AS 7666:2022

Australian STANDARD®

Train Protection and Control Interoperability

RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Train Control Systems Standard

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This Australian Standard® AS 7666 Train Protection and Control Interoperability was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

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The Standard was approved by the Development Group and the Train Control Systems Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

This Standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

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This paragraph is used to indicate if this Standard supersedes other documents in whole or in part.

Objective

The objective of this Australian Standard is to provide the railway industry with guidance including a framework and process for planning and implementing any change to a TPC system where the change has potential to impact interoperability. In particular, this Standard will support the introduction of next generation train protection and control technologies such as in-cab signalling, which have been rolled out across rail networks within Australia.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A

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Preface

The aim of interoperability is to enable the various railway operating systems and infrastructures to work together in such a way that, to the end user, the transfer between systems and infrastructures appears seamless. AS 7450, which this document supports, provides the Australian rail industry with a process for addressing the interoperability of current and future systems, assets or processes.

Train protection and control (TPC) systems are an essential enabler for the safe and efficient movement of trains between networks, and the protection of track workers in the rail corridor. Continued development and implementation of new technologies (e.g. ETCS and CBTC systems) provides new opportunities and risks to interoperability.

TPC systems which do not achieve the required level of interoperability can be a barrier to achieving the required operational outcomes. The appropriate consideration in the specification, design, operation and management of TPC systems is therefore crucial to achieving interoperability.

1 Scope and general

1.1 Scope

This Standard provides guidance to the Australian rail industry on the implementation of AS 7450 to TPC systems.

This Standard describes considerations for TPC interoperability covering:

(a) key interfaces for TPC interoperability;

(b) development of a system integration management plan covering the requirements of a new or modified TPC system, including operational and functional requirements;

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 7450 Rail systems interoperability
- AS 7473 Complex system integration in railways

NOTE: Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

1.3.1

CBTC

Communications based train control

1.3.2

ETCS

European train control system

1.3.3

STM

Specific transmission module

1.3.4

TPC

train protection and control

integration interface between wayside systems, trackside systems and onboard systems enabling the safe and efficient movement of rail traffic and the protection of track workers

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

2 TPC Interoperability

2.1 Principles

TPC interoperability refers to the engineering side (engineering risk controls) of a system of safeworking as distinct from the network rules and procedures (administrative risk controls).

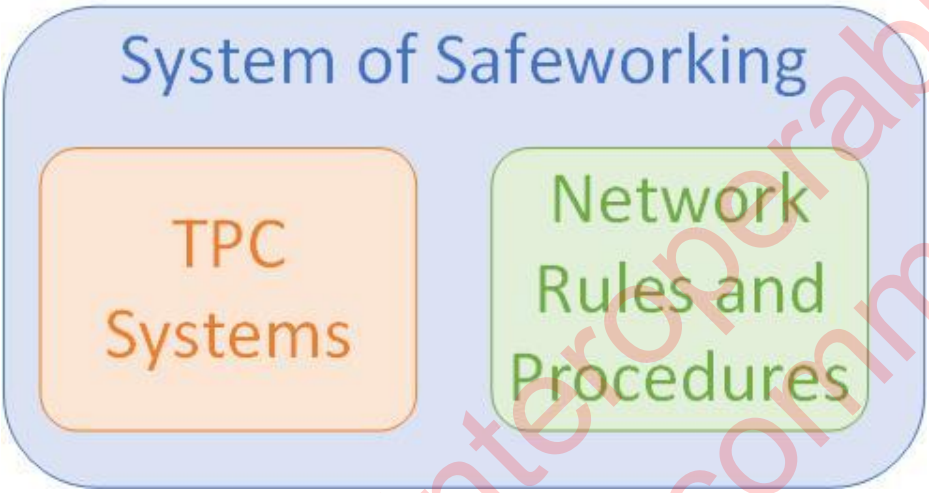

Figure 1: System of safeworking

Whist acknowledging the strong interdependency between TPC systems and network rules and procedures, this Standard considers the engineering aspects of interoperability only. Network rules and procedures are addressed in other Standards, Codes of Practice and Guidelines.

There is currently no legislated requirement for individual rail infrastructure managers (RIMs) to consider TPC interoperability, either internally or externally. However, development of interoperable systems can:

a) improve safety;

b) enable efficient operations;

c) maximise the productivity of the overall railway network;

d) minimise the use of administrative controls (interface agreements) and improve the effectiveness of engineering controls to manage interfaces.

Applicable international and national Standards should be reviewed in conjunction with this Standard, with the aim of developing interoperable solutions with internationally recognised protocols, messaging, etc.

