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FOR THE SAFETY OF AIR NAVIGATION

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The Human Factors Case: Guidance for Human Factors Integration

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Abstract

This document sets out the guidance for producing a Human Factors Case, a comprehensive and integrated approach to ensure that the design and implementation of a technical, human and/or procedural ATM system can deliver the desired performance improvements. The Human Factors Case, intended as a summative document, highlights the key issues and referencing studies that have been performed to assess these issues. The Case is in four parts:

1. Fact Finding and Human Factors Issue Analysis (HFIA).
2. Human Factors Integration (HFI).
3. Monitoring.
4. Human Factors Case Assessment.

This guidance highlights the approaches and tools needed to produce a Human Factors Case.

Keywords

Human Factors Case	Human Factors Issue Analysis (HFIA)	Human Factors Integration
Monitoring	Human Factors Case Assessment	

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0.2	21.02.2003		Draft 1	All
0.3	03.07.2003		Draft 2	All
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1.0	27.08.2004	040201-08	Released Issue (agreed on 28-29.01.2004) (final document configuration and editorial adjustments)	All

CONTENTS

EXECUTIVE SUMMARY

The Human Factors Case has been developed to provide a comprehensive and integrated approach to ensure that the design of a technical, human, and/or procedural system can deliver desired performance improvements. The Human Factors Case is designed to be simple, practical and effective, with four key stages:

- **Stage 1 – Fact Finding and Human Factors Issue Analysis (HFIA).** Recording of factual information about the project background, system and system environment, as well as key stakeholders and documentation. Identification of the project-specific Human Factors (HF) issues at the early, middle and late phases of the project life cycle, as well as the importance and urgency with which these issues need to be addressed, the safeguards and arrangements already in place and a description of the further actions required to address the issues in a suitable and sufficient manner.
- **Stage 2 – Human Factors Integration.** Integration of human factors approaches to optimise system performance, and assessment of the HF work carried out within the project to demonstrate that the main HF Issues have been addressed adequately. Statements of key conclusions from HF studies with references to the relevant sources of evidence so that they can be challenged if it emerges that they are critical to the outcome.
- **Stage 3 – Monitoring.** Description of the monitoring arrangements (planned or implemented) for the operational phase of the project in order to provide feedback on the performance of the system with respect to the HF Issues identified within the Human Factors Case.
- **Stage 4 – Human Factors Case Assessment.** Independent assessment of the Human Factors Case.

Each stage should correspond with a section of the Human Factors Case report. The approach utilises team-based issue identification and analysis, and assists in integrating HF by suggesting methods and tools that can be used within a ‘ladder’ approach, where different levels of HF integration are stipulated to help plan the required HF activities and record the key conclusions. The following ‘six Human Factors Issues’ underlie the whole approach to help identify, assess, and monitor issues relevant to a project:

- Human-Machine Interaction,
- Organisation and Staffing,
- Training and Development,
- Procedures, Roles and Responsibilities,
- Teams and Communication
- Recovery from Failures.

The Human Factors Case approach is being applied to a number of EATM[1] projects and a Web version of the Human Factors Case was developed (see 1.5 further in this document).

[1] In 1999 the ‘European Air Traffic Control Harmonisation and Integration Programme (EATCHIP)‘ was renamed ‘European Air Traffic Management Programme (EATMP)‘. Since May 2003 it is known simply as ‘European Air Traffic Management (EATM)‘.

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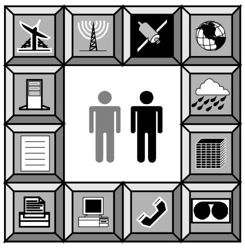
1. INTRODUCTION

1.1 The Human Factors Case

Human factors can be defined as “an interdisciplinary science concerned with the application of knowledge about human psychology, physiology and anatomy to the design of the things we use (i.e. tools, machines, ‘systems’, etc.) and the places (or environments) in which we use them, so as to improve their effectiveness and usability, and increase our safety, comfort and satisfaction” (EATMP, 2000a). In short, human factors is ‘designing for human use’ (McCormick, 1976), i.e. designing technical and work systems, tasks, objects, and places for people, within a wider social and organisational context. Hence, human factors is a broad discipline, which considers many other factors that influence human and system performance, such as job or role, procedures and task design, team issues and Human-Machine Interface (HMI) design. In addition, the impact of human resource practices is also incorporated, such as selection, training, planning, staffing, competency checking and licensing, and so on.

The application of human factors methods is a key part of the system design, evaluation, and timely implementation, but the process can be complex and difficult to understand. This guidance proposes a standardised and straightforward process to enable project managers to ‘make a case for human factors’. The Human Factors Case can be defined as follows:

'The Human Factors Case is a comprehensive and integrated approach to ensure that the design and implementation of a technical, human and/or procedural system can deliver the desired performance improvements'.



The Human Factors Case has three key functions:

- First, it helps to confirm and support the realisation of intended system performance objectives and criteria. In this sense the Human Factors

Case offers predicted performance assurance, which may be in terms of increased landing rate, sector flow throughput, improved conflict resolution, etc.

- Second, it helps to guide and manage the HF aspects in the design cycle so that negative aspects do not arise and prevent the system reaching its optimum performance level.
- Third, it helps to identify and evaluate any additional detailed HF safety aspect not already found in the Safety Case.

A unique aspect of the Human Factors Case is that it prompts attention at the earliest possible stage of the project life cycle to planning, training and staffing issues, to help ensure that competencies and resources (e.g. training) are available for the timely implementation of new systems. New systems cost a great deal of money and past experience has typically demonstrated that many planning and staffing issues are not considered until too close to the promised implementation dates, consequently leading to costly delays. The time required to retrain staff needs a long lead-time to maintain day-to-day operations. These issues therefore, must be considered earlier in the process than may be first thought.

The overall approach of the human factors case aims to be:

SIMPLE **PRACTICAL** **EFFECTIVE**

1.2 Benefits of a Human Factors Case

It is valid to ask: what benefits does a Human Factors Case offer over and above a Safety Case, individual HF studies, real-time simulations, etc.? The Human Factors Case shares good practice from these approaches, but provides a simple and straightforward approach to HF integration and a means to help ensure that the total system meets its performance objectives. Therefore, the Human Factors Case provides a framework for the project team to manage human factors integration. The key benefits of a Human Factors Case, and differences from these other systems, are summarised below.

1.2.1 Comparison with Safety Cases

The focus of a Human Factors Case differs from that of a Safety Case. A Safety Case serves two main purposes:

- to give the regulator confidence that the ‘project’ is controlling risks to safety properly;
- to provide a comprehensive working document against which the project, organisation and regulator can check that the accepted risk control measures and safety management systems have been put into place and continue to operate in the way in which they are intended.

The Human Factors Case is more focused on performance optimisation - augmenting human strengths and compensating for human limitations to improve total system performance. However, the Human Factors Case may also highlight some new safety-relevant issues, provide greater detail and identify better control measures. This is achieved by a detailed examination of human factors issues such as 'human error', (particularly via human error prediction methods, which are often not effectively used to support Safety Cases), human recovery from system failures, and reduce the potential for fatigue and workload problems, etc.

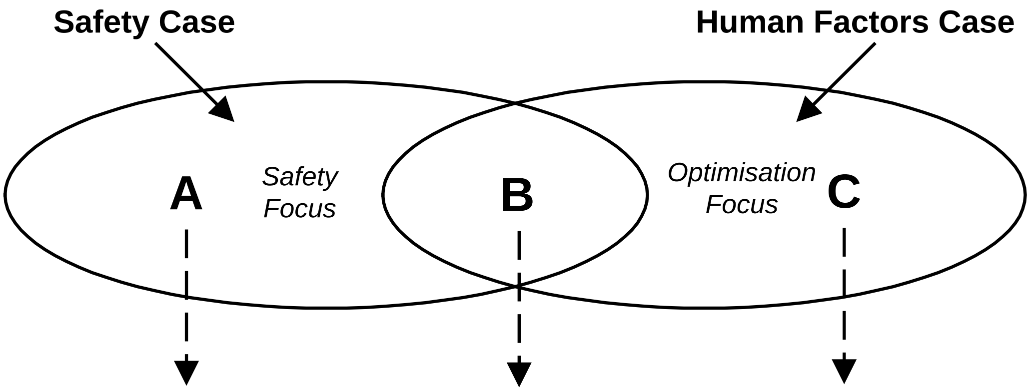
Such issues will normally be addressed at some level in a Safety Case. However, other important HF Issues are often not addressed at all in a Safety Case. These include workstation ergonomics, HMI usability, trust in and acceptance of the system, longer-term planning and staffing, skill changes and so on (see Table 1 below). The EUROCONTROL Safety Assessment Methodology (SAM) (EATMP, 2000b) is not designed to assess such issues, even though such issues may sometimes be identified using the methodology. For instance, the Functional Hazard Assessment (FHA) methodology is a group-based method driven by the identification of failure modes based on the application of a list of guide words to system functions or tasks. This method is not suitable for the detailed analysis of issues such as trust, comfort, system acceptance and so on. These issues, if not properly addressed, can lead to the failure of a socio-technical system, which may be demonstrated to be 'safe' in a Safety Case. There are several cases where HF Issues, such as HMI legibility and staffing, have hindered implementation of large-scale ATM projects, after approval of a Safety Case (e.g. The Guardian, 2002a, b, c).

Table 1 would prompt a number of questions, for example:

- Will the controllers trust the new/changed system or tool?
- Will they be motivated to use it?
- Will there be excessive training and re-training costs?
- Will a different type of profile be needed to select candidates?
- Will the system fit in with conventional job roles, and if not have new roles been considered?
- Will controllers have the right skills, and has training been planned?
- Will the controllers still be able to take over if/when the system fails or starts to generate bad data?
- Will there be sufficient Air Traffic Control Officers (ATCOs) available?

The Human Factors Case can be a way of ensuring project success by managing such issues explicitly.

Table 1: Typical issues captured in Safety Cases and Human Factors Cases



A *Pertinent issues captured in a Safety Case* **Example issues**	**B** *Pertinent issues normally captured in a Safety Case and a Human Factors Case* **Example issues**	**C** *Pertinent Issues normally captured in a Human Factors Case* **Example issues**
Software	Retrospective human error management approach	Human error prediction
Hardware	Training and procedures	Ageing and experience
Safety management	Workload	Stress management
External events	Impacts on team roles and teamwork	Planning and staffing
Power supply	Rostering and fatigue	Workstation ergonomics
	Situation awareness?	Lighting, noise, air quality
	Human recovery from system failures?	Training development, methodology and conduct
	Safety attitudes and behaviours	Knowledge and skill changes
		Trust and confidence
		Sociological and cultural impacts
		Motivation and boredom
		HMI usability and acceptability

1.2.2 Comparison with HF Studies and Simulations

HF studies are often essential in ensuring that the system meets its primary objectives. Such studies may address, for example, HMI usability specification and evaluation, Training Needs Analysis, situation awareness assessment, etc. A number of different studies may be required, and need to be integrated into the overall project plan. Experience has shown there is a great deal to be gained from performing these studies much earlier than is common practice in order to maximise performance optimisation and avoid unnecessary wastage of resources. The Human Factors Case, therefore, is not a replacement for HF studies and simulations but it helps to identify the studies that are required to be implemented at the most effective time, and helps to combine the key findings and references in one document.

Simulations are frequently used in the middle and late phases of system development. In practice, some of the HF Issues in Table 1 such as workload, situation awareness, and team-working, are tested in simulations (generally real time). However, such simulations do not always offer high-fidelity characteristics in terms of HF impacts. For example, controllers in simulations can often handle far more traffic than in real life, for a number of reasons (e.g. fewer distractions during simulations). So whilst simulation is a valuable platform upon which HF methods can be employed, it usually occurs too late to improve the system cost-effectively, and cannot usually assure overall performance in isolation. Hence, simulation should constitute one HF method within an integrated approach.

1.2.3 Comparison with Quality and Project Risk Management Approaches

The Human Factors Case has some similarities with quality management and risk-based project management approaches. Project risk management enables the management of risk as an integrated part of project management through all project phases. With increasing project complexity, tighter schedules, demanding budgetary constraints and the need to comprehend an escalating volume of information, make it increasingly difficult to maintain focus and stay in continuous control of a project. Traditional project management techniques often fail to address uncertainty in the decision-making process. This leads to a reactive approach to risk management, where ‘fire-fighting’ becomes the norm. Risk-based project management provides a more transparent and structured approach to understand, communicate, and manage project risk. Proactive risk management provides continuous focus on the most important threats and opportunities, allowing more informed decisions to be made, seize opportunities and avoid pitfalls, thus increasing the chance of project success. We can gain insights from such approaches that help to predict and manage threats and opportunities. However, they will not necessarily ensure that the pertinent HF Issues are addressed.

1.3 Human Factors Case Initiation

The Human Factors Case should be initiated at the earliest possible stage in the *project* or *programme* so that HF Issues are identified and dealt with while opportunities exist to resolve them satisfactorily. The Human Factors Case guidance divides the EATM phases into three summary phases: *early*, *middle* and *late* (see Figure 1). In the rest of this document processes will apply to one or more of these summary phases.

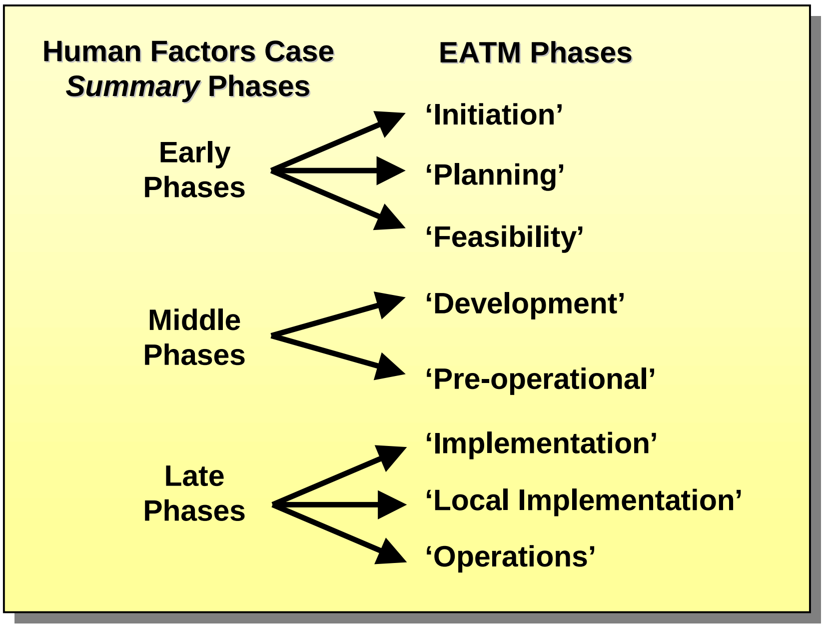


Figure 1: EATM life cycle phases relevant to the Human Factors Case

1.4 Human Factors Case Structure

The structure and contents of the Human Factors Case can be customised to suit specific project requirements. However, the information presented should fall under the following broad categories:

- **Part 1 – Fact Finding and Human Factors Issue Analysis (HFIA).** The first part first records factual information about the project background, system and system environment, as well as key stakeholders and documentation. It then identifies the key project-specific human factors issues at the early, middle and late phases of the project life cycle, rates the importance and urgency with which these issues need to be addressed, identifies the safeguards and arrangements already in place and describes any further action that may be required to address the issues.

- **Part 2 – Human Factors Integration.** The second part of the Human Factors Case identifies and integrates HF approaches to optimise system performance, and provides key findings and references relating to the HF work performed to demonstrate that the main HF Issues have been adequately addressed. Part 2 of this guidance documentation provides 'ladders' of generic human factors issues which must be considered by the project, in addition to those highlighted in Part 1, to help project teams plan the required HF activities. Statements of key conclusions from HF studies with references of the sources of evidence are entered on the worksheets to provide an integrated and simple summary source of project HF activity.

- **Part 3 – Monitoring Arrangements.** The third part provides a description of the monitoring arrangements (planned or implemented) for the operational part of the project, to help ensure that the system (including people) performs as expected. Lessons learned throughout the project should also be documented.

- **Part 4 – Human Factors Case Assessment.** The final part provides an independent assessment of the Human Factors Case. This is performed by an independent assessor on submission of the Human Factors Case.

The Human Factors Case process and structure is illustrated in Figure 2, along with the key personnel involved in each stage, and the outputs of each stage.

This guidance encourages the concept of an evolving Human Factors Case as set out below:

- The **Preliminary Human Factors Case** aims to identify the HF Issues in relation to the early phases of the EATM life cycle process. At this point the HF Issues associated with various design options can be considered.

- The **Interim Human Factors Case** is an expansion and refinement of the preliminary Human Factors Case. This will build on the preliminary Case as a result of new and refined information as well as analyses, evaluation and testing.

- The **Operational Human Factors Case** takes account of commissioning experience and forms the submission seeking final assessment (Part 4) and approval.

It is envisaged that the Human Factors Case will be assessed at the preliminary, interim and operational phases.

After the preparation of the operational Human Factors Case, any further amendment to the deployment of the system, must be examined against the assumptions and objectives contained in the Human Factors Case.

