AEO Guide to Human Factors Integration

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Document history

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For queries regarding this document, please email the ASA at standards@transport.nsw.gov.au or visit www.asa.transport.nsw.gov.au

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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 version is a complete revision of the original guidance document issued in March 2013 as an interim guide. This new version is to support authorised engineering organisations (AEOs) and prospective AEOs in their application of T MU HF 00001 ST Human Factors Integration Standard - General Requirements. This guide describes the following:

- human factors
- human factors integration process requirements
- common human factors topics

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 approach to all phases of an asset's life cycle, ensuring its fitness for purpose.
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1. **Introduction**

This document aims to provide guidance to an authorised engineering authority (AEO) on implementing the requirements for managing human factors (HF) relevant to providing engineering services to Transport for NSW (TfNSW), across the life cycle of an asset.

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

The benefits of considering human factors (HF) in the engineering design process are not limited to safety. Equally there are valuable benefits regarding the operability and maintainability of the system. Considering HF is essential if a system is to meet its intended performance levels, and to be able to deliver the expected benefits to customers.

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

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

This guide should assist organisations to satisfy the requirements of the standard T MU HF 00001 ST Human Factors Integration - General Requirements.

2. **Purpose**

This AEO Guide to Human Factors Integration provides guidance to an authorised engineering organisation (AEO) on how to integrate human factors (HF) activities into the engineering design activities and services that they provide to Transport for NSW (TfNSW). This guide is a companion document to the standard T MU HF 00001 ST Human Factors Integration - General Requirements.

The objective of this document is to ensure that HF considerations form an integral part of the specification, design, and development process, rather than being seen as an add-on or as an afterthought following completion of the design and development activity.

The intent of this guidance is to promote the value of HF to an equal level with other disciplines that should be considered within design. The Asset Standards Authority's intent is to ensure that engineering design decisions are properly informed by adequate information about human-related issues, and that decisions relating to design alternatives or assessments consider HF data to provide the optimal design solution for the whole asset life cycle.
2.1. **Scope**

This document provides guidance on human factors integration (HFI) primarily for the following stages of the asset life cycle:

- feasibility
- concept
- design

However, most of the concepts and principles described are equally applicable to the following stages of the life cycle:

- fabrication, manufacturing, and construction
- installation
- integration, test, and commissioning
- asset operations and maintenance
- decommission and disposal

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

They are relevant to providing new or altered assets including commercial off the shelf (COTS) and ‘like for like’.

The Asset Standards Authority (ASA) HF interest is assurance of the operability and maintainability of a delivered asset including the validation and verification of the HF requirements. Therefore, the following are details regarding scope:

- within the scope of this document is provision of guidance on the use of HF principles and knowledge to ensure that the asset is designed and delivered such that it can be operated and maintained safely and efficiently
- beyond the scope of this document is the application of HF principles and knowledge to the organisation of the day-to-day operation or maintenance of assets following its hand over to the operating and maintenance entities

In addition, the inclusion of HF data is beyond the scope of this document. There are many reputable sources of data and an authorised engineering organisation (AEO) should identify sources of data that are applicable to the specific project and issue that is being addressed.

Other ASA documents that maybe useful to read in conjunction with this guide include but are not limited to the following:

- T MU HF 00001 ST Human Factors Integration - General Requirements.
This describes the requirements for HFI for Transport for NSW (TfNSW) projects.

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

### 2.2. Application

The Asset Standards Authority (ASA) intends this guide to be used by existing authorised engineering organisations (AEOs) and by suppliers planning to become AEOs. It applies to managing human factors (HF) issues that may affect system performance, and therefore ultimately may influence the operability and maintainability of the delivered asset.

The ASA created this guide for managers, designers, and engineers engaged under an AEO to provide new or altered assets to Transport for NSW (TfNSW). However, some HF consideration should also be made for like-for-like replacement projects, to avoid repeating past mistakes or reintroducing the same problems.

The sections of this document are as follows:

- **Section 5** introduces what is HF and why it is important. It will be of most interest to those individuals who have not previously been involved in HFI.

- **Section 6** describes the process of HFI. As such, this forms the major part of this document and is directly related to the ability of an AEO to demonstrate its capability to manage HF within its service provision. It will be of direct relevance to those responsible for the design of the HFI process within their own organisation, and to those responsible for the application of that process within their service provision (projects).

- **Section 7** describes some common HF topics and gives some practical advice on how these can be managed within a range of different projects.

- **Section 8** includes a list of terms commonly used to describe different HF analyses performed to support design activities.

### 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
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

brownfield a project that has constraints imposed by existing systems and infrastructure, and so forth

CAD computer-aided design

concept of operations a document that describes the characteristics of a proposed system from the viewpoint of all individuals who will use that system. The concept of operations is used to communicate the quantitative and qualitative system characteristics to all stakeholders. These documents are widely used in the military, governmental services, and other fields

ConOps see concept of operations

COTS commercial off the shelf
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

**ergonomics** see human factors

**error resistance** ability of a system to minimise the probability of error occurring

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

**ETA** event tree analysis

**FMEA** failure mode and effect analysis

**FTA** fault tree analysis

**HAZOP** hazard and operability study

**HCI** human-computer interface

**HF** human factors

**HFI** human factors integration

**HFIP** human factors integration plan

**HMI** human-machine interface

**HRA** human reliability analysis

**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

**HVAC** heating, ventilation, and air conditioning

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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

Maintainer an organisation that maintains an asset

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

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 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

operational personnel a personnel role to operate the asset. For example a train driver, train guard, controller, bus driver, driver trainer, station staff, deck hand, and ferry captain

Operator an organisation that operates an asset

PPE personal protective equipment

premises standards Disability (Access to Premises-Buildings) Standards

RAMS reliability, availability, maintainability, and safety
SFAIRP so far as is reasonably practicable
SME subject matter expert
SMS safety management system
TfNSW Transport for New South Wales

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

WHS work health and safety

5. Introduction to human factors in asset life cycle

Incorporating human factors (HF) through the asset life cycle, and particularly early in the design process, provides the most benefit. The following list of topics explains the concepts of HF, how it is integrated into engineering and design projects, and why authorised engineering organisations should include it within the asset life cycle:

- What is human factors?
- What is human factors integration?
- Goals of human factors integration in the asset life cycle
- Why include human factors?

