HUMAN FACTORS AND BATTLEFIELD TECHNOLOGIES

Guest Editors

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INTRODUCTION

Human Factors, the discipline that is concerned with "the scientific study of the relationship between man and his working environment" [1], has much to offer in support of the design, evaluation, and implementation of battlefield technologies. In particular, theories of human and complex system performance and structured methodologies for describing and evaluating performance are increasingly being employed in these contexts. The discipline abounds with books on methods which will aid the development and understanding of the ways of working in complex systems [2]. This understanding can lead to the identification of new models of Command and Control [3]. The methods can also be used to support the design and evaluation of new battlefield technologies, such as digital Battlespace Management systems [4,5]. Legacy approaches, such as Cognitive Work Analysis [6] and Socio-Technical Systems Theory with some 50 years pedigree, have been applied to offer new insights [7, 8]. New methods have been developed to examine the distributed nature of situation awareness in command systems [9]. Taken together, these works amongst others have redressed the balance of Command and Control technology, with more emphasis on human aspects of systems. More recently, softer concepts such as "trust" have been used to explain the relations between military teams, organizations and technology [10]. The point here is that Battlefield Technology should be as much about the people who use it in pursuit of their mission goals as it is about the equipment.

This special issue presents some of the recent work of Human Factors in this area to show how it can assist the development of battlefield technologies and associated training programs, as well as the warning of what will happen if these lessons are not put into practice. The papers presented cover a range of key areas surrounding battlefield technologies, including technology acquisition, the design and evaluation of new technologies, human processes, methodological evaluation and selection, and training. There are three papers covering approaches to design and evaluation of digital technology, three papers considering the human processes in command and control, and three papers considering training needs, technologies and skill fade. Whilst this does not present the broader coverage of the Human Factors discipline, it does provide a snapshot into some of the important aspects applied to Battlefield Technology. A brief introduction to each of the papers is presented along with a summary of the main conclusions at the end of the editorial.

DESIGN AND EVALUATION OF DIGITIAL TECHNOLOGY

Carroll and Fidock (Embedding ICT into the mobile land battlespace) are concerned with the problem that Information and Communication Technologies often fail to achieve all of their intended benefits. This problem is a classic socio-technical systems problem [See 8], where the social aspects of the organization (that is, the people with their established ways of working in formal and informal social structures) are expected work-around the introduction of a new technological system (Salmon et al, this issue, show what can happen and Diggelen, this issue, propose a new method for dealing with the problem). This problem is particularly acute for mobile land battlespace, where data and information communication occurs on the move across a myriad of platforms for a broad and varied range of tasks. The problem is made even more challenging by the varieties of technological systems used and the inherent incompatibilities with social and technical interoperability. The problem is that any new technology is faced with a multifaceted 'fit' test; the technology should fit with organizational goals, mission goals, environmental and scenario demands, social systems, user abilities, goals and tasks, as well as any legacy systems. Added to this, the timescale from initial specification to implementation in the field can take years, in which time any of the aforementioned variables could change with implied consequences for the other variables. Carroll and Fidock offer the Model of Technology Appropriation as a framework for acquiring Information and Communication Technologies in this complex domain. The approach places emphasis on maintaining flexibility in the appropriation through the processes of exploration, evaluation and adaptation. This may be likened to the joint optimization of social and technical systems advocated by socio-technical theory [8] by adapting technology and ways of working at the same time in order to optimize system performance.

Diggelen et al (Mutual empowerment in mobile soldier support) argue that the complexity of modern operations means that the soldier requires even more support and that mobile support systems could provide an appropriate solution. It has been suggested that every soldier could be a sensor in the battlefield, and that this information could be shared with other soldiers together with information of their own forces and enemy forces capabilities. In this paper, Diggelen et al demonstrate how Human Factors can be incorporated into the design and development process using their Situated Cognitive Engineering methods. This approach comprises three tools for cognitive engineering, prototyping and testing. They argue that the failure to consider Human Factors in the design process will lead to ultimate failure of the technology in the field. To demonstrate the point of good practice, they present a case study of the development of their mobile soldier support system. This starts with three broad design principles: the human must be kept in the decision loop, the system should promote understanding though simplicity and transparency of operation, and the system should complement and support existing working practices. The cognitive engineering module was used to determine

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which aspects of the mobile soldier support system were required. The prototyping module was used to visualize the potential working of the mobile soldier support system in a variety of scenarios. The testing module was used to conduct human-in-the-loop simulation with the prototype mobile soldier support system. The authors argue that the modular development of the mobile soldier support system using their Situated Cognitive Engineering methods helped to get early adoption of Human Factors in the design and development process.

Salmon et al (Task and error analysis for battlefield technology evaluation) argue that usability and user interface and interaction design is crucial to battlefield technologies. Poor design could significantly hinder operational performance and led to very negative consequences. There are major concerns that digitization of military processes and products that have evolved over decades of refinement will not necessarily lead to improvements in system performance. These concerns are often due to the way in which these implementations have been manifested, rather than the idea of digitization per se. The authors examine the case of a recently developed Battle Management System, which have had a profound effect on the work previously undertaken with paper maps, overlays, whiteboards and flipcharts [5]. The research took a task analytic approach, using Hierarchical Task Analysis (HTA) and the Systematic Human Error Reduction and Prediction Approach (SHERPA) to model and analyse normative and non-normative system behaviour respectively. These analyses revealed underlying system design flaws and the likely effects on system performance. The analysis was aligned to the Combat Estimate planning process, colloquially called the 'seven questions'. Through detailed examination of the system goals with HTA, the analysts were able to identify incompatibilities between what the command staff were trying to achieve and what the digital Battle Management System would let them do. Scrutiny of these activities through SHERPA provided insights into what could go wrong. These analyses together revealed many problems with the system, in that it did not support many of the tasks the command staff were trying to undertake and the processes were error-prone. The authors conclude that the design of the system had paid little attention to even the most basic Human Factors principles and that it brought into question whether all aspects of Battle-space Management needs to be digitized in the first place.