TPC interoperability can be achieved in various means, including dual-fit of train and of track, use of common interfaces, or use of multi-function components, which may need development (e.g. ETCS STM). These options have different costs, benefits, and limitations. Planning for interoperability should consider all options in project planning.

The basic principles of TPC interoperability are as follows:

a) The number of systems a network control officer is required to have direct interaction within a mixed TPC environment is minimised, or the system provides for a uniform controller interface within a mixed TPC environment.

b) The number of systems a driver is required to have direct interaction within a mixed TPC environment is minimised, or the system provides for a uniform controller interface within a mixed TPC environment.

c) Onboard systems are designed and managed to maximise the accessibility for rollingstock to be operated in multiple TPC environments.

d) Transitions between areas of control of different TPC systems are designed and managed to avoid errant operation or unsafe states.

e) Engineering based interfaces should use open standards such as international or national standards.

It is important to note that not all components of a TPC system need to be interoperable. Interoperability need only apply to those components or systems that directly interface with other TPC systems or that are required to achieve interoperability. For example, the actual interfaces shown in Figure 3 should have the ability to be interoperable, however the internal components of the different systems and equipment may not need to be.

To assess what components and systems require interoperability an interoperability assessment report should be developed as per AS 7450.

2.2 Characteristics of TPC interoperability

TPC interoperability encompasses links between internal systems (such as train control systems, telecommunication systems, wayside systems, etc), and links to external systems (such as between two adjoining networks). TPC systems are further supported by administrative controls such as network rules and procedures. Characteristics of effective TPC interoperability can be described as below[1]:

Figure 2: The Interoperability Framework

[1] Adapted from National Framework for Rail Interoperability (NFRI): Overview and discussion paper

(a) Functional – The set of systems includes options that deliver the required functionality for efficient rail operations in each context.

(b) Upgradable – Systems need to be supported and provide a pathway to further enhancements / integration with other systems.

(c) Scalable – National interoperability requires a suite of options that includes one or multiple systems that can be cost-effectively applied across all types of railways in a seamless way, i.e. suburban, coal, interstate and regional.

(d) Integrated – The ability for each train fleet to operate over the required network(s) with only one onboard system (or multiple systems working harmoniously) for network control purposes

(e) Harmonized – Harmonising of safeworking systems across network boundaries, wherever one signalling and control system is used, the same safeworking rules are applied.

(f) Feasible – Cost burden for RIMs is manageable, cost passed onto operators is minimised.

2.3 Assessing interoperability

Initially a RIM should conduct an interoperability assessment as detailed in AS 7450. Where a level of TPC interoperability is found to be required the RIM should develop a systems integration management plan (SIMP) to manage the introduction of the interoperable system (refer section 5). This plan should define the required interoperability outcomes for any new or modified TPC system and the process by which interoperability with other TPC systems will be achieved.

Further guidance on managing complex system integrations is provided in AS 7474.

3 Key interfaces for TPC interoperability

Achieving TPC interoperability is related to the effective flow of information between the network of sub systems and users of the TPC system. This is the case both within and across rail network boundaries. The consideration of these interfaces and harmonisation of information flowing across them is therefore key to interoperability.

The key interfaces for interoperability shall be defined and appropriate integration plans established. This will facilitate the appropriate flow of information to achieve the required interoperability outcome.

To assist in this process the following context diagram provides a model showing the key components of a generic TPC system and the interfaces between these components. This diagram shows a typical architecture only to illustrate the large number of interfaces across a TPC system and is not intended to be applied literally.

