consultation with TfNSW.

It is expected that by deploying ETCS L2 compatible signalling infrastructure the amount of ‘tailoring’ needed on any future TMS system will be minimised as will the development and ongoing support costs. Even with the variations surrounding the implementation of an ETCS L2 system it is expected that many issues will still be addressed and resolved by other international rail operators prior to any roll-out in Sydney Trains. This aligns well with the overall strategy to encourage international proven systems in preference to the use of bespoke systems. However, this could potentially involve significant changes in network operating procedures and practises currently employed by Sydney Trains’ Operations. Nonetheless, in the long term, the benefits of deploying a widely used standardised system with standardised interfaces and the associated change management are still expected to greatly outweigh the associated costs of a heavily customised system.

One of the key future benefits of introducing ETCS L2 and a TMS will be the ability to use advanced Automatic Train Regulation (ATR). It can also be used to manage power usage and the demands on the electrical system by regulating the movement requests and ultimately the acceleration of multiple trains at the same time.



4.2.11 Condition Monitoring / Telemetry

Remote access to data that can provide the condition of trackside equipment, failure information, environmental condition, security breaches etc. is becoming more prevalent as new digital technologies are introduced and radio communications become more widely available on the rail network. Managing the amount of information and reliability of the data being presented will become a challenge but at the same time is also expected to bring significant benefits.

The main monitoring systems in use on Sydney Trains are: SCADA 2000 (in house), Cerberus (adaption of SCADA 2000), Kingfisher. Dupline and iMAC systems are used to a lesser extent and are undesirable for future roll-out. In general, with more CBIs being deployed the need for these monitoring systems will gradually diminish. Other off-the-shelf telemetry products will be considered for type approval and deployment in order to provide alternative solutions; a further requirement of this strategy.

The use of condition monitoring as a basis for predictive maintenance scheduling and reducing physical inspections in the danger zone, particularly for point machines, has historically struggled to demonstrate the benefits needed for widespread deployment. Determining and demonstrating what data is needed to identify precursors to failure and when to alert the operator will be the challenge. Simply providing the end user with more data will not be acceptable. Excessive information can potentially have a negative impact on asset operation, as frequent or unreliable alarms go ignored or excessive maintenance requests cause resourcing and operational issues.

Short to medium term benefits expected from condition monitoring include a better understanding of asset deterioration to support optimised maintenance plans, and the capturing of data to support fault finding. Repeat failures and self-rectifying failures take up considerable investigation time and place increasing pressure on workers to remove multiple systems in the hope of preventing re-occurrence. Introducing technology that can provide remote diagnostic / condition data will improve failure investigation timeframes and target the most appropriate LRU to replace. However, any implementation must still be able to demonstrate value for money and not be implemented as simply the latest trend to gather more data.

4.2.12 Traction Return / Impedance Bonds

Traction returns and impedance bonds play an important factor in the reliable operation of the currently preferred track circuit technologies. The impedance bonds evenly balance the traction return currents through the running rails without presenting a short circuit to the track circuit. Imbalances in traction return currents arising from inadequately rated impedance bonds or poor bonding connections can cause failures of track circuits, which are difficult to diagnose and replicate due to the large traction currents involved. With ever increasing power demands from new rolling stock and more frequent services, traction return could have a significant impact on network reliability.

The strategy to implement axle counter technology will remove this issue entirely. Ultimately it will result in the removal of impedance bonds and associated failure modes and maintenance. Until this time, adequately rated impedance bonds will need to match the existing and any increase expected in traction return.


Once axle counters are deployed and impedance bonds are no longer required responsibility for the maintenance of all track bonding is expected to move from being a signalling function to an electrification function where still required. However, this issue will require more formal resolution and agreement.

4.2.13 Power Supplies

The power supply strategy is aimed at better aligning power supply requirements to the type and criticality of equipment being supplied. This will require new systems suitable for supplying CBI upgrades and ETCS L2 technology. Uninterruptable supplies should become common place and provide the required backup capability to address power changeovers and temporary power outages. Smaller 'online' UPS systems can be considered for locations where full power backup is not considered necessary. These provide resilience to 'brown outs' where temporary voltage drops in the local power supply causes surges in the system and significant reliability issues. Power companies often experience this during storms where loss of supplies requires power switching and power management to retain the remaining systems. Improvements in design and cost reduction has made 'online' UPSs more affordable for this use while also isolating the output from noisy inputs and surges without the need for additional filtering.

