Human Factors Integration (HFI)

Practical Guidance for IPTs

Tables

Figures

Contents

Foreword by Deputy Chief of the Defence Staff (Equipment Capability)

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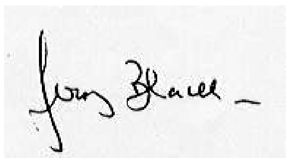
Capability is not just a function of equipment performance, but depends on a combination of interacting elements. Some of the most difficult issues to address lie in the human factors area. The types of systems we are specifying and procuring now will shape the roles, responsibilities and career paths of future servicemen and women. They will also have to be operated in very demanding circumstances of fatigue, hunger, stress and even fear, by the sort of men and women we recruit. They will therefore determine not just the working environment of our people but ultimately, their utility in these harsh conditions will determine our operational success and our ability to retain the right people.

Approaching our defence needs from a capability direction, rather than a platform or replacement one, will heighten the need for HFI to contribute to acquisition. We must set out to deliver solutions that balance our equipment aspirations with a more sophisticated understanding of the role of people in the operation of our future systems. The challenge is to integrate the people provided by the Armed Forces, with the equipment developed by industry and delivered by the Defence Procurement Agency, in a way that maximises capability within the real operational environment.

Everyone involved in the acquisition process must understand the operational environment and be sensitive to the need for HFI. Getting it right at the outset is the key to success. To assist Capability Working Groups and Integrated Project Teams this HFI guidance document has been developed and harmonised with the SPI procedures laid down in the AMS.

HFI remains a key factor in the drive to improve military capability and equipment cost effectiveness, and we must build on the foundation already established in applying human factors to future projects.



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This guide has been developed under MoD Corporate Research Package TG5, a strategic research package that helps provide the tools and methods necessary to implement the HFI approach. The guide is intended for people who have a responsibility for ensuring that appropriate HFI activities are undertaken in an acquisition project (members of Integrated Project Teams (IPTs) and Capability Working Groups (CWGs) who between them share the responsibility for HFI).

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1. Introduction

1.1 Scope of the guide

MoD recognises the crucial role of the human element of military capability. The 'Integration' part of HFI means it is not a stand-alone discipline. HF activities must be made to influence engineering and other decisions about procured equipment, manpower and training provision. This guide offers practical advice on how to conduct HFI as an integral part of a project within the MoD acquisition process. It explains how to use HFI to help achieve the acquisition goals of 'better, faster and cheaper'. In particular, the guide:

- ∆ Gives a whole life perspective on the application of HFI within a project, from Concept onwards
- ∆ Defines a common approach to be adopted by MoD acquisition projects for identifying and managing human-related risks and opportunities
- ∆ Offers advice on how to undertake the core HFI activities in support of project objectives
- ∆ Describes HFI contributions to add value to project outputs
- ∆ Gives guidance on the contribution that can be made by specialist technical activities
- ∆ Advises how to perform a high-level pass of technical tasks when time, resources and priorities do not allow you to bring in specialist support
- ∆ Provides guidance on co-ordinating HFI activities with other stakeholders.

1.2 Who should use this guide

This guide is for members of Integrated Project Teams (IPTs) who have a responsibility for HFI. It is mainly intended for people who are not HFI specialists. It will also be of interest to members of Capability Working Groups who wish to understand how the IPT's work relates to their own responsibilities for HFI, as explained in the leaflet *HFI and Capability management*.

The guidance is for the 'HFI Focus'. This is a mandatory role, but in practice the responsibility for HFI might be shared by another role within the team. In any case, even though one person might be co-ordinating HFI, most members of the team should be aware of how HFI affects their roles, particularly:

- ∆ IPT Leader
- ∆ Project Engineer
- ∆ Requirements Manager
- ∆ Integrated Logistics Support (ILS) Manager
- ∆ Equipment Support Manager.
- ∆ Associate IPT members representing:
  Training, Safety, Operational Analysis, Service use.

2. HFI within a project

HFI is one discipline embedded within a project. It cannot be conducted in isolation, and is very dependent on relationships with the large number of other players who have a stake in the people aspects of capability, and hence a stake in HFI.

2.1 HFI process

The core process of HFI is very simple, and is focussed round an understanding of human related issues that might represent risks, requirements or opportunities for the project. Four key processes surround this central set of issues:

- Identifying (& managing) the Issues – the driving process
- Supporting analysis – necessary to underpin decisions and plans
- Co-ordination – essential to avoid duplication and mismatch
- Contribution to project outputs – how the value gets added

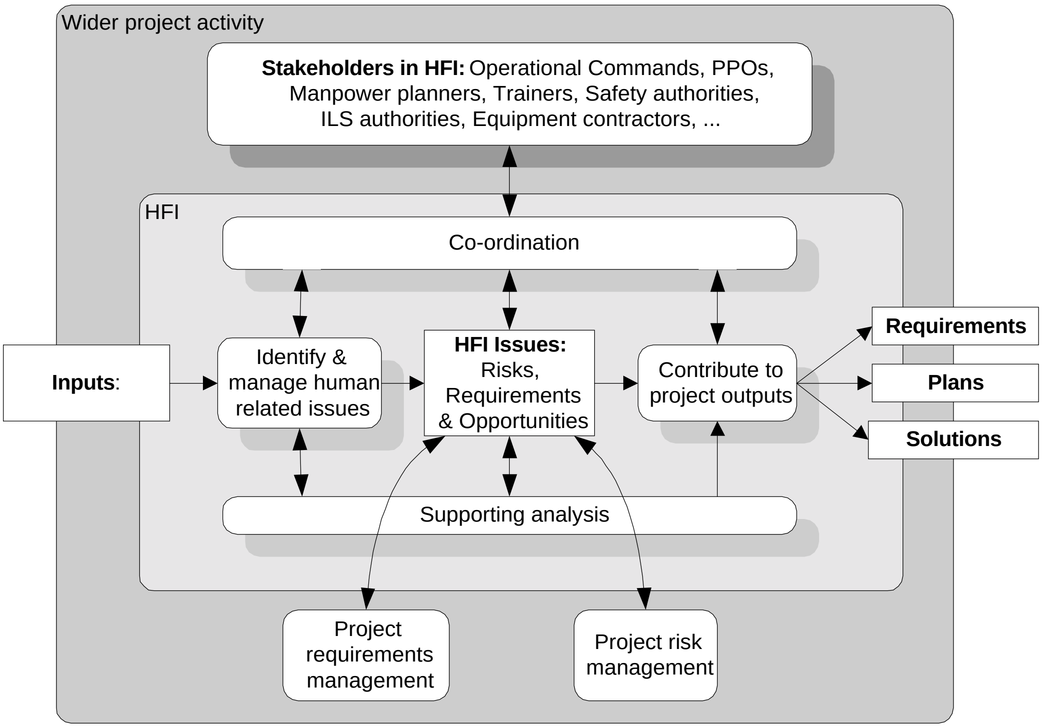

Figure 1 HFI process within a project

2.2 HFI relationships

Good HFI depends on good relationships, as well as on well-applied knowledge. Many organisations and specialities have a stake in HFI. Involve stakeholders early.

- ∆ Identify key and peripheral stakeholders (including those who will be useful sources of information and those who will be affected by the project). See Figure 2 and Table 1 below.
- ∆ Identify and make contact with those who can contribute to thinking on HFI (e.g. those organisations that hold information about user characteristics, lessons learned from in-service equipment and knowledge about future technologies and operations).
- ∆ Review other project plans and activities for required HFI inputs

Within MoD, HFI concerns are grouped into six domains that relate closely to the different groups of HFI stakeholders (Section 6.1 defines HFI Domains)

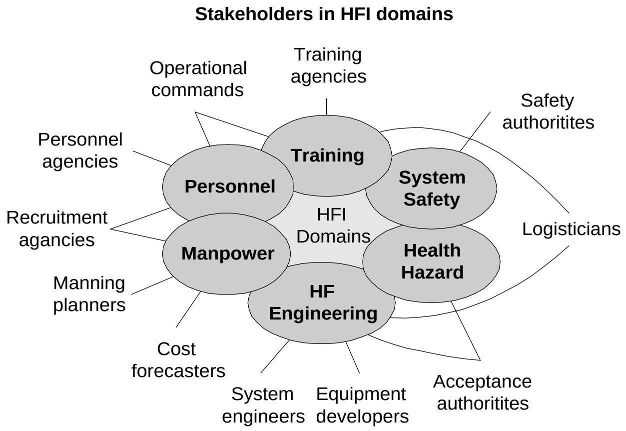

Figure 2 Stakeholders related to HFI domains

Be aware that some terms are used differently by different stakeholders (see section 6.5)

HFI concerns cross-organisational boundaries within MoD, and responsibilities within the project team. The emphasis of HFI should be on integration across the whole system. The range of issues covered by the HFI activity will usually be far larger than the available resources can support. Effective sharing and re-use of activities and information from other areas of the project can significantly add to what HFI can achieve from its own budget.

- ∆ Encourage different stakeholders to share common data (e.g. about tasks) instead of generating separate versions of the same thing.

Table 1 Key relationships & shared interests

Stakeholder	Shared Interest	Stakeholder's role	Your role (HFI Focus in IPT)	Notes
Manpower planners or complementers	Manpower	Develop feasible schemes to man the system or platform.	Ensure links to other activities that influence manpower needs, e.g. automation, design of team structures.	Complementing is a highly constrained process that has to iterate over several stages.
HFI analyst (or ILS analyst or Training Analyst)	Task analysis	Analyse user tasks, and their implications for workload, performance, error, etc., in appropriate detail.	Ensure they understand the required scope and context, and have access to relevant users, domain experts and information. Review and promulgate the result.	HFI specialists will have the expertise to do the analysis, but typically need military, system and other factual input.
System engineers	Prototyping	Build and evaluate partial solution representations.	Ensure prototype relates to HFI risks and can be evaluated by potential users and/or human interaction specialists.	Engineers are normally keen for user involvement, providing the ground rules are clear.
Safety authorities, system engineers	Safety	Analyse potential system hazards and how to reduce them. Develop safety case to demonstrate acceptable level of risk.	Help quantify human contribution to potential hazard. Identify ways to minimise the risk of human related failures.	Judgement based on operational experience might be adequate for a first pass, but seek specialist advice on human errors and the factors that contribute to it.
Training analyst (HFI analyst)	Training Needs Analysis (TNA)	Identify training gap and how to close it (by training provision or making system easier to learn).	Ensure TNA is done early enough to influence design. Ensure continuity with more formal analysis to define training.	TNA for training purposes is normally done later, and in more detail than TNA to influence design. See *Tri-Service Guide to Training Needs Analysis.*
Operational Analyst	Mission Analysis, scenarios	Define scenarios to represent the threat, and typical missions to test the whole system	Identify related HFI issues. Ensure missions feed HF analysis. Elaborate scenarios to test the human component.	Ensure scenarios provide enough information for contractors calculations and assessments of critical human performance, workload, etc.

Stakeholder	Shared Interest	Stakeholder's role	Your role (HFI Focus in IPT)	Notes
Requirements manager, Systems engineers	System requirement	Produce manageable, consistent and testable requirements on which to base contracts and design decisions. Reconcile conflicts.	Ensure human related requirements are captured and adequately specified.	Requirements Engineering is an extended, iterative process.
Specifier, acceptance authority, operational staffs	Test, evaluation & Acceptance	Specify how the system will be evaluated and accepted. Monitor early evaluation. Oversee acceptance.	Ensure requirements for human related performance are adequately specified. Ensure ITEAP includes methods and procedures to detect risks of human related failure early enough to take remedial action.	Work with the acceptance authorities to ensure they recognise HFI goals and accept HFI input.
Operational analyst and Cost forecaster (and HFI specialist)	COEIA (Combined Operational Effectiveness & Investment Appraisal)	Develop criteria and method to quantify system effectiveness and costs in a way that differentiates between options	Ensure the analysis can differentiate between the different human components in the options. Ensure that adequate data on human performance can be obtained or approximated	Some Measures of Effectiveness (MoEs) should be directly sensitive to human performance.
Scrutineer	COEIA	Review and advise on validity of the COEIA analysis	As above	As above
ILS analyst	Logistics support (ILS)	Prepare information for all aspects of system support. Influence design to be supportable. Support the system.	To ensure human aspects of support are integrated and used to influence design.	ILS manages human as well as equipment information, including training and support.
HFI specialist (or training analyst or ILS analyst)	Target audience description (TAD)	To provide timely, reliable, usable information about the human component.	Agree required scope and level of detail. Facilitate access to sources of information. Review and promulgate the result.	Different stakeholder communities have different needs, but ought to be able to share information. See *Management guide to the preparation and use of Target Audience Descriptions in the acquisition of defence capability.*

Stakeholder	Shared Interest	Stakeholder's role	Your role (HFI Focus in IPT)	Notes
Industry project manager (during competition)	The role of HFI	Understand importance of HFI to MoD in relation to other factors. Exploit this in competition.	Project a clear view of the priority of HFI. Remove barriers that might undermine HFI.	Competitors must focus on what will win. If HFI appears low in priority, MoD could be deprived of better, more cost-effective total system solutions.
Industry HFI team (during competition)	HFI issues, requirements, & risks.	Understand HFI issues in depth. Advise how best to satisfy MoD and obtain competitive advantage	Provide support. Ensure adequate access to data and users. Encourage participation where beneficial.	During competition, HFI staff can be subject to conflicting pressures that restrict the flow of information.
Contractor project manager (as a partner)	Efficient HFI co-ordination.	Ensure HFI contributes to project objectives and does not cause any failures of relationship or outcome.	Ensure HFI is properly co-ordinated across the project. Participate in any trade-offs between HFI and other factors.	In the short term HFI represents additional contractor costs. The project manager must be sure that they will be balanced by appropriate down stream benefits.
Contractor HFI team (as a partner)	Human centred design leading to operability acceptance	Influence design to achieve HFI acceptance as early as possible, at lowest cost	Support HFI activity and provide access to user representatives. Ensure acceptance activities are appropriate and that evidence provided is meaningful and realistic. Determine whether compliance with requirements has been demonstrated.	The contractor HFI team needs to operate within realistic commercial constraints.

2.3 HFI Working Group

The HFI working group provides a means for effective communication, co-ordination and consensus formation among the stakeholders in HFI. The scale of its activities will depend on the project.

- Set up and manage HFI Working Group as early as possible
- Define its terms of reference
- Obtain support and backing from the lead DEC and/or IPT Leader, with a clear line of reporting to them
- Include representation from user representatives, other technical areas of the project and all stakeholders with an interest in human aspects of the capability (see Table 1).

Identify other working groups with significant impact on the effectiveness of the HFI effort and ensure HFI is represented on them, for example:

- ILS
- Training
- Maintenance
- Safety
- Acceptance, Test and Evaluation
- Requirements management

2.4 Co-ordination & Management

Integrating Human Factors concerns within a project can be challenging; much subject matter relates to “soft” human issues that can be difficult to describe, measure and specify. Co-ordinating contributions from the many stakeholders with an interest in human issues can be complicated by the organisational boundaries involved. The Integration Authority (IA) or Joint Capability Board (JCB) might provide useful input of "pan IPT" issues and requirements.

The foundation work for HF integration should begin as early as possible in acquisition, when ideas are embryonic during the Concept phase.

- Actions during Concept Phase
  - Quickly develop an outline HFI Plan (accounting for priorities established by CWG)
  - Ensure that any HFI issues are identified early enough to influence option selection
  - Begin identifying major HFI issues as soon as possible (to assist in obtaining an appropriate share of the project resources)
  - Ensure the URD and Plan for Assessment and beyond do not contain undue risks related to HF
- Actions during Assessment and subsequent phases
  - Review HFI plan from previous phase and identify aspects of HFI that must have priority attention during phase
  - Identify key HFI goals and agree HFI strategy for the phase with IPTL

2.5 HFI trade-off

Trade-off is inherent in system engineering, especially under the demanding constraints that typify military systems. Trade-off is not unique to HFI, but trading human issues against equipment issues can be more difficult than trading like with like. Do not let human aspects get eclipsed by the needs of technology.

Careful identification of the human implications of options is essential. This should draw on the assessment of identified HFI issues. Try to quantify the impact of human issues in similar terms to those used to assess the factors against which trade-off is sought. Often this means identifying the impact on system performance, but it might equally mean the risk of legislative infringement or the impact on manpower costs. Thorough investigation of the HFI issues should provide a pool of evidence from which to draw, but unanticipated topics might need fresh analysis. For successful trade-off you must be confident you understand the merits of competing options.

Always ensure that the full consequences are made explicit, preferably with their monetary and down-stream impact. This might be hard to quantify, but it should help the user community to form a better view of its severity compared with other more tangible equipment related consequences.

The trade-off will change some of the assumptions on which prior work has been based. Work through the impact of these ‘knock-on’ effects (which might sometimes be beneficial) to identify any changes to human related constraints that require further action.

2.6 Different acquisition means

How capability is acquired or upgraded depends on what changes and how.

The change space – depends on the degree to which the human and equipment components of the capability are changed.

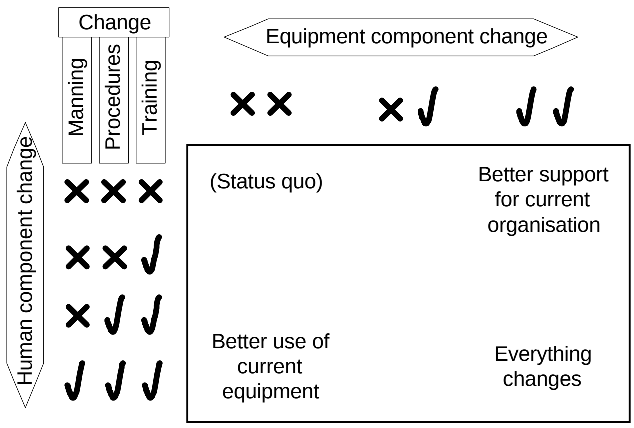

Figure 3 Change – equipment v human component

- ∆ Most projects work between the extreme cases shown.
- ∆ HFI activity increases towards the bottom.
- ∆ HFI risk is greatest when a project thinks it is operating at top right, but the consequences of the change actually force an unplanned move to bottom right.
- ∆ Ensure you know where your project needs to operate in this space

The supply space – depends on what is supplied and the extent to which it is specific to the required capability.

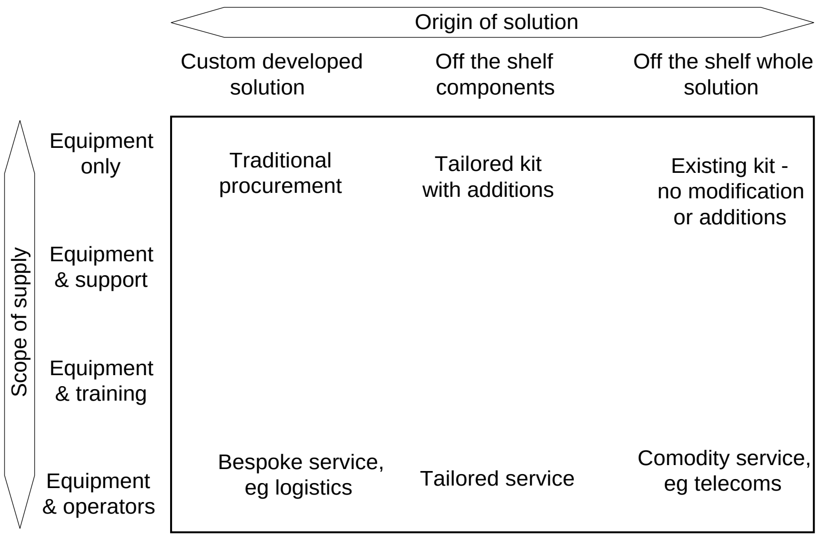

Figure 4 Supply scope v origin of solution

- Smart procurement requires projects to consider solutions away from the traditional top left corner.
- Where the project chooses to operate has a significant influence on how HFI is conducted.
- Ensure you know where your project needs to operate in this space

Development v Off-the-Shelf – With developed equipment, HFI can inform all stages from requirement through outline design and development to acceptance. At all stages there is scope for some intervention to cater for any discovered factors prejudicial to human-equipment integration. With major components off-the-shelf, intervention must be before equipment selection. Any shortcomings of human-equipment integration not anticipated and caught early can only be rectified by equipment modification (which can be prohibitively expensive or impossible) or by trying to 'bend' the human component to fit. That can be equally costly in the long term, since it affects training and possibly manpower, and even then it might not yield the required performance, thus undermining the capability.

The greater the proposed Off-the-Shelf content (COTS – Commercial Off The Shelf, or GOTS Government Off The Shelf) – the more important it is for HFI to inform the equipment selection decision. Otherwise cheap COTS **equipment** could incur the risk of high down stream **human related costs**, and/or poor **overall system performance**.

- Distinguish between 'Off-the-Shelf' and 'Off Someone Else's Drawing-Board'. Both prevent you changing the specification, but only the first can provide evidence of performance in use.
- Identify all human related issues prior to selection (see section 1.1).
- Obtain evidence of human performance with the equipment in its current context of use (see sections 5.3.2 and 5.3.7).
- Predict the performance degradation due to the proposed changed context of use (see section 5.3.6).
- Identify the need for modifications, additional items, changes to other systems, procedural work-arounds, modified training or additional skills needed to guarantee the required performance of the human component with the proposed equipment.
- Identify the feasibility of any required changes to the organisation & manning needed to ensure adequate performance of the human component.
- Predict the full, through-life cost of all the above (see section 5.3.7).

Equipment v Service - The SRD specifies a system to provide the capability. The system will include human and equipment components. When a contract is let to provide one or more components, the interfaces are defined and acceptance checks what has been delivered, and tests the performance at the boundary. When the contractor provides equipment only, all the human-equipment interfaces (operator, maintainer and support) are contractual boundaries, subject to HFI acceptance. If the contractor provides a service package, then some human-equipment boundaries will be internal to the scope of supply, and not subject to acceptance, providing the service meets its requirements (e.g. reliability) and does not violate any imposed constraints (e.g. legality).

