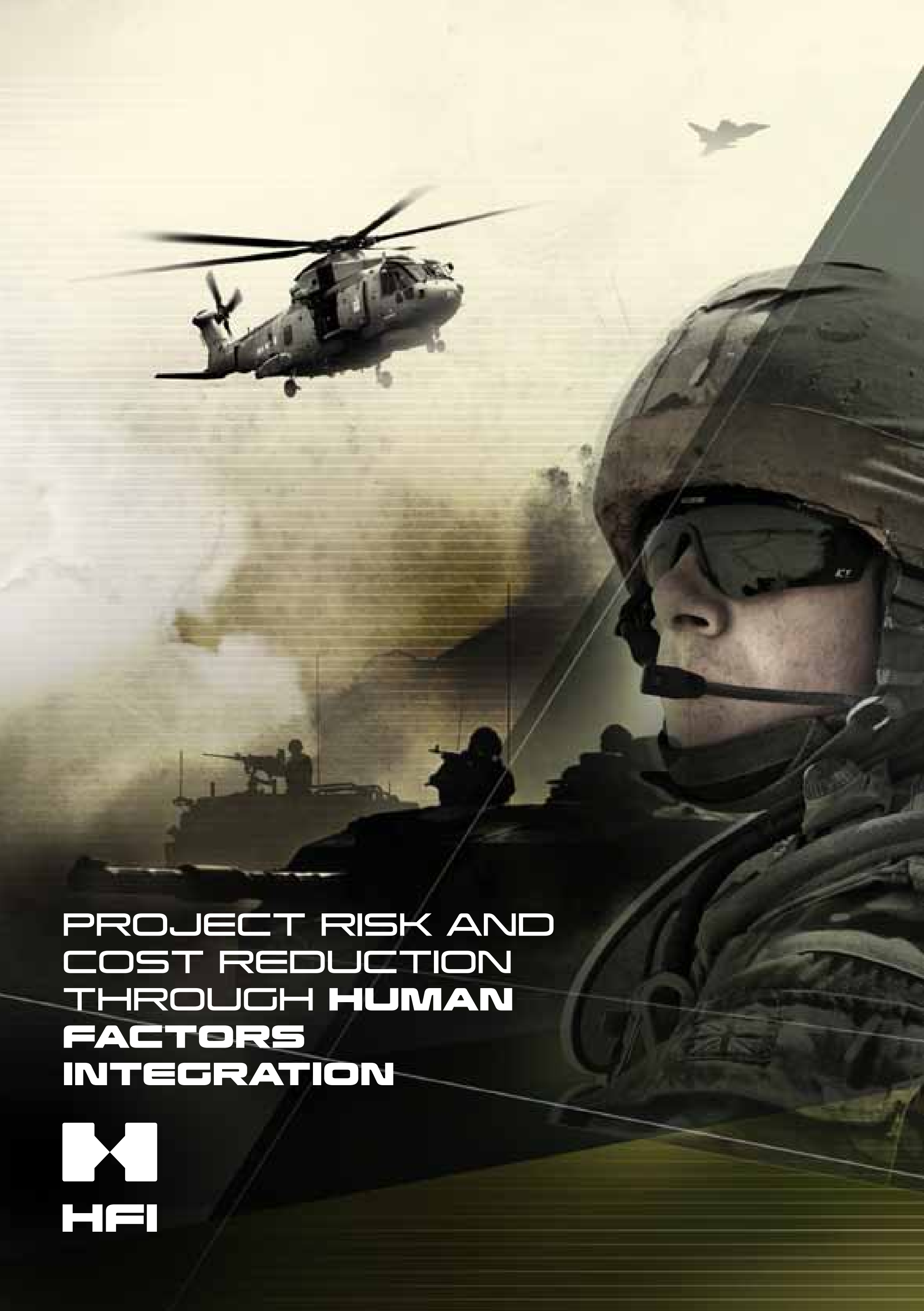
PROJECT RISK AND COST REDUCTION THROUGH **HUMAN FACTORS INTEGRATION**

VERSION 1
NOVEMBER 2014
DEFENCE HUMAN CAPABILITY
SCIENCE & TECHNOLOGY CENTRE

ASSESS | INTEGRATE | PERFORM

HFI



PROJECT RISK AND COST REDUCTION THROUGH **HUMAN FACTORS INTEGRATION**

HFI

CONTENTS

1

INTRODUCTION

1.1

THE NEED FOR THIS BOOKLET

People form a critical component of military capability. All military systems rely on human performance for their effectiveness (in operation, support and maintenance). The process of Human Factors Integration (HFI) has evolved to ensure that issues associated with the human component of capability are properly considered from the earliest stages of acquisition, and that the associated risks to performance, cost and time are managed effectively.

Despite the proven importance of HFI, it is sometimes neglected – either because it is perceived as an extra cost or out of a mistaken belief that people-related risks do not exist. Implementing HFI does have a cost, as does any risk management activity. However, if risks are understood early, then mitigation actions can be planned and solutions found before the problems emerge. This approach will cost much less than simply trying to find solutions after problems appear – especially as they often do not fully appear until the system is in service when the anticipated military capability is not realised.

Quantifying the benefits of HFI is complicated by lack of access to suitable evidence and by the fact that benefits are often long term, or in some cases intangible. At the start of a project, when it is most important to understand the risks, it is often impossible to quantify the benefits, so decisions to invest effort in HFI must be made on the basis of generic arguments. Risks can only be quantified when they have been identified and investigated.

What is Human Factors Integration?

***"HFI is a systematic process for identifying, tracking and resolving human-related issues ensuring a balanced development of both technological and human aspects of Capability"* (Def Stan 00-250, 2008).**

The equivalent term, Human Systems Integration (HSI), is sometimes used outside of the Ministry of Defence (MOD). It captures the systemic nature of the process which must be closely coupled to Systems Engineering and Project Management. In other words, it cannot be conducted in isolation.

HFI must not be confused with much narrower concerns having similar acronyms, like HMI or HCI (Human Machine Interface or Human Computer Interface), which is only a part of the whole. HFI also embraces the abilities, competencies and quantity of people needed by the capability (i.e. aspects to do with personnel, training and manpower), the organisational and social structures that enable them to function effectively, and any adverse impacts that are due to humans being part of the system (such as health hazards and system safety).

HFI should be considered, at an appropriate level, throughout the system lifecycle from the earliest stage.

1.2

THE AIMS OF THIS BOOKLET

This booklet is aimed at anyone who may be responsible for making (or influencing) decisions or allocating resources in Capability acquisition projects.

It restates the arguments for why HFI is essential in defence acquisition, and it supports the arguments with a set of case studies that illustrate the link between successful outcomes and the people-related work that led to them.

The case studies in the booklet all show positive outcomes, but many others could have been found where failure to resource and prioritise HFI has led to lower quality solutions, loss of performance and/or additional costs and delays.

Heed the message of this booklet and ensure that projects you are associated with have positive outcomes.

