Human Factors Integration – Rolling Stock

Version 2.0

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Standard governance

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Document history

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Preface

The Asset Standards Authority (ASA) is a key strategic branch of Transport for NSW (TfNSW). As the network design and standards authority for NSW Transport Assets, as specified in the ASA Charter, the ASA identifies, selects, develops, publishes, maintains and controls a suite of requirements documents on behalf of TfNSW, the asset owner.

The ASA deploys TfNSW requirements for asset and safety assurance by creating and managing TfNSW's governance models, documents and processes. To achieve this, the ASA focuses on four primary tasks:

- publishing and managing TfNSW’s process and requirements documents including TfNSW plans, standards, manuals and guides
- deploying TfNSW’s Authorised Engineering Organisation (AEO) framework
- continuously improving TfNSW’s Asset Management Framework
- collaborating with the Transport cluster and industry through open engagement

The AEO framework authorises engineering organisations to supply and provide asset related products and services to TfNSW. It works to assure the safety, quality and fitness for purpose of those products and services over the asset's whole of life. AEOs are expected to demonstrate how they have applied the requirements of ASA documents, including TfNSW plans, standards and guides, when delivering assets and related services for TfNSW.

Compliance with ASA requirements by itself is not sufficient to ensure satisfactory outcomes for NSW Transport Assets. The ASA expects that professional judgement be used by competent personnel when using ASA requirements to produce those outcomes.

About this document

This standard provides human factors integration requirements specific to rolling stock projects, in addition to the general requirements for human factors integration provided in T MU HF 00001 ST Human Factors Integration – General Requirements.

This standard is a second issue, expanding version 1.0 to include driver only operation (DOO) and automatic train protection (ATP).
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1. Introduction

For railway rolling stock to deliver the expected levels of benefits to our customers, it is essential that human interactions with the system are well designed through the application of established human factors principles and knowledge. Human factors integration (HFI) is the process for achieving this.

Authorised Engineering Organisations (AEOs) and other organisations undertaking work for Transport for NSW (TfNSW) need to ensure that the assets they provide to TfNSW are safe to operate and maintain, and that all safety risks have been eliminated or minimised so far as is reasonably practicable (SFAIRP) during the design process, in addition to their professional duty of care.

Supporting evidence demonstrating HFI activities within the safety risk management will provide an important part of the overall safety assurance argument in most cases.

HFI in the engineering design process produces tangible benefits in safety as well as efficiency and effectiveness in operability and maintainability of the asset over its life cycle.

2. Purpose

This document details the minimum requirements for demonstrating HFI in the procurement of new rolling stock or alterations made to existing rolling stock.

The objective of this human factors (HF) standard is to ensure assurance of the delivered asset, including the following:

- safe, effective and efficient use and maintenance of a delivered asset
- validation and verification of the HF requirements for operability and maintainability

2.1. Scope

This standard provides the requirements for HFI within the following activities:

- procurement of new rolling stock
- alterations to existing rolling stock (changes to operational context or physical alterations to rolling stock other than those due to maintenance activities, including decommissioning and removal of rolling stock from service)

This standard does not cover the design or alteration of road-rail vehicles.

2.2. Application

This standard applies to the AEOs and other organisations undertaking work for TfNSW. This standard is intended for use by human factors specialists, design professionals including...
engineers, and managers acting on behalf of organisations contracted to provide new or altered rolling stock to TfNSW.

This document should be read in conjunction with other applicable TfNSW standards including, but not limited to the following:

- T MU HF 00001 ST *Human Factors Integration – General Requirements*
- T MU HF 00001 GU *Guide to Human Factors Integration*
- T MU MD 20001 ST *System Safety Standard for New or Altered Assets*
- T HR SC 01650 SP *ETCS Onboard Equipment*
- TS 10504 AEO *Guide to Engineering Management*

T MU HF 00001 ST *Human Factors Integration – General Requirements* provides the generic requirements for HFI and applies to rolling stock projects. T MU HF 00001 GU *Guide to Human Factors Integration* provides guidance on implementing these requirements.

This standard is not applicable to the following activities:

- HFI in manufacture, construction, installation, or commissioning phases of rolling stock projects
- HFI relating to the organisation of the day-to-day operation or maintenance of the rolling stock following its handover to the operating and maintenance entities

Although this document does not apply to these activities, there are benefits that an organisation conducting these activities can realise by applying an HFI process and HF knowledge in their day-to-day business.