Accompanying any UPS fitment should be battery monitoring systems and a temperature controlled environment to monitor the deterioration of the expected backup capacity and also to prolong the life of the batteries.

Earth leakage detectors shall be fitted to enhance staff safety and reduce requirements for insulation testing. This shall be combined with other projects to improve the quality of earthing at all sites. The fitment of surge protection devices (discussed earlier in this document) still requires good earthing to correctly operate and even more so when protecting digital telecommunications and computer equipment.

4.2.14 Cabling Systems

The strategy for cable systems considers the expected advancements in signalling technology and an increased use of fibre optic and radio communications.

Cable routes will continue to be located alongside the track away from the danger zone, adjacent to boundary fences. Buried versus surface cable routes shall be determined on the risk of vandalism and the planned roll-out of ETCS L2, which will considerably reduce the amount of lineside equipment.

With the advent of more fibre optic and radio communications between locations the size of cable routes and the required life expectancy will reduce. Future standards should reflect this and consider more cost effective solutions.

The provision of diverse routes to increase resilience to single point failures, physical damage (from engineering works and vandalism) and maintenance access will continue to be required. The use of more fibre optic will remove the need for separate power and communication routes and also improve the network's resilience to lightning and power surges.

4.2.15 Level Crossings

Level crossings present an inherent interface risk between road transport, pedestrians and rail traffic. Wherever possible these should be avoided or removed and alternatives considered when assessing the whole of life costs associated with safety issues, monitoring requirements and vandalism.

Where the use of level crossings cannot be avoided, they shall be upgraded where needed to meet current safety standards. Non-protected level crossings (where no lights, bells or booms are provided) are deemed the highest priority. The remaining priorities will be centred on the risk profiles associated with the road, footpath, level grading, line speed and lighting.

To improve reliability and operational availability of the level crossings, adequate redundancy of warning systems is required and remote monitoring provided. Historically the remote monitoring system itself has contributed to failures of level crossings requiring trains to be cautioned where it is not possible to monitor the correct operation of the crossing. To achieve the desired reliability of the monitoring system, duplication may be necessary following a RAMS assessment.

Standardisation of equipment across a relatively small level crossing population will assist with spares management and improve response to fault reports.

4.3 Strategy Details (General)

This area addresses the strategy for general aspects surrounding technology including: obsolescence management, system architecture, climate change, disaster recovery management, whole of life costing etc. It provides a renewed focus on delivering technology that meets operational objectives and aligns with both TfNSW and Sydney Trains key strategic principles and business requirements.

4.3.1 Track Access

To meet increasing customer demands for more services and higher reliability there is a need for technology and processes to reduce track access and possession needs. Disruptive practices of large scale possessions for renewals and signalling upgrades is becoming less acceptable.

Selecting technology and smarter tools that provide a seamless transition for Operations with minimal or no possession needs for installation, testing and commissioning will be crucial to meeting Sydney's Rail Future. Where possessions are unavoidable, the use of smarter planning tools and resource management should reduce the risk of possession overruns or the need for additional possessions to complete the works.

Technology choices such as axle counters will allow assets to be overlaid on current infrastructure and tested without impacting existing operations. Computer based systems and simulators will introduce the ability to undertake more testing offline, further reducing the need for large scale possessions.

The strategy to reduce the amount of track access needed for maintenance, faulting and minor renewals is addressed throughout this document by the use of: Line Replaceable Units, improved asset diagnostics, optimised maintenance regimes, centralised assets located outside the danger zone, etc.

4.3.2 Modular pre-assembled systems

The use of technology and the strategy to develop standard designs and testing practices will encourage more modular designs and pre-assembly of systems off-site. In addition to supporting the need to reduce track access time, the wider use of modular pre-assembled systems will also provide the following benefits:

- Reduced risk of human error introduced by time constraints on-site, particularly when unplanned issues arise or weather impacts installation;
- Controlled off-site environment can provide more consistent build quality;

- Time and cost savings can be achieved from grouping similar construction tasks in one off-site location;
- Reduced impact of adverse weather on site;
- Improved quality control;
- Enhanced safety from limiting the time on the track; and
- Reduced workforce needed on site.

The use of line replaceable units (LRUs) is becoming more prevalent as the complexity of systems become more difficult to fault find and the general cost of units fall. Furthermore, with the increase in train services, access to the track to undertake detailed fault analysis or complete the replacement of individual components will not be possible. Equipment designs that utilise LRUs that require no location specific configuration for fast emergency response times and minimised time within the danger zone will be needed. If desired the LRUs may then be tested/rectified/maintained in a suitable environment or discarded.