1.3
CONTENTS AND NAVIGATION

Section 2 introduces and explains the two key arguments for HFI. This is followed by examples of Military case studies that support and illustrate the arguments.

They are grouped by military domain as follows:

Land Domain Case Studies	Project Categorisation (Based on Project Cost)[1] and Urgent Operational Requirement (UOR)
Fire Shadow – User centred development process enabled project to meet rapid timescale for capability acceptance	Cat A
Talisman Trainer – Analysis leading to affordable training solution	Cat D and UOR
Pelvic Protection – Adaptable solution balancing protection against wearability	Cat D and UOR
Glock 17 Pistol – Human factors assessment provides objective evidence for down-selection of Commercial-Off-The-Shelf Pistols	Cat D
Watchkeeper Unmanned Air Vehicle (UAV) Containers – Innovation solved manual handling risks without additional lifting gear	Cat A
Psychometric Screening reduced training costs, potentially saved lives and reduced injuries	

[1]The projects from which the studies were drawn cover Land, Maritime and Air, spanning from Category A (over £400M) to Category D (under £20M), and include UORs (Urgent Operational Requirements) as well as conventional acquisitions.

Maritime Domain Case Studies	Project Categorisation (Based on Project Cost)[2] and Urgent Operational Requirement (UOR)
Astute Submarine – Ensuring usability of optronics console to replace submarine periscope	Cat A
Astute Submarine – HMI design of Platform Management System provides usable, task based information and greater flexibility of control	Cat A
Roll and Pitch Information Display System (RAPIDS) – Critical role of task analysis in design of helicopter landing aid for frigate	Cat D
Queen Elizabeth Class Aircraft Carrier – Influencing system design to minimise ship manning	Cat A
Air Domain Case Studies	
Lynx Wildcat AW159 Helicopter – Ergonomic cockpit and data integration design to prevent high crew workload	Cat A
C130J Hercules Transport Aircraft – Essential role of Human Factors in aircraft acceptance	Cat A
Sea King ASaC Helicopter Mission System – User centred design alleviates the effects of stress on operational performance	Cat B

[2]The appendix provides a summary table that links the arguments made with the thirteen case studies

2

PROJECT RISK AND COST REDUCTION ARGUMENTS FOR HFI

Why do we attempt to integrate the consideration of human factors into the development of military solutions? It is not just about trying to provide benefits for the end user in terms of satisfaction in the use of equipment (although this is a major factor influencing motivation, retention and thus personnel costs). The key reason is to reduce risk: risk of failing to meet the capability requirements or of incurring extra cost or project delay, any of which can flow from failure to integrate the human and non-human components of the proposed solution.

For example, a man-portable equipment may be designed to be within the weight that a soldier can carry, but if he cannot manage it due to the other equipment that he already carries, he may choose to leave it behind, thus wasting the cost of its acquisition, and failing to realise the intended capability.

Such failures often lead to escalating costs for the MOD: such as acquisition costs being higher than forecast in order to correct emergent people-related problems, or incurred by operating organisations who may find it necessary to employ more staff or provide more training.

The process of HFI within the MOD has developed over many years to address these and many other aspects of integrating people into systems. The experience gained supports two arguments. These arguments are further supported by the case studies reported in this booklet.

Argument 1: HFI reduces project risk by correctly integrating people into systems, and hence optimises project costs

- ***HFI reduces the likelihood of failure to meet capability requirements:*** The human component is a key element in the system solution. The HFI process can ensure that the solution makes best use of human abilities and is not undermined by human limitations. It does this through optimising the relationship between human and non-human parts of the solution, the balance of human tasks and jobs within the context of use, and by ensuring that organisational characteristics and constraints are satisfied, (including manpower sustainability and turnover, appropriate hierarchies and team structures), as well as identifying cost effective training solutions.

- ***HFI reduces potential need to re-engineer the solution:*** Appropriate HFI analysis during the early phases of the project, and integration of the results with the design, development, test and trials processes, avoids the need for projects to revise solutions late in development when it is more costly. It also reduces the need for suppliers to build large risk margins into their cost budgets.

- ***HFI helps to reduce health and safety risks, thus minimising accidents and reducing injury claims:*** Solutions have to be safe for and safe from the effects of people. Operators, maintainers, support personnel and anyone else must not be exposed to undue risk of accident or long term health impairment. The system must be designed to avoid human error, and where possible to be tolerant of human error. HFI ensures that appropriate working environments for users are identified, and that survivability is maximised. Safety and survivability cannot be assured in isolation of people-related aspects. The HFI process manages these aspects.

Argument 2: HFI improves solution quality, which leads to further operational and organisational benefits

- ***HFI leads to people-related benefits:*** HFI leads to solutions where people are properly integrated into the system to the benefit of the user experience. For example, intuitive, easy to use technology with appropriate task aids can reduce fatigue and enhance motivation, which improve attention span and alertness, and enhance human performance. Better designed jobs and technology improve personnel retention, thus reducing costs of recruitment and training, or the need to restrict personnel selection to those able to operate difficult equipment.

- ***When appropriately scoped, applied, managed and resourced, the costs of HFI are more than compensated for by downstream quality benefits:*** Undertaking HFI on a project requires investment of time and resources, both by the supplier and the MOD. This appears as a cost. But as with other similar disciplines (e.g. safety), even though initial cost reduction is not an aim, the costs expended are more than recouped by the reduced risk of later unplanned expenditure (see argument 1). In some cases, HFI can be specifically directed to achieving through life cost savings, for example by reducing the manning or skills required, or redesigning the organisation to be more efficient.

These arguments can be supported by evidence from case studies in this booklet which provide tangible illustration of the successful impact of HFI, i.e. projects where problems have been avoided as a result of HFI activities.

3
CASE STUDY EVIDENCE
3.1
LAND DOMAIN
3.1.1
FIRE SHADOW
USER CENTRED DEVELOPMENT PROCESS ENABLED PROJECT TO MEET RAPID TIMESCALE FOR CAPABILITY ACCEPTANCE

Fire Shadow is a "Loitering Munitions" Indirect Fire Precision Attack (IFPA) System developed by industry and the MOD for the Royal Artillery. In order to meet the challenges of rapid development of complex weapons systems, the project team recognised the need for early and continued involvement of the end user and adopted a joint HFI approach (with Customer, Supplier and User representatives) in the management of human-related concerns. As a result the time to capability acceptance was significantly reduced.

Fire Shadow provides a 24 hour precision attack capability against moving and static targets at long range in complex environments. The system is designed to have an operator in the loop to control the mission with an on board sensor providing imagery to the Ground Control Station operator to support targeting and engagement decisions.

The joint HFI approach was achieved through the following means:

- The project developed and adhered to a comprehensive HFI plan, and maintained an audit trail of HFI activities and evidence.
- Regular joint HFI working groups were held and a joint human concerns register was maintained.

