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T MU HF 00001 ST

Standard

Human Factors Integration – General Requirements

Version 1.0

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Document history

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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

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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.

This is a new standard to support authorised engineering organisations (AEOs) in the development and application of human factors integration. This standard describes the need for the following:

- a human factors integration process
- generic human factors requirements

Meeting these needs will optimise overall system performance through the systematic consideration of human capabilities and limitations within the design process.

Adequate integration of human factors complements the systems engineering approach to all phases of an asset's life cycle, ensuring its fitness for purpose.

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1. Introduction

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

The aim of the HFI process is to ensure the human-system interactions optimise system performance, and identify and mitigate risk.

An authorised engineering organisation (AEO) ensures that the assets they provide to TfNSW are safe to operate and maintain, and that all safety risks have been minimised so far as is reasonably practicable (SFAIRP) during the engineering design process, in addition to their professional duty of care.

Supporting evidence, demonstrating HFI in safety risk management activities, will provide an important contribution to the overall safety assurance argument in most cases.

The benefits of considering HF in the engineering design process are not limited to safety. Equally valuable are benefits regarding the overall operability and maintainability of the system.

To achieve these benefits, it is important to take into account HF early in the asset life cycle, starting with feasibility, optioneering, conceptualising, and continuing through the full design process.

Guidance material to assist with implementing this standard is provided in T MU HF 00001 GU *AEO Guide to Human Factors Integration*.

2. Purpose

This document details the requirements for the demonstration of a systematic process for human factors integration and for the application of recognised human factors principles, within the engineering design process.

2.1. Scope

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

- provision of engineering design services including the management of the process
- provision of new or altered assets to Transport for NSW (TfNSW)
- provision of like-for-like replacement of assets

This document is to be used in conjunction with other applicable Asset Standards Authority (ASA) documents including but not limited to the following:

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- T MU HF 00001 GU *AEO Guide to Human Factors Integration*

  This provides guidance on how this standard could be implemented.

- TS 20001 *System Safety Standard for New or Altered Assets*
- TS 10502 *AEO Authorisation Requirements*
- TS 10504 *AEO Guide to Engineering Management*

The ASA human factors (HF) interest is assurance of the operability and maintainability of a delivered asset including the verification and validation of the HF requirements.

This standard is not applicable to the following activities:

- HFI in manufacture, construction, installation, or commissioning phases of assets
- HFI relating to the organisation of the day-to-day operation or maintenance of assets following hand over to the operating and maintenance entities

Although this document does not cover 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.

2.2. Application

The Asset Standards Authority (ASA) intends for authorised engineering organisations (AEOs) to apply this standard. ASA intends this standard for use by human factors specialists, design professionals including engineers, and managers acting on behalf of an AEO that is contracted to provide applicable services and assets to Transport for NSW.

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 (Access to Premises-Buildings) Standards

Disability Discrimination Act

Disability Standards for Accessible Public Transport

NSW legislation

NSW Rail Safety (Adoption of National Law) Regulations

NSW Work Health and Safety Act

NSW Work Health and Safety Regulations

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Rail Safety (Adoption of National Law) Act

Rail Safety National Law Regulations

TfNSW documents

T MU HF 00001 GU AEO Guide to Human Factors Integration

TS 10502 AEO Authorisation Requirements

TS 10503 AEO Guide to Engineering Competence Management

TS 10504 AEO Guide to Engineering Management

TS 20001 System Safety Standard for New or Altered Assets

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

DDA *Disability Discrimination Act*

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 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 tolerant ability of a system or component to continue in normal operation despite erroneous inputs

HCI human-computer interface

HF human factors

HFI human factors integration

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,

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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

human-system interaction all instances where a human interacts with a delivered asset within the system

like-for-like a like-for-like replacement is a new item similar in form (shape, material, and so forth), fit (size and means of installation), and function (performs the same role) to the previous item

