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Data entry – draft starts next page

Standard number	AS 7470
Version year	2024
Standard name	Human Factors Integration in Rail Engineering Projects
Standing Committee	Operations
Development group member organisations	Acmena Group, Alstom Transport India, Arcadis, ARCH Services, Aries, Aurizon, BRANDT HFSE, Distilled Consulting, Ferrovia, GES Consulting, HF Integration Pty Ltd, Jacobs, Metro Trains Melbourne, Mott MacDonald, ONRSR, PTA, Queensland Rail, Ricardo, Sydney Metro, TasRail, Transport for NSW, Vic Dept Transport & Plan, Vline
Review type	
First published	AS 7470:2016
Revised	AS 7470:2024
ISBN	ISBN 978-1-76035-631-6
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Development draft history

Draft version	Draft date	Notes
V0.12	30/11/2023	1st Draft conversion to new template
	07/02/2024	2nd Draft DG Meeting 3
	21/02/2024	3rd Draft DG Meeting 4
	06/03/2024	4th Draft DG Meeting 5
	20/03/2024	5th Draft DG Meeting 6
	22/03/2024	6th Draft DG Meeting 6
	30/05/2024	7th Draft Including GL material
	19/06/2024	8th Draft GL Material DG Review
	05/07/2024	9TH Draft Including DG review Guideline material
	17/07/2024	10th Draft DG Meeting 10
	01/08/2024	10th RSTKIH Revision
	07/08/2024	10th RSTKIHGK Revision 11
	22/08/2024	11th Draft DG Meeting 12
	28/08/2024	12th Draft DG Meeting 13

Preface

This Standard was reviewed and prepared by the AS 7470 Human Factors Integration in Engineering Design – General Requirements Development Group, overseen by the RISSB Safety and Operations Standing Committee.

Objective

This Standard has been prepared to support Human Factors Integration (HFI) into the system lifecycle within the Australian Rail Industry. The information presented in this Standard is consistent with the Rail Safety National Law (RSNL) in providing assistance for RTOs to meet their requirements under RSNL Regulations 2012, Schedule 1, Section 17. Specifically, RTOs are required to have procedures to ensure that human factor matters are taken into account during the development, operation and maintenance of the safety management system and for the integration of Human Factors principles and knowledge into all relevant aspects of operational and business systems. This Standard describes the requirements for organisations conducting or procuring engineering design activities, services, or products to; Incorporating HFI into the engineering design process also facilitates a high level of system acceptance amongst end users.

The aim of the HFI process is to identify then mitigate and prevent Human Factors related risk and ensure that human-system interactions are optimized for system performance, safety, and fitness for purpose.

The aim of the requirements specified in this document is to optimize overall system performance through the systematic consideration of human capabilities and limitations as inputs to an iterative design process.

For an operational system to deliver the expected benefits, it is essential that the human interactions with or within the system and system elements are well designed through the application of established HF principles, knowledge, and methods. The process for achieving this is HFI.

A supplier of engineered assets to the Australian rail industry is responsible for ensuring that the assets and systems they provide are safe to operate and maintain, and that all safety risks have either been eliminated or managed so far as is reasonably practicable (SFAIRP). Supporting evidence, demonstrating HFI in safety risk management activities, will provide an important contribution to an overall safety and operational assurance argument for most assets.

The benefits of considering HF in the design process are not limited to safety. Equally valuable benefits can be gained regarding the operation and maintenance of the system. These include but are not limited to; improving effectiveness, improved user comfort, and increased system acceptance, and minimising errors. To achieve these benefits, it is important to take HF into account early, starting with feasibility, solution optioneering, conceptualising, and throughout the full design process. In addition, information can be found in the supporting RISSB Guidelines for the Integration of Human Factors Across the Project Lifecycle and the Integration of Human Factors in Engineering Design.

Compliance

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

(a) Requirements.Recommendations.Permissions.Constraints.

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

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

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

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

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

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

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

Appendices in RISSB Standards may be designated either "normative" or "informative." A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Section 1 Scope and general

1.1 Scope

This Standard provides the requirements for Human Factors Integration (HFI) within the following activities:

(a) Design or procurement of new or altered systems and assets to the rail industry. This includes any design changes to an asset throughout its lifecycle.

(b) Assurance of the suitability of Commercial Off the Shelf (COTS) and like-for-like (see Section 2.2 *Process requirements*) replacement of systems or assets within the rail industry.

(c) Application of WHS Safe Design requirements.

(d) Construction staging including temporary works over or alongside an operational environment.

Procurement of new or altered assets can involve design and manufacture, use of existing products or replacing like-for-like items. The requirements in this Standard are focused around enabling effective Human Factors integration in the system-engineering life cycle. However, the HFI is scalable to enable support to other procurement strategies.

This Standard includes the requirement for Human Factors Integration (HFI) primarily for the following stages of the asset life cycle:

(a) Nomination and Feasibility

(b) Development and Planning

(c) Preliminary Design

(d) Detail Design

(e) Construction

(f) Testing and Commissioning

(g) Transition into Service

Many of the concepts and principles described should also be applied to the following stages of the life cycle:

(h) Fabrication, manufacturing, and construction

(i) Installation

(j) Integration, test, and commissioning

(k) Asset operations and maintenance

(l) Decommission and disposal

RISSB intends this Standard to be applied by Human Factors specialists and is provided for use and understanding by systems engineering and safety assurance practitioners, design professionals including engineers and project and change managers within a Rail Transport Operator (RTO) or within an organisation that is contracted, including downstream contractors, to provide engineering services and/or assets to an RTO.

While the aim of this Standard applies to the design life cycle, the HFI principles, when applied, will later support the organisation of the day-to-day operations or maintenance of assets following hand over to the operating and maintenance organisation.

It should be noted that different terms may be used other than those referred to in this Standard within different organization when referring to some of these activities.

1.2 Out of scope

There are benefits for organisations to conduct an HFI process and apply HF knowledge in their day-to-day business. However, this Standard is not intended for (although they are not prevented from using it): miniature railways and amusement railways; and sugar cane, tourist, and heritage operations.

1.3 Normative references

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

- *Disability Standards for Accessible Public Transport*
- *Disability Discrimination Act*
- *GL Integration of Human Factors Across Project Lifecycle V1.0*
- *GL Integration of Human Factors in Engineering Design V1.0*
- iMOVE 6-002, *Australian Size Variation for Design - M004: Detailed anthropometry dataset - V2.0 30/06/2023*
- *Rail Safety National Law*
- *Rail Safety National Law National Regulations*
- *WHS Act 2011, Section 22*

NOTE:

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

1.4 Defined terms and abbreviations

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

1.4.1
anthropometric
is a reference to the data used in anthropometry

1.4.2
anthropometry
is the science of measuring the variability of human physical characteristics. These include size, shape, weight, strength, range of motion

1.4.3
asset
any good, product, equipment, facility, or other tangible resource (excluding people) which comprises part of a rail system and which is under the control of a rail transport operator

1.4.4
augmented reality (AR)
interactive experience of a real-world environment whereby the objects that reside in the real world are augmented by computer-generated perceptual information

1.4.5
culturally and linguistically diverse (CALD)
individuals who have cultural backgrounds different from the majority or ‘Anglo-Celtic’ Australian culture. This includes individuals and communities who communicate in languages other than English, either exclusively or alongside English

1.4.6
cognitive ergonomics
a domain of ergonomics concerned with mental processes such as perception, memory, reasoning and motor response, as they affect interactions among humans and other elements of a system

1.4.7
commercial off the shelf (COTS)
prepackaged systems or products that remain "as is" or require aftermarket modification. COTS hardware or software are standard products that are not designed or made to order and are sourced from existing commercial stock

1.4.8
DDA
Disability Discrimination Act

1.4.9
DSAPT
Disability Standards for Accessible Public Transport

1.4.10
EHFA
Early Human Factors Analysis

1.4.11
end user
individuals interacting with or affected by an asset during its operation, including crew, staff, maintenance personnel, customers, and the public, classified based on their level of interaction or impact

1.4.12
end user benefit realization
confirmation of ensuring that benefits are derived from outputs and outcomes

1.4.13
end user identification
identification of the relevant end-users who will be impacted by the engineering, design or change during the project

1.4.14
ergonomics
human factors that involve understanding people's physical and mental strengths and limits in a work environment to improve comfort and efficiency. Also, Human Factors

1.4.15
error resistance
ability of a system to minimize the probability of error occurring

1.4.16
error tolerance
ability of a system, through its design, to minimize the consequence of the human error and to support error recovery and/or to continue in safe operation

1.4.17
human centred design
a problem-solving approach that focusses the design processes from the human perspective to ensure that the systems developed are usable, useful and enjoyable

1.4.18
HCI
human-computer interaction

1.4.19
Human Factors Assurance Reports (HFAR)
document containing any specific HF analysis activities undertaken to support design development activities that can be referenced as part of the design HF assurance case

1.4.20
HFIL/HFIR
human factors issues log/register

1.4.21
HFIP
human factors integration plan

1.4.22
HFUR
human factor user requirements

1.4.23
HFURR
human factors user requirements register

1.4.24
HMI
human machine interface

1.4.25
HRA
human reliability analysis

1.4.26
human error
an action (or inaction) that can result in an unintended outcome

1.4.27
Human Factors (HF)
the scientific discipline concerned with understanding 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 optimize human well-being and system performance. Also, ergonomics

1.4.28
human factors integration (HFI)
the process of adding human needs and abilities into system design to balance technology and user requirements for safety and effectivenes

1.4.29
human-system interaction
all instances where a human interacts with a delivered asset within the system

1.4.30
like-for-like
replacing or comparing items that are identical or very similar in function, quality, and specification

1.4.31
maintainability
the ease with which equipment or systems can be fixed and returned to normal operation within a set time using the correct methods, while ensuring maintenance is safe, effective, efficient, and tolerant of human errors

1.4.32
mock-up
a model or representation of a design that ranges from simple sketches or paper models to detailed 3D CAD designs or finished prototypes, used to visualize and test the design, with less flexibility for changes as fidelity increases

1.4.33
negative transfer
a situation in which a user applies skills from one system or equipment to another where they don't fit, leading to mistakes like missing tasks, using wrong controls, or operating the right controls incorrectly

1.4.34
neurodiversity
the range of differences in individual brain function and behavioural traits, regarded as part of normal variation in the human population (although the term is often used in the context of ASD, neurodiversity includes ADHD, dyscalculia, dyslexia and dyspraxia)

1.4.35
new or altered systems or assets
the changes made to assets other than those due to maintenance activities, including decommissioning and removal of assets

1.4.36
OCD
operational concept documentation

1.4.37
operational concept document
a verbal and graphic statement of an organisation's assumptions or intent in regard to an operation or series of operations of a system or a related set of systems. (ANSI/AIAA G-043 Guide for the preparation of Operational Concept Documents). An element of systems engineering

NOTE: The operational concept is designed to give an overall picture of the operations using one or more specific systems, or set of related systems, in the organisation's operational environment from the users' and operators' perspective. See also concept of operations (ISO/IEC/IEEE 29148)

1.4.38
operability
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

1.4.39
operational integration
a process or set of activities, encompassing HF, training, competence, and change management, to ensure and assure the optimum performance of the complete system

1.4.40
organisational ergonomics
a domain within ergonomics concerned with optimisation of the sociotechnical systems. Examples will include organisational structures, policies, processes, role allocation, team-working, workforce planning, job design, and socio-cultural factors.

1.4.41
physical ergonomics
the study of how human body measurements and characteristics impact physical tasks, including factors like access, workspace, reach, and posture

1.4.42
post implementation review
a review of the project to identify the human factor lessons learned and to identify any remaining issues and how they can be resolved

1.4.43
premises standards
disability (access to premises-buildings) standards

1.4.44
priority seating
seating for passengers with disabilities and other groups in need of special assistance (for example, the aging) as defined in DSAPT

1.4.45
rail transport operator (RTO)
an organisation that has responsibility for ensuring, so far as is reasonably practicable, the safety of the operator's railway operation

1.4.46
SFAIRP
so far as is reasonably practicable as defined in the RSNL s47.

NOTE: Refer to *Meaning of duty to ensure safety so far as is reasonably practicable* guideline by ONRSR for more information

1.4.47
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

1.4.48
supplier
any organisation providing engineering services or assets to a rail operator or maintainer

1.4.49
system
an asset and its context of use

1.4.50
system thinking
an approach that makes sense of complex systems from a holistic perspective that considers the interconnected parts of the system together to produce patterns of behaviour over time

1.4.51
V&V
verification and validation

1.4.52
violations
deliberate but not necessarily reprehensible deviations from a rule or formal arrangement (such as a specified procedure)

1.4.53
virtual reality (VR)
interactive experience taking place within a simulated environment

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

Section 2 Human Factors Integration Process

Human Factors Integration (HFI) is the formal process to integrate Human Factors (HF) into the system-engineering life cycle. It involves applying a systematic and scientific approach to the identification, tracking, and resolution of issues related to human-system interactions. Effective HF integration ensures the balanced development of both the technological and human aspects of the system and delivers the desired safety and operational capability.