Picture source: ©MBDA 2013

- **Reduced risk of failure to meet capability requirements**
- **Reduced potential need for re-engineering**
- **Improved solution quality leading to people-related benefits**

The approach facilitated the effective and timely management of people-related issues and provided a mechanism for progressive assurance. Through feedback from the Royal Artillery 'Implementation Team', human factors activities were included in the iterative experimentation programme:

- A series of synthetic-environment experiments to exercise the mission control system;
- Hardware trials to exercise equipment deployment procedures.

These activities enabled timely and effective management of human factors concerns relating to interface design, personnel, manpower, training and safety.

Other benefits were:

- Early visibility of human related concerns across stakeholders;
- Progressive assurance of system usability and utility;
- Early capture of critical design changes, reducing re-work time and cost;
- A reduced training burden due to user familiarity with the system;
- Shared understanding of system operation across stakeholders;
- End User buy-in and formal acceptance.

Picture source: ©MBDA 2013

Fire Shadow has been formally accepted, but due to subsequent changes in operational tempo, the MOD has been re-evaluating the IFPA User Requirement.

The user centred joint HFI approach, with early and continuous end user involvement is regarded as applicable to any large scale engineering project and the lessons are being applied across other MOD projects.

3.1.2

TALISMAN TRAINER
ANALYSIS LEADING TO AFFORDABLE TRAINING SOLUTION

Analysis demonstrated that a low-fidelity simulator based on commercial equipment could provide a cost effective way to enhance the training of teams operating the Talisman route clearance system.

Talisman is a suite of eight vehicles with a mix of sensors and equipments operated by a troop of thirty Royal Engineers. It is used for Route Proving and Clearance (including mitigating Improvised Explosive Devices (IED) threats). After individual equipment training, the team needs training to operate collectively. Previously, this team training in the Jordanian desert was constrained, with months often elapsing between equipment training and team training or team training and operational deployment. Nor could the training cover all scenarios (e.g. a close environment or heavily compounded areas, or complex insurgent scenarios). Adverse weather sometimes limited activities (e.g. high winds preventing use of Talisman's micro Unmanned Aerial Vehicle (UAV)).

The Talisman Training Advisory Team (TTAT) recognised this limitation on the human component of Talisman capability. TTAT commissioned a Training Needs Analysis (TNA) to explore the feasibility of additional training to supplement live training in Jordan. TNA is a systematic analysis of skills gaps and effective ways of providing training to satisfy them. The analysis drew on earlier work (including human factors work) already completed during system development.

Picture source: ©Thales 2013

- **Costs of early HFI were more than compensated by downstream benefits**

A whole team trainer with real military equipment or linked high-fidelity individual training systems would have been prohibitively expensive and taken too long to deliver, but the TNA demonstrated that the essential procedural skills could be trained using low cost commercial hardware, thus rendering the trainer affordable.

The resultant trainer uses commercial computers and makes extensive use of standard software. It can be dismantled into 'building-blocks', transported and reassembled in one space or in separate spaces. Each vehicle 'bay' includes partitions, tables, chairs and equipment.

The whole team procedural training supplements live desert training. It can be provided when needed and can cover scenarios not available in the desert. Used prior to Jordan it is highly rated by all participants – one user said "this is the first time we have all come together, and I now understand what my role is and how I integrate into the whole". Time in Jordan can thus be used more effectively to develop individual and troop competencies. Post-Jordan, the simulator is used for further development of the command elements, using more complex scenarios, or to cover any deficiencies in Jordan (e.g. from equipment failure).

According to TTAT *"The simulator has significantly improved the training progression of Talisman Squadrons since its introduction in 2011. It provides a safe environment to deliver initial collective training, so that individual soldiers understand their role and position within a Talisman Troop prior to live training in a collective environment. There was a marked increase in the start standard of Talisman troops' skills that had benefited from pre-Jordan simulation.*

Picture source: ©Thales 2013

The simulator provides a valuable means of testing emergent TTPs[3] without removing a live system from the operational training line. The simulator can deliver complex scenarios that cannot be replicated within live training. It is without question a force multiplier to force generation and training."

[3]Tactics, Techniques and Procedures

3.1.3

PELVIC PROTECTION
ADAPTABLE SOLUTION BALANCING PROTECTION AGAINST WEARABILITY

Systematic human factors analysis led to a solution that balanced level of protection against the impact on soldiers' tasks and wellbeing, which has a high uptake, and is very effective in use.

Improvised Explosive Devices (IEDs) are a major operational threat, and the pelvic region of dismounted soldiers is particularly vulnerable to injury from them. Faced with unacceptable levels of injuries, in 2009 the Army raised an Urgent Operational Requirement for pelvic protection. Various devices were on the market, but no Army had previously been systematically equipped with such protection.

The requirement is a demanding one – as well as resisting penetration the system must permit normal movement while engaged in the full range of operational tasks, without chafing, injury, or causing undue thermal or other stress on the body. It must also fit all shapes and sizes of military personnel.

MOD recognised that getting the comfort and utility right was essential to ensuring that the protection would be worn.

So as well as assessing the penetration resistance of candidate devices and technologies, MOD initiated a process of iterative human factors assessment and trials using levels 1 & 2 of HFAF (Human Factors Assessment Framework), a flexible process of which the three levels are:

Picture source: ©MOD Crown Copyright 2010

- **Reduced risk of failure to meet capability requirements**
- **Reduced health and safety risks and injury claims**
- **Improved solution quality leading to people-related benefits**

1: Rapid inspection and evaluation to identify immediate issues or risks that may affect the user, with a few (approximately three) representative users;

2: Trial with more (six to twelve) representative users in a realistic field environment using subjective and objective metrics to evaluate soldier performance;

3: Controlled laboratory trial, using participants or simulations (e.g. thermal manikins), to provide objective data on human physiological or cognitive responses.

This led to a tiered solution, which allows users to appropriately consider their options before selecting what to wear: Tier 1 (for routine use by all troops) meets stringent comfort requirements, with low physiological burden and minimal movement constraint. Tier 2 (for higher risk situations) offers more protection. Tier 3 (for use during IED disposal) offers most protection.

Integrating human factors work from the earliest stage did not significantly delay the process compared with a less systematic selection and procurement process without human factors input. It also ensured a "right first time" solution, which avoided the subsequent re-work and modification often needed to fix problems found in service. Integrating human factors work cost less than 1% of the total acquisition cost.

The tiered approach led to high utilization rates in service. The system is liked by the troops, and has resulted in significant reduction in pelvic injuries from IEDs, which is the principal benefit of the Pelvic Protection programme.

Picture source: ©MOD Crown Copyright 2010

Early feedback from theatre included: *"The initial opinion of the plastic surgeon who operated on the wounds to the soldier's perineal region was that, having performed further surgery at the Royal Centre for Defence Medicine on cases with similar types of injury, the garment appears to have made significant (and to him, surprising) reductions in the patterns of injury and ingress of debris"*.

3.1.4

GLOCK 17 PISTOL
HUMAN FACTORS

A human factors (HF) assessment was applied to eleven Commercial-Off-The-Shelf (COTS) firearms to select a replacement for the current in service pistol for all general service military users. An objective, evidence-based, assessment process was followed, ensuring all risks and considerations for Usability, Integration of the pistol with the body armour, respirator, gloves and holster and Acceptability were identified and considered in order to find the optimal solution and promote user confidence in the weapon.