5.1. What is human factors?

Human factors (HF) considers the capacity and limitations of humans in the context of a system, with the goal to optimise human and system performance. Legislation relating to safety and accessibility should be considered as part of the application of the HFI process.

Figure 1 shows a simple diagrammatic representation of human aspects and technical aspects overlapping in a system context. Within the Transport for NSW (TfNSW) context, the term human factors is synonymous with ergonomics.

The International Ergonomics Association defines HF as:

Ergonomics (or 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 in order to optimise human well-being and system performance.

Further, there are three commonly regarded categories of HF:
• physical - this is concerned with human anatomical, anthropometric, physiology, and biomechanical characteristics as they relate to physical activity within the workplace.

For example, the passenger door controls on older Sydney trains were placed on a panel above the crew cab door. Taller guards were able to reach and operate the controls without too much discomfort. However, about 25% of guards had trouble with reaching the controls. Newer trains have the controls positioned on the side panels at a much more convenient height for the majority of users.

• cognitive - this is concerned with mental processes such as perception, memory, reasoning, mental workload, decision making, and so forth, as related to the non-physical aspects of a job or specific task

An example is designing a new control centre, which requires considering the workload imposed on the operational personnel under normal, degraded, and emergency scenarios. Another example is designing an alarm system, which requires providing information in a format that the operational personnel can easily understand and act upon hence reducing the probability of error response to the alarm.

Figure 1 - A diagrammatic representation of the interplay between HF and engineering within the context of the system and organisation

• organisational - this is concerned with the organisation of sociotechnical systems including organisation structures, policies and processes, teamwork, and so forth
For example, when designing shift patterns, the physical and cognitive demands of the work, the number of hours, and when these hours are worked need to be considered to manage fatigue.

Across the asset life cycle, the organisational aspects of HF are the responsibility of the Operator and Maintainer rather than the asset owner.

Relevant transport legislation and work health and safety (WHS) legislation places requirements on designers, their contractors, and ultimately on the Operators and Maintainers of a system to consider human related safety issues. It is appropriate for designers to address this element of compliance to WHS legislation within the human factors integration (HFI) process. WHS legislation also places technical requirements on authorised engineering organisations (AEOs) to address within the design process. From a practical perspective, in the early stages of the system life cycle, all these activities aim at designing a system that is safe to operate and maintain.

During the construction, installation, and testing, and commissioning phases, WHS takes on a much more significant role as workers are exposed to hazards that are typically more significant. Application of the organisation’s safety management system (SMS) manages and controls these hazards. Many of these hazards are transient to construction activities, but some will remain through subsequent asset life cycle stages.

Management and control of the residual WHS risk during operations and maintenance lies within the responsibility of the Operator or Maintainer and the application of their SMS.

In addition to the impact on the workforce, WHS legislation explicitly includes consideration of system safety and of the safety impact of systems on ‘other persons’. Delivery of required levels of safety needs explicit consideration of HF aspects at both a workforce and a system level in design.

For example, the weight of a component that needs to be manually handled into place during maintenance would be a WHS issue related to maintainability. The potential to install that component incorrectly subsequently leading to a failure would be a system safety and an operability issue or both. At the design stage, consider and address both these aspects as part of the HFI process. In both cases, reduce the safety risk so far as is reasonably practicable (SFAIRP).

A significant contributor to system failures is ‘human error’. It is human to err and so, in design, consider this human limitation. HFI considers human dependability and reliability.

Compliance with the Disability Discrimination Act (DDA) and specifically the Disability Standards for Accessible Public Transport (DSAPT) and Disability (Access to Premises-Buildings) Standards (premises standards) legislation lies within the general remit of HF.
5.2. **What is human factors integration?**

The process that considers human factors (HF) within an integrated approach to the engineering design and development process (asset life cycle) is human factors integration (HFI). Various models of HFI exist, and it is an iterative and dynamic process integral to design and development.

ISO/TS 18152:2010(E) *Ergonomics of human-system interaction – Specification for the process assessment of human-system issues* gives the following definition of HFI:

> Systematic approach to the identification, tracking and resolution of human-system issues in order to ensure the balanced development of both the technological and human aspects of operational capability. Adapted from UK MoD Human Factors Integration – An Introductory Guide 2000.

The Asset Standards Authority (ASA) defines HFI in more detail as the following:

> 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.

A number of publically available models about how to undertake HFI exist. These range from complex, highly prescriptive processes through to more simplified generic processes. The topic Human factors integration process in the asset life cycle gives the reader information on the critical components of the process that would be expected to form part of an authorised engineering organisation's (AEO's) approach to HFI. The AEO should then define a process that is commensurate with the nature of their range and scope of services to Transport for NSW (TfNSW).

In other contexts, often involving software development, the process for incorporating HF may be referred to as human-centred design (ISO 9241:210:2010 *Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems*) or user centred design.

A definition for human-centred design (ISO 9241:210:2010) is:

> Approach to systems design and development that aims to make interactive systems more usable by focussing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques

**Note 1** The term "human-centred design" is used rather than "user-centred design" in order to emphasize that this part of ISO 9241 also addresses impacts on a number of stakeholders, not just those typically considered as users. However, in practice, these terms are often used synonymously.
Note 2: Usable systems can provide a number of benefits, including improved productivity, enhanced user well-being, avoidance of stress, increased accessibility and reduced risk of harm.

An AEO that can demonstrate that it has already implemented a human-centred design approach, throughout the design and development life cycle, is not required to change its documentation to reflect the terminology of HFI.

From a TfNSW context accounting for HF:

- does not mean simply asking end users what they want and then giving it to them. Nor is it a licence to ignore the experience of end users simply because it does not seem to reflect the designer’s thoughts. Rather, it is a process of appropriately defining a set of end user requirements, that when incorporated into the design will enable the system performance to match its expected level

- includes usability for both operational and maintenance aspects of a system

HFI is not a simple linear process. There will be many occasions, as is the case with the development of design solutions, where initial options will need revisiting and in some cases changing. In these circumstances the HF considerations need to be revaluated and fed into the design development and decision making process. Therefore, view the HFI process as being highly iterative and dynamic, and as an integral part of the design and development process.