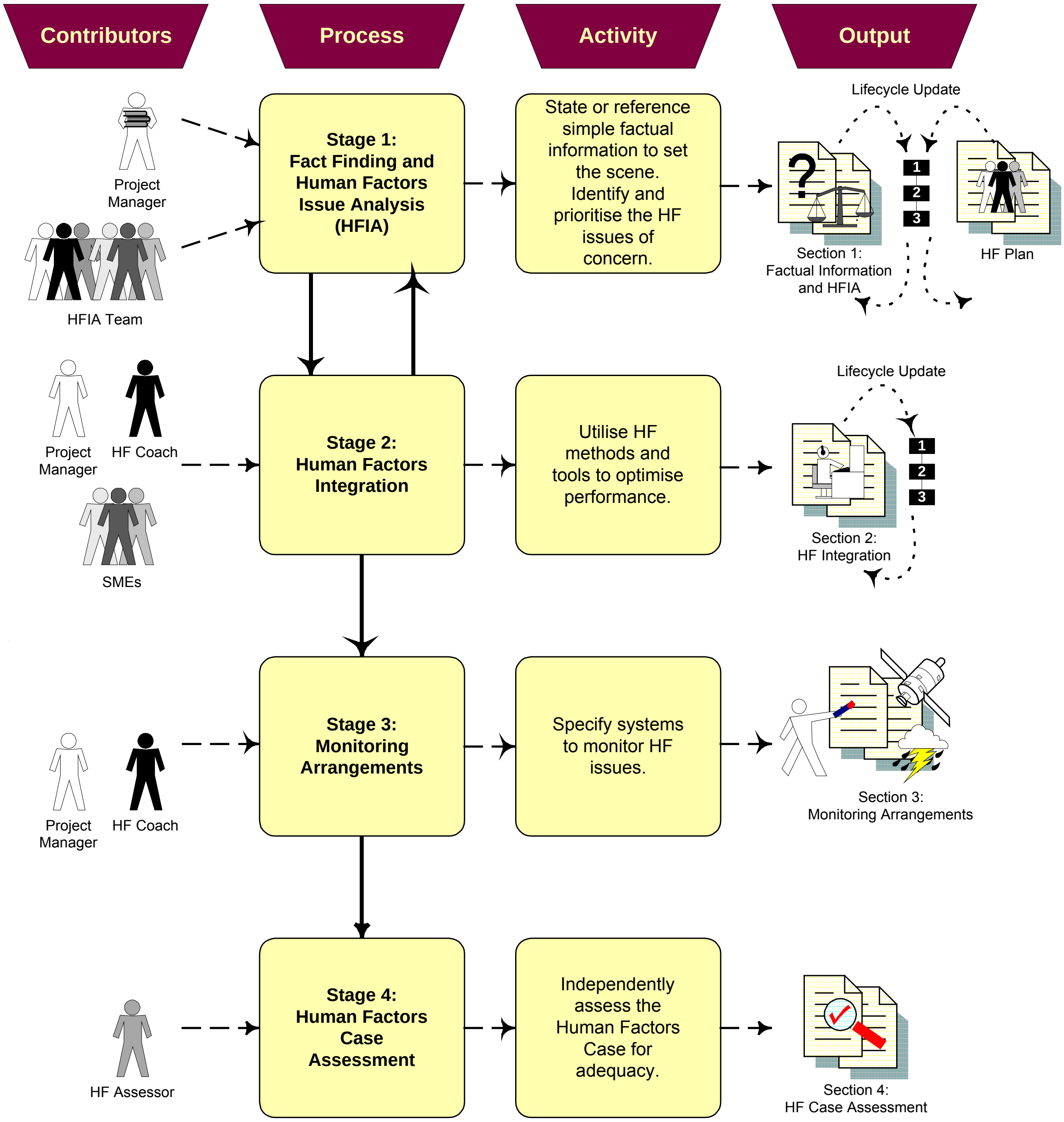


Figure 2: Human Factors Case process

1.5 Human Factors Case Format

A Web site has been designed to assist project teams with the Human Factors Case. This provides all of the materials in this report, including on-line forms. From 2005 the Internet application of the HF Case can be accessed via http://www.eurocontrol.int/eatmp/hifa/ (click on **Human Factors Case** in the menu).

1.6 Human Factors Case Focus

1.6.1 System Focus

A Human Factors Case should be prepared for all:

- bespoke systems – new, tailor-made systems;
- commercially available systems – 'Commercial Off The Shelf' (COTS) systems and products;
- systems implemented elsewhere – main emphasis on local implementation issues;
- modified systems that are:
  - extended by new system level functionality;
  - changed to have a new or modified fit, including technology updates;
  - proposed for a change of role or operational use which was not envisaged in the previous Human Factors Case, even where there is to be no change in system configuration.

1.6.2 Personnel Focus

A variety of personnel or system users may be considered within a Human Factors Case. These personnel may include ATCOs, engineers and maintenance personnel, control and monitoring and control personnel, trainers, supervisors, management and support personnel. In short, a Human Factors Case should consider anyone who is affected by system changes and whose performance contributes to the total system performance.

1.7 Key Roles in the Human Factors Case Process

1.7.1 Project Manager

The project manager's role is already well-defined within EATM. With regard to the Human Factors Case the project manager should continue to maintain high-level management of the human factors activities. It is also the project manager's responsibility to clearly define the concept or new system and ensure that everybody involved in the Human Factors Case process has the same baseline understanding.

1.7.2 Human Factors Coach

The HF coach should be responsible for the day-to-day implementation of the tasks identified in the Human Factors Integration Plan (HFIP). On larger projects the HF coach may coordinate a team of HF personnel, each of whom being responsible for different parts of the overall project. The HF coach should be solution-oriented but realistic and pragmatic. This role requires a high level of cooperation and involvement. The HF coach is a key member of the team, and should, if possible, remain with the project over its entire life cycle.

1.7.3 Facilitator

A trained facilitator should be available to facilitate and moderate Human Factors Issue Analysis (HFIA) sessions. The facilitator should be sufficiently knowledgeable of HF Issues, with at least basic training in human factors. Ideally, the facilitator should be otherwise independent of the project in order to maintain impartiality while conducting the HFIA, where the facilitator's main task is to adhere to the HFIA process and timetable.

1.7.4 Human Factors Case Key Stakeholder Team

The Human Factors Case key stakeholder team should be established at the start of the project or programme. The project manager is responsible for identifying the key stakeholders who are likely to include representatives and Subject Matter Experts (SMEs) for design, safety, training, etc. The key stakeholders will meet several times during a project life cycle. The frequency of the meetings will vary depending on the project/programme size and phase and Human Factors Case stage, but should be sufficiently frequent to ensure that the actions are understood and can influence development at the right time.

The Human Factors Case key stakeholders will play an important part in implementing the actions and requirements identified and their subsequent monitoring.

1.7.5 Independent Human Factors Assessor

The independent HF assessor should be concerned with the adherence of the HF work to the HFIP and with the quality of the work. The independent HF assessor should be sufficiently qualified to carry out the duties assigned, and be sufficiently commercially and managerially independent from the project so that the activities can be independently assessed and judged from a human factors perspective, free from any possible conflict of interest. Initially, the HF assessor is likely to be a member of the Human Resources (HUM) team. However, in future it would be desirable for the assessor to be independent of the HUM team.

1.7.6 Stakeholder-Task Matrix

The various responsibilities of above-mentioned people are expressed in Table 2 below.

Table 2: Stakeholder-task matrix

Tasks	Project Manager	HF Coach	Facilitator	Stakeholder Team	HF Assessor
Identify relevant stakeholders and project interfaces (e.g. related systems)	Yes				
Identify key documents	Yes	Yes		Yes	
Determine project staffing (including users and experts)	Yes				
Ensure sufficient budget to deal with HF Issues	Yes	Yes			
Ensure that timescales are realistic and life cycle intervention is appropriate to deal with HF Issues	Yes	Yes			
Ensure that effective communication processes are in place	Yes				
Consider commercial issues (e.g. copyrights, patents)	Yes				
Ensure that appropriate collaboration and partnership take place	Yes				
Identify project risks and dependencies	Yes				
Facilitate the HFIA meetings to ensure proper progression			Yes		
Identify HF Issues in HFIA session	Yes	Yes	Yes	Yes	
Prioritise HF Issues	Yes	Yes			
Ensure that all analyses are carried out in accordance with the HFIP	Yes	Yes			
Learn lessons from previous and similar project experience	Yes				
Conduct human factors studies		Yes		Yes	
Audit the project for compliance with relevant standards, guidelines, etc.					Yes
Audit the classification, interpretation and any subsequent refinement of categories in HFIA					Yes
Independently review a sample of HF analyses of the system					Yes
Check that HF requirements are adequately specified and appropriately influence development	Yes	Yes		Yes	
Review testing programmes to ensure that they adequately address the human factors issues	Yes	Yes		Yes	
Sign off the Human Factors Case to verify that the work has been conducted	Yes	Yes			Yes

1.8 Human Factors Issues

At the heart of the Human Factors Case are six ‘Human Factors Issues’. These form the basis for each stage of the Human Factors Case, providing a common structure to identify, integrate and assess human factors. The Human Factors Issues are illustrated in Figure 3 in a ‘pie’. This pie can be used and re-used to rate or represent graphically the relative importance of each issue for a particular project or programme, and/or at any given Human Factors Case summary phase (see Figure 4).

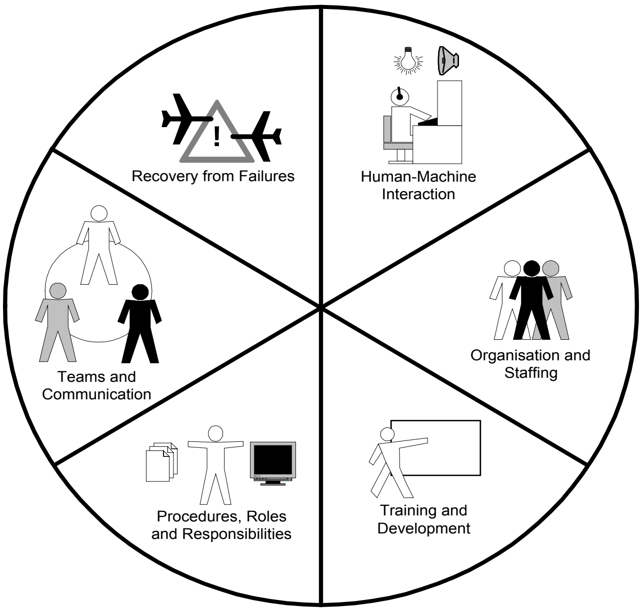


Figure 3: Human Factors Issues represented throughout the Human Factors Case approach

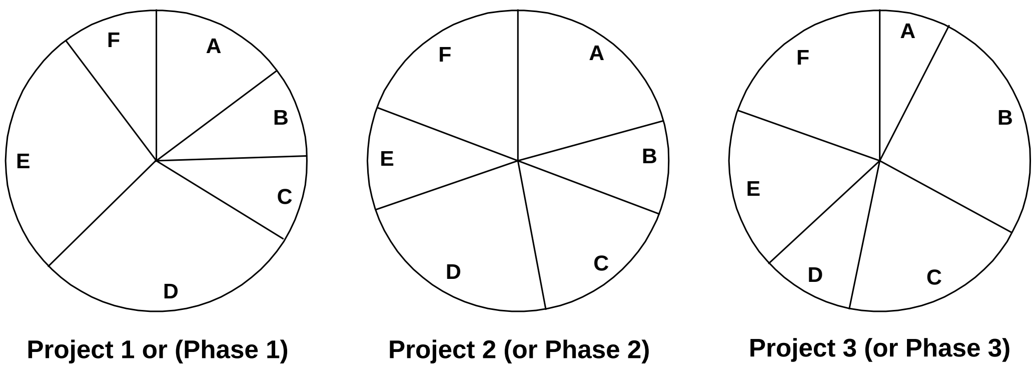


Figure 4: Example of relative importance of Human Factors Issues for different projects or throughout a project life cycle

The six Human Factors Issues were specified to best reflect the potential impacts on human performance, and system performance, and to ensure that an even coverage of sub-issues within each high-level issue is encouraged. To ensure that the Human Factors Case has proper links to the 'Human Factors Integration in ATM (HIFA)' approach (see EATMP, 2000a, c, d) - an aid to Human Factors Integration (HFI) - and to other EATM tools such as HERA-JANUS (the 'Human Error in ATM' approach - see EATMP, 2003), the Human Factors Case Issues are mapped onto HIFA's 'HFI domains' and HERA's 'Contextual Conditions' in Table 3. Therefore the Human Factors Case approach has been designed to be compatible with existing EATM HF approaches.

Table 3: Mapping of Human Factors Issues onto relevant HIFA Domains and HERA Contextual Conditions

Human Factors Case Issues	HIFA's 'HFI Domains'	HERA's Contextual Conditions
1. Human-Machine Interaction	Task and Interface Design (TID); Health Hazard Assessment (HHA)	Workplace Design and HMI; Environment
2. Organisation and Staffing	Personnel (P); Manpower (M); Health Hazard Assessment (HHA)	Personal Factors; Organisational Factors
3. Training and Development	Training (T)	Training and Experience
4. Procedures, Roles and Responsibilities	Task and Interface Design (TID)	Workplace Design and HMI; Traffic and Airspace; Documentation and Procedures
5. Teams and Communication	TID	Pilot-Controller Communication; Team Factors
6. Recovery from Failures	System Safety (SS)	Training and Experience
		HERA also includes: - Pilot Actions, - Traffic and Airspace, - Weather.

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2. STAGE 1 - FACT FINDING AND HUMAN FACTORS ISSUE ANALYSIS

Stage 1 of the Human Factors Case process comprises two activities, as depicted in Figure 5 below.

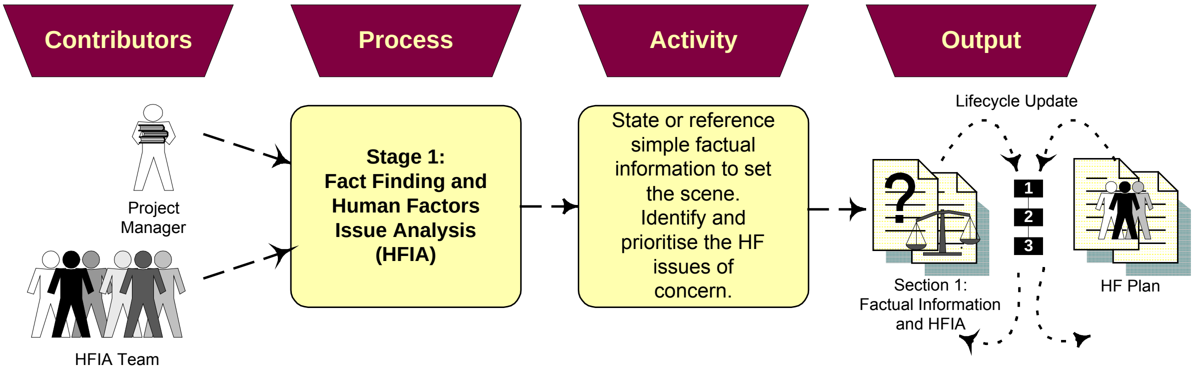


Figure 5: Stage 1 - Fact Finding and Human Factors Issue Analysis (HFIA)

2.1 Fact Finding

The first part of the Human Factors Case should set the scene and provide the necessary background information about the proposed system or design change. Useful information to contribute to this section may be found in the Operational Concept document or project plan.

In order to simplify this process, a standard form has been designed to produce the minimum necessary factual information (see Table 4). It is important that only key information is included - the form is only intended to be a quick reference tool. The project manager should gather all the necessary information described and, along with the HF coach, review this to ensure that it is a sufficient basis for the Human Factors Case.

At this point the project manager and HF coach should also prepare a description of the human factors activities that are planned to address generic human factors issues, such as those illustrated in the Ladder assessments.

Certain aspects of this form are explained more fully below.

2.1.1 High-level Project Objectives

This section should provide a concise summary of the high-level project objectives.

2.1.2 Project Background and System Description

This section should provide a short description of the project background and basic system architecture. It should include some information on the context into which the system will be integrated and the likely external factors that might affect it. This may include a description of the relevant Air Traffic Management, and Communications, Navigation and Surveillance (ATM/CNS) context (e.g. traffic characteristics, aircraft performance and equipment, adjacent centre capabilities, airport infrastructure), as well as relevant environmental characteristics outside the ATM/CNS domain (e.g. weather, environmental constraints).

2.1.3 Life Cycle Phase

Indicate here the system life cycle phase relevant to the time when the Human Factors Case was prepared.

2.1.4 Related or Predecessor Systems

Identify related or predecessor systems and external interfaces.

2.1.5 Key Safety Documentation

Identify any key safety documentation (e.g. safety assessments).

2.1.6 Key Design and Testing Documentation

Identify any key design and testing documentation (e.g. functional specifications, test plans, etc.).

2.1.7 Human-centred Automation Principles

Human-centred automation is defined as automation designed to work cooperatively with human operators in pursuit of stated objectives. The human-centred automation approach has emerged following various problems arising from too much or poor automation (Billings, 1991). This approach has received the endorsement of ICAO (1994). To be able to comply with their legal responsibilities, pilots should remain in command of their flight and controllers should remain in command of air traffic. That command authority should only be limited for compelling reasons after consultation with the users that will ultimately be affected. Nine principles for human-centred automation are stated (see Table 4), which include and follow from the principle of human command.

Commitment to these principles should ultimately help to:

- reduce the likelihood of human error encroaching on automated systems;
- keep the operators aware of the system operation and progress;
- present a context for system design by incorporating the users and what they have to achieve in the field;
- make a system more intuitive to use;
- enhance the operators' trust and confidence in the system.

The Human Factors Case writer should indicate whether the system is intended to adhere to these principles. Expanded notes may be made relating to each principle.

2.1.8 Stakeholders

It will be necessary to define the roles and responsibilities of the persons, departments and organisations involved in the Human Factors Case process. These stakeholders may include, for instance:

- project manager,
- HF coach,
- system designer / software engineer,
- engineer,
- safety expert,
- training expert,
- manpower expert,
- selection expert,
- users (e.g. ATCOs, flight crew),
- maintenance,
- sponsor/customer.

Table 4: Part 1 – Factual Information

HUMAN FACTORS CASE **PART 1 – FACTUAL INFORMATION**					
Date					
Project Name					
Project Manager		Tel		E-mail	
HF Coach		Tel		E-mail	

Type of Project							
Traffic / Situation Display		Controller Tool		Communication		Navigation	
Surveillance		System Control & Monitoring		Other (state)			
High-level Project Objectives							
Project Background and System Description							

System Life Cycle Stage							
Early Phases			*Middle Phases*		*Late Phases*		
Initiation	Planning	Feasibility	Development	Pre-operational	Implementation	Local Implementation	Operations

Human Factors Case Version		
Preliminary Human Factors Case	Interim Human Factors Case	Operational Human Factors Case

Related or Similar Existing / Predecessor Systems (inc. Operational Experience and Data)

HUMAN FACTORS CASE **PART 1 – FACTUAL INFORMATION**
Key Safety Documentation (e.g. Previous FHA Documentation, Safety Case/Assessments)
Key Design and Testing Documentation (e.g. Design Documentation, Trial/Simulation Data)

Human-centred Automation Principles			**?**
Rate the principles below in terms of whether the subject system adheres to these principles.			
1. The human must be in command.			
2. To command effectively, the human must be involved.			
3. To be involved, the human must be informed.			
4. Functions must be automated only if there is good reason for doing so.			
5. The human must be able to monitor the automated system.			
6. Automated systems must, therefore, be predictable.			
7. Automated systems must be able to monitor the human operator.			
8. Each element of the system must have knowledge of the others' intent.			
9. Automation must be designed to be simple to learn and operate.			