4.3.3 Simplification of field assets

Minimising the diversity of assets, in particular small populations within Maintenance Territories, will reduce issues surrounding limited asset knowledge and provide for standardised maintenance and faulting, and more efficient local spares management. To support this strategy, it is preferred in the short term to consolidate suppliers where possible and to minimise the variety of equipment brought into the network, providing a sufficient level of competitive procurement can be maintained.

Benefits from rationalising the variety of assets include: opportunities for bulk order discounts, improved continuity of service; reduced training requirements; minimising spares, reduced risk of incorrect equipment or configuration being used. To allow this, the remaining choice of equipment will need to be scalable (capable of working in a variety of locations, yards, mainline, small and large interlockings). Some of these benefits can only be achieved through the use of large internationally recognised signalling suppliers.

This strategy will also drive a rationalisation of suppliers. A balance will be needed to maintain competition and manage the risk of suppliers monopolising the market and increasing costs or running into financial difficulties and withdrawing all product support.

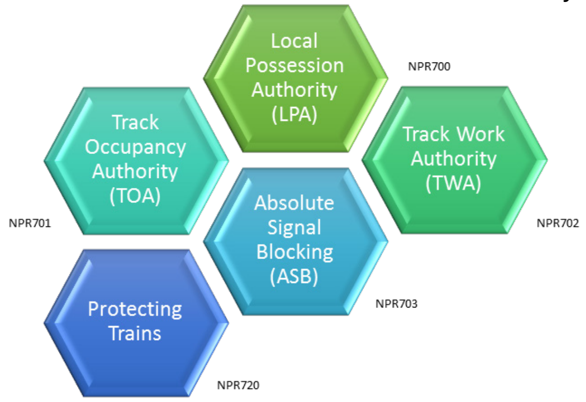
Simplification of designs and consolidation of trackside equipment to locations outside of the ‘Danger Zone’ also brings improvements in staff safety and asset reliability. Technologies that allow communication with field equipment over longer distances will minimise the number of equipment housings and allow assets to be co-located at more convenient areas, e.g. stations, and fitted out with effective UPS, air conditioning, security systems, surge/lightning protection, etc.

4.3.4 Trackside Protection

Technology solutions shall be trialled and implemented to reduce the reliance on human processes to protect track workers. Although a reduction in assets and in particular assets in the ‘danger zone’ will reduce the amount of work on the track, there will still be a need for staff to access the operating railway. Technology solutions that provide robust engineering controls for staff protection while creating minimum disruption to train services will be needed.

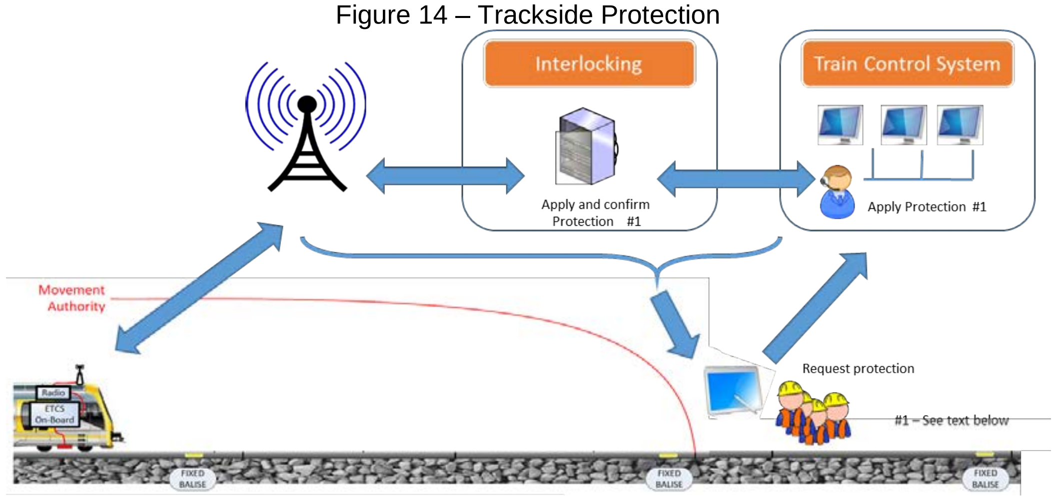
ETCS L2 will introduce its own changes to the way trackside protection is applied and managed. In-cab signalling will remove the need for trackside signals and the ability to place signals at danger, and axle counter train detection will remove the ability to use Track Circuit Operating Devices, both impacting current protection procedures.