5.3. Goals of human factors integration in the asset life cycle

Human factors integration (HFI), in the life cycle of an asset, aims to achieve rigor, a human focus, a multidisciplinary approach, and safety, among other goals.

The goals of the HFI process in the asset life cycle are to ensure the following:

- structured, rigorous consideration of human factors (HF) issues from the beginning of the asset life cycle (feasibility) and continuing throughout the life cycle to disposal

- systematic treatment of HF issues throughout projects and the asset life cycle

- the project has a human focus and uses iterative design

- HF principles, good practice, and appropriate techniques, tools, methods, and data are applied

- design reflects the concept of operation, meets end user needs, matches end user characteristics, and Operator and Maintainer organisational requirements

- design adopts a multi-disciplinary approach

- end users are involved in system design and evaluation
5.4. Why include human factors?

When human factors (HF) is adequately considered within the engineering design and development process, the overall operability and maintainability of the system will deliver benefits to our customers. This may be through enabling staff to work more effectively, efficiently, and safely, or through the direct provision of a design feature to the paying customer, or through all of these.

Specifically, considering human capabilities and limitations during the design process reduces the likelihood of human errors, violations of procedures, and injury.

The sound application of HF during the design process can reduce redesign work and the possibility of assets failing verification of end user or business requirements.

For Operators and Maintainers the sound application of HF to the design of assets can result in saving of time and money for operation and maintenance.

5.4.1. The thing about humans is…

Humans are flexible and adaptable, which means we can be trained and can work with poorly designed systems and work them reasonably successfully most of the time. Experience shows us, however, there will be times when a person will make an error due to poor design, and these errors usually occur when people are distracted, or under stress, or the system is there are problems with the system and it is not working as it should.

Errors due to poor design often require our human component to function at its most effective level to avoid further problems and incidents, and to mitigate and recover from an escalating situation.

On many occasions, skilled human intervention has saved a system that is operating outside of its design envelope. The most well publicised occurrences of this type are from the aviation industry where a pilot or crew has managed to save an aircraft following system failures. Examples include Aloha Airlines Flight (1988), Sioux City (1989), Hudson River Landing (2009), and Qantas Flight 32 (2010).

In the rail environment, applying fail-safe design provides a high degree of control against such system failures. However, the ability of people to recover from system failure remains an important factor, particularly in meeting operational requirements. Consideration should be made of human factors issues of operating under these degraded modes if the system is to continue to operate safely.
In other transport modes, it may not be possible to implement fail-safe design principles. In these modes, positive intervention from operations personnel is often relied upon to maintain system safety.

6. Human factors integration process in the asset life cycle

An authorised engineering organisation (AEO) needs to manage all human factors (HF) relevant to their scope of work. To achieve this, an AEO should have a process that identifies the need for human factors integration (HFI), the actual HF topics that are required to be considered, and the depth or scale to which they need to be addressed. To be efficient, effective, and leverage the greatest benefit, this process should start early in the asset life cycle.

The depth and scope of the HF activities required in delivering a new or altered asset depends on the level of novelty, number, and complexity of human interfaces, the use of unique or non-standard configuration, the associated level of safety risk, and the exposure of personnel, customers, or the public to the change.

The nature and context of the HF activities required depends on the adopted procurement strategy. Procurement of assets for Transport for NSW (TfNSW) can range from commercial off the shelf (COTS) through to fully tailored design. Altered assets can be a total redesign to a simple like-for-like replacement. Integrating HF into the asset life cycle should enable an appropriate level of HF for all of these strategies, to ensure that decisions consider the whole life cycle costs.

AEOs may wish to elaborate or enhance the details on some or all of these elements depending on the context in which they operate, to a large degree on the complexity of projects and services, and the risk of those projects. However, by implementing the process as described, an AEO should be able to meet HF management requirements as identified within T MU HF 00001 ST Human Factors Integration Standard - General Requirements and TS 10502 AEO Authorisation Requirements.

Readers with working knowledge of ISO 31000 Risk management -- Principles and guidelines, the structure of the HFI process that follows will be familiar (see Figure 2). The aspect of communication and consultation is of critical importance in the HF domain.
To fulfil the critical elements of HFI do the following:

- Establish the context of use
- Identify human factors issues
- Analyse human factors
- Assess human factors
- Adopt and test solutions

Applying the HFI process will likely give the following outputs:

- concept of operations
- HF (end user) requirements
- HF issue log or register (HF register)
- human factors integration plan (HFIP)
- HF analysis results, reports, briefing papers, and so forth

These outputs are described in more detail in the appropriate section of the HFI process.
Table 1 summarises how these outputs link to elements of the process.
Of critical importance is timely delivery of the outputs from the HFI process, and their inclusion within the project critical path analysis. Early identification of issues results in easier and cheaper fixes. From a cost-benefit analysis perspective, it is not acceptable to argue that the costs of changes are too high because the design has progressed in isolation of the HF input.

As with any structured process, the HFI process needs to be auditable and traceable, including decisions taken not to provide any further action or to pursue an alternative design option. A lack of proper documentation of these processes has led to many wasted hours of trying to justify design decisions to a new manager, client, stakeholder, or end user group.
Table 1 - Tabular form of the HFI process indicating the result of each stage, the material required, and what may change through it