### 3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

**International standards**


**Australian standards**

AS 7470:2016 Human Factors Integration in Engineering Design - General Requirements
AS 7533.1-2013 Railway Rolling Stock - Driving Cabs – Part 1: Locomotive
AS 7533.3-2013 Railway Rolling Stock - Driving Cabs – Part 3: Passenger
AS 7533.4-2013 Railway Rolling Stock - Driving Cabs – Part 4: Infrastructure Maintenance

*Note: These standards are published by RISSB.*
Transport for NSW standards

T HR RS 00100 ST RSU 100 Series – Minimum Operating Standards for Rolling Stock – General Interface Standards
T HR RS 04001 ST Passenger Rolling Stock Access and Egress
T MU HF 00001 GU Guide to Human Factors Integration
T MU HF 00001 ST Human Factors Integration – General Requirements
T MU MD 20001 ST System Safety Standard for New or Altered Assets
TS 10504 AEO Guide to Engineering Management

Legislation

Disability Standards for Accessible Public Transport (Cwlth)

4. Terms and definitions

The following terms and definitions apply in this document:

AEO Authorised Engineering Organisation

ATP automatic train protection

crew operational personnel who operate the rolling stock. For example, the train driver, train guard, locomotive engineer

DOO driver only operation

DSAPT Disability Standards for Accessible Public Transport

end user people who will interact with, or are impacted by, an asset during the operational phase. Typical end users of a transport asset include crew, control room staff, cleaners, trainers, managers, signallers, maintenance personnel, customers, and the public including pedestrians, cyclists and road users. For a specific asset, all the end users need to be identified. Users may be considered primary, secondary, and tertiary end users depending on their level of interaction or impact on the system or parts of it (AS 7470:2016)

error tolerance ability of a system or component to continue normal operation despite erroneous inputs (IEEE Std 610.12-1990)

HF human factors

HFI human factors integration

HFIP human factors integration plan

human error an action (or inaction) that may result in an unintended outcome (AS/RISSB 7470:2016)
human factors  the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and system performance. Synonymous with ergonomics (International Ergonomics Association website)

human factors integration is the formal process to integrate human factors into the system-engineering life cycle. To do this it applies a systematic and scientific approach to the identification, tracking, and resolution of human-system related issues to ensure the balanced development of both the technological and human aspects of operational capability to deliver good overall system performance.

maintainability characteristics of a design and installation that determines the probability that a failed or non-compliant piece of equipment, machine, or system can be restored to its normal operating state within a given timeframe using the prescribed practices and procedures. From a human factors perspective, this means maintenance tasks can be carried out safely, effectively and efficiently and are tolerant to human error (AS/RISSB 7470:2016).

maintenance personnel a personnel role to maintain an asset. For example, an equipment technician, locomotive maintenance technician, an infrastructure worker.

negative transfer occurs when an end user who is familiar with a procedure or piece of equipment (learned skill) automatically transfers that skill to an alternate system or equipment when it is not appropriate. This can often result in tasks being omitted, operating the wrong controls, or operating the correct controls in the wrong direction (AS/RISSB 7470:2016).

operability is the ability to keep a piece of equipment, a system, or an entire industrial installation in a safe and reliable functioning condition, according to pre-defined operational requirements (AS/RISSB 7470:2016). From a human factors perspective, this means operational tasks can be carried out safely, effectively and efficiently and are tolerant to human error.

SFAIRP so far as is reasonably practicable

TfNSW Transport for New South Wales

5. Rolling stock-specific human factors integration

AEOs and other organisations contracted to supply new or altered rolling stock to TfNSW shall apply a human factors integration (HFI) process to all contracts with TfNSW in line with "Human Factors Integration – General Requirements".

The AEOs and other organisations undertaking work for TfNSW shall document the HFI process, and this process shall form part of the engineering management (see "Guide to Engineering Management").
The organisation undertaking work for TfNSW shall provide a human factors integration plan (HFIP) covering but not limited to the following areas:

- driving and crew cabs in accordance with AS/RISSB 7533:2013 *Railway Rolling Stock - Driving Cabs*)
- crew and other personnel interfaces not in the cab
  - Typically these include but are not limited to the following:
    - crew and other personnel workstations and controls outside of the cab
    - catering provisions
    - internal equipment lockers, emergency equipment, and any external equipment access points including coupling equipment, required by operational and maintenance personnel
    - expectations of crew relating to familiarity of other rolling stock they drive, including the introduction to crew of new systems or operations not currently used by them and integration of the different elements and tasks that drivers and other personnel will be required to carry out
- access and egress
- passenger areas on the rolling stock and their interfaces to infrastructure including platforms
- simulators and emulators
- maintenance considerations

6. **Human factors design requirements for rolling stock**

Rolling stock design requirements relating to human factors involve identifying and considering end users and human interactions, including different interfaces and human-system interactions, and creating a human factors integration plan (HFIP).