Note: Supporting information is available in the RISSB Guideline Integration Human Factors in Engineering Design and RISSB Guideline Integration of Human Factors Across Product Lifecycle.

2.1 HF competence

People undertaking any Human Factors activities shall hold recognized industry qualifications at a level appropriate to the scale, scope and complexity of the services they are providing. Recognized industry qualifications shall be defined as:

(a) Tertiary qualifications in Human Factors, or a related discipline such as Psychology, Ergonomics, Industrial Design or Engineering;

(b) If the specialist has not graduated with tertiary qualifications, then they shall demonstrate suitable experience that evidences HF principles, methods and processes within their vocation relevant to the services they are providing; and

(c) Preferably hold:

  (i) Relevant post-graduate qualifications;

  (ii) Certified/Chartership with a recognized HF society for complex / high-risk projects; and/or

  (iii) Membership with a recognized and accredited HF society (Australian or International) under the IEA competency framework.

Persons who have not yet achieved the required level of competence may undertake specific activities under the supervision of a competent HF practitioner.

2.2 Process requirements

Process requirements for HFI include documentation, scalability, evidence, reporting, outcome verification and demonstrated competency.

The processes described in this Standard shall be read in conjunction with the supporting Guidelines, *Human Factors Integration of Engineering Design* and *Integration Human Factors Across Project Lifecycle*.

Human Factors Integration requirements include:

(a) HFI process requirements shall apply to all engineering design and procurement contracts or projects;

(b) the HFI process shall form part of the RTO's and any supplier’s engineering management procedures;

(c) the HFI process shall be scalable in its application, based on the risk, novelty, change impacts, reliance on human performance, and complexity of each specific project to ensure the effectiveness and efficiency of its application;

(d) relevant HFI requirements shall be specified within the appropriate project scope and requirements documentation;

(e) the HFI process shall be applied throughout the project design lifecycle, commencing with feasibility, solution optioneering, and/or conceptualising, and continue throughout the full design process to the completion of the operationally ready system or asset;

(f) the HF activities and any associated deliverables shall be specified and integrated into the appropriate project documents and plans;

(g) the HFI process and the results of HFI activity at each step in the process shall be documented;

(h) HFI activities shall be reported at each of the defined project milestones. These can be contractual milestones or other internal milestones defined in the project plan;

(i) the HFI shall be documented in a manner that explains what areas will be investigated, why these areas are being investigated, and how they will be assessed in terms of appropriate method, technique and holistic approach;

(j) demonstration of the HFI process (including justification of its scale and scope) shall form part of the assurance of the project;

(k) if through the application of its HFI process, an organisation determines that no additional HF activities or planned activities are required, the organisation shall document and present this decision and reasoning as part of the overall assurance argument for the project at the first relevant project milestone and re-evaluate at each subsequent project milestone;

(l) organisations engaged in conducting or procuring engineering design activities, services, or products on behalf of the Australian Rail Industry shall provide justification, in consultation with a HF SME, for any deviations from the process requirements set out in this Standard;

(m) recommendations or proposals for design changes shall be considered within the organisation's engineering design review process. Decisions regarding the adoption or rejection of such changes shall be documented;

(n) assessment of the appropriateness of COTS systems or assets to ensure they do not introduce inefficiencies and/or errors; and

(o) determination of the level of HFI relevant to COTS systems and assets, avoiding the assumption that COTS products have a level of HFI applied already.

2.3 Management of Human Factors integration process

The HFI process described in this Standard is compatible with the risk management process described within ISO 31000 (a process overview is illustrated in Figure 1).

As a minimum, an organization shall:

(a) establish and document the context of the use of the system, to the following:

   (i) Identify how the new or altered system will integrate into the existing system or systems.

   (ii) Consider systems thinking and end users.

   (iii) Understand the operational concepts.

   (iv) Define user tasks and activities.

   (v) Identify all applicable regulatory requirements.

   (vi) Identify end-user attributes for example; population sectors, expected level of training, levels of use etc.

   (vii) Specify end-user and HF requirements.

(viii) Ensure the end-user and HF requirements are integrated into the broader requirement management system.

(ix) Identify all relevant human-system and human-human interactions as far as is reasonably practicable.

(x) Identify end-user benefit realization.

(xi) Characterize the criticality of HFI to project success by taking into account, among other relevant factors, the importance of human performance to system success, the extent of human-system interactions, and the extent of HF related risk.

(xii) Incorporate lesson learnt from previous projects to inform HF requirements.

(b) documented the planned HF integration activities. An HFIP is one method for documenting the HF integration process;

(c) identify, record, and manage the HF issues to be addressed within the design of the asset or system. A list of common Human Factors topics that are particularly relevant to rail projects is described in Section 3 of this document;

(d) analyse, manage, and control the identified HF issues, including:

(i) conducting analyses to identify potential controls, using appropriate techniques and to the relevant level of detail, given the nature of the issue and the risk and complexity of the project;

(ii) demonstrating that HF is integrated in all risk and engineering design analyses that can have an impact on any human interactions with the system;

(iii) demonstrating compliance with the generic end-user and Human Factors requirements set out in Section 3.1 to Section 3.7 of this document; and

(iv) integrate and support iterative design processes to assess the adequacy of any identified HF controls and determine whether changes to the design or additional controls are required.

(e) test and adopt the human interactions and HF controls within an iterative design process. This shall include the following:

(i) Monitoring the effectiveness of these interactions and controls throughout the design development process (from early preliminary designs to later verification and validation phases).

(ii) Testing the human interactions as part of the holistic task design in a representative operational environment as part of assurance of systems integration (during verification and validation phases).

(iii) Areas of human interaction that need to be considered for testing shall include elements that could impact safe, effective and efficient performance; examples include but not limited to:

(i) physical Ergonomic and Anthropometrics in relation to working space;

(ii) psychological and cognitive elements such as human error, workload, usability;

(iii) predicted organisational or operational factors such as staffing levels, training, job design; and/or

(iv) 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.

(f) communicate and consult with all stakeholders and end-user groups throughout the design development or procurement process;

(g) monitor and review the effectiveness of its HFI process within a specific project and its deployment throughout the organisation;

(h) capture and record lessons learnt to improve future project outcomes so that they can be fed into projects;

(i) the Human Factors integration process shall be iterative and shall regularly gather feedback from end users and stakeholders to incorporate into the system design;

(j) evidence that each of the above steps has been conducted and the results of each step, including the influence on the design, shall be documented:

(i) A Human Factors Issues Log is one method of capturing and tracking risks and issues.

(ii) A Human Factors User Requirements Register is one method of recording requirements and compliance evidence.

(iii) A Human Factors Assurance Report is one method of recording evidence the HF activities have been undertaken.

(iv) Managing non-compliance - non-conformance (SMS/ MOC or HFI).

Figure 1 provides a diagrammatic representation of the HFI process, which follows the structure of the risk management process described in ISO 31000:2018.

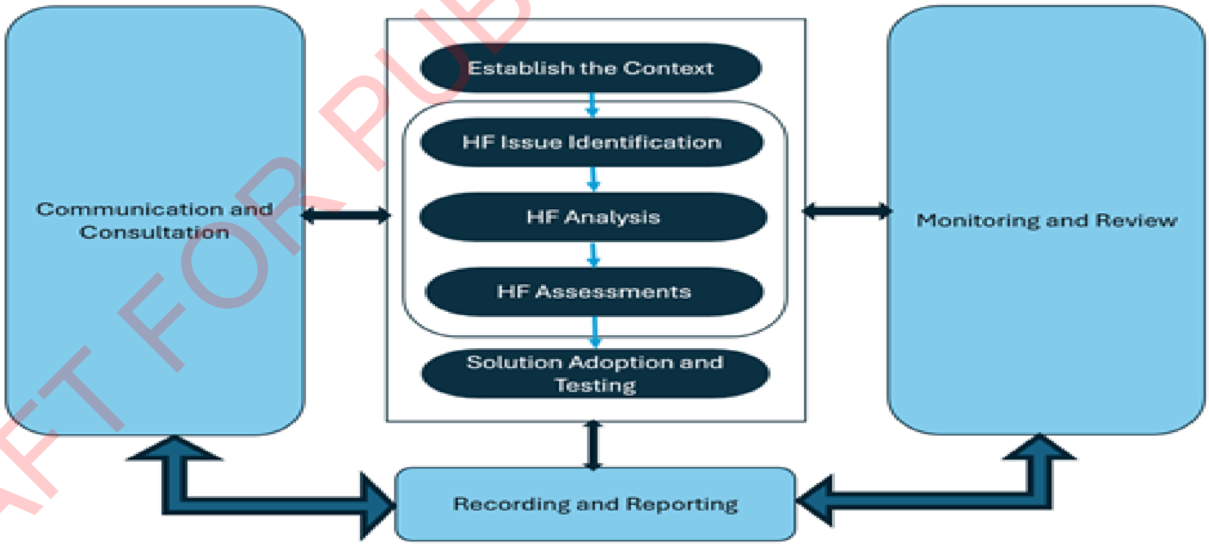


Figure 1 HFI process

NOTE:
This diagram is to be read in conjunction with the RISSB *Integration of Human Factors Across the Project Lifecycle Guideline*, 2019.

2.4 The project lifecycle

Figure 2 provides an example of HFI with a typical life cycle for projects. In addition, HFI also aligns with systems engineering verification and validation phases, in which case, see Figure 1 in Section 2.3 of the RISSB Guideline titled *Integration of Human Factors Across the Project Lifecycle* for further details.

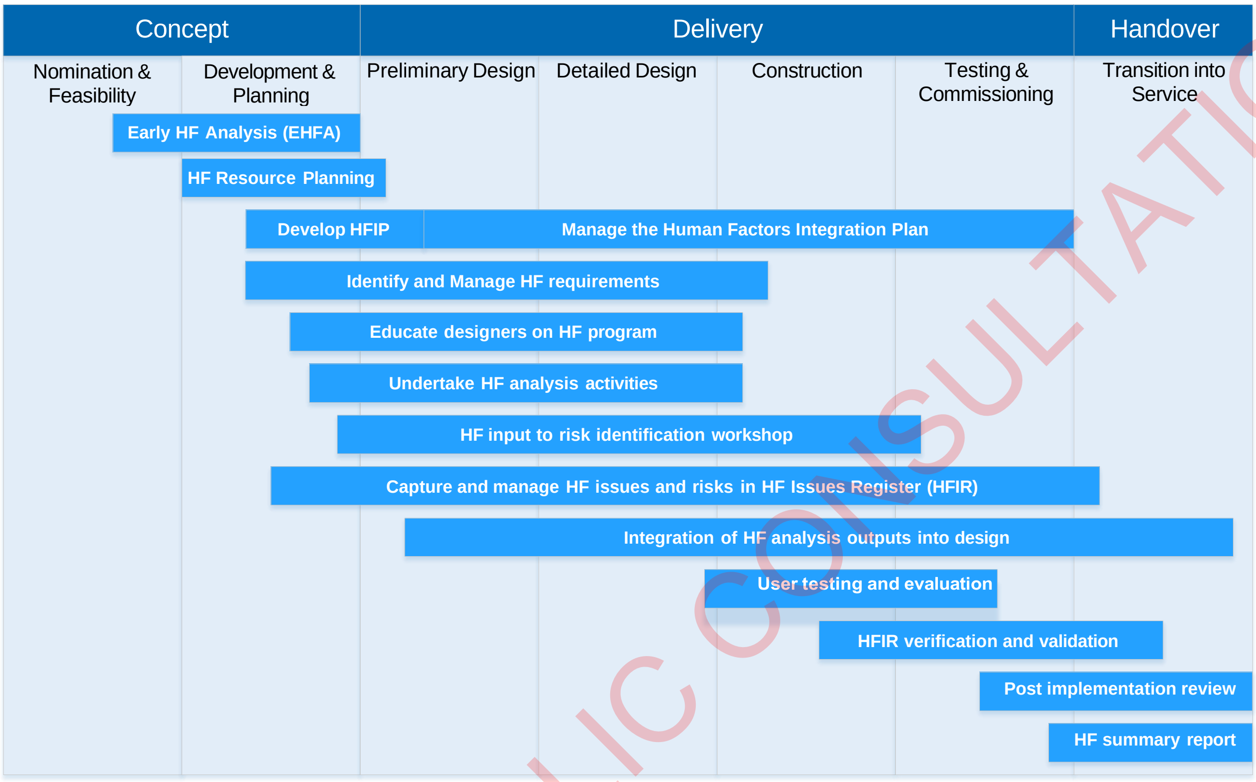


Figure 2 Typical project lifecycle

NOTE: Some organisations will have different terms for the different stages across the lifecycle.