- ∆ Identify human equipment boundaries that involve service personnel. Specify the interfaces, equipment and human performance at the interface. Specify characteristics of the human component relevant to the interface. (See sections 5.2.2, 5.2.1, and 5.3.4).
- ∆ Identify human components, and human equipment boundaries wholly within the scope of supply. Specify constraints drawn from legality, duty of care and policy (e.g. safety, health, working environment, conditions of service) (See section 5.2.2).
- ∆ Identify the need for service personnel to replace the human component in fallback or extreme circumstances. Determine the weighting this requires and specify appropriately based on a combination of the above.

PFI projects - PFI (Private Finance Initiative) means acquiring a solution where the contractor invests money and then draws revenue throughout the life of the contract. PFI is more common with 'service provision' projects (i.e. operating lower in the space shown in Figure 4) but could also apply to a solution where the contractor leased equipment to MoD, but provided no other services (i.e. operating at the top of the diagram).

3. Lifecycle HFI

3.1 Overview

Concept: HFI must begin in Concept phase, with an analysis of human issues related to the acquisition of the proposed capability, and an assessment of the associated risks and requirements. The issues drive detailed HFI planning for subsequent phases. The HFI objective is to ensure that the issues are fairly reflected in the Initial Gate submission.

Assessment: In Assessment, more detailed work explores and quantifies the HFI issues and risks, gathering information about user tasks, working conditions and expected performance. Major issues, such as manpower reduction, workload, performance shortfalls or safety are assessed for different options. Contractors develop HFI aspects of their potential solutions, supported by demonstrations and other evidence. MoD's HFI objective is to ensure that contractors clearly focus on the human related issues, and that HFI results are fairly represented in the Main Gate submission.

Demonstration: After Main Gate, specifications are refined to ensure robust HFI content, with clear human performance targets. Contractor offerings are evaluated to predict operability, etc of the eventual solutions. HFI concerns must be included in the down-selection criteria for equipment characteristics, associated services, overall integration and the process offered to develop and deliver the solution and reduce risks. After down selection, contractor HFI effort becomes more closely coupled to MoD activities like training and support analysis. MoD provides user expertise to support the contractor's HFI team.

Manufacture: The contractor HFI team will lead on most aspects of equipment HFI, with MoD ensuring integration with training development, tactics development, support strategy, etc. MoD tracks contractor provided evidence, with increasing input from representative end-user trials, to grow confidence in equipment operability, leading to acceptance and subsequent hand-over to DLO.

In-service: Declaration of In-service date (ISD) follows demonstration of effective integration of the equipment with the human component (personnel, procedures, support and training regimes) under operational conditions. While in-service, HFI evaluation helps to identify any human related performance shortfalls or failures of human-equipment integration. Where capability increments are proposed the HFI process repeats in microcosm of the earlier phases.

Disposal: The aim is to dispose of the equipment efficiently, effectively and safely. HFI involves assessment of health and safety issues of the disposal process.

3.2 Objectives in each phase

This section lists HFI objectives for each stage of acquisition against the corresponding project objectives from the Acquisition Handbook.

Table 2 HFI objectives supporting project objectives

Stage	Project Objectives:	Related HFI objectives.
Concept	1. Produce User Requirements Document (URD) 2. Form the IPT 3. Begin dialogue with industry 4. Identify technology & procurement options for further investigation 5. Plan & obtain funding for Assessment phase (with time, cost and performance boundaries) 6. State outline cost & performance boundaries for whole project 7. Pass Initial Gate (IG)	1. Contribute to relevant sections of URD based on human related issues 2. Nominate HFI Focus in IPT 3. Involve industry HFI teams in identification of HFI issues 4. Identify human implications of technology & procurement options 5. Plan Assessment work to quantify and mitigate HFI risks, and to provide HFI data 6. Identify outline HFI activities needed throughout the project life cycle. 7. Contribute to the IG submission, in terms of human related costs and effectiveness of human integration. 8. Undertake or commission HFI analysis to support the above
Assess-ment	1. Produce Systems Requirement Document (SRD) to meet URD needs. Establish & maintain links from System to User requirements 2. Establish full IPT 3. Identify most cost-effective technological & procurement solution 4. Develop the SRD, trading time cost & performance to identify a solution within Initial Gate boundaries 5. Reduce risk to permit delivery of acceptable performance within tight time and cost bounds 6. Refine TLMP & agree funding and plan for subsequent phases 7. Pass Main Gate (MG) with approved time, cost & performance boundaries	1. Identify key human related system requirements for SRD (including interfaces, operability, human performance, training, safety, etc) Trace to statements in URD. 2. Fully resource role of HFI Focus 3. Identify human impact on cost & performance for different options 4. Explore & quantify human related trade-offs as part of option assessment process. 5. Undertake analysis and evaluation to quantify and mitigate human related risks to overall performance & cost. 6. Ensure adequate provision for HFI analysis & evaluation in support of other activities during future phases. 7. Contribute to the MG submission, in terms of human related costs and effectiveness of human integration 8. Undertake or commission HFI analysis or evaluation to support the above. 9. Continue HFI dialogue with industry

Stage	Project Objectives:	Related HFI objectives.
Demon-stration	1. Eliminate development risk to fix performance targets for manufacture, maintaining linkage between solution and SRD, URD. 2. Place contract(s) to meet SRD.	1. Evaluate HFI aspects of proposed solutions. Predict human related performance where necessary, and relate this to SRD & URD. 2. Ensure contracts cover provision of HFI evidence in support of proposed solutions. Ensure industry access to HFI information and user experience.
	3. Demonstrate ability to produce integrated capability.	3. Demonstrate ability to deliver operability. Co-ordinate human aspects of system design, training analysis and support analysis. Conduct progressive operability trials
	4. Down select to single contractor	4. Contribute HFI criteria for solution & contractor assessment.
		5. Undertake or commission HFI analysis or evaluation to support the above.
		6. Work closely with industry to manage HFI risks of the solution
Manu-facture	1. Deliver solution within time and cost limits appropriate to this stage.	1. Co-ordinate development of human related components of capability, i.e. manpower, training, support, …
	2. Complete development and production.	2. Support contractor with input to continued HFI evaluation.
	3. Accept the system in accordance with the SRD.	3. Accept operability by monitoring operability acceptance trials and assessing the evidence produced.
	4. Transfer management to Defence Logistics Organisation (DLO).	4. Transfer HFI information produced in procurement for use in the support phase.
	5. Transfer customer function to 2nd customer.	5. Support HFI evaluation of field trials, feeding back lessons learned.
In Service	1. Confirm the required capability is available for operational use.	1. Initiate in-service HFI audit. Identify issues requiring action.
	2. Support the front-line.	2. Monitor exercise & operational reports for evidence of HFI issues. Act if needed.
	3. Maintain performance within agreed levels, while driving down annual cost of ownership	3. Monitor efficiency & effectiveness of maintenance, support, operation, etc.
	4. Carry out agreed upgrades or improvements, refits or acquisition increments,	4. Re-run procedures used during main procurement, at a reduced scale, and drawing on stored HFI data.
Dis-posal	1. Dispose of the equipment efficiently, effectively and safely.	1. Assess HF issues of proposed disposal process. Take action as required

3.3 HFI during Concept

HFI must begin in Concept phase, with some analysis of human issues related to the acquisition of the proposed capability, and assessment of the associated risks and requirements of possible options. The technique to help do this is known as Early Human Factors Analysis (EHFA). The issues identified by EHFA drive detailed planning of HFI tasks for Assessment phase, as well as any in-Concept-phase activities.

The HFI objective in Concept is to ensure that the outputs submitted at Initial Gate take account of any human-related issues that could seriously affect the ability to meet the project's objectives. This applies to all outputs, including:

- Requirements - User Requirements Document (URD), possibly draft System Requirements Document (SRD) and Statements of Work (SoW) to accompany Invitations to Tender for work during Assessment.
- Plans - costed plan for Assessment, Through Life Management Plan (TLMP), Integrated Test and Evaluation & Acceptance Plan (ITEAP) and contribution to specialist plans such as Safety and Integrated Logistics Support (ILS)
- Support for the Business Case – e.g. pre-COEIA cost-effectiveness assessment, with impact of human costs and performance on the Concept of Assessment (CoA).

3.3.1 Relationships

By the time the IPT is formed, and the HFI Focus is appointed, the CWG should already have made considerable progress formulating ideas about the capability, and in many cases already initiated some form of HFI working group, and begun EHFA. The IPT must therefore build the relationship with the CWG, and in particular the relevant DEC, while at the same time progressively taking over and building up support tasks such as running the HFI working group, generating requirements databases, etc. During this period, the HFI Focus should be working very closely with the DEC as well as the IPTL. See also Table 1.

During Concept phase of a large project, the IPT might use industry support for exploratory studies, either with a single contractor or with a 'rainbow' team. This can provide access to industry HFI expertise on a 'customer's friend' basis. In any case, potential equipment contractors should be engaged in dialogues with the IPT, providing an opportunity to build relationships with their respective HFI teams.

3.3.2 Meeting HFI objectives

3.3.2.1 Contribute to URD

The URD specifies the required military capability, which in almost all cases will be provided by some combination of equipment, manpower, training, doctrine, support, etc. The URD plays a pivotal role in the whole acquisition project, since it drives all later requirements and plans. It is extremely rare for people not to form part of a capability. It is therefore important to provide appropriate high level 'hooks' in the URD to which more specific HFI requirements in the SRD etc. can be traced. The URD is owned by the DEC, and for a simple project might be written by one or more members of the CWG, but in many cases the final document will be prepared with assistance from the IPT. Section 4.1.1 indicates typical HFI content of each section of a URD.

3.3.2.2 Nominate HFI Focus in IPT

HFI Focus is a mandatory role within the IPT. In a small IPT, it will normally be shared with another role. The HFI Focus need not be (and in practice, rarely will be) an HFI specialist, but should be committed to properly managing the human issues within the project. Since much HFI activity involves influencing other stakeholders whose responsibility HFI overlaps, the HFI Focus should be a good ‘influencer’. The IPTL has ultimate responsibility for HFI, and in some cases might assume the working level role as well.

3.3.2.3 Involve industry HFI teams in identification of issues

During Concept, the IPT will normally brief industry on the emerging requirement and seek ideas on relevant technology developments. These briefings should include reference to human related issues, especially where the issues arise from weaknesses of human integration in current capability or from proposed changes in the relationship between human and equipment. Ideally, the HFI Focus will open two way dialogues with relevant HFI teams within industry. Section 2.2 describes the relationship with industry.

3.3.2.4 Identify human implications of options

This is the key HFI activity in Concept phase. An understanding of the human related risks and opportunities should drive the whole HFI effort, since the human component is a major source of cost, and usually a critical factor in system effectiveness. Early Human Factors Analysis is a simple, systematic process for identifying and assessing human issues, and then deciding what to do about them. Pointers to human related risks can be found in operational experience, in changes to the operational context, in procurement constraints, in research programmes, and elsewhere. Section 5.1 describes the conduct of EHFA.

3.3.2.5 Plan HFI for Assessment phase

Wherever you identify significant human related risk or opportunities, you will need to put in some work to quantify and then mitigate HFI risks, and to explore the opportunities. This work, whether analysis, experiment, prototyping or trials must be planned to ensure it provides timely results to influence project decisions. Planning is a project wide activity. Section 4.2.1 gives specific advice related to HFI planning.

3.3.2.6 Identify outline life cycle HFI activities

The two major, long-range project plans that begin in Concept phase are the TLMP and the ITEAP. Both require inclusion of activities related to HFI. The TLMP will show how HFI activities, methods and data integrate with other aspects. The ITEAP will show how HFI requirements are quantified in testable terms, how the performance targets are evolved and how the integration between equipment and human components will be progressively evaluated, tested and ultimately accepted. Sections 4.2.3 & 4.2.2 give advice on HFI content of a TLMP and ITEAP respectively.

3.3.2.7 Contribute to the IG submission

The high-level business case submitted at Initial Gate (IG) would not normally mention HFI explicitly, but the strength of the case will rest on the underlying project results, including HFI. Where the human component plays a major part in the proposed capability, or where there are critical human related shortcomings to overcome, being able to demonstrate that the key human related issues have been considered and properly accounted for will be an important part of this support.

3.3.2.8 Undertake or commission HFI analysis

The sections above describe how HFI supports the main project objectives for Concept phase. In order to do this, you will need to undertake or commission some supporting analysis. What analysis you need at this stage will depend on the project's specific needs and on the human related issues you identify. Whether you can undertake such analysis in high level form yourself, or whether you need to contract in specialist support will also vary from project to project. Section 5.3 describes a range of supporting HFI analysis techniques, with an introductory table to show when, and under what conditions you would normally use each .

Typical activities at this stage might include exploring human aspects of missions and scenarios (see 5.3.1), comparison with other systems (see 5.3.2), outline description of key tasks (see 5.3.3) and preliminary information about likely hands-on user groups (see 5.3.4). For a major acquisition there would be HFI Input to the Concept of Analysis (see 5.3.7).

3.4 HFI in Assessment

In Assessment, more detailed work is undertaken to understand, quantify and begin to reduce the HFI risks identified during Concept phase. This will usually involve gathering more detailed information about the characteristics and numbers of end users (expected to be available, and needed), operational tasks and working conditions, expected performance standards and support strategy. It will involve exploring major issues, such as manpower reduction, workload, performance shortfalls or safety, and a large number of smaller items.

Assessment includes a more systematic and informed analysis of options, including gathering evidence to quantify human performance and the cost of different options. Simulation, modelling, prototypes and mock-ups might be used to capture requirements and identify where savings can be made. The list of human issues is reviewed and updated.

Contractors will work in support of MoD on some of the above, as well as working in parallel with MoD to develop the HFI aspects of their own solutions. They will deliver demonstrations and documented evidence of the operability, workload, etc. of their prototype solutions. MoD's HFI objective is to ensure that contractors clearly focus on the human related issues, as well as addressing them within MoD. HFI results are represented in the stage outputs submitted at Main Gate:

- Requirements - revised URD, SRD and Invitations to Tender (ITT) Statements of Work (SoWs)
- Plans - costed plan for Demonstration, TLMP, ITEAP and contribution to other specialist plans such as Safety and ILS
- Cost effectiveness assessment (COEIA) - impact of human performance and human costs.

3.4.1 Relationships

The wider scale of activity during Assessment increases the number of active working relationships for the HFI Focus (see Table 1). Helping to create the SRD means making explicit, and reconciling many aspects of HFI detail 'owned by' stakeholders outside the IPT. These include (at least) operational commands, training, personnel & recruitment, manpower planning, safety, ILS, ARM.

Industry has a much greater role to play, in most cases overtly competitive. The HFI Focus must build on relationships with contractor teams, particularly HFI teams, to ensure effective information flow on HFI issues, and to provide contractors with adequate access to service users (both subject matter experts and hands-on users) while respecting commercial sensitivities. This can be particularly demanding in PFI projects, where the contractor has more freedom in terms of what solutions are offered.

3.4.2 Meeting HFI objectives

3.4.2.1 Identify requirements for SRD

The SRD specifies what a system must do to provide the military capability required by the URD. It does not specify a particular solution, but where there are important constraints, the SRD must identify component boundaries and performance budgets for components (e.g. the need to inter-work with an existing system or specific manning constraints). The SRD specifies the whole system, including the human components, structured so that industry can contract for a solution to meet a well-defined subset of its requirements. A baseline allocation of function (see section 5.2.2) for each technology option will help define these boundaries. Key human related requirements must be included to ensure that equipment and human components properly integrate. System requirements must trace back to the URD. This might reveal areas where the URD needs clarification. Section 4.1.2 indicates typical HFI content of an SRD.

3.4.2.2 Fully resource the role of HFI Focus

The role of HFI focus includes a lot of co-ordination, which is easy to under estimate. The job will be bigger in Assessment than it was in Concept. Even if the role remains a shared one, the responsibilities with which it is shared must leave sufficient time to do the job effectively. The HFI plan for Assessment should indicate the size of the task.

3.4.2.3 Identify human impact on cost & performance

The decision at Main Gate hangs on being able to make reliable estimates of overall cost and effectiveness of each technology option. Human related costs typically dominate Whole Life Costs, and human performance caused by poor integration can undermine the effectiveness of apparently good equipment. The human dimension of COEIA is therefore critical, more so when the options differ significantly in nature. Section 5.3.6 gives guidance on human performance modelling and section 5.3.7 on how to assess human performance impact and human related costs in support of the COEIA process.

3.4.2.4 Explore and quantify human related trade-offs

The equipment component of the solution cannot be optimised in isolation. Equipment trade-offs that change the performance or function at the interface with the human component (operators, maintainers or support staff) must be assessed to determine how they affect the human performance. Likewise, opportunities to improve human performance, to reduce training or manning, etc by changes to equipment must also be explored.

3.4.2.5 Quantify and mitigate human related risks

Risks identified in Concept should be reviewed, and any new risks assessed (see section 5.1.4). Quantifying human related risks requires detailed analysis, which will vary with the nature of the risk. See below for suggestion of likely types of supporting analysis.

3.4.2.6 Ensure adequate provision for later HFI analysis & evaluation

Depending on the human related issues and risks identified, significant effort might be required in future phases, especially for modelling, prototyping, evaluation or trials. This must be made clear in the TLMP (see section 4.2.3). Where it is most appropriate for MoD to undertake or commission the work this needs budgeting. Where other agencies undertake the work, e.g. training analysis, this needs a CSA. Where contractors will be expected to do the work and produce the results as evidence, this must be made clear in the Statements of Work (SoWs) accompanying Invitations to Tender (ITTs), Invitations to Submit Outline Proposals (ISOPs) and Invitations to Negotiate (ITNs). Where service personnel are needed for trials or evaluation, this must be agreed with the appropriate organisation. Section 4.2.1 gives guidance on HFI planning, section 4.2.3 describes typical HFI content within a TLMP and section 4.3.1 describes HFI requirements in SoWs.

3.4.2.7 Contribute to MG submission

The high-level business case submitted at Main Gate is a relatively short document that summarises the whole project output. Explicit references to HFI will be few and short, but the strength of the case, even at high level will rest on an understanding of the issues and assumptions about integration and performance of the human component within the system. The business case must demonstrate that key human related issues have been considered and properly accounted for.

3.4.2.8 Undertake or commission HFI analysis

The plan prepared during Concept phase will determine major areas of analysis to be done, but the scope and priorities should still be driven by the currently assessed risks. Section 5.3 gives guidance on different supporting HFI analysis activities.

Typical HFI activities at this stage might include a high level task analysis (5.3.3) (for operation, maintenance & support), human performance modelling (5.3.6) (linked to the main OA to determine key HFI trade-offs and effectiveness levels) and producing a detailed Target Audience Description (TAD) for the selected option. Related activities might include review of manpower and personnel requirements and costs (in conjunction with manning & complementing authorities), Training Needs Analysis (in conjunction with training organisations).

3.4.2.9 Continue HFI dialogue with industry

Industry insights should help MoD to understand the human issues associated with various options. It is also important to ensure that the contractors are aware of the human related risks MoD needs addressing. During Assessment, contractors are normally in competition, and this presents barriers to communication that must be overcome.

3.5 HFI in Demonstration

After Main Gate, project focus shifts from deciding what is needed, to ensuring that it can be delivered at acceptable risk, while refining the detail. This will be reflected in the HFI specification and evaluation work.

There is work to refine and check the detail of specifications to be used for procurement, so that the HFI content is robust, i.e. unambiguous and testable, and that human performance targets are adequately covered. Time is spent working with the respective contractors' HFI teams to ensure that HFI requirements are understood and specified in ways that will help them to be implemented cost effectively. Traceability to the SRD and URD will be particularly important after Main Gate.

Evaluation of contractor prototypes and demonstrators will continue, now focussed on predicting the operability, etc of the eventual solutions, rather than simply to explore human integration issues.

The nature and weighting of the HFI related parts of the assessment scheme for contractor down-selection will be agreed within the IPT, and subsequently implemented as part of the assessment process. HFI assessment during Demonstration will include all aspects of contractor proposals, including equipment characteristics, any associated services (e.g. training or support provision), and the overall integration of the solution. It should also cover the process offered to develop and deliver the solution, reduce the attached risks, and to provide the visibility needed to allow MoD to control its non-exportable risks.

Following contractor down selection, and the removal of competitive barriers, the contractor HFI effort must become more closely coupled to the complementary HFI activities within MoD, including training and support analysis. MoD will ensure sufficient user expertise is available to support the contractor's HFI team. Unforeseen HFI issues arising out of design specification or evaluation will be resolved as they arise, as will any early changes arising from externally imposed factors.

3.5.1 Relationships

The relationships built up during Assessment will continue (see Table 1), but with the shift from requirement to solution, the HFI Focus will develop stronger relationships with trials agencies, acceptance authorities and those involved with the down-selection process. The close working relationship with the contractors must be maintained to gain maximum benefit from demonstrations and evaluations.

After down selection, the relationship with the successful contractor's HFI team should change to one of partnership (within the terms of the contract). Smoothly negotiating the many human-equipment integration problems that any project encounters will depend critically on this relationship.

3.5.2 Meeting HFI objectives

3.5.2.1 Evaluate proposed solutions

Risk reduction is the main focus of Demonstration. Many of the HFI risks at this stage relate to human performance. Contractors should be producing prototypes and demonstrators that can be evaluated by practical trials with representative hands-on users. This will not cover the whole scope of system operation, and so performance prediction will still be needed in critical areas. The SRD and URD should provide the basis of which areas to evaluate. Modelling, careful extrapolation from the prototypes, or appropriate comparison with operational experience can help. For guidance, see section 5.2.4 on operability evaluation, section 5.3.6 on human performance modelling, and section 5.3.2 on comparison with other systems.