<table>
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<tr>
<th>Process Stage</th>
<th>Aspects</th>
<th>Develop</th>
<th>May Iterate</th>
<th>Materials Required</th>
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<tr>
<td>Establish Context of Use</td>
<td>• What and how it's used&lt;br&gt; • Fit with existing ops&lt;br&gt; • All end users&lt;br&gt; • Human interactions</td>
<td>ConOps (may exist)</td>
<td>ConOps</td>
<td>ConOps</td>
</tr>
<tr>
<td>Identify HF Issues</td>
<td>• Identify&lt;br&gt; • Record&lt;br&gt; • Plan</td>
<td>ConOps&lt;br&gt; • User/Bus/System requirements</td>
<td>ConOps&lt;br&gt; • User/Bus/System/HF requirements</td>
<td></td>
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<tr>
<td>HF Analysis</td>
<td>• Detailed analysis of particular issues or groups of issues</td>
<td>HF register</td>
<td>HF register</td>
<td>ConOps&lt;br&gt; • User/Bus/System/HF requirements&lt;br&gt; • HF register&lt;br&gt; • HFIP</td>
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<tr>
<td>HF Assessment</td>
<td>• Working with other disciplines to incorporate HF analysis findings into design understanding&lt;br&gt;</td>
<td>HF reports or input into other report</td>
<td>HF register</td>
<td>ConOps&lt;br&gt; • User/Bus/System/HF requirements&lt;br&gt; • HF register&lt;br&gt; • HFIP</td>
</tr>
<tr>
<td>Solution Adoption and Testing</td>
<td>• Solution review&lt;br&gt; • Resolve issue and no new issues</td>
<td>HF reports on solution review</td>
<td>HF register</td>
<td>ConOps&lt;br&gt; • User/Bus/System/HF requirements&lt;br&gt; • HF register&lt;br&gt; • HFIP</td>
</tr>
</tbody>
</table>

The 'HF register' is the HF Issues register and may be a standalone register/log or incorporated into the project risk/issues register/log (see Section 6.2.1). The HFIP may be a standalone plan or incorporated in the project/engineering plans (see Section 6.2.2).
6.1. **Establish the context of use**

The first stage of human factors integration (HFI) is to understand the context of the system. From a human factors (HF) perspective, this includes describing the following:

- what the system will be used for, how it will be used and any current applicable practice
- how the new or replacement system or subsystem fits into the existing operation (for brownfield projects)
- who the end users of the system are, including all end user groups, not just front line operational personnel or customers
- what the human interactions with the system are, and what tasks are required to be performed successfully for the system to meet operability and maintainability requirements

If available, a critical source of information would be the concept of operations (ConOps) document and the initial end user, business, and system requirements. If no ConOps exists, then the information gathered above can be used as the basis for developing one and agreeing it with the operator.

Good practice in other industries is to use the ConOps document as one of the tools for verifying the final design.

The end user, business, and system requirements form a substantive basis for the identification of the HF issues and human interactions that need addressing. In some cases, the requirement may almost directly translate into a specific HF requirement, while in other cases a number of more detailed HF requirements may need development. These are often called derived requirements. These should be added to the requirements tracking process. Some projects also develop specific user description documents. These are used to assist the development and identification of the different end users, their requirements, and the system requirements derived from these.

End users are those people who will interact with the delivered asset. They can be the primary end users who use it every day, such as the drivers and customers on public transport. Secondary end users are those people who interact with the asset as their primary task, but who are not primary end users. Examples of secondary end users for a transport vehicle include cleaners, trainers, and maintainers. Then there are tertiary end users, those who interact with the asset but more at a distance, such as platform staff with a train, controllers in a public transport operations control room, and managers who require information about asset performance. Each of these end users will have an interest in the asset and its design, as it will have a direct affect on their work. Therefore, identify all these end users and determine their requirements. When designing for end users, address the requirements of the *Disability Discrimination Act* (DDA) legislation appropriately.
It can be helpful for complex projects to divide the project into parts, and identify the end users of each part and the nature of their interaction for that part. The level and nature of interaction often varies between parts. For example, in the context of a railway, a train driver is a primary end user for a train but may only be a tertiary user of a depot.

At this stage, determining measures for successful performance can help. For example, this may involve stating how many people are required and target times for changing out a faulty component.

6.2. Identify human factors issues

An authorised engineering organisation (AEO) should have a process that enables it to identify the nature, scope, and scale of the human factors (HF) topics, considerations, and issues that it should address for providing a particular project or service.

Specifically, an AEO should identify the effect of human error on the performance of a system as an issue that needs addressing. Traditionally, all areas of HF investigation on a project are called issues, implying both positive and negative aspects. These can include consideration of human interaction, specific topics (for example, how people will interpret a display), topics for investigation (for example, error detection), as well as areas of concern (for example, the aisle width is narrow, how does this impact passenger flow rates and will this provide adequate emergency egress?). From this point, this document will refer to them collectively as 'issues'.

Lessons learnt from past projects and end users of similar existing systems can be useful initial sources for identifying issues.

In those cases where the project is of a complex or novel nature, to minimise risk to the AEO, it is most likely that the identification of HF issues is best suited to a HF subject matter expert (SME). A HF SME may be an in-house or a contracted resource. An AEO needs to be able to demonstrate that the competence of the HF SME is appropriate to the project or service offered.

For simple projects, using past experience through providing a HF checklist or some other form of prompt used by the project manager or by project engineers is likely to suffice.

As the project develops, and the AEO identifies the details of a design solution or alternative solutions, additional issues, including HF issues, may appear. Therefore, expect the identifying of issues to be an iterative process.

6.2.1. Record human factors issues

Recording human factors (HF) issues is useful for managing the issues, and is usually done in a stand-alone document or integrated into an existing project document.

Record all identified HF issues. Recording is usually through the development of a HF issues register. This may be a stand-alone document, or the relevant information integrated into the project risk register, issues register, or hazard log. If an AEO takes the latter approach, then it is
advisable to identify any HF issues with a flag for easy identification and reporting. This register or log is useful for recording management of issues through the project to closure.

6.2.2. Manage human factors issues

After identifying human factors (HF) issues, manage them. Managing HF issues involves the project plan, or human factors integration plan (HFIP), working on critical paths, and interactions with design processes.

For the issues identified, authorised engineering organisations (AEOs) should develop a set and scope of HF activities. These can demonstrate adequate consideration of HF within the project or service, and integration of HF within the overall project plan. HF activities may be contributors to the system safety assurance plan.

In the case of projects that are more complex, demonstration that HF activities are adequately considered may be in the form of a human factors integration plan (HFIP), one of the series of plans developed by the project and referenced from the overall project plan. In these cases, typically the project director is ultimately accountable for the implementation of the HFIP.