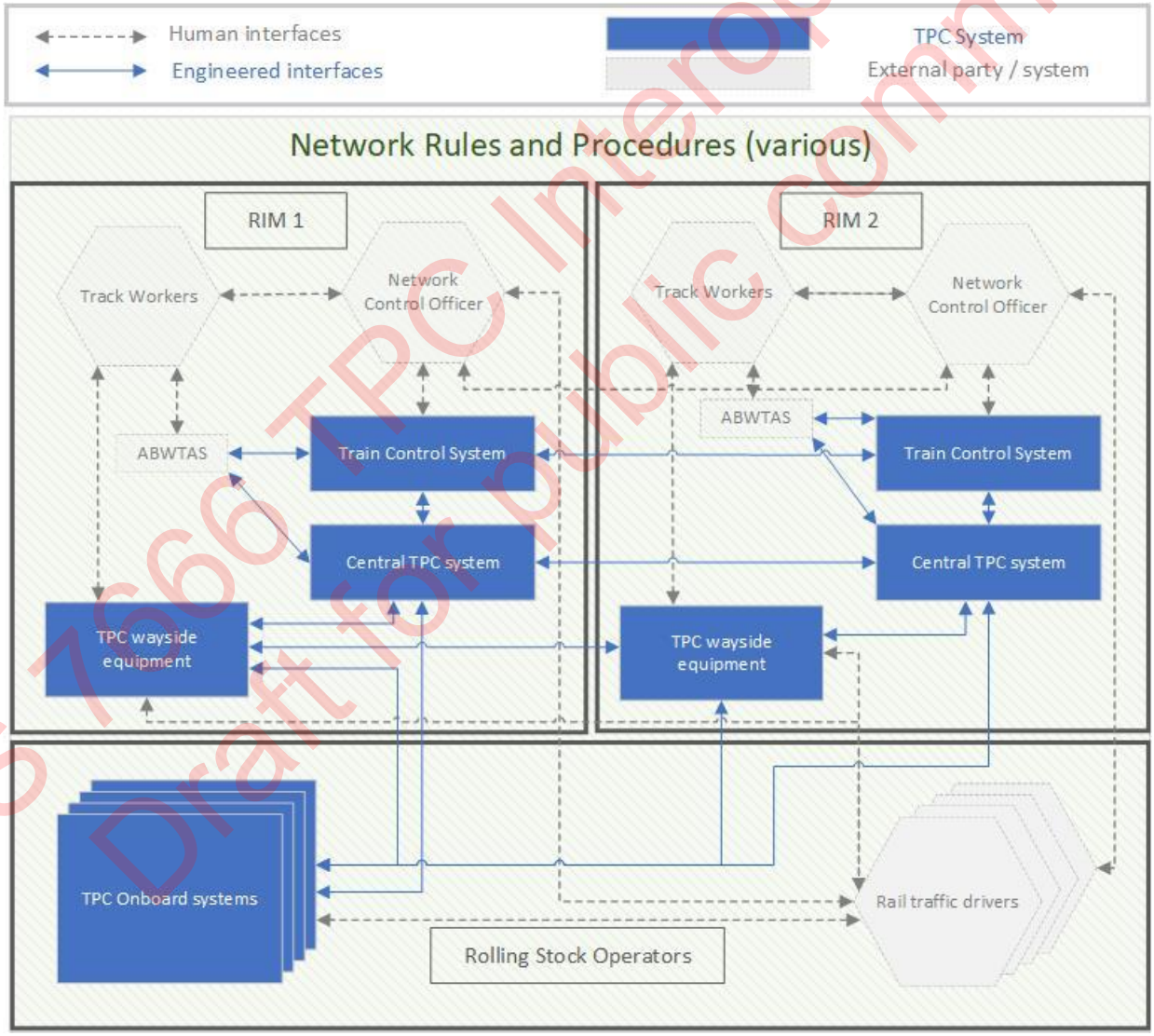

Figure 3: TPC generic context diagram

The key interfaces which shall be considered for interoperability include but are not limited to the following[2].

(a) Train control system

The train control system (TCS) supports the network control officer (NCO) to manage the safe movement of trains on the network. This is achieved through the NCO interfacing with rail traffic drivers, track workers, and control panels to create movement authorities.

(b) Central TPC system

The central TPC system enables safe train operation through the receipt of authority information from the TCS to maintain train separation on the network. Rail traffic (through actions by the TPC wayside equipment and / or the rail traffic driver) responds to generated authority information to maintain safe train operation ensuring trains remain separated on the network.

(c) TPC Wayside equipment.

The wayside system interface supports the transfer of authority information from train control systems to onboard systems and rail traffic drivers. The method of communication will vary depending upon the nature of the safe working system, including traditional wayside signaling, Automatic Warning System magnets, train stops, transponders and their controllers, etc.

The wayside system also supports the transfer of information generated by the wayside system regarding the actual status of field equipment, such as signals and level crossing equipment.

(d) ABWTAS

Authority based work on track systems (ABWTAS) enable field track workers to directly interface with the TCS and central TPC system to mange work on track authorities. Further information is provided in AS 7725.

(e) Onboard systems

The onboard systems interface supports the transfer of information confirming the actual location and speed of trains on the rail network. This information is required for safe working and network operational management and can be passed from the train to the wayside system.

The onboard system interface further supports the transfer of information generated by the wayside system regarding the actual status of field equipment, such as signals and level crossing equipment, movement authorities, speeds, and other operational information to the rail traffic driver. Rail traffic drivers react to this information through interaction with the onboard system. The addition of multiple onboard systems can complicate this interface.

(f) Rail traffic drivers, network control officers, and track workers.

