The next generation of defence capability

While drone swarms, self-driving 'tanks' and other semi-autonomous weapon systems will no doubt be the future of warfare, the role of humans will always be crucial in their design, deployment, maintenance and, of course, control. Here we look at how human factors can help maximise capability.

People will remain a critical component of military capability and while their position may change from being an active participant in conflict to taking a more supervisory role, the new systems will have to be designed to get the most effective performance out of the human operator. The process to achieve this currently in the UK defence sector is termed 'Human Factors Integration' (HFI) and is currently mandated in the MOD's Joint Service Publication (JSP) 912, entitled *Human Factors Integration for Defence Systems*.

Every item of equipment procured by the MOD's Defence Equipment and Support (DE&S) organisation, from a pair of soldier's boots to a multi-billion pound aircraft carrier, has to undergo HFI to identify, track and address people-related considerations. This applies throughout the equipment's lifecycle, from delivery, training of personnel, maintenance, use and disposal.

For the past 30 years, human factors specialists from the MOD and industry have worked together through the MOD-Industry HFI Working Group to promote HFI and best practice within the defence sector. This group has now joined the CIEHF as the organisation's Defence Sector Group. Laird Evans, Chair of the MOD-Industry HFI Steering Group, was delighted with the move. He said: "The aim is to share ideas, learn about best practice and distribute these as widely as possible throughout the defence sector. It makes sense to align with the CIEHF as our work closely matches its aims and we can learn from the excellent work being done in other sectors."

Steve Harmer, current Defence Sector Group MOD Co-Chair, agreed: "It gives us access to a wider community of human factors practitioners and this is important for us to share an understanding of approaches to human-centred design being developed and applied in other sectors."

Laird added: "Human-Machine Teaming is emerging as an important topic for the defence HFI community. There's a lot of overlap with the CIEHF's Healthcare Sector Group, where we can learn from their experience of complex decision making, the increased use of semi-autonomous systems, as well as the use of augmented and virtual reality to support training and operations."

The CIEHF Defence Sector Group consists of a Steering Group, chaired by Laird, which discusses HFI policy and processes, and a Liaison Group, co-chaired by Steve and Gareth Shaw (of BAE Systems) which serves as a forum for those working within MOD and industry. It's already attracted interest from the wider human factors community with 80 people tuning in to its first virtual meeting in September and 154 attendees at its webinar on the history of HFI in UK defence in November. The webinar was presented by Chris Kelly, a long-term Defence Sector Group member and Steering Group Industry representative.

While HFI is mandated in all procurement projects through JSP 912, it's not always explicitly defined in detail in all tenders, as Chris explained: "The extent that HFI is addressed in a project is very much dependent on how the particular MOD project team expresses it in their original requirements documents. This often determines how industry responds to the tender, and why the uptake of HFI is a bit patchy across defence projects. It's improved in recent years but there is some confusion with engineers over the terms human factors and HFI. HFI is more about managing the process to ensure human factors is really integrated across all the HFI domains and an integral part of a systems engineering approach."

The MOD is constantly reviewing its 'capability gaps' to ensure it's prepared for new types of offensive activity

The profile of HFI within the MOD has increased as DE&S has expanded its team of human factors specialists from two a couple of years ago to 14 this year. However, it's still a small

team for the huge range of complex projects the MOD undertakes – buying, supporting and supplying vital equipment and services for the Royal Navy (RN), British Army and Royal Air Force.

Laird noted: "In addition to developing HFI policy and processes, our main role in DE&S is to work with project teams to promote HFI best practice and support them in their engineering projects. It's important that we get involved as early as possible so we can ensure HFI is firmly embedded in the lifecycle of any procurement."