A human factors assessment was commissioned by DE&S to support the Light Weapons, Photography and Batteries Project Team and supplemented a series of live firing trials which reviewed the safety and engineering aspects of the pistol.

HF concerns of military users were recorded during a test battery of 27 military tasks for evaluation of each pistol and a further six tasks for evaluation of the holster. The tasks involved a range of static and dynamic movements. The test battery was designed using Infantry Training pamphlets, military advisors and the System Requirements Document (SRD) in which specifications are detailed that the system must meet and equipment listed that it must integrate with.

Relevant user tasks selected for this assessment were:

- Normal Safety Precautions;
- Stripping Cleaning and Assembling;
- Loading and Unloading;
- Stance and Holding;
- Simulated Firing in low light conditions;
- Equipment Integration;
- Holster Use – A review of a series of holsters was conducted as a secondary task to the assessment of the pistols.

- **Reduced risk of failure to meet capability requirements**
- **HFI leads to people-related benefits**

For each task, military users were asked to give their expert opinion on whether they believed they would be able to successfully complete the task to their expected standard. They were then asked to judge the acceptability of the pistol during the task. The choice of replies was constrained to 'acceptable', 'acceptable with modifications' and 'not acceptable'. A questionnaire was administered which covered key HF aspects including usability, integration and acceptability of the task.

The completion of the task battery identified risks and issues about:

- Usability – Ease of use and intuitive design, comfort and positive feedback, secure grip and hindrance;
- Integration – With respirator, goggles, glasses, gloves, holster and body armour;
- Acceptability – Satisfaction, appearance and confidence.

This information was analysed to produce recommendations for down-selection. Out of the eleven pistols assessed, the Glock 17 Generation 4 Model was successfully selected based on completion of 100% of all tasks, scoring highest in terms of acceptability and overall score for subjective feedback.

Picture source: ©MOD Crown Copyright 2010

3.1.5

WATCHKEEPER UNMANNED AIR VEHICLE (UAV) CONTAINERS

INNOVATION SOLVED MANUAL HANDLING RISKS WITHOUT ADDITIONAL LIFTING GEAR

The need to assemble sizeable Air Vehicles in locations without heavy lifting equipment raised severe manual handling risks that were successfully managed by considering the human component when designing the containers used to transport them.

Watchkeeper provides Unmanned Air Vehicles (UAVs) that can carry radar, electro-optic and/or infra-red sensor payloads to deliver intelligence, surveillance, target acquisition and reconnaissance (ISTAR) capability.

The air vehicles (disassembled) can be transported in containers to operating bases, which may be improvised (i.e. austere) and may not have access to heavy lift equipment. The air vehicles cannot carry all the sensor payloads simultaneously, therefore the payloads and their containers are kept separate from the air vehicles in transit in order to provide flexibility for deployment of UAV and payload in theatre.

From its inception, the Watchkeeper project systematically considered how the overall system capability would be affected by the human component of the system, and identified the associated risks. Among these were issues related to the assembly of air vehicles at locations without heavy lifting gear, which were resolved by the resultant design of the Payload Container and the Air Vehicle container.

The **Payload Container** protects the sensors in transit and must meet a stringent anti-vibration requirement. A conventional anti-vibration mount (a sprung metal cradle) could not be made light enough to move without heavy lift equipment. A lighter solution was possible by using foam cushioning, and accepting a small trade-off in the anti-vibration requirement. The resultant Payload Container was just manually manoeuvrable, but would still incur an injury risk. Further optimisation based on an analysis of handling tasks led to a two-part container, with a lighter inner container that can be slid from a side entry hatch in the heavier outer container. This achieves maximum protection for the payload in transit, while permitting a lighter load that is safer to handle, but still provides adequate protection when the Flight Line personnel move the sensor on the ground.

- **Reduced risk of failure to meet capability requirement**
- **Reduced potential need for re-engineering**
- **Reduced accidents, health and safety risks and injury claims**
- **Costs of early HFI were more than compensated by downstream benefits**

The **Air Vehicle Container** is a standard ISO container in which two complete (disassembled) air vehicles are protected in storage and during transit. At the operating base, the ground crew must remove and assemble the components, connecting the undercarriage, wings and V-tails to the fuselage, and they must do so without damage, even in severe weather. The components are large for manual handling (fuselage >6m, and wing span >10m) and are made of composite materials that could be damaged by mis-handling. Analysis of the assembly tasks, taking account of human capabilities, led to the requirement for a suite of mechanical handling and assembly aids as part of the system. As a result, the container was designed with pull-out gantries and a winching mechanism on each side to enable the crew to hold the various components while assembling the Air Vehicle.

Both containers work well in service, and allow the ground crews to assemble the air vehicles efficiently and reliably without risk of injuries to themselves or damage to the air vehicles.

Picture source: ©MOD Crown Copyright 2013

3.1.6

PSYCHOMETRIC SCREENING

REDUCED TRAINING COSTS, POTENTIALLY SAVED LIVES AND REDUCED INJURIES

The Ammunition Technical Officer (ATO) role is part of the Explosive Ordnance Disposal (EOD) team. The British Army require ATO candidates to have a suitable personality with a balanced propensity to take risk. Psychometric screening has resulted in reduced training costs and potentially saved lives and reduced injuries.

- **Reduced risk of failure to meet capability requirements**
- **Reduced accidents, health and safety risks and injury claims**
- **Costs of early HFI were more than compensated by downstream benefits**

Psychometric screening was applied to assess EOD candidates applying for the role of ATO in the British Army. Candidates with at least two years military experience attend a one day session at an assessment centre prior to training to determine whether they have suitable personality traits and attitudes.

Screening activities include:

- Personality questionnaire;
- Test to assess abstract reasoning;
- Biographical questionnaire assessment;
- One to one feedback interview.

The output from the screening is a report summarising personnel selection findings with a recommendation for training using a simple red, amber, green allocation. Candidates who are unsuitable (red and possibly amber) are selected out, saving their training costs (many such individuals would be identified only once training had commenced), and potentially saving their lives by removing those who have, for example, an inappropriate propensity to take risk.

The cost of screening is between 2% and 8% of the cost of training. Therefore return on investment based on the cost of training alone (without even considering potential lives saved or costs of deploying unsuitable individuals) is between 12% and 50%.

Other benefits of screening are:

- Greater effectiveness of EOD activities;
- Fewer throughput of personnel and hence reduced training costs;
- Increased numbers of appropriately trained ATO operators;
- Reduced likelihood of injury and fatalities.

The scientific validity of the screening is based on previous research: a Job analysis report and norm groups developed from assessment of previous candidates over ten years.

As a result, the assessment centres have continued for over ten years and received the following customer accolade from Defence EOD *"Without your assistance we would still be behind the power curve and I am very grateful for the lives saved"*.