Figure 13 – Trackside Protection Procedures Affected by Strategy



Future trackside protection will be applied by the train controller and update the movement authority transmitted to the train, as well as providing the necessary confirmation and assurance to trackside workers.

Figure 14 – Trackside Protection



The specifics surrounding how future train control systems and interlockings will manage the application of trackside protection is still to be developed. However, in accordance with this strategy (refer to section 3.2.2 ‘Design’), solutions shall consider the strategy to separate critical and non-safety critical elements wherever possible to enable cost effective design, testing and commissioning solutions.

4.3.5 Telecommunications

Sydney Trains utilises a variety of in-house telecommunication networks ranging from copper transmission to optical fibre and wireless digital train radio. New signalling systems are driving demand for more bandwidth, higher availability while maintaining an appropriate level of security and integrity.

The current strategy is to continue the deployment of the Digital Train Radio System (DTRS) to provide the communication platform for ETCS L2. The Operations Critical Data Network (OCDN) will be further developed to meet the increasing demands for data capacity and security.

Security is a key issue for safety critical systems. Historically point to point communications have delivered the required level of system integrity and security. However, with a strategy that is driving consolidation of assets and reduction in trackside equipment it will be necessary to apply security measures at the application level to use the OCDN or other common or public communication mediums. Where further security measures are demanded for safety critical operations and the risk of cyber security threats, an appropriate level of isolation from non-critical systems may be warranted. This not only provides an additional level of security from 'hacking' of systems, but also prevents threats of 'Denial of Service' where system availability is compromised from excessive data placed on the network.

An example of a network architecture that may be appropriate to address Sydney Trains' integrity and security requirements is as follows:

1. Vital Network – For applications that provide safety critical functions e.g. signalling equipment and interlockings;

2. Operational Critical Data Network (OCDN) – For applications that are critical to operations e.g. train control, passenger information displays, etc.,

3. IT Network – for all other non-safety or non-critical applications.

Within Sydney Trains, the Operational Technology business unit is responsible for providing a specific strategy for telecommunication systems that will support this signalling and control system strategy. This telecommunications strategy should be referenced as part of the introduction of any telecommunications systems and assets.

4.3.6 Design Support Tools

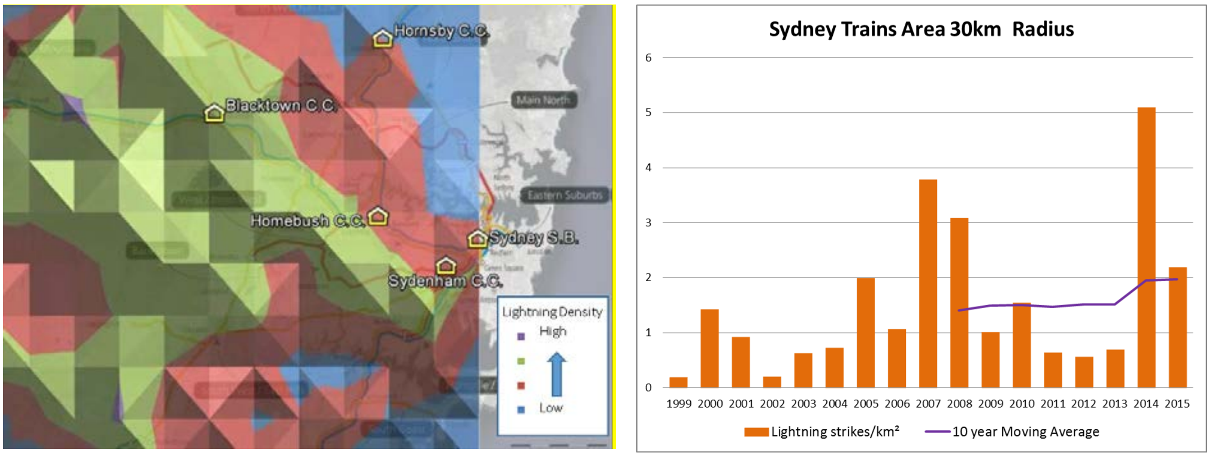
The introduction of more complex software based safety systems, including those in areas of technology such as interlockings and train control systems, has resulted in an increased use of design, simulation and testing tools that themselves play a significant role in maintain the integrity of the systems.