3.5.2.2 Ensure contracts cover provision of HFI evidence

Prior to contract let, competitive pressures will encourage contractors to supply any evidence they perceive MoD will value. After contract let, the contract will dominate what is or is not provided, even with co-operative working. The contract must therefore clearly state wherever contractors need to provide evidence to justify the acceptability of their proposed solutions. HFI evidence is very easy to overlook in favour of things like equipment performance, unless the requirement for it is explicitly specified.

Much HFI evaluation requires access to representative users, including hands-on users. Contractors should be required to state their needs, to permit planning for adequate provision. See section 4.3.1 on HFI requirements in ITTs.

3.5.2.3 Demonstrate ability to deliver operability

Demonstrating the ability to deliver integrated capability includes operability evaluation and trials of prototypes and demonstrators (and similarly for maintenance and support). It also involves putting in place the mechanisms to ensure integration of human aspects of system design across many organisational boundaries: equipment development, training analysis, support analysis and the evolution of operational thinking.

3.5.2.4 Contribute HFI assessment criteria

Down selection and commitment to a single contractor is a critical decision. Once selected, the contractor will control many aspects contributing to effective human-equipment integration. The contractor's ability to deliver a solution that meets HFI requirements must be thoroughly covered by the assessment criteria. Section 5.2.3 gives guidance.

3.5.2.5 Undertake or commission HFI analysis

The plan prepared during Assessment phase will determine major areas of analysis to be done, but the scope and priorities should still be driven by the currently assessed risks and prior to selection, on the need to differentiate between the competing solutions. Section 5.3 gives guidance on different supporting HFI analysis activities.

Typical activities at this stage might include detailed performance modelling (5.3.6) (supported by more detailed task analysis), anthropometric assessment (5.3.5) and cross domain analyses, e.g. the interaction of design and training. ,

3.5.2.6 Manage HFI risks with industry

Management of risks in the solution is a shared responsibility, especially following down-selection when the contractor becomes a full member of the IPT. While the contractor (through acceptance criteria) will carry the risk for equipment induced aspects of operability, there are still risks in the wider aspects of how people, operational procedures and equipment perform together, especially where the capability is to be met by a people intensive system. Guidance on HFI risk assessment is in section 5.1.3.

3.6 HFI in Manufacture

The contractor HFI team will lead on most aspects of equipment HFI during the Manufacture phase. MoD will provide a supporting role, ensuring continuing integration with complementary activities such as: training development, tactics development and support strategy.

MoD will continue to track contractor provided evidence (from demonstrations, evaluations or analysis) to support the growth of confidence in the operability, maintainability and supportability of the equipment, i.e. its effective human integration. This will progress in successive stages of acceptance and certification until the requirements of the SRD (as at Main Gate) have been demonstrated. Later trials will increasingly rely on representative hands-on users whose provision must be facilitated by MoD.

Transfer of the IPT from the Defence Procurement Agency (DPA) to the Defence Logistics Organisation (DLO) should not raise any special HFI issues, but is likely to involve effort ensuring that HFI data are in proper shape for through life support (including successive evolutionary increments of capability).

Unforeseen HFI issues will continue to be resolved, as will externally imposed changes.

3.6.1 Relationships

Most relationships are well established by this phase (see Table 1). Those with stakeholders in the services are likely to broaden, as production equipment becomes available and undergoes preliminary training and work up with operational teams. This provides the opportunity for the HFI Focus to develop the new relationships that will be needed to maintain effective contact with the operational context of use, when the system enters service.

The relationship with the contractor is likely to become more routine, providing the developmental problems have been ironed out.

3.6.2 Meeting HFI objectives

3.6.2.1 Co-ordinate development of human component

New or upgraded capability normally involves significant change or development to the human component: operational procedures, manpower, training, support, and so on, in parallel with equipment production. These developments will require information about the equipment (and about each other) to ensure time and cost limits are met. They might also generate issues that need to be addressed by changes to the equipment. Some of this co-ordination will occur between the groups involved, but the IPT as overall co-ordinator will need to be involved, especially in equipment related links. Guidance on co-ordination is in section 2.4.

3.6.2.2 Support contractor HFI evaluation

Smart acceptance is based on helping the contractor to get it right, as much as on testing to see whether this has been achieved. While completing the development, the contractor will continue to meet technical issues that must be resolved. Some HFI issues will not be readily resolvable internally, and will require MoD support by way of information, decision of compromise. If this support is not readily forthcoming, the contractor will be faced with either compromising timescale or circumventing the issue, and thus building HFI risk into the solution. Advice in contractor support is in section 4.4.1.

3.6.2.3 Accept operability

Acceptance of operability (and also maintainability and supportability) is potentially complex, because of the need to account separately for those aspects that are properly the responsibility of the equipment contractor and those that accrue from the wider interaction of human and equipment components within the overall system. These should be stated separately in the SRD, but it can be difficult to draw the boundary between them when testing, especially in people intensive or information intensive systems.

Acceptance of equipment operability should conform to the overall project acceptance strategy whereby normally the contractor presents evidence based on conducting agreed tests (which MoD may witness if desired). Detailed schedules and procedures for conduct of the tests must also be agreed. The contractor will require support in the form of suitably experienced service personnel to take part in the tests. Advice on HFI acceptance is in section 5.2.5.

3.6.2.4 Transfer HFI to support phase

Transfer of the project from DPA to DLO is mainly an administrative process whose HFI impact should be small. The issues are likely to be some re-distribution and re-sizing of IPT roles, that could affect the role of HFI Focus, and the need to ensure that HFI data gathered during the procurement phase can be transferred and maintained through life, ready to support the acquisition of future capability increments.

3.6.2.5 Feed back lessons learned

The formal transfer to the 2nd Customer will be accompanied by extensive trials and work-up with 2nd Customer's personnel. This will be a more severe test of the human-equipment integration and performance than what has preceded it. It is important to capture the valuable HFI lessons learnt during this phase. Section 5.1.4 covers feedback from experience.

3.7 HFI while In-service

In-service date (ISD) will be declared[1] when the required capability, as specified at Main Gate, is available for operational use. To show that the operational capability has been provided requires demonstration of the operational integration of the equipment with the intended personnel, procedures, support and training regimes. HFI evaluation will contribute to this effort with in-service operability audit, monitoring of work-up trials, etc. HFI intervention will help remedy any detected shortfalls, typically 'real use' problems not predicted by analysis or detected in factory trials.

During the remainder of the in-service period, HFI will contribute to the support of front-line performance by helping to identify any human related performance shortfalls, particularly failures of human-equipment integration. Where changes result from such problems, or where capability increments are proposed to cope with changes, then the HFI role will be a microcosm of that described for the earlier phases of the life cycle.

3.7.1 Relationships

Many relationships change after ISD, along with the move to DLO. The work of the IPT, and hence of the HFI Focus, is almost certainly much smaller, apart from periods of capability enhancement. The HFI Focus might combine with another role, or be shared between projects (a good opportunity to pass corporate memory between projects).

Providing an effective part of front line support requires effort to maintain the relationships with operational, support and training teams, through the extended periods when information flow might be quite low.

3.7.2 Meeting HFI objectives

3.7.2.1 In-service HFI audit

When the system is bedded down in service, there should be an audit to check the integration of human and equipment, and to identify HFI issues requiring action. Some issues always slip through trials and work-up unnoticed, but become more significant during sustained routine operation, while others could not have been detected earlier.

3.7.2.2 Support operation

From time to time throughout the system's life, front line personnel will detect HFI weaknesses in the system, often because some facet of operational practice has changed.

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[1] ISD might be declared during the Manufacture phase.

Equipment fault reporting mechanisms often cannot handle these problems, because they are not clear-cut equipment failures. The IPT should put in place a means to detect and respond to usage problems that cannot be resolved locally by the operational personnel, e.g. by periodically checking exercise & operational reports for evidence of HFI issues.

3.7.2.3 Monitor cost effectiveness

Once equipment has been procured, manpower and support dominate the ongoing system costs. Service experience might lead to more efficient ways of operating, maintaining or supporting the system. Cost reduction is not the primary goal of front line forces, so the IPT should put in place means to detect such opportunities, possibly using the same links and reporting mechanisms as above.

3.7.2.4 Re-run procedures for upgrades

Whenever a significant modification or upgrade is required, the acquisition procedures described for earlier phases will be re-enacted on a smaller scale.

3.8 HFI in Disposal

The aim of this phase is to dispose of the equipment efficiently, effectively and safely. The main HFI contribution will involve assessment of health and safety issues of the proposed disposal process.

3.8.1 Relationships

As noted below, the HFI content of disposal might be negligible. Where there are issues, the important relationships are with the safety authorities, with the disposal personnel and with the service personnel to ensure there are no safety issues from the hand-over process.

3.8.2 Meeting HFI objectives

3.8.2.1 HF issues in disposal

Many disposal activities are routine, and are adequately managed by disposal contractors. In other cases, disposal can entail significant hazards to the disposal personnel or to other people. The hazards must be assessed, and quantified. Any appropriate mitigating actions must be put in place. Other agencies might undertake this process, but the IPT will be responsible for ensuring it is properly carried out.

4. HFI contribution to project outputs

HFI yields value by influencing project outputs. In the early phases, these are mainly documents: requirements and plans. As the project progresses, solutions predominate. Documents are the major determinants of what system is acquired, and the 'solution' is what ultimately matters. HFI contribution to documents should not be restricted to the 'HFI section', as the contents of many other areas will have human implications. HFI contribution (from the IPT) to 'solutions' is mainly supportive and enabling. Table 3 lists key project outputs with the section where HFI contribution to each is described. The number of dots indicates typical emphasis throughout the life cycle.

Table 3 HFI contribution to outputs by phase

Output	*Sect-ion*	*Con-cept*	*Assess-ment*	*Demon-stration*	*Manu-facture*	*In-service*	*Dis-posal*
URD	4.1.1	•••	••	•		•	
SRD	4.1.2	•	•••	••		•	
Project management plan	4.2.1	•	••	••	•	•	
ITEA plan (ITEAP)	4.2.2		••	•••	•	•	
Through Life Management Plan (TLMP)	4.2.3	•	••	•	•	•	
Specialist plans (Safety, ILS, ARM, etc)			••	•		•	•
Contracts & ITTs	4.3.1	•	••	••		•	•
Customer-Supplier Agreements (CSAs)	4.3.2	•	••	•		•	•
Solutions	4.4			••	•	•	

4.1 Requirements

Effective HFI makes an important contribution to achieving Key User Requirements (KURs). Investment in HFI must ensure that any human related issues with a significant impact on a system's ability to deliver the required capability are properly captured in the requirements at Initial Gate, Main Gate and subsequent evolutionary approvals. To be effective the HFI contribution must be fully integrated with all other material.

The process is essentially the same in both Concept and Assessment phases.

- ∆ Identify what documents are to be produced and who 'owns' those with a bearing on the human aspects of the capability.
- ∆ Identify sections in relevant documents that will require (or benefit from) consideration of human related issues.
- ∆ Discuss with the document owner what contribution HFI can make
- ∆ Agree the form and time-scales for HF contributions: key human issues in high level documents and more detail in lower level documents.
- ∆ Ensure contributions reflect human performance assumptions and human related risks & opportunities.
- ∆ Ensure that contributions are properly integrated with other parts of the document.

The document sets for individual projects will differ slightly. Talk to the authors of any other project documents that could be enhanced by appropriate inclusion of human related issues, and make appropriate agreed contributions.

4.1.1 HFI content of URD

The reason for the human dimension of a capability requirement can be:

1. A human-free solution is not acceptable for some reason (ethical, moral or legal).
2. Support to humans is the objective (transporting them, housing them, providing them with information, etc).
3. The most cost-effective (or only technically feasible) solution involves humans.
4. Constraints apply to humans used in the solution.

In cases 1 & 2, humans are inherent to the requirement, and must be fully covered by requirements within the URD.

In case 3, human inclusion is a matter for the solution domain, i.e. the SRD. The URD should not therefore specify humans in the solution. It might however be sensible to word requirements in the URD in such a way that they can be readily interpreted in terms of human components if this is likely, in order to simplify later trace from SRD to URD.

In case 4, the human aspects are constraints on the solution, rather than requirements for what it must be able to do. These constraints (at a suitable level) must be covered by the URD unless (anticipating the SRD) humans can be categorically ruled out of the solution.

HFI contribution to the URD varies depending on which of the above applies. HFI must inform requirements where people either are or might be involved, even if the human contribution to the capability itself is subsumed within more general statements. This will help avoid later difficulties when the more specific SRD is being derived from the URD.

The suggested HFI contributions below are based on the URD structure in *The Desk Officer's Guide to Producing User Requirements Documents.* Sections unlikely to require HFI input are not mentioned here.

General description (Part 1)

Section	Suggested HFI contribution
Background	State inherent human related need (Case 1 or 2 above)
Single statement of need	Human issues probably not explicit unless: - Human performance is a key driver (e.g. needs enhancing from what could be achieved with current equipment in future scenarios) - Manpower cost is a key driver (e.g. must be reduced while maintaining operational effectiveness)
Assumptions	Future manning, personnel & training, Projects that could share resolution of human related issues, Equipment human component must inter-operate with
Dependencies	Human component in related capabilities, Outcome of trials
General constraints	Limits on manning, personnel deployment and factors required to avoid degrading the performance and sustainability of the human component
Users [of the capability]	Where capability users will interact with it directly, e.g. hands-on or receiving information from it as part of their operational tasks, describe key characteristics. (Enough to help focus on concepts and options that match intended users)

Key User Requirements (KURs) (Pt 2)

Key requirements form a small, subset of high level requirements that epitomise the whole need. If they fall short, then the whole capability is undermined. Most military capabilities are critically dependent on human related requirements. Whether they appear as separate top level items, or are aggregated with other concerns will depend on the specific situation.

User requirements & constraints (Pt 3)

Most HFI input will appear in the set of atomised requirements and constraints. The structure will vary with the capability. HFI contributions might include:

- ∆ **Human functions** – Inherently human tasks that must form part of the capability
- ∆ **Human support functions** – Specific equipment capabilities needed to enable effective performance and safety of the human component
- ∆ **User and organisational constraints** – E.g. the expected availability, characteristics and performance of the human component
- ∆ **Measures of effectiveness (MoEs)** – Where capability is quantified, ensure that the MoEs cover all the capabilities of the required system, in particular those that depend on the performance of the human component.

Context documents (Pt 4)

These supplement, and provide extra depth to help understand the user need, particularly for those less familiar with the background to the requirement, e.g. industry. They are vital for formulating validation and acceptance tests and trials. Context documents express the conditions under which effectiveness must be achieved. Key reports of HFI studies, particularly EHFA, should feature among the context documents.

In some cases, there will also be a role for HFI contributions to other context documents, where the people issues feature strongly.

Priorities

HFI requirements must fit within the overall priority structure.

Table 4 HFI requirement priorities for URD

Priority	Definition	Example HFI requirements
Mandatory (M)	Must be met. Requirements and constraints represent legal obligations.	Health and safety at work. Conditions of employment
Key User Requirement (KUR)	Mission critical to users of the capability. Functions not tradable. Performance trade-off below a given level might require re-endorsement.	Factors affecting human performance of critical functions. Factors affecting ability to man the solution.
Essential (E)	Subject to affordable technical capability. Functions not traded without reference to the user.	Factors affecting manpower costs
Highly Desirable (H)	Tradable, but more important than Desirable	Factors affecting working efficiency and non-critical error rates
Desirable (D)		Other human related enhancements

Performance requirements may be specified at different priority levels, e.g. maximum number of actions to perform a critical function might be (KUR) 4, (E) 3, (H) 2, (D) 1.

4.1.2 HFI content in SRD

The SRD specifies a solution to the requirement in terms of what it will do. In most cases, the SRD also makes (some, high level) decisions about which components (equipment or human) will provide different functions. The boundary around those functions allotted to equipment will represent the contractual boundary for its procurement. The SRD must therefore be explicit about the interfaces between functions, and the performance requirements (of human and equipment) at the interfaces.

The SRD structure mirrors that of the URD (see above) with the detailed internal structure of the requirement depending on the nature of the system being specified. The types of information below will typically be needed.

Equipment components in SRD

Table 5 Typical HFI content within an SRD (equipment component)

Equipment	Typical HFI related content
Context	Human related assumptions, Reference to a high level task structure, Reference to a TAD (see below)
Functional	Functions needed to support the human operator or maintainer, Functions needed to enhance or compensate for human performance limitations,
	Functions needed to provide for human safety and well being
Performance	Required equipment responsiveness to the human users
Non-Functional	
- Reliability	Requirements to minimise the risk and impact of human errors that could cause failure. E.g. inadvertent operational error (violation of safety rules, loss of information...) or maintenance error (incorrect settings, things fitted wrongly ...)
- Maintainability	Requirements to reduce the demands on the time and/or skill of maintainers (e.g. to reduce manpower or training costs).
	Requirements to reduce stress and/or hazard to the maintainer (e.g. ease of access, visibility, ease of fitting)
- Operability	Required human performance using equipment (Error, time, accuracy)
	Human interaction requirements (Legibility, comprehensibility, ability to manipulate controls, performance over extended periods, trainability, etc)
- Safety	Requirements to mitigate adverse effects of the system on the people who come into contact with it (e.g. ‘standards’, legislation, duty of care)
	Requirements to avoid hazards caused by human action (e.g. erroneous use of confusing controls)
	Requirements relating to operator safety, stress, fatigue, boredom, (might change dramatically with changed technology)
- Security	Requirements to make human aspects of security effective (e.g. memorable passwords)
	Requirements for support to human security enforcement (e.g. usable security audit tools)
	Any emergency over-rides and safeguards (if appropriate)

Equipment	Typical HFI related content
- Engineering standards	Requirements to accommodate human size, strength, etc (including future populations) – see sections 5.3.4, 5.3.5 and 1.1. Requirements for consistency of use with other systems (e.g. style guides, conventions)
- Environmental	Aspects that would affect performance or well being of the human component. (e.g. vibration, air quality, heat efflux)
- Support	Key human aspects of support requirements. Constraints on size, weight, portability, etc Requirements to simplify loading, assembly, set-up, etc
External interface	Interfaces to operators, maintainers, support personnel, or other people (detail will vary with the type of system)

Operability is listed as 'another NFR' in the SRD template, but it is fundamental to the effectiveness of systems involving people. Operability is about the equipment's effect on human performance. Human Performance requirements predominate and should be testable by operator performance trials supplemented where appropriate by task walk-throughs. In areas where there are well proven design rules to enhance operability, these should be specified, and will generally be tested by inspection or demonstration of the corresponding equipment function. See 5.2.5 on HFI acceptance.

Human Components in SRD

The main documents for specifying the human components are the Target Audience Description (TAD) (see 5.3.4) and a (high level) task description (see 5.3.3).

Table 6 Typical HFI content within an SRD (human component)

Human	*Typical content*
Context	Human related assumptions, Task & role context
Human tasks	Tasks to be performed (and any associated training implications): - Inherent human functions - Human functions that must be supported - Human functions to support equipment - Human tasks (outside system) that form part of role holder's job.
Human performance	Required performance of key tasks
Target Audience Description (TAD)	Physical, sensory and psychological, social and cultural characteristics. Organisation, training and career structure
Manning	Availability
Constraints	Policy, legal and other constraints covering health, safety, well being, etc.

Acceptance criteria

All requirements should be accompanied by agreed acceptance criteria. These might not be fully defined at initial issue, but should be completed before Main Gate. Pass thresholds (values of criteria to be exceeded) should be agreed before contract. If this is not possible, the ITEAP should define a mechanism and a programme for agreeing them. See section 5.2.5 on HFI in acceptance.

4.2 Plans

‘Plans’ are of two broad types.

- **Management plans** - define what will be done: when, by whom, to what criteria, with what resource, under what assumptions, with what dependencies.
- **Specialist ‘plans’** - are more comprehensive than management plans. They contain extra supporting information, records of key decisions and results that help to justify the plan. These include the ITEA Plan, Safety Plan, Reliability Plan, and ILS Plan. HFI requires co-ordination with many of these plans. The TLM Plan is an umbrella structure embracing all of these as well as the outline vision of the project through life.

4.2.1 HFI Plan

There should be an HFI section in the project management plan for each phase, typically supported by reference out to a more detailed HFI plan. Effective HFI relies on good communication across technical areas and organisations, with regular access to user representatives (subject matter experts and hands-on users).

4.2.1.1 Actions

- Review HFI issues and risks (raised by EHFA, see section 1.1)
- Agree HFI Priorities for this phase
- Establish long term HFI strategy (through acceptance, integration and into service)
- Co-ordinate with other specialist plans, and identify dependencies between organisations, and requirements for co-ordination
- Determine key milestones and time-scales (tied to the project plan)
- Write HFI plan for next phase
- Define complementary roles for MoD, its agents and contractors
- Specify how progress will be monitored and controlled

4.2.1.2 Content of HFI Plan

Table 7 Content of HFI Plan

Suggested content of HFI Plan:	*Notes*
HFI issues & risks to be addressed	Account for all so far identified, including any deemed not critical for this phase.
Assumptions and constraints relevant to HFI	
HFI studies, actions & mitigation strategy to address each issue or risk	Stating whether by DPA, by equipment contractors, by project support studies, etc.
Plan of action	Timing and duration of each activity, who will perform it, effort and resources required
Dependencies	E.g. between organisations, or on events
Strategy for integrating HFI data with CALS	
Key milestones	Tied in with overall project plan
Quantified need for service participation	Both subject matter experts and hands-on users
HFI deliverables	Stating how and when they will be used
Method for trade-off	Especially including HFI in system level trade-off
Methods for assessing progress against the plan	

4.2.1.3 Checklist

Is it clear, for each planned activity indicate:

- ∆ what risk or uncertainty it will address
- ∆ how it will be done
- ∆ who will do it
- ∆ its anticipated cost
- ∆ its likelihood of success
- ∆ the impact if it is not done
- ∆ when and how the results will feed into other planned activities

4.2.1.4 Tips

- ∆ Making sure other specialist plans (system engineering, AR&M, training, etc) show links to HFI is as important as showing links to them in the HFI plan.
- ∆ Competing requirements for end user time make it essential that the plan should allocate as much time as possible to be available.
- ∆ Make the case for investment in HFI early enough to get budgets in place.