Steve was recently involved in a research project for the Defence Science and Technology Laboratory (Dstl) to understand the level of awareness of HFI in the MOD's three Front Line Commands – where the Chiefs of Staff for the Army, RN and RAF have responsibility for developing their service to deliver military capability. Steve said: "In general, there was a lack of awareness about the requirement for HFI, which shows we need to do more to communicate this. We need senior commanders in the Front Lines to promote and trigger the HFI process. Ensuring that requirements associated with the human component of capability are understood and defined from the onset is key. We call it the 'golden thread': the higher the level of requirement that's set at the beginning, the more uptake there will be throughout the acquisition process."

In addition to communicating the importance of HFI, human factors practitioners in defence are also facing the challenge of getting the best up-to-date research to support the development →

PROJECT: LYNX WILDCAT AW159 HELICOPTER

Issue: To develop an ergonomic cockpit and data integration design to prevent high crew workload.

HFI benefits: The resulting cockpit and display reconfiguration allowed the crew to perform their tasks effectively, achieving high situation awareness without excessive workload.

Details: Although the upgrade of the Lynx helicopter to the Lynx Wildcat AW159 gave crews more sensor capability, there was a lack of data integration across the various sensors and displays that had the potential to create excessive workload for the two cockpit crewmembers. Therefore considerable effort went into designing the ergonomics of the cockpit and displays to ensure that the information from the various sensors was combined effectively. This involved cockpit cabin mock-ups to assess ergonomics, rapid prototyping of displays using the Virtual Applications Prototyping System and using the Engineering Development Simulator to allow simulation of tasks using realistic sorties that were then assessed using an Ergonomics Assessment Rating Scale.

A DE&S Lynx Wildcat customer 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. 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". →

● Case studies that show the project risk and cost reduction benefits of implementing Human Factors Integration (HFI) within various MOD projects across the army, navy and air force.

Source: Defence Human Capability Science and Technology Centre (DHCSTC)

of methods, guidance and standards, particularly as the nature of warfare is changing rapidly. With the increase in asymmetric conflicts and the emergence of new forms of cyber warfare, the MOD is constantly reviewing its 'capability gaps' to ensure it's prepared for new types of offensive activity.

Although the UK Government's announcement last year of a £16.5 billion boost for defence spending was welcomed, there is an ever-present efficiency challenge. However, for human factors practitioners, pressure on budgets provides a renewed emphasis on getting more from the capability the MOD already has, and that means getting more from its military personnel – which is where human factors plays a critical role.

Gareth Shaw, Industry Co-Chair of the Defence Sector Group, explained: "Due to a reduction in the number of armed forces personnel in recent years, there is an evolving requirement to do more with less. The appropriate application of technology and consideration of human factors will ensure delivery of military capability by dramatically increasing the capability each person can provide. A huge number of technologies will underpin future capability including increased use of Artificial Intelligence (AI), increased automation and autonomy, improved data processing and visualisation, increased networking and interoperability of systems, increased use of robotics and developments in wearable technologies."

Gareth added: "The increased use of these technologies, and the adoption of development approaches such Agile methodologies, will require developments in HFI processes, tools and guidance. AI is an example of a huge growth area where standards will need to evolve to ensure it's implemented effectively to support human-machine teaming."

Through the development and promotion of HFI process, standards and guidance, the Defence Sector Group (and the legacy MOD Industry HFI Working Group) has made a significant contribution to the development and acquisition of some of the UK's most advanced military systems. The ability to share best practice and novel approaches with other CIEHF sectors will serve to support refinement of future process, standards and guidance and therefore support development of the next generation of military capability. ●




Chris Kelly, Gareth Shaw, Laird Evans and Steve Harmer
are leading members of the CIEHF's Defence Sector Group

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PROJECT: PELVIC PROTECTION FOR SOLDIERS

Issue: To provide an adaptable solution that balances protection against wearability.

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

Details: The pelvic region of a dismounted soldier is particularly vulnerable to injury from Improvised Explosive Devices (IEDs) so the Army raised an Urgent Operational Requirement for pelvic protection. However, the protection not only needed to resist penetration but also permit normal movement for the soldier 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.