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

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 assets the changes made to assets other than those due to maintenance activities, including decommissioning and removal of assets. 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

premises standards *Disability (Access to Premises-Buildings) Standards*

priority seating is seating for passengers with disabilities and other groups in need of special assistance (for example, the aging) as defined in DSAPT

SFAIRP so far as is reasonably practicable

stakeholder the persons or groups that have claims on ownership, rights, or interest in a project or its activities in the past, present, or future

system asset and its context of use

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violations deliberate but not necessarily reprehensible deviations from rule or formal arrangement (such as a specified procedure). They are deviations from a known correct path. Rules might be violated because it is perceived that there is a better way to achieve the end, to cover up mistakes, or to assist colleagues

5. Human factors integration – process requirements

Process requirements for human factors integration (HFI) include documentation, scalability, evidence, reporting, and demonstrated competency.

An authorised engineering organisation (AEO) contracted to supply applicable engineering services to Transport for NSW (TfNSW) shall apply an HFI process to all contracts with TfNSW.

The AEO shall document the HFI process.

The HFI process shall form part of the AEO's engineering management. For guidance on this, see TS 10504 *AEO Guide to Engineering Management*.

The HFI process shall be scalable in its application, based on the risk, novelty, reliance on human performance, and complexity of each specific project to ensure the effectiveness and efficiency of its application. The AEO shall integrate the activities and specified deliveries into the project plans.

For any project, the AEO shall demonstrate and have evidence that they have carried out their HFI process.

Demonstration and justification of the HFI process shall form part of the assurance of the project. AEOs shall report HFI activities at each of the baseline stage gateways. For guidance on this see TS 10504.

Competent resources shall undertake all human factors (HF) activities as appropriate to the activity being undertaken. The AEO should demonstrate the competency in accordance with the AEO process for managing competence described in TS 10503 *AEO Guide to Engineering Competence Management*.

If, through the application of its HFI process, an AEO determines that no HF activities are required, the AEO shall document and present this decision and reasoning as part of the overall assurance argument for the project at the first project gateway, and re-evaluate at each subsequent gateway. For guidance on this, see TS 10504.

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5.1. Human factors integration process

The human factors integration (HFI) process requires an authorised engineering organisation (AEO) to carry out tasks such as recording, analysis, assessment, and communication to meet risk management principles.

The HFI process is based on established risk management principles and, as a minimum, shall require an AEO to:

1. establish the context of the use of the system, and in particular do the following:
    - identify how the system will be used to support determining of functional requirements and how it will integrate into the existing system or systems
    - identify all stakeholders and end user groups, all applicable regulatory requirements including the applicable requirements of the *Disability Discrimination Act*, *Disability Standards for Accessible Public Transport* and *Disability (Access to Premises-Buildings) Standards* legislation
    - identify the end user attributes and requirements
    - identify all human-system interactions
    - characterise the criticality of HFI in the project
2. identify, record, and manage the human factors (HF) issues and human-system interactions through the stages of the asset life cycle
3. analyse, manage, and control the identified HF issues and human-system interactions, including:
    - conducting analyses using appropriate techniques and to the relevant level of detail, given the nature of the issue and the risk and complexity of the project, to identify potential controls
    - demonstrating that HF is integrated in all risk and engineering design analyses that may have an impact on any human interactions with the system
4. assess, based on the output of the HF analyses, if changes to the design are required, including the adoption of any identified HF controls
5. adopt and test the human interactions and HF controls within an iterative design process. This shall include the following:
    - monitoring the effectiveness of these interactions and controls as part of the verification and validation process
    - closing out HF issues. Where this close out requires commitments from other parties, these commitments shall be agreed and documented prior to claim of the close out

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6. communicate with and consult with all stakeholders and end user groups throughout the design development
7. monitor and review the effectiveness of its HFI process within a specific project and across the organisation
8. capture and record lessons learnt regarding the operability and maintainability of the design from each project, so the lessons learnt can be fed into other projects

A human factors integration plan is one method for documenting the human factors integration process.