All rolling stock designs shall comply with T MU HF 00001 ST *Human Factors Integration – General Requirements*. In addition to the requirements of that standard, there are human factors requirements that apply specifically to rolling stock. This standard lists these requirements.

Rolling stock shall be designed to cater for the needs of all end users, which typically include but are not limited to passengers, crew, maintenance personnel, cleaners, controllers, signallers, trainers, managers, and the public.
The organisation contracted to supply new or altered rolling stock to TfNSW shall identify all the end users as part of the HFI process.

The rolling stock shall be designed to interact and interface with the infrastructure including, but not limited to, track, signalling, stations and platforms, control centres, yards and depots, and the end users associated with these areas and activities.

The human factors (HF) planning for all rolling stock projects shall be described and demonstrated in a HFIP. Different projects will have varying levels of impact on human interactions in different areas and therefore the scale, complexity, and focus of the HFIP will vary according to the specific project.

For some projects, the HFIP may only need to consist of the identification of human factors activities within a project schedule or other related documents. For others a more detailed, standalone document may be required.

6.1. Lessons learned for rolling stock

Incorporating lessons learned from past projects regarding human factors for rolling stock is helpful for new projects.

The organisation contracted to supply new or altered rolling stock to TfNSW shall source both positive and negative lessons learned from previous rolling stock projects and apply the knowledge to their current project. To better understand the NSW context and improve its solution for TfNSW, the organisations should consult TfNSW about human factors lessons learned on previous rolling stock procurement and alteration projects.

Examples of specific areas for consultation and review for lessons learned include, but are not limited to, the following:

- train (driver) safety system including the following:
  - vigilance systems, including the task linking aspects
  - operator enable system
  - automatic train protection (ATP)
- glare and reflection problems within cabs including issues experienced with commercially available display screens and its relation to human-computer interface (HCI) design
- haze and reduced visibility through the windscreen
- provision of alarms and alerts
- use of closed circuit television (CCTV) systems for monitoring the interface between the platform and the train
• provision of space for writing and electronic tablet tasks and for equipment required to be carried by crew, trainers, examiners, and other personnel with crew

• crew access steps

• roles of operational personnel other than the driver (for example, train guard, crew trainers, station staff)

• handrail and grab pole placement for crew when carrying out standing tasks

• train management system HCI

• equipment, systems, and actions for emergencies

• provisions for ancillary personnel including maintenance personnel, cleaners, and those carrying out security and revenue protection duties

• passenger areas including provision for Disability Standards for Accessible Public Transport (DSAPT)

To ensure consistency for crew when moving between sets and to reduce negative transfer implications and training needs, the design process shall include reviews of the look, functionality and location of crew controls and displays in relation to other sets of a similar generation. Knowledge of crew rotations between different rolling stock during shifts is imperative in this regard.

Organisations undertaking work for TfNSW shall incorporate reviews by a range of end users including drivers, crew, and other operational and maintenance personnel and organisational stakeholder representatives into the design and engineering process.

The organisations undertaking work for TfNSW shall determine the level of review and consultation required for the project based on the risk and the amount and complexity of the human interactions required or changed.

6.2. Design of driving and crew cabs

The design of rolling stock driving and crew cabs has specific human factors requirements. These requirements include but are not limited to the following:

• lessons learned

• driving and crew positions and tasks

• controls and displays

• ensuring that there is no conflicting information being presented to the crew

• the quantity and method used to provide information, including the design of alarm provisions and the provision of screen text messages
• visibility including consideration of glare and reflection
• cab interior design including environment
• crew access and egress
• ease of accessing and maintaining equipment

These requirements can be met by following certain parts of AS 7533:2013 *Railway Rolling Stock - Driving Cabs*.

The design of driving and crew cabs shall comply with the following parts of AS 7533:

- Part 1: Locomotive
- Part 3: Passenger
- Part 4: Infrastructure Maintenance

### 6.2.1. Driving and crew positions

Driving and crew positions require human factors considerations to cater to safety and comfort.

Driving is a constrained work position.

The primary driving position shall be the seated. All drivers within the anthropometric design range shall be able to operate safety, effectively and efficiently from the primary driving position. To enable a substantial change in posture it is often appropriate to cater for a standing driving posture. For the purposes of this document, this is deemed a secondary driving position.

Any secondary driving position shall cater comfortably for a substantial percentage of the anthropometric design range of drivers.

All drivers within the anthropometric design range shall be able to operate safely from all positions.

When other personnel need to work in the cab simultaneously with the driver, then the personnel shall be able to do so without any physical or task conflicts occurring between them and the driver.