Section 3 HF Integration in the early and concept design phase

It is important to establish an HF integration process early in the design phase of the project lifecycle. This involves HF activities as outlined in Table 1 and provides the foundation for the HF program as the project progresses. The option of starting some HF activities at the business case, feasibility, or definition design phases must not be precluded.

This will be determined by the processes and procedures of the organization in question. It should be noted that different terms may be used other than those referred to in Table 1 within different organization when referring to some of these early design activities.

Table 3-1 HF and HF Integration in the Early Design Phase

Inputs	HF activities	HF Outputs/deliverables
Business Case	Benefit realization predictions Definition design HF review of options assessments Establish the context of use.	Initial user requirements Preliminary HFIP, HFIR (or HFIL), HFUR and summary of findings Input into operational concept document (OCD).
	Undertake an early human factor analysis (EHFA).	EHFA report.
	Assess the level of significance.	Include level of significance in HFIP.
	HF requirements generation.	Input into user, business and system requirements.
	HF resource requirements.	Suitability qualified and experienced HF personnel engaged.
	Commence HF integration management documentation.	HFIP (initial version). HFIR (initial version.) HFUR (initial version))

In relation to establishing the context of use, the activities outlined in Table 1 are the first steps in HF integration. They seek to understand the proposed project and where and how it fits with the existing system or operations.

3.1 Assessing the level of HF integration significance

This section shall be read in conjunction with the HF Project Lifecycle Guideline Section 3.2 Assessing the Level of HF Integration Significance.

The level of HF integration required to support a project shall be assessed based on a number of factors including but not limited to:

(a) the level of novelty or complexity or use of unique or non-standard configuration.

(b) the context of use and potential interaction with other systems/assets.

(c) the number and complexity of human interfaces.

(d) the exposure to and impact on end users including staff, customers and the public.

(e) the associated level of safety risk (including the potential for increases in human error or adverse impact on human performance, particularly where such errors have personal safety or rail system safety implications).

3.2 HF integration scalability

The focus will be upon the nature of the proposed change and the user impact. Factors to consider include but not limited to:

(a) the level of human interaction.

(b) the novelty of the system.

(c) the level of risk.

(d) the potential interaction with other systems.

(e) the complexity of the HF.

(f) the scale of change.

(g) lessons learnt from similar past projects/events.

(h) understanding the context of use.

3.3 Establishing context of use

The context of use shall be established using the following list:

(a) What the system will be used for, how it will be used and any current applicable practice.

(b) How the new or replacement system or subsystem fits into the existing operations.

(c) Who the end users of the system are, including all end user groups, not just front-line operational personnel or customers.

(d) What the human interactions with the system are, and what tasks are required to be performed successfully for the system to meet operational and maintenance requirements.

3.4 Undertaking an early Human Factors analysis

A key HF activity in the early or concept phase is commonly known as an Early Human Factors Analysis (EHFA). For moderate and minor changes, it may be sufficient to simply identify likely HF input rather than complete an EHFA.

The HF specialist must decide what level of EHFA is required taking into account the following criteria:

(a) look at the potential impact on end users:

 (i) look at the identification of users likely to be affected by the change. These users will include primary, secondary and tertiary users.

 (ii) identification of the changes on each of the user groups. These can incorporate implications for training, procedures, work processes, workload, staff numbers, and skill and knowledge requirements for personnel, for example.

(b) safety-related risks.

The EHFA shall consider the following activities and documented in detail:

(c) identification of potential HF issues for consideration.

(i) These can include interface/control design, usability, error avoidance and error tolerance, workload, and attention/distraction issues, for example. These also include any HF-related areas of concern or issues learned from previous related projects.

(ii) meetings with end users and/or stakeholders.

(iii) resources required to support the project or change event.

If during the EFHA process the potential impact of the change was considered but no action was needed to be taken it still needs to be documented.

3.5 Identifying end users

End users that need to be considered are as follows but not limited to:

(a) Drivers: Driving operations including signal sighting, route drivability (including SPAD mitigation), platform working, responding to emergencies and degraded modes, lineside activities on the mainline and in the yard.

(b) Other rail vehicle operators: including other RTO drivers who use the network as well as operators of plant and other road rail vehicles used during infrastructure works.

(c) Maintainers: Accessing the rail corridor or rail structures/buildings to inspect or maintain assets and equipment and maintain new/novel systems. This includes:

(i) signals and telecommunications.

(ii) track and infrastructure.

(iii) civils (i.e. structures, viaducts, tunnels, cuttings).

(iv) Electrical.

(v) buildings (i.e. stations, equipment rooms).

(vi) tolling stock, including those in train maintenance facilities.

(vii) systems (including signalling, train control, OCS and fire and life).

(d) Station and customer service staff: Providing customer support and assistance as well as those interfacing with station control systems during normal, degraded and emergency conditions.

(e) Operations controllers: Whether signallers, train controllers or electrical control. Responsible for managing any changes to signalling operations, monitoring and managing the electrical network and coordinating operations during normal, degraded and emergency conditions.

(f) Network safety and security staff, where systems associated with access control, security (including CCTV) or fire and life activities are affected.

(g) System users: Can be members of staff or the public directly interfacing with a new or amended system, such for the purposes of carrying out work tasks, receiving or providing information or for communication.

(h) Cleaners: Requirements for support tasks associated with cleaning of stations and precincts to maintain a positive customer experience, or with respect to access to rolling stock.

(i) Public: Accessing or interfacing with the railway and associated infrastructure, including stations and bridges, station precincts (shared user paths, parking, interface with other transport modes, etc.), and pedestrian and level crossings. Consider all users, age, tasks, commuting, travelling with luggage/bikes, travelling with children and level of mobility and sensory function.

(j) Emergency services: Access to rail buildings or the rail corridor to support the operator and the public in the event of an emergency, and interface with emergency/fire and life systems (e.g. station control monitoring systems/CCTV).

3.6 Specifying end-user requirements

The following considerations shall be applied when specifying end-user requirements:

(a) The characteristics of at least primary and secondary users and how much variation there is in these. Characteristics can include age, gender, background knowledge, experience, and skills.

(b) The intended context of use, possible variations and their effect on the user requirements shall be determined. This can also lead to requirements for training to address any anticipated skill or knowledge gaps.

(c) The major activities of users related to the project, including core tasks and functions. Developing typical usage scenarios showing expected user interactions as well as possible difficulties of users and main variations can be helpful in illustrating this.

(d) Any user feedback on the current asset, system or process or lessons learned from other similar systems or assets as experienced through other projects.

(e) HF-related performance criteria for the asset, system or process including:

   (i) general criteria for typical use of the product (performance time, error rate, satisfaction, etc.), including any conditions of use from type approval applications;

   (ii) acceptable time limit to learn how to use the product, which can also feed into training requirements;

   (iii) a test plan for the ergonomics or user experience with respect to the product or system. Show the targeted performance of the product or system for critical task;

   (iv) acceptance limits for the ergonomics or user experience of the product or system in a user test. This limit can be set according to an initial evaluation plan and captured as a process requirement; and

   (v) any user performance requirements that need to be met during transition or upon implementation of a new asset, system or process.

(f) Relevant usability or health and safety issues for users:

   (vi) Applying applicable requirements from existing, relevant standards or regulatory requirements; and

   (vii) Establishing minimum requirements for comfort and health (minimize forces, repetitions, awkward and static postures).

(g) Requirements for supporting transition into service, such as assistance for users once the project is implemented – what will be available and how will this be communicated?

HF requirements may be derived from a number of sources, including:

(h) relevant HF and ergonomic standards;

(i) HF analysis and assessment activities;

(j) applicable good practice or recognized HF design principles;

(k) user-based conditions of use identified in type approvals, waivers or management of change assessments;

(l) end user workshops; and

(m) outputs from lessons learned from other, similar projects.

HF requirements shall be:

(n) captured in a requirements matrix or management system for tracking and management;

(o) verified and validated as part the HF activities to support transition into service; and

(p) described in the HFIP to document the approach taken to capture, manage, verify and validate.

3.7 Deliverables

This early or concept phase will see the following documents produced:

(a) EHFA summary document

(b) Initial HFIP

(c) Initial HFIR

(d) Initial HFUR

The outcomes of the EHFA undertaken during the early design phase are summarized in the EHFA summary document. This provides the basis for the other HF management documents – the initial HFIP, HFIR and HFUR. These documents will evolve as the project progresses and more issues and requirements are derived through the HF integration activities. These activities that will be outlined in the HFIP.

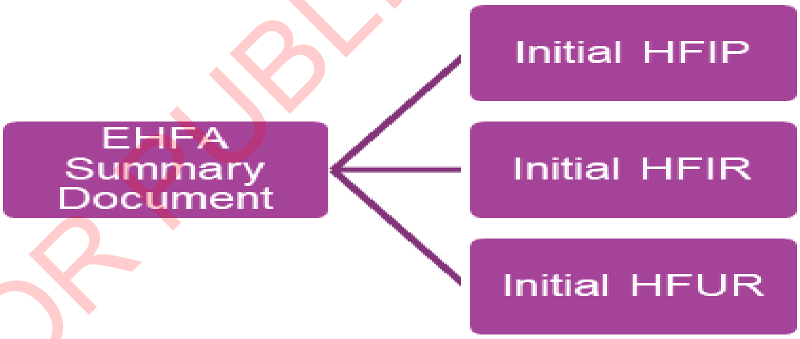


Figure 3 HF Management documents – HFIP, HFIR, HFUR

Section 4 HF integration in the detailed design phase

4.1 Engineering design

For larger-scale complex system projects, there shall be HFI input into system level architecting and design decisions in order to ensure that the HF component is being included adequately.

For larger-scale complex system projects, HFI shall support overall system integration planning.

From a sequential programming perspective, the design phase uses the outputs of the Concept phase and may continue to derive the requirements which in turn drive the design decisions and maturation into technical specifications to design against. The design phase is also forward looking, as the design shall have accompanying test plans that will enable effective integration and verification against the specification that will occur in the subsequent Implementation and Testing phases. HFI practitioners will be primarily concerned with ensuring that the design will satisfy the user and HF requirements, however, shall be nascent of the broader relationships to the overall system requirements.

Table 4-1 HF and HF Integration in the Design Phase

HF inputs	HF activities	HF outputs
EHFA HFIP HFIR Operational concept HF requirements	HF activities such as task analyses, human error analyses, mock-ups and simulations, usability testing, specific experimental evaluations to compare alternatives or find solutions, review of design packs, design reviews	Update HFIP or for simpler projects an HF section within the overall project plan Updated HFIR; New issues, open/closed issues Depending on the project processes, HF issues determined as risks due to their particular impact shall be transferred to project risk registers with cross-references provided to demonstrate traceability. This is to ensure HF issues are integrated into the overall systems engineering process management activities and are not considered standalone and therefore forgotten. An updated HF requirements matrix as an input to the design phase to ensure the design meets the physical, function and performance needs of its identified end users. Updated HF requirements into engineering or project documentation e.g. final operational requirements, systems requirements specifications
	Design testing	Tested device, system or process

HF inputs	HF activities	HF outputs
	Safety assurance	A standalone design HFAR or section within the safety assurance documentation. The HFAR shall summarize the HF input to a particular design, or aspect of the design. The HFAR shall detail the approach and methodology used and the analysis outputs, which might include a set of additional derived requirements or HF controls and risk mitigations. The report shall describe how those requirements or proposed controls were addressed during design development. The report shall form part of the HF assurance case, detailing how HF was integrated into the design process.