Number	**Notes**

Key Stakeholders

Name	**Role**	**Tel**	**Email**

2.2 Human Factors Issue Analysis

Once the factual information has been gathered, the specific human factors issues of concern to the project are identified and analysed. This is a crucial stage in the development of any project and of the Human Factors Case. This process, outlined below, is referred to as Human Factors Issue Analysis (HFIA).

HFIA is an iterative process, normally conducted during each of the three summary phases of the EATM life cycle (see Figure 6). The first HFIA is conducted once during the early phases. The second HFIA is conducted during the middle phases. The third HFIA is conducted during the late phases. The outputs of the HFIA are therefore reviewed, revised and refined throughout the life cycle. The factual information is also reviewed at these phases. If necessary, the HFIA may be conducted more frequently.

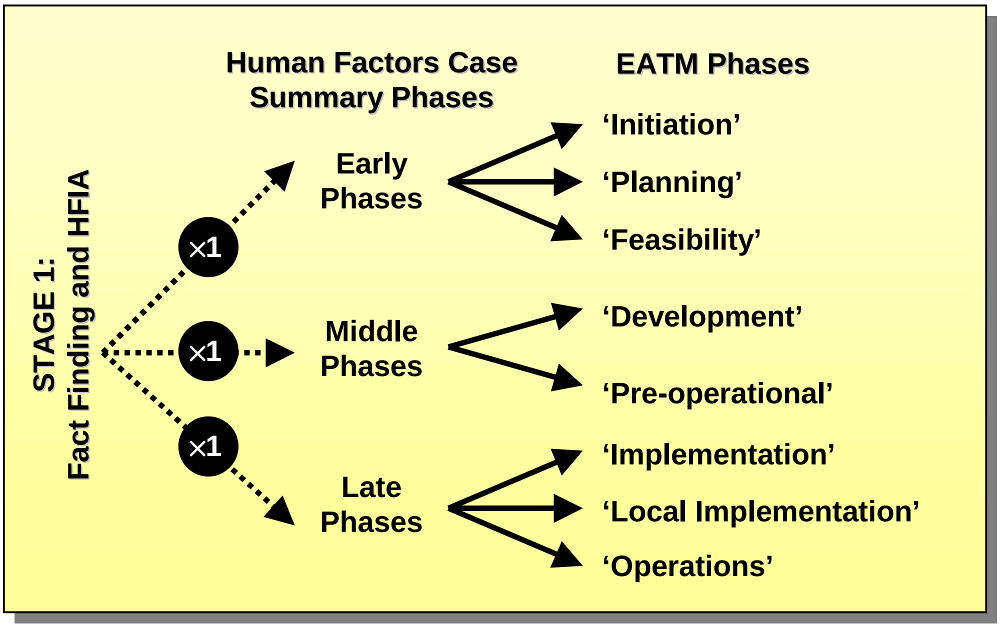


Figure 6: EATM life cycle phases relevant to the Human Factors Case Stage 1

Two alternative ways of conducting a HFIA are outlined below:

- default method: group-based HFIA,
- alternative method: checklist approach.

It should be emphasised again that the purpose of the HFIA is to identify contextual, project-specific HF Issues. Generic HF Issues are covered within Part 2 of the Human Factors Case.

2.2.1 Default Method: Group-based Human Factors Issue Analysis

The group-based HFIA is proposed as a robust and comprehensive method for identifying project-specific HF Issues. The key feature of this approach is that it utilises expertise from a number of areas of the project. This helps to identify HF Issues comprehensively, and helps to gain commitment and 'buy-in' of human factors issues by other project team members. In order to gain most benefit from this process it is important that the exercise focuses on project-specific HF Issues as opposed to the generic issues identified within the 'ladders' that form Part 2; the general HF Issues will be covered in a specific way. The benefits of using this methodology are summarised in Figure 7. Therefore, this is considered to be the default option for most projects. However, the resource implications of this method may be too great for some smaller projects.

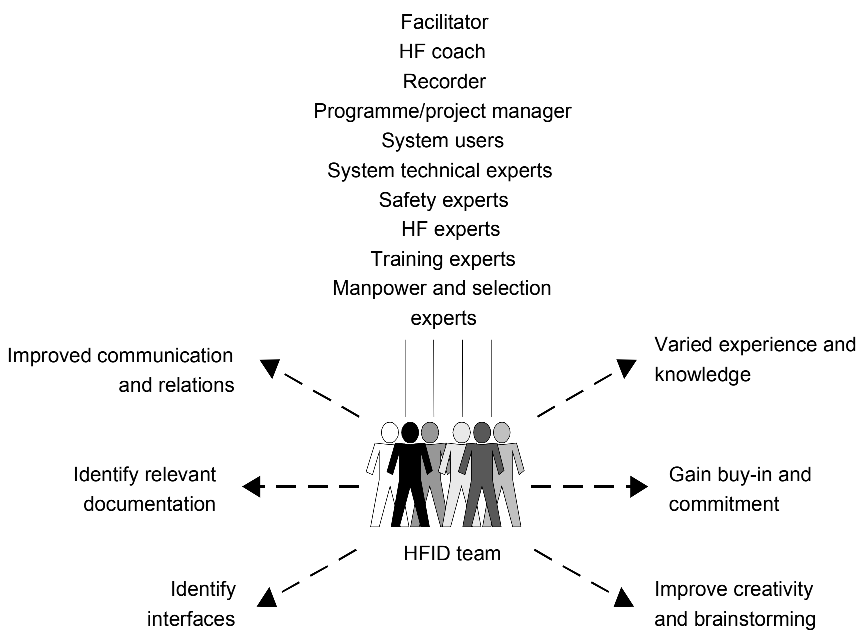


Figure 7: Benefits of a group-based HFIA

2.2.2 Alternative Method: Checklist Approach

If the group HFIA is not feasible, there are two alternatives as follows:

- use of the HF Issues checklist by the project manager and the HF coach. This would entail a desk-based exercise involving exploring each of the six HF Issues to identify the areas of concern;

- use of the HIFA checklists (EATMP, 2000c).

2.2.3 Process Selection Criteria

Table 5 is provided for the project manager and HF coach to justify the option selected. The methods are described in detail below.

Table 5: Human Factors Issue Analysis (HFIA) – process selection

<table>
<tr><th>Method</th><th>Tick</th><th colspan="2">Guidance Criteria</th></tr>
<tr><td>Default Method:
• Group HFIA</td><td></td><td colspan="2">• Large scale project with many interfaces between departments, groups, etc.
• Project output affects more than one target audience group / end-user group.
• Project output changes the nature of the roles of the target audiences / user groups and/or end-user groups as compared to current practice.
• Novel outcome expected from the project.
• Budget for human factors work has not yet been determined.
• The reliability of human actions forms a significant part of the Safety Case justification.</td></tr>
<tr><td>Alternative Methods:
• HF Issues Checklist</td><td></td><td colspan="2" rowspan="2">• Significant experience of previous similar projects and lessons learned is available.
• Project is a relatively small change to an existing system.
• Project timescales/costs preclude the use of a group process.
• Human actions do not form a significant part of the justification of a Safety Case.</td></tr>
<tr><td>• HIFA Checklists</td><td></td></tr>
<tr><td colspan="2">Signature (Project Manager)</td><td>Date</td><td>Signature (HF Coach) | Date</td></tr>
<tr><td colspan="2"></td><td></td><td></td></tr>
</table>

2.2.4 Group-based Human Factors Issue Analysis

2.2.4.1 Description of the Technique

Group HFIA is designed to help identify and manage key human factors issues throughout the project life cycle using a thorough, systematic, multi-disciplinary and group-oriented technique. The mix of knowledge and experience of the HFIA team will lead to a broader, more comprehensive and more balanced consideration of the HF Issues than the other HFIA options. The process involves a structured brainstorming approach to identify project specific HF Issues using a team of experts, led by a facilitator. The application of the technique takes the form of a meeting over three to four days, depending on the scale of the project. The HFIA process is described over the next sub-sections.

2.2.4.2 Before the HFIA Session

Literature search and generation of checklist

Because the task context is so critical in HF, it is often necessary to research the area prior to conducting the HFIA study. The HF coach therefore prepares an HF Issue checklist, populated by a *literature search* of relevant issues and knowledge of past projects, to ensure that all specific project issues are covered. This search should encompass sources of information both internal and external to EUROCONTROL. The result is a simple checklist of HF generic issues relevant to the project, structured around the six Human Factors Issues illustrated in Section 1.8 (Figure 3). A default checklist is provided in Table 6. This may be supplemented or modified in light of the context of the project. The checklist is provided to the HFIA facilitator. The participants are supplied with a list of generic HF Issues to help prompt them to identify project specific items.

Table 6: Checklist items

Human Factors Area	Item
1. Human-Machine Interaction	Input devices, visual displays, information requirements, alarm handling, console/working area, HMI usability, user requirements, health risks, fatigue, distraction and concentration, noise, lighting, temperature/humidity/air quality, workplace arrangement, workplace accommodation.
2. Organisation and Staffing	Staff requirements, manpower availability, ATCO profile/selection criteria, job attractiveness, ageing, shift organisation.
3. Training and Development	Training needs, performance/competence standards, training content, training methods and media, negative transfer of training, trainer role/responsibilities/competency, transition from classroom to On-the-Job Training (OJT), emergency/unusual situation training, testing of training effectiveness, negative effects on operational task performance.
4. Procedures, Roles and Responsibilities	Allocation of function, involvement, workload, trust/confidence, skill degradation, procedure format and positioning, procedure structure, procedure content, procedure realism.
5. Teams and Communication	Team structures/dynamics/relations, (inter-) team coordination, position handover processes, communication workload, phraseology, national language differences, changes in communication methods, interference effects, information content.
6. Recovery from Failures	Human error potential, error prevention/detection/recovery, detection of and recovery from system failures.

Arrange and prepare HFIA meeting

Time and effort will need to go into the planning and organisation of the meeting. The time schedule and resources required may need to be planned well in advance. Around four days should be expected for a comprehensive HFIA for a new system. For a modification to an existing system, three days may suffice. Or a small change to an existing system, two days may be sufficient. Ideally, the HFIA should be done in a block of several days. If this is not possible, HFIAs should be spaced as closely together as possible to reduce problems of forgetting.

An appropriate number of participants will be required, with a diverse range of roles. These stakeholders may be representatives of one or several organisations concerned with the specification, design, construction, testing and use of the system. Table 7 indicates some likely attendees.

Table 7: Potential group HFIA attendees

Person	Attendance	Group HFIA Role
HUM expert	Essential	Facilitator
HF coach	Essential	Contributor/facilitator
Secretary or HUM expert	Essential	Recorder/secretary
Project manager	Essential	Contributor
Users (e.g. controllers)	Essential	Contributor
Sponsor/customer	Recommended	Contributor
Safety expert	Recommended	Contributor
Systems designer / Human-Machine Interaction developer	Recommended	Contributor
Training expert	Recommended	Contributor
Manpower expert	Recommended	Contributor
Selection expert	Recommended	Contributor
Other HF expert	Optional	Contributor

It is important to ensure that free speech is not inhibited by the mixture of roles in the room. The presence of some people must not inhibit others from contributing openly. The size of the group is also important. It is recommended that the total group size (including facilitator, recorder, HF coach, project manager and other stakeholders) is:

- no less than six.
- no more than ten.

These guidelines are based on much previous experience of similar meetings. Very small groups can fail to capture all of the pertinent issues because of a lack of the range of expertise available, while very large groups tend to be difficult to manage, often spitting off into smaller groups.

A briefing note should be issued to all attendees by email or post, which includes the factual information, an explanation of why the HFIA is taking place, the aims, and a summary of the HFIA process. The sender should ensure that each participant has received and understood this in plenty of time.

Some objectives will need to be set for the group HFIA meeting. These may be based on the following:

- Identify the key Human Factors Issues that are associated with the system (i.e. *what HF Issues may hinder the success of the project/system?*).
- Determine the potential impact if issues are not addressed properly (i.e. *what would happen if the problem did occur?*).
- Identify the current or planned initiatives (i.e. *what is already being done about it*?).
- Assess the importance of the issues (i.e. *how important are they? Consider the costs of ignoring them.*).
- Assess the urgency which issues should be addressed (i.e. *how soon should human factors integration occur?*).
- Calculate priority scores (i.e. sum of *importance and urgency*).
- Derive recommendations to deal with issues as part of a HF Plan (i.e. *what more may need to be done?*).
- Feed into the specification/design/development of the system.

(In practice, urgency, importance and priority ratings may be allocated off-line after the meeting (e.g. by the project manager and HF coach), once the entire set of key issues has been identified.)

2.2.4.3 During the HFIA Session

Open the HFIA meeting

The project manager or HF coach will normally open the meeting, with the usual safety/security announcements, introductions, timetable, objectives and definition of system elements, and specification of assumptions. The facilitator will then provide a description and explanation of the HFIA technique/process and the ‘rules for brainstorming’. It is helpful to illustrate the brainstorming process with a very simple problem to illustrate the principles, for five minutes or so. One often used example is ‘other uses for a broom’.

Delineate high-level system elements

The HFIA has an issue orientation, rather than breaking the system down into detailed components. This tends to encourage creative thinking. However, for a very large system it may be useful to breakdown a small number of system elements (e.g. flight phases, HMI components, operational scenarios, design options), and examine each in turn in terms of the six Human Factors Issues. Since each element is interrogated by the six Human Factors Issues, it is important to keep the number of elements as low as possible. In addition to providing group members with a copy of the factual information, the project manager should give a clear and precise presentation of the system and the breakdown of system elements.

Specify assumptions

It is important that all members of the HFIA group are working with the same set of assumptions about the system or project. Assumptions are necessary as there may be little-detailed information available. Assumptions may include aspects of operational environment, system scope and other concepts in place, etc. Failure to adhere to a common set of assumptions results in a ‘shifting sands’ effect throughout the HFIA. Hence, the project manager should first propose a set of assumptions for review prior to the HFIA, then present this to each participant on the day of the HFIA (e.g. as a handout and flipchart page). It may be useful to use the ‘pie’ to help structure some of the human factors assumptions or ‘givens’. For instance, it might be stated that continuation training will be provided, and so there would be no need for issues to be raised relating to a lack of continuation training.

Following this, the group enters into a cycle of activities as follows.

Select an HF Issue to examine

Depending on the project priorities, the project manager, project team or HFIA group may wish to examine the HF Issues in a particular order. This can either be stated in advance of the HFIA meeting, or the HFIA team can use a voting technique to choose the order. The importance of the HF Issues may be indicated by the number and nature of the individual brainstorm findings.

Identify ‘HF Issue Components’

HF Issue Components (HFICs) are aspects of the HF Issue specific to the system that need to be considered. For instance, they may be pertinent questions about deviations from expectations or intentions (users’, designers’, managers’, etc.). HFICs can be posed by any team member (including the facilitator and recorder) using the standard group-based brainstorming technique. The group identifies the HFICs for **all** of the HF Issues. This helps to ensure that all of the HFICs are identified, even if they are not analysed straight away. This helps to maintain a more global focus, and prevents certain HF Issues from being neglected. When the team is no longer able to identify additional HFICs, the facilitator should consult the checklist to help prompt additional ideas, resulting in an additional level of thoroughness. It may also be worthwhile to consider splitting the group after generating the HFICs as a whole group. For example:

- two sub-groups could look at all HF Issues for different elements of the system; **or**

- two sub-groups look at different HF Issues from the 'pie' for the same system element.

- **Then** each sub-group reviews the work of the other.

Brainstorming should be limited to a **set time** for each HF Issue – between fifteen and thirty minutes.

Participants should be allowed to think widely, imaginatively, and initially without criticism during the HFIC brainstorming stage. Participants should be encouraged to think beyond their own experience.

HFICs may be expressed as a question or statement. They could take the form of, for example:

- 'What if …?'
- 'Could the …?'
- 'Is it possible that …?'
- 'Have we …?'
- 'How to …?'
- 'We need to …'
- 'I wish / I think …'
- etc.

Participants may use any form of words that raises an HF-related question or statement that needs to be addressed by the project. The six HF Issues are designed to address both immediate or active issues and long-term or latent conditions.

It is important that the HFICs are clear. If they are not clear, it becomes difficult to re-examine them after a period of time, e.g. if there is a break of several days or weeks between meetings. The facilitator needs to be skilled in re-phrasing the HFICs as concisely as possible, preferably in one sentence or phrase. The facilitator also needs to ensure that the group does not linger over details. Similarly, the recorder needs to be skilled and experienced in listening, in understanding the issues, and in typing and using the Web site (on-line) or software recording package (off-line) quickly and accurately.

Once the participants have finished brainstorming, the facilitator should refer to the checklist to ensure that the issues have been covered, or else raise them to the group and record them if they are considered relevant.

The number of HFICs raised, and the depth of analysis following, will depend partly on the system's phase in the EATM life cycle. It is important not to overlook pertinent HFICs at the early and middle phases, even if the impacts etc., are unclear at this stage. This will ensure that potential issues are not forgotten.

Organise and review HF Issue Components[2]

Once the HFICs have been brainstormed, or at the end of the day, it is useful to break (e.g. finish for the day) so that the HF coach and facilitator can:

- cluster broadly similar types of HFICs into groups (i.e. collocated rows on the worksheet);
- synthesise very similar types of HFICs into 'themes' (i.e. summarise a single row on the worksheet).

If there are a relatively small number of HFICs, these clustering and synthesis can be performed as a group if necessary.