4.2.2 Integrated Test, Evaluation & Acceptance Plan (ITEAP)

The Integrated Test, Evaluation & Acceptance Plan is a key document defining how the project will ensure that the required 'equipment capability' is being produced, and then confirm that it has been. Those aspects of the capability that relate to integration between human and equipment components require HFI input to the ITEAP.

The ground for ITEA must be laid during Concept, with the ITEA Plan completed in outline by Main Gate, and fully developed in Demonstration prior to contract let. It will then evolve.

4.2.2.1 Actions

During Concept

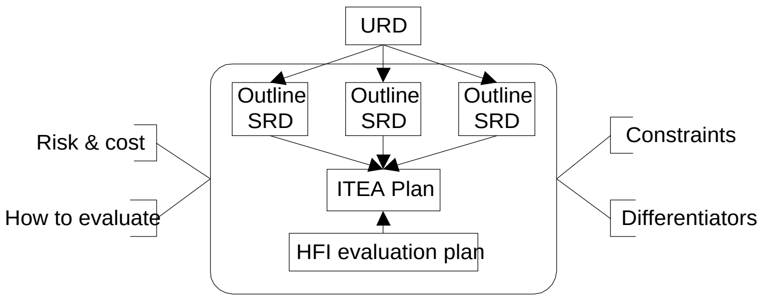

Figure 5 HFI contribution to ITEAP in Concept

Ensure verifiable requirements in the URD specifying:

- ∆ Inherent contribution of human performance to capability
- ∆ Contribution of equipment to support and safeguard humans

Ensure all requirements with human dependence are covered by verification criteria that would be sensitive to failure of the human component or failure of human-equipment integration.

Specify activity in Assessment (in the HFI Plan) to differentiate between options, and inform the subsequent ITEA Plan.

During Assessment

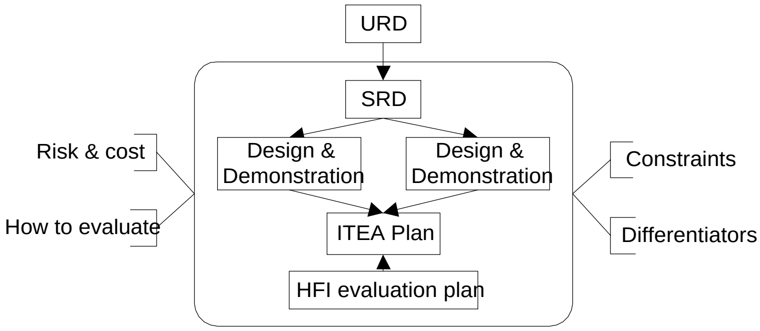

Figure 6 HFI contribution to ITEAP in Assessment

Specify testable criteria for all human related requirements in the SRD.

- Identify aspects of human performance that make significant contribution to the achievement of the capability.
- Quantify any aspects of human performance where prior experience raises concerns, where there are known inherent human limitations, or where the context of operation will differ significantly from prior experience.
- Identify as far as possible (for each option if necessary) the roles and tasks involved.
- Identify the context of use for each option.
- Specify the level of human performance needed in each case.

Clarify attribution of human performance requirements.

- If human performance depends on task support, then create an (equipment) operability requirement, tested by human performance using the equipment.
- If human performance depends on inherent human capability, rather than equipment quality, then specify it as part of the TAD and TNA, and refer to these in the relevant Customer Supplier Agreements (CSAs).

Define HFI evaluation programme

- Determine HFI evidence needed to inform down-selection decisions.
- Establish feasibility of demonstrating key HFI attributes using prototype or demonstrator equipment.
- (If so) specify the evaluation to be conducted, the evidence to be gathered, and how the results should be assessed.
- (If not) then identify other ways to gather equivalent human performance data.
- Determine what evidence MoD will require to understand human performance issues (to clarify or elaborate human performance requirements, or to de-risk eventual HFI acceptance).
- Identify how such evidence could be gathered (e.g. experiments, field trials, surveys, data analysis) and insert into HFI plans for the future.
- Specify and cost appropriate HFI evaluations.

During Demonstration

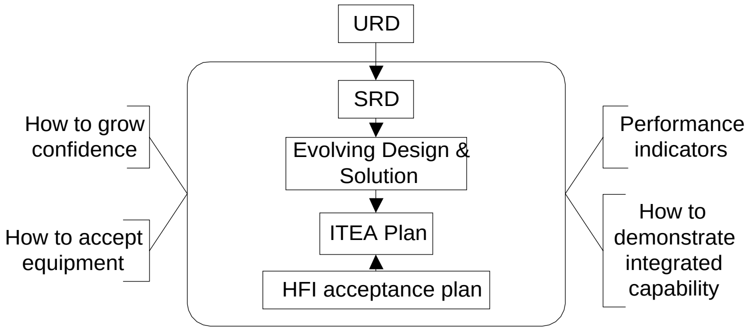

Figure 7 HFI contribution to ITEAP from Demonstration onwards

Refine evaluation & test programme for the chosen option.

- Refine plans for HFI evaluation
- Specify detailed criteria for acceptance against HFI requirements (see section 5.2.5 on the conduct of HFI acceptance).

4.2.2.2 HFI content of ITEA Plan

Items should be complete by Main Gate except where noted.

Section	*Typical HFI related content*	*Comment*
Introduction	Background to HFI requirements	Brief philosophy underlying operability evaluation – importance of human performance as a measure of equipment operability.
Scope of system	Describe the human component and identify key interactions between human and equipment (that is subject to HFI acceptance).	Identify any complicating factors, e.g. incremental build up of equipment function might prevent full role based operability testing until later phase.
System acceptance strategy	Strategy for acceptance against HFI requirements and how it fits in overall acceptance strategy	Underlying principles of operability acceptance. Scope for use of common scenarios, dual use of trial opportunities, etc.
Acceptance risk statements	Describe HFI risks to be removed by evaluation & acceptance.	Supported by links to human related items in the project risk register.
Overall process	Describe how the equipment's ability to integrate with, and support the human elements will be evaluated, tested and accepted. Identify the criteria required for HFI testing and how they will be derived.	This should identify the main areas, e.g. physical compatibility, legibility, comprehensibility, task performance, task degradation over time, health & safety
Derivation of acceptance criteria	Process for deriving test thresholds from the requirements	Likely to require a combination of independent reference data and early trials to confirm criteria. Note that tests involving human performance must account for intrinsic human error rates.
Acceptance risks & strategy	Describe how risks inherent in the acceptance process will be managed, together with any imposed constraints.	Risks might include trial subjects being unfamiliar with new equipment and procedures. Constraints might be practical limit on numbers of trials and subjects
Acceptance activity	Describe how HFI evaluations and tests will be conducted	Outline only at Main Gate – Complete during Demonstration phase
Assessment & review process	Describe how HFI evaluations and tests will be validated, and the process for handling subjective data gathered during trials	Outline only at Main Gate – Complete during Demonstration phase
Resource management	Describe how HFI evaluation, test and acceptance will be managed, especially how it will be integrated with non HFI activity	Only needed after Main Gate for ITEAP, but note that resource estimates should be included in TLMP and in the plan for Demonstration phase
Plans	Include a section on HFI evaluation & acceptance plans, calling up more detailed trials plans, acceptance schedules, etc.	Only needed after Main Gate for ITEAP

4.2.2.3 Checklist

- ∆ Have you contacted the agencies that will be responsible for accepting the system off contract and into service?
- ∆ Is the human contribution to the capability defined in a measurable way?
- ∆ Have criteria been defined for determining whether the human performance is adequate?
- ∆ Have tests been defined to enable the above to be measured in practice?
- ∆ Are the plans comprehensive enough to be able to cope with any likely human related performance problems?

4.2.2.4 Tips

- ∆ Deciding on the required performance measure is fairly easy once you understand the problem. Deciding on the pass criterion for operability acceptance is much harder. The threshold should be high enough to ensure the equipment will not let down the human, but low enough to ensure that inherent limitation of human performance will not fail adequate equipment. If necessary, specify the performance measure, and plan trials or experiments to determine the criterion by a given date.
- ∆ Do not under estimate the cost of trials needed to obtain reliable data on human performance, especially if the task or scenarios are complicated.
- ∆ For capability based on sophisticated equipment support (for example, tactical decision aids) it might be unrealistic to use deterministic ‘acceptance tests’, and more appropriate to use assessment techniques that take account of human decision making.

4.2.3 Through Life Management Plan (TLMP)

The TLMP enables stakeholders to inform and visualise the project, by presenting a whole life perspective of its objectives, assumptions, plans and resources. Its aim is to demonstrate completeness, realism and relevance.

4.2.3.1 Actions

- Review previous TLMP (if there is one)
- Identify key HFI activity for the rest of the life-cycle
- Co-ordinate HFI planning with system level plan(s)
- Contribute to TLMP

4.2.3.2 HFI content of TLM Plan

The TLMP consists of a set of documents, all of which will be updated as the project progresses. HFI contributions to the TLMP should include:

- HFI strategy
- HFI issues log
- Key HFI decisions
- Long term outline HFI plans
- HF working group constitution and procedures
- Division of responsibility between various stakeholders in HFI regarding shared activities such as TNA, TAD, Task Analysis and user support. This should form part of the PRM (Programme Responsibility Matrix).
- Procedures for management and sharing of HFI data throughout the life cycle
- Key HFI trials results
- HFI audit results following introduction to service
- HFI management strategy for evolutionary upgrades.

4.2.3.3 Tips

- Define future events in enough detail for the current purposes. Beyond the current phase, the main need is to form realistic views of HFI costs, to be sure that there is a credible strategy for controlling HFI risks, and to provide long range warning of the need for resources (e.g. service manpower and trials time).

4.3 Agreements

HFI activity called up by the HFI plan to be done outside the IPT will require either a contract or a Customer Supplier Agreement (CSA). These must be supported by explicit Statements of Work (SoWs) that define what is required, to the same level of detail as the project HFI plan. The way this is written will vary with the work and who is doing it.

The IPT is at the hub of a network of formal agreements about how to provide the capability. The HFI Focus is responsible for helping to set up those agreements in a way that supports the project HFI needs, and then managing the day to day liaison throughout the project to ensure that the agreements work. Figure 8 portrays these relationships schematically.

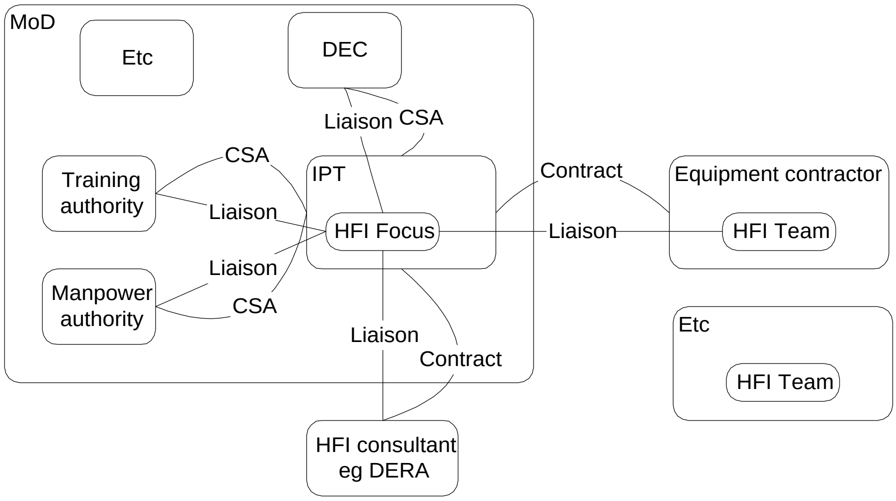

Figure 8 HFI Focus relationships

4.3.1 Contracts & Invitations to Tender (ITTs)

Work by bodies outside MoD will be subject to a contract, normally preceded by an Invitation to Tender (ITT). A Statement of Work (SoW) must support them both.

SoWs for (potential) equipment and/or service suppliers should specify:

- The evidence to be produced in support of claims about the operability etc of equipment solutions (including details of how it was derived)
- The use to be made of military users (subject matter experts and hands-on users)
- The information to be exchanged with other HFI stakeholders
- The format and timing of information, demonstrations, trials, etc.

SoWs for HFI support (DERA or consultants) should specify:

- Relationship with IPT and division of responsibilities for HFI
- Scope of HFI analysis, evaluation, trials, etc. to be undertaken
- The use to be made of service users (subject matter experts and hands-on users)
- The information to be exchanged with other HFI stakeholders
- The format and timing of information, demonstrations, trials, etc.

4.3.2 Customer Supplier Agreements

CSAs are the equivalents of contracts within MoD. The Acquisition Handbook focuses on the IPT's agreement with the DEC to supply equipment and/or equipment support. CSAs in respect of aspects of capability outside the IPT's control help the IPT to meet its wider remit of providing capability. Most of these involve people, and come within the scope of HFI.

Each CSA should be supported by an explicit Statement of Work (SoW) to define what is required, to the same level of detail as the HFI plan. How this is written will vary with the work and who is doing it.

There will be CSAs for the supply of capability in respect of doctrine, force structure, manning, training, sustainability, integration, interoperability, etc from the supplier to the DEC (or FLC) as customer. Supporting CSAs are needed to enable the IPT to deliver equipment capability that is effectively integrated with the human component. CSAs between the IPT and other parts of MoD need to cover three other main areas:

1. Provision to the IPT of information about future personnel who will form the human component of the capability
2. Provision of people to support the IPT and contractor(s) during the project
3. Provision of the human component of the capability

The first concerns the timeliness and reliability of the information, with procedures to manage changes initiated on either side of the agreement. Information will typically cover the characteristics, skills, aptitudes, numbers and availability of people, how they will be trained and organised, their other tasks and responsibilities, and so on.

The second will include the time of subject matter experts to support the IPT, equipment designers and supporting analysts. It will also include timely access to representative service personnel to take part in evaluations, trials, etc. It is very easy to underestimate the need for this type of support.

The third relates to the design of the total system (human & equipment). For the whole to be reliably engineered, tested and accepted, each separately supplied component (human as well as equipment) must have defined boundaries, and defined performance at those boundaries. Any trade-off affecting budgets, e.g. between training and equipment cost or between manpower and automation cost must be negotiated within this CSA.

4.4 Solutions

4.4.1 Equipment

The contractor produces the (equipment) solution, and responsibility for equipment HFI rests with the contractor HFI team. The HFI Focus plays the indirect, but very important role of facilitator, co-ordinator and reviewer. This support includes:

- Regular contact, interest and stimulating questions
- Ensuring that service users (subject matter experts and hands-on users) are available when needed to participate
- Responding to requests for information, advice or other technical input
- Ensuring that the contractor is aware of relevant issues arising from the development of the human component (recruitment, ability, training, organisation, etc)
- Helping to resolve any HFI conflicts or problems
- Ensuring that the results of such resolution are fed back to other affected stakeholders
- Encouraging and reviewing contractor supplied HFI evidence for acceptance.

4.4.2 The human component

Other MoD stakeholders will produce the human related parts of the solution: procedures, training, manning schemes, and people. The HFI Focus can best support this by:

- Regular contact, and being aware of developments
- Ensuring timely flow of project related information between different stakeholders (including the contractor)
- Responding to requests for information or advice
- Helping to resolve any HFI conflicts or problems
- Ensuring that the results of resolution are fed back to other affected stakeholders.

5. HFI activities

This section describes the main HFI activities undertaken in support of acquisition projects: what they are and what value they add. The descriptions assume that you need either to act as an ‘informed customer’ for specialist work, or to perform a high level ‘initial pass’ because time or other constraints rule out more detailed analysis.

The table lists the section where each is described, and the number of dots indicates typical emphasis throughout the life cycle.

Table 8 HFI activities by phase

Topic	*Section*	*Con-cept*	*Assess-ment*	*Demon-stration*	*Manu-facture*	*In-servic e*	*Dis-posal*
Manage human related issues (EHFA)	**1.1**						
Establish baseline for HFI	5.1.1	●●	●			●	
Identify issues	5.1.2	●●	●●	●		●	●
Assess human related risks	5.1.3	●●	●●	●	●	●	●
HFI in systems engineering	**1.1**						
HFI in requirement management	5.2.1	●	●●	●●	●●	●	
HFI in system design	5.2.2	●	●	●		●	
Assess contractor HFI	5.2.3		●●	●●●			
HF Test & evaluation	5.2.4			●●	●●	●	
HF Acceptance	5.2.5			●●	●●	●	
HFI analysis	**1.1**						
HF in missions & scenarios	5.3.1	●●	●●●	●●		●	
Learning from other systems (ECA)	5.3.2	●●	●			●	
Task description & analysis	5.3.3	●●	●●●	●●	●	●	●
Specify human component	5.3.4	●●	●●	●			
Anthropometric Assessment	5.3.5		●●	●●	●		
Model human performance	5.3.6	●	●●	●●●	●	●	
HFI support to COEIA	5.3.7	●	●●				
HFI and safety	5.3.8	●	●●	●●	●	●	●

5.1 Managing human issues (EHFA)

Managing human related issues and risks is central to HFI. The basic process is known as EHFA (Early Human Factors Analysis). It was developed as a 'one shot health check' for use early in the life cycle when human issues are often missed but where there can be high gains if they are caught. With Smart acquisition, the process should be started in Concept, developed in Assessment, and be periodically revisited at major decision points through life.

Based on established risk management techniques, EHFA helps define and track key human related issues at an early stage when there is limited information about potential solutions. It contributes directly to project requirements and risk management.

EHFA need not be complex nor require major resource. Project size and complexity drive the effort needed, as will the expected human role in the system and the quality and ease of access to suitable information sources. Where limited resources are available (e.g. with smaller projects) the technique can be undertaken effectively by one person who has appropriate analysis skills and awareness of the potential scope of human issues.

EHFA comprises three steps:

- Establish the baseline for HFI
- Identify HFI issues
- Assess HFI related risks.

5.1.1 Establish the baseline for HFI

5.1.1.1 Actions

- Identify all material defining the baseline (the fixed inputs, background, objectives and scope of the project, relevant standards, etc.).
- Check for content relevant to the HFI domains, noting what is 'core' to HFI.
- Identify what is known, or is current thinking, about human-related issues.
- Determine what is 'fact' and what is 'assumption', and document both.
- Note any likely HFI distinctions between options under consideration.
- Identify areas where there is no information on HFI matters and decide how to fill gaps.
- Agree HFI analysis activities, time-scales and outputs.

5.1.1.2 Outputs

- HFI Baseline, with reference to facts, decisions, assumptions, constraints
- HFI Assumptions register including (for each assumption):
  - a unique reference number and description of the assumption
  - related concept options or concerns
  - the source of the assumption and when it was raised
  - a statement of the assumption's validity
  - the sensitivity of the project to the assumption.

5.1.1.3 Checklist

Documents containing human related information could be about:

- The operational need
  - Missions, scenarios and operational context
  - Concept of use, interoperability
- Predecessor system(s)

  - ∆ Manpower or personnel problems
  - ∆ Training methods, facilities and problems
  - ∆ User interface, workplace layout or environment features and problems
  - ∆ Maintenance and support philosophy, organisation, facilities, practices and problems
  - ∆ Operator, maintainer and support personnel performance
- ∆ Future trends
  - ∆ Demographics, recruitment
  - ∆ Policy for manning, training, maintenance and support
  - ∆ Philosophy, organisation and infrastructure for maintenance and support
  - ∆ Legislation on safety, health and working conditions
- ∆ Capability options
  - ∆ Organisational structure
  - ∆ Personnel options, problems and/or constraints
  - ∆ Recruitment and retention policy
  - ∆ Equipment, maintenance and support options

5.1.1.4 Tips

- ∆ Assumptions are often implicit and unrecorded, making it hard to know when and what assumptions are being made. Always make assumptions explicit and record them.

5.1.2 Identify HFI issues

5.1.2.1 Actions

- ∆ Set up registers to manage HFI assumptions and issues. (Use a matrix of options v HFI domains to help ensure thoroughness).
- ∆ Review information sources for a high level assessment of potential HFI assumptions and issues.
- ∆ Consult stakeholders to identify assumptions and issues.
- ∆ Identify areas where HFI is likely to have a high impact on cost, time-scales, personnel safety or system effectiveness.
- ∆ Document the assumptions and issues.

5.1.2.2 Outputs

- ∆ HFI Issues register including (for each issue):
  - ∆ a unique reference number and description
  - ∆ likely impact on cost, time-scale, safety or system effectiveness.

5.1.2.3 Checklist

For each option, have you considered:

- ∆ The system
  - ∆ Human related risks of procurement strategy
  - ∆ Time available for HFI activities
  - ∆ Availability of HFI data
  - ∆ Human-equipment integration
- ∆ Manpower
  - ∆ Potential manpower shortages or surpluses
  - ∆ Cost of too high or too low manpower forecast
  - ∆ Potential accommodation problems
  - ∆ Wider organisational implications (e.g. manning for damage control or guard duty)
  - ∆ Allocation of tasks between organisations, teams and individuals
- ∆ Personnel
  - ∆ Potential skill or knowledge mismatch, risks of new skill requirements
  - ∆ Requirements for increased multi-skilling

  - Task failures and errors
- Training
  - Training capacity and likely training demand
  - Potential new training needs
  - Novel types of training need
  - Skill fade (i.e. loss of basic skills due to infrequent use)
  - Negative transfer (mismatch of responses learned from other experience)
- HF Engineering
  - Physical or mental workload (operation, maintenance or support)
  - Workplace layout and environment
  - Situation awareness with automated systems
  - Quality of teamwork
  - Maintenance problems (e.g. access and visibility, variety of tools, adequacy of help facilities)
- System Safety
  - Workspace and platform constraints – visibility, ingress and egress
  - Work/rest cycles
  - Safety related tasks
- Health Hazard Assessment
  - Hazardous operations or conditions
  - Hazardous equipment or material
  - The working environment, posture and duty cycles

5.1.2.4 Tips

- It can be helpful to subdivide issues into:
  - Concerns – cannot be dismissed, but need not be resolved now
  - Risks – Key issues representing risk that must be managed
  - Requirements – Potential requirements that if accepted would resolve the issue
- If you lack critical information, make and record assumptions as the basis for further progress. Then even if your assumption is later falsified, you will be able to allow for this, providing you track the relationship between assumptions and risks, etc.
- Not all issues will apply to all capability options. You need to track which issues apply to all options, and which to specific ones.
- Some issues might arise in one domain, but make their impact, or need mitigating action in another domain, e.g. better HF Engineering might solve a training problem.