4.2 During this phase

If an HF working group has been deemed as required, it shall be established (if not done within the previous phase) and actively engaged within the overall engineering design team and activities.

HF activities shall be carried out as outlined in the HFIP or, for simpler projects, within the overall project plan. HF activities can include task analyses, human error analyses, mock-ups and simulations, usability testing, specific experimental evaluations to compare alternatives or find solutions, reviews of design packs, technical design review process.

Design solutions in this phase should be progressively matured through involvement of end-user groups. This should be achieved by:

(a) Low and high-fidelity mock-ups;

(b) Prototypes; and

(c) AR/VR simulations.

HFI scalability, and the design phase shall determine appropriate fidelity.

Mock-up activities such as low fidelity testing can be undertaken as part of early design phase.

HF requirements:

(d) shall be defined at the required various levels e.g. system level to various subsystem level(s) depending on the project and aligned with the systems engineering processes;

(e) derived across the design development phase shall be used as inputs to inform the design; and

(f) shall be reflected and refined in the project requirements documentation developed in the Concept Stage. Engineering/project documents can include Final Operational Requirements, System Requirements Specifications, Engineering Assurance Plan.

Major activities within a system safety assurance plan shall include an HF component. System safety activities may include risk assessment, reliability, availability, maintainability and safety (RAMS) analysis; failure mode and effect analysis (FMEA); fault tree analysis (FTA); and so forth. For smaller and less complex projects, a well conducted hazard and operability study (HAZOP), or Human HAZOP may be sufficient.

Detailed HF analysis to provide a full understanding of the scale and nature of the issue and to identify suitable control measures shall be undertaken if the outputs of system safety analyses indicate the need for further investigation.

Collaboration with other disciplines shall occur during this phase as part of the integrated process in order to determine prospective design solutions. Decisions around design solutions shall occur during multi-disciplinary design reviews, considering all relevant aspects of the design.

When identifying prospective design solutions based on HF activities, the proposed solution shall be tested. This is to ensure it addresses/solves the issue and that it optimizes further working processes and practices and to ensure that any new issues introduced by the proposed solution are identified and assessed.

Design testing shall include structured end-user evaluation.

Design reviews shall be undertaken during the design phase.

The design review shall:

(g) consider alignment with HF standards, guidance and good practice.

(h) evaluate design outputs against the identified HF requirements.

(i) evaluate whether the design has integrated the outputs of HF analyses outlined in the HFIP; and

(j) evaluate whether the design has addressed identified HF issues in the HFIR.

(k) Plan test schedules against the maturity of the design with verification and validation in mind.

For larger-scale complex system projects, HFI design activities shall support overall system integration planning.

As the design process is iterative, the HFI activities b) to m) shall also be performed iteratively.

An evidence-based argument shall be developed to demonstrate that HF Integration has been effectively implemented in accordance with the agreed HFIP, to support the submission of the design assurance case. This usually takes the form of a Human Factors Assurance Report (HFAR). A HFAR shall reflect the outcomes of activities undertaken during the Design Phase, according to the intended assurance approach outlined in the HFIP and/or Systems Engineering Management Plan (SEMP).

4.3 Deliverables

Artefacts shall be developed in accordance with the HFIP. They may be standalone artefacts or integrated with engineering and systems assurance artefacts. Major deliverables in this phase are usually:

(a) an updated HFIP or for simpler projects an HF section within the overall project plan;

(b) an updated HFIR detailing:

  (i) new issues, open/closed issues;

  (ii) depending on the project processes, HF issues determined as risks due to their particular impact shall be transferred to project risk registers with cross-references provided to demonstrate traceability. This is to ensure HF issues are integrated into the overall systems engineering process management activities and are not considered standalone and therefore forgotten.

(c) An updated HF requirements matrix as an input to the design phase to ensure the design meets the physical, function and performance needs of its identified end users:

 (i) Updated HF requirements into engineering or project documentation e.g. final operational requirements, systems requirements specifications.

(d) A standalone design HFAR or section within the project assurance reporting:

 (i) This shall summarize the HF input to a particular design, or aspect of the design. It shall detail the approach and methodology used and the analysis outputs, which might include a set of additional derived requirements or HF controls and risk mitigations. The report describes how those requirements or proposed controls were addressed during design development. The report forms part of the HF assurance case, detailing how HF was integrated into the design process.

4.4 Human Factors principles

Human Factors principles shall be considered during the design phase. ISO 26800 outlines the principles as follows:

(a) Place the human at the centre of the ergonomics approach to design.

(b) Take into account the diversity of the human population.

(c) Take into account the implications of the task for the human.

(d) Take into account the environment in which the outcome of the design is to be used.

(e) Placing the human at the centre of the approach to design and as an essential element of the system.

Section 5 HF integration in the build/implement phase

In this phase the HF focus is on supporting the implementation of the proposed design or change, with continued assessment as necessary including involvement in the evaluation of any last-minute changes ahead of the implementation.

Providing HF input into key documents including:

(a) competency and learning plan, including detail on training implementation;

(b) demonstrating the coverage of the specific risks and hazards for which training was identified as a risk control;

(c) operational readiness and business readiness reporting;

(d) construction readiness, including construction risk assessments. For example, how does HF integrate with new construction methods or input into controls regarding risks associated with construction over or alongside an operating railway?

(e) preparation of the testing and user acceptance plan, to ensure there are testing activities planned that will verity that the design meets HF requirements as well as technical;

(f) MoC plan implementation; and

(g) SFAIRP/safety case (where required).

Section 6 HF integration in the testing phase

HF integration during this phase involves evaluating the system against the identified user requirements to ensure they have been met and that the system functions as required.

HF Integration activities during the testing phase shall include:

(a) input to systems acceptance; deriving user evaluation criteria to ensure user requirements for system design and function have been met;

(b) support to the verification and validation (V & V) of HF requirements and identified HF risk controls, particularly where testing was identified as the verification means;

(c) identifying and confirming any residual HF risks and handing these over to the designated risk owners; and

(d) finalising the HFAR to present the HF assurance case showing how the HF issues, risks and requirements have been resolved during transition into service.

Section 7 HF integration in the in-service phase

This phase is focused on operations and maintenance including monitoring performance and ensuring that the benefits have been realised in line with the project plan. A post-implementation review shall be undertaken in this phase.

7.1 Post-implementation review

The purpose of a post Implementation Review is to demonstrate that the identified controls and mitigations have been implemented as per the design, that the identified HF controls are effective, and that no additional or unforeseen HF issues have arisen with the implementation of the change.

HF integration activities during post-implementation review shall include:

(a) the verification and validation of HF controls, requirements or other mitigations that could not be closed ahead of change implementation;

(b) closing out the HFIR, and any identified HF requirements, demonstrating with evidence that they have been met, or flagging where they have not;

(c) the identification of any additional HF issues arising through the transition into service of a change or system;

(d) the capture of HF Integration lessons learned; and

(e) a summary report detailing the HF Integration activities undertaken to support the project or change event. This may be a standalone report or may be integrated into a broader project completion or change implementation report depending on the complexity of the project.

7.2 HF monitoring and on-going review

The project shall be monitored and analyzed to ensure the following outcomes are being achieved:

(a) Safety

(b) System performance

(c) Usability

(d) Cost-benefit

(e) Health and well-being

Section 8 HF integration in the end of service life

8.1 Planning for decommissioning

Decommissioning is the process of retiring a system, process, or asset, usually at the end of its lifecycle or when it's being replaced and shall be considered in the design and development phase.

HF shall be integrated throughout the decommissioning, dismantling, demolition, and disposal of waste process.

An HFIP shall be developed at the earliest stages of the project and outline HFI activities to be carried out at each phase of end of service life.

The HFIP shall also describe:

(a) the HFI work required and how it will be resourced and delivered;

(b) potential HFI issues or risk, safety, and environmental issues impacting on end users such that steps can be taken to eliminate or mitigate prior to decommissioning commences;

(c) how the transition phase shall address the potential safety issues associated with the cessation of operations and appropriate steps taken to mitigate or eliminate risk;

(d) any consideration of how to manage change from operations to decommissioning with emphasis on organizational changes required through the transition;

(e) an Impact Analysis shall be completed to assess potential changes to tasks and activities, ensuring that critical tasks can still be performed effectively;

(f) HF input into any options analysis for the decommissioning approach, ensuring that Human Factors are considered in decision-making process;

(g) the decommissioning/demolition process, with a strong focus on worker management and safety, the novelty of the activity, and the interface with other systems and processes;

(h) the impact on workers and resourcing, considering any adjustments needed;

(i) changes to workload and ensure they are manageable; and

(j) changes to available functions, determining if key functions can be retained through alternative means.

8.2 End of service life

Implementation and execution of HFI shall consist of the following, but not limited to:

(a) HF input:

  (i) Implement the HF activities outlined in the decommissioning and/or HFI plan, ensuring that all tasks are performed safely and efficiently.

  (ii) Treat the decommissioning as a new project, applying the full project lifecycle process, starting from the concept phase, to ensure thoroughness and compliance with HF requirements.

(b) Review and Reporting:

  (iii) HF requirements shall relate to satisfying the compliance requirements and the agreed works have been carried out, and a close-out report shall include appropriate evidence.

(iv) Conduct a post-implementation review after decommissioning and/or demolition and disposal of waste to assess the effectiveness of the process and identify any areas for improvement.

Section 9 Generic Human Factors design requirements

Section 9.1 presents a list of design requirements which are mandatory for all projects.

The application of the HF requirements described in Section 9.2 to Section 9.9 are context specific and their application will be dependent on the nature of the system being designed. Therefore, not all of the requirements listed in these sections will be applicable to all projects. For requirements that are deemed to be applicable to a specific project, an organization shall provide justification for any deviations from the generic HF requirements set out in this Standard. Further, this is not a comprehensive list of all HF requirements. A project shall 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.

Human Factors Integration (HFI) aims to ensure optimization of human-system interactions to provide effective system performance, safety and acceptability. Incorporating Human Factors through the life cycle, and particularly early in the design process, provides the most benefit. To aid this process, this section sets out a list of common generic Human Factors requirements that are likely to be applicable to most rail projects:

(a) design requirements

(b) anthropometric data

(c) information content

(d) audibility and intelligibility of messages

(e) alarms and alerts

(f) controls and displays

(g) workspace and task design

(h) glare, reflections, and line of sight

(i) customers and the public

For each of the above issues, a number of generic Human Factors requirements are described in the following sections. Other than the mandatory adherence to the design requirements set out in Section 3.1, there is no implied hierarchy or importance associated with the order of presentation of these HF requirements.

9.1 Design requirements

Integrating HF into the design/procurement process involves providing assurance through the form of physical and documented evidence to show that human capabilities, limitations, and other characteristics have been considered in order to ensure a safe and fit-for-purpose system or asset:

(a) The design shall be based on established Human Factors principles including but not limited to those set out in this section.

(b) The design of systems and equipment shall take into account the following:

(i) The context of use; i.e., the context in which the system operates or will operate. Contextual details can include but are not limited to; objectives, means, end users, limitation, exceptions, stakeholders, physical and technology constraints, and environmental consideration.

(ii) Human variability, to ensure the system can cater for all specified ranges of end-user characteristics, including the range of disability identified in the Disability Discrimination Act, as appropriate.

(iii) Human physical and cognitive capabilities and limitations.

(iv) Human Centred Design considerations so that the design is based on the needs of the end user. The process is user focused but not user led.

(c) The design shall take into account the demands on, and the requirements of, end users during normal and degraded operations, routine and unplanned maintenance, cleaning, and emergency situations.

(d) The design shall include consideration of the overall environment for all end users. These considerations shall include, but are not limited to, interior climate, the acoustic and visual environments, lighting, and exposure to vibration.

(e) The design of a system shall ensure, as far as is reasonably practicable, that its correct use or operation is also the easiest or most obvious to the end user(s).

(f) The design of systems and equipment shall be error-tolerant and shall provide a means of error identification and recovery shall an error occur. Where possible, a single human error shall not result in system failure. Where a human error can result in a significant hazard multiple defences to control the hazard shall be provided.

(g) The system shall be designed to eliminate, or manage SFAIRP, the potential for negative transfer.

(h) The reasons people might deliberately act incorrectly with the systems shall be identified and accounted for within the design to minimize violations.