The HFIA brainstorming technique will tend to raise a wide variety of issues. It can be difficult to determine what HFICs are really 'in-scope'. To help resolve this problem, answer the following questions for each HFIC when reviewing the HFICs (also outside of the HFIA brainstorming session).

THREE GOLDEN QUESTIONS FOR HF ISSUE COMPONENT (HFIC) REVIEW

1. **Is it the responsibility or authority of the project manager to address the issue?**

   Some HFICs cannot be addressed within the project. The project manager has ultimate authority to answer this question.

2. **Is it a HF Issue?**

   Some HFICs may be purely technical, management or regulatory. The HF coach has ultimate authority to answer this question. Refer to the definition of Human Factors in Section 1.1 of this document.

3. **Is the HFIC valid for this project?**

   Some HFICs may not really relate to the project, e.g. ex-scope or based on a faulty assumption. The project manager has ultimate authority to answer this question.

Figure 8: Three golden questions for HF Issue Component (HFIC) review

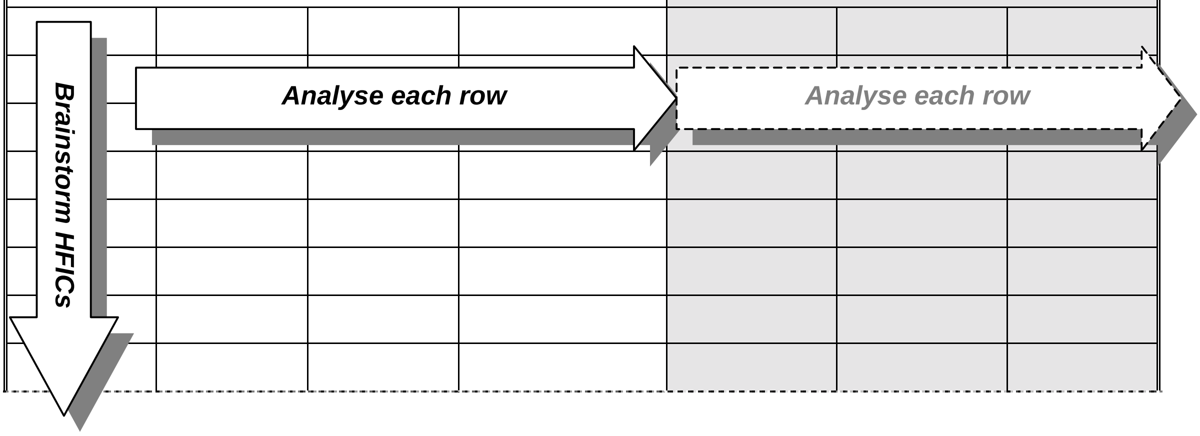
[2] This facility may not be provided by the Human Factors Case Web site.

If the answer to any question is 'no', then the HFIC is retained but marked 'N/A' in all other columns, with a comment inserted explaining why it was not analysed. All such HFICs can be copied to the bottom of the worksheet. This provides a degree of 'auditability' in case the same questions were raised later. The issue should also be referred to the relevant person and recorded in Section 4, 'Stage 3: Monitoring Arrangements'.

Table 8 provides a sample format for capturing the information in the HFIA. There would typically be one table for each relevant Issue (e.g. 'Human-Machine Interaction', 'Training and Development', etc.).

Table 8: Typical group HFIA output table

HF Issue (e.g. 'Human-Machine Interaction')						
HF Issue Component	**Likely Impact**	**Current/ Planned Initiatives**	**Recommendation**	**Importance** L(1) M(2) H(3)	**Urgency** L(1) M(2) H(3)	**Priority** (I+U)
Brainstormed and analysed during the HFIA session				**Analysed during or after the HFIA session**		



Determine likely impact

Once all of the HF Issue Components (HFICs) for a particular category have been answered, the likely impacts are detailed for each HFIC. These are generated using the question: **'What if the HFIC is not addressed adequately?'** Group HFIA requires the input of the project team experts to evaluate the likely impact or the consequences of not addressing each issue appropriately. Impacts may be concrete or abstract, e.g.:

- poor user performance,
- loss of situation awareness,
- increased workload,
- time pressure,
- increased likelihood of errors and possible risks to safety,
- loss of skill level,
- loss of user morale,
- fatigue,

- project over-run,
- etc.

It is important to note and emphasise to participants at this point that the impacts identified in the tables are stated *irrespective* of the current or planned initiatives, i.e. *as if they were not in place*. This enables the importance of the initiatives to be determined.

Certain HFICs may actually have a positive impact. These impacts should also be noted.

Identify current or planned initiatives

Once the impacts have been detailed the team examines current or planned initiatives that should help to address (e.g. prevent, control or mitigate) the HF Issue Component (HFIC) or its impact. Examples may include job aids (e.g. checklists), training, Team Resource Management (TRM), specific procedures, software/hardware, planned checks, HF studies, design methods, etc.

Initiatives must be **currently under development** OR **formally planned and documented within the overall project plan**. The project manager must be able to provide evidence of this if required. Otherwise the initiatives raised must be recorded under the ‘Recommendations/Comments’ column. It is important that common-sense safeguards are recorded to make sure they are not forgotten.

At this stage, there are two options for progression:

- specify recommendations,
- rate importance and urgency.

It is recommended to choose the first option, ‘specify recommendations’. This is because the analytical thought processes involved in rating importance, urgency, and feasibility will slow down the HFIA significantly and distract participants. Also, the ratings may ‘shift’ throughout the HFIA, so it is often better to conduct these ratings later when HFICs can be considered collectively.

However, one drawback of specifying recommendations here is that, since importance and urgency has not been rated, recommendations may be insufficient for critical issues or excessive for minor issues. Therefore, the recommendations should be revisited following the rating exercise, to ensure that they are commensurate with the importance and urgency ratings for that issue.

Generate recommendations

If the team is not satisfied with the robustness of current or planned initiatives, or otherwise perceives a need for further study, recommendations for further action should be proposed for consideration.

Recording

Full recording is used throughout the group HFIA study. This means that HF Issue Components are identified and recorded even if the current or planned initiatives are considered to be adequate by the team. This method demonstrates that a thorough study has been carried out and provides an auditable document for future reference as part of the Human Factors Case. Also, full recording enables the participants of the study group to see and verify the findings of the analysis.

After the HFIA, the HF coach / facilitator / recorder needs to review the log sheets as soon as possible, ensuring that all entries can be understood.

Feedback

The group should be asked after the HFIA about their general feelings about the session(s). A record should be made of this feedback and lessons learned for future HFIAs. The collated results of the group HFIA should also be fed back to the group, to verify the accuracy of the inputs, ensure that no critical issues have been forgotten, and to verify the results of the prioritisation exercise particularly if this was done ‘off-line’.

Meeting conduct

Facilitating and recording this type of meeting is a potentially difficult task and should be undertaken by an experienced and skilled moderator/facilitator. The key challenges include keeping to the time schedule without rushing through or omitting issues or getting stuck on one issue, maintaining a structured approach, and keeping the discussion relevant, without suppressing new or unexpected ideas.

The EUROCONTROL Safety Assessment Methodology (SAM) (EATMP, 2000b, pp. I-29 to I-35) provides generic guidance on conducting such group-based studies. Some of this guidance is adapted in Figures 9 and 10. The EATM Human Factors Team has received training in facilitation skills, and specialised training in conducting an HFIA.

Group Dynamics

- ***Understand participant's background and motivation for attendance.*** Participants should have a common purpose. Circulate a pre-meeting briefing to clarify this, and repeat during the introduction on the day. Allow some time for introductions, asking participants to provide some information on their backgrounds and current roles.

- ***Maintain an optimum group size.*** Groups should be between six and ten (including facilitator and recorder). Very large groups tend to split into sub-groups while very small groups may not have the necessary breadth of expertise and experience.

- ***Understand potential subtle differences in people's behaviour when in group settings.*** Behaviour in a group setting varies according to personality, status and often nationality. For example, in collectivist societies such as those found in South-peripheral Europe, close consultation is required for decision-making, and open conflicts are avoided - solidarity and harmony are valued. In South and East Europe, there tends to be a need to resolve ambiguity and uncertainty quickly, and also reduced tendency to question or contradict superiors directly. Hierarchical relationships between individuals should be taken into account when selecting participants to avoid dominance and reticence. It is vital to allow all participants equal opportunity to contribute.

- ***Overcome defensiveness.*** Participants closely involved in system development may find it hard to admit potential problems. It should be made clear that the identification of potential issues should not be seen as a criticism of any work carried out.

- ***Be aware of confidentiality issues.*** The facilitator needs to be aware of any issue that may affect open discussion, particularly where representatives of different organisations are present.

Adapted from EUROCONTROL Safety Assessment Methodology (EATMP, 2000b)

Figure 9: Group dynamics to consider when conducting a group HFIA

Meeting Practicalities

- ***Consider location and timing of the session.*** This should minimise inconvenience and travel cost.
- ***Consider space, comfort, visibility and audibility.*** An oval or horse-shoe shape (with the facilitator at the open end) is usually the best arrangement. Ensure sufficient open area at the back of the room or elsewhere for coffee, etc.
- ***Provide adequate breaks and refreshments.*** Consider the attention span and fatigue of the facilitator and recorder, as well as participants.
- ***Make allowance for participants being unavailable at the last minute.*** Travel problems or operational duties may result in some participants being unavailable on the day. Potential substitute participants should be kept in reserve if possible.
- ***Provide adequate visual aids.*** On-line projection is an effective and efficient way to record the group HFIA. However, posters, white boards or flipcharts are useful to note other issues such as study boundaries and assumptions, and to provide a 'parking lot' for issues to be addressed later.
- ***Consider varying the presentation of the session.*** In order to maintain attention and motivation, it may be useful to vary the style of presentation (e.g. use of visual aids), timing of breaks, and to change facilitator/recorder roles.

Adapted from EUROCONTROL Safety Assessment Methodology (EATMP, 2000b)

Figure 10: Meeting practicalities to consider when conducting a group HFIA

2.2.4.4 After HFIA Session

It is recommended that the following activities be performed after the HFIA, though they may be addressed within the HFIA if desired or if there is time left over after the analysis above has been completed.

Rate importance of Issue

Following the identification of impacts and current or planned initiatives, the group, or a sub-group, may assess the importance of the HF Issue

Component - the degree of significance in terms of potential impacts on project success (user acceptance, publicity, system performance, safety, personnel well-being, morale/motivation, etc).

The rating of importance should take account of both:

- the severity of the likely impact;
- the probability, likelihood and duration of the impact *in light of the current or planned initiatives.*

In order to determine the rating some simple subjective criteria of 'Low', 'Medium' and 'High' categories are used (in common with some project risk management approaches). Some prototypical anchors for each of these ratings are suggested in Table 9, though other anchors may be used as agreed by the project manager and HF coach.

Table 9: Example importance ratings, criteria, and anchors

Rating	Criteria	Example Anchors
Low	Operability	• May cause small and short-term deviation from required operational performance, or no deviation at all. • Small improvements and fine-tuning may be required. • The issue may not have affected similar projects previously, but it is feasible that it could.
	Acceptability	• Perhaps some minor initial problems with user acceptance, which are quite easily overcome. • No external publicity.
Medium	Operability	• Some risk of system not meeting operational requirements. • Some re-work required. • The issue has been known to have affected the output of one or a small number of similar projects in the past.
	Acceptability	• User acceptance likely to be an obstacle. • Some short-term negative publicity.
High	Operability	• Safety implications. • High risk of system not meeting operational requirements. • Significant rework required. • Long-term problem requiring consistent attention. • The issue is a common cause of failure to meet project outputs.
	Acceptability	• Very low user acceptance. • Wide-scale or long-term damaging publicity.

Rate urgency of Issue

Following the specification of the importance of each issue, the urgency of the issue within the project life cycle is determined, that is the degree to which the HFIC requires speedy attention and/or action. Again, simple subjective criteria of 'Low', 'Medium' and 'High' are used, depending on the system's current EATM phase compared to that at which the issue will need to be addressed. Some anchors for each of these ratings are suggested in Table 10.

Table 10: Urgency ratings, criteria and anchors

Key: A = Current phase   B = Phase at which issue must be addressed

Rating	**Anchor**							
Low	Likely to require addressing in the third or later phase after the current phase within the life cycle.							
Example	Initiation	Planning A	Feasibility	Develop- ment	Pre- operational B	Implement -ation Planning	Local Implement -ation	Operations B
Medium	Likely to require addressing in the second phase after the current phase within the life cycle.							
Example	Initiation	Planning	Feasibility A	Develop- ment	Pre- operational B	Implement -ation Planning	Local Implement -ation	Operations
High	Likely to require addressing in the next discrete phase within the life cycle.							
Example	Initiation B A	Planning B	Feasibility	Develop- ment	Pre- operational	Implement -ation Planning	Local Implement -ation	Operations

The urgency ratings can be expressed as follows:

- Low: $B \geq A + 3$ EATM project phases,
- Medium: $B = A + 2$ EATM project phases,
- High: $B \leq A + 1$ EATM project phase.

Calculate issue priority

The **issue** importance and urgency feasibility ratings are **summed** to give a priority weighting between 2 and 6. The issues identified can then be ranked in terms of priority:

Hence, for both the importance and urgency criteria, the following ratings and scores are applied:

- Low = 1 point,
- Medium = 2 points,
- High = 3 points.

The two ratings are then added to give a score between 2 and 6. This gives a *priority rating*, as follows:

- Low = 2 points,
- Low-Medium = 3 points,
- Medium = 4 points,
- Medium-High = 5 points,
- High = 6 points.

The priority ratings help to plan the level of effort that should be spent on implementing recommendations.

Participants may want to prioritise without examining impacts and current or planned initiatives. However, this is difficult and unreliable and may result in unnecessary spending of valuable resources on trivial matters. Prioritisation should therefore normally only be done after impacts and initiatives have been examined. If a ‘pre-filter’ needs to be applied to cut down the number of issues (e.g. identify the ‘top-40’ issues), it needs to be borne in mind and reported that this filter is preliminary, pending examination of impacts and initiatives.

Feasibility of recommendations

A final rating concerns the **feasibility of recommendations** - the degree to which each recommendation is practical, in light of cost, complexity, availability of expertise, system impacts, etc. This should also help identify ‘quick-wins’. Again, this could be rated subjectively as high, medium and low, or using a more elaborate scheme. Each recommendation is assigned an owner, who follows up the recommendation. This activity is coordinated by the project manager. An example is shown in Table 11. This activity does not form part of the group process and is simply meant to be a further aid to the project manager and HF coach.

Table 11: Example format for recommendations, and rating feasibility for issues of the same priority

Recommendation	Owner	Date to Complete	Issue Priority	Feasibility
1. Example recommendation	Person A	01/09/02	H	H
2. Example recommendation	Person B	01/10/02	H	M
3. Example recommendation	Person A	01/11/02	M-H	L
4. Example recommendation	Person C	01/12/02	M	H
5. Example recommendation	Person B	01/01/03	M	M
6. Example recommendation	Person C	01/02/03	L-M	H
7. Example recommendation	Person A	01/03/03	L	L

2.3 Alternative Methods[3]

The two alternative methods that may be considered, in line with the advice provided in Table 5, are the HF Issues checklist and HIFA checklists. The decision to use one or the other of these should be made jointly by the project manager and HF coach.

2.3.1 HF Issues Checklist

The HF Issues checklist presented in Table 6 can be used jointly by the project manager and HF coach, and ideally with a facilitator also present, in a more informal meeting to discuss and identify the key issues and actions. The recording format should be determined in advance by the project manager and HF coach.

2.3.2 HIFA Checklists

The HIFA approach presents a checklist for each of the EATM project phases to serve as prompts to consider appropriate HF Issues at appropriate phases, covering the pertinent HIFA domains (see EATMP, 2000c).

[3] These alternative methods are not necessarily supported by the Human Factors Case Web site.

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3. STAGE 2 - HUMAN FACTORS INTEGRATION

Human Factors (HF) Integration, the second stage of the Human Factors Case, is where the necessary HF studies are planned and conducted (see Figure 11). HF Integration is conducted throughout the EATM life cycle, as required. The project manager and HF coach should jointly decide exactly when HF Integration studies should occur. However, various Subject Matter Experts (SMEs) will be involved with, or responsible for, specific studies.

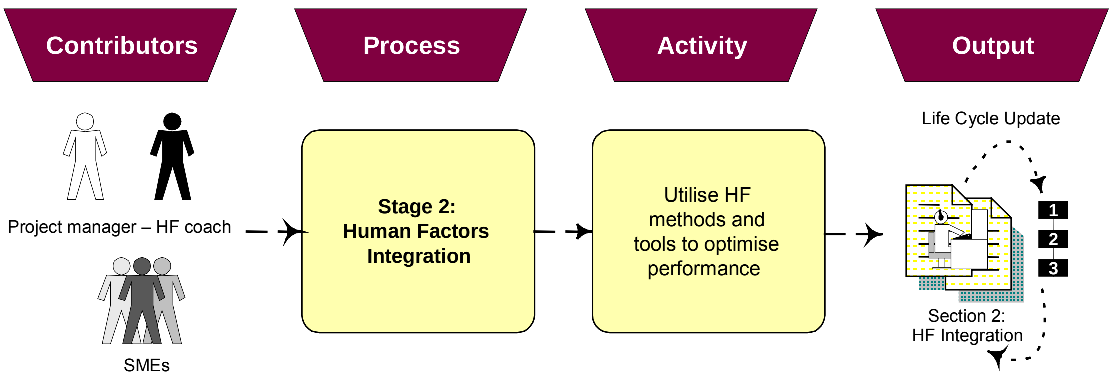

Figure 11: Stage 2 - Human Factors Integration

The project manager and HF coach need to review the HFIA tables and identify each HF Issue where recommendations and actions were specified for further consideration, work or studies. At each summary phase, it would be sensible to review – as a minimum – the higher priority issues identified during the HFIA. For example, if particular HF Issue Components within ‘Procedures, Roles and Responsibilities’, ‘Training and Development’ and ‘Recovery from Failures’ were rated as high priority during a particular project, then these issues would be considered in more detail during HF Integration. This is achieved using a set of ‘Human Factors Integration (HFI) Ladders’ (Appendix A) and associated recording forms (Appendix B) (see Table 12).