Picture source: ©MOD Crown Copyright 2011

3.2

MARITIME DOMAIN

3.2.1

ASTUTE SUBMARINE

ENSURING USABILITY OF OPTRONICS CONSOLE TO SUCCESSFULLY REPLACE SUBMARINE PERISCOPE

User interface problems identified from previous experience of automating the periscope function led to a comprehensive HFI approach to developing the console for the very successful Optronics mast system used on Astute class submarines.

Replacing a conventional periscope with a non-hull-penetrating mast carrying optical sensors offers many advantages, including reducing the risk of detection and removing a constraint on control room layout and the location of the periscope operator. Migrating the periscope functions to an operator console offers many opportunities, but it fundamentally alters the way the submarine command team operates, and it requires a very different, and potentially more complex, Human Machine Interface (HMI).

The Astute Class submarines are equipped with two (side-by-side) Optronics consoles that redundantly allow control of two Optronics masts. These masts carry a range of imaging and non-imaging sensors in place of the traditional attack and search periscopes. The development of the console HMI for these masts benefitted from earlier experience with the self protection masts (SPM) on the Vanguard Class submarines, which are essentially remotely controlled periscopes.

The design of the HMI for the SPM was carried out in conjunction with the Royal Navy, but contracted as a primarily engineering task, with relatively limited operator involvement. The resultant HMI was functional but less than optimal for the task, and was not well received by operators.

Development of the Optronics mast used on the Astute class incorporated human factors input from the earliest concept stage. The HMI was developed along with, and in partnership with, the design of the mechanics, optics, electronics and software. The requirements for the user interface were based on a task analysis, and a clear understanding of how the facilities would be used as part of the overall submarine operation. HMI designs were preceded by mock-ups and prototype designs. At each stage multiple operators were involved in assessing and critiquing the HMI with their feedback being directly incorporated into the design process.

- **Reduced risk of failure to meet capability requirements**
- **Reduced potential need for re-engineering**
- **HFI leads to people-related benefits**

Throughout the submarine acquisition, the integration of the consoles into the submarine control room was a formal element of the HFI programme which included operability trials (with representative users performing realistic tasks) as part of the equipment acceptance.

This process led to smooth integration and acceptance of the equipment into service. Operator acceptance has been universal, and several have commented that they would not like to move back to a traditional periscope.

Picture source: ©MOD Crown Copyright 2013

3.2.2

ASTUTE SUBMARINE

HMI DESIGN OF PLATFORM MANAGEMENT SYSTEM PROVIDES USABLE, TASK BASED INFORMATION AND GREATER FLEXIBILITY OF CONTROL

Historically the monitoring and control of primary, secondary and power and propulsion systems on submarines was via hard wired meters, push buttons and yokes, and usually spread across several locations. This was a time consuming process as it meant collecting the data from individual hard-wired equipment for each task. Technology has now evolved such that real time information can be presented to an Operator on a single console. The Platform Management System (PMS) provides increased flexibility of control and increased situation awareness of availability of status information through the provision of task based information in multiple locations of the submarine.

PMS information is displayed on several control consoles, including the Submarine Control Console and the Centralised Control Console using primarily touch screen technology. The PMS enables greater availability of information and flexibility in control by allowing operation from several remote locations. The PMS has also paved the way for technology demonstration for control and monitoring on submarines.

The PMS underwent a series of HFI activities prior to implementation on the Astute Class, to ensure all Ship Operating Procedures (SOPs) and tasks were operable via the human interface.

HFI activities included:

- Analysis of HFI Requirements;
- Development of the HCI Specification following creation of a project specific interface style and following the guidance from Defence Standard 00-25[4];
- Rapid Prototyping of the HMI;
- User trials with representative users.

- **HFI leads to people-related benefits**

Inclusion of HFI resulted in the following benefits in the design and implementation of the PMS:

- Improvement of control room and manoeuvring room operability;
- Improved steering and diving human interface;
- Greater functionality by allowing a greater degree of remote control, some additional automation and diagnostic capability achieved through single operational consoles;
- Task based pages that provide tailored real time information to the Operator.

The Astute PMS is currently in-service and feedback received for the HFI contribution has been positive. The Astute PMS provided the baseline design for Successor although the detail of the HMI is being substantially developed.

Picture source: ©MOD Crown Copyright 2012

[4]DEF STAN 00-25 has since been superseded by DEF STAN 00-250

3.2.3

ROLL AND PITCH INFORMATION DISPLAY SYSTEM (RAPIDS)

CRITICAL ROLE OF TASK ANALYSIS IN DESIGN OF HELICOPTER LANDING AID FOR FRIGATE

A thorough task analysis led not only to an effective display design, but also to a significant equipment cost saving.

Compared to previous helicopters, the safe landing of Merlin helicopters on Royal Navy frigates requires more accurate prediction of flight deck movements, and a system is required to provide Flight Deck crew with the necessary information.

The system, SHOLIS (Ship Helicopter Operating Limits Instrumentation System) monitors ship movement (lateral velocity, heave, roll and pitch) on the basis of which the crew can make a go no-go decision. SHOLIS includes RAPIDS (Roll and Pitch Information Display System) which displays information to the crew, and was initially specified to include a display on the Flight Deck, for use by the Flight Deck Officer.

Given the safety critical nature of the decision of when to land a helicopter, the MOD commissioned a human factors study to ensure that the information displayed would be legible, and could be reliably interpreted in all conditions.

- Reduced risk of failure to meet capability requirements
- Costs of early HFI were more than compensated by downstream benefits

The study began with a comprehensive task analysis, informed by observation of flying operations onboard HMS Lancaster near the Isle of Wight, flying with the Royal Navy from the 'Dummy Deck' training area at Royal Naval Air Station Culdrose and reviewing accident statistics at Royal Naval Air Station Yeovilton.

As well as producing a more effective display design, the task analysis led to a better understanding of the tasks and information needs of the personnel involved. This showed that the Flight Deck Officer did not need to view the displayed information whilst marshalling the helicopter outside on the Flight Deck (his workload was too high). As a result, the display could be located inside the hanger where the environmental requirements were less stringent. The project was thus able to save the considerable expense of installing a fully ruggedised display system outside on the Flight Deck.

The customer said: *"The RAPIDS solution provided benefits in user performance, safety and comfort and saved costs [over thirty times the cost of the Human Factors work]. RAPIDS was an essential tool for bringing the Merlin helicopter onboard a Type 23 Frigate"*.

Picture source: ©MOD Crown Copyright 2011

3.2.4

QUEEN ELIZABETH CLASS AIRCRAFT CARRIER

INFLUENCING SYSTEM DESIGN TO MINIMISE SHIP MANNING

Manpower is one of the Navy's biggest costs, and MOD investment in the design of the human component of the Capability (the ships company) is predicted to yield significant through life manpower cost savings.

The Queen Elizabeth Class (QEC) aircraft carriers will be the Royal Navy's biggest and most powerful surface warships. Through life affordability was a key design driver, and since manpower represents a major cost there was an early focus on optimising the design of the total system (i.e. both the crew complement and the equipment).