6. Generic human factors requirements

Human factors integration (HFI) aims to ensure optimisation of human-system interactions to provide effective system performance. Incorporating human factors (HF) through the life cycle, and particularly early in the design process, provides the most benefit. To aid this process, this document identifies some generic HF requirements that are likely to be applicable to most Transport for NSW (TfNSW) projects, including but not limited to the following:

- Design requirements
- Anthropometric data
- Controls and displays
- Information content
- Audibility and intelligibility of messages
- Alarms and alerts
- Workspace and task design
- Seating
- Glare and reflections
- Customers and the public

The application of these HF requirements is context specific and authorised engineering organisations shall base the application on the system being designed. Therefore, not all of the requirements will be applicable to all projects.

This is not a comprehensive list of all HF requirements. A project should use this list as a starting point and identify and address other applicable HF requirements or develop more detailed HF requirements based on the context of the system being designed.

No implied hierarchy or importance associated with the order of presentation of these requirements.

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6.1. Design requirements

Human factors (HF) requirements for design need evidence and justification to show that human capabilities, limitations, and safety, in various circumstances are taken into account.

When designing systems and equipment, authorised engineering organisations (AEOs) shall take into account the following:

- the context of use; the context in which the system operates
- human variability, to ensure the system can cater for the specific range of end users, including the range of disability identified in the *Disability Discrimination Act*, as appropriate
- human capabilities and limitations regarding physical and cognitive attributes

AEOs shall base design decisions on relevant and valid data. AEOs shall record the justification for the choice of data used for design decisions.

AEOs, in their design decisions, shall take into account the demands on, and the requirements of, end users during normal, degraded, maintenance, cleaning, and emergency situations.

AEOs shall design systems and equipment to be error-tolerant, and to provide a means of error identification and recovery should an error occur. Where possible, a human error shall not be able to result in system failure.

AEOs shall design systems to minimise violations.

AEOs shall identify the reasons people might act incorrectly with the designed systems.

AEOs should design systems to reflect the 'easy way of doing something being the correct way' philosophy.

Designs shall identify foreseeable misuse of the equipment or asset. Where practicable, the AEO shall introduce measures to prevent such action or to minimise damage to the asset.

The design shall not introduce workload and distraction that impairs the primary safety task.

AEOs shall design the overall environment for all end users around good ergonomics principles. Areas of ergonomics applicable include, but are not limited to, interior climate, the acoustic and visual environments, and vibration.

AEOs shall incorporate into the design safe access to equipment during maintenance.

AEOs shall design systems and equipment to enable ease of maintenance including cleaning.

AEOs shall incorporate design reviews by end users and stakeholders into the design engineering process, at a level appropriate to the nature of the project being undertaken and its affect on the end users.

AEOs shall identify the impact of design decisions on operational training requirements and shall take into account this impact in design reviews and as part of the consultation process.

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6.2. Anthropometric data

Human factors (HF) integration requirements use anthropometric data to determine the appropriate values for size, proportions, weight, strength, flexibility, mobility and working capacity of humans within the design, where values are specified by legislation these need to use.

Authorised engineering organisations (AEOs) shall base designs on anthropometric data. For all projects the design anthropometric range for adults shall be from at least the 5th percentile female or male (whichever has the smaller value) to the 95th percentile male or female (whichever has the larger value). AEOs shall justify the suitability of the data chosen for use for Transport for NSW projects. If AEOs choose a lesser range, they shall justify this variation based on the end user and system requirements. Where practicable, designs should allow for at least up to the 97.5th percentile value to provide a level of future proofing for population change.

For projects aimed at a specific group, or parts of an asset used by a specific group, AEOs shall include a wider range of end users in the design anthropometric range. Examples of such groups include children, people with ambulatory aids, and people in wheelchairs. For any project, AEOs shall identify these groups as part of the context of use. The design anthropometric range shall include these groups.

Where values are specified in the *Disability Standards for Accessible Public Transport* or the *Disability (Access to Premises-Buildings) Standards* for specific uses, these shall be deemed a minimum requirement when applied for these specific uses.