Table 12: HFI Ladders and recording forms

Human Factors Issue		HFI Ladders (Appendix A)	HFI Recording Forms (Appendix B)
1	Human-Machine Interaction	Table A1	Table B1
2	Organisation and Staffing	Table A2	Table B2
3	Training and Development	Table A3	Table B3
4	Procedures, Roles and Responsibilities	Table A4	Table B4
5	Teams and Communication	Table A5	Table B5
6	Recovery from Failures	Table A6	Table B6

3.1 Human Factors Integration Ladders

The HFI Ladders form the basis for planning and integration of HF activities. Each HF Issue is split into a number of tasks. Each set of tasks is intended to broadly capture the main elements of that HF Issue. For each task three criteria are stated which indicate *activities* that provide options as to how the task might be addressed.

- ***Best Practice*** ☺ -- This indicates the application of best-practice HF principles to the issue concerned. The activities in this column are additional to those in the 'satisfactory' column.
- ***Satisfactory*** 😐 - This rating indicates an adequate response to the question. The aim should be to achieve at least a satisfactory rating, and then decide which areas would benefit most from the application of best practice.
- ***Attention Required*** ☹ - This rating indicates that there is an increased likelihood of poor performance. Further attention is required to improve this rating or otherwise to provide justification.
- ***Not Applicable*** ✖ - This indicates that the question is not applicable to the project.

An extract from one of the HFI Ladders is shown in Table 13.

Table 13: Extract from HFI Ladder for 'Human-Machine Interaction"

☹	😐	☺
1. Select appropriate input devices (e.g. keyboard, mouse, roller-ball, touch-screen).		
➔Input devices not designed according to ergonomic principles using specific methods or tools. ➔No adequate consideration of user needs.	➔Select or design input device taking into account design guidelines/checklists. ➔Ensure that input devices adhere to relevant standards. ➔Involve a representative sample of users in selection/design and testing. ➔ Investigate user needs using structured methods. ➔Test input devices in realistic environment. Any identified performance problem resolved.	(😐 + …) ➔Collect objective data on input device use in prototyping and testing (e.g. human error data, efficiency).
Typical HIFA Methods and Tools	Observational Techniques Questionnaires Checklists Real-time Simulation Design Guidelines	Objective Performance Measurement Human Error

3.2 Human Factors Integration Recording Forms

Each HFI Ladder has an associated HFI recording form. The same set of tasks is proposed for each HF Issue. For each task the recording form comprises:

- ‘criteria’ rating columns,
- ‘planned activities’,
- ‘key conclusions and evidence’.

The criteria rating columns are the same as those above with the addition of:

- ***Not Applicable*** ✕ -This indicates that the question is not applicable to the project.

The Ladders are initially used to plan what generic HF activities are required. This can help to provide input to and modify a HF Integration Plan (HFIP) - a project plan specific to the HF activities that may be part of the project plan, and will determine what detailed HF work is carried out. The project manager and HF coach use the HFI Ladders at Appendix A to determine the target criterion to be reached, and therefore what HF methods and tools should be used, depending on the priority of the issue and the resource impact. Hence, throughout the project phases, the ‘current’ and planned’ level of HF integration may change, and be indicated on the Ladders as ‘C’ = current, ‘P’ = planned. Bullet points indicating the planned activities should be inserted for each relevant task.

Once the planned HF activities have been carried out, the ‘key conclusions and evidence’ box allows the Human Factors Case writer to provide summary conclusions, comments and references in response to each question. As indicated in the ‘criteria’, it may be necessary to refer to several types of information in order to provide evidence for each answer and traceability of the Human Factors Case process.

Typically, the project manager and HF coach will jointly conduct this activity. However, it is likely that various stakeholders may be consulted or involved in the process. These contacts will be able to provide further clarification on the issue, help conduct studies, find information, etc, if required. It is recommended that the HF coach coordinates this activity.

Throughout the project it is important that effective top-down and bottom-up communication processes have been established to help manage human factors changes. A formal change management system should be in place to manage all changes that affect end-users and to ensure that all the potential impacts of the change on the project have been considered.

During the implementation and operations phase bottom-up communication processes (e.g. an improvement suggestion scheme) could be established to enable feedback on any human factors issue which is considered good or bad.

An extract from one of the HFI recording forms is shown in Table 14.

Table 14: Extract from HFI recording form for ‘Human-Machine Interaction’

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Select appropriate input devices (e.g. keyboard, mouse, roller-ball, touch-screen). *Key factors: data type, speed, accuracy, frequency of use, duration of use, response time, feedback, consistency, display-control relationship, logical and functional arrangement, ‘population stereotypes’, labelling, location, handedness, comfort, clearance, redundancy/choice.*					*	*

** These columns have been condensed.*

4. STAGE 3 - MONITORING ARRANGEMENTS

The purpose of this stage of the Human Factors Case is to help to identify and define appropriate monitoring arrangements for the operational phase that relate to the key human factors issues identified within the Human Factors Case (see Figure 12). Monitoring of human factors implementation during the previous project phases is deemed to be the responsibility of the project manager and therefore is not specifically addressed as part of the Human Factors Case.

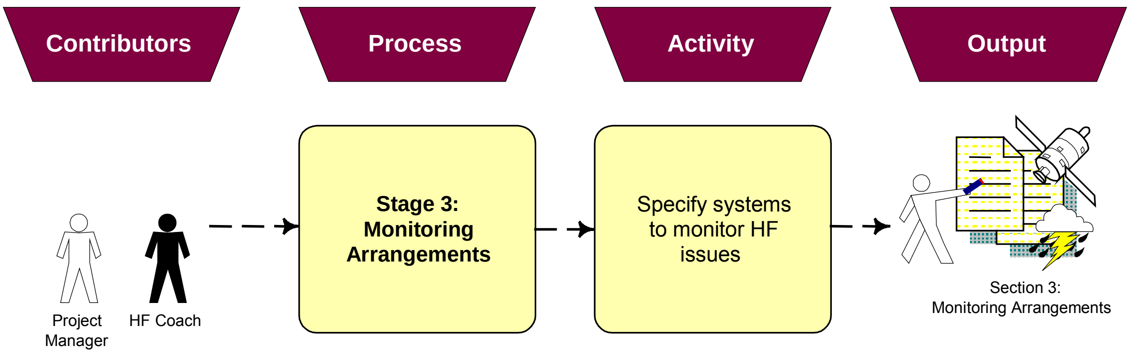

Figure 12: Stage 3 - Monitoring Arrangements

In order to successfully monitor that a system is performing to the required or anticipated standard it is necessary to develop the details of the monitoring system prior to implementation, even though such arrangements may change in practice. A number of factors need to be considered when selecting and identifying monitoring arrangements. In general terms these include:

- the nature of the data to be collected,
- the practicalities of data collection and analysis,
- the planning of monitoring activities,
- the importance of feedback and
- lessons learned.

These issues are discussed in more detail in the following sections.

4.1 The Nature of the Data to be Collected

Monitoring systems can be considered to be active or reactive. *Active* monitoring systems provide indications of potential problems before an adverse event occurs. *Reactive* monitoring systems provide data on the adverse events themselves. Therefore it is obviously beneficial to have as much active monitoring as practical in order to help minimise the actual number of adverse events. However, it is necessary and desirable to also collect data about adverse events and therefore monitoring systems tend to comprise a mixture of both aspects.

4.1.1 Active Monitoring Systems

Active monitoring is particularly important where the total effectiveness of the proposed system safeguards is uncertain. Typically this will relate to those cases where there is a heavy reliance on procedural or management system controls. Active monitoring systems are therefore often used to check compliance with performance standards for these types of issues. Some examples of active monitoring include:

- inspections of workplaces, equipment and practices to ensure continued effective operation;
- direct observation (e.g. usability issues) and random operation (e.g. 'HF tours' conducted by HF experts);
- surveys and audits of users' perceptions regarding HF Issues (usability, working environment, trust, etc.);
- error investigation and near-miss reporting and investigation systems (sometimes considered as reactive monitoring systems).

The level of active monitoring proposed should be proportional to the importance of the key issues as determined in the Human Factors Case. Key HF Issues should be monitored in more detail or more often than less important issues.

4.1.2 Reactive Monitoring Systems

Reactive monitoring systems are triggered after an event, primarily to help an organisation to learn from mistakes and most provide data sources that are typically used for to identify events to be subject to more detailed incident investigation, etc. However, there are some important reactive monitoring arrangements that should be considered in the Human Factors Case in order to ensure that reportable errors, hazards, ill-health, and 'efficiency losses' are reported. Typical arrangements may include:

- investigations of errors, and incidents, which have resulted in some form of loss e.g. separation, operational capacity, etc. Include HF expertise and tools (e.g. HERA-JANUS - EATMP, 2003);
- reporting of actual system problems and hazards (e.g. issues associated with response times, reliability, operability, error 'traps', feedback, etc.);
- reporting of health issues, such as stress or upper limb disorders associated with keyboard or mouse use;

- weaknesses or omission in performance standards.

4.1.3 Incident Investigation

In order to investigate incidents relating to human factors issues it is suggested that incident investigation tools that have been developed specifically for this purpose be utilised (e.g. EATMP, 2003).

4.2 The Practicalities of Data Collection and Analysis

General guidance on the development of performance monitoring systems usually addresses the following issues.

- Why measure?
- What to measure?
- When to measure?
- Who should measure?
- How to measure?

In addition the project manager needs to estimate the degree to which existing data collection mechanisms and systems can be utilised for the purpose of the Human Factors Case. There are both advantages and disadvantages to using existing systems. These are illustrated in Table 15.

Table 15: Advantages and disadvantages of using existing data collection systems

Disadvantages of using existing data collection systems	Advantages of using existing data collection systems
May not be amenable for the type of data required	Familiarity of staff with procedures and format
Potential low credibility if system has not been well adopted in the past	Potential high credibility with staff
	Analysis mechanisms already developed

4.2.1 Why Measure?

The reasons for developing monitoring system have already been described in previous sections. However for the successful implementation of a monitoring system it is necessary for the stakeholders of the system to fully buy into the operation of the monitoring systems. Therefore, it is important that these systems are developed in collaboration with stakeholders and that all stakeholders are fully aware of the nature and intended use of the data being collected.

4.2.2 What to Measure?

The actual issues to be measured will be developed from the list of critical issues within the Human Factors Case. It is important to recognise however that it will not always be possible to develop a single measure that will fully address each issue. Typically a number of measures may have to be developed in order to obtain a balanced view of performance in that area. Therefore for each issue the project manager and HF coach should determine:

- the actual measure or measures required,
- the required frequency of measurement (for active measurements),
- how the measurement is carried out and by whom,
- how the data will be analysed,
- how the data will be used to support design changes or not,
- how feedback on the results of the measurement activity will be given.

4.2.3 When to Measure?

This section of the Human Factors Case is aimed at the operational phase. It is likely that measurement activity will be most intensive in early operational phases. Once it has been ascertained that the system is performing to requirements in a certain area then a decision can be taken to reduce the frequency of measurement or even to cease active measurement of that particular item.

4.2.4 Who Should Measure?

Measurement activities should be undertaken by a variety of project or system stakeholders including:

- Users, maintainers, supervisors, etc. Typically these data collection activities relate to routine or on-line systems. The level of feedback is typically highly influenced by the culture within the organisation and the visibility of changes made as a result of the feedback.

- Project specialist. Typically these would be specific exercises to investigate certain critical areas of the design or operation.

- Independent audit. In certain cases an independent ‘audit’ of monitoring activities should be carried out. The value of this process is to get an external view on the overall capability of the monitoring systems and the level of compliance with their use.

4.2.5 How to Measure?

There are a number of ways that information can be gained. Direct information can be obtained from taking physical measurements, extracting system log information, examining event histories, etc. Where this is the case it is essential that all users are fully consulted. Indirect measures such as perceptions, subjective views, etc., can also be obtained through a variety of means. In general therefore, there are typically three sources of information that can be accessed:

- direct observation of conditions and people's behaviour,
- talking to people to elicit facts, their experiences and views,
- examination of documents such as event reports, shift logs, etc.

4.3 The Planning of Monitoring Activities

As has been previously described, measuring the performance of systems requires resources from a number of potential stakeholders including the users. Therefore it is important to coordinate measurement effort in order to minimise the potential disruption. Others will also wish to carry out some measurement activity. Therefore it is suggested that the project manager develop a 'measurement' plan in order to best coordinate all the necessary measurement activities.

Table 16 may help the project manager and HF coach to document the planned monitoring arrangements.

Table 16: Planned monitoring arrangements (with brief example entries)

HF Issue Area	Planned Monitoring Arrangements			
	Measure	***Method or Tool***	***Timing/Frequency***	***Responsible***
Human-Machine Interaction	Workstation comfort	Survey	+ 1 month	DM
	Usability problems	HF reporting system	Continuous > 12 months	DM
Organisation and Staffing	Staff satisfaction	Survey	+ 3 months + 6 months	JH
Training and Development	Training effectiveness against objectives	Monitoring	+ 1 month + 3 months	SO
Procedures, Roles and Responsibilities	Workload assessment	AIM	+ 1 month + 3 months + 6 months	DM
	Documentation	User group	+ 1 month + 3 months	BW
Teams and Communication	Phraseology	HF reporting system	+ 1 month + 3 months	DM
	Team functioning	Observation and discussion	+ 2 months	DM
Recovery from Failures	Errors	HF reporting system	Continuous > 12 months	DM
		Direct observation	+ 1 month	DM
	Software problems	HF reporting system	Continuous > 12 months	DM

4.4 The Importance of Feedback

One of the key factors that determines the success of a measuring activity is the level of feedback given to the providers of the information. Feedback should be given even if there is going to be no change and that the measurement activity indicates that the system is performing to the required standard. Feedback should also be given on the status of any proposed change.

4.5 Lessons Learned

It is also useful to make effective use of the very valuable insights and lessons learned throughout the Human Factors Case process, i.e. what worked and what didn't work. This can help to prevent problems, and save resources, in future similar problems

Table 17 provides the ability to record lessons learned during the project and after implementation that may be of benefit to future similar or related projects.

Table 17: Lessons learned

Human Factors Issue Area	During Project Development	After Implementation
Human-Machine Interaction		
Organisation and Staffing		
Training and Development		
Procedures, Roles and Responsibilities		
Teams and Communication		
Recovery from Failures		

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5. STAGE 4 - HUMAN FACTORS CASE ASSESSMENT

Once Stages 1, 2 and 3 have been completed by the project manager and HF coach, the Human Factors Case is assessed by an independent human factors assessor (see Figure 13).

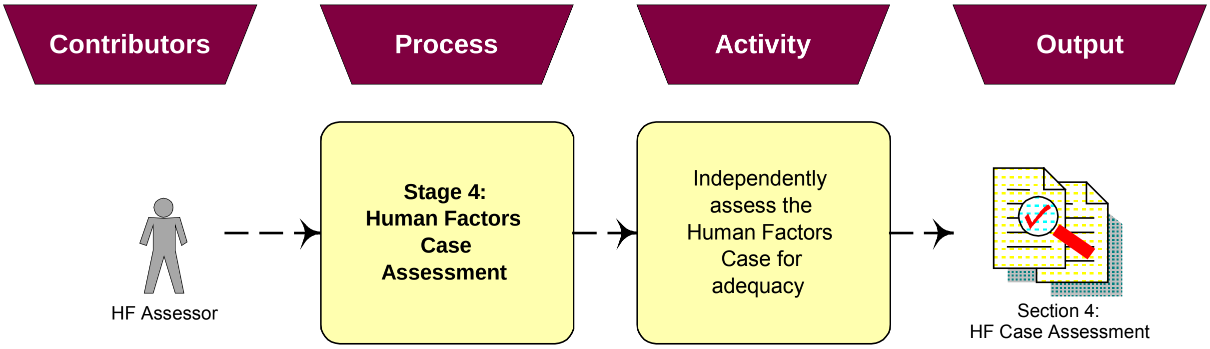

Figure 13: Stage 4 - Human Factors Case Assessment

This assessment will focus primarily on the process and output of the HFIA (Stage 1) and HFI (Stage 2). Initially, this activity is likely to be conducted by a HUM expert, but ultimately this process should be conducted by an HF expert who is independent of EATM. The formats to be used for the Human Factors Case assessment are under development and will be specified at a later date.