5.1.3 Assess impact of HFI risks

5.1.3.1 Actions

- Enlist support of people with operational experience and HFI specialists as needed.
- Assess the likelihood and impact of each risk (high, medium or low) – ensure impact ratings conform to project wide definitions.
- Combine these using a standard risk matrix (see Table 9 below) to give an overall score, and hence priority.
- Document the assessment.
- Record HFI risks in the Project Risk Register. Where necessary, aggregate to achieve granularity consistent with other project risk statements.
- Provide EHFA report to CWG for review.

Table 9 Risk scoring matrix

Impact Failure to meet HFI requirement will… ***Likelihood*** Based on…	***High*** ... prevent system achieving specified performance	***Medium*** … prevent system achieving specified performance, but can be managed within system margins	***Low*** … be within system performance margin
High Ambitious or ill defined performance goals, need for new, unproven technology	6	5	2
Medium Well defined, achievable performance goals, technology proven in prototype or similar system	5	4	1
Low Approach demonstrated with prototype equipment in operational scenario	4	3	1

5.1.3.2 Outputs

- ∆ HFI Issues register including (for each issue):
  - ∆ proposed strategy for mitigating the associated risks.
- ∆ EHFA report (that can then be called up by the TLMP) containing:
  - ∆ validated assumptions, requirements, constraints and concerns
  - ∆ prioritised, agreed HFI risks, with mitigation strategies for each.

5.1.3.3 Checklist

- ∆ Have you identified strategies or actions to mitigate all HFI risks?

5.1.3.4 Tips

- ∆ Strategies for mitigating HFI risks can be of many types, depending on the risk and the acquisition phase at which it is to be managed. They include:
  - ∆ Funding additional research, studies or data collection
  - ∆ Requesting HFI work outside the project, e.g. through the ARP
  - ∆ Amending the list of COIEA options, or the Measures of Effectiveness used in the Concept of Analysis
  - ∆ Seeking changes to the system concept, technical requirements or performance criteria
  - ∆ Highlighting HFI concerns in the Business Case
  - ∆ Highlighting HFI concerns in Statements of Work (SoWs)
  - ∆ Requesting demonstrations or HFI analysis from bidders
  - ∆ Including warranty, fitness for purpose or Liquidated damages clauses in contracts
  - ∆ Relying on training interventions.
- ∆ Use EHFA to drive project plans and requirements, as well as the project risk register.
- ∆ Prior to option selection ensure that effort goes into clarifying risks that differ between options.

5.1.4 Managing issues through life

The major focus of EHFA is during Concept and Assessment, when the options are being explored and defined. Many of the HFI issues identified early will not be fully resolved by Main Gate, and more will arise during subsequent phases. The HFI issues registers should be kept live throughout the project, and EHFA revisited at all key events. As the project progresses, the main source of issues to be managed will shift progressively from exploratory work, research and experience with other systems to feedback from the evolving experience of the system itself. You need to ensure the necessary communication mechanisms are in place to capture this experience.

Table 10 Through-life HFI issue management

Phase	Event	HFI activity feeding issues
Concept & Assessment	*Many inputs and trade-offs*	*Main phases for EHFA*
Demonstration	Contract award	Identify impact of negotiated changes
	Major trials	Assess impact of human performance
Manufacture	Equipment acceptance trials	Assess impact of any shortfalls
	Initial operational work up	Draw issues out of military users' initial experience
In Service	Routine deployment	In service HFI audit after settling down
	Extended use	Feedback from the front line
	Proposed upgrade	Assess new issues driven by change
Disposal	Decommissioning	Identify any non routine hazards

5.2 HFI in Systems Engineering

The creation of most military capability requires an integrated system based on both human and equipment components. Systems engineering is the discipline needed to deliver coherent, cost effective systems, of whatever nature. System engineering therefore plays a prominent role in Smart acquisition. HFI provides an important dimension to systems engineering when integrating the whole (human + equipment) system.

5.2.1 HF in Requirements Management

The HFI contribution to the main project requirements (URD & SRD) is described in section 4.1. This section describes how HFI concerns are integrated into the process of creating and managing the requirements, especially as they change.

Requirements change because:

- ∆ The need changes during acquisition
- ∆ One component might have to change in response to new information about what is and is not achievable with another component.

Requirements need clarification and interpretation in order to support design decisions with information at a level of detail not contained in the SRD.

The difficulty is to understand the side effects of the changes on the huge web of dependent assumptions, requirements, constraints and design decisions. Because of the pervasive nature of human issues, trade-offs made anywhere in a system design can have potential implications for the HFI requirements. These all need careful management.

HFI requirements can be complex and difficult to specify precisely. Managing change in HF requirements is challenging even with the support of a good change management system, but it is one of the most important aspects of effective HFI.

5.2.1.1 Actions

- ∆ Identify emergent requirements
  - ∆ Identify HFI issues that could be resolved by changed requirements.
  - ∆ Discuss the implications of the changes with other stakeholders.
  - ∆ Agree them with the requirements manager (if appropriate).
  - ∆ Specify HFI acceptance criteria as appropriate.
- ∆ Manage human implications of changes
  - ∆ Monitor changes in non-HFI areas of the URD and SRD.
  - ∆ Consult with the ‘owners’ to ensure they are fully understood
  - ∆ Predict how they will affect the people, tasks and procedures.
  - ∆ Predict the impact on human related issues
  - ∆ If appropriate, negotiate suitable trade-offs and document the rationale
  - ∆ Respond to questions and issues raised by contractors.
- ∆ Explore unclear requirements
  - ∆ Identify, with the requirements manager, any human related requirements where the implications are unclear.
  - ∆ Check this against the current record of HFI assumptions and issues (already established by EHFA).
  - ∆ Exploit HFI analysis, assessment, prototypes, mock-ups, simulations etc.

- ∆ Revisit the risks, requirements and opportunities

  - For any new or changed human related requirements, assess whether the HFI risks have changed, and whether the measures currently planned to mitigate them are still appropriate.
  - If not, then modify the plans, or take other suitable action.

5.2.1.2 Outputs

- A contribution to a more complete, well balanced and accurate set of requirements, taking account or the human related issues
- A traceable record of agreed changes and rationale.

5.2.1.3 Checklist

- Is the requirement (or change) properly expressed and understood?
- Have all the operability, training, etc. implications of proposed requirements (or changes) been identified?
- Have changes to HFI requirements been justified in a traceable way?
- Is the HFI part of the ITEAP still valid in the light of the change?
- Does the change warrant additional analysis or assessment to quantify and mitigate the associated human related risk?
- Does the change affect any HFI requirements that have already been tested or accepted? If so, will the change invalidate those results?
- Have corresponding HFI risks been recorded for any rejected HFI requirements or any very ambitious system requirements?

5.2.1.4 Tips

- Contractors will often require (rapid) clarification or elaboration of requirements in order to make progress.
- The requirements manager must respond to contractors' requests, but will rely on HFI input from you.
- Consequences of undetected human implications of requirement changes might appear late in development, or in operation, when the impact could be severe.

5.2.2 HFI in system design

The overall system design results from many decisions, taken at many levels, affecting the equipment, operating and support procedures, training and job allocation. The IPT is responsible for the quality of the overall design, though many aspects are delegated to others: the contractor's engineering teams, the operational command, PPO staff, trainers, and logisticians.

The SRD embodies a high level design, the allocation of functions between equipment and people. This defines the bounds within which the equipment must be implemented, and can also have a major impact on human performance, and hence overall system effectiveness. As the design evolves, more decisions are needed to interpret the intent of the SRD (and the URD), to overcome constraints and to compensate for emergent deficiencies. All these decisions need to be informed by HFI input.

Allocation of functions between people and equipment or between different human roles can have a major impact on the collective performance of the system.

5.2.2.1 Actions

- Explore alternative allocations of function
  - Focus on critical scenarios.

  - ∆ Focus on functions near the boundary.
  - ∆ Determine whether functions are critical to the integrity of a role.
  - ∆ Use domain experts to assess the impact of alternative solutions.
  - ∆ Determine whether variable allocation is needed.
  - ∆ Ensure that the SRD reflects the optimum allocation of function.
- ∆ Monitor the evolving design
  - ∆ Ensure key HFI issues drive thinking about system design.
  - ∆ Find out what issues are emerging from the design process.
  - ∆ Identify any with human related implications.
  - ∆ Help the problem owners to understand the human implications.
- ∆ Provide support
  - ∆ Ensure timely provision of data where needed.
  - ∆ Ensure availability of users and domain experts where required.
- ∆ Ensure co-ordination
  - ∆ Make sure information generated by HFI activities is made available to other areas of the project (including other MoD agencies) and that information from other areas is available for HFI work.
  - ∆ Help resolve issues that run across organisational boundaries.
  - ∆ Ensure the HFI programme is being carried out appropriately, and that the results are having appropriate influence on design decisions.
  - ∆ Be an active participant in relevant working groups.

5.2.2.2 Outputs

The key outputs of this process are contributions to the high-level system design (i.e. the SRD) and the evolving design solutions.

Subsidiary HFI outputs will include:

- ∆ supporting HFI data
- ∆ recommendations from periodic HFI audits
- ∆ records demonstrating that HFI has influenced design decisions.

5.2.2.3 Checklist

- ∆ Are the HFI requirements and other design requirements reasonably consistent with each other?
- ∆ Is there a workable document defining requirements for HFI coherence in design (e.g. a style guide)?
- ∆ Do the designers understand the context of use?
- ∆ Does the design process provide for adequate disclosure, review and evaluation of HFI aspects?
- ∆ Is user involvement at a level that is likely to identify underlying issues, rather than just superficial details?

5.2.2.4 Tips

- ∆ Issues raised by design teams have a natural dynamic. There is often a time of receptiveness to new ideas, followed by a progressive closure around ideas that have emerged. A timely, even if ad hoc, HFI response to a problem can often be more effective than a more comprehensive, but delayed response.
- ∆ The best way to get designers interested in HFI is for HFI people to show interest in design problems.

5.2.3 Assessment of contractor HFI

Down selection of contractors is a major project decision. Contractors are judged not only on the solutions offered, but also on an assessment of their ability to deliver what they offer. At the time of selection, many HFI issues will be only partly explored, with few fully resolved. The contractor will exert influence over conduct of HFI after down selection, both as an IPT member, and more significantly in terms of the design and development process.

For the system to be effective, the benefits of HFI gained during the project's early phases must be carried through into implementation. Evidence of the contractor's competence to do this must be sought and used as part of a balanced selection process.

5.2.3.1 Actions

Assess HFI content of contractor results produced so far

- ∆ HFI analysis, assessments and trials
- ∆ Contribution to HFI Working Group
- ∆ Prototypes and demonstrators
- ∆ Understanding of context of use

Assess HFI content of plans and processes offered

- ∆ Active management of human-related issues
- ∆ Involvement of users in design and review
- ∆ Use of prototypes and progressive evaluation of operability etc.
- ∆ Acceptance tests for operability and key aspects of human performance
- ∆ Mechanisms by which HFI work will be able to exert influence
- ∆ Dependence on GFE.

Assess HFI competence

- ∆ Quality of HFI team
- ∆ HFI well integrated in the organisation
- ∆ Good working links between HFI and development teams

5.2.3.2 Outputs

HFI contribution to overall contractor scoring scheme

- ∆ It should have identifiable HFI components under all three aspects: the solution offered, the proposed plan and the contractor's capability.
- ∆ It should reflect the key HFI issues.
- ∆ Overall, HFI should be weighted according to the human related project risks.

HFI assessment scores for each contractor, based on application of the agreed scheme.

5.2.3.3 Checklist

- ∆ Do the plans reflect key project issues (derived from EHFA) and priorities?
- ∆ Is the contractor aware of all HFI domains, not just HF Engineering?
- ∆ Has the contractor been open on HFI during earlier phases?
- ∆ Has the contractor taken the initiative on HF related issues?
- ∆ Are prototypes used to obtain insights, not just 'sell ideas'?
- ∆ Does the team have realistic plans to access user experience?
- ∆ Is there evidence of real commitment to HFI and making it drive design?
- ∆ Is the level of HFI effort commensurate with the proposed programme?

5.2.3.4 Tips

- Contractors aim to put in compliant bids. They will offer HFI if it is asked for. You must decide whether it has substance or is a token offering.
- You need to form judgements about the likely quality and adequacy of what will actually be done (or whether it might not get done at all) and the value it will add to the fielded system.
- A good HFI team must be able to influence design and development teams if it is to add value to the process.
- Remember that good HFI costs the contractor money, but will pay MoD dividends later in the life cycle with better performance and lower support costs.

5.2.4 HFI test & evaluation

Testing and evaluation are fundamental to Smart Procurement, with the ITEAP (Integrated Test, Evaluation and Acceptance Plan) playing a central role. Successful management of the integration of the equipment with the human components requires evaluation as early as possible. The evaluation must cover all aspects of the equipment that will affect organisation, manning, personnel selection and training, and in particular:

- operability
- maintainability
- supportability
- trainability

This evaluation must continue during introduction into service, and periodically throughout the system life, to ensure that the technology continues to deliver benefits in the real context of use.

5.2.4.1 Actions

- Assess HF aspects of evolving design.
  - Review prototypes, demonstrators, and partial items of equipment.
  - Involve users in identifying human related issues and risks.
  - Ensure evaluation will read across to intended operational equipment.
- Assess HF aspects of emergent equipment:
  - Seek opportunities to gain extra value from equipment trials, by inclusion of explicit assessment or evaluation of human related aspects.
  - Ensure early gathering of evidence for HFI acceptance.
  - Ensure contractors are clear where evidence adequate for acceptance has been or has not been demonstrated.
  - Ensure that any deficiencies revealed by HF evaluation are tackled.
- Assess HF aspects of equipment in service:
  - Undertake post introduction HFI audit.
  - Put in place feedback mechanisms.
  - Conduct usage review when considering major upgrade.

5.2.4.2 Outputs

- Confidence that the equipment and human component will integrate.
- Early warning of any failure to meet HFI requirements in SRD or URD.
- Objective information to guide any necessary design interventions.
- Evidence to support HFI acceptance.

The evidence will be accumulated in (or called up from) appropriate sections of the evolving TLMP, and may be used to drive plans for subsequent phases.

5.2.4.3 Checklist

- ∆ Are early HFI evaluations planned to assess all currently identified human related risks?
- ∆ Are the HFI evaluations producing useful, valid results?
- ∆ Are all parties conducting the HFI evaluations in an open and constructive way?
- ∆ Is maximum value being extracted from HFI evaluations, and are results being fed back to drive design of the equipment, training, operational procedures, support systems, etc.
- ∆ Are the HFI evaluations being co-ordinated with other development and experimental work in a way that minimises overall cost and time to the programme?

5.2.4.4 Tips

- ∆ Early evaluation should focus on finding out information and building confidence.
- ∆ Informal or semi formal evaluations that can be done cheaply, quickly and early are often much more effective than formal evaluation that requires more time and resources. A suitable, early evaluation will often uncover the great majority of human issues.
- ∆ Formal evaluation is usually necessary to gather evidence suitable for acceptance or design sign off.
- ∆ Operability tests must involve representative users. It is critical to allow adequate allowance for familiarisation and training on the new equipment before any data are gathered.
- ∆ Evaluation involving human subjects or assessors must allow for inherent human limitations and variability.

5.2.5 HFI Acceptance

Acceptance is the formal process to certify that contractual commitments have been met, and that the deliverables meet their requirements. Equipment acceptance is based on evidence that the equipment has the required attributes and performs as specified in the SRD. This evidence is normally based on a combination of inspection (of the equipment and supporting documentation) and tests or trials (of the equipment). Evidence should be gathered incrementally during development and manufacture.

Where HFI requirements are expressed in terms of conventionally testable equipment attributes (size, weight, brightness, etc.) based on well proven standards or the result of prior trials, then their acceptance is no different from that of any other equipment attribute – see the first two types of test in Table 11. Other HFI requirements can not be expressed and tested in this simple way, but require direct evidence about how the equipment and users interact with each other, as shown by the third and fourth types of test in Table 11. These requirements (for operability, maintainability, trainability and supportability) must be tested using people as ‘test instruments’. Doing this reliably needs special procedures and techniques.

In rough terms, the tests are in order of increasing cost. It is therefore good practice to ensure that those items that can be simply tested are appropriately specified to permit this. The available trials budget and time should not be used up performing operability trials to check well-proven details. Operability trials and task walk-throughs should be used for areas of uncertain task interaction, task complexity and overall integrated task performance. They should also be used to test things such as performance degradation over extended periods and skill retention during periods of non-use, as appropriate.

Table 11 Types of acceptance test

Type	Description
Design inspection	Formal inspection of design documentation, against principles and requirements in the specification.
Functional demonstration	Formal controlled presentation of equipment and its working to assess the presence or absence of functionality.
Task walkthrough	Formal controlled presentation of task support facilities. Test criteria are based upon the ability to complete tasks, and qualitative measures of user acceptability.
Operability Trial	Formal, controlled, structured data collection of Human Performance or subjective user reaction against agreed, pre-defined criteria.

Acceptance of complete capability goes beyond the contractor's remit, and certifies that the IPT has met its obligations under the CSA (Customer Supplier Agreement). The IPT does not have control over all elements of the capability (notably the human components) but has a responsibility to work with the PPO and Operational Command to ensure that the capability is provided. This is a less clear division of responsibility. The Acquisition Handbook does not define a formal 'acceptance' process, but just the 'declaration of In Service Date (ISD)'. Nevertheless, evidence for this final and most important integration between the equipment and the human component is critical. It must verify that the capability specified in the URD has been met, and that the IPT's obligation is discharged.

The diagram shows the overlapping contributions to capability, shaded according to who is responsible for them. The darker shade of contractor responsibility denotes basic 'fitness for purpose' while the lighter shade indicates extended responsibilities for operability, etc. imposed by specific requirements in the SRD.

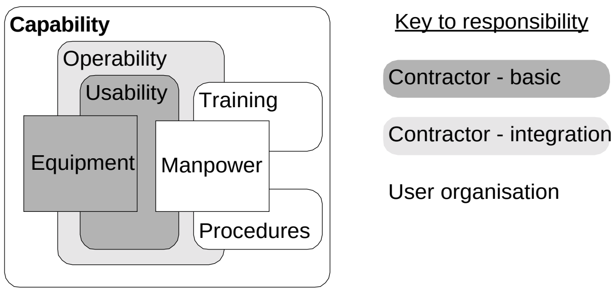

Figure 9 Responsibility for different parts of capability

5.2.5.1 Actions

- Ensure the Human Factors Acceptance Strategy is issued and agreed at the start of Demonstration phase.
- Ensure availability of adequate evidence to cover all HFI requirements.
  - Work with acceptance authorities to clarify the scope of evidence required (test plans, test schedules, validation criteria).
  - Work with developers to ensure HFI related test results are valid for acceptance.
  - Work with trials authorities and the user community to ensure that context of use is adequately reflected in trials generating evidence for acceptance.
  - Work with developers to gain approval of aspects that can be 'frozen' once they have been proven to meet HFI requirements.
- Help resolve acceptance problems.
  - Identify any trial or test constraints that could undermine the validity of HFI results.

  - ∆ Seek acceptable alternative means of assessing the adequacy of the solutions.
  - ∆ Identify early any risk of failing to meet HFI requirements in the SRD.
  - ∆ Ensure that the issues are addressed and resolved by appropriate parties.
  - ∆ Provide access to suitable representative users to support HF acceptance.
- ∆ Prepare to declare ISD
  - ∆ Work with the providers of all components of the capability (equipment, personnel, training and operational procedures).
  - ∆ Identify any aspects where there is a risk of failing to meet HFI related capability requirements in the URD.
  - ∆ Ensure the issues are addressed and resolved by appropriate parties.

5.2.5.2 Outputs

The key output of (equipment) acceptance is the confirmation that the equipment supplied has the attributes specified in the SRD. This should enable it to integrate fully and safely with the human component.

The key output of capability acceptance (needed to declare ISD) is evidence that all parts of the capability, human as well as equipment, do indeed work effectively together.

5.2.5.3 Checklist

- ∆ Are all involved parties (acceptance authorities, contractors, customer 2, and other stakeholders) 'signed up' to the HFI acceptance strategy?
- ∆ Do planned activities (contractor, MoD and other stakeholders) generate evidence to cover all HFI requirements in the SRD (for equipment acceptance) and in the URD (for declaration of ISD)?
- ∆ Does any of the evidence generated have questionable validity?
- ∆ Does any of the evidence that has been generated fail to support acceptance?
- ∆ If so, are there plans to resolve the problems?

5.2.5.4 Tips

- ∆ Taking an active interest in the HFI acceptance process will help to gain commitment of other parties to make it work.
- ∆ Building early confidence of all parties in the HFI acceptance strategy, and the evaluation and testing that underlies it, will greatly simplify the process of final acceptance.
- ∆ Distinguish between the contractor's absolute obligations to meet the requirements of the SRD and his (shared) responsibility to help resolve any shortcomings to satisfy the overall requirements of the URD.
- ∆ Any shortcomings identified in HFI acceptance will be easier to resolve if the evidence is clear, unbiased and well presented.