It is anticipated that further reviews will be required to determine the extent to which these systems will require a similar level of assurance and type approval as the operational systems they support. This should be a primary consideration of the assurance and type approval planning process prior to the introduction of any new systems of this type.

4.3.7 Resilience to Climate Change

Addressing 'climate change resilience' is a requirement of the TfNSW Long Term Master Plan [4]. The impact of severe weather events has been particularly prominent on the rail network in recent years with strong winds, high rainfall, extreme changes in temperature and lightning strikes.

Figure 15 – Lightning Density (1999 to 2015) – [Ref 11]



The expectation is for an increase in frequency and severity of these events in different combinations and areas [Sydney Trains - Climate Change Risk Assessment and Adaptation Management Plan] [Ref 10]. Investing in technologies that can withstand these events, or at least minimise their impact will be necessary to meet the demands of the customer during all weather events.

Lightning and surge protection is an area of particular interest as the effects can cause significant damage to large amounts of sensitive electronic equipment. With more computer based equipment being rolled-out and controlling larger areas of the network from fewer locations, the effect of these events could severely impact the ability to meet customer expectations of a modern railway.

4.3.8 Whole of Life Costing

Recognition of whole of life costs aligns with the development of long term plans for Sydney's Rail Future. Decisions on product selection, system design, supplier rationalisation can all affect the sustainability of operating the network and ultimately the cost. A low cost product or signalling design solution may cost more over the entire asset lifecycle due to high training, maintenance, renewal and disposal costs, limited supplier support, and early obsolescence.

A decision to proceed with a higher capital outlay may cost less over the full lifecycle for a variety of reasons including:

- Long term support from internationally recognised suppliers;
- Products that can overlay an existing system and be tested without impacting services; and
- Systems that allow for regular small upgrades rather than infrequent major upgrades impacting customers.

4.3.9 Obsolescence

The lifecycle of new technologies coming onto the market are becoming shorter as the pace of innovation quickly supersedes previous models. This will present many challenges for Sydney Trains as product support for older models is withdrawn by the manufacturer. To address these challenges more industry collaboration to develop obsolescence strategies is expected.

Consideration of equipment obsolescence will become part of future equipment selection criteria and the whole of life costing of the asset. This will include assessment of the available equipment over the life of the asset; ability to upgrade the asset at end of life, decommissioning costs and impact to the operating railway and potential for frequent smaller upgrades. The pace of technology, particularly computer based and wireless communications, could see system lifecycles being reduced to years instead of decades, and these issues must be managed in consultation with Sydney Trains Procurement.

To further align with other areas of this strategy, it is preferred to select equipment with a wide scale internationally established installation base. Major suppliers of a large asset base are expected to assure the provision of product spares, support and upgrade paths for their products. It is important to avoid a single supplier monopolising the market and increasing the risk of expensive/non-existent equipment support and upgrades in the future.

Obsolescence of existing assets and the need to continue operating them until new systems are rolled–out is a major issue. This is particularly noticeable where, for cost efficiencies, upgrades will be delayed awaiting the deployment of ETCS Level 2. While an interim upgrade may be considered expensive, it may be essential in order to adequately manage the reliability and integrity risk or assets being signed out of use due to insufficient spares or lack of maintenance/faulting skills. To address this issue, asset management plans will continue to program in the replacement of obsolete systems. Obsolescence plans shall also be developed detailing how systems will be managed in the meantime, including the sourcing spares and retention or sourcing of external skills.

Mechanical Signalling and Mechanical Signal Boxes

All remaining mechanical signalling and Signal Boxes are to be replaced as soon as practical. Any interim changes to mechanical locking systems shall be avoided and instead used to support the requirement for early replacement.

Ground Frames, Interlocking Keys and Releasing Switches

Ground frames and channel rodding shall be phased out. They require physical effort to operate, present trip hazards and generally considered no longer suitable from a Work Health and Safety perspective. Furthermore, there is becoming a shortage of skills available to maintain these systems or fix them from wear and tear or loss of keys.

Electric Train Staff

The last remaining Train Staff section was removed with the Kiama Bomaderry Staff Line Wire Replacement Interlocking upgrade project in 2014.

Train Control Systems

The remaining obsolete Sigview and WestCAD systems are scheduled for replacement in 2019.