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ABBREVIATIONS AND ACRONYMS

For the purposes of this document the following abbreviations and acronyms shall apply:

ARSQ	ATM Real-time Simulation Questionnaire
ATC	Air Traffic Control
ATCO	Air Traffic Controller / Air Traffic Control Officer *(US/UK)*
ATM	Air Traffic Management
CBT	Computer-based Training
ATM/CNS	Air Traffic Management systems, and Communications, Navigation and Surveillance
COTS	Commercial Off-The-Shelf
DAP	Director(ate) ATM Programmes *(EUROCONTROL Headquarters, SD)*
DAS	Directorate ATM Strategies *(EUROCONTROL Headquarters, SD)*
DAS/HUM *or just* HUM	Human Factors Management Business Division *(EUROCONTROL Headquarters, SD, DAS)*
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme *(later renamed 'EATMP' and today known as 'EATM')*
EATM(P)	European Air Traffic Management (Programme) *(formerly known as 'EATCHIP')*
ET	Executive Task *(EATCHIP/EATM(P))*
FEAST	First European ATCO Selection Test (Package) *(EATM(P), HRS, MSP)*
FHA	Functional Hazard Assessment
HAZOPs	Hazard and Operability Studies
HERA	Human Error in ATM (Project) *(EATM(P)/HRS/HSP)*
HF	Human Factors

HFFG	Human Factors Focus Group *(EATM, HRT)*
HFI	Human Factors Integration
HFIA	Human Factors Issue Analysis
HFIC	Human Factors Issue Component
HFIP	Human Factors Integration Plan
HHA	Health Hazard Assessment
HIFA	Human Factors Integration in ATM *(EATM(P)/HRS/HSP)*
HMI	Human-Machine Interface
HRS	Human Resources Programme *(EATM(P))*
HRT	Human Resources Team *(EATCHIP/EATM(P))*
HSP	Human Factors Sub-Programme *(EATM(P), HRS)*
HUM	Human Resources
ICAO	International Civil Aviation Organization
M	Manpower
MSP	Manpower Sub-Programme *(EATM(P), HRS)*
OJT	On-the-Job Training
OJTI	On-the-Job-Training Instructor
OR	Operational Requirement
P	Personnel
REP	Report *(EATCHIP/EATM(P))*
SAF	Safety *(EATCHIP/EATM(P))*
SAM	Safety Assessment Methodology *(EUROCONTROL)*
SD	Senior Director, EATM Service Business Unit *(EUROCONTROL Headquarters)*
SHAPE	Solutions for Human-Automation Partnerships in ATM *(EATM(P), HRS, HSP)*

SME	Subject Matter Expert
SS	System Safety
ST	Specialist Task *(EATCHIP/EATM(P))*
SUMI	System Usability Measurement Inventory
T	Training
TID	Task and Interface Design
TRAINDEV	Training Development *(EUROCONTROL)*

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APPENDIX A – HUMAN FACTORS INTEGRATION LADDERS

Table A1: Human-Machine Interaction Ladders

☹	😐	☺
1. Select appropriate input devices (e.g. keyboard, mouse, roller-ball, touch-screen).		
➔Input devices not designed according to ergonomic principles using specific methods or tools. ➔No adequate consideration of user needs.	➔Select or design input device taking into account design guidelines/checklists. ➔Ensure that input devices adhere to relevant standards. ➔Involve a representative sample of users in selection / design and testing. ➔ Investigate user needs using structured methods. ➔Test input devices in realistic environment. Any identified performance problem resolved.	(😐 + …) ➔Collect objective data on input device use in prototyping and testing (e.g. human error data, efficiency).
Typical HIFA Methods and Tools	Observational Techniques Questionnaires Checklists Real-time Simulation Design Guidelines	Objective Performance Measurement Human Error
2. Ensure that visual displays are of sufficient quality.		
➔No or limited reference to ergonomic guidelines or standards in the design of displays. ➔A small number of potential users involved in the design process.	➔ Design or select visual displays taking into account design guidelines/checklists. ➔Design displays according to a style guide or relevant standard. ➔Involve a representative sample of users throughout development. ➔Perform detailed ergonomic studies to ensure that design features (e.g. display legibility) are within acceptable limits. ➔ Investigate user needs using structured methods. ➔Evaluate displays using objective and subjective methods during prototyping and simulation.	(😐 + …) ➔Conduct detailed task analysis studies during design, preferably eliciting the cognitive components of the task. ➔Assess human error potential. ➔Perform detailed usability evaluation using formal usability assessment tool (e.g. SUMI).

<table>
<tr><th>☹</th><th>😐</th><th>☺</th></tr>
<tr><td>Typical HIFA Methods and Tools</td><td>Observational Techniques
Questionnaires
Checklists
Real-time Simulation
Objective Performance Measurement
Design Guidelines
System Design and Analysis</td><td>Task Analysis
Cognitive Task Analysis
Integrated Task Analysis
Method for Usability Engineering
Usability
Human Error Assessment
Performance Assessment
Human Error</td></tr>
<tr><td colspan="3">3. Take information requirements into account.</td></tr>
<tr><td>➔Limited or no HF studies.
➔Little or no user involvement in studies to identify what information is required.</td><td>➔Involve a representative sample of potential users in design and development to ensure that all relevant information is supplied and easy to access and identify without having to memorise.
➔Test information requirements using objective and subjective methods during prototyping and simulation.
➔Investigate potential differences between user groups.</td><td>(😐 + …)
➔Conduct detailed (cognitive) task analysis studies to determine required information and the risk of information overload.
➔Gain deeper subjective information.
➔Track changes in information requirements throughout the development life cycle.</td></tr>
<tr><td>Typical HIFA Methods and Tools</td><td>Questionnaires
Objective Performance Measurement
Real-time Simulation</td><td>Structured Interviews
Task Analysis
Cognitive Task Analysis
Integrated Task Analysis
Method for Usability Engineering
Verbal Protocols
Cognitive Walkthrough</td></tr>
<tr><td colspan="3">4. Develop alarm handling (including alerts) according to human factors principles.</td></tr>
<tr><td>➔Alarms and alerts do not sufficiently take into consideration human limitations.
➔Basic adherence to technical standards but no adequate use of HF methods.</td><td>➔Develop and apply a consistent Alarm philosophy/policy.
➔Apply best-practice standards and relevant guidelines throughout the design and development.
➔Carry out prototyping studies involving HF experts and a representative sample of potential users, and objective and subjective responses measured.
➔Perform task analysis on the alarm handling process.
➔Carry out a basic assessment of workload using simple methods.</td><td>(😐 + …)
➔Use a variety of objective and subjective data collection methods throughout the life cycle.
➔Identify potential human errors
➔Investigate the cognitive aspects of the task.
➔Carry out detailed usability evaluations through application of usability tools such as SUMI.</td></tr>
</table>

☹	😐	☺
Typical HIFA Methods and Tools	Questionnaires Task Analysis Checklists Real-time Simulation Objective Performance Assessment Design Guidelines Subjective Workload Assessment Workload	<Data Collection> Cognitive Task Analysis Usability Verbal Protocols Cognitive Walkthrough Influence Diagrams <Human Error Assessment> Human Error
5. Take the ergonomics of the console or immediate working area into consideration.		
➔Ergonomic guidance not used in the development of workspaces. ➔Workstation design takes little account of user characteristics, despite some input from potential users.	➔Use ergonomic guidance in the development of workspaces, with input from a representative sample of potential users. ➔Use prototyping to collect basic objective and subjective data. ➔Apply the relevant anthropometric data for the target population to the design of workstation layouts. ➔Ensure that potential differences between user groups are investigated. ➔Ensure that maintenance needs (e.g. access requirements) are taken into account.	(😐 + …) ➔Apply task analysis methods to help determine workplace configuration. ➔Use physical mock-ups during the developmental process.
Typical HIFA Methods and Tools	Observational Techniques Questionnaires Checklists Anthropometry Workspace and Workplace Design Design Guidelines	Activity Analysis Charting and Networking Methods Link Analysis Task Analysis
6. Ensure that the usability of the general HMI is acceptable.		
➔No measurements of usability performed. ➔Data is limited or out of date.	➔Apply general data collection methods used during prototyping (e.g. questionnaires). ➔Apply style guide and HMI guidelines to use as a source of reference. ➔Collect objective and subjective usability data in controlled conditions using basic data collection methods.	(😐 + …) ➔Apply detailed usability evaluation techniques such as specific usability tools (e.g. SUMI).
Typical HIFA Methods and Tools	Various <Data Collection> Checklists Design Guidelines Objective Performance Assessment	Usability Method for Usability Engineering

☹	😐	☺
7. Ensure that user requirements have been identified.		
➔User requirements not elicited or elicited from a small number of individuals.	➔Involve users throughout the project to input to detailed project requirements. ➔Apply basic data collection methods to determine user requirements.	(😐 + …) ➔Apply detailed user requirements techniques to elicit information, including gender differences, shift differences, language and cultural differences. ➔Develop a target audience and user profile. ➔Ensure that potential cultural differences are assessed.
Typical HIFA Methods and Tools	Structured Interviews Questionnaires	Task Analysis Cognitive Task Analysis Integrated Task Analysis Method for Usability Engineering
8. Ensure that potential new health risks are removed or minimised.		
➔Potential new health risks not addressed. ➔No structured analysis to demonstrate management of existing risks.	➔Involve a representative sample of users in the system design, development and implementation to identify and address potential health impacts. ➔Develop a risk register or similar reporting system to record potentially reported health risks. ➔Check display screen equipment and input devices for potential new health risks.	(😐 + …) ➔Involve an occupational health specialist or ergonomist in the design life cycle. ➔Use questionnaires and interviews to collect subjective data on health impacts.
Typical HIFA Methods and Tools	Checklists Design Guidelines Anthropometry Workspace and Workplace Design	Questionnaires Structured Interviews
9. Ensure that the potential effects of human-computer interaction on fatigue are assessed.		
➔Potential effects on fatigue not assessed. ➔There are inadequate controls in place to prevent fatigue.	➔Investigate the causes for previous incidences of fatigue. ➔Use questionnaires to examine the potential fatigue implications. ➔Identify the required frequency, duration and timing of controlled breaks necessary to avoid fatigue.	(😐 + …) ➔Interview controllers about any previous (particularly unreported) problem with fatigue. ➔Use real-time simulations to assess to ensure that underload or overload does not occur and lead to fatigue. ➔Design the working environment to mitigate against potential fatigue problems. ➔Monitor absences and carry out health checks for signs of fatigue.

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Typical HIFA Methods and Tools	Checklists 🕮 🛠 Design Guidelines 🛠 Functional Allocation 🕮 Questionnaires 🕮 🛠	Critical Incident Analysis 🕮 Workspace and Workplace Design 🕮 Real-time Simulation 🕮 Objective Performance Measurement 🕮 Subjective Workload Assessment 🕮 Physiological Workload Assessment 🕮 Performance Assessment 🛠 Rating Scales 🛠 Workload 🛠
10. Identify potential distractions and other potential impacts on concentration.		
➔Potential distractions not addressed.	➔Design the working pattern and working environment to reduce distractions (e.g. use guidelines and checklists to reduce distractions). ➔Use questionnaires to examine the potential impacts of distractions. ➔Review previous incidents associated with distraction.	(😐 + ...) ➔Conduct observations of users using the system, and take objective measures during simulations and in the operational environment to assess distractions. ➔Interview controllers about any previous (particularly unreported) problem with distractions. ➔Identify critical human errors associated with distraction.
Typical HIFA Methods and Tools	Checklists 🕮 🛠 Design Guidelines 🛠 Questionnaires 🕮 🛠	Observational Techniques 🕮 Critical Incident Analysis 🕮 Real-time Simulation 🕮 Objective Performance Measurement 🕮 Hazard and Operability Analysis 🕮 Human Error 🛠
11. Ensure that background noise levels are acceptable.		
➔Noise levels not considered.	➔Monitor noise levels to reveal any negative effect. ➔Ensure that background noise is reduced to a minimum (e.g. sound insulation). ➔Evaluate whether speech intelligibility is affected. ➔Apply the relevant checklists, guidelines or standards to the design	(😐 + ...) ➔Conduct formal assessments of noise levels formally using objective methods to reduce potential negative impact on communications, comfort, distraction and health.
Typical HIFA Methods and Tools	Checklists 🕮 🛠 Design Guidelines 🕮 🛠 Workspace and Workplace Design 🕮	Noise Survey ○
12. Ensure that lighting levels are acceptable.		
➔Lighting levels not assessed.	➔Use lighting arrangements that are based on current or previous acceptable arrangements. ➔Provide the facility to adjust lighting arrangements according	(😐 + ...) ➔Formally assess lighting using appropriate methods to optimise performance and reduce or eliminate glare and reflections.

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	to user feedback. ➔Apply relevant checklists, guidelines or standards to the design. ➔Monitor the lighting levels to identify potential shortfalls.	➔Consider and evaluate the potential use of directional and natural lighting within the design
Typical HIFA Methods and Tools	Checklists Design Guidelines Workspace and Workplace Design	Lighting Survey
13. Ensure that temperature, humidity and air quality levels are acceptable.		
➔Temperature, humidity and air quality not assessed.	➔Use previously acceptable temperature, humidity and air quality arrangements. ➔Provide facility for users to change the temperature, humidity and air quality according to user feedback. ➔Ensure that users are not exposed to noxious vapours, gases, dust, or smoke. ➔Apply relevant checklists, guidelines or standards to the design.	(😐 + …) ➔Apply best-practice principles to the design of the temperature, humidity and air quality system to ensure optimum levels of comfort. ➔Monitor the temperature, humidity and air quality to reveal any negative effect.
Typical HIFA Methods and Tools	Checklists Design Guidelines Workspace and Workplace Design	
14. Design the workplace arranged ergonomically.		
➔Workplace not arranged ergonomically.	➔Apply ergonomic principles in the early phases to help the development of positions, sectors etc. in order to ensure the most logical, functional and efficient arrangement. ➔Carry out simulations to ensure functional and effective design for the target population. ➔Apply relevant standards to the design	(😐 + …) ➔Utilise link analysis during early and middle phases to record the frequency and importance of links within the overall layout. ➔Apply further data collection methods used to demonstrate the effectiveness of the layout. ➔Assess the effects of layout on objective performance measures.
Typical HIFA Methods and Tools	Workspace and Workplace Design Anthropometry Real-time Simulations	Activity Analysis Observational Techniques Questionnaires Checklists Link Analysis Objective Performance Measurement

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15. Ensure that the workplace can accommodate all of the people, equipment and furniture required.		
➔Insufficient consideration given to the accommodation of all the people, equipment and furniture required.	➔Ensure that the workplace can accommodate all people at peak staffing levels. ➔Ascertain that there is sufficient room for OJT, watching handovers, etc. ➔Apply relevant standards to the design.	(😐 + …) ➔ Carry out real-time simulations and use other data collection methods to help determine accommodation requirements. ➔Develop manpower plans to ensure that workplace can accommodate predicted future staffing levels. ➔Ensure sufficient potential for additional people, equipment and furniture.
Typical HIFA Methods and Tools	Workspace and Workplace Design	Observational Techniques Questionnaires Checklists Real-Time Simulations Manpower Planning Training & Manpower

Table A2: Organisation and Staffing Ladders

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1. Identify staff requirements for pre-operational and implementation phases.		
➔No explicit consideration of manpower requirement during pre-operational and/or implementation phases.	➔Develop and maintain a plan and communicate to key stakeholders. ➔Assess tactical manpower requirements, accounting for a limited range of staffing scenarios. ➔Assess the air traffic demand to determine the Operational Requirements (ORs) and therefore the minimum number of staff to run a stable roster for a given OR. ➔Ensure that appropriate staff are consulted. ➔Analyse existing manpower issues and shortfalls and compare to new system.	(😐 + …) ➔Analyse different scenarios and contingencies analysed (including emergency scenarios) to determine possible manpower impacts. ➔Utilise experts to identify strategic manpower requirements ➔Develop and implement a long-term manpower planning. ➔Ensure that EATM best-practice guidance is followed. ➔Carry out real-time simulation and performance assessment to assess staffing during peak workload. ➔Carry out manpower planning to consider requirements of operational, maintenance, training and support personnel and to account for training patterns/requirements. ➔Take career progression and projected staff turnover into account in manpower planning.
Typical HIFA Methods and Tools	ATCO Requirements Checklist	Training & Manpower Manpower Planning Equivalent Long-term Planning Tool <Performance Assessment> Real-time Simulation Operational Analysis

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2. Ensure that potential effects on manpower availability are considered.		
➔ No explicit consideration of manpower availability during pre-operational and/or implementation phases.	➔Develop and maintain a plan and communicate to key stakeholders. ➔Assess tactical manpower requirements, accounting for a limited range of staffing scenarios. ➔Assess the air traffic demand to determine the Operational Requirements (ORs) and therefore the minimum number of staff to run a stable roster for a given OR. ➔Estimate the number of personnel available by analysing inflow, through-flow, and out-flow.	(😐 + …) ➔Use scenario and contingency analysis (including emergency scenarios) to determine possible manpower impacts. ➔Utilise experts to identify strategic manpower requirements. ➔Develop and implement a long-term manpower planning. ➔Ensure that EATM best-practice guidance is followed.
Typical HIFA Methods and Tools	ATCO Requirements Checklist	Training & Manpower Equivalent Long-term Planning Tool
3. Ensure that potential impacts on the ATCO profile/selection criteria are considered.		
➔Potential impacts on the ATCO profile not considered.	➔Conduct an assessment of new skills, knowledge, attitudes and abilities. ➔Ensure that EATM selection guidelines are followed.	(😐 + …) ➔Assess potential impacts on cognitive ability and personality characteristics. ➔Review existing selection criteria for applicability. ➔Monitor performance with respect to the new profile, using both active and reactive measures. ➔Ensure that the issues regarding the new profile are communicated to relevant parties. ➔Monitor and verify skill requirements in implementation and operational phases of development.
Typical HIFA Methods and Tools	EATM Technical Documentation Real-time Simulation Selection	FEAST Questionnaires Task Analysis Objective Performance Measurement Performance Assessment Selection

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4. Ensure that the attractiveness of the job is maintained.		
➔Potential impacts on the job attractiveness not considered.	➔Consult a representative sample of staff about the acceptability of changes to their jobs.	(😐 + …) ➔Develop a policy or value statement identifying the attributes or qualities that should not be negatively Impacted by changes. ➔Conduct simulation to assess the potential effects on job attractiveness.
Typical HIFA Methods and Tools	Interviews	Questionnaires Real-time Simulation
5. Identify whether there potential new issues associated with staff ageing.		
➔Potential issues associated with ageing not addressed.	➔Ensure that EATM selection guidelines are followed. ➔Consult a representative sample of users to identify the potential issues associated with ageing. ➔Review previous incidents that may be associated with ageing. ➔Develop organisation and staffing arrangements to account for the potential effects of ageing.	(😐 + …) ➔Apply questionnaires and interviews to collect subjective data on potential impacts of age. ➔Carry out a literature review of current developments in this area.
Typical HIFA Methods and Tools	Selection Critical Incident Analysis Training & Manpower	Questionnaires Interviews Literature Review
6. Ensure that the potential impacts of shift organisation are identified.		
➔Potential new health risks not addressed.	➔Consult staff to determine the acceptability of the proposed shift organisation. ➔Analyse working patterns (including timing, frequency and duration of shifts and breaks) to identify and address potential causes and effects of fatigue. ➔Develop controls and monitoring arrangements for working patterns (max. shift length, max. number of shifts in sequence, min. rest time between shifts, min. rest days per week/month, shift swapping, overtime). ➔Ensure that the suitability of particular staff to the proposed shift organisation has been assessed.	(😐 + …) ➔Involve an occupational health specialist or ergonomist in the shift design. ➔Use questionnaires and interviews to collected subjective data on impacts. ➔Interview controllers about any previous (particularly unreported) health problem. ➔Ensure that flexibility is built into the rostering system to enable rest days after periods of exceptional workload. ➔Ensure that controls on working patterns are regularly reviewed in light of experience. ➔Investigate absence s and carry out health monitoring for