For simpler projects, the activities may be included within the overall project plan. In these cases, typically the project manager is accountable for the conduct of the HF activities identified, and their integration into the design process.

In either case, it is important to identify critical paths and interactions between HF activities and design processes so that HF input can be gathered and used in a timely manner within the engineering decision making process.

For example, it is common practice in rolling stock projects to include a mock up process as part of the development process, and as a way of gaining end user feedback on the emerging design. If a mock-up is to be a useful design review tool, it is essential that information gathered during mock-up review can be used to influence the design; otherwise, the mock-up can become simply a representation of the production design when there remains little opportunity for change.

6.3. Analyse human factors

Analysis of human factors (HF) should be appropriate to the stage of the project life cycle, use relevant sources of data, and use established tools and techniques.

The authorised engineering organisation (AEO) should conduct HF analyses on those issues and human interactions identified, and to the level of detail that is appropriate to the following:

- nature, complexity, reliance on human performance, and risk of the project
- stage of the project life cycle
In the early stages of the life cycle, information regarding the proposed design will be limited and high-level, and the HF analyses need to reflect this, focusing on key decisions and issues. As the design progresses, information that is more detailed becomes available, and therefore the AEO can carry out analyses that are more detailed.

For example, the layout of a crew cab is about human-system interactions. Therefore, it should be highly influenced by HF principles. In the early stages, focus may be on the primary controls, displays, and interactions, but as the design develops, the understanding of the more detailed interaction requirements is revealed. HF analyses should support the cab design process. A good time to start HF analyses during development of the preliminary concept.

In conducting HF analyses, an AEO should do the following:

- identify the relevant sources of HF data (human reliability data, population stereotypes, anthropometric data, and so forth) that are applicable to the specific issue being addressed
- use established HF tools and techniques where available

Within engineering analyses, there should be a HF component. For example, a HF subject matter expert (SME) may attend workshops, or a set of HF guidewords may be used, or both.

The topic Example: human reliability analysis discusses an example area for analysis. This area is chosen because human reliability is a key factor in many system failures. The topic Common human factors analyses terms gives a list of common terms for describing different HF analyses.

6.3.1. Example: human reliability analysis

An example of human reliability analysis as an area for human factors (HF) analyses gives an understanding of how to work through the HF analysis process.

An understanding of how the human interactions with a system can fail is critical to producing a design that is error tolerant, and that can be operated and maintained safely. The level of analysis required will be appropriate to the complexity, risk, reliance on human performance, and scale of the project. A good indicator of the level of effort required is to review the system safety assurance plan for the project. Each of the major activities within this plan (for example: risk assessment, reliability, availability, maintainability and safety (RAMS) analysis; failure mode and effect analysis (FMEA); fault tree analysis (FTA); and so forth) should have an HF component.

For smaller and less complex projects, a well conducted hazard and operability study (HAZOP) will probably be sufficient. Authorised engineering organisations (AEOs) are encouraged to develop HF guidewords to be included as prompts when performing hazard analysis studies such as HAZOPs. Examples of such words include ‘more than’, ‘less than’, ‘misread’, and ‘wrong order’.
In cases of more complexity, the output of the HAZOP may lead to the requirement to conduct a more detailed analysis to provide a full understanding on the scale and nature of the issue, and to identify suitable control measures. In these cases, as with other engineering disciplines, it is likely that a HF subject matter expert (SME) will be required to conduct the analysis.

In a small number of cases, it may be necessary to perform a quantified human reliability analysis (HRA). As the result of a quantified HRA can have significant impacts on the calculated availability or reliability of a system, it is likely that a HF SME will be required to conduct this type of analysis.

In conjunction with the guidance above, AEOs may use the Australian standard AS IEC 62508 Guidance on human aspects of dependability to determine the specific activities required at the various stages of the project life cycle.

6.4. **Assess human factors**

Human factors (HF) assessment interprets the results of the HF analyses in terms of the potential effect on system performance. Authorised engineering organisations (AEOs) should consider the level of this effect holistically within the design process, and a decision made as to whether solutions or controls to any issues need incorporating within the design. Typically, this decision-making process best occurs during multi-disciplinary design review discussions on considerations of all relevant aspects of the design.

Where changes are required or controls identified, if possible, AEOs should identify and assess many options. Options should be subject to so far as is reasonably practicable (SFAIRP), cost-benefit analysis or other analyses as for other proposed design changes. Often it is more difficult to quantify the effect from an HF perspective than for other disciplines. However, it is usually possible for the AEO to provide some level of analysis to aid the decision-making process.

6.5. **Adopt and test solutions**

A solution to a human factors (HF) issue needs to follow the correct process for adoption and testing.

After identifying a prospective design solution, it is valuable to test it to ensure the following:

- the proposed solution actually addresses and solves the issue
- it does not introduce any new issues

As the design process is iterative, the adoption and testing of HF controls and solutions need to be iterative too.

An authorised engineering organisation (AEO) may achieve early testing of proposed design solutions in a number of ways. In its least costly form, an AEO can test through scenario-based
discussions with end user groups using the proposed design information. For example, it is now common practice to use 3D computer-aided design (CAD) models as part of this process. However, depending on the complexity of the project and even with the use of 3D modelling, it can be difficult for end users to understand the design concepts, and in these cases, the use of mock-ups can provide significant benefit.

The term mock-up relates to all forms of mock-up, and is not limited to the high cost high fidelity mock-ups commonly specified as a project deliverable within rolling stock procurement or alteration.

AEOs need to conduct final testing of HF requirements to provide evidence for the validation and verification process. Specific HF tests should be part of the overall testing and commissioning activities conducted by the project.

6.6. **Communicate and consult**

Throughout the human factors integration (HFI) process, communication and consultation is critical to the success of the project. An authorised engineering organisation (AEO) should identify mechanisms for all forms of communication, including the internal communications within the design team, and the external communications with Transport for NSW (TfNSW), stakeholders, and end users.