5.3 Supporting HFI analysis

You will need supporting HFI analysis whenever:

- ∆ Human related risks can't be quantified using readily available knowledge
- ∆ The best approach to mitigating the risks is not clear
- ∆ There is insufficient information to specify tight HFI requirements

Analysis techniques described in this section are listed, with the number of dots indicating typical emphasis throughout the life cycle.

Table 12 Supporting HFI analyses by phase

Topic	Sect.	Con-cept	Assess-ment	Demon-stration	Manu-facture	In-service	Dis-posal
HF in missions and scenarios	5.3.1	••	•••	••		•	
Learning from other systems (ECA)	5.3.2	••	•			•	
Task description and analysis	5.3.3	••	•••	••	•	•	•
Describing the human component (TAD)	5.3.4	••	••	•			
Anthropometric Assessment	5.3.5		••	••	•		
Modelling human performance	5.3.6	•	••	•••	•		
HFI support to COEIA (cost-effectiveness)	5.3.7	•	••				
HFI and safety	5.3.8	•	••	••	•	•	•

Much HFI analysis in support of the project will be conducted by specialists outside the IPT, either under contract or CSA. In some cases early, members of the IPT with suitable background can, adequately carry out high-level assessments.

To manage HFI analysis:

- ∆ Prioritise high-risk issues from the previous phase and from EHFA, and agree the overall plan and budget for HFI studies.
- ∆ Identify and plan supporting activities, either in-house or external.
- ∆ Conduct (or subcontract) the work.
- ∆ Evaluate significance of the results
- ∆ Integrate findings of each task with information from other relevant studies and feed into project outputs.

Each study definition should include:

- ∆ purpose
- ∆ time-scale
- ∆ resource requirements
- ∆ data to be collected
- ∆ indication of analysis methods and treatment of results
- ∆ reporting & progress monitoring methods
- ∆ who will use the results and conclusions

Study reports for each analysis should include:

- description of issues to be resolved
- methods employed
- technical data
- significance of results to relevant project areas, and recommendations

Review and evaluate requirements for HFI studies in different areas before producing detailed plans. Try to integrate the results of HFI studies across the project to produce data usable by more than one technical area and to meet the needs of all relevant stakeholders

5.3.1 HF in missions and scenarios

Operational scenario(s) form one element of the capability requirement. Scenarios specify conditions under which the capability must be provided: the part of the world, the type of operation, the degree of local political support, etc. Mission and scenario descriptions also underpin much HFI work (from EHFA through to ‘man in the loop’ simulation) but often need detail not required for other purposes.

5.3.1.1 Why

Operational scenarios needed for other purposes often do not contain the level of detail needed for HFI evaluation and assessment.

5.3.1.2 When

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
••	•••	••		•	

5.3.1.3 Actions

Identify aspects relevant to HFI:

- Identify and recruit appropriate military knowledge and skill to project forward to envisaged capability.
- Identify and describe the likely ‘macro conditions’ (e.g. doctrine, objectives, mission duration, etc) that will affect system performance within each scenario.
- Identify and describe the likely ‘micro conditions’ (practical context, duty hours and cycles, environmental and climatic conditions) that will apply within each scenario.

Describe elaborated scenario threads.

- Ensure scenario threads are consistent with the higher level scenarios, CONOPS, embryonic Use Study etc.
- Ensure scenario threads have military credibility.
- Ensure scenario threads are detailed enough to support HFI analysis.
- Ensure scenario threads cover all relevant aspects of military deployment, not just those involved in an engagement.

5.3.1.4 Outputs

Elaborated scenarios - descriptions of events, consistent with the endorsed scenarios in sufficient detail for use in HFI studies. Often this will include narrative, time-based accounts of typical events, not just statements of disposition and capability of forces.

Concept and Assessment and subsequent phases differ in the level of detail needed. In each case, this depends on the planned HFI activities in the following phase.

5.3.1.5 Checklist

- ∆ Do the main project scenarios adequately represent the human contribution to the capability?
- ∆ Will the elaborated scenarios support HFI analysis in the next phase?

5.3.1.6 Tips

- ∆ Allow for 'non-system' tasks of hands-on users in operational scenarios (e.g. guarding equipment, attending briefings, preparing defensive positions, preparing food) if they are likely to affect availability of key personnel, or their ability to sustain performance.
- ∆ Contractors use scenarios as the basis for all performance calculations that are not explicitly covered by the specification. Any aspects not visible in the scenario set available to the contractor will receive much less emphasis in the design.
- ∆ Producing operational Scenarios during Concept means contractors can base their work on them from the start of Assessment, whereas any not developed until Assessment might be too late to influence early thinking and critical decisions.
- ∆ Consult service, training and doctrine staffs as appropriate.
- ∆ Ensure that the elaborated scenarios can provide an adequate basis for all future acceptance tests associated with fitness for use. This includes calculations or assessments of critical human performance, error rate, workload, etc.

5.3.2 Learning from other systems (ECA)

Early Comparability Analysis (ECA) provides an early assessment of human issues and risks to the proposed new system by drawing upon experience from other systems that have similar features. Because the two systems will never be entirely the same, it will be necessary to allow for the differences in the two contexts of use.

A process of this nature is often intuitively employed by domain experts (and members of CWG) who draw upon their previous experience. The process is described formally to encourage its systematic application and thus, in turn, the availability of a wider range of experience than is available to a single person.

5.3.2.1 Why

Learning from prior experience can be more cost effective than repeating it.

5.3.2.2 When

ECA is most useful before the system is built, or when contemplating a major upgrade. The process is essentially the same whenever it is applied.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
••	•			•	

5.3.2.3 Actions

- ∆ Identify comparable system(s)
  - ∆ Identify systems with some key characteristics similar to the proposed options.
  - ∆ Identify information about existing systems that can be read across to proposed options (e.g. about human performance and integration).
  - ∆ Study predecessor system (if one exists) for information relevant to HFI.
  - ∆ Review operational or exercise debriefs, acceptance or trials reports, information at training schools and operational commands for valuable HFI lessons.

- Establish existing issues, concerns and performance margins
  - Obtain information about human integration, performance and contribution to effectiveness within the chosen system(s).
  - Use any sources available, trials reports, operational debriefs, audits, and user experience.
  - Identify areas of operation where there is actual shortfall.
  - Identify areas where margins are unacceptably small (i.e. where any slight increase in the imposed task, or any slight reduction in skill or endurance of the people, would be likely to cause failures).
  - Identify opportunities for major improvement in either performance or cost.
- Identify similarities & differences
  - Identify similarities between the proposed and existing system(s).
  - Identify differences between these systems that are likely to affect carry over of the identified issues (e.g. scenario, task structures, workload, manning structures, personnel profiles and operating procedures).
- Extrapolate data to project context
  - Determine how issues will carry over from one system to the next (will system differences ease or aggravate problems).
  - Quantify the influence of human issues on system performance.
  - Review the collective picture of issues that will read across from the other system(s) and assess their severity.
  - Ask people with experience of the systems involved to assess the conclusions and the rationale.
  - Feed the issues into EHFA (see section 5.1).
  - Feed any evidence about human performance into HFSC (see section 5.3.7).

5.3.2.4 Outputs

Validated assumptions and issues to feed into EHFA together with outline information on human performance data that may be used for cost effectiveness assessment.

5.3.2.5 Checklist

- Have the differences in context of use been adequately accounted for?
- Are the resulting indicators reliable enough to use in this project?

5.3.2.6 Tips

- Failures of human integration are often easier to detect in systems already in service than they are to predict for a new system.
- You can often get useful read-across from systems with similar characteristics as they affect the human users (e.g. operating in cramped conditions) even if the systems are not superficially similar (e.g. land vs. sea).
- It is tempting to believe that the new system will be so different from previous ones that there will be no read-across. The technology might change, but the people, many of their tasks and the military context will change much less.
- If the technology is going to change a lot then the human integration risks will be higher. It is important to be forewarned of potential problems so that they can be overcome.

5.3.3 Task description and analysis

- Task description captures what users do or will be required to do.
- Task analysis explores the implications in terms of the users' ability to perform them, how they relate to each other, the scope for errors, etc.

The analysis results should be used to inform the design of equipment, training, maintenance etc. It is most useful early in the life cycle, but should be used subsequently whenever significant changes are proposed. Task analysis can reveal changes to the task structure that could enhance performance and/or cost. A high-level task description is an essential part of the requirement. Detailed analysis is a specialist activity (see the third set of actions below).

5.3.3.1 Why

A clear understanding of what the users of a system actually do is fundamental to most aspects of HFI. It provides a key input to many other technical activities.

5.3.3.2 When

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
••	•••	••	•	•	•

5.3.3.3 Actions

- Identify user tasks.
  - Determine roles of all people involved in delivering the capability.
  - Consider all tasks (some of which might not involve direct use of the system equipment).
  - Focus on key tasks (and any that are inherently human).
  - Identify different user tasks for different options.
  - Link task descriptions to roles if possible.
  - Consider operators, maintainers and support personnel.
  - Start at high level and only decompose to lower level tasks as necessary.
  - Draw information from current or predecessor systems, extrapolating forward to the new system.
- Document the task structure
  - Make the structure clear and easy to navigate (task descriptions can be longer than you expect).
  - Take care over terminology (some people using it will not be familiar with the operational context).
  - Use explanatory notes for tasks where there is likely to be any uncertainty.
  - Use a tool to represent the task structure (System engineering tools, flowcharting tools, word processors and spreadsheets have all been used).
- Analyse user tasks, workload, etc.
  - Consider (in Concept) the consequences of tasks already identified (much of this will be informal support to EHFA).
  - Focus on the 'high driver tasks' - difficult or critical tasks that are likely to drive the design of the human-equipment interface, the functionality of the equipment, or the manning of a team.
  - Identify and access user expertise to assist with these analyses.
  - Tabulate and describe the highest risk tasks (e.g. too difficult, too slow, work overload or wrong skill set).
  - For each high-risk task, define its critical aspects (issues likely to cause problems).
  - Provide an input to analysis in the following phase to ensure that correct information is supplied to contractors or agencies via SoW or CSA.

5.3.3.4 Outputs

A structured task description presented in a suitable format and with sufficient detail for the people who will use it.

Analysis report(s) describing the workload, skills and knowledge required, performance risks, etc, depending on the project needs.

- ∆ In Concept - the main output will inform thinking about the URD, and provide a reference task structure that can be given to contractors and others in Assessment as a common baseline for their work. It will not normally include equipment dependent detail, but might differ between options.
- ∆ In Assessment - outputs will include revisions and more detail for the selected option. This detail will inform the 'Context', 'System Functions, 'System Performance' and 'Non-Functional Requirement' sections of the SRD. The task description at Main Gate should form a definitive reference for defining evaluation trials and tests on the basis of which down selection, and in due course equipment acceptance will be made.
- ∆ In subsequent phases, the task description may be revised, and further analysis commissioned if required, e.g. in support of a change proposal. Contractors will draw on the task descriptions and analyses when assembling evidence to support their proposed solutions.

5.3.3.5 Checklist

- ∆ Does the structure only include a small number of goals (high level tasks) per role? If there are more than about half a dozen, examine them to see whether some naturally group together.
- ∆ Will people without operational, maintenance or support knowledge understand the descriptions?
- ∆ Do the descriptions include the conditions under which tasks will be performed (for individual tasks or the whole job, as appropriate)?
- ∆ Is the required performance indicated (e.g. time, accuracy) for critical tasks?
- ∆ Has someone with current knowledge of the tasks and a vision of the future capability reviewed the description?

5.3.3.6 Tips

- ∆ Task analysis can get too detailed, and be too late to have effect. Think about how much detail is needed for the people who will use the results. With a hierarchical description you can readily add detail later.
- ∆ Tasks need to be described in simple, direct terms, using 'action verbs' and objects (e.g. 'locate target', 'prepare launcher', 'cancel track', set-up system') rather than vague noun based forms (e.g. 'initialisation', 'track management'). This makes it clearer what people will actually do.
- ∆ If you are unsure about what the equipment will do, add a note to that effect and describe the higher level task. Unless the user loses all responsibility, there is always a high level decision making task, even if it is limited to knowing when to push the button (or not push the over-ride button).
- ∆ You will need specialist support to carry out a large or complex task analysis. This guidance applies mainly to relatively simple early task descriptions that you might perform yourself.

5.3.4 Describing human components (TAD)

5.3.4.1 Why

A common understanding of the human component of the capability, i.e. the people who are likely to be involved with the equipment(s) is vital to many of the individuals and groups involved in acquisition. Initially descriptions will be high level in order to underpin the exploration of human issues. Eventually descriptions will evolve into a fuller detailed TAD (Target Audience Description). For further information see *Management guide to the preparation and use of Target Audience Descriptions in the acquisition of defence capability*

5.3.4.2 When

- ∆ In Concept, for each option, descriptions should focus on describing the organisation and roles (see first two sets of actions).
- ∆ In Assessment, descriptions need to be more detailed to support the SRD at Main Gate. A TAD at an appropriate level of detail, must cover both Manpower (numbers) and Personnel (attributes) - see remaining sets of actions.
- ∆ In subsequent phases, the TAD might require review and update, especially if the user population has changed by the time a major upgrade is proposed.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
••	••	•		•	

5.3.4.3 Actions

- ∆ Identify organisation(s) & roles
  - ∆ Consider the people who form part of the capability (for each different option).
  - ∆ Identify all hands-on users (operators, maintainers, support personnel) and people whose jobs will be influenced by the system.
  - ∆ Identify the significant roles that people within these groups will play.
  - ∆ Determine how each significant role would affect the ability to deliver the capability.
- ∆ Describe key aspects and issues.
  - ∆ Develop descriptions for each organisation and role in sufficient detail to ensure that major manpower or personnel issues are clear and able to influence future project decisions.
- ∆ Determine detail needed for TAD (normally not before Assessment).
  - ∆ Review descriptions of organisations and roles.
  - ∆ Determine the level of detail of user information needed to support system design, training, etc (for all technology options).
  - ∆ Determine the level of detail needed at Main Gate, for input to Demonstration (for the selected technology option).
  - ∆ Assess the relative priority of different types of information.
  - ∆ Provide detailed specifications for critical factors related to key issues and risks (identified in EHFA).
  - ∆ Provide outline specifications for factors not related to key issues or risks.
- ∆ Define manpower options and describe personnel requirements.
  - ∆ In consultation with the PPOs, determine relationship between manning requirements and mission profile(s), different technology options and career path options.
  - ∆ Consider the draft numbers of personnel, work-rest cycles, expected levels of maintenance and any likely manpower constraints.
  - ∆ Define personnel requirements for manning options.
  - ∆ Describe any likely constraints and possible changes in skills needed, physical or personal characteristics that might be forced by the equipment options.
  - ∆ Identify any recruitment and personnel issues.

- Δ Document user description.
  - Δ Keep to the agreed level of detail.
  - Δ Specify the likely characteristics needed to fulfil key job requirements, (rank and branch, knowledge and skills, personal attributes, training and career objectives).
  - Δ Consider the key tasks assigned to each user group and the operational and organisational conditions under which tasks will be performed.
  - Δ Provide outline descriptions of the future organisation in terms of operation and maintenance, including any constraints.

5.3.4.4 Outputs

Description of the human component in enough detail to act as a reference for other project activities.

- Δ Information to identify manning and personnel issues (at Initial Gate).
- Δ At least an outline TAD (at Main Gate).
- Δ A full TAD (before contract let)

5.3.4.5 Checklist

Does the statement:

- Δ Identify the range of different hands-on user groups
- Δ Identify the organisations involved in supplying or supporting users
- Δ Identify where major changes to current manning policy can be anticipated
- Δ Allow for demographic trends
- Δ Cover operational, maintenance and support personnel
- Δ Specify skills and knowledge
- Δ Include enough detail for the people who will use the information
- Δ Cover all the system options (separately if necessary)?

5.3.4.6 Tips

- Δ Manpower and personnel issues might be latent in existing structures, e.g. shortage or surplus personnel, career progression problems, ineffective organisational structures, skill deficiencies, poor allocation of key tasks to users.
- Δ New issues can often be found by exploring assumptions about what will change and what will not change. This should identify any mismatches between requirements and availability, or risks associated with the need for new skills.
- Δ For radically different options, the most relevant predecessor might not be the system being replaced, e.g. if replacing a mine system with a missile system to provide anti-armour protection. Consider the 'nearest fit(s)' from other systems in terms of the user groups and the tasks they undertake.
- Δ The system will affect more people than its direct operators. Consider also: those who maintain, support or replenish it, those who use its products and anyone whose job will be influenced by it.
- Δ Many manpower and personnel issues have wide reaching ramifications, and do not fit neatly into the confines of the system being considered. You need care to distinguish between factors relating to the new system, factors left over from the old system and factors driven from outside the system.

5.3.5 Anthropometric assessment

5.3.5.1 Why

The human component (operators, maintainers & support personnel) comes in widely differing shapes, sizes and strengths. Designing equipment to fit this wide range is very demanding, especially where space and/or weight are at a premium as they often are in military equipment. Slight misfits that might be tolerable for short periods in a benign environment can have drastic effects when endured for long periods in moving, high stress environments.

Design is complicated by the fact that different populations can differ significantly at the extremes of the distribution. Not only do nations differ (which is relevant for multi national procurements) but also groups within nations differ (e.g. military v civilian, aircrew v ground crew, male v female). Equipment for a mixed sex force must cater for a significantly greater range of sizes than for a single sex force. During the lifetime of an item of equipment, the size range of the population that uses it can change measurably. (Historically, changes in the order of a millimetre per year have been found).

Anthropometric modelling helps give confidence that when the equipment is built and fielded, it should be suitable for the physical characteristics of the people, carrying out the anticipated tasks.

5.3.5.2 When

Anthropometric modelling is needed mainly during early development. MoD might commission anthropometric assessment in support of option evaluation, but in any case will be involved in reviewing equipment contractors work in support of equipment design, especially when it is offered as evidence to support the acceptability of the equipment.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
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5.3.5.3 Actions

- ∆ Obtain and validate anthropometric data
  - ∆ Review information in the Target Audience Description (TAD) (see 5.3.4) to identify significant groups within the user population (operators, maintainers, support personnel) and the main ways in which they are likely to differ physically. Identify key information and pointers to primary data sources.
  - ∆ Review information in the Task Analysis (see 5.3.3) to identify tasks likely to require extremes of posture, movement, force or frequency.
  - ∆ Access the relevant data sources. Identify the most relevant sets of data. Check their validity (when the data were recorded and how long they will remain valid).
  - ∆ (Exceptionally) initiate data collection if available data are inapplicable in the project context and there is a reasonable prospect of gathering sufficient data to be reliable in the required time scales. This might need to be funded by one of the MoD's research programmes.
- ∆ Apply data in design process
  - ∆ Identify model needs. This is very dependent on the way the people and equipment interact. Areas of tight constraint (e.g. headroom, critical reach, sight lines or heavy lifts) usually need exploring.
  - ∆ Customise data for use. Extract subsets and combine data items (and any assumptions) in ways that will simplify the process and reduce the risk of error.
  - ∆ Develop and apply models. This is iterative, and closely linked with the design process. Clearances and sight lines are best handled by geometric modelling (which can begin with simple 2-D approximations). Sophisticated software tools can handle movement and predictions of forces at body parts, but these need careful interpretation. Some form of tabulation and assessment is useful to check where limits are being approached.

5.3.5.4 Outputs

Project specific data - assembled from different sources, extracted, adapted and simplified to suit project needs. Appropriate clothing allowances should be included. Presenting data clearly and in appropriate form will greatly reduce the cost of using the data and the risk of errors.

Visualisation - Human mannequins integrated into equipment designs in 2D and 3D CAD make it easier to appreciate the implications of the interaction between the equipment and the human bodies.

Analysis - Tabular, graphical or other summaries of clearances, strength margins, etc.

5.3.5.5 Checklist

- ∆ Has the analysis explored critical physical constraints for all relevant user groups (operators, maintainers and support personnel)?
- ∆ Has the analysis explored critical physical constraints for an adequate range of tasks, operational work patterns and postures?
- ∆ Has adequate allowance been made for clothing and any restraints on body, limb or head movement?
- ∆ Have reasonable combinations of large and small dimensions of users been assessed?
- ∆ Have the modelling results, particularly any visualisations, been reviewed by users?
- ∆ Are the models, and the source data on which they are based, believed to be valid for the anticipated system during its life? If not, what can be done to reduce the risk of basing the solution on invalid results?

5.3.5.6 Tips

- ∆ Anthropometric modelling is most effective within the context of generating a design solution. Designers need to understand how the human body interacts with different parts of a design, and how different tasks will affect that interaction.
- ∆ There is no such thing as a 97%ile user. The statistics relate to individual dimensions (stature, eye height, functions reach, etc). Someone who is tall does not necessarily have long arms. Someone who is short does not necessarily have thin thighs. Of the larger number of possible combinations, some are more critical to the design than others.
- ∆ Designing for the 3rd to 97th%ile sounds impressive, but means that 1 in every 16 will fall outside the design range.

5.3.6 Modelling human performance

Performance achieved with current equipment (operational or experimental) can provide a good starting point for estimating future performance. The context of use of the new capability (i.e. the scenario, environment, user group, and organisation structure), the tasks and level of automation are rarely the same as what is being replaced. Some means of prediction to allow for this is essential.

Computer modelling can be an extremely cost-effective way of predicting human performance in future systems. It can help assess different concepts to establish the level of human performance achievable in different scenarios. Modelling is often used to predict:

- ∆ whether users are likely to be able to cope with the workload imposed on them
- ∆ how long users will take to perform tasks
- ∆ how long users will take to respond to critical stimuli
- ∆ how user performance might degrade with physical and other stressors
- ∆ the probability and effects of human errors

Predictions need careful interpretation, but with good input data, they can be as good as engineering models. The quality of data available to model the performance of different tasks, and the effect on it of physical, environmental and physiological stressors, shift-patterns, etc. is advancing all the time.