Work in the earliest phase identified major manpower drivers, notably relating to flight deck operation, weapons handling and catering. In each area, the design concepts were optimised by working with other disciplines to optimise the design of the working spaces, the equipment and the work to be performed, in order to ensure effective and safe operation of the ship in all scenarios while containing manning requirements.

Monte-Carlo modelling[5] of complement numbers enabled the human factors requirements, (including accommodation, catering, escape and evacuation) to be determined to a high degree of confidence, and these aspects of the design have not needed subsequent re-scaling despite changes in customer business practice (unlike the costly changes that have been common on other similar projects).

- **Costs of early HFI were more than compensated by downstream benefits**

[5]*A heuristic mathematical technique for evaluation or estimation of intractable problems by probabilistic simulation and sampling.*

With a clear baseline of the manning requirement established, continued effort enabled objective assessment of requests for increased manning in various specialist areas. Where these were not justified this could be demonstrated, and where they were justified, the changes could be made in a timely manner, thus reducing the cost and disturbance of late changes.

As a result, the Ship's Company of the QEC has been held at approximately the same number as was needed to operate its predecessor, despite QEC being a more capable ship of more than twice the size and able to operate and support at least twice as many aircraft. As well as the Ship's company (at sea) the ship may require additional support personnel ashore when in harbour, to ensure sustainability through life.

Early indications as the first crew members joined are that embedding the Ship's Company into the Trials programme – which will inform the ongoing manning process – will facilitate a smoother introduction into service, with fewer manning issues than recent Royal Navy ship classes, thus reducing the period between ship acceptance and fully operational units being realised.

Direct savings in predicted through life manpower costs amount to around seventy times the cost of the manning modelling.

Picture source: ©MOD Crown Copyright 2014

3.3

AIR DOMAIN

3.3.1

LYNX WILDCAT AW159 HELICOPTER

ERGONOMIC COCKPIT AND DATA INTEGRATION DESIGN TO PREVENT HIGH CREW WORKLOAD

The change from the original Lynx to Lynx Wildcat AW159 offers an increase in sensor capability — in particular, radar capability (number of objects that can be tracked, resolution and angular coverage) has increased by over three times[6]. An impact of this increase led to concerns that two crew would not be able to cope with the additional amount of information. Some of the integration of the sensors with other equipment was traded out to reduce overall cost, and this heightened concerns about the impact on workload.

Since the start of the Assessment Phase in 2002, AgustaWestland has worked with the British Army and Royal Navy to provide a high degree of commonality between their helicopters to allow aircraft to switch roles easily, principally by changing equipment according to roles. The first aircraft was delivered in early 2012, becoming fully operational with the Army in 2014 and the Royal Navy in 2015.

The mission systems on board these helicopters supply the crew with maps, electro-optics, data transfer and a missile warning system. A lack of data integration across the various sensors and displays had the potential to create excessive workload for the two cockpit crewmembers, and could have led to project cancellation.

How did the project team solve the problem?

Considerable effort went into designing the ergonomics of the cockpit and displays to ensure that the information from the various sensors was combined effectively.

Activities to address cockpit and mission system design risks for both Army and Royal Navy users consisted of the creation of various prototypes early in the project:

- Cockpit cabin mock-up to assess ergonomics;
- Rapid prototyping of displays using VAPS (Virtual Applications Prototyping System);
- Engineering Development Simulator with person in the loop to allow simulation of tasks using realistic sorties that were then assessed using an Ergonomics Assessment Rating Scale.

- **Reduced risk of failure to meet capability requirements**
- **Improved solution quality leading to people-related benefits**

[6]The 3 times capability is a subjective assessment of the improved capability over the Lynx Mk8. In detail the max range of the radar is double that of the Mk8 so the effective area covered is more than doubled, hence the subjective 3 times. The aircraft (and operator) can handle more tracks (around 3 times) and the radar does have greater resolution and angular coverage further supporting the 3 times statement.

The benefits of this work ensured:

- Crew can perform their tasks effectively, achieving situation awareness without excessive workload;
- Facilitation of a common platform approach for the Army and Royal Navy;
- Efficient cockpit, cabin and mission system design;
- Integration of sensors to provide situation awareness.

Since its delivery, the DE&S Lynx Wildcat customer has said: *"The Wildcat project has had a high level of HFI input from the start. This has essentially saved time and reduced redesign/re-work in the Design and Manufacture phase. When considering physical HFI, this has been generally successful, during this project there are one or two small areas of aircraft design that now need re-work, looking at the reason for this re-work it is apparent that minimal or nil HFI input was sought or accepted in these specific areas. As part of the Wildcat mission system software design much input has been sought from a HFI point of view, this has ensured that the final product has met the customer's requirements".*

Picture source: ©AgustaWestland 2014

3.3.2

C130J HERCULES TRANSPORT AIRCRAFT

ESSENTIAL ROLE OF HUMAN FACTORS IN AIRCRAFT ACCEPTANCE

Inadequate understanding of the impact of a simultaneous technology upgrade, crew size reduction and major changes in operational use led to a risk of project cancellation, but a systematic human factors approach identified an affordable way for the aircraft to meet its objectives and enter successful service.

The Hercules transport aircraft entered United States (US) service in the 1950s, and has since evolved through many versions, and been used by many nations. The C130J variant was a major technology upgrade with a 'glass cockpit' and a crew reduced from five to three (Pilot, Co-pilot & Loadmaster, with no Navigator or Flight-engineer). It was a joint UK/US/Australia acquisition, but initially certified to US civil standards only – not military.

Although some human factors work was done throughout the project, work to really understand the differences in operational use of the new variant, and especially the mismatch between civil certification and military use, was not well understood until later in the project.

Prior to entering RAF service, Boscombe Down test teams participated in initial operational flight trials at the manufacturer's facility in America. This led to a long list of approximately two-hundred and seventy recommendations for improvements. Fixing them all would have been unaffordable, and the MOD procurement team considered cancelling the contract.

The situation was resolved with the help of a human factors specialist who began by undertaking a comprehensive task analysis, taking account of crew performance requirements in all different missions and scenarios. This structured approach based on human capability enabled the trials team, together with the manufacturer and the Australian and US customers, to devise a set of scenarios and task performance criteria to be used in further trials.

- Reduced risk of failure to meet capability requirements
- Reduced potential need for re-engineering
- Improved solution quality leading to people related benefit

These trials (live and simulated) demonstrated that crew performance in the basic transport role was adequate (but not in the more demanding scenarios like low level, night vision or UK air-to-air refuelling). This allowed the aircraft to be released for service for the less demanding scenarios. It was also now possible to transform the unstructured list of faults into a prioritised list of approximately seventy mission critical defects that had to be fixed to deliver the more demanding scenarios and about two-hundred non mission critical defects that it would be possible to live with.

After the mission critical changes had been made, further trials demonstrated that the required human performance could be met in all missions and scenarios.

The programme of human factors work required five man years of effort (excluding the cost of re-design). Had the work been done earlier in acquisition it could have identified high risk aspects of the design long before acceptance trials. In the event, the structured consideration of the people and equipment as a system (which is the essence of HFI) helped to smooth entry into service of what has since proved a very effective aircraft.