The AEO’s design process should already have internal communication mechanisms, including design review meetings, quality reviews, risk assessment activities, and so forth. All of these should consider human requirements. In the majority of cases, the human factors (HF) subject matter expert (or other person responsible) should be involved in these processes, and output from HF activities should form input into these activities.

An AEO should also identify the means to conduct communications with the stakeholders and end users. Stakeholders need time to organise appropriate representation. Access to operational and maintenance personnel and management in particular, needs planning so that the Operator and Maintainer are able to make the necessary arrangements for release of personnel for workshops, review, testing, and so forth.

The NSW Work Health and Safety Act has mandatory consultation requirements that need to be conducted, and there may be additional formal mechanisms of consultation within industrial agreements between the employer and employees that need to be addressed.

The description of communication and consultation arrangements may form part of the human factors integration plan (HFIP).

Apart from specific communications, many projects have found it beneficial to increase the awareness of human factors, its goals and benefits generally across the project, and to communicate the HFI process and plan.
6.7. **Monitor and review**

Monitoring and review should form a part of any design and development process, and in this context, an authorised engineering organisation (AEO) should incorporate human factors integration (HFI) monitoring and review into its existing process for validation and verification of its product.

In line with good practice and depending on the complexity and scope of the project, an AEO should include a number of mechanisms for the review of the effectiveness of its HFI process, and the results of human factors (HF) activities within the early stages of a project. This is particularly useful for projects that involve a high degree of novelty, complexity, or reliance on human performance.

AEOs should record lessons learnt from the actual operability and maintainability of the design to allow the lessons to feed into other projects.

6.8. **Special considerations**

New and altered asset projects require special considerations because their effect on the scale and scope of the human factors integration process may not be obvious.

Consider the following issues:

- 'Like-for-like' replacement
- Commercial off the shelf procurement
- Safe design in new and altered structures projects
- Transition of systems and equipment from old to new

6.8.1. **'Like-for-like' replacement**

In the case of like-for-like replacements, human factors (HF) analysis is less important, particularly for smaller and less complex projects. However, do not dismiss the need for HF to be analysed, as even in these projects there may be lessons learned from the operational or maintenance context that could further improve performance. Additionally, replacing the single components on a like-for-like basis may introduce changes at a system level. Therefore, authorised engineering organisations (AEOs) are encouraged to seek some end user input in such projects.

6.8.2. **Commercial off the shelf procurement**

Procuring commercial off the shelf (COTS) equipment can have a number of commercial benefits throughout the asset life cycle. However, these systems may require changes in training, and operational and maintenance procedures and practices. Additionally, implementing
such systems may lead to negative transfer of behaviours from the old to the new system or vice versa. In many cases, transfer of behaviours from new to old systems may be more of a concern, as older systems often do not have the same level of engineered safety functions as new ones. Therefore, the application of human factors integration (HFI) within this process is essential to informing decisions based on the following:

- the true life cycle cost of the equipment
- an understanding of the potential human factors (HF) risks and identification of proposed controls, particularly during extended periods of implementation where both old and new systems are operational at the same time (see Transition of systems and equipment from old to new)
- the changes that may be required to the operating and maintenance regimes to use the equipment as designed and procured.

### 6.8.3. Safe design in new and altered structures projects

New and altered structures projects need to comply with legislation and standards regarding operability and maintainability. The human factors integration (HFI) process can help with this.

Organisations that design structures currently incorporate a safe design or safety in design procedure within their overall approach to engineering design and management. This is a requirement of Section 22 of the NSW Work Health and Safety (WHS) Act. For organisations primarily involved in the design and delivery of static infrastructure such as buildings, track, signal infrastructure, overhead infrastructure, bridges, and so forth, it is likely that the application of the safe design process will be sufficient to meet the requirements of T MU HF 00001 ST Human Factors Integration – General Requirements, as long as there is sufficient focus on effective and efficient operability and maintainability as well as safety.

A key element to providing evidence that there is sufficient focus on operability and maintainability is user (client) involvement in the design review process from an early stage.

For example, an organisation may be providing an asset that includes a number of plant rooms. The preliminary design approach for lighting of these rooms may be to provide the minimum level of lighting required at a fixed ceiling pattern around the room. Evidence of the appropriate consideration of human factors (HF) in this case requires that the organisation has assured itself that this approach is appropriate through understanding the nature of the equipment to be installed, and that the required operational and maintenance tasks can be carried out within the lighting provision made in the design. Another example would be that the proposed work in an office space has influenced the layout and equipment chosen.

Organisations that are involved in the delivery of more dynamic systems such as passenger rolling stock, track vehicles, railway control and communications systems, and so forth, are
more likely to need to incorporate a specific HFI process within their engineering design and management system to address properly the HF requirements of the projects that they deliver.

6.8.4. **Transition of systems and equipment from old to new**

Negative transfer, part of the human factors (HF) domain, increases risk for the transport operator when changing from old systems and equipment to new...

Given the scale and scope of the transport industry, the transition to new systems or equipment is often conducted over a prolonged period of time, when it is necessary for simultaneous operation of old and new equipment to occur. For the operator, this period can represent a period of heightened risk, and one source of this risk lies within the HF domain.

Negative transfer occurs when an end user who is familiar with a procedure or piece of equipment automatically transfers that behaviour to an alternate system or equipment when it is not appropriate. In the early stages of implementation, this is likely to occur from old to new but in latter stages with experience of the new system and less exposure to the old system, it can occur from new to old. This can often result in tasks being omitted, operating the wrong controls, and operating the correct controls in the wrong direction. A common example is driving an unfamiliar car that has the turn indicators on the opposite side to what the driver is used to.

As a general principal, avoid the potential for negative transfer. However, this is not always practical because of the changing environment in which the industry operates.

In most cases, errors resulting from negative transfer can be recovered without any real consequences. However, it is essential to identify the potential for negative transfer. In those cases where errors could be significant, it may be appropriate to change the design, or alternatively put additional controls in place until full implementation of the new system.

To identify the potential for negative transfer it is of course necessary to understand the current system in terms of how it operates, who the current end users are, their experiences and current practices.

7. **Common human factors topics**

Certain topics are common in human factors (HF) across all projects.