AEOs shall use shoe, clothing, and personal protective equipment allowances as appropriate when determining values, for example, dimensions, reach envelopes, and forces.

6.3. Controls and displays

Human factors (HF) requirements for controls and displays relate to layout, type, safety, security, and labelling.

Controls and displays include those provided on or through a computer or other graphic user interface.

Authorised engineering organisations (AEOs) shall base the layout and position of controls and displays on the principles of frequency, sequence of use, importance, and functional groups.

Primary controls shall be within reach of the normal operating position. Primary displays shall be visible from the normal operating position.

Control and display selection and operation shall incorporate population stereotypes and expectations as far as is reasonably practicable when determining the appropriate operational movements and other qualities.

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AEOs shall determine the type of display used by the information requirement of the end user and the rate of change of the parameter being measured. Examples of types of display are digital, analogue, or moving pointer.

The end user shall not have to convert displayed information into another format or unit to support task performance.

AEOs shall ensure that the potential for negative transfer to result in system failure when an end user moves from one system to another is minimised.

In situations that require humans to reach controls there shall be safe methods for the design anthropometric range of end users to reach them, even if the controls are infrequently used.

AEOs shall design controls to minimise the potential for circumvention.

It shall be impossible to place any control in a mid-state position such that the control is not in a position corresponding to a designed state.

In situations where controls may be used without direct viewing, the controls shall be differentiated using both visual and tactile means to minimise the risk of inadvertent activation.

AEOs shall use layout design and control selection to minimise the consequence of inadvertent operation of a control.

All labelling of controls and displays shall be visible and legible from the expected viewing positions and distances for the expected range of end users.

6.4. Information content

Human factors (HF) requirements for information content relate to visibility, legibility, importance, and adherence to established guidelines and standards.

Any information displayed shall be relevant to the end user requirements and be visible, legible, and intelligible from the expected viewing distances and positions.

The type of information displayed, the level of information required, the expected reasonable viewing distance, and the expected end user groups shall determine the size and type of the display. *Disability Standards for Accessible Public Transport* includes specific requirements that the authorised engineering organisation (AEO) shall address.

All information provided shall be unambiguous and in English.

Only information needed to enable an end user to effectively work or use the system in normal, degraded, and emergency situations shall be presented.

AEOs shall determine the end users for the information to be provided. AEOs shall ensure that the way information is provided caters for those end users. Different end users may have different requirements and this may require the AEO to provide more than one means of information presentation.

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The AEO shall design all human-computer interfaces (HCI) in accordance with established HCI and useability guidelines. AEOs shall identify which HCI standards or guidelines have been used to develop their HCI.

6.5. Audibility and intelligibility of messages

Human factors requirements for the audibility and intelligibility of messages relate to the project's expected acoustic environment.

Messages delivered acoustically shall be audible and intelligible to those who are to receive them within the expected acoustic environment.

6.6. Alarms and alerts

Human factors requirements for alarms and alerts involve safety, sufficient information, relevance, prioritisation, and accessibility.

Authorised engineering organisations (AEOs) shall provide alarms to the end users so the end users are able to take the required action to maintain the system in a safe and operable state or act appropriately in a degraded situation or emergency. *Disability Standards for Accessible Public Transport* includes specific requirements for alarms and alerts that AEOs shall address.

Alarms should contain sufficient information to allow the end user to take the required action in a timely manner.

End users shall only experience alarms that relate to them.

AEOs shall prioritise alarms according to their impact on the system and the required action by the end user. AEOs should use no more than three levels of prioritisation for alarms.

Alarms of different priorities shall be distinguishable both visually and audibly.

In the case that a single event raises multiple alarms there should be a single method of acknowledging all the related alarms.

End users shall hear audible alarms within the expected acoustic environment.

6.7. Workspace and task design

Human factors (HF) requirements for workspace and task design include support for the end user to do work safely and comfortably.