Picture source: ©MOD Crown Copyright 2008

3.3.3

SEA KING ASAC HELICOPTER MISSION SYSTEM

USER CENTRED DESIGN ALLEVIATES THE EFFECTS OF STRESS ON OPERATIONAL PERFORMANCE

The MOD's central focus on the Human Machine Interface to enable operators working under stress to handle the additional information from a major system upgrade led to a successful solution.

The Sea King Airborne Early Warning version, in use since the Falklands war, had a Mission System operated by a crew of two in a high stress environment. The Airborne Surveillance and Control (ASaC) variant that replaced it as the Royal Navy's 'eyes in the sky' was a major upgrade, with far more information from datalinks and a more capable radar, and with a more demanding role expanded to include Anti-Air, Anti-Surface, Littoral Manoeuvre, Land Surveillance and Anti-Submarine Warfare.

The MOD recognised workload as an issue from the outset, along with the critical role of the HMI. The MOD surveyed existing HMIs across the Western World, all of which fell short of what was needed for the ASaC role.

The MOD actions to mitigate the risks associated with sensor control, situation awareness, information integration and crew workload included:

- A working group of four hand-picked operators to undertake a needs analysis based on operators' tasks. One of this group was tasked 'full time' to develop the functional requirements of the system, and how they were to be executed within the HMI. This was conducted over a two year period with regular 'peer review' to approve the direction being taken.
- The detailed HMI was subjected to six months of rapid prototyping with tasks performed by operators of varying experience. This 'proof of concept' was an important de-risking tool.
- The acquisition regime at the time required a de-scoped contractual requirement, but the detailed HMI specification was provided to bidders for information. Significantly, all chose to adopt it rather than offer a different solution.

- **Reduced risk of failure to meet capability requirements**
- **Reduced potential need for re-engineering**
- **Improved solution quality leading to people-related benefits**

- Competing contractors were required to include a demonstrator HMI to show how the information would be integrated, and workload managed.
- The successful contractor was obliged to work with the Operators Working Group, to develop further those areas of the HMI that could not be predetermined, e.g. system specific radar controls. Although only mandated for six months, dialogue between operator and design authority continued throughout the Design and Manufacture phase.
- The contractor was mandated to incorporate up to two HMI and Mission System software upgrades per year throughout the system life, to permit maintenance of capability and interoperability within an evolving digital battle space.
- Early inclusion of a Mission System trainer was required. (This also allowed software upgrades to be run for extended periods before being installed on the live systems.)

These actions laid the foundations for the system to be smoothly introduced into operational service. The HMI enables operators to perform effectively by supporting their needs and not imposing excessive workload on them. The system's role has since been successfully extended to support new Warfighting Roles, such as Ground Movement Target Indication surveillance over Afghanistan.

Picture source: ©Thales 2013

According to the customer *"The Sea King ASaC Mk7 had a high level of HFI input from its inception, and from initial operation in 2001 quickly earned its spurs as the HMI Gold Standard that follow-on projects emulated".*

4

CONCLUSIONS

This booklet set out to demonstrate the importance to the MOD of Human Factors Integration (i.e. of understanding how the human and equipment parts of capability need to work together, and then investing appropriate effort and resources to develop them in a coherent way and ensure that they do perform as intended).

The arguments for HFI were stated and then illustrated with a small sample of case studies. The projects from which the studies were drawn cover Land, Maritime and Air, spanning from Category A (over £400M) to Category D (under £20M), and include UORs (Urgent Operational Requirements) as well as conventional acquisitions.

The case studies selected were intentionally small vignettes that can be easily described within the confines of the booklet. Most of the projects from which they are drawn are far more complex, but it would take more space than is available here to attempt to describe all aspects of HFI within them.

In the cases presented, a successful outcome flowed from some form of systematic consideration of the human element within the overall system. The converse is also true that failure to consider the human element early enough, or failure to give adequate priority to people-related issues, invariably leads to adverse outcomes of one kind or another, for the acquisition project, for the operating organisation or both.

So, to reiterate the statement in the introduction:

Heed the message of this booklet and ensure that projects you are associated with have positive outcomes.

5

ACRONYMS

ATO	Ammunitions Technical Officer
ASaC	Airborne Surveillance and Control
COTS	Commercial Off The Shelf
DHCSTC	Defence Human Capability Science and Technology Centre
EOD	Explosive Ordnance Disposal
GMTI	Ground Movement Target Indication
HCI	Human Computer Interface
HF	Human Factors
HFAF	Human Factors Assessment Framework
HFI	Human Factors Integration
HMI	Human Machine Interface
HSI	Human Systems Integration
IED	Improvised Explosive Device
IFPA	Indirect Fire Precision Attack
ISO	International Standards Organisation
ISTAR	Intelligence Surveillance Target Acquisition and Reconnaissance
MOD	Ministry of Defence
PMS	Platform Management System
QEC	Queen Elizabeth Class
RAF	Royal Air Force
RAPIDS	Roll and Pitch Information Display System
SHOLIS	Ship Helicopter Operating Limits Instrumentation System
SOP	Standard Operating Procedure
SPM	Self Protection Mast
SRD	System Requirements Document
TNA	Training Needs Analysis
TTAT	Talisman Training Advisory Team
TTP	Tactics, Techniques and Procedures
UAV	Unmanned Air Vehicle
UOR	Urgent Operational Requirement
US	United States
VAPS	Virtual Applications Prototyping System

6

ACKNOWLEDGEMENTS

The assistance of the following in providing details of the case studies in the booklet is greatly appreciated:

- AgustaWestland
- BAE Systems
- Dstl
- MOD Boscombe Down
- HKB Training Solutions
- Liveware
- MBDA
- MOD DE&S (many different PTs)
- QinetiQ
- Quintec Associates Ltd
- Thales
- TTAT (Talisman Training Advisory Team)

7

FURTHER READING

HFI DTC (2009) The People in Systems TLCM Handbook. BAE Systems on behalf of the HFI DTC Consortium.

JSP 912 version 2, 2013 Joint Services Publication: Human Factors Integration for Defence Systems.

MOD, Defence Standard 00-250 Human Factors for Designers of Systems (2008).

MOD AOF, “MOD Acquisition Operating Framework” The Acquisition Operating Framework is the main source of policy and guidance on acquisition for the Ministry of Defence and industry partners. www.gov.uk/acquisition-operating-framework.