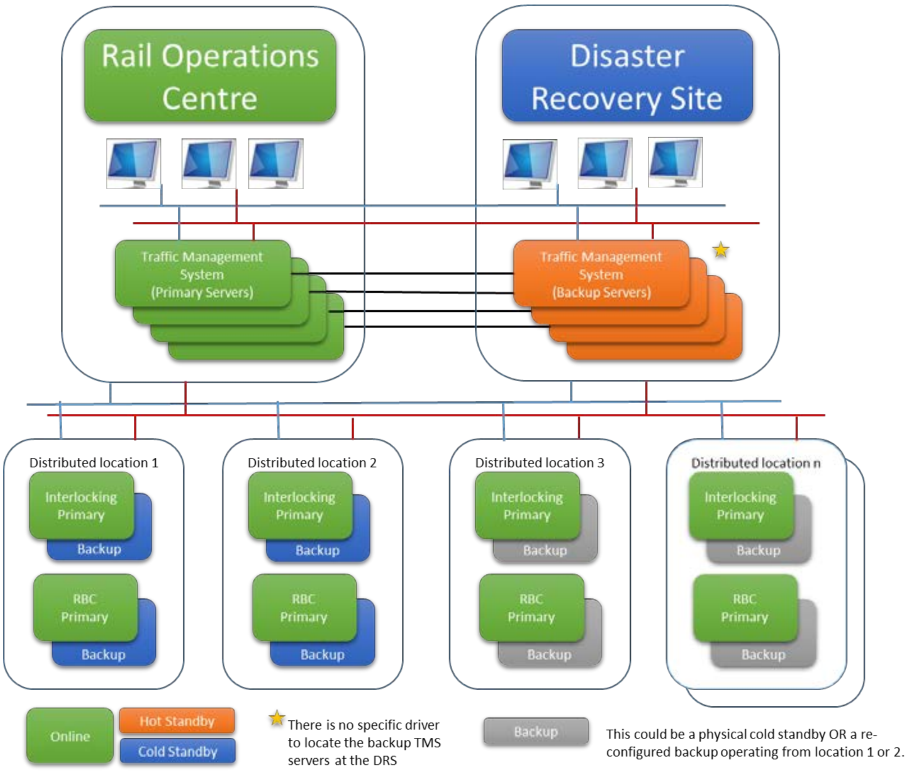
4.3.10 Disaster Management / Recovery

Operational disruption from major system failures can be minimised through integrated degraded mode operations, or other operational resilience solutions, allowing the network to keep operating albeit potentially at reduced capacity.

Major incidents or disruptions, e.g. as a result of extreme weather events, could severely impact the operation of the Rail Operations Centre or a major interlocking, potentially bringing large parts of the network to a standstill. To manage this risk, the strategy includes:

- The establishment of a separate Disaster Recovery Site (DRS) to duplicate the Train Control operations of the ROC;
- Sectorised interlockings and Radio Block Centres (RBC) at convenient locations such as Network Maintenance Bases;
- Duplication of interlockings and RBC equipment for critical control areas;
- Backup TMS servers to be located at the DRS, although with an adequate data network they could also be co-located with the interlockings and RBCs;
- A diverse data network to mitigate the loss of a data line or single asset; and

- Axle counter implementations that can support self-restoration following failure or power loss.



Various configurations have been reviewed as part of the ATCS project, and while full whole life cost and RAM analysis for any product solution would need to be undertaken, this configuration is expected to provide a balanced solution between cost and customer expectation. It has also considered the lack of any established interlocking products that have the capability for a separate hot standby configuration.

Benefits include:

- Physical redundancy of TMS servers and workstations across two geographic locations and resilience in Disaster Scenarios;
- Sectorised interlockings and RBC located at Network Bases aiding maintenance, fault finding and repairs; and
- Minimum number of duplicated interlockings and RBCs provides optimum network wide installation, testing and maintenance costs (dependent on interlocking solution and full cost analysis) while balancing recovery time.

Issues include:

- High dependency on data network; and
- Dependent on system architecture to enable re-configuration and testing of location specific data for interlockings and RBCs in acceptable timeframes.

The provision of standardised interfaces, internationally demonstrated off-the shelf systems, collaboration with other parties and other considerations covered within this strategy should facilitate these developments.