### 6.2.2. Human factors for controls in driving and crew cabs

Design of controls in driving and crew cabs require human factors considerations.

If a design incorporates a combined traction and brake controller, then the braking range should be forward and the power range backwards.

The design of any control associated with train (driver) safety systems shall minimise the potential to circumvent the control so far as is reasonably practicable (SFAIRP). Consideration shall be made for actions that cause a less safe method of operation.
Any safety system override control that a second person needs to operate shall not be operable from the driving position.

6.2.3. **Visibility from driving and crew cabs**

Drivers and crew require suitable visibility in various driving conditions when in seated and standing positions.

Signal visibility shall comply with T HR RS 00100 ST RSU 100 Series – *Minimum Operating Standards for Rolling Stock – General Interface Standards* unless otherwise specified in the contract.

Signals and associated signal indications shall be visible from the driving position when the train is in operation, including both moving and stationary. The organisation contracted to supply new or altered rolling stock to TfNSW shall achieve this visibility with all cab equipment and furnishings in place.

The clarity of vision through the front windscreens shall meet the required level for all sun positions, brightness levels, and other external light conditions.

The organisation shall provide equipment to maintain visibility through the front windows in all driving conditions including frost, ice, rain, large temperature differential between cab and exterior, debris, and insects. This equipment shall not impede visibility under normal conditions.

6.2.4. **Cab interior design**

HF considerations for interior design for cabs include providing a safe and comfortable environment that is easy to maintain and free from unnecessary distractions.

The interior finishes shall provide for a pleasant working environment for the personnel and shall not introduce reflections and glare on controls or displays.

The organisation contracted to supply new or altered rolling stock to TfNSW, when choosing the finishes and materials, shall take into account the ease of cleaning, repairing, and replacing as well as ensuring durability.

6.2.5. **Crew access and egress**

Crew access and egress from rolling stock has important human factors safety considerations.

The organisation contracted to supply new or altered rolling stock to TfNSW shall provide a safe means of access to and egress from the cab from either side of the train.

Crew shall be able to use the provided means of access and egress under all foreseeable normal, degraded, and emergency scenarios, including to and from track level including areas that are ballasted.
For passenger multiple unit rolling stock, the organisation shall provide a means of access and egress for personnel between the crew cab and the passenger area, with appropriate security to eliminate unwanted access.

6.3. **Driver only operation**

Driver only operation (DOO) refers to trains operated by one-person crew who is responsible for all safety operations. DOO for freight operations refers to operating freight trains with only one crew member, in the form of a driver. For passenger services this means operating with a driver but no guard. Other crew may be on board passenger services, but remain responsible for customer services only and not train safety. DOO has important human factors considerations for the changed operating and maintenance practices, including functionality such as driver operated passenger doors.

Where DOO is implemented for passenger services, the driver shall have ease of visibility of the platform train interface to ensure safety of passengers boarding and alighting the train, and be able to safely operate the relevant doors from all driving positions. Technology shall be available to assist the driver in completing a thorough safety check of the door status and platform train interface area to confirm the area is free of any potential hazards. The technology should consider the appropriate coverage area and at a minimum provide the driver with visibility of the full length of the body side doors.

Any customer focused roles that are included in driver tasks should be assessed, and technology used where appropriate. This includes tasks such as the following:

- help point management
- emergency situations
- customer focused tasks

Where DOO is implemented, the driver shall be assisted by appropriate technology to support them in their tasks and minimise workload impacts. Consideration should be given to the available systems to support out of course driver actions, such as having to leave the cab.

6.4. **Automatic train protection**

Automatic train protection (ATP) has important human factors considerations including consistency between rail operator sets for procedures and functionality, the driver machine interface (DMI) and user interactions, including operations and maintenance.

Where an ATP system is to be implemented, consistency between base ATP standard and rail operator sets needs to be considered, particularly in relation to the following:

- driver start of mission procedures through the DMI
- wording of text messages on the DMI
• provision of icons – meaning colour, position, status (steady or flashing)
• location of information on the screen
• DMI screen technology

Text messages shall be configured to have sufficient meaning for each stakeholder to action the message.

In-cab signalling, as relates to level 2, without line-side signals, will require changes to driving and guard practices. Specific considerations will be identified in a future version of this document.

6.5. **Automatic train operations**

Automatic train operations (ATO), on occasion, require manual movement of trains, which requires human factors considerations for operations and maintenance.

For rolling stock that is generally not driven by a person, for example those operated under ATO Grade of Automation (GoA) 2 or 3 that requires a person to move the train in some circumstances, a position shall be identified from which the anthropometric design range of people are able to safely operate and move the train for the periods anticipated. For this work position, AS/RISSB 7533:2013 *Railway Rolling Stock - Driving Cabs* shall apply. In circumstances where it is not necessary to provide a driver’s seat, a justification for a standing driving position shall be provided that includes consideration of driver tasks, including duration of tasks.

6.6. **Crew and other personnel interfaces not in the cab**

Interfaces for crew and other personnel not in the cab have human factors considerations.

The organisations contracted to supply new or altered rolling stock to TfNSW shall apply appropriate aspects of AS/RISSB 7533:2013 *Railway Rolling Stock - Driving Cabs* to these interfaces. This includes fault management processes.

For any crew and other personnel interfaces not in the cab, T MU HF 00001 ST *Human Factors Integration – General Requirements* shall apply.

6.7. **Rolling stock passenger areas**

Rolling stock areas for passengers have human factors considerations including access and egress, and interior finishes and materials.

For passenger areas, T MU HF 00001 ST *Human Factors Integration – General Requirements* shall apply, including any means of access and egress to and from the vehicle for normal, degraded, and emergency use. For passenger rolling stock refer to T HR RS 04001 ST *Passenger Rolling Stock Access and Egress*. 
If the contract does not define egress rates, the organisation contracted to supply new or altered rolling stock to TfNSW shall determine these based on the operational context, including but not limited to expected peak passenger numbers, emergency scenarios, and routes the rolling stock will service.

The interior finishes shall provide customers with a pleasant travelling environment.

The interior finishes shall minimise reflections and glare.

When choosing the finishes and materials, the organisation shall take into account the ease of cleaning, repairing, and replacing, and ensuring durability and resistance to vandalism.

Where any equipment is located in the passenger areas, it shall not impede passenger access or egress or impact passenger safety or the travelling environment.

6.8. **Mock-ups used for design evaluation**

A mock-up is a representation of a design solution. It can range in fidelity from a simple paper prototype of a computer interface, a rough sketch model, cardboard and paper representation of a particular aspect of a physical interface, to a highly finished high fidelity mock-up using some real controls and finishes to represent a full work or passenger area. A working prototype can be viewed as a mock-up, as it is a representation of the proposed design. However, typically as the mock-up fidelity increases, the opportunity to change the design reduces. The mock-up process can often start with simple rough mock-ups, and progress through to a higher fidelity mock-up as the design matures.

Design evaluation can involve the use of mock-ups, which have requirements such as suitability, fidelity, and opportunity to generate feedback for improving design.

The organisation contracted to supply new or altered rolling stock to TfNSW shall use mock-ups throughout the design process.

Mock-ups shall be appropriate for the scale and scope of the project. Different aspects of the project may have different needs for mock-ups. The fidelity of any mock-ups used should be reflective of the tested information and the design's maturity.

The organisation contracted to supply new or altered rolling stock to TfNSW shall incorporate feedback gained from mock-ups and reviews into design. Reasons that should warrant changes to the proposed design include but are not limited to the following:

- noncompliance with standards, legislation, specification, or requirements
- potential for significant discomfort, dissatisfaction, or operational or maintenance difficulties experienced by the crew, maintenance, cleaning, and other personnel carrying out required tasks
- potential for negative transfer to have adverse effects on safety, operational, or maintenance tasks including cleaning performance
• design features that do not cater for the full anthropometric design range, and are considered to have a negative impact on the operability and maintainability of the system

• demonstrated lack of error tolerance within the system design, including normal and emergency operations

• demonstrated potential for inadvertent operation of controls that would impact operations or safety

• potential for significant discomfort, dissatisfaction, or potential significant vandalism or misuse by passengers

• identification of common work, health, and safety (WHS) hazards such as slips, trips, pinch points, sharp edges, catch points, and closing traps

6.9. **Rolling stock simulators and emulators**

Simulators and emulators for rolling stock have human factors considerations regarding ease of use, safety, customisation, and feedback.

Simulators and emulators shall comply with T MU HF 00001 ST *Human Factors Integration – General Requirements*.

Simulators and emulators used for training and evaluation shall do the following:

• be easy to run and assess and evaluate trainees

• allow trainers to develop and alter many scenarios

Simulators and emulators should allow the easy input and modification of a range of track layouts and environmental conditions, and other operational movements including degraded and emergency situations.

• provide immediate feedback on trainee performance to enable the trainer to identify performance improvement requirements

• reflect the characteristics of the real asset given its intended use

Organisations shall design simulators and emulators to ensure safe operation and good environmental conditions for both trainers and trainees. Simulators and emulators shall be easy to maintain and update.