(i) The design shall, where practicable, include features to prevent foreseeable misuse of the asset or minimize the consequences of misuse.

(j) The design shall not impose workload or create distractions that would impair performance of any primary or safety critical tasks.

(k) The design shall enable safe access to equipment for operations and maintenance.

(l) The design shall enable ease of maintenance tasks including cleaning, repair and replacement of components or systems.

(m) The design shall not allow parts to be installed incorrectly.

(n) The design shall incorporate provision for functional testing to reveal installation or maintenance errors prior to the equipment being accepted into service or returned to operation.

(o) Design reviews involving end users and stakeholders shall be part of the engineering design process. The number and level of review shall be appropriate to the nature of the project being undertaken and its impact on end users. These shall be established as part of the HFI process set out in Section 2.

(p) The impact of design decisions on operational training requirements, staffing and resourcing shall be assessed during design reviews and as part of the end-user consultation process.

(q) The design shall utilize evidence-based data from HF analysis and review to support and inform the design. Any deviation away from the data need to be able to be justified SFAIRP and recorded as evidence of a deviation.

(r) The design shall use relevant, current and valid Human Factors data where these are available. The use of data shall be justified as part of the design process.

(s) Any conflicts in HF requirements shall be reviewed objectively via a trade-off process. The evaluation shall consider feasibility, safety risk, and how the requirements align with the system/asset objectives, end-user needs, and design constraints. Outcomes from the trade-off shall be documented and recorded as part of the design process.

9.2 Anthropometric data

The physical design of the system shall use relevant and appropriate anthropometric data regarding size, shape, weight, strength, range of motion, and working capacity of the end users. In those cases, where these values are specified in legislation then the design shall comply with the legislative requirements.

For all projects, the minimum design anthropometric range for adults shall be from the 5th percentile female or male (whichever has the smaller value) to the 95th percentile male or female (whichever has the larger value). Australian anthropometric data for this purpose is provided as guidance in Appendix C. The RTO (or their nominated representative) shall nominate an alternative dataset where it is judged to be more representative of a specific target user group.

1st to 99th percentile of the anthropometric range shall be specified where full population accommodation is required. These situations may include the following:

(a) Where it is safety critical to the design;

(b) Where it is a key determinant of operational performance:

  (i) where there would otherwise be an injury risk; and

  (ii) where comfort would otherwise be compromised.

(c) Where it is proposed that the design is to accommodate a lesser anthropometric range than that required under (b) and (c) above, this shall be fully justified based on:

  (iii) physical constraints;

  (iv) the end user population;

  (v) system performance requirements (e.g. a trade-off between one requirement and another); and

  (vi) excessive cost.

For assets, or parts of assets, designed for specific groups of users, the design 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. These groups shall be identified as part of the design's context of use. 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.

The design shall incorporate shoe, clothing, and personal protective equipment allowances as appropriate when determining anthropometric values, for example, dimensions, reach envelopes, and forces.

9.3 Information content

Decisions regarding the design and content of the information presented to end users shall take into account its comprehension, visibility, legibility, importance, and adherence to established guidelines and standards.

The project shall determine the end users' requirements for the information to be provided. A project shall ensure that the way information is provided caters for those end users. Different end users may have different requirements, and this can require the design to provide more than one means of information presentation.

Any information presented shall be comprehensible, visible, and legible, from the expected viewing distances and positions under all expected environmental conditions.

The type of information displayed, the level of information required, the expected viewing distance, and the expected end user groups shall determine the size and type of the display and its contents.

(a) The design or provision of any information shall accommodate any specific requirements of the Disability Standards for Accessible Public Transport.

(b) All information provided shall be unambiguous and in English.

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

(d) Where non-operationally important information can possibly be required for other reasons (e.g., a supplier's logo or label can be a necessary identifier for maintenance purposes), it shall be inconspicuous.

NOTE:

"Inconspicuous" in the above requirement means that the item shall not feature properties (such as size, movement, brightness or colour contrast) to the extent that it visually "stands out" from its background or is more conspicuous than operationally important information.

9.4 Audibility and intelligibility of messages

Auditory information, including messages delivered acoustically, shall be audible and comprehensible to the intended end users within the expected range of acoustic environments.

The delivery of auditory information shall not be at a level that could cause hearing damage.

9.5 Alarms and alerts

HF requirements for alarms and alerts involve safety, sufficient information, relevance, prioritization, and accessibility. Methods of presenting alarms include, but are not limited to, audible, visual, and tactile means.

(a) Alarms shall enable the end users to take the required action to maintain the system in a safe and operable state or act appropriately in a degraded situation or emergency.

(b) The system shall comply with any specific requirements for alarms and alerts set out under the Disability Standards for Accessible Public Transport.

(c) Alarms and alerts shall contain sufficient information to allow the end user to take the required action in a timely manner.

(d) Alarms and alerts shall, where feasible, only be directed to the end user who is required to take action upon that alarm. For some roles, for example in a control room, it can be useful for another end user to be made aware of an alarm.

(e) Alarms and alerts shall be prioritized according to their impact on the safety of the system and the required action by the end user.

(f) No more than three levels of prioritisation of alarms shall be used.

(g) Alarms and alerts of different priorities shall be distinguishable by the end users.

(h) In the case that a single event raises multiple alarms or alerts, there shall be a single method of acknowledging all the related alarms providing this does not delete information that the user must rely upon for subsequent action. Design decisions affecting alarm response and/or cancellation actions shall be based on appropriate risk-based task analysis.

(i) End users shall be able to hear and, where applicable, distinguish between audible alarms within the expected range of acoustic environments.

(j) Assessments shall consider if end users will receive multiple alarms and alerts from different systems. In such instances and where feasible, the following shall be undertaken in collaboration with designers:

    (i) provide considerations for alarm and alert consistency requirements so to reduce the risk of conflict or human error in alarm management;

    (ii) unifying HMI presentation of alarms and alerts between systems;

    (iii) such requirements shall be verified and validated with end users; and

    (iv) Such requirements shall consider cognitive performance impacts for example human error and workload.

9.6 Controls and displays

Controls and displays include all means by which a user can provide input to the system and the system provides information to the user. They includes commercial off the shelve (COTS) products and those provided on or through a computer or other graphic user interface and status indications on equipment.

(a) All human-computer interfaces shall be designed in accordance with established human computer interaction (HCI) and usability guidelines. A project shall identify which standards or guidelines have been used to develop their interface and justify their application for the specific project.

(b) The layout and position of controls and displays shall be determined based on the principles of frequency, sequence of use, importance, and functional groups.

(c) Primary controls shall be within reach of the normal operating position allowing the end users to reach all controls safely.

(d) Controls which are infrequently used shall be accessible for the end users to reach safely.

(e) Primary displays shall be visible from the normal operating position.

(f) Control and display selection and operation shall incorporate relevant user conventions and mental models as far as is reasonably practicable when determining the appropriate operational movements.

(g) Control and display selection and operation shall incorporate other qualities for example symbols, icons, colours, and actions shall be consistent with other equipment used by the same end users.

(h) The type of display used shall be determined by the information requirements 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.

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

(j) Touchscreens shall be positioned:

    (i) 380 mm to 560 mm from the user's eye reference point; and

    (ii) to avoid upward reach by the end user.

(k) Controls shall be designed to minimize the potential for circumvention and inadvertent operation.

(l) It shall be impossible to place any control in a position that does not correspond to a designed state.

(m) In situations where controls can be used without direct viewing, the controls shall be differentiated using both visual and tactile means to minimize the risk of inadvertent operation.

(n) The control layout design and control selection shall minimize the likelihood of the inadvertent operation of a critical control. And no other controls shall be inadvertently operated in the belief that a critical control has been operated, e.g., e-stop.

(o) All labelling of controls and displays shall be comprehensible to end users.

(p) 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.

(q) The design shall consider future proofing calculations so that a nominal contingency for growth and expansion has been considered without risking impact to efficiency, safety or usability.

(r) The design shall consider staffing level calculations remain appropriate so:

(iii) not to risk overload;

(iv) operations remain safe, efficient and effective under all modes of operation that;

(v) are verified and validated with end users; and

(vi) suitable techniques that are comparable with the project life cycle and complexity of the proposed operation can be adopted.

NOTE:

Appendix B provides references and information about how the nature and context of Human Factors activities are influenced by the chosen procurement strategy, ranging from commercial off-the-shelf (COTS) to like-for-like replacement.

9.7 Automated systems:

Automated systems shall:

(a) provide sufficient information to keep the user informed of its operating mode, intent, function, and output. (these can also be applied to AI or other decision aids);

(b) inform the user of automation failure or degradation;

(c) inform the user if potentially unsafe modes are manually selected;

(d) not increase the demands for cognitive resources (thinking or conscious mental processes);

(e) prevent the removal of the user from the command role; and

(f) provide the user with an opportunity for detection and recovery from error.

9.8 Workspace and task design

Workspaces and tasks shall be designed to enable the end user to work safely, effectively, and comfortably.

(a) The design process shall ensure that workspace design:

(i) accounts for the difficulty, importance, frequency, and sequence of the tasks to be performed;

(ii) accounts for workflow relating to interactions between groups of end users and/or different roles;

(iii) eliminates or minimizes the potential for hazardous tasks to be performed;

(iv) eliminates or minimizes the potential for constrained work positions to be adopted;

(v) accounts for the environmental conditions that are relevant to performance of the task;

(vi) accounts for tools and equipment relevant to the performance of the task; and

(vii) appropriate considerations of anthropometrics.

(b) The design shall provide safe working space for maintainers. A range of body movements shall be considered when determining spatial provisions such as standing, kneeling, squatting, lying down, and stooping at a piece of equipment.

(c) Scenarios to map against any anthropometric analysis must consider reactive and planned maintenance. This must include the full end-to-end task sequence of the maintainer activities, including:

(i) access to the asset;

(ii) completing the actions with any equipment including consideration of Personal Protective Equipment (PPE) such as heavy clothing, helmets and boots;

(iii) completion of tasks; and

(iv) exit from the asset or site.

(d) The design shall consider the working space dimensions when determining spatial provisions to ensure that the maintainers shall have sufficient room to when working at a piece of equipment to:

(i) stand;

(ii) lie down;

(iii) stoop;

(iv) kneel; and

(v) squat.

(e) When an end user is required to maintain a stationary position for long periods, the workstation design shall allow the end user to maintain a comfortable working position with opportunities for substantial changes in posture, including alternation between sitting and standing, where feasible.

(f) Seating provided for the specified range of users shall be appropriate for the tasks to be conducted within the operating environment.

9.9 Glare, reflections, and line of sight

The design shall enable any line-of-sight requirements necessary for safe and effective operation of the system or asset. New structures or equipment shall not interfere with established operational line of sight requirements.

Glare and reflections shall be eliminated where feasible. Where elimination of glare and reflections is not feasible, glare and reflections shall be minimized within and on workstations, controls, and displays SFAIRP.

Methods shall be provided to eliminate or minimize reflections and glare in work areas, with particular attention given to crew cabs, control rooms and other dynamic or safety-critical locations.

9.10 Customers and the public

There are generic Human Factors requirements that are also specifically applicable to customers and the public. These are set out in the following sections.

9.10.1 Users with disabilities

Human Factors requirements for users with disabilities including those with Neurodiversity shall comply with legislation.

The design of all systems and assets, including customer accessible areas, service provision, and other facilities that require customer interaction, 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.

9.10.2 Assessment of bridges and structures

HF assessments in relation to bridges and fences shall verify and validate reduction controls to the risk of intrusion and climbability using Ergonomic modelling that considers anthropometric ranges using approved databases.

9.10.3 Information for customers and the public

Human Factors requirements for information for customers and the public relate to language use, clarity, ambiguity, symbols, and testing. Symbols and icons have been shown to be an effective way to convey information.

(a) All information for customers and the public shall be in English. However for precinct and plaza areas, secondary information for Culturally Linguistically Diverse (CALD) customers shall be considered.

(b) Where necessary for safety, specified as a business requirement, or otherwise considered appropriate, equivalent information shall also be provided in the other specified language(s).

(c) 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, unambiguous and avoid excessive or repetitive signage.

(d) Established or well recognized symbols and icons shall be used when they are available.

(e) The effectiveness of the proposed way of presenting information, including the use of new symbols and icons, shall be verified through end-user testing.