4.4 'Technology' Differences from Previous RailCorp Strategy

- New signalling projects and equipment selection will need to be ETCS Level 2 compatible;
- "Off-the-shelf" products with no customisation and minimal configuration are preferred. The use of bespoke products and in-house development shall be avoided wherever possible;
- Advanced axle counters with intelligent reset capability and more resilient degraded mode operations will replace track circuits as the preferred train detection technology;
- Point systems that remove the need for high cost and high maintenance air system operation will support the safety and reliability demands of the future network;
- Air systems are no longer supported as part of the long-term technology roadmap and will be progressively decommissioned with the removal of trainstops as part of the introduction of ETCS Level 2;
- Obsolete train control technology such as push-button panels will be replaced by the in-house ATRICS system and progressively centralised within the new Rail Operations Centre (ROC);
- Traffic Management System (TMS) will align with a TfNSW strategy which defines the interdependencies between control of the existing Sydney Trains (ATRICS) network and the requirements associated with the introduction of ETCS Level 2;
- Sectorisation of interlockings is now a preferred strategy with a limited number of interlockings at convenient locations such as network maintenance bases;
- Equipment housing design has moved from passive temperature control in geographically distributed locations to the use of more centralised air conditioned locations;
- Greater emphasis has been placed on modular and pre-assembled systems, ability for system upgrades without impacting operations; and
- It is anticipated that further reviews will be required to determine the extent to which design, simulation and testing tools for interlockings and train control systems will require a similar level of assurance and type approval as the operational systems they support.

5 Delivering the Strategy

This high level technology strategy for Signalling and Control Systems will require significant support from other Divisions within Sydney Trains, TfNSW cluster organisations and industry. Without the support to underpin all the aspects of the people, process and technology changes it will be difficult to deliver the strategy and ultimately deliver TfNSW's vision of Sydney's Rail Future.

With the complexity and breadth of interfaces, managing the delivery of the strategy will become more than just a Signalling and Control Systems strategy and more of a Sydney Trains business change project. The following sections discuss the key risks to delivering the strategy and how the divisions and organisations outside of S&CS will be required to support.

5.1 Key Risks to delivering the Strategy

The high level risks in delivering the strategy are considered to be:

- **Embedding the S&CS Strategy in the development of new schemes and projects.** Without the support from TfNSW and Sydney Trains project delivery functions, new schemes and projects will continue to be developed around existing technologies and processes to manage their delivery risk. It is important to ensure that projects are aligned with this strategy in addition to being compliant with ASA standards.
- **Aligning Network Rules and Operational Procedures with the new technologies.** Some of the new technology systems will challenge the way we currently manage train detection, trackside protection, train/track interfaces, etc. These will require significant changes to rules and procedures that have been used for many years with relatively few alterations. Reluctance to make changes could result in costly, inefficient, suboptimal solutions being implemented for the long term.
- **Early commitment and oversight of the strategy.** The timeframes involved in product selection, type approval, safety case and subsequent upskilling, procedure development, etc. can be significant. Without the drive, support and oversight to deliver the strategy, these timeframes will extend too far and new schemes will be forced to continue with the existing systems and processes to meet deadlines and de-risk their projects.

5.2 Supporting delivery of the strategy

To support the delivery of this strategy and overcome the anticipated key risks, a suite of business plans will be developed to provide further detail on the steps, timeframes, responsibilities and accountabilities. All this will be used to support a wider Sydney Trains Business change project involving support from the following areas of Sydney Trains, TfNSW and industry.

5.2.1 Network Maintenance

One to the most significant areas to be impacted by this strategy is the role of Network Maintenance. A shift towards more computer and telecommunication systems will require new skills. In-cab signalling will introduce a new interface with fleet maintenance that will need managing. Rules for trackside protection will change with the introduction of axle counters and future removal of signals. All of which will require extensive support and cooperation from Network maintenance in order to succeed.

To deliver this strategy, support will be needed from Network Maintenance to:

- Manage the training and upskilling or recruitment of staff to maintain and fault more computer and telecommunication based systems;
- Contribute to the development of optimised maintenance schedules and allow the frequency of maintenance visits to be driven by asset criticality and eventually asset condition;
- In-collaboration with S&CS, Rolling stock and Fleet Maintenance develop processes to maintain and fault find at the interfaces of the on-board and trackside control systems; and
- Contribute to the development of processes to manage axle counters. Unlike track circuits, the introduction of axle counters will require issues surrounding rail integrity, reset & restore, rail grinding etc. to be resolved.

5.2.2 Train Crew

In-cab signalling will bring a fundamental change to the way drivers perform their duties. The S&CS strategy will require major support from Train Crewing including:

- Development of training material and familiarisation with in-cab signalling and degraded mode operation;
- Coaching and mentoring of train crew in the transition from driving to trackside signals and speed signs to driving to a speed profile displayed in the cab; and
- Familiarisation of the operation of axle counters and the need to move away from using Track Circuit Operating Devices (TCODS) for emergency track protection.