AEOs shall demonstrate that the overall workspace and task design supports the end user to perform their required work tasks including maintenance and cleaning.

AEOs shall ensure that work task design:

- accounts for the difficulty, importance, and frequency of the tasks to be performed

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- is assessed for hazardous manual tasks and those identified shall be controlled and managed
- identifies constrained work positions

AEOs shall ensure that when an end user is required to be in a stationary position for long periods, the workstation allows the end user to maintain a comfortable sitting position. Opportunities for substantial changes in posture should be included in design where possible, for example, to enable safe, easy maintenance and operation from a standing position.

6.8. Seating

Human factors (HF) requirements for seating relate to suitability and dimensions.

The authorised engineering organisation (AEO) shall select and design seating and the seating layout to suit the task and environment.

The AEO shall determine the seating dimensions using anthropometric data for the specified end user population range. The AEO shall justify compromises required due to access and egress or end user requirements regarding seating and standing capacity or other areas where conflicts occur.

6.9. Glare and reflections

Human factors requirements for glare and reflections involve elimination and minimisation.

Authorised engineering organisations (AEOs) shall eliminate glare and reflections where possible. Where elimination of glare and reflections is not possible, glare and reflections shall be minimised within and on workstations, controls, and displays.

AEOs shall provide minimisation methods to control reflections and glare in work areas, with particular attention given in crew cabs and control rooms.

6.10. Customers and the public

Human factors (HF) general requirements are applicable to customers and the public and in addition specific human factors requirements that relate to providing services to customers and the public are in the following topics:

- Users with disabilities
- Information for customers and the public
- Customer seating
- Handrails, poles, and grab points

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6.10.1. Users with disabilities

Human factors (HF) requirements regarding users with disabilities involve showing compliance with legislation.

All customer accessible areas and service provision shall meet the requirements of the *Disability Discrimination Act* (DDA), *Disability Standards for Accessible Public Transport* (DSAPT), and *Disability (Access to Premises-Buildings) Standards* (premises standards) legislation.

When providing assets that include the need for customer interactions, authorised engineering organisations (AEOs) shall demonstrate compliance with DDA, DSAPT and premises standards requirements.

6.10.2. Information for customers and the public

Human factors (HF) requirements for information for customers and the public relate to language use, clarity, ambiguity, symbols, and testing.

The authorised engineering organisation (AEO) shall provide all information in English. Where considered appropriate or specified as a business requirement, the AEO shall present the equivalent information in additional languages.

Information provided for customers or the public for effective and safe navigation of the transport system or its environs, or to take action in response to any abnormal or emergency event, shall be clear and unambiguous. Symbols should be used to convey information.

The AEO shall test the effectiveness of the proposed way of presenting information using the actual way in which the information is to be presented.

6.10.3. Customer seating

Human factors (HF) requirements for customer seating involve access and egress, handles, grips, and suitability.

On transport vehicles, the following applies to customer seating:

- seat and seating layout design shall enable access and egress to all seats and through the vehicle as required under normal and emergency situations
- handles and grips shall be associated with seating to help customers to get in and out of the seats and move through the vehicle
- the authorised engineering organisation shall provide assurance of the suitability of customer seating and arrangements. This may be provided through one of the following options:

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- user trialling with a representative sample of end users. The trialling should replicate the layout and context as closely as possible
- for off-the-shelf solutions, evidence of use in comparable operating contexts may be acceptable

6.10.4. Handrails, poles, and grab points

Human factors (HF) requirements for handrails, poles, and grab points involve safety and priority seating.

On transport vehicles, the authorised engineering organisation shall provide handrails, poles and hand grabs to do the following:

- assist passengers to safely access and egress the vehicle
- give steadying points for standing passengers whilst the vehicle is moving
- assist passengers to safely move around the vehicle
- lead people to the priority seating
- encourage movement away from or obstructing doorways and passageways
- ensure smooth passenger movement without potential for catching clothes, bags or other personal items

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