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		indications of health problems due to the shift organisation.
Typical HIFA Methods and Tools	Checklists Design Guidelines Interviews	Questionnaires Functional Allocation Critical Incident Analysis Objective Performance Measurement Subjective Workload Assessment Physiological Workload Assessment Performance Assessment Rating Scales Workload

Table A3: Training and Development Ladders

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1. Ensure that training needs are adequately considered (Initial Training, Unit Training, Continuation Training, Development Training).		
➔No adequate, formal evaluation of skill changes and training needs.	➔Conduct a Training Needs Analysis at the early phases to provide cost effective training methods for task requirements and to provide an audit trail for training decisions. ➔Establish a training and development plan. ➔Conduct a review of the strengths and weaknesses of current or previous similar or related systems. ➔Use the results of the Training Needs Analysis to determine requirements for refresher training (specifically for infrequently used but important skills) and retraining. ➔Plan for teams to be trained together for team tasks. ➔Assess the effects of new procedures and equipment to identify the required changes to training and development plans	(😐 + …) ➔Update the Training Needs Analysis and training plan continuously as assumptions and requirements are revised. ➔Carry out a detailed task analysis, preferably emphasising the cognitive aspects of the task. ➔Apply training tools such as TRAINDEV to support the development of curricula for basic and rating training. ➔Feed the results of skill analysis into the system design, task analysis and Training Needs Analysis.
Typical HIFA Methods and Tools	Training Needs Analysis Training	Task Analysis Cognitive Task Analysis Integrated Task Analysis Training & Manpower
2. Specify performance/competence standards.		
➔Performance standards not set and assured in testing, etc., or not validated sufficiently.	➔Utilise existing performance and competency standards if there are no changes or base them on the Training Needs Analysis. ➔Involve relevant personnel in developing and checking performance and competency standards. ➔Ensure that testing (e.g. examinations) is based on the performance standards.	(😐 + …) ➔Conduct performance assessments to demonstrate that trainees have reached the required performance standards. ➔Develop structured methods for retraining for trainees who do not initially reach required standard.
Typical HIFA Methods and Tools	Training Needs Analysis Training Objective Performance Measurement	Performance Assessment

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3. Design the content of training appropriately (Initial Training, Unit Training, Continuation Training, Development Training).		
➔Training content designed based on expertise of current controllers/operators, supervisors, etc. without use of specific methods and tools.	➔Develop training for the use of all job aids (including procedures and ancillary equipment). ➔Ensure that rationale, risks and performance standards are emphasised during training.	(😐 + …) ➔Carry out a detailed task analysis, preferably emphasising the cognitive aspects of the task Use the task analysis to determine the content of the training. ➔Apply the use of training tools such as TRAINDEV.
Typical HIFA Methods and Tools	Training Needs Analysis Training	Task Analysis Cognitive Task Analysis Integrated Task Analysis Training & Manpower
4. Design the training methods and media appropriately.		
➔No analysis or evaluation to support training methods.	➔Employ a variety of different training methods using appropriate domain experts. ➔Ensure that training methods and media are appropriate to training content and training objectives. ➔Ensure that training methods are totally familiar to the instructors.	(😐 + …) ➔Develop training methods with reference to EATM or other best-practice guidance. ➔Carry out an evaluation of physical instructional and dynamic fidelity of training media. ➔Adjust the training methods used according to the composition of the class. ➔Conduct an analysis of methods appropriate to the composition of class. ➔Ensure that training methods are appropriate to the instructors' training, i.e. no instructor uses methods with which they are not familiar and in which they are not practised.
Typical HIFA Methods and Tools	Training	
5. Ensure that the potential for 'negative transfer of training' is minimised (i.e. interference between old and new methods of operation).		
➔The potential for negative transfer of training not assessed.	➔Identify potential effects of negative transfer effects using the Training Needs Analysis. ➔Involve a representative sample of users in the identification of potential negative transfer effects. ➔Ensure that the potential negative transfer effects are highlighted in training.	(😐 + …) ➔Conduct a comparative task and error analysis to identify potential negative transfer effects and new error forms. ➔Assess performance objectively and subjectively to identify potential negative transfer effects. ➔Ensure that all documentation

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		is cross-referenced in order to ensure that no contradictions exist. ➔Ensure that training and operational documentation are compatible. All training documentation for new procedures is cross-referenced to ensure that no contradiction exists.
Typical HIFA Methods and Tools	Training Needs Analysis	Task Analysis Cognitive Task Analysis Integrated Task Analysis Objective Performance Measurement Performance Assessment Human Error Assessment Human Error
6. Ensure that the role, responsibilities and competency of trainers is maintained.		
➔The role, responsibilities and competency of trainers not considered adequately.	➔Deliver trainers and mentors formal training in the use of training methods and assessment.	(😐 + …) ➔Develop performance standards for trainers and monitor performance against those standards. ➔Carry out a Training Needs Analysis at the early phases to identify key skills, knowledge and attitudes for trainers, and to identify the training needed to take trainers to the required performance standard. ➔Develop a system to monitor and address performance of both new and existing trainers. ➔Develop a system to ensure knowledge update of trainers and feedback between trainers. ➔Develop procedures for the monitoring of trainers and coaching of new trainers.
Typical HIFA Methods and Tools	Training	Training Needs Analysis
7. Ensure optimisation of the transition from classroom to the organisation of OJT.		
➔There are no arrangements in place to coordinate adequately the transfer classroom and OJT.	➔Ensure coordination between personnel involved in classroom and OJT. ➔Employ appropriate methods to increase the training fidelity prior to OJT. ➔Calculate and allocate appropriate time for the training using past experience.	(😐 + …) ➔Develop arrangements to ensure a smooth transition and formally document in a training plan. ➔ Ensure procedures in place to allow feedback from OJT to the training provider.

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	➔Develop a formalised system for monitoring and assessment of OJT. ➔Develop procedures to allow feedback from On-the-Job-Training Instructors (OJTIs) to the academy highlighting deficiencies/areas for improvement.	
Typical HIFA Methods and Tools	Training Real-time Simulation	Training Needs Analysis
8. Develop provisions for (aircraft-related)emergency/unusual situation training.		
➔Arrangements for emergency, recovery and contingency training are inadequate.	➔Provide emergency training for all safety critical scenarios. ➔Employ the use of simulators and/or Computer-Based Training (CBT) for emergency training.	(😐 + …) ➔Develop training in detection of and recovery from errors derived from a structured human error identification method and system failures. ➔ Involve aircrew in the emergency training. ➔Training in emergencies allows for discussions with aircrew.
Typical HIFA Methods and Tools	Training Real-time Simulation	Human Error Assessment Human Error
9. Ensure that training effectiveness is tested.		
➔Training effectiveness is assumed. ➔Training effectiveness measured but there is no mechanism for ensuring that improvements are properly implemented.	➔Ensure that training effectiveness is evaluated immediately after training. ➔Develop mechanisms to ensure that further feedback can be provided. ➔Develop mechanism to ensure that feedback is formally recorded and fed back to trainers, and potential changes are made as necessary.	(😐 + …) ➔Evaluate training effectiveness on a regular basis, including several months after training. ➔ Develop measures to ensure that responses are collected. ➔Assess actual task performance and relate it back to training objectives.
Typical HIFA Methods and Tools	Training	Objective Performance Measurement Performance Assessment
10. Ensure that potential negative effects on operational task performance are minimised.		
➔No consideration of potential negative effects of training on task performance.	➔Investigate the potential negative effects of training through using the relevant personnel to ensure that there are no adverse effects (e.g. distraction, loss of practice/ familiarity). ➔Use simulators and/or CBT for practice of higher-risk tasks prior to live trials.	(😐 + …) ➔Carry out a structured analysis (e.g. HFIA or human error analysis) to determine potential problems including human errors to ensure that training and examination does not adversely affect task performance. ➔Employ other data collection

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		methods to investigate potential negative effects
Typical HIFA Methods and Tools	Real-time Simulation	Questionnaires Structured Interviews Critical Incident Analysis Rating Scales Human Error

Table A4: Procedures, Roles and Responsibilities Ladders

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1. Ensure that allocation of function between personnel, and between personnel and technology is optimised. This includes: *a) Responsibility for command and control.* *b) Ability to monitor (human > technology; technology > human).* *c) Responsibility for checking and intervention.*		
➔Allocation of function not adequately taken human capabilities and limitations into account using acceptable methods.	➔Apply appropriate functional analysis methods in the design process. ➔Apply appropriate checklists/design guidelines in the design process ➔Test the effectiveness of functional allocation using HF methods in prototyping and simulation with representative users in a realistic environment. ➔Assess workload to ensure that the human operator is not under or overloaded. ➔Assess performance using objective data. ➔Employ the use of subjective data collection methods/tools employed to elicit user opinions.	(😐 + …) ➔Perform task and error analysis. ➔Adopt socio-technical systems design philosophy.
Typical HIFA Methods and Tools	Functional Analysis Checklists Design Guidelines Real-time Simulation Questionnaires Structured Interviews [Performance Assessment] Workload	Task Analysis Human Error HERA PREDICT
2. Ensure that the human remains appropriately involved in the task in order to be able to maintain adequate levels of situation awareness.		
➔Human involvement not adequately considered or tested, despite involvement of representative users throughout system development.	➔Carry out tests of the level of human involvement using HF methods in prototyping and simulation with representative users in a realistic environment. ➔Apply appropriate checklists/design guidelines. ➔Assess workload to ensure that the human operator is not under or overloaded. ➔Assess performance using objective data. ➔Employ the use of subjective data collection methods/tools	(😐 + …) ➔Perform task analysis to model all human involvements in the task. ➔Apply appropriate tools (e.g. situation awareness) during early development phases to ensure adequate human involvement.

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	employed to elicit user opinions. ➔Test whether the human is able to monitor critical automated functions. ➔Assess the value of attention-getting devices and if used check their effectiveness.	
Typical HIFA Methods and Tools	Checklists Design Guidelines Real-time Simulation Questionnaires Structured Interviews Objective Performance Measurement Objective Workload Assessment Subjective Workload Assessment Physiological Workload Assessment Workload	Task Analysis Performance Assessment Tools Human Error Assessment Human Error System Design and Analysis Situation Awareness Assessment
3. Ensure that workload issues are assessed.		
➔Potential impacts on workload not assessed or measured.	➔Employ the use of simple assessment methods. ➔Carry out simulations and prototyping activities to develop objective workload and performance assessments methods ➔Employ the use of subjective data to supplement the above	(😐 + …) ➔Reemploy the use of data collection methods throughout the life cycle. ➔Perform task analysis during design to support workload assessments. ➔Perform subjective and physiological workload assessments.
Typical HIFA Methods and Tools	Observational Methods Questionnaires Objective Performance Assessment Objective Workload Assessment Real-time Simulation	Activity Analysis Task Analysis Subjective Workload Assessment Physiological Workload Assessment Rating Scales
4. Ensure that potential trust and confidence issues are addressed.		
➔Potential impacts on trust and confidence not assessed or measured sufficiently.	➔Employ the use of simple assessment methods. ➔Apply checklists and design guidelines. ➔Involve an appropriate sample of personnel in design, development and testing.	(😐 + …) ➔Reemploy the use of data collection methods throughout the life cycle. ➔Perform an examination of cognitive aspects of work. ➔Perform a usability evaluation to measure trust and confidence.
Typical HIFA Methods and Tools	Observational Methods Questionnaires Checklists Real-time Simulation Design Guidelines	Interviews Critical Incident Analysis Verbal Protocols Cognitive Walkthrough Usability Performance Assessment

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5. Ensure that the skill degradation potential is minimised.		
➔Skill degradation not adequately taken into account	➔Involve a sample of users to determine potential skill degradation issues. ➔Employ system design methods to ensure that the human is in-the-loop, performing meaningful tasks.	(😐 + …) ➔Employ the use of subjective data collection mechanism during simulations to supplement objective data collection. ➔Develop mechanisms to assess performance to ensure that no degradation takes place. ➔Perform task analysis to investigate and compare the cognitive aspects of the job. ➔Carry out Training Needs Analysis to identify the potential for loss of basic skills.
Typical HIFA Methods and Tools	Structured Interviews Checklists Design Guidelines	Questionnaires Psychometric Scaling Task Analysis Cognitive Task Analysis Integrated Task Analysis Real-time Simulation Training Needs Analysis Performance Assessment
6. Ensure that procedures and documentation are presented in an appropriate format and positioned in the appropriate place.		
➔Procedure format does not fully consider the users and context of use.	➔Develop style guides to ensure that procedures are designed according to the context of use (e.g. briefing, during operations, training) with some HF guidance. ➔Involve a representative sample of users in the development and evaluation of procedure formats. ➔Develop a mechanism which allows for consideration of the users' level of expertise to develop procedures. ➔Identify where procedures and documentation should be located to facilitate their best use according to user requirements.	(😐 + …) ➔Employ HF data collection methods to elicit opinions from users. ➔Apply HF checklists and guidelines to incorporate best-practice during design. ➔Develop methods for sharing best-practice information within the organisation. ➔Develop a mechanism that incorporates a high level of user involvement in development of procedures with guidance from HF and systems designers.
Typical HIFA Methods and Tools	Procedure Audit/Survey	Questionnaires Structured Interviews Checklists

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7. Ensure that the internal structure (including sectioning) of procedures and documentation is adequately considered.		
➔Internal structure of procedures and documentation evolved with user input but not developed with the application of HF methods.	➔Involve a representative sample of users to partly determine and evaluate procedure structure. ➔Assess the need for appropriate devices to be included to attract attention, encourage checks and assist place-keeping. ➔Develop a mechanism which allows for consideration of the users' level of expertise to develop procedures.	(😐 + …) ➔Perform task/system analysis studies to help determine procedure structure. ➔Employ the use of HF data collection methods used to elicit opinions from users. ➔Develop a mechanism to ensure that the internal structure of procedures and documentation is properly evaluated. ➔ Apply HF checklists and guidelines to incorporate best practice during design. ➔Develop methods for sharing best-practice information within the organisation.
Typical HIFA Methods and Tools	Questionnaires □ 🛠 Observational Techniques □ Charting and Network Methods □ Procedure Audit/Survey O	Verbal Protocols □ Cognitive Walkthrough □ Task Analysis □ 🛠 Cognitive Task Analysis □ Integrated Task Analysis □
8. Ensure that the content of procedures or documentation is clear and comprehensible.		
➔Content of procedures and documentation evolved with user input but not developed with the application of HF methods.	➔Involve a representative sample of users in the design and evaluation of procedure content ➔Develop tests to assess comprehension of the procedures. ➔Employ checklists to assess that the procedure contains appropriate warnings, cautions, diagrams and all other pertinent information included (e.g. why procedure is required, who is involved in the task, where and when task is performed, what is to be achieved and how task should be performed).	(😐 + …) ➔Perform task/system analysis techniques studies to help determine procedure content. ➔Develop mechanisms to ensure that content of procedures and documentation are properly evaluated by users ➔Provide training to procedure writers. ➔Employ the use of HF data collection methods used to elicit opinions from users. ➔Develop methods for sharing best-practice information within the organisation.
Typical HIFA Methods and Tools	Questionnaires □ 🛠 Observational Techniques □ Procedure Audit/Survey O	Cognitive Walkthrough □ Verbal Protocols □ Task Analysis □ 🛠 Cognitive Task Analysis □ Integrated Task Analysis □

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9. Ensure that procedures are realistic and reflect the way tasks are actually carried out.		
➔Procedures are normative and do not necessarily reflect the way that tasks are actually carried out.	➔Perform a structured analysis of the task to help form the basis for the procedure. ➔Involve a representative sample of users to assess the realism of the procedure.	(😐 + …) ➔Perform task analysis to ensure that procedures have taken into account the cognitive components of the task. ➔Test and evaluate procedures tested in the middle phases to assess realism. ➔Perform tests of procedural compliance and identify the potential for procedural violations in later phases.
Typical HIFA Methods and Tools	Task Analysis	Cognitive Task Analysis Integrated Task Analysis Real-time Simulation Questionnaires Observational Techniques (Human Error Assessment) Human Error

Table A5: Teams and Communication Ladders

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1. Ensure that potential adverse effects on team structures (e.g. supervision, team formation), team dynamics and relations (e.g. from dual-controller to single controller) are minimised.		
➔Team structures, team dynamics and relations not properly considered.	➔Involve a representative sample of users involved in addressing potential issues associated with team structures, dynamics and relations. ➔Use HF methods to assess the effects of team functioning on job satisfaction. ➔Utilise the results of functional allocation studies to help determine appropriate team structures. ➔Carry out a workload assessment has to examine distribution across team members.	(😐 + …) ➔Use real-time simulations to assess the effectiveness of team functioning using objective and subjective methods and/or OJT.
Typical HIFA Methods and Tools	Questionnaires Observation Functional Allocation Subjective Workload Assessment Workload Rating Scales SHAPE Measures	Real-time Simulation Objective Performance Measurement Performance Assessment HERA OBSERVE ARSQ
2. Ensure that potential adverse effects on (inter-)team coordination are minimised.		
➔Team coordination not properly considered.	➔Involve a representative sample of users involved in addressing potential issues associated with team communication. ➔Utilise the results of functional allocation studies to help determine appropriate team coordination arrangements. ➔Carry out a workload assessment has to examine distribution across team members.	(😐 + …) ➔Use real-time simulations to assess the effectiveness of team coordination using objective and subjective methods and/or OJT.
Typical HIFA Methods and Tools	Questionnaires Observation Functional Allocation Subjective Workload Assessment Workload Rating Scales SHAPE Measures	Real-time Simulation Objective Performance Measurement Performance Assessment HERA OBSERVE ARSQ

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3. Ensure that potential adverse effects on current position handover processes are minimised.		
➔Position handover processes not properly considered.	➔Involve a representative sample of users involved in addressing potential issues associated with the handover process. ➔Develop a formal handover process using data from the analysis of previous incidents and observations of the current process.	(😐 + …) ➔Perform task analysis to model the handover process and to help determine any new issue. ➔Use real-time simulations or OJT to assess the effectiveness of the handover process. ➔Utilise both objective and subjective data. ➔Develop and test with a representative sample of users a handover checklist ➔Review the solutions to past problems and identify potential problems introduced.
Typical HIFA Methods and Tools	Observational Techniques SHAPE Measures Critical Incident Analysis	Questionnaires Task Analysis Real-time Simulation Objective Performance Measurement Performance Assessment
4. Ensure that potential impacts on communication workload are identified and assessed.		
➔Potential impacts on communication workload not assessed or measured sufficiently.	➔Perform basic data collection activities. ➔Carry out simulation and prototyping assessment of workload. ➔Carry out subjective data collection activities. ➔Investigate the potential effect of language and accent difficulties.	(😐 + …) ➔Reemploy the use of data collection methods throughout the life cycle. ➔Perform task analysis during design to support workload assessments. ➔Perform subjective and physiological workload assessments.
Typical HIFA Methods and Tools	Observational Methods Questionnaires Objective Performance Assessment Objective Workload Assessment Real-time Simulation SHAPE Measures	Activity Analysis Task Analysis Subjective Workload Assessment Physiological Workload Assessment Rating Scales
5. Ensure that issues concerning phraseology are considered and evaluated.		
➔Phraseology not considered using any particular method. ➔Perhaps some user input.	➔Apply and adhere to current relevant standards. ➔Involve a representative sample of users (including different native speakers if appropriate) to develop and evaluate phraseology.	(😐 + …) ➔Perform detailed ergonomic studies to identify phraseology requirements. ➔Analyse phraseology for efficiency and error potential.