HUMAN PROCESSES IN COMMAND AND CONTROL

McMaster, Baber and Bond (Sensemaking in a combat support headquarters) explore the usefulness of the concept of sensemaking in helping to understand how the Combat Support Headquarters is able to function as part of a wider logistics supply network. They focus on the functional aspects of sensemaking, which they define as: the information needed, the way in which that information is shared or distributed and the process of collaborating and sharing information. McMaster et al report their finding from a study of two Combat Support Headquarters over the course of a four day training exercise. The role of the Combat Support Headquarters is to plan support activities (such as the resupply of fuel, weapons, food, spares, ammunition, etc) in support of an operation. They use a planning process similar to the Combat Estimate, called the Operational Estimate that comprises six questions. The planning process is far from straight-forward, and is characterised by ambiguities in the nature of the planning problem which require resolution as well as many external constraints on the potential solutions. The finding from the observational studies suggest that most of the emphasis in planning is put on informal, ad hoc, meetings between staff from different specialisms to resolve problems with a multiplicity of implications. The Combat Support Headquarters were very reliant on collaboration and sharing of information to find workable solutions and understand the potential consequences of one course of action over another. The formal Operational Estimate was rarely used in the way intended, although parts of it did help to identify which specialisms would be needed to be invited to the meetings. The research also found that artifacts play a major role in displaying the shared information. McMaster et al noticed that there were three interacting classes of artifact: public (such as whiteboards and flipcharts), personal (such as notebooks) and digital (such as IT). From their observations they identified a cycle of activity whereby public information would be recorded in personal notebooks and then used to interrogate digital systems to get information, which was the presented on the public information. This cycle of artifact recording and transformation seemed to play a major role in collaborative sensemaking. The authors suggest a number of ways in which to capitalise on the collaborative sensemaking processes that would support the informal, ad hoc, public, problem solving, nature of the work.

Stanton, Rafferty and Forster (Contemporising the combat estimate) propose an update to the Combat Estimate for human terrain mapping, by integrating the tools for hard and soft effects into a single procedure. Undoubtedly, modern military activities are very different than those for which the Combat Estimate was originally designed; existing tools are best suited for planning for an enemy with the intention of delivering hard kinetic effects. Modern military operations have broadened to incorporate peace keeping, stabilisation, humanitarian aid, and reconstruction activities. Planning tools that can support these soft effects and influence operations are required. Rather than develop completely new tools, this project sought to utilise those from political campaigns and product marketing, on the assumption that those disciplines have already gained experience in analysing and influence population behaviour. The authors present a set of tools that have been integrated into the Combat Estimate process. A study was conducted to compare the performance of command staff planners using the new process with command staff using the traditional process for a scenario that required a combination of hard and soft effects. The results of the study showed that the teams using the new toolset were more likely to produce a plan that had population-centric themes for influence effects. This shows that the new toolset made it easier to conduct human terrain mapping and plan for influence effects. The new toolset integrates well into the Combat Estimate process and works alongside the traditional products.

Sorensen and Stanton (Should we assess distributed situation awareness before, during or after command and control activity) take a distributed cognition perspective on an important battlefield concept, situation awareness, proposing it to be an emergent property of systems that occurs at the point of exchange in space and time as the situation develops and changes. In addressing the problem of how to analyse distributed situation awareness in systems during the design and evaluation of battlefield technologies, the authors consider three approaches to data collection. An idealised view of distributed situation awareness may be modeled using HTA, showing what information exchanges and transactions should occur within the system. An assessment of distributed situation awareness in situ can be undertaken by recording communications between system agents (such as voice and written information for communications between people and data input and output information for communications between people and machines). Finally, a retrospective view of distributed situation awareness may be collected using the critical decision interview method, which can incorporate system logs of activity and behaviour where it is recorded. The authors contrast the three approaches of collecting data to identify when each might be appropriate. As each of the approaches collect that data in different ways, the authors speculate that comparison of the data could provide comprehensive insights into the nature of distributed situation awareness in complex military systems.

TRAINING NEEDS, TECHNOLOGIES AND SKILL FADE

Huddlestone and Pike (Team and collective training needs analysis) argue that relatively few techniques address the problem of training needs analysis beyond the level of the individual. This is surprising given the increasing need to conduct synthetic rather than live training. Identifying training needs analysis for teams and collectives is more than simply scaling up from individual training needs analysis. Rather, the unit of analysis within a systems perspective requires methods appropriate to that level. The authors propose a team training model that presents the relationships between team members, properties, processes, environments and outputs. Analysing the team as the functional unit within the system should help identify needs and objectives appropriate to that level. The method that Huddlestone and Pike propose has three main stages: analyse the team context for the training scenario, analyse the team tasks, and develop the team training objectives for the team tasks within the context of the team training scenario. The output of the method is team training needs in tabular formats. The approach has been used in several exemplar case studies and the authors propose that future work should focus on formal validation of the methods.

Whitney, Fidock and Ferguson (Assessing the effectiveness of simulation-based counter-IED training) argue that simulation-based systems have much potential to offer counter-IED training, such as immersion, realism, controlled expose, repetition, recording of responses, and the presentation of a range of scenarios. The advent of desktop simulation, such as those found in gaming environments, has made this medium much more accessible. The evidence base to support the benefits of simulation-based training is scant however, at best it is equivocal. Often, no controlled studies are conducted and no performance data are collected. Where data is collected, it is often self-reports of preferences rather than objective data showing training improvements or otherwise. In response to this