Simple models can be constructed using a spreadsheet and calculation. More complex models require some sort of software modelling tool capable of representing tasks, user characteristics, performance shaping factors (PSFs), and the humans response to them, as well as events in the world. Typically they produce results by averaging over many runs with random distribution of delays, etc.

5.3.6.1 Why

To give confidence that human performance will not compromise system effectiveness.

5.3.6.2 When

Before the equipment is available, human performance modelling can predict performance to inform option selection and design decisions. As the system takes shape, practical evaluation using real equipment takes over. MoD might sponsor modelling mainly during option selection, and will need to review the adequacy of modelling results offered by contractors as evidence to support the acceptability of evolving equipment designs.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
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5.3.6.3 Actions

- ∆ Identify likely problem areas:
  - ∆ tasks that are critical to system performance
  - ∆ tasks that are more complex or demanding than predecessor tasks
  - ∆ tasks that are performed under stress
  - ∆ situations that impose high workloads or time pressure
  - ∆ response in emergencies
- ∆ Identify the key human performance indicators
  - ∆ Determine the most important aspects of human performance (task completion, task time, availability for other tasks, task errors, decision quality, etc).
  - ∆ Identify human characteristics (visual skills, endurance, etc) critical to the tasks, and determine how they vary across the user population (possibly from the TAD).
- ∆ Identify Performance Shaping Factors (PSFs) (that degrade or enhance performance):
  - ∆ training and experience
  - ∆ environment (motion, darkness, noise, temperature, time of day)
  - ∆ fatigue and stress
  - ∆ individual or team working
- ∆ Design the model
  - ∆ Identify what data can be generated.

  - ∆ Ensure the model represents variables needed for "what if" analyses.
  - ∆ Ensure the model allows different scenarios to be represented easily at run time.
- ∆ Obtain basic data and develop model(s)
  - ∆ Identify simulation parameters to reflect the key human performance indicators.
  - ∆ Use data from research, exercises, trials or standards.
  - ∆ Define task networks, dependencies and factors affecting performance.
  - ∆ Validate models against known results.
- ∆ Explore models to understand predicted performance
  - ∆ Define critical scenarios, task sequences, performance criteria.
  - ∆ Explore "what if" scenarios.
  - ∆ Run models (or undertake analysis).
  - ∆ Interpret results in the system context.
  - ∆ Look at the sensitivity to changes in assumptions and basic parameters.

5.3.6.4 Outputs

Data tables and graphs - These present selected data on key human performance indicators, and how they are affected by Performance Shaping Factors (PSFs). Common dimensions of performance typically measured include:

- ∆ time to perform given tasks
- ∆ delays between events in the world and human response
- ∆ 'workload' - the fraction of an individual's capacity that is consumed by tasks arriving at a given rate
- ∆ attentional demand - the demand tasks make on the user's cognitive resources (verbal, aural, perceptual, reasoning, etc)
- ∆ accuracy - for quantitative tasks like aiming or estimation
- ∆ error rate - for discrete tasks like selection or classification
- ∆ ability to complete - for physical or complex mental tasks
- ∆ endurance - ability to sustain performance over a period

Executable software models - These simulate behaviour explicitly, representing the timing of events, variations in task duration and the probability of making different decisions. The results are normally presented statistically based on a large number of runs. Predictions that are not statistically based should be treated with even greater caution. Human performance models can be free standing or embedded within a system performance model. Models should be capable of being used to explore the implications of different scenarios ("what if" analysis).

Calculations - Assessment of workload or response time for simple task sequences can often be calculated on paper or using a spreadsheet.

Comparability assessments - These predict likely performance by analogy with known situations, taking account of factors that would enhance or impair performance. This is most useful where the new context of use has strong similarities to a known situation, and where there are inadequate data to develop detailed quantitative models.

5.3.6.5 Checklist

- ∆ Are the results understandable and credible?
- ∆ Does the model focus on areas where there are real issues?
- ∆ Are there adequate, relevant data to predict performance without building models?
- ∆ Can a comparability assessment adequately predict user performance?
- ∆ Have the models captured the critical tasks?
- ∆ Do the models realistically capture how tasks are to be performed?

5.3.6.6 Tips

- ∆ Modelling can help to focus thinking.
- ∆ A short sharp modelling exercise might be more valuable than a long complex one
- ∆ A simple model that is easy to understand and validate might be more useful than a complicated model that only the modellers can understand.
- ∆ The real power of a model usually only comes by running ‘what if’ scenarios once it is built; building a model that does not allow different scenarios to be explored can be very poor use of resources.
- ∆ Critical human performance limits might come from maintainers and support staff, as well as operators.
- ∆ The person who is critical to military capability might not be a ‘typical’ person, but the least capable individual, or the individual suffering extreme stress or fatigue.
- ∆ Models can bring data to life, and dramatically illustrate performance inadequacies, but they depend on intelligent and careful interpretation. Computer generated predictions are not the same as actual human performance.
- ∆ A model is no better than the data from which it is built, even if the data are hidden. If some of the times for elemental tasks (like viewing a piece of information, making a decision or operating a control) are only guesses, then the model results should be treated with extreme caution.

5.3.7 HF support to COEIA (HFSC)

5.3.7.1 Why

The human component of capability critically affects system costs and effectiveness, and must therefore be covered by the COEIA (Combined Operational Effectiveness and Investment Appraisal) used to compare options. COEIA is applied at Main Gate, with pre-COEIA activity at Initial Gate, and continuing comparison to justify down-selections. Human Factors Support to COEIA (HFSC) is a specialist activity that contributes to COEIA and mirrors its structure. This section describes HFSC in simple terms.

5.3.7.2 When

- ∆ In Concept phase HFI contributes by considering human contribution to cost and effectiveness.
- ∆ During Assessment phase, a formal HFSC study will normally be commissioned if human aspects have a major impact on option selection.
- ∆ In subsequent phases, a mini COEIA might be needed to justify a major upgrade.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
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5.3.7.3 Actions

- ∆ Contribute to Concept of Analysis.
  - ∆ Agree with the scrutineers whether a formal Human Factors study is needed and recruit specialist HFI support if required.
  - ∆ Review the Concept of Analysis (CoA) to ensure that it takes account of the role of the human, and can differentiate between options with significantly different human contributions.
  - ∆ Identify all human contributions to system effectiveness and ensure that they are adequately represented in Measures of Effectiveness (MoEs).

  - ∆ Consult specialists in human performance modelling and identify what is likely to be quantifiable, what can be modelled and what will require military judgement.
  - ∆ Ensure scenarios and test cases will be sensitive to the human value added and will differentiate between options.
- ∆ Ensure available evidence on human contribution to effectiveness.
  - ∆ Consider each Key Performance Parameter and establish the 'value chains' of factors that enable it to be achieved.
  - ∆ Determine which links in the chain will depend on equipment, which on people and how they will interact.
  - ∆ Describe likelihood and impact of contributory links in the chain.
  - ∆ Review proposed models of human performance
  - ∆ Ensure military judgement is harnessed to fill gaps in human performance data.
  - ∆ Ensure the overall process is reviewed for military credibility
- ∆ Ensure available evidence on human contribution to costs.
  - ∆ Determine processes that will invest money in people needed as part of the capability. Consult cost analysts, manpower-planning authorities in the PPOs, training authorities.
  - ∆ Ensure that the costs and forecasts used for option assessment reflect true whole life cost of investment in people
- ∆ Ensure available evidence on other human contributory factors.
  - ∆ Identify any human related differences between options that ought to be considered (e.g. morale and its impact on attrition or performance; demographics and the extent to which suitable manpower is likely to be available service-wide, career progression and compatibility of procedures.
  - ∆ Consult with the PPOs, trainers, and others involved with the people, their provision, support and welfare.
- ∆ Ensure human contribution to option comparison
  - ∆ Review the conclusions and recommendations of the COEIA (or pre COEIA) studies
  - ∆ Review the comparisons to ensure they fully reflect the human contribution to different options and that the conclusions reflect the human impact on risks
  - ∆ Discuss with the analysts and scrutineers how any missing aspects can best be included and quantified.

5.3.7.4 Outputs

Agreed contributions into COEIA studies that reflect, and differentiate between, the human components of the different system options.

HFSC report in support of the above.

5.3.7.5 Checklist

- ∆ Have you agreed an approach to including the human element in the COEIA (or pre COEIA) study?
- ∆ Have you agreed with the scrutineers whether a formal HFSC study should be conducted?

- Have MoEs been identified to account for all the major human contributions to the capability?
- Do the manpower-related costs properly reflect the cost of employing people to help deliver the capability?

5.3.7.6 Tips

- People related factors are easy to miss from assessment models, but can be key to system effectiveness
- Equipment performance is easier to measure than human performance. Don't let it dominate the MoE unreasonably.
- Manpower costs often dominate through life costs, but are difficult to establish reliably. Many costs can be 'hidden', and some, e.g. training costs can differ significantly depending on the equipment solution.
- Military judgement can be used to fill the gaps in models of human contribution to system effectiveness, but ensure it is not over used, or open to manipulation of the answer.

5.3.8 HFI and safety

An equipment or platform capable of causing a hazard to people needs evidence to demonstrate that it will be safe. Different bodies will certify different types of equipment (ship, aircraft, ordnance, fuel handling, etc). Each will stipulate specific evidence required for certification, and this evidence will include some form of safety case that:

- identifies how the (manned) system could fail or could operate incorrectly
- identifies design measures taken to mitigate the resultant hazards
- derives resultant measures of the residual risk

The evidence is based on a combination of design audit, testing, analysis and demonstrated safe working attributes. The safety case is accepted when it has demonstrated that all reasonable measures have been and will continue to be taken, and that the residual risk is as low as reasonably practicable (ALARP).

System Safety Analysis is a specialist activity. Safety analysis uses knowledge about the expected system design and its likely failures to define causal chains showing what factors would combine to create particular hazards, or what hazards could (in part) be caused by particular failures. Safety analysts will seek ways to make the design more robust, to reduce the chance that hazards will occur, and to minimise the impact if they do. Equipment contractors will play a leading role, but as the system operating authority, MoD is ultimately responsible for system safety.

HFI helps identify safety issues caused by the interaction of human and equipment.

5.3.8.1 Why

People contribute to the risk of incorrect operation and they also normally provide a vital link in many fault recovery and hazard avoidance mechanisms. A safety case that does not properly account for the human contribution is likely to be misleading, and therefore invalid.

5.3.8.2 When

- In Concept phase, the main activity is to identify safety-related issues.
- In Assessment phase, there will be more detailed analysis. Depending on the depth and complexity, this might need specialist HFI support.

- In Demonstration, the safety case must be developed, with detailed design audit and practical demonstration of protection mechanisms etc. This should cover human error performance, equipment operability, safety procedures and error recovery mechanisms.
- In Manufacture, the safety case will require evidence of the above under realistic operating conditions.
- The safety case must be maintained through life and revalidated in major upgrades. Unsafe procedures or human violations must be dealt with.

Concept	Assessment	Demonstration	Manufacture	In-service	Disposal
•	••	••	•	•	•

5.3.8.3 Actions

- Assess human contribution to risks
  - Identify human errors and characteristics that might contribute to a hazard
- Consider how to reduce human induced risk.
  - Is human involvement necessary? Usually it is to cater for exceptions, but in some cases advances in technology might mean that it is not.
  - Could the equipment provide better support? (e.g. making controls and displays less confusing, providing automated checks and reminders)
  - Could procedures be strengthened? (e.g. drill, checklists or dual role actions)
  - Could the people be better trained? (e.g. more background knowledge to handle unusual conditions)
- Consider how to enhance human contribution to protection.
  - Ensure that the equipment design and procedures help the human to diagnose and handle abnormal situations.
- Monitor the safety analysis
  - Ensure that the potential for safety related human errors, and equipment design features to minimise them, are given adequate prominence in thinking about system design.
  - Find out what assumptions about human performance are being made in the safety analysis.
  - Help the problem owners to understand the human implications of hazards and hazard prevention.
  - Ensure allowance for reasonable variability in human capabilities and behaviour.
- Support the safety process by ensuring:
  - timely provision of human performance and error data where needed
  - that data in the Task Analysis and Target Audience Description are used where appropriate
  - that HF analysts are available to support the safety analysis where required
  - that HFI evaluation and trials cover safety related areas and will provide data to support the safety case

5.3.8.4 Outputs

Contributions to the Hazard Log, Hazard Analysis Reports and Safety case.

Supporting HFI analyses and evaluation or trial data e.g. relating to human error rates or human ability to take recovery action in the event of a mishap

5.3.8.5 Checklist

- Does the hazard identification include factors arising from the operating domain, e.g.:
  - shock
  - vibration
  - extreme temperatures, pressures, climate
  - noise

    - exposure to toxic substances
- Does the hazard identification include factors arising from operating procedures, e.g.:
    - training and instruction
    - health hazards
    - user errors
    - equipment ergonomics
- Does the safety analyses reflect:
    - the expected roles (operational, maintenance and support) of people in the system
    - the context in which the system will be used
    - the human contribution to hazards
    - the human ability to help avert hazards
- Is the system design likely to increase or reduce the risk of safety related human errors?

5.3.8.6 Tips

- An early Human Factors contribution to the fault tree analysis can bring clarity to the otherwise vague area of 'human error', especially if it is linked to a formal review process managing human related risks.
- Initial judgements based on operational experience might be adequate for the first pass, but you should seek specialist advice on human reliability and the factors that contribute to it.
- Human Factors insights can often provide better design interventions where there is a need to reduce the risk of human error.
- HFI involvement can help draw together safety related strands that affect training, maintenance and support, as well as operational system design.
- Good early HFI input does not mean 'the HFI has been done'. Many details will not emerge at the level of description available during Concept and Assessment phase.
- The best way to get safety analysts interested in Human Factors is for HFI people to show interest in safety problems.

6. HFI Reference

6.1 HFI Domains

MoD classifies HFI concerns in six domains. The icons are used in MoD HFI documents.

6.1.1 Manpower

The Manpower domain concerns the number of military and civilian personnel required, and potentially available, to operate, maintain, sustain, and train for systems

Table 13 Manpower sub domains

Sub domains	Description
Phasing	Planning the availability of operational, maintenance and support personnel at introduction and throughout the life of system.
Force Structure	Allocation of tasks between branches, arms and trade groups. Implicit with these are organisational policy (e.g. rank and responsibility), military/civilian balance, reservists and the peace/war establishment.
Availability	The proportion of labour resources and their demography required for all of the specified tasks involved, including operation, maintenance and support. This can be based on military, reservist and civilian personnel.
Workload	The amount of work expected to operate, maintain and support the system. Factors affecting this are the balance between manning numbers, shift size, and task sustainability.

6.1.2 Personnel

The Personnel domain concerns individual characteristics (physical & cognitive, features & abilities), needed to train, operate, maintain and sustain the system effectively.

Table 14 Personnel sub domains

Sub domains	Description
Physical	Current and future profiles including fitness levels, physical size, gender and non-typical specific requirements e.g. colour vision.
Cognitive	Current and future profiles including trainability and mental aptitude.
Recruitment and Retention	Engaging newly tasked personnel from non-similar tasked military, reservist or civilian sources, or maintaining the currently tasked personnel.
Cultural and Social Factors	Influential factors based on military and/or national culture. Expectations with regard to career prospects, ambience and aesthetics.
Previous experience and training	Inherent attributes from previous experience or training, which will provide a closer match or disparity with the requirement. E.g. educational requirements and achievement, current trade, career patterns or knowledge of parallel systems.
Inter personal interaction	Structure of envisaged interaction between roles, whether based on team or individual work, and the likely role of personality in interaction.

6.1.3 Training

The Training domain concerns the instruction or education, and on-the-job or unit training required to provide personnel with their essential job skills, knowledge, values & attitudes

Table 15 Training sub domains

Sub domains	Description
Legacy transfer	Coping with new systems that require different skills from those acquired with previous systems, e.g. a switch between different styles of operation. 'De-skilling' can occur when basic functions are automated.
Type	Mix of training technologies and their effect on performance enhancement, such as synthetic environments, computer based war gaming, battlefield war gaming. Use of individual versus group sessions. The fidelity of the training experience. Use of instructors with actual experience versus simulated experience. Definition of standards of performance,
Availability	Timing and proportion of initial and continuation training for new and existing personnel; therefore requiring facilities of correct type and size. Minimisation of the 'training bottleneck'.

6.1.4 Human Factors Engineering

The HF Engineering domain concerns the integration of human characteristics into system definition, design, development, and evaluation to optimise human-machine performance under operational conditions

Table 16 Human Factors Engineering sub domains

Sub domains	Description
User - equipment interface	The means for the hands-on user (operator, maintainer or supplier) to interact with the equipment (actively or passively). Performance factors at the interface will be physical and cognitive i.e. matching of interface to user size, strength and dexterity, comprehensibility of displayed information and operation of controls, etc.
Task Allocation	Mapping tasks to individuals and groups, in terms of quantity, timing and skills needed. Consideration of the associated effects on performance including stress, fatigue, workload and motivation.
Environment	All external effects on design of the user's working position. Primarily based on neighbouring equipment and users, also linked with scenario type and effects of clothing. Where appropriate this should include accommodation and habitability as a separate issue.

6.1.5 Health Hazard Assessment

The Health Hazard Assessment domain concerns the short or long term hazards to health occurring as a result of normal operation of the system.

Table 17 Health hazard assessment sub domains

Sub-areas	Description
Noise and Vibration	Continuous or impulsive sound or vibration, that can cause damage to hearing or vibration injuries, either acutely, or by prolonged degradation.
Toxicity	Poisonous materials or fumes generated by equipment, capable of causing injury, death or long term health impairment.
Electrical	Equipment that can provide easy exposure to electric shock.
Mechanical	Exposed equipment with moving parts capable of causing injury.
NBC	Nuclear, Biological or Chemical hazards resulting from exposure to plant or weapons.
Musculo-skeletal	Tasks that adversely affect either the muscles or skeleton, separately or in combination, e.g. lifting of heavy equipment, repetitive movement, high G forces.
Thermal	Sources that provide potential heat or cold hazard, either generated from equipment or from exposure to the environment.
Optical	Equipment that could to provide ocular damage or burns caused by light sources through optics.
EM radiation	Other electromagnetic sources not described under the other sub-areas that produce hazard e.g. magnetic fields or microwaves.

6.1.6 System Safety

The System Safety domain concerns the safety risks occurring when the system is functioning in an abnormal manner.

Table 18 System Safety sub domains

Sub-areas	Description
Error sources	Ways in which human errors can contribute to the cause of a hazard or reduce the effectiveness of defensive mechanisms. Ways in which system characteristics and behaviour could adversely influence user performance and lead to a hazard.
User behaviour	The scope for misuse or abuse of systems that could cause hazards, whether caused through ignorance, laziness or fatigue, frustration, or accepted ‘short cuts’.
Surroundings	External and environmental conditions that can cause hazard to the user, or hazard to a third party.

6.2 HF standards & legislation

Tables of selected HF standards follow this introduction, including DefStan, ISO, HSE, etc. This guide does not attempt to list all possible standards, of which there are many covering different types of system. Those listed here are mainly of more general applicability.

The nature of HF standards

The coverage by HFI standards of the six HFI domains is not even. The domain of HF Engineering is by far the most heavily represented, followed by health and safety.

HF standards vary considerably in scope and nature, as well as in origin. Few HFI standards are entirely prescriptive in the way that say standards for nuts and bolts are. The interface with people is rather subtler than the interface between a pair of steel threads. The spirit of some is summed up in the introduction to Def Stan 00-25: ‘This standard should be viewed as a permissive guideline, rather than a mandatory piece of technological law’.

It is helpful to think about standards for the ‘3 Ps’. Each has strengths and weaknesses:

- Product – specifies what the product must be like
- Performance – specifies how well the product and its users must perform
- Process – specifies how the product and use must be developed and proved

Def Stan 00-00 favours ‘*Technical specifications … in terms of performance rather than design or descriptive characteristics’.* Even so, in some cases it is more practical to specify a product attribute or a process.

Normative standards that prescribe equipment attributes are easier to implement, but carry the risk of over generalisation. It is very hard for the requirements engineer to cover all eventualities, given the complex nature of the human interface and diverse contexts of use. Specifying performance is often a safer way to ensure that the system (people & equipment) works as intended; it places the onus on the system designer to allow for the context of use and to demonstrate acceptable performance.

DefStan 00-25 ***Human Factors for Designers of Equipment*** is **the** MoD human factors standard, but its diversity can cause problems. It contains three main types of information:

- Design guidance – methods and advice on ‘how to get it right’
- Informative data – information about human characteristics and their variability, human function and human limitation
- Normative data – recommended equipment characteristics such as dimensions, clearances, and brightness.

MilStd 1472E *DoD Design Criteria Standard - Human Engineering,* has been widely used in defence, and contains mostly normative data. MilStds are low on MoD’s preference list.

Standards such as ISO 13407 *Human Centred Design for Interactive Systems* differ from either of the above by specifying a process. Use of proven processes gives a degree of assurance that ‘the right things will be done’ and also provides a framework within which to monitor satisfactory progress towards the goal. ISO 13407 describes a process framework that can be implemented in different ways according to what is being developed.

- Avoid over prescription of process - specify key activities to be undertaken - not how they should be done.
- Focus on the outputs to be produced, especially if they contribute towards the evidence MoD needs to support of acceptance.

MoD preference hierarchy for standards

Standards come from many bodies, and often overlap.

MoD standards policy favours some sources over others. The order [2] (preferred first) is:

- Regional - British Standards implementing European Standards[3] or common technical specifications
- International - British Standards implementing international standards
- National - Other British Standards
- STANAGs and QSTAGs
- UK MoD Defence Standards
- UK MoD Departmental Standards and Specifications
- Other nation's military standards
- Recognised industry, partnership or consortium standards.