The MOD recognised that getting the comfort and utility right was essential to ensuring that the protection would be worn so it initiated a process of iterative human factors assessment and trials using levels 1 & 2 of the Human Factors Assessment Framework including field trials, as well as a controlled laboratory trial using participants and manikins to provide objective data on human physiological and cognitive responses.

This led to a tiered solution which allows users to consider their options before selecting what to wear: Tier 1 (for routine use by all troops) meets 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 the most protection.

The tiered approach led to high utilisation rates in service and has resulted in significant reduction in pelvic injuries from IEDs.

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PROJECT: QUEEN ELIZABETH CLASS AIRCRAFT CARRIER

PROJECT: ASTUTE CLASS SUBMARINE

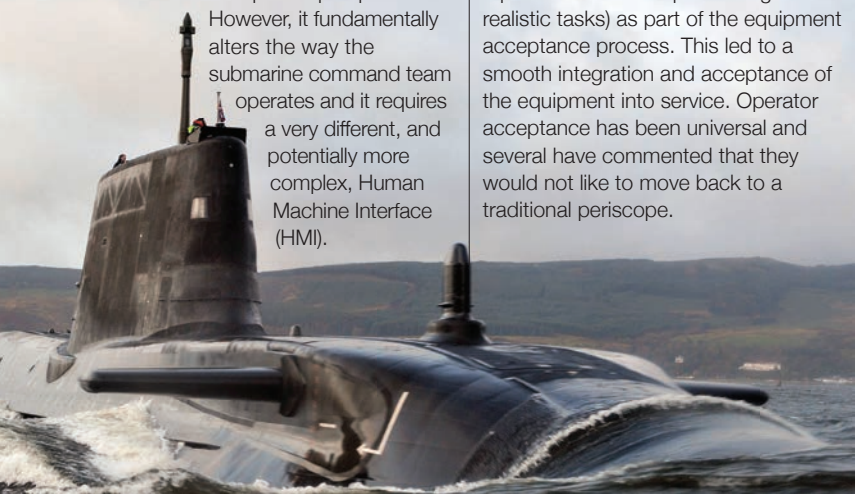
Issue: To ensure the usability of an optronics console to successfully replace the submarine periscope.

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

Details: 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. However, 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 development of the optronics mast incorporated human factors input from the earliest concept stage, and 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.

Throughout the submarine design, 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 process. This led to a 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.



PROJECT: TALISMAN VEHICLE TRAINING

Issue: Developing cost-effective training for personnel.

HFI benefits: 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. The costs of early HFI were more than compensated by downstream benefits.

Details:The Talisman vehicle is used by the Royal Engineers for route proving and clearance, including mitigating Improvised Explosive Devices (IED) threats. Training for Talisman teams traditionally takes place in the Jordanian desert, but this does not cover all training scenarios such as encountered in built up areas.

The Talisman Training Advisory Team (TTAT) recognised this limitation on the human component of Talisman capability and commissioned a Training Needs Analysis (TNA) to explore the feasibility of additional training to supplement live training in Jordan. This drew on earlier work (including human factors work) already completed during system development.

The TNA demonstrated that the essential procedural skills could be trained using low cost commercial hardware to create an easy-to-assemble training simulator in the UK and to both prepare teams for desert training as well as covering training scenarios not available in the desert.

According to TTAT: "The simulator has significantly improved the training progression of Talisman Squadrons since its introduction. 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."

Issue: To influence system design to minimise ship manning levels.

HFI benefits: Manpower is one of the Navy's biggest costs and MOD investment in the design of the human component of the ship's company is predicted to yield significant through-life manpower cost savings. Costs of early HFI investment were compensated by downstream benefits.

The Queen Elizabeth Class (QEC) aircraft carriers are 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, that is, 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.

Modelling 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.

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. Direct savings in predicted through-life manpower costs amount to around 70 times the cost of the manning modelling.