(f) The results of such tests shall be documented as evidence of their validity and conclusions.

9.10.4 Customer seating

The following applies to customer seating (including seating on transport vehicles):

(a) Seating dimensions shall be determined using anthropometric data for the specified end user population range. Any compromises to this requirement due to physical constraints (e.g., vehicle width limitations) shall be justified.

(b) Seat design and seating layout shall enable access and egress to all seats and thoroughfares (including through vehicles) under normal and emergency conditions.

(c) Handles and grips shall be associated with seating to help customers to get in and out of the seats and, in vehicles, to move through the vehicle.

(d) Maintain contrast and visibility of passenger equipment.

(e) Assurance shall be provided of the suitability of customer seating and standing arrangements. This may be provided through one of the following options:

  (i) User trialling with a representative sample of end users. The trialling shall replicate the layout and context as closely as possible.

  (ii) For off-the-shelf solutions, evidence of use in comparable contexts accompanied by appropriate justification of its use shall be acceptable.

9.10.5 Handrails, poles, and grab points on vehicles

On transport vehicles, handrails, poles and hand grabs shall be designed to enable the following:

(a) Assist passengers to safely access and egress the vehicle.

(b) Give steadying points for standing passengers whilst the vehicle is moving.

(c) Assist passengers to safely move around the vehicle.

(d) Lead people to the priority seating.

(e) Encourage movement away from obstructing doorways and passageways.

(f) Ensure smooth passenger movement without potential for catching clothes, bags or other personal items.

9.10.6 Passenger flows and wayfinding

Wayfinding systems aid users by providing information to support navigation, orientation, route decision-making, route progress monitoring and destination recognition.

Design of wayfinding systems shall include the following:

(a) Passenger flow modelling shall be used to support the design of publicly accessible areas.

(b) All signs used to support wayfinding shall be positioned to enable the user to easily locate, read, understand and act on the information provided in a timely manner and without obstructing passenger flow.

(c) Signs shall be positioned so they are legible from all directions and distances at which their information will be required.

(d) Signs shall be positioned at decision points to reduce stopping time and support continuous progression along a route.

(e) Wayfinding systems and signage shall be consistent and integrated with the existing built designs or purpose designed for new environments. Principal routes through a space shall be clearly defined. This may be achieved by the use of signs, spatial planning, lighting and surface finishes.

(f) A logical sequence of wayfinding information shall be provided to support user journeys along a route, not just at the origin and destination points.

(g) Accessible information shall be provided throughout a space to provide inclusivity for users with a range of different needs.

(h) Wayfinding information shall be provided in multiple ways or formats to support different types of end users and reinforce route cues. This shall include a combination of architectural features, graphics, dynamic displays, audible and tactile information, and text.

(i) Wayfinding systems and signage shall not impede operational sightlines.

9.10.7 Platform screen doors

HFI of Platform Screen Doors (PSDs) shall consider the following:

(a) Ergonomic reviews of space provisions for operations and maintenance of PSDs.

(b) Entrapment assessment needs to consider:

(i) relevant data population class, anthropometric data points (i.e. chest breadth and height);

(ii) undertake space-proofing/entrapment studies based on Australian population anthropometric sizes considering from 5th percentile children (male and female of 2-years of age) to 95^{th} percentile (male and female adult) to make sure that humans are not entrapped between PSD, platforms and rolling stock during all operational scenarios; and

(iii) the design is sized to prevent any person being trapped between the PSD and the Rolling Stock.

Appendix A RISSB Hazard Register (Informative)

The table below identifies the hazards listed in the RISSB Hazard Guideline that are addressed, at least, to some extent by the contents of this Standard. In many cases other controls, for example technological etc., will also be required to mitigate the overall risk so far as reasonably practicable. For this reason, the table below is to be considered only illustrative.

Hazard Number	Hazard	Heading Number
4.1 Harm to the environment	Poor maintenance of locomotives Poor maintenance of plant and equipment Poor infrastructure maintenance	2,3,4,5,6,7,9
Harm to the environment (Rolling Stock)	5.9.1.2 Network control error 5.9.1.19 Poor cab vision so that the driver effectively 'ignores' signals	2,3,4,5,6,7,9
5.5 Harm to rolling stock related processes	5.5.1.45 Design deficiency causing the inability to operate trains	2,3,4,5,6,7,9
5.6 Out of Control Train	Background noise level in train being too high so that train crews are unable to hear the telecommunication system resulting in Train Control and train crews being unable to communicate Speaker levels in trains are too soft so that train crews are unable to hear the telecommunication system resulting in Train Control and train crews being unable to communicate 5.6.1.37 Alarms being inadequate	2,3,4,5,6,7,9
5.8 Collision	5.8.1.5 Poor cab vision causing collision with stop blocks 5.8.1.21 Poor cab vision	2,3,4,5,6,7,9
5.9 SPAD	5.9.1.19 Poor cab vision so that the driver effectively 'ignores' signals	2,3,4,5,6,7,9
5.11 Brakes ineffective when stationary	5.11.1.3 Hand / park brakes not being applied	2,3,4,5,6,7,9
5.14 Alerting System Failure	Alarms lacking visibility or audibility (Alerting system alarms not noticed) Alarms lack differentiation to other alarms (Alerting system alarms not noticed) 5.14.1.14 Methods of monitoring not being applicable to all sizes, shapes, mass etc. of the driver population (Failure of the deadman system)	2,3,4,5,6,7,9

Hazard Number	Hazard	Heading Number
5.17 Poor Cab Vision	Blinds restricting vision Glare from cab instrument lighting Glare from oncoming headlights Glare from the sun through windscreens or off consoles Windscreens being too small in area (Windscreens affecting vision) Windscreens being badly scratched or cracked (Windscreens affecting vision) The view from seating positions being affected by cab structures and / or equipment (Seating position affecting vision) Short persons with low seats and high windscreens (Seating position affecting vision) Tall persons and seats with low windscreens (Seating position affecting vision)	2,3,4,5,6,7,9
5.20 Driver Fatigue	5.20.1.3 Complicated, continuous cognitive functioning being required to operate trains 5.20.1.8 Excessive cab control equipment forces 5.20.1.10 Uncomfortable temperature 5.20.1.11 Displays being difficult to read Uncomfortable controls creating an uncomfortable driving position Uncomfortable seats creating an uncomfortable driving position Inadequate room for persons creating an uncomfortable driving position Controls and footrests being too far from seating positions creating an uncomfortable driving position	2,3,4,5,6,7,9
5.21 Driver Distraction	5.21.1.1 Continual interruptions / messages from the train management system 5.21.1.5 Drivers being distracted by alarms or other controls and equipment	2,3,4,5,6,7,9
5.22 Over speed	5.22.1.6 Speedometer arrangement being inconsistent with other rolling stock	2,3,4,5,6,7,9
5.45 Evacuation	5.45.1.3 No instructions being provided so persons do not know how to evacuate (Evacuation not successfully initiated)	2,3,4,5,6,7,9
5.47 Brakes applied too little to late	Brake controls not being within reach (Driver applies brakes too late) Being unable to move brake controllers into higher rate positions (Driver applies insufficient brake)	2,3,4,5,6,7,9

Hazard Number	Hazard	Heading Number
5.50 Unintended brake application	5.50.1.1 Crews accidentally applying emergency brakes	2,3,4,5,6,7,9
5.51 Inadequate vehicular access	Trips and falls Inadequate or missing handrails or hand holds No exterior stairs or ladders	2,3,4,5,6,7,9
	5.51.1.5 Access paths being too narrow or not tall enough 5.51.1.10 Not meeting DSAPT standards (Not suitable for persons with a disability, the elderly, prams, etc.).	2,3,4,5,6,7,9
6.6 Harm to infrastructure	6.6.1.33 Driver error	2,3,4,5,6,7,9
6.11 Collision	6.11.1.8 Poor cab vision	2,3,4,5,6,7,9
6.12 Poor cab vision	Short drivers with low seats and high windscreens Tall drivers having seats with low windscreens Driving position views being obstructed by cab structures and equipment	2,3,4,5,6,7,9
6.18 Falls	6.18.1.44 Poor lighting	2,3,4,5,6,7,9
Collision Harm to persons Damage to Rolling Stock Harm to environment	7.1.1.13 Poor ergonomic design 7.1.1.15 Poor equipment layout 7.2.1.13 Poor ergonomic design 7.2.1.15 Poor equipment layout 7.3.1.5 Poor resources and or excessive workload 7.3.1.13 Poor ergonomic design 7.3.1.15 Poor equipment layout 7.4.1.13 Poor ergonomic design 7.4.1.15 Poor equipment layout	2,3,4,5,6,7,9
8.4.11.24 & 8.4.11.33 LPA Authorization error by NCO	Blocking inadvertently removed	2,3,4,5,6,7,9
9.5 Wireless Comms Failure	9.5.1.1 Human factors interfaces 9.5.1.12 Ergonomics	2,3,4,5,6,7,9
9.10 Signals failure	9.10.1.3 Failure to consider signal sighting	2,3,4,5,6,7,9
9.11 Train authority system failure	9.11.1.7 Human factors requirements not being considered	2,3,4,5,6,7,9
9.18 Control system failure	9.18.1.8 Ergonomics	2,3,4,5,6,7,9

Appendix B Commercial off the shelf and like-for-like procurement (Normative)

RISSB Guideline for the Integration of Human in Engineering Design mentions that the nature and context of the HF activities depends on the adopted procurement strategy. The procurement strategy can range from commercial off the shelf (COTS) through to like-for-like replacement.

For COTS procurement, organizations may choose to select, elaborate, or enhance some of the design requirements described in the document. The number of HF design requirements can vary depending on whether the COTS item is used in isolation or in combination with other systems. The organization shall decide which design requirements are appropriate based on the context in which the equipment will be used and the complexity and risk of the overall project.

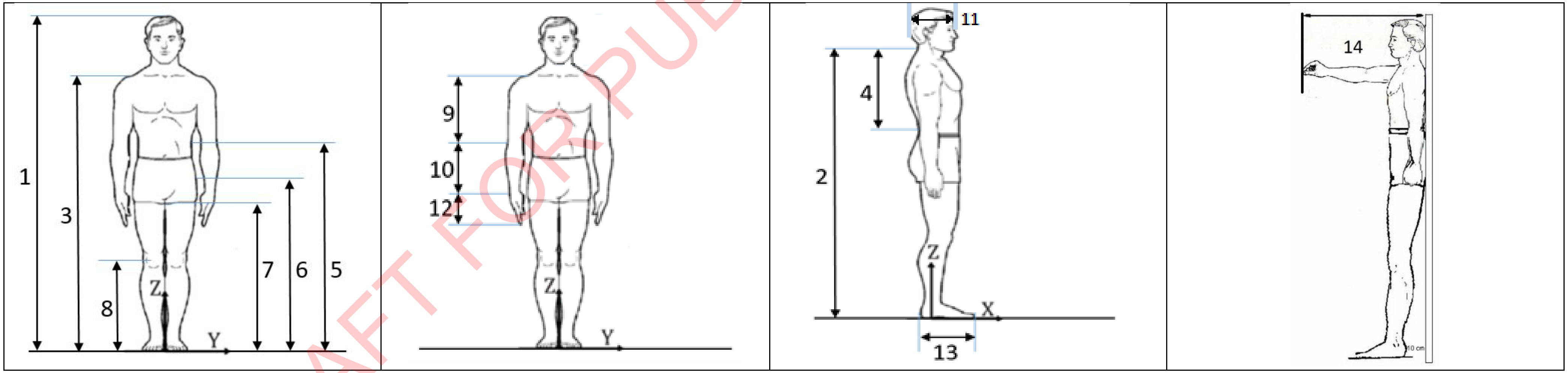
In the case of like-for-like replacement, detailed HF analysis can be less important for smaller and less complex changes. However, it is still important to consider HF in these projects as there can be lessons learned from the operational or maintenance context that could further improve performance. Additionally, even in like-for-like replacements, there can still be changes at a system level that need to be considered.

Overall, the procurement strategy involving COTS and like-for-like replacement shall consider the specific requirements of the project, the context of use, and the potential impact on Human Factors and user experience.