The rail traffic driver / network control officer / trackside worker interface supports the transfer of authority information for the purposes of securing both the safe working of the railway and the separation of trackside workers from

[2] The descriptions below of each interfaces are typical examples but are not to be interpreted as exhaustive and limiting other applications.

train movements. This information is typically in the form of work on track authorities. The method of communication can be verbal, or through digital means such as application based work on track authority systems (see AS 7725).

(g) Network rules and procedures

Network rules and procedures are provided to support engineering systems. These are adapted at interface points to allow for differing scenarios that could occur in normal operation and failure situations. This can include special work on track rules due to different network rules either side of the interface, or network rules to permit passing signals at stop where the section authority is given by one system to enter the adjoining system.

4 System integration management plan

4.1 General

Where TPC Interoperability is found to be required a system integration management plan (SIMP) shall be developed which outlines the strategy, roles and responsibilities for achieving the required interoperability outcomes. As TPC systems can be complex the development and management of TPC systems should be in accordance with AS 7473.

Development of the SIMP should involve key stakeholders, such as vendors / suppliers, end users and applicable RTOs.

The content of the plan should:

(a) be appropriate to the change and TPC technology;

(b) define the expected interoperability outcome of the TPC system and how it is to be achieved;

Further detail on SIMP contents is provided in section 5.2

4.2 Contents of the system integration management plan

The contents of the plan shall include as a minimum:

(a) a sufficient description of the TPC system to allow the key sub systems, users, functions and interfaces pertinent to interoperability, to be defined and subsequently specified (Refer to section 4 of this Standard);

(b) relevant functional and non-functional requirements pertinent to interoperability. Functional requirements could include, for example, the functions described in section 5.4 below. The non-functional requirements should include for example key integration requirements relating to safety, reliability, availability, maintainability and performance.

(c) roles and responsibilities for the agreement of the required interoperability outcomes, lower level technical and operational details;

(d) consideration of current and future migration paths;

(e) operational requirements (as per section 5.3 of this Standard);

(f) roles and responsibilities for system management including the roles and responsibilities of the TPC system authority. This could include for example the role of the TPC system authority in interface performance management and in the whole of life management.

(g) the testing regime, including access for testing, of both systems and their interoperability;

(h) how cyber security requirements are to be met (refer AS 7770);

(i) commissioning of new interoperable systems (refer AS 7717).

4.3 Operational requirements

4.3.1 General

An organisation proposing any implementation or change to a TPC system shall assess the operational needs of the affected stakeholders. This includes the integration and harmonisation of operational and user requirements to deliver the required interoperable outcomes. These should be clearly expressed, for example, through an appropriately detailed operational and maintenance concept document and agreed between relevant stakeholders.

The aim should be to achieve Level 2 (full) interoperability as per AS 7450.

A stakeholder can be other than an immediately adjacent RIM. Rail traffic crew, network control officers, track workers, and other frontline rail safety workers can all be impacted by a lack of interoperability.

To facilitate a commonality of operating procedures, it may be appropriate to provide an increased level of similarity between the systems.

4.3.2 Considerations for the operational requirements

Considerations for the operational requirements should include:

(a) the required operational outcomes for the system, particularly in relation to cross-border operations and interoperability;

(b) identification of the system users, stakeholders and the required interactions and processes between them;

(c) how the interoperability solution will:

i. reduce or eliminate existing hazards;

ii. improve performances and efficiencies;

iii. harmonize technologies and equipment.

(d) reliability, availability, maintainability, and safety (RAMS) of the system;

(e) how the system is to be operated, maintained and administered throughout its whole life including the roles of key stakeholders and the roles and responsibilities of other key personnel involved in system management. This may be particularly complex where the system could have a long life and where ultimately multiple variants could be in operational service at the same.

(f) the required behaviour of the system in all relevant circumstances. This should include a sufficient definition of the information that should be presented to users to achieve the required interoperability outcomes. This information could include:

i. user configuration;

ii. modes of operation (including failure modes) and levels of functionality;

iii. the operational requirements for transitioning between different TPC systems, both internally and externally.

(g) the information required by all system users including drivers, operational staff, trackside workers and asset management personnel;

(h) the need for on-going technical coordination amongst the different stakeholders once the solution rolled out;

(i) the required operational behaviour of the system when the system is operating normally but the railway is not (perturbed mode of operations). For example, in the case of a communications based train control system, a common requirement which may be relevant to interoperability is for the system to support the movement of trains fitted with only limited or no onboard TPC equipment.