6.2.1 Military HFI standards

Table 19 Military HFI standards

Reference	Title	Description
DefStan 00-25 (1987 – 2000)	Human Factors for Designers of Equipment (14 parts)	1- Introduction, 2 - Body Size, 3 -Body Strength and Stamina, 4 - Workplace Design, 5 - Stresses and Hazards, 6 - Vision and Lighting, 7 - Visual Displays, 8 - Auditory Information, 9 - Voice Communication, 10 - Controls, 11 - Design for Maintainability, 12 - Systems, 13 - Human Computer Interface, 14 -Military Land Vehicle Design
Mil Std 1472E (1998)	DoD Design Criteria Standard – Human Engineering	[Widely used, but low on MoD preference order] "Presents human engineering design criteria, principles and practices to … integrate the human into the system …for effective … safe operation, training and maintenance."
Mil Std 2525 v1 (1994)	Common Warfighting Symbology	Collation of earlier separate symbology standards for Land (STANAG 20219, APP-6) and Maritime (STANAG 4420)

There are many more detailed standards, not listed here, notably STANAGs relating to air systems.

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[2] DefStan 00-00 Annex T

[3] Many ISO standards are adopted as both European and British standards. This is shown by a compound designator, eg BS EN ISO 13407.

6.2.2 Health & Safety regulations

What is colloquially called the 'six pack' is a set of legislation, introduced to UK law in the early '90s in response to European directives about Health & Safety at work.

Table 20 The HSE 'six pack'

Reference	Title	Description
HSE Books (1992, revised 1999)	Management of health and safety at work regulations (MHSWR 1992)	Risk assessment, Principles of prevention, Health and safety arrangements, Health surveillance, Health and safety assistance, Procedures for serious and imminent danger and for danger areas, Contacts with external services, Information for employees, Co-operation and co-ordination, Persons working in host employers' or self-employed persons' undertakings, Capabilities and training, Employees' duties, …
HSE Books (1998)	Safe use of work equipment	Suitability, Maintenance, Inspection, Specific risks, Information and instructions, Training, Conformity with community requirements, Dangerous parts of machinery, Protection against specified hazards, High or very low temperature, Controls for starting or making a significant change in operating conditions, Stop controls, Emergency stop controls, Controls, Control systems, Stability, Lighting, Maintenance operations, Markings, Warnings, Etc.
HSE Books (1992)	Workplace (health, safety and welfare) Regulations	Maintenance of workplace, equipment, devices and systems, Ventilation, Temperature in indoor workplaces, Lighting, Cleanliness and waste materials, Room dimensions and space, Workstations and seating, Condition of floor and traffic routes, Falls or falling objects, Washing facilities, Etc.
HSE Books (1992)	Personal Protective Equipment at Work Regulations	Personal protective equipment (PPE), Compatibility of PPE, Assessment of PPE, Maintenance and replacement of PPE, Information, instruction and training, Use of PPE, Selection, use and maintenance of PPE (head protection, eye protection, foot protection, protective clothing for the body).
HSE Books (1998)	Manual Handling	Duties of employers, Avoidance of manual handling, Risk assessment, Reducing injury, The load - providing additional information, Reviewing the assessment, Duty of employees
HSE Books (1992)	Health and Safety (Display Screen Equipment) Regns.	Analysis of workstations, Requirements for workstations, Daily work routine of users, Eyes and eyesight, Provision of training, Provision of information

Table 21 Useful HSE booklets

Reference	Title	Description
HSE Books (2000)	Health and safety regulation	Short guide – a useful introduction to legislation
HSE Books (1992)	The Health & Safety System in Great Britain	Definitive document (Legal Framework, Acts, Regulations, HSE, Enforcement, etc)
HSE Books (1999)	Reducing error and influencing behaviour	Human factors, Human failure, Design for people, impact on human performance, Case studies
HSE Books (1997)	Successful health & safety Management	Policies, Organisation, Planning, Implementing, Monitoring, Auditing

6.2.3 ISO HFI 'product' standards

There are detailed standards in different areas, not listed here. ISO9241 (some parts of which are process standards, see above) is notable because although its scope is defined as 'office work with visual display terminals', in practice its requirements apply to a wide range of contexts where people interact with significant amounts of information.

Table 22 ISO HFI product standards

Reference	Title	Description
BS EN ISO 9241 parts 3-9 (1997 - 2000)	Ergonomic requirements for office work with visual display terminals (VDTs)	Requirements for: 3 - Visual displays, 4 - Keyboards, 5 - Workstation layout & posture, 6 - Environmental, 7 - Display reflections, 8 - Displayed colours, 9 - Non-keyboard input devices.
BS EN ISO 9241 parts 10 & 12-17 (1996 -1999)	Ergonomic requirements for office work with visual display terminals (VDTs)	Specifies principles relating to: 10 -Dialogue, 12 - Presentation of information, 13 - User guidance, 14 - Menu dialogues, 15 - Command language dialogues, 16 - Direct manipulation dialogues, 17 - Form-filling dialogues
BS EN ISO 13406 (1999)	Ergonomic requirements for work with visual displays based on flat panels	Applies to flat panel displays where BS EN ISO 9241 might not apply. It is a product standard aimed at designers and manufacturers.
BS EN ISO 10075 (2000)	Ergonomic principles related to mental workload	1 - General terms, 2 - Design principles, 3 -Measurement of Assessment. Guidance on design of work systems (including mental components of mainly physical tasks).
BS EN ISO 11064 (2000)	Ergonomic design of control centres	1 - Principles for design, 2 - Principals for the arrangement, 3 - Layout, 4 - Layout and Dimensions, 5 - Human Centred Interfaces, 6 - Environmental Requirements, 7 - Principles for evaluation. Primarily non-mobile, but much applies to mobile centres.
BS EN ISO 8468 (1995)	Ships bridge layout and associated equipment: requirements and guidelines	Basic functional design requirements for bridge configuration, arrangement, equipment and environment. Aimed at naval architects and designers. Applies to sea going ships where bridge duty is regularly maintained.

6.2.4 ISO HFI process standards

Table 23 ISO process standards

Reference	Title	Description
BS EN ISO 6385 (1981)	Ergonomic principles in the design of work systems	Describes fundamental principles: the aims and objectives of ergonomics, on which ISO13407 is based
BS EN ISO 13407 (1999)	Human-centred design processes for interactive systems	Specifies a generic system development process for the whole life cycle of any work system involving people. It is a tool for managing design processes and provides guidance on sources of information and standards relevant to the human-centred approach to 'enhance effectiveness and efficiency, improve human working conditions, and counteract possible adverse effects of use on human health, safety and performance'.
BS EN ISO 9241-1 (1997)	Ergonomic requirements for office work with visual display terminals (VDTs) - General Introduction	Introduction to the multi-part standard ISO 9241 (ergonomic requirements for the use of visual display terminals for office tasks), explanation of underlying principles, guidance on application and conformance statements.
BS EN ISO 9241-2 (1997)	Guidance on task requirements	Design of tasks and jobs involving work with visual display terminals, guidance on identifying and specifying task requirements within individual organisations, and incorporating task requirements into system design and implementation processes.
BS EN ISO 9241-11 (1998)	Guidance on Usability	Defines usability as 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'. Guidance on information needed to specify or evaluate usability, to describe context of use (for hardware, software or service), usability within a quality system.
ISO 15288 (2001 draft)	Life Cycle Management - System Life Cycle	Specifies the system engineering process for developing systems configured to include hardware, software, humans, procedures and facilities. Thinking behind the standard has influenced Smart procurement.
BS EN ISO 11399 (1995)	Ergonomics of the thermal environment: principles and application of relevant international standards	Summary process and performance standard calling up other standards. Covers extremes of hot and cold as well as moderate environments. Includes evaluation of work environments and also evaluation of protective clothing.

6.2.5 Other MoD references

Table 24 HFI Related documents

Title	Reference	
1. Tri- Service Guide to Training Needs Analysis	JSP 502	Describes the Systems Approach to Training (SAT) with staged process leading to from task analysis to a recommended training solution.
2. Management guide to the preparation and use of Target Audience Descriptions in the acquisition of defence capability	HFI Web, AMS	Guidance for IPTs on the scope and role of a TAD within acquisition, with advice on the practical aspects of how and when to commission appropriate specification work.
3. Human Factors Support to COEIA (HFSC)	HFI Web, AMS	Describes a process mirroring the COEIA process to enrich the scope of analysis to take full account of human contribution to costs and effectiveness.
4. Human Factors Integration: an introductory guide	HFI Web, AMS	Introduces HFI, describing why it is needed, how it supports acquisition and how it is managed.
5. Naval Equipment Procurement Human Factors Integration Management Guide	SSP10	Detailed guidance on management of HFI tailored to naval platform and equipment. Written for Downey procurement, with mapping to CADMID
6. Naval Equipment Procurement Human Factors Integration Technical Guide	SSP11	Detailed guidance on technical HFI processes, structured in terms of naval platform and equipment technical areas. Written for Downey procurement, with mapping to CADMID
7. The Desk Officer's Guide to Producing User Requirements Documents	HFI Web, AMS	'Best practice' guidance for desk officers with little knowledge of Systems Engineering or Smart Requirements to create a User Requirement Document.
8. HFI and Capability management	HFI Web, AMS	Guidance on early HFI for members of Capability Working Groups
9. The Acquisition Handbook	AMS	Introduction to Smart Procurement and definition of its processes and products.

6.3 HFI contacts

Table 25 HFI contacts

Subject	Branch	Extn. / Exch.
MOD customer for Human Sciences corporate research	DGS(R&T)/RPS(6)	80362 MB
MoD/R-DERA Focus for HFI policy and advice	Future Business Group, FBG-HFI-1	31663 ABW
HFI focal point for Naval Systems	Sea Technology Group STGSS3a	35094 ABW
Naval Combat Systems HFI policy co-ordination	Sea Technology Group STG CSHF	ABW
HF for Marine Engineering	DME/ME253	83947 FA
HF in EAC Submissions/COEIA	DG(S&A) ADOA (Sea/CIS)	81543 MB
HF Specialist Advice: human factors engineering, personnel selection and training; HFI project support	DERA Centre for Human Sciences	01252 394475 FRN
Head of Human Factors Dept	Institute of Naval Medicine (INM)	68312 ALV
ILS issues, maintenance task analysis & TNA	Directorate of Defence Logistics	68738 ENS
Naval Manpower Planning/Future Manpower Requirements	Naval Manning Agency	27525 PY
Army Manpower Planning/Future Manpower Requirements	Directorate of Manning (Army)	5035 UP
Air Manpower Planning/Future Manpower Requirements	Air Member for Personnel	5568 GE
Warship Accommodation & Habitability	DNSC1	27242 PY
Personnel clothing/protection	Defence Clothing and Textiles Agency	4802 CV
		2324 COL
Training Needs Analysis (TNA)/Training advice - Naval	RN School of Educational & Training Technology (RNSETT)	01705 724019 PY
Training Needs Analysis (TNA)/Training advice - Army	Army School of Training Support (ASTS)	01980 615457 UP
Training Needs Analysis (TNA)/Training advice - RAF	Training Development and Support Unit (TDSU)	01296 626303 HAL
DPA Focal Point for Safety	SSO	31871 ABW
Land System Safety Policy & Advice	ALTG LSSO	31681 ABW
Ship Safety Policy & Advice	STGSSM	35132 ABW
RN Safety for Munitions/Explosives	CESO(N)/CINO	68213 EN
H&S, Environment and Fire Safety focus for the NSC	CESO(N) AD(S)	68293 EN
RAF Focal point for H&S, Environmental Protection	CESO (RAF)	6448 BRA
Munitions Safety	Ordnance Board/OSGS	31884 ABW

6.4 Jargon Buster

Table 26 Glossary

Acronym	Term	Meaning
	Acceptance	The process (under control of the DEC as acceptance authority) to confirm that the user's needs for military capability have been met by the systems supplied. The two formal stages are: System Acceptance and In-Service Date (AMS)
ALARP	As Low As Reasonably Practicable	The principle underlying most safety management systems. It requires that the level of control shall be proportionate to the level of risk.
AMS	Acquisition Management System	See AMS for description
AR&M	Availability, Reliability and Maintainability	The cross specialism engineering discipline focussed on ensuring that equipment will be available, by minimising failures and ensuring that when they occur, the equipment can be quickly and reliably repaired
ARP	Applied Research Programme	That part of MoD's funded research focussed on issues whose resolution is should help fill anticipated capability gaps that have not yet been defined clearly enough to form acquisition projects.
BITE	Built in Test Equipment	Equipment features that provide early warning of incipient failures, and simplify diagnosis following a failure, by providing some diagnostic information, e.g. lights on individual components to indicate state
BS	British Standard	Designator for UK standards. Many correspond to EN & ISO standard
BSI	British Standards Institute	UK standards making body
CADMID	Concept, Assessment, Demonstration, Manufacture, In-service, Disposal	The six phases of the Smart acquisition cycle
CALS	Computer Aided Logistics System	
	Capability	The ability to achieve a specified operational outcome or effect
CoA	Concept of Analysis	The first stage of a COEIA, which defines the Measures of Effectiveness (MoEs) to be used, and how they are to be derived.
COEIA	Combined Operational Effectiveness and Investment Appraisal	Formal process for comparing options to meet a capability requirement by evaluating, quantifying and putting bounds on the effectiveness and whole life costs of each. Also the summary document reporting the conclusions of the analysis. COEIA is mandatory at Main Gate with pre-COEIA work desirable at Initial Gate for major procurements.

Acronym	Term	Meaning
COTS	Commercial, Off-The-Shelf	Components of commercial origins, used as part (or the major part) of the solution to meet a capability need, but whose specification and development have not been driven by the needs of the capability.
CRP	Corporate Research Programme	That part of MoD's funded research focussed on issues not linked to individual capability areas.
CSA	Customer Supplier Agreement	In-house equivalent to a contract between different organisations within MoD
CWG	Capability Working Group	See AMS for description
DEC	Director Equipment Capability	The person within the Capability Management Group who acts as First Customer and Acceptance Authority for an Acquisition project
DERA	Defence Evaluation and Research Agency	
DLO	Defence Logistics Organisation	Part of MoD managing an IPT prior to ISD
DPA	Defence Procurement Agency	Part of MoD managing an IPT after ISD
ECA	Early Comparability Analysis	A technique for assessing human issues and risks associated with potential solutions, at an early stage, by drawing on the experience of other systems and making appropriate allowance for the different contexts of use: the tasks and people involved, the environment, and the demands of the operational scenario.
EHFA	Early Human Factors Analysis	A technique for identifying, assessing and prioritising human related issues relevant to the provision of a capability, identifying the risks associated with them and defining suitable mitigating actions. It can be applied very early, and subsequently reviewed at key points throughout the life cycle.
EC	Equipment Capability	That part of Military Capability (MC) delivered by equipment. NB: EC is more than equipment performance. EC includes the capability of the equipment to work effectively with the human component in a way that enables the human component to deliver its allocated part of MC
ECC	Equipment Capability Customer	The branch of MoD whose role is to act as formal customer for acquisition projects prior to In Service Date (ISD)
EN	European Norm	Designator for European standards. Many correspond to ISO standard
FLC	Front Line Command	The military organisation that will use the delivered capability, and from which the 2^{nd} customer is drawn.
GFE	Government Furnished Equipment	Equipment supplied by MoD rather than by a contractor as part of a system.
GOTS	Government Off The Shelf	Equipment previously developed to a government requirement other than the currently considered acquisition.
HF	Human Factors	The body of scientific knowledge relating about people and how they interact with their environment, especially when working.

Acronym	Term	Meaning
HFE	Human Factors Engineering	HFI domain concerned with designing equipment to be compatible with needs & limitations of the people who operate, maintain and support it.
HFI	Human Factors Integration	Management discipline concerned with co-ordination across all disciplines related to the safe, cost effective functioning of people as parts of human - machine systems.
HFSC	Human Factors Support to COEIA	A formal process based on, and enriching, COEIA, by analysing the human contributions to both effectiveness and whole life costs.
HFWG	Human Factors Working Group	A working group of stakeholders in HFI aspects of a project.
HMI	Human Machine Interface	The means through which people interact with the equipment: displays, interaction devices, their behaviour and the software controlling them.
HSE	Health & Safety Executive	The UK regulatory body responsible for enforcement of health and safety legislation.
IA	Integration Authority	The person or group responsible for delivering effective performance from an interconnected set of separately supplied components, which might include multiple equipments or equipment and people, depending on the context.
IG	Initial Gate	Approval point to pass from Concept phase into Acceptance
ILS	Integrated Logistics Support	See AMS for description
IPT	Integrated Project Team	See AMS for description
IPTL	Integrated Project Team Leader	See AMS for description
ISD	In Service Date	The point at which all components of a capability are confirmed to be integrated to achieve Military Capability (MC)
ISO	International Standards Organisation	Also designator for international standards
ISOP	Invitation to Submit Outline Proposal	Early point in acquisition leading to PFI where contractors are invited to offer outline solutions in response to a requirement.
ITEAP	Integrated Test, Evaluation and Acceptance Plan	See AMS for description
ITN	Invitation To Negotiate	Point in acquisition leading to PFI where contractors are invited to explore ways of aligning their solutions more closely with MoD’s more detailed requirement.
ITT	Invitation to Tender	Formal request for contractors to submit costed proposals in response to a statement of requirement.
JCB	Joint Capability Board	Forum representing the interests of all the DECs.
KUR	Key User Requirement	One of a small subset that epitomise the whole requirement.

Acronym	Term	Meaning
LCC	Life Cycle Cost	A synonym for Whole Life Cost (WLC)
MC	Military Capability	The ability to achieve a militarily useful operational effect or outcome
MG	Main Gate	See AMS for description
MoE	Measure of Effectiveness	A measure of whether a specific aspect of a capability is achieved
MTBF	Mean Time Between Failure	A measure of the reliability of an equipment.
MTTR	Mean Time to Repair	A measure of the ease of repair of an equipment. MTTR and MTBF between them give a measure of availability.
NBC	Nuclear, Biological, Chemical	A collective term for contaminants, protection against which is vital for personnel, and which typically places constraints on their functioning.
OJT	On the Job Training	Training gained while in post, either by doing the job, or by training experiences interleaved with it.
OR	Operational Requirements	Part of MoD representing the user need, prior to Smart Procurement.
PPO	Principal Personnel Officer	Generic term for the head of the personnel organisation (or the organisation itself) of each of the three armed services.
PRM	Programme Responsibility Matrix	Formal division of responsibility for a project between MoD stakeholders
PSF	Performance Shaping Factor	An aspect of the task or task environment that modifies the expected performance of the person undertaking it (usually degradation).
	Safety Case	A formally documented argument supported by objective evidence that a system can be operated safely, i.e. with an acceptably low risk of causing hazard through its life.
	Safety Management System	The means of ensuring that a system will be operated safely, consisting of the means to detect hazards, to take mitigating action to maintain the safety case
	Second Customer	See AMS for description
SoW	Statement of Work	Explicit statement of what contractors are required to do, as distinct from what they are required to produce.
SRD	System Requirement Document	See AMS for description
	Stakeholder	Anyone with a legitimate stake in the project outcome, e.g. users of the capability, project managers, PPOs, trainers, manpower planners, contractors, safety authorities, support agencies, end users, …
TAD	Target Audience Description	Formal definition of the characteristics of the human component(s) of a capability (the people who will interact with the equipment) and their range of variability in these characteristics. Typically this includes physical, cognitive and organisational characteristics of operators, maintainers & support personnel.
TLC	Through Life Cost	Synonym for Whole Life Costs (WLC)

Acronym	Term	Meaning
TLMP	Through Life Management Plan	See AMS for description
TNA	Training Needs Analysis	Formal process for identifying the ‘training gap’ between expected and required skills of the human components of the capability, and how best to provide the required training. See Tri-Service TNA Guide.
URD	User Requirement Document	See AMS for description
	Value chain	Representation of causality between all the factors that influence an aspect of military effectiveness.
WLC	Whole Life Costs	See AMS for description

6.5 Confusion Buster

The terms below mean different things to different people.

User

- Traditionally in MoD the term ‘User’ (capital U) meant the OR desk officer defining an equipment Requirement.
- Traditionally in the HFI community, ‘user’ (small u) means any person interacting with the equipment (or ‘end user’ to avoid confusion with ‘User’ as above) i.e. operators, maintainers and support personnel.
- AMS defines ‘user’ to include all ‘users of the capability’ (not ‘users of the equipment providing the capability’). In general therefore, AMS excludes hands-on users of equipment, who themselves form part of the capability.
- Some work on AMS uses the term ‘end user’ to refer to customer 2, thus even this term cannot be unambiguously used to refer to people who actually interact with the equipment.

This guide avoids the unqualified term ‘user’ except in terms such as User Requirement Document. Where appropriate, it uses ‘hands-on user’ and ‘human component of the capability’.

System

- Traditionally in MoD procurement, a system has been seen as an integrated set of equipment (hardware and software).
- Traditionally in HFI, a system (sometimes called a ‘total system’ to distinguish it) has included all the components, human and procedural as well as equipment, that interact to deliver a result.

AMS focus on capability, and the ‘System Requirement Document’ as a specification of what will provide it, supports the second meaning, which this guide uses, with the term ‘equipment system’ used for the first meaning.

Validation, Verification, Acceptance

- In traditional ‘engineering’ terminology, ‘verification’ means checking the output of a development step against the input specification to the step, and ‘validation’ means checking the end product against wider, real world criteria. ‘Acceptance’ is the process of confirming that contractual obligations have been met by what is delivered.
- AMS embeds the concept of verification (as defined above) within the continuous process leading to acceptance. The AMS definition of ‘verification’ is roughly equivalent to ‘validation’ (as defined above).

Performance

- In traditional ‘engineering’ terminology, a ‘task’ is what is done and ‘performance’ is how well it is done.
- In the military training community ‘performance’ refers to what is done and ‘standards’ to how well it is done (see ‘Tri-service Guide to Conduct of Training Needs Analysis’).

This guide uses ‘performance’ in the engineering sense.

7. Index