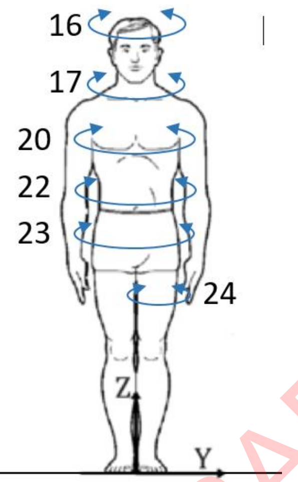
Appendix C Australian anthropometric data (Informative)

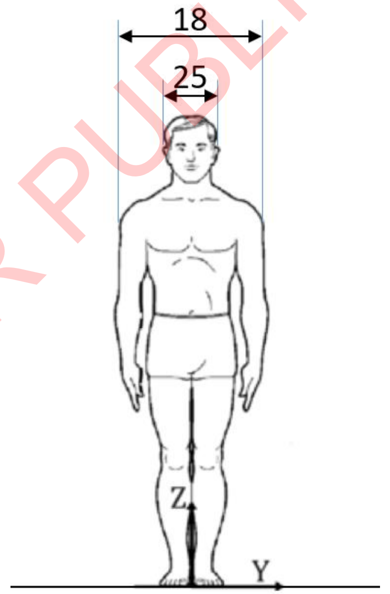
Australian anthropometry - adults 18-64 years old. - Standing measurements – heights and lengths (cm)

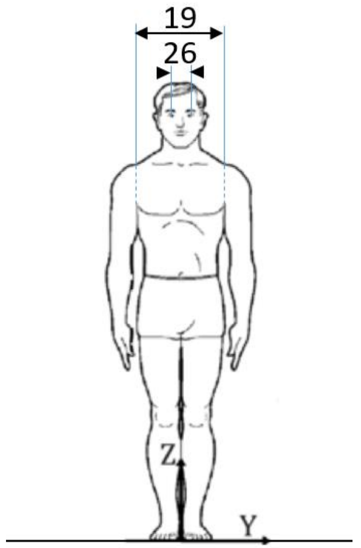
	Males							Females						
Percentile	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**
1. Stature	159.7	163.1	170.8	176.1	181.2	188.7	194.0	147.4	151.5	157.9	162.5	167.5	174.2	179.3
2. Cervicale height	135.4	140.6	147.0	152.0	156.8	163.8	168.6	125.8	129.8	135.4	139.8	144.2	150.2	155.2
3. Acromion height	128.3	133.3	139.6	144.7	149.1	156.5	160.3	118.9	123.1	129.5	133.6	137.9	143.9	148.4
4. Back length (waist back)	40.2	42.2	45.1	47.6	50.0	53.5	56.1	33.9	35.1	37.6	39.4	41.0	44.0	46.6
5. Waist height	89.6	94.0	99.3	103.0	107.3	112.5	116.5	88.9	91.4	96.5	100.3	103.7	109.5	113.3
6. Hip height (at max. circ.)	75.1	79.2	84.3	88.2	91.6	97.0	102.8	69.8	72.9	77.4	81.2	86.1	93.8	98.1
7. Crotch height	67.0	70.4	75.6	79.1	82.6	87.4	91.5	63.8	66.4	70.9	73.9	76.9	81.4	84.6
8. Knee height standing	42.6	44.6	47.2	49.1	51.2	53.7	56.0	38.8	40.1	42.3	44.0	45.9	48.4	49.9
9. Acromion-radiale length	27.9	29.5	31.3	32.6	34.0	35.8	36.8	25.7	27.1	28.6	29.8	31.1	32.9	34.5
10. Radiale-stylion length	23.0	24.0	25.3	26.2	27.4	29.0	30.6	20.5	21.5	22.7	23.7	24.7	26.1	27.3
11. Head length	18.3	18.7	19.6	20.0	20.5	21.3	21.8	17.0	17.6	18.3	18.8	19.3	19.9	20.3
12. Hand length	17.9	18.6	19.5	20.2	20.9	22.0	23.1	16.1	16.6	17.4	18.1	18.8	19.8	20.8
13. Foot length	23.2	24.4	25.7	26.6	27.7	29.0	30.4	21.3	22.0	23.0	23.9	24.8	25.9	27.0
14. Thumb tip reach	71.4	73.6	77.8	80.6	83.8	87.5	91.0	65.2	67.8	70.7	73.6	76.3	79.7	83.1



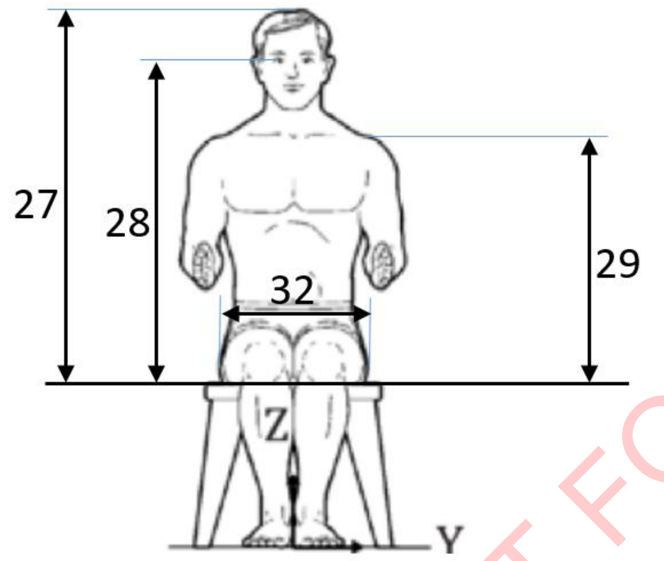
Australian anthropometry - adults 18-64 years old. - Standing measurements – weight, circumferences, breadths, and widths (cm)														
	Males							Females						
Percentile	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**
15. Weight (kg)	56.2	63.5	75.3	85.5	98.0	118.1	134.7	45.1	50.3	59.6	69.8	83.4	105.7	121.3
16. Head circumference	54.4	55.3	56.8	57.9	58.9	60.7	61.7	52.0	52.5	54.0	55.3	56.5	58.5	60.2
17. Neck circumference	40.9	42.5	44.9	46.7	48.7	52.1	55.1	36.1	37.4	39.5	41.2	43.0	46.9	49.2
18. Shoulder breadth	42.5	44.2	47.5	49.7	52.2	55.6	59.0	37.2	38.7	41.2	43.2	45.9	49.8	54.5
19. Back width	34.2	35.7	38.2	40.3	42.2	44.8	47.7	30.4	32.1	34.3	36.2	38.8	42.5	45.1
20. Chest circumference	84.3	88.8	97.6	104.2	112.1	122.8	135.3	78.4	82.2	90.0	96.9	108.2	123.0	137.1
21. Chest circ. under bust								66.7	69.5	75.2	80.4	88.5	101.5	110.2
22. Waist circumference	70.0	75.8	84.5	90.9	99.3	115.1	131.1	61.1	64.1	72.1	79.7	91.5	107.7	119.8
23. Hip circumference	87.2	92.3	99.3	104.7	111.0	121.6	131.3	88.2	91.7	98.9	106.6	116.1	133.3	143.7
24. Thigh circumference	47.7	52.5	57.3	61.1	65.3	73.1	78.1	48.6	51.6	56.7	61.7	67.7	77.3	82.0
25. Head breadth	14.2	14.6	15.2	15.6	15.9	16.6	17.2	13.4	13.8	14.4	14.7	15.1	15.7	16.2
26. Inter-pupillary distance	5.7	5.9	6.4	6.8	7.2	7.8	8.3	5.3	5.8	6.3	6.6	7.0	7.5	7.9

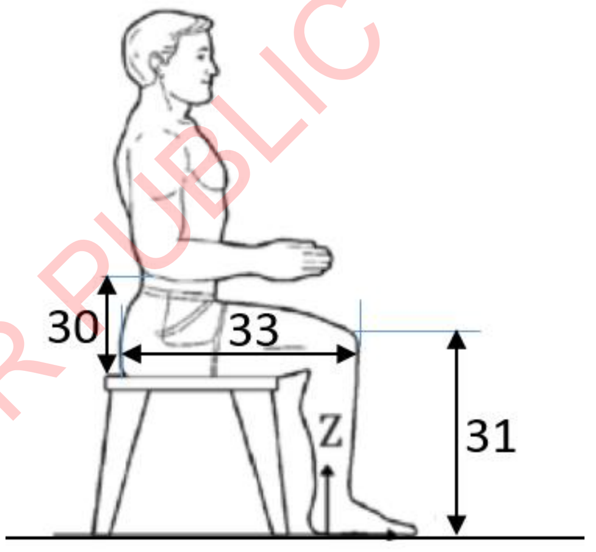


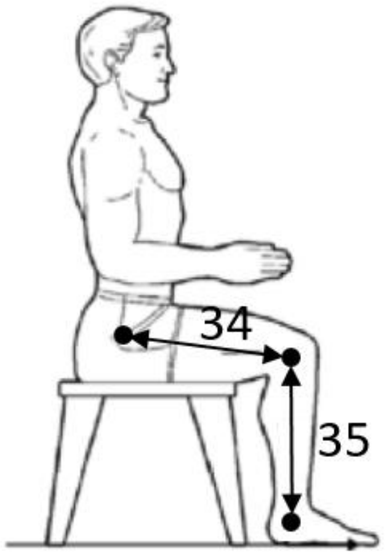




Australian anthropometry - adults 18-64 years old - Sitting measurements (cm)														
	Males							Females						
Percentile	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**
27. Sitting height	82.7	85.1	89.1	91.8	94.5	98.0	101.4	77.2	80.1	83.7	85.9	88.1	91.8	94.4
28. Eye height sitting	71.5	73.7	77.7	80.1	82.6	86.1	89.1	66.9	69.5	72.8	74.9	77.2	80.5	83.3
29. Acromion height sitting	53.1	54.7	57.9	60.3	62.6	65.5	67.6	49.9	51.9	54.5	56.5	58.5	61.2	63.8
30. Elbow height sitting	17.5	19.1	22.1	24.1	26.2	28.9	30.4	17.3	19.4	21.8	23.6	25.4	28.0	30.4
31. Knee height sitting	48.3	50.8	53.6	55.7	57.8	60.5	63.3	44.8	46.2	48.7	50.4	52.6	55.0	57.1
32. Hip breadth sitting	31.1	33.4	36.1	38.1	40.6	44.6	48.1	33.8	35.2	38.3	41.4	44.9	50.7	53.7
33. Buttock-knee length	53.4	55.9	59.5	61.6	63.6	67.2	70.2	50.8	53.0	56.4	58.6	61.6	64.9	68.8
34. Thigh length	37.0	38.9	41.7	43.5	45.2	47.7	49.6	34.6	36.4	39.0	41.0	42.8	45.5	47.4
35. Shank length	35.2	36.8	38.9	40.6	42.3	44.5	46.5	32.5	33.3	35.2	36.7	38.2	40.3	41.8

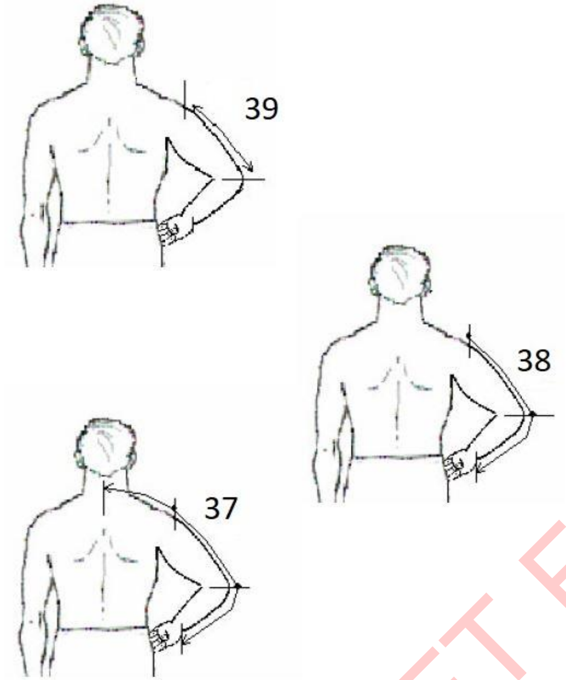


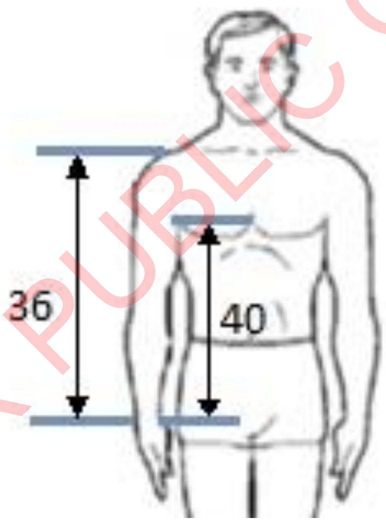


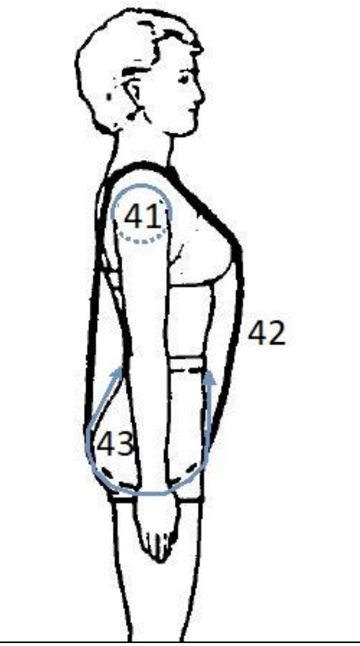


Australian anthropometry - adults 18-64 years old - Clothing related measurements (cm)