(j) a consistent approach to degraded mode requirements supports a simplified and consistent operating rule set. The operational requirements in the event of a partial or complete loss of function of the TPC system (degraded mode of operation) should therefore be considered. Typically involving the use of operational rules, some form of degraded mode system solution involving contingent hardware (e.g. points position indicators) may also be provided.

(k) harmonisation of competencies creates the potential to realise whole life cost efficiencies resulting from, for example, freedom of labour movement and competitive dynamics within the national and global supply chain. Requirements for the competency of each of the key system users should be considered. These could include network control officers, signallers, train drivers, train maintainers, trackside workers, system maintainers and system designers.

4.4 Functional requirements

A diverse range of train protection and control technologies, processes and procedures are used on the Australian rail networks to achieve the required operational outcomes. The functions of TPC systems are evolving with the introduction of new technologies and can include the following:

(a) Preparation of a rail traffic plan.

(b) Management of operations and asset management personnel.

(c) Planning of occupancy authorities.

(d) Issue of occupancy authorities.

(e) Execution of occupancy authorities.

(f) Enforcement of occupancy authorities.

(g) Planning of infrastructure maintenance.

(h) Incident management.

(i) Managing work on track authorities.

These functions may relate to the required interoperability outcomes and therefore should be considered when implementing a new or modified TPC system.

When implementing a new TPC system or modifying an existing system the functional requirements shall be sufficiently defined to allow full consideration of interoperability.

To assist in this process, Appendix B provides a list of typical features and functions of a TPC system.

5 Verification and validation

The SIMP developed to support the delivery of the TPC shall incorporate a verification and validation process which complies with the requirements defined in AS 7450 and the safety management systems of the identified RIM.

Appendix A RISSB hazard register

Hazard Source	Factors
Alerting system failure and / or train protection system failure	Hidden failure where detection effectiveness is not being verified (Failure with interface to wayside systems - Hardware faulty - System faulty)
	Inadequate performance of vehicle equipment (Failure with interface to wayside systems - Hardware faulty - System faulty)
	Incorrect location of vehicle equipment (Failure with interface to wayside systems - Hardware faulty - System faulty)
Cable communications failure (Design)	Communications interface and design
Signals (Definition: Any indication given to a driver, lights on stick, driver display, notice boards) failure (Design)	Interfaces between different signalling systems (different aspect sequences)
	Interfaces with physical rail infrastructure
Train Authority Systems failure (Design)	Operator Interfaces--there may be conflicting systems
Interlocking failure (Design)	Interfaces to signalling objects being inappropriate
Control system failure (Construction)	Interface with existing controls, interlocking's and maintenance facilities
Power supply failure (Construction)	Incorrect interface to existing systems
Interlocking failure (Construction)	Unexpected or incompatible interfaces, software and communications
Control system failure (Test and Commission)	On site and off site interface testing remaining incomplete

Appendix B Interoperability characteristics and considerations

The implementation of the following technical and operational features within each TPC should be given careful consideration in order to facilitate progress towards interoperability between TPC systems:

(a) Track layout.
(b) Curves, points crossings.
(c) Axle load and speed limits.
(d) Curve speeds.
(e) Grades.
(f) Interlockings.
(g) Onboard TPC systems.
(h) Communication and telemetry systems (onboard and wayside).
(i) Traffic management systems.
(j) Train detection, track circuits and / or axle counters.
(k) Train localisation i.e. GPS, Inertial, odometer, video.
(l) Train protection i.e. trainstop, train protection and warning systems, etc
(m) Train integrity detection i.e. brake pipe monitor, end of train monitor.
(n) System braking performance.
(o) Point operation.
(p) Safeworking (including shunting operations) system.
(q) Automatic train protection system.
(r) Automatic train operation system.
(s) Bridge load limits.
(t) Height and width loading limits.
(u) Weather related limits.
(v) Level crossings.
(w) Wayside detection systems, such as hot axle box, wheel impact load detection, washaway.
(x) Train path requirements, including route compatibility and routing information requirements.
(y) Train lengths.
(z) Onboard systems.
(aa) Rollingstock profiles i.e. wheel diameters, couple heights, etc.
(bb) Motive power.
(cc) Onboard train protection systems i.e. vigilance systems.
(dd) Worksite protection systems (key switch, portable modules).

For successful interoperation between TPC systems, the management and exchange of data relating to each of the relevant features and functions should be considered in the system integration management plan.

Appendix C Bibliography

The following referenced documents are used by this Standard for information only:

(a) AS 7511 Onboard train protection systems

(b) AS 7717 Signal testing and commissioning

(c) AS 7725 Application based work on track authority systems

(d) AS 7770 Rail cyber security

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