An organisation or practitioner is encouraged to seek guidance of a more detailed nature on these topics as applicable to the nature and complexity of the project.

T MU HF 00001 ST *Human Factors Integration – General Requirements* includes some generic HF requirements for application to all projects as appropriate.

The list of topics below is not comprehensive and the order of presentation is not indicative of their importance or relevance to any specific situation.
Common HF topics include the following:

- Error and violation
- Using anthropometric data
- Users with disabilities
- Level of automation
- System design
- Workstation design
- Human-computer and human–machine interface
- Alarms and alerts
- Workload and job design
- Training
- Operating and maintenance manuals

### 7.1. Error and violation

Human factors (HF) considers error because humans make errors. Any system design should consider this. Design systems to do the following:

- take human capabilities and limitations into account so the systems are error resistant. A simple example is that they should not require people to make fine distinctions in the colour of a display to identify changes in state of the system.

- prevent predictable small errors from having catastrophic consequences, or at least allow people to detect the error and correct it. For example, when a user requests a file to be deleted, software typically asks whether they really want to delete the file, and even after the user agrees to the deletion the software stores the deleted file for a period so that the file can be retrieved if the user later realises they have made an error.

- not encourage people to take short cuts in procedures (these are called violations), especially short cuts that could be unsafe. Humans tend to take short cuts to reduce the perceived effort they need to expend. Therefore, to discourage violations, designs should make the easy way to do something the correct way to do it.

Therefore, review designs to consider how people could make errors and whether the design will encourage them to violate procedures.
7.2. Using anthropometric data

Humans are variable, and 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.

All projects should determine the appropriate anthropometric range to use for the end users. There could be different ranges for different groups, for example, operational and maintenance personnel, customers, and the public. Some considerations include the appropriate percentiles and age ranges, for example including children or only working adults.

By using anthropometric data, designers are able to design systems that cater for the physical variability of humans. For example, by knowing the smallest reach, a designer can ensure all those in the anthropometric range can reach a control. Another example is that by using the weakest twist strength all those within the range can use a handle.

The use of anthropometric data should consider the context of the task. Examples include the following:

- the frequency of use and the task may influence the acceptability of a design solution. Importantly, a frequently used doorway has to cater well for all those within the design range. However, if the use of the doorway is infrequent then access may only need to be adequate if there are other constraining factors.

- anthropometric data typically are static single numbers and applied as if a person does not move. However, there are times where it is appropriate to consider how a person would move when applying the data. For example, for an infrequent reach to a control it may be reasonable for a person to bend to extend their reach.

When applying anthropometric data, consider clothing, shoes, personal protective equipment (PPE) and movement, and other corrections. For example, clearance heights in a depot may need to consider the height of tall males wearing work boots and a safety helmet.

7.3. Users with disabilities

Integrating accessibility considerations into the human factors integration (HFI) process can benefit the designs.

The Disability Discrimination Act (DDA) legislation requires considering people with disabilities in design. For customers using public transport there is a requirement to meet Disability Standards for Accessible Public Transport (DSAPT).

This specialised area is often considered separately. However, there is value in integrating this area into the structured HFI process. For many projects there may be a human factors (HF) subject matter expert (SME) and accessibility SME but they should work together to ensure the
design works well for people with a range of abilities. In many cases, design for the less able actually makes the design perform better for others as well.

7.4. Level of automation

Design of automated systems benefits from considering human factors (HF).

Decisions around which functions to automate and which require human intervention should be made at the early stage, and should be reflected in the operational concept and end user requirements documentation. This is often referred to as the process of function allocation.

As systems become more automated, there may be a tendency to dismiss the importance of HF. This approach has been proved inconsistent with the goal of improved system performance in other industries such as aviation.

Even in highly automated systems, human interactions are critical in degraded, emergency, and recovery situations. For example, automatic train operations (ATO) rolling stock requires a person to recover an unresponsive train, or for movements around the depot.

7.5. System design

System design includes the design of plant and equipment deployed within a system. Design systems such that:

- account is taken of the end users limitations, capabilities, and physical characteristics
- all safety hazards to the end user that cannot be eliminated are demonstrated to be minimised so far as is reasonably practicable (SFAIRP)
- in operation it complies with work, health, and safety (WHS) legislation under normal, degraded, and emergency scenarios
- impossible to fit equipment or component parts incorrectly during maintenance
- easy to recognise the status of the system and it is difficult to leave a system unintentionally ‘off-line’ after maintenance
- if a component of a system must be configured for a specific application, the configuration status is easily determined

7.6. Workstation design

Workstation design benefits from considering human factors (HF) principles.

Workstations should be designed taking account of the following principles:

- controls used in a set sequence should be laid out in that sequence
• important and frequently used controls are to be within reach from the normal operating position. Given the complexity of modern systems, some compromises may be required, and where this is the case, these should be justified according to the principles above.

• critical displays and information are to be clearly visible from the normal operating position or positions

• function grouping of equipment and displays

• existing stereotypes should be maintained with respect to existing control operations and population stereotypes where possible

• where humans are expected to reach controls (whether used frequently or not) there should be a safe method provided to use them. For example, heating, ventilation, and air conditioning (HVAC) vents are often placed in the ceiling and are not within reach of most people, yet most are intended to be adjusted easily.

• potential for negative transfer from existing equipment to new and vice versa as transitional arrangements progress should be assessed, and if required transitional controls be put in place

• potential for negative transfer where a new system is going to be used along side an existing system should be assessed and avoided where possible. For example, train crew using several fleets within a shift.

7.7. Human-computer and human–machine interface

Design the human computer interface (HCI) such that information presented to the end user is relevant to the role or tasks that they carry out. In line with increased levels of sophistication and technology, there is a tendency to present more and more information to the user. This is not always of benefit and can add additional costs to the overall life cycle.

Specifically, the HCI should do the following:

• present information that is relevant and appropriate to the user and the tasks that they are conducting

• provide information in a format that is readily assimilated by the user and in terms they understand

• present information in such a way that it supports the task requirements without the need for the user to convert it to another format

• comply with population stereotype in terms of structures of displays and menu hierarchies, and so forth

• make appropriate use of colour and font as a distinguishing feature of critical information
For software systems development and assessing the presentation of system information, it is a relatively simple task to provide ‘screen’ demonstration of how a system will look to test the interface. Use these demonstrations early, iteratively and with end users and other stakeholders.