	Males							Females						
Percentile	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**
36. Sleeve outseam	50.7	52.7	55.6	57.7	60.0	62.9	65.3	46.3	48.0	50.2	52.2	54.4	57.4	59.3
37. Spine-wrist length	76.6	79.2	83.1	85.5	88.3	92.4	95.2	69.6	71.8	74.8	77.5	80.2	83.9	86.4
38. Shoulder-wrist length	56.4	58.5	61.7	63.8	66.3	69.9	72.5	51.1	53.0	55.7	58.0	60.4	63.6	65.5
39. Shoulder-elbow length	28.8	30.5	32.3	33.6	35.0	37.3	38.8	27.0	28.1	29.9	31.2	32.6	34.4	36.3
40. Arm inseam	39.3	40.4	43.0	45.1	47.4	50.2	52.2	35.4	37.3	40.1	41.8	43.9	46.8	48.4
41. Armscye circumference	37.0	39.0	42.6	45.1	47.9	52.5	54.8	31.9	33.5	36.6	39.1	42.6	48.5	51.4
42. Trunk circumference	153.1	156.3	165.4	171.7	179.2	190.3	198.6	139.6	144.1	151.7	158.2	165.9	179.5	185.8
43. Crotch length	54.3	57.3	61.7	64.7	68.7	78.0	84.8	54.5	59.2	66.3	70.8	75.8	83.3	88.1

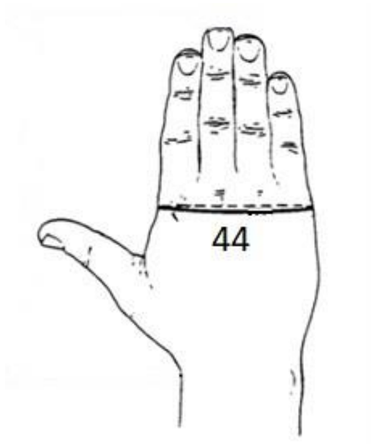


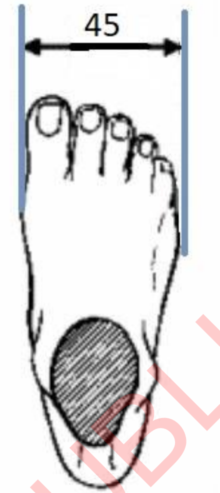


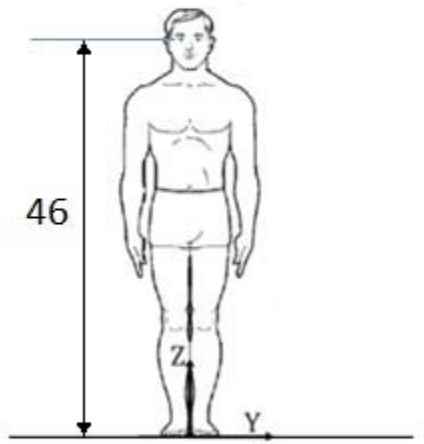


Australian anthropometry - adults 18-64 years old – Foot, Hand, Standing (additional measures) (cm)

	Males							Females						
Percentile	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**	**1st**	**5th**	**25th**	**50th**	**75th**	**95th**	**99th**
44. Hand Circumference	18.8	19.4	20.5	21.2	22	23.1	23.7	16.2	16.9	17.8	18.5	19.2	20.3	21.1
45. Foot Breadth (Rt)	8.8	9.2	10	10.5	11	11.7	12.1	7.6	8.2	8.9	9.3	9.9	10.6	11.1
46. Standing Eye Height (Rt)	145.8	149.4	156.6	162	167.2	174.8	180.2	135.2	138.8	145	149.8	154.4	161	166.6







Australian child anthropometry – boys (2-17 years old)										
Percentile		**1st**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**99th**
2-3 years old	Weight (kg)	11.3	12.3	12.8	14	15.3	17	19	20	22.6
n = 575	Height (cm)	81.3	86	88	91.2	96.9	101	105	107	108.9
	Waist circumference (cm)	41	45	46	49	52	54	56	57	63
4-5 years old	Weight (kg)	14	15.4	16.3	18	20	22.6	27.4	31	42.5
n = 585	Height (cm)	97	100	102	106	111	117	125	134.5	144.6
	Waist circumference (cm)	44	47	49	52	55	58	62	66.9	70.3
6-7 years old	Weight (kg)	16.6	18.8	19.9	22	24.7	29.1	34.8	38	44.4
n = 507	Height (cm)	105	111	113	119	124	130	135	139	143.9
	Waist circumference (cm)	47	50	51	54	57	61.2	68	72	79.9
8-9 years old	Weight (kg)	17.9	20.4	22.1	25.5	30.1	35.6	42	47	54.6
n = 524	Height (cm)	106.2	113.7	119	127	132.6	139	144	146.8	151.3
	Waist circumference (cm)	48	51	53	56.9	60	67	73.3	77	89.6
10-11 years old	Weight (kg)	25.5	29.3	30.5	33.9	40.4	49	57.4	61.8	75.6
n = 486	Height (cm)	127.4	133.2	136	141	146.7	152	157	158.9	165.8
	Waist circumference (cm)	52.9	56	58	61.5	67	75	83	88.8	96.1
12-13 years old	Weight (kg)	32.5	36.6	38.5	44	51.8	60.2	73.9	82.4	98
n = 466	Height (cm)	140.7	146	148.4	153.1	160.3	167.5	173.5	177.9	183.4
	Waist circumference (cm)	53.9	60	61.9	66.1	72	80	91.8	99	115
14-15 years old	Weight (kg)	35.3	41.9	45.5	53	61.5	71.3	83.4	90	104.9
n = 546	Height (cm)	145.1	152.3	157.1	165	171.1	177	183	185.5	189.2
	Waist circumference (cm)	57.5	63	65	70	76	84.5	93	97.8	109.1
16-17 years old	Weight (kg)	47.8	52.3	55.2	61.8	70.6	82.2	94.8	103	126.3
n = 590	Height (cm)	158	163	167	171	176.5	182.5	187	188.4	192.2
	Waist circumference (cm)	62.9	67.4	70	74	79	89	99	104.5	119.3

NOTE:

It is difficult to report child data as they are constantly growing. These tables present child measurements in 2-year segments, with the final design dependent on the application requirements.

Australian child anthropometry – girls (2-17 years old)										
Percentile		**1st**	**5th**	**10th**	**25th**	**50th**	**75th**	**90th**	**95th**	**99th**
2-3 years old	Weight (kg)	9.9	11.4	11.8	13.2	14.8	16.1	18	19.4	26.3
n = 550	Height (cm)	76.5	84	86	89.6	95	99.7	104	106	110
	Waist circumference (cm)	39.5	45	45	48	50	53	56	59	65
4-5 years old	Weight (kg)	13.2	15.3	16.1	17.6	19.8	22.8	28	33.3	41.3
n = 569	Height (cm)	94.4	99.6	101.9	106	111	117	126.1	132.7	142.1
	Waist circumference (cm)	44	47	49	51	54.3	58	63	68	76.6
6-7 years old	Weight (kg)	16.6	18.1	19	21.2	24	28.8	34.5	40	46.4
n = 465	Height (cm)	103.8	108.6	111	116.5	123	129	134	139.3	148.1
	Waist circumference (cm)	44.6	48	50	53	56.6	61	67	72.4	82
8-9 years old	Weight (kg)	17.4	19.3	21	24	28.3	34.2	41	45	50.1
n = 454	Height (cm)	105.3	112	115.5	123	131	136.8	143	147	153.2
	Waist circumference (cm)	46	50.3	52	55	59.5	65.2	70.2	75.3	81.5
10-11 years old	Weight (kg)	25.1	29.1	30.6	34	39.7	46.5	54.1	58.1	77.6
n = 459	Height (cm)	130	134	137	142	147.5	153	157	160	164.4
	Waist circumference (cm)	50	54.5	56	59	65	71	77.5	81	96.9
12-13 years old	Weight (kg)	33.9	35.5	40.2	44	50.4	58.3	68	75	89.1
n = 436	Height (cm)	138.4	143.5	148.3	153	158	163	168	170	175
	Waist circumference (cm)	56	60	61	64	68.9	75.5	84	87.5	103.2
14-15 years old	Weight (kg)	36.1	41.2	44.3	50.8	57.2	66	79	86.2	106.7
n = 503	Height (cm)	146	151	153	158	163	167	171.1	174.9	179
	Waist circumference (cm)	57	60	62.1	66	72	79	89	95	106
16-17 years old	Weight (kg)	40.1	46.4	49	54.1	60.7	68.6	79.2	87.2	108.1
n = 607	Height (cm)	149	153	155	159	164	169.4	173	175	179
	Waist circumference (cm)	58.1	63	65	69	73	81	88	94	111.1

NOTE:

It is difficult to report child data as they are constantly growing. These tables present child measurements in 2-year segments, with the final design dependent on the application requirements.

Guidance Notes:

1. The anthropometric dimensions above are given for semi-nude individuals, i.e., in underwear. In real life situations, one must account for clothing, shoes and other equipment. As a general rule, we recommend adding 40mm to stature (and other heights when relevant) to account for footwear, and 20mm to widths and depths to account for clothing. For specific Personal Protective Equipment, it is important to aim to acquire correction values relevant to the equipment being considered.

2. These data have been created using a published validated method, which uses statistics to reweight an existing anthropometric dataset with representative body size data from Australian Bureau of Statistics Health Surveys. These data were found to be the most representative dataset that currently exists for the Australian population. Other datasets, including the commonly used Peoplesize 2020, were found to be inaccurate and unrepresentative in comparison. Where a measure does not exist in the AS7470 dataset then the Human Factors specialist has flexibility to select that measure from an alternative dataset, after carefully considering the representativeness and any associated risks or implications for the related design decision. The measures presented here are the most commonly used 46 for Human Factors analyses, an additional 53 measures are available in the original iMOVE dataset for any other purposes.

3. Some measures were originally measured on both left and right sides in the source dataset. Differences between right and left on the same person were found to be negligible, therefore the summary statistics presented here are the average of both measures (applies to # 8,9,10,29,34,35,36,40).

Reference for data is: (2023) iMOVE 6-002 Australian Size Variation for Design M004: Detailed anthropometry dataset. (2023) Fraysse, F., Wade, A., Furnell, A., Kirsch, C., and Murray, P.

Appendix D Bibliography (Informative)

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

- ISO 18152:2010, *Ergonomics of human-system interaction – Specification for the process assessment of human-system issues*
- ISO 9241 Series, *Ergonomics of human-system interaction, including Part 820: Ergonomic guidance on interactions in immersive environments including augmented reality, and virtual reality*
- ISO 1164, *Ergonomic design of control centres parts 1-7*
- MIL-STD-1472H, *DEPARTMENT OF DEFENSE DESIGN CRITERIA STANDARD: HUMAN ENGINEERING (15-SEP-2020)*
- *INCOSE Systems Engineering Handbook - A Guide for System Life Cycle Processes and Activities. 5TH edition, 2023*
- *International Ergonomics Association (IEA) 2000, Definition of Human Factors, Cognitive Ergonomics and Physical Ergonomics accessed 19/07/2024*
- *ONRSR SFAIRP Guideline*
- *RISSB Safe Decisions*