8

USEFUL CONTACTS

DE&S Engineering Group,
Human Factors Integration Policy,
MOD Abbey Wood.
E-mail: destech-eghfi-team@mod.uk
Mil: 9352 37553
Civ: 030679 37553

Defence Human Capability and Science and Technology Centre (DHCSTC web page); includes overview of research themes, theme lead contact details and list of suppliers.
www.defencehumancapability.com

Dstl,
Defence Science and Technology Laboratories,
Human Systems Group,
Porton Down, Salisbury, Wiltshire SP4 0JQ.
01980 613121
www.dstl.gov.uk

9

APPENDIX:
CROSS-REFERENCING CASE STUDIES AND ARGUMENTS

LAND DOMAIN:

		Project Title	Fire Shadow – User centred development process enabled project to meet rapid timescale for capability acceptance	Talisman Trainer – Analysis leading to affordable training solution	Pelvic Protection – Adaptable solution balancing protection against wearability
ARGUMENTS	HFI reduces project risk	HFI reduces the likelihood of failure to meet capability requirements	The application of the HFI process early in design ensured all capabilities and limitations were managed, identified and mitigated ensuring end user buy-in and formal acceptance		Key to the success of any personal equipment is a high uptake in the field. Achieving the right balance between protection and the 'cost of use' is crucial to uptake
		HFI reduces potential need to re-engineer the solution	The application of the HFI process led to early visibility of human related concerns across stakeholders. The approach facilitated the effective and timely management of human issues and provided a mechanism for progressive assurance		
		HFI helps to reduce health and safety risks, thus minimising accidents and reducing injury claims			Injury reduction was a primary goal, and was achieved with a design that ensured high uptake
	HFI improves solution quality	HFI leads to people-related benefits	A reduced training burden due to user familiarity with the system		Reducing the risk of injury benefits morale, as does the provision of equipment that troops want to use, rather than are required to use
		When appropriately scoped, applied, managed and resourced, the costs of HFI are more than compensated for by downstream quality benefits		The cost of the TNA was repaid by enhanced performance that the trainer has delivered	

LAND DOMAIN:

		Project Title	Glock 17 Pistol – Human Factors Assessment provides objective evidence for down-selection of Commercial-Off-The-Shelf Pistols	Watchkeeper Unmanned Air Vehicle (UAV) Containers – Innovation solved manual handling risks without additional lifting gear	Psychometric Screening reduced training costs, potentially saved lives and reduced injuries
ARGUMENTS	HFI reduces project risk	HFI reduces the likelihood of failure to meet capability requirements	The assessments ensured the selected pistol was found to be easily usable and compatible with current clothing and equipment. Failure to address this may have led to weapon handling and firing issues	Early consideration of the manual handling aspects of payload and air vehicle containers enabled the development of a solution that avoided the risk of equipment damage during operation	Reduces the risk associated with sustainability and turnover of personnel. The assessment centre screens out unsuitable high risk candidates before they undergo training and therefore reduces drop outs in training
		HFI reduces potential need to re-engineer the solution		A solution that ignored manual handling constraints would probably have needed re-engineering after adverse operational experience	
		HFI helps to reduce health and safety risks, thus minimising accidents and reducing injury claims		A solution that ignored manual handling constraints would undoubtedly have led to injuries and accidents to ground personnel	Reduces the risk by removing personnel who have an inappropriate propensity to take risk in a high risk EOD role. Strong likelihood that the assessment centre has prevented fatalities
	HFI improves solution quality	HFI leads to people-related benefits	Assessment of usability, integration with body armour, respirator, gloves and holster and user acceptability provided confidence in selecting the best weapon from a range of commercial of the shelf options		
		When appropriately scoped, applied, managed and resourced, the costs of HFI are more than compensated for by downstream quality benefits		The cost of the human factors work, and of the additional engineering to meet the people-related requirements will be more than offset by the reduction in damaged equipment and reduction in injury costs	The return on investment based on the cost of training alone (without including potential lives saved or costs of deploying inappropriate individuals) is between 12% and 50%

9

APPENDIX CONTINUED:
CROSS-REFERENCING CASE STUDIES AND ARGUMENTS

ARGUMENTS	Project Title	MARITIME DOMAIN: Astute Class Submarine – Ensuring usability of optronics console to successfully replace submarine periscope	MARITIME DOMAIN: Astute Class Submarine – Human Machine Interface design of the Platform Management System provides usable, task based information and greater flexibility of control	MARITIME DOMAIN: Roll and Pitch Information Display System (RAPIDS) – Critical role of task analysis in design of helicopter landing aid for frigate
HFI reduces project risk	HFI reduces the likelihood of failure to meet capability requirements	Early involvement of users with mock-ups and prototypes ensured that they would be able to use the equipment effectively		The task analysis enabled the needs of the personnel to be fully understood, thus enabling the equipment design to efficiently support their job in ensuring safe landings
HFI reduces project risk	HFI reduces potential need to re-engineer the solution	The development went smoothly without any need for unplanned re-engineering		
HFI reduces project risk	HFI helps to reduce health and safety risks, thus minimising accidents and reducing injury claims			
HFI improves solution quality	HFI leads to people-related benefits	User response is so positive that some would not like to revert to using a traditional periscope	The HFI has led to a greater degree of remote control, some additional automation and diagnostic capability. The HFI has promoted situation awareness on the provision of instant status information	
HFI improves solution quality	When appropriately scoped, applied, managed and resourced, the costs of HFI are more than compensated for by downstream quality benefits			A small investment in the task analysis yielded insights that enabled the project to make a significant saving in equipment cost

ARGUMENTS	Project Title	MARITIME DOMAIN: Queen Elizabeth Class Aircraft Carrier – Influencing system design to minimise ship manning	AIR DOMAIN: C130J Hercules Transport Aircraft – Essential role of human factors in aircraft acceptance	AIR DOMAIN: Lynx Wildcat AW159 Helicopter – Ergonomic cockpit and data integration design to prevent high crew workload	AIR DOMAIN: Sea King ASaC Helicopter Mission System – User centred design alleviates the effects of stress on operational performance
HFI reduces project risk	HFI reduces the likelihood of failure to meet capability requirements		The task and workload analysis enabled the project to find an affordable way to get the aircraft into service	Rapid prototyping, mock-up assessments and simulator assessments of mission system sensor displays have facilitated a common platform approach for the Royal Navy and British Army	Early task analysis and user involvement ensured that the design would enable the operators to work without becoming overloaded, thus avoiding degraded system performance
HFI reduces project risk	HFI reduces potential need to re-engineer the solution				The requirement for the system to be capable of regular HMI upgrades permitted the design to evolve in line with operational experience without major unplanned re-engineering costs
HFI reduces project risk	HFI helps to reduce health and safety risks, thus minimising accidents and reducing injury claims				
HFI improves solution quality	HFI leads to people-related benefits			HFI has resulted in the design of sensors to provide information that provides situation awareness without unacceptable workload for a two-man crew	Designing the HMI around the operators' needs so that they do not become overloaded reduces their stress, with corresponding enhanced wellbeing, and improved performance
HFI improves solution quality	When appropriately scoped, applied, managed and resourced, the costs of HFI are more than compensated for by downstream quality benefits	The through life savings in manpower costs will more than offset the cost of the early manning work			

HFI

ASSESS | INTEGRATE | PERFORM

HFI, Engineering Group, Director Technical, Elm 1a #4125,
Abbey Wood South, MOD, Bristol. BS34 8JH.
Email DES TECH-EG **destech-eghfi-team@mod.uk**