In many situations, the human interface is not via a computer screen (or not only via a computer screen) but directly with the machine, human machine interface (HMI). Apply the general principles above appropriately to these situations. For example, dials should be able to be seen and read from the location being viewed (placement, letter size, colour usage); the strength to operate controls should take into account human capacities, and so forth.

7.8. Alarms and alerts

Design of alarms and alerts needs consideration of criticality, levels of alarms, and role of the end user.

Alarms and alerts can be delivered via a computer or computers or from a number of different sources. Regardless of delivery method, all the alarms and alerts should be considered as part of an alarm and alert system. When part of the computer system they can be considered a specific subset of the human-computer interface (HCI), but which warrant special attention. A generally accepted concept is that an alarm is a condition that requires the person to act, whereas an alert can be provided for the presentation of information such as a degradation of performance that may affect how the task is performed. Design the system for the following considerations:

- critical alarms should be clearly distinguishable by the end user and should generally be notified in both audible and visual form
- alarms should be classified according to their importance and it is common practice to use no more than three levels of alarms
- where a series of alarms related to the same event is triggered on more than one system, the user should be able to acknowledge all the alarms from one place

In computer systems that are used by a number of different roles and allow for separate role sign in, the alarms and alerts should be designed to be only delivered to the relevant role and in a form most appropriate for that role. For example, for a train operating system that allows drivers, guards, and maintainers to sign in as different roles, then the alarms and alerts for drivers are likely to be different to those for guards and maintainers.

7.9. Workload and job design

The overall job design for a role lies within the remit of an Operator, but the authorised engineering organisation (AEO) will often be altering or replacing equipment into an existing role, or may be delivering the related equipment for the whole role (crew cab). In either case,
the AEO should ensure that an appropriate consideration of workload is made to ensure that the user of users can safely operate the resultant design.

For example, it could be the case that the introduction of a small task due to a new piece of fitted equipment takes the overall workload to an undesirable level.

### 7.10. Training

Most organisations would automatically recognise training as a requirement accompanying the provision of new or altered systems or assets. In many cases, however, the implication of design decisions on training is not considered within the design process, and therefore in these cases training simply becomes an output of the final design.

The design of the equipment has a fundamental effect on the level of training required, and in order for the overall system to achieve its goals, it is essential that there is clear understanding of the consequences of design decisions on the level of training required to use a system.

Situations that typically require increased training include the following:

- providing a ‘different’ layout or arrangements other than the existing one
- providing new equipment, functionality, or both to the users
- enhancing or altering the use of technology
- introducing new tasks or practices
- having potential for negative transfer between systems

Identify and use the implications on the project life cycle costs of these increases to make informed decisions with stakeholders.

Training requirements should be determined using a structured approach such as training needs analysis, and this should take into account existing training provision where appropriate.

### 7.11. Operating and maintenance manuals

Starting work on manuals early, making them task-orientated, and in a suitable format gives benefits to the Operator and Maintainer.

Manuals are part of the documentation suite delivered with a project. As is the case with most documentation, this element tends to be left until late in the process. In some ways, this is understandable in terms of the cost effectiveness gained from working from a finalised design. However, this approach often leads to difficulties in training and preparation for operational readiness. A further benefit of starting manuals early is the identification of hidden operational and maintenance difficulties before it is has an impact on project delivery.
Manuals often reflect the technical capabilities of the system and describe the system features and how to use them. However, they are often not organised around tasks, requiring the user to flick back and forth between different sections to get the information they require.

Take a systems approach to the design of manuals and information provision so information is provided in an appropriate format and level of detail for the nature of the task being carried out.

Design manuals with the following considerations:

- the intended purpose and use of the manual is clear. Training manual, reference on shelf, used while carry out task, in office, in the field, and so forth
- the information reflects the needs of the user and is presented in a consistent format
- it provides information in a sequence that enables tasks to be carried out, and avoids the necessity for constant references between different sections
- developed to a standard format and subject to document control processes

Manuals do not have to comprise of thick books of many pages they may take the form of aide-memoires, diagrams, apps, web-based instructions, and so forth

Depending on the specification of the contract, the Operator or Maintainer may need to adjust its operating procedures or processes in line with the new equipment or system. This task requires early consultation with these organisations to ensure that they are able to demonstrate their operational readiness to use the system.

8. Common human factors analyses terms

To carry out human factors (HF) work, there are a large number of possible analyses, methods, tools, and techniques. The most appropriate analyses to use to answer a particular question will depend on many factors; a few of which include whether the project is for a new or altered asset, the context, time, required depth, and phase of the project. A HF analysis may involve the use of one or more different tools to understand a particular issue. Below is a list of terms commonly used to describe different HF analyses performed to support design:

- requirements analysis
- review of existing system and lessons learnt
- task analysis
- allocation of function
- workload (physical and cognitive or mental) assessment
- human error identification
- human error quantification
• cognitive workload or performance assessment
• team design and performance analysis
• layout, workspace, and workstation assessment
• job and task design analysis
• training needs analysis
• user interface (human-computer interface (HCI) and human-machine interface (HMI)) analysis
• human reliability analysis (HRA) (also see Example: human reliability analysis Section 6.3.1)
• commercial off the shelf (COTS) solution analysis
• situational awareness analysis
• scenario, mock-up, and prototype analysis
• safe design or safety in design (including operability and maintainability) analysis
• engineering analyses (human-related components)

For virtually all HF work there is a need to collect data. Data can be collected in a number of ways including the following:
• workshops (for example, brainstorming, risk, lessons learnt, scenarios, walk-through, design review with users or stakeholder)
• observations
• checklists
• questionnaires
• user working groups
• focus groups
• interviews
• literature

Many references are available that provide assistance in:
• choosing appropriate techniques, tools and methods
• comparing their relative strengths and weakness
• obtaining specific details on how to carry out specific techniques, tools, and methods