☹	😐	☺
Typical HIFA Methods and Tools	Questionnaires Structured Interviews	Real-time Simulation Cognitive Reliability and Error Analysis Human Error SHAPE Framework
6. Ensure that national differences and language issues (including dialects and accents) are taken into account.		
➔National differences and language (inc. dialects and accent) problems not considered.	➔Involve a representative sample of users involved throughout the development process.	(😐 + …) ➔Carry out a survey of different nationalities to determine any pertinent difference in language.
Typical HIFA Methods and Tools		Real-time Simulation Questionnaires
7. Ensure that potential negative effects of changes in communication methods are minimised (e.g. from spoken to manual input).		
➔Potential effects of changes in communication methods not considered.	➔Carry out simulations to detect potential problems. ➔Conduct detailed task analysis to assess the effects of changes in communication methods. ➔Carry out performance testing.	(😐 + …) ➔Task analysis performed to ensure that cognitive aspects of the change in communication media are evaluated. ➔Identify human errors using analytical tools. ➔Investigate potential issues around situation awareness during design
Typical HIFA Methods and Tools	Observation Questionnaires Checklists Design Guidelines Task Analysis Real-time Simulation Objective Performance Assessment	Cognitive Walkthrough Event Trees Fault Trees Cognitive Reliability and Error Analysis Performance Assessment SHAPE Framework
8. Ensure that potential interference effects or conflicts between competing sources of information are minimised.		
➔Potential conflicts between competing sources of information not identified using structured methods.	➔Apply data collection methods in development and testing to identify potential problems.	(😐 + …) ➔Perform task analysis (e.g. link analysis) during early phases to determine potential communication conflicts. ➔Conduct a formal analysis and evaluation of the communication process (charts, modelling) etc ➔Carry out some objective measurement of performance. ➔Identify potential interference effects in ongoing HF reporting system.

☹	😐	☺
Typical HIFA Methods and Tools	Observation Questionnaires Checklists Design Guidelines Real-time Simulation	Charting and Network Methods Task Analysis Link Analysis Objective Performance Assessment
9. Assess the content of the communication.		
➔ Information content assumed to be unaffected but not analysed. ➔ No effects known.	➔Employ both objective and subjective data collection methods used in development to identify any problem. ➔Involve a representative sample of potential users involved in the development process.	(😐 + …) ➔Perform task analysis (e.g. Hierarchical and/or Functional Task Analysis) to determine required or any change in information content.
Typical HIFA Methods and Tools	Observation Questionnaires Charting and Network Methods Real-time Simulation	Task Analysis SHAPE Framework

Table A6: Recovery from Failures Ladders

☹	😐	☺
1. Ensure that the human error potential is assessed for both normal and abnormal scenarios.		
➔The human error potential has not been assessed OR ➔Some basic assessment to fulfil the requirements of the Safety Case.	➔Carry out Hazard and Operability Studies (HAZOPs), Functional Hazard Assessments (FHAs) or equivalent. ➔Carry out studies to assess the potential human errors for normal and abnormal scenarios/operations. ➔Develop event trees (or similar) to identify the consequences of human error on system performance. ➔Use simulation and prototyping to gain some basic objective performance measurement on reliability of human performance and frequency of error occurrence.	(😐 + …) ➔Perform predictive human error identification studies based on task analyses. ➔Perform human error dependency analysis (e.g. through fault tree or other appropriate methods). ➔Carry out in-depth interviews throughout the early, middle and late phases to gain a deeper understanding into error potential. ➔Carry out objective performance measurement / observational techniques in late phases.
Typical HIFA Methods and Tools	Real-time Simulation Observational Techniques Objective Performance Measurement <Human Error Assessment> HERA OBSERVE	Structured Interviews Task Analysis Critical Incident Analysis <Human Error Assessment> Human Error HERA PREDICT SHAPE Framework
2. Ensure that error prevention, detection and recovery mechanisms are developed.		
➔Error prevention, detection and correction not formally considered.	➔ Formally consider error prevention, detection and correction in the design process. ➔Apply checklists and design guidelines to derive requirements. ➔Carry out prototyping and simulation to provide some objective and subjective data to highlight problems in error prevention, detection and correction. ➔Carry out performance assessment studies to show that errors can be detected with sufficient time for correction.	(😐 + …) ➔Perform task and error analysis in the early and middle phases to determine error detection and correction requirements. ➔Carry out usability studies. ➔Use scenario analysis to check error prevention, detection and recovery during emergency procedures.
Typical HIFA Methods and Tools	Checklists Design Guidelines Real-time Simulation Observational Techniques Objective Performance Measurement Questionnaires	Task Analysis Usability <Human Error Assessment> Human Error HERA PREDICT SHAPE Framework

☹	😐	☺
3. Ensure that potential detection of and recovery from system failures is optimised.		
➔Recovery from system failures has not been formally considered.	➔Identify whether system failures are immediately evident in all operating conditions and in all modes of operation. ➔Develop backup procedures developed in case of system failures. ➔Apply checklists and design guidelines to derive requirements for recovery from system failure. ➔Assess whether users are free to concentrate on recovery tasks uninterrupted, or assistance is available immediately to focus on recovery tasks. ➔Apply structured methods (e.g. SHAPE) used to identify system failures and potential outcomes. Steps taken to incorporate the results of the analysis into recovery procedures.	(😐 + …) ➔Perform task and error analysis in the early and middle phases to determine error detection and correction requirements. ➔Perform usability studies. ➔Use scenario analysis to assess error prevention, detection and recovery for several workload scenarios. ➔Carry out prototyping and simulation to provide some objective and subjective evidence that system failures can be recovered in time. ➔Carry out performance assessment studies to show that system failures can be detected with sufficient time for response and recovery. ➔Develop a mechanism for monitoring and analysing Incidents to ensure effective recovery in the future. ➔Develop a mechanism to ensure that changes to equipment, procedures and staff initiate a review of recovery arrangements.
Typical HIFA Methods and Tools	Checklists Design Guidelines SHAPE Framework	Observational Techniques Questionnaires Task Analysis Critical Incident Analysis Real-time Simulation Objective Performance Measurement <Human Error Assessment> Safety Analysis

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APPENDIX B – HUMAN FACTORS INTEGRATION RECORDING FORMS

Table B1: Human-Machine Interaction Human Factors Integration (HFI) Recording Form

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Select appropriate input devices (e.g. keyboard, mouse, roller-ball, touch-screen). *Key factors: data type, speed, accuracy, frequency of use, duration of use, response time, feedback, consistency, display-control relationship, logical and functional arrangement, 'population stereotypes', labelling, location, handedness, comfort, clearance, redundancy/choice.*						
2. Ensure that visual displays are of sufficient quality. *Key factors: frequency of use, duration of use, legibility, visibility, labelling, luminance, screen size, coding (e.g. colours, symbols, letters, numbers), complexity, consistency, location, fitness for purpose.*						
3. Take information requirements into account. *Key factors: accessibility, identification, relevance, importance, quantity, handover information requirements.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
4. Develop the alarm handling (including alerts) according to human factors principles. *Key factors: number and frequency of alarms, auditory alarms, visual alarms, detection and identification, prioritisation, quality of alarm lists and mimics/schematics, user input, overview, coding, response required; acknowledgement, false alarms, navigation and investigation.*						
5. Take the ergonomics of the console or immediate working area into consideration. *Key factors: working posture, working envelope, comfort, space requirements, communication, positioning, flexibility, adjustability, dimensions, maintenance, cleaning, clearance, seating design, footrests.*						
6. Ensure that the usability of the general HMI is acceptable. *Key factors: learnability, feedback, affordances, intuitiveness, compatibility with working practices, error rates, error recovery, navigation, system response times, interoperability.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
7. Ensure that user requirements are identified. *Key factors: goals, task demands, current working practices, information requirements, expectations, feedback, comfort.*						
8. Ensure that potential new health risks are removed or minimised. *Key factors: stress, upper limb disorders, back pain, vision problems, hearing problems, neck pain, fatigue, electrical hazards, radiation hazards.*						
9. Ensure that the potential effects of Human-Machine Interaction on fatigue are assessed. *Key factors: boring tasks, poor lighting, temperature, humidity, long shifts, shift pattern, on call requirements, overtime, sleep, rest breaks (timing, frequency and duration), errors, performance.*						
10. Identify potential distractions and other potential impact on concentration. *Key factors: boring tasks, poor lighting, temperature, humidity, long shifts, shift pattern, distractions, noise levels, alerts and alarms, automation, monitoring, mentoring.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
11. Ensure that background noise levels are acceptable. *Key factors: sound level, pitch, exposure, audibility of communications, distraction, maintenance/construction noise, operating and emergency alarms, health impact.*						
12. Ensure that lighting levels are acceptable. *Key factors: screen glare, readability, eyestrain, artificial lighting design, natural lighting, luminance.*						
13. Ensure that temperature, humidity and air quality levels are acceptable. *Key factors: heat, cold, humidity, smoke, dust, fumes, vapours, air conditioning, personal preferences, health problems and effects, equipment requirements, breaks, concentration impacts.*						
14. Design the workplace ergonomically *Key factors: information/ communication requirements, space requirements, positioning, flexibility, maintenance, cleaning, clearance.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
15. Ensure that the workplace can accommodate all of the people, equipment and furniture required. *Key factors: access, storage, space, emergency egress, staffing levels, expansion.*						

Table B2: Organisation and Staffing Human Factors Integration (HFI) recording form

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Identify staff requirements and potential effects on ATCOs, for pre-operational and implementation phases. *Key factors: number of ATCOs and other staff required, ATCOs per position, type of ATCOs, traffic demand, competencies, emergency management, additional tasks, shift design, breaks, operating and maintenance personnel, workload, traffic handling capability, personnel surplus or shortage, recruitment, inflow, outflow, training.*						
2. Ensure that potential effects on manpower availability are considered. *Key factors: Length of training in short term, licence ratings, impact on length of training time for ab initios (initial and unit), effect of staff turnover.*						
3. Ensure that potential impacts on the ATCO profile/selection criteria are considered. *Key factors: role changes, skills, knowledge, attitudes, abilities, age, cognitive requirements, computer literacy, language capabilities, personality profiles.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
4. Ensure that the attractiveness of the job is maintained. *Key factors: education requirements, job content, job role, job satisfaction, professional status, career progression.*						
5. Identify whether there are potential new issues associated with staff ageing. *Key factors: manual dexterity, reaction times, memory, decision-making, vision, flexibility, multitasking, attention, fatigue.*						
6. Ensure that potential impacts of shift organisation are identified. *Key factors: shift patterns, length of shifts, position of breaks, rest periods, cover for holidays and sickness, potential for shift swapping.*						

Table B3: Training and Development Human Factors Integration (HFI) recording form

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Ensure that all training needs have been adequately considered (Initial Training, Unit Training, Continuation Training, Development Training). *Key factors: skills, knowledge, attitudes, skill transfer, competence standards, training content, training methods/media, training frequency, flexibility, specialisation, refresher training, emergency and incident training.*						
2. Specify performance/ competency standards. *Key factors: skill levels, knowledge, attitudes. minimum competency, performance standards.*						
3. Design the content of training appropriately (Initial Training, Unit Training, Continuation Training, Development Training). *Key factors: quantity of information, rationale, warnings and cautions, task steps, key checks, job aids, equipment, performance standards.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
4. Design the training methods and media appropriately. *Key factors: simulator, OJT, Personal Computer (PC), classroom, group interactive sessions vs. individual learning, exploratory vs. taught, individual needs vs. generic training, examination vs. performance, feedback.*						
5. Ensure that potential 'negative transfer of training' is minimised (i.e. interference between old and new methods of operation). *Key factors: previous training, task similarities, key differences.*						
6. Ensure that the role, responsibilities and competency of trainers is maintained. *Key factors: training requirements, competence, responsibilities, skills, knowledge, attitudes.*						
7. Ensure optimisation of the transition from classroom to the organisation of OJT. *Key factors: training format, transition period, training schedules, work-training conflict.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
8. Develop provisions for (aircraft-related) emergency/unusual situations training. *Key factors: emergency plans and scenarios, unfamiliar situations, event-based procedures, frequency of emergency training, staffing.*						
9. Ensure that training effectiveness is tested. *Key factors: performance standards, assessment criteria, testing, feedback and feed forward links, attainment and retention.*						
10. Ensure that potential negative effects on operational task performance are minimised. *Key factors: work-training conflict, workload, distraction, errors, situation awareness, stress.*						

Table B4: Procedures, Roles and Responsibilities Human Factors Integration (HFI) recording form

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Ensure that allocation of function between personnel, and between personnel and technology is optimised This includes: a) responsibility for command and control; b) ability to monitor (human > technology, technology > human); c) responsibility for checking and intervention. *Key factors: command and control, monitoring, workload, human reliability, intervention, system feedback.*						
2. Ensure that the human remains appropriately involved in the task in order to be able to maintain adequate levels of situational awareness. *Key factors: workload, interaction, display quality, task meaningfulness, projection, distractions, communication.*						
3. Ensure that workload issues are assessed. *Key factors: mental demands, physical demands, temporal demands, performance level, effort, frustration, individual differences, normal and abnormal conditions.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
4. Ensure that potential trust and confidence impacts are addressed. *Key factors: trust, confidence, system usability, system reliability, control, competence, team relations.*						
5. Ensure that the skill degradation potential is minimised. *Key factors: task design, skill practice, increased monitoring, level of experience.*						
6. Ensure that procedures and documentation are presented in an appropriate format and positioned in the appropriate place. *Key factors: context of use, checklists, briefing notes, formal procedures, binding, durability, location, user requirements.*						
7 Ensure that the internal structure (including sectioning) of procedures and documentation is adequately considered. *Key factors: context of use, uniformity, readability, learnability and training, warnings and cautions.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
8. Ensure that the content of procedures or documentation is clear and comprehensible. *Key factors: font size, spacing, language, sequence of instructions, jargon, tables, charts, highlighting, headings, index, numbering.*						
9. Ensure that procedures are realistic and reflect the way tasks are / should be carried out. *Key factors: user input and feedback, practicality, level of use.*						

Table B5: Teams and Communication Human Factors Integration (HFI) recording form

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
1. Ensure that potential adverse effects on team structures (e.g. supervision, team formation), team dynamics and relations (e.g. from dual-controller to single controller) are minimised. *Key factors: allocation of function, role, team interaction, team structures, task sharing, team training, Team Resource Management (TRM), supervision, team communication, social support, morale, power-distance relationships, individualism/ collectivism.*						
2. Ensure that potential adverse effects on (inter)team coordination are minimised. *Key factors: workload distribution, allocation of function, role, team interaction, team structures, task sharing, team training, TRM, supervision, team communication, social support, morale, power-distance relationships, individualism/collectivism.*						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
3. Ensure that potential adverse effects on current position handover processes are minimised. *Key factors: information requirements, display quality, situation awareness, communication methods, checklists.*						
4. Ensure that potential impacts on communication workload are identified and assessed. *Key factors: frequency, duration, speed, information type, communication media.*						
5. Ensure that issues concerning phraseology are considered and evaluated. *Key factors: inter-centre, intra-centre, potentially confusing words (e.g. call-signs), standard protocol, regulations, expectations.*						
6. Ensure that national differences and language issues (including dialects and accents) are taken into account. *Key factors: accent, dialect, tone, speed, fluency, grammar, protocols, uncertainty avoidance, power-distance relationships, individualism/collectivism*.						

Questions	Criteria				Planned Activities	Key Conclusions and Evidence
	☹	😐	☺	✕		
7. Ensure that potential negative effects of changes in communication methods are minimised (e.g. from spoken to manual input). *Key factors: speed of communication, multitasking, read-back, feedback, confirmation, mode confusion errors, input errors, non-verbal communication, manual workload, visual demand, expectation, emergency situations, redundancy.*						
8. Ensure that potential interference effects or conflicts between competing sources of information are minimised. *Key factors: mode confusion errors, visual vs. auditory, misidentification, cross-communication.*						
9. Assess the content of the communication. *Key factors: time availability, length of message, memory demands, message structure, information coding, communication protocol, abbreviations, information requirements, flexibility.*						

Table B6: Recovery from Failures Human Factors Integration (HFI) recording form

Questions	**Criteria**				**Planned Activities**	**Key Conclusions and Evidence**
	☹	😐	☺	✕		
1. Ensure that the human error potential is assessed for both normal and abnormal scenarios. *Key factors: human error probability, error modes, error mechanisms, performance shaping factors.*						
2. Ensure that error prevention, detection and recovery mechanisms are developed. *Key factors: error prevention, error detection, error correction, system feedback, undo functions, forcing functions, training.*						
3. Ensure that potential detection of and recovery from system failures is optimised. *Key factors: clarity of failures, backup systems, control and monitoring, procedures, training.*						

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