5.2.3 Asset Management

The Asset Management division are responsible for the development of the Sydney Trains Asset Management Plan and subsequent planning and scheduling of the annual maintenance program and works plans. Their support in the following areas will be key to a successful delivery of the strategy:

- Aligning and embedding the strategy within signalling scheme developments. For example, identifying schemes where it may be possible to remove or replace the remaining air powered systems to allow the total removal of the air main; consolidating trackside equipment at easily accessible locations; simplification of the variety of field assets, etc.;
- Develop processes to incorporate asset criticality in the development and optimisation of Technical Maintenance Plans;
- Encourage the type approval of new assets by separating the funding and removing the responsibility from individual projects so as to de-risk the project delivering to time and budget. This may not be applicable for the likes of a new

control system, but the type approval of axle counters, point machines etc. could be managed separately. Once the assets become type approved they will be available for consideration in new projects; and

- Develop Asset Management Plans to support the introduction of new technology, new processes, and outsourcing of specific work to encourage industry collaboration with Sydney Trains.

5.2.4 Fleet Maintenance

With the introduction of in-cab signalling and wireless communications between trackside and train, the historical boundaries of rolling stock and signalling will gradually start to overlap. Fleet maintenance will therefore need to support this strategy through:

- Contributing to the development of new processes to manage the maintenance and fault finding of train borne systems that interface with the signalling systems; and
- Training of the workforce on new systems and establishing competence criteria and potential licencing to work on the safety related systems.

5.2.5 Network Operations

Signallers and train controllers will see a step change in the way trains are controlled. Consolidation of control systems into a central Rail Operations Centre has already begun. Increased use of Automatic Route Setting and future more advanced Automatic Train Regulation will support the train controller in managing more flexible geographical areas. To support these and other changes, Network Operations will need to contribute to:

- Training and upskilling staff to operate the new systems being introduced;
- Development and review of changes to Network Rules and Procedures;
- Development of new processes to manage the network under degraded modes;
- The development of systems and processes to provide safe working protection with the replacement of track circuits and the future removal of lineside signals.

5.2.6 Safety, Environment, Quality & Risk

Network Rules, train operation manuals, incident management are all areas that will be affected by the changes brought about by this strategy. Train operation, degraded mode, trackside protection etc. will need to be significantly updated. With the temptation to minimise change and business risk by limiting the changes to these well-established processes, the long term benefits brought by these new technologies and process changes will be significantly impacted. To avoid this outcome while still managing the safety of rail operations, SEQR will need to support the delivery of the strategy through:

- Structured and evidence based safety reviews of systems to support changes in Network Rules and Procedures; and
- Assess the safety implications of the overall integrated systems in addition to individual system assessments.

5.2.7 TfNSW Cluster (including Asset Standards Authority)

TfNSW developed the long-term Rail Systems Strategy and Medium-Term Rail Development Plan, both of which this S&CS strategy is aimed at supporting. Delivery of all of these strategies will require commitment and collaboration between Sydney Trains and the other areas of TfNSW. In particular support is needed to:

- Develop appropriate standards in line with international practices. These standards should be created with a level of detail to ensure standardisation across the industry without restricting AEOs individual innovation, efficiencies and general competitiveness;
- Encourage the introduction of well-established and demonstrated products used by other rail operators, through efficient type approval and cross-acceptance standards;
- Ensure that TfNSW rail systems projects and, in particular, the introduction of ETCS Level 2 as part of the ATCS Project, are fully aligned with this Sydney Trains Strategy;
- Support the development of a cross-industry competency framework with a suite of standardised competencies; and
- Continued support of cross-industry forums and working groups to ensure good practice is identified and captured.

5.2.8 Industry (AEOs, product suppliers etc.)

This strategy highlights the need for greater industry collaboration in many areas of the asset lifecycle. Particular areas where industry can support the delivery of this strategy include:

- The development of products that simplify installation, testing, and maintenance. Particular consideration for the future includes products that can be installed, upgraded and decommissioned without impacting daily train operations;
- The development and introduction of products that will deliver a step change in reliability and integrity to meet increasing customer expectations;
- Knowledge transfer to Sydney Trains to support the upskilling of core staff, potentially through secondments of Sydney Trains staff into industry projects or vice versa, to develop in-house product competency; and
- Support the development of cross-industry competency frameworks, including the competencies required to support greater industry involvement in type approval and signalling design.

Appendix A - Technology (Equipment and Systems) Roadmap