Standard

Human Factors Integration – Rolling Stock

Version 1.0

Issued Date: 22 August 2014

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Standard governance

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Document history

<table>
<thead>
<tr>
<th>Version</th>
<th>Summary of change</th>
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<tbody>
<tr>
<td>1.0</td>
<td>First issue</td>
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For queries regarding this document, please email the ASA at standards@asa.transport.nsw.gov.au or visit www.asa.transport.nsw.gov.au
Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance based to create opportunities for innovation and improve access to a broader competitive supply chain.

For rolling stock projects, the ASA document T MU HF 00001 ST Human Factors Integration – General Requirements applies. That document provides the generic requirements for human factors integration (HFI). The supporting ASA document T MU HF 00001 GU AEO Guide to Human Factors Integration provides guidance on implementing these requirements.

This new standard provides additional human factors (HF) requirements specific to rolling stock projects.
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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.

An authorised engineering organisation (AEO) ensures that the assets they provide to Transport for NSW (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.

Human factors integration (HFI) in the engineering design process produces tangible benefits in safety, operability, and maintainability of the asset over its life cycle.

2. Purpose

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

2.1. Scope

This standard provides the requirements for human factors integration (HFI) within the following activities:

- procurement of new rolling stock
- alterations to existing rolling stock

Use this document in conjunction with other applicable Asset Standards Authority (ASA) standards including, but not limited to the following:

- T MU HF 00001 ST Human Factors Integration – General Requirements
- T MU HF 00001 GU AEO Guide to Human Factors Integration
- TS 20001 System Safety Standard for New or Altered Assets
- TS 10504 AEO Guide to Engineering Management

The objective of this human factors (HF) standard is assurance of the delivered asset including the validation and verification of the HF requirements for its operability and maintainability and that it is safe to operate and maintain.
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 hand over 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.

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

2.2. Application

Authorised engineering organisations (AEOs) need to apply this standard. Asset Standards Authority (ASA) intends this standard for use by human factors specialists, design professionals including engineers, and managers acting on behalf of an AEO contracted to provide new or altered rolling stock to Transport for NSW (TfNSW).

For rolling stock projects, the ASA document T MU HF 00001 ST Human Factors Integration – General Requirements applies. That document provides the generic requirements for human factors integration (HFI). The supporting ASA document T MU HF 00001 GU AEO Guide to Human Factors Integration provides guidance on implementing these requirements. This rolling stock standard provides additional requirements specific to rolling stock.

3. Reference documents

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

**Australian legislation**

Disability Standards for Accessible Public Transport

**NSW Legislation**

Rail Safety (Adoption of National Law) Act

Rail Safety National Law Regulations

NSW Rail Safety (Adoption of National Law) Regulations

NSW Work Health and Safety Act

NSW Work Health and Safety Regulations
Australian standards

AS 7533.3-2013 – Australian Standard – Railway Rolling Stock - Driving Cabs – Part 3: Passenger
AS 7533.4-2013 – Australian Standard – Railway Rolling Stock - Driving Cabs – Part 4: Infrastructure Maintenance

ASA documents

T MU HF 00001 ST Human Factors Integration – General Requirements
T MU HF 00001 GU AEO Guide to Human Factors Integration
TS 10504 AEO Guide to Engineering Management
TS 20001 System Safety Standard for New or Altered Assets
ESR 0001 -100 (RSU 160) General Interface Requirements

4. Terms and definitions

The following terms and definitions apply in this document:

AEO authorised engineering organisation

anthropometric is a reference to the data used in anthropometry

anthropometry is the science of measuring the variability of the physical human characteristics. Apart from size, other physical characteristics include shape, weight, strength, mobility, flexibility, and working capacity

ATO rolling stock automatic train operation rolling stock. These rolling stock are not typically under the control of a ‘driver’ during normal operations, although the rolling stock may be moved manually (by a person) in some scenarios

ATP automatic train protection

DSAPT Disability Standards for Accessible Public Transport

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

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 and cyclists. 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

**error tolerance** ability of a system or component to continue normal operation despite erroneous inputs

**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

**human factors** is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design to optimise human well-being and system performance. Synonymous with ergonomics

**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

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

**mock-up** 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

**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

**new or altered rolling stock** new rolling stock or the changes made to the rolling stock other than those due to maintenance activities, including decommissioning and removal of rolling stock from service. Maintenance activities are those made by AEOs with authorisation for maintenance activities and conducted under that authorisation scope

**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

**operational personnel** a personnel role to operate the asset. For example for rolling stock, train crew, train driver, train guard, crew trainers, station staff

**Operator** an organisation that operates an asset

**SFAIRP** so far as is reasonably practicable

**TfNSW** Transport for New South Wales

### 5. Rolling stock-specific human factors integration

An authorised engineering organisation (AEO) contracted to supply new or altered rolling stock to Transport for NSW (TfNSW) shall apply a human factors integration (HFI) process to all contracts with TfNSW in line with Asset Standards Authority (ASA) document T MU HF 00001 ST Human Factors Integration – General Requirements.

The AEO shall document the HFI process, and this process shall form part of the AEO’s engineering management (see TS 10504 AEO Guide to Engineering Management).

The AEO shall provide a human factors integration plan (HFIP) covering but not limited to the following areas:

- driving and crew cabs (in line with the appropriate part of AS 7533 -2013 – Australian Standard – Railway Rolling Stock - Driving Cabs)
- crew and other personnel interfaces not in the cab. Typically these include but are not limited to:
  - 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
- access and egress
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, considering interfaces, and creating a human factors integration plan (HFIP).

All designs shall comply with the Asset Standards Authority (ASA) standard 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 section lists these requirements.

For the design of the rolling stock, the authorised engineering organisation (AEO) shall take into account the needs of all end users, which typically include but are not limited to passengers, crew, maintenance personnel, cleaners, controllers, trainers, and managers.

The AEO shall identify all the end users as part of the human factors integration (HFI) process.

For the design, the AEO shall consider how the rolling stock will 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.

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.

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 authorised engineering organisation (AEO) shall source lessons learned from previous rolling stock projects and apply the knowledge to their project. The AEO should source both positive and negative lessons learnt.

To better understand the NSW context and improve its solution for Transport for NSW (TfNSW) the AEO should consult TfNSW about human factors lessons learnt on previous rolling stock procurement and alteration projects.
Examples of specific areas for consultation and review for lessons learnt include, but are not limited to, the following:

- 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 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
- 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)

AEOs 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 AEOs 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
- controls and displays
- the quantity and method used to provide information, including the design of alarm provisions
- visibility including consideration of glare and reflection
- cab interior design including environment
- crew access and egress

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: Locomotives
- 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 posture shall be the seated position. To enable a substantial change in posture it is often appropriate to cater also 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, they 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 driver safety systems shall minimise the potential to circumvent the control so far as is reasonably practicable (SFAIRP).

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.

Signal visibility shall comply with ESR 0001 - 100 (RSU 160) *General Interface Requirements* 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 authorised engineering organisation (AEO) 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 AEO 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**

Interior design for cabs has human factors considerations to provide a safe and comfortable environment that is easy to look after.

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 authorised engineering organisation (AEO), when choosing the finishes and materials, shall take into account the ease of cleaning, repair, and replacement.

6.2.5. **Crew access and egress**

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

The authorised engineering organisation (AEO) shall provide a safe means of access and egress to 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 AEO 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. Automatic train operations

Automatic train operations (ATO), on occasion, require manual movement of trains. This need brings human factors considerations.

For rolling stock that is generally not driven by a person, for example, those operated under automatic train operations (ATO), but requires a person to move the train in some circumstances, there shall be a position from which the design range of people are able to safely operate and move the train for the periods anticipated. For this work position, AS 7533 - 2013 – *Australian Standard – Railway Rolling Stock - Driving Cabs* shall apply.

6.4. Crew and other personnel interfaces not in the cab

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

The authorised engineering organisation (AEO) shall apply appropriate aspects of AS 7533 - 2013 – *Australian Standard – Railway Rolling Stock - Driving Cabs* to these interfaces.

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

6.5. 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.

If the contract does not define egress rates, the authorised engineering organisation (AEO) 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 AEO shall take into account the ease of cleaning, repair, and replacement.

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

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 authorised engineering organisation (AEO) 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 AEO shall incorporate feedback gained from mock-ups or reviews into design. Reasons that should warrant changes to the proposed design include but are not limited to the following:

- non compliance with standards, legislation, specification, or requirements
- potential for significant discomfort, dissatisfaction, 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 including cleaning performance
- design features that do not cater for the full anthropometric design range, and are considered to have an 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
6.7. Rolling stock simulators and emulators

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

For providing simulators and emulators, Asset Standards Authority (ASA) document T MU HF 00001 ST Human Factors Integration – General Requirements shall apply.

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

- be easy to run and assess
- 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

Authorised engineering organisations (AEOs) shall design simulators and emulators to ensure safe operation and good environmental conditions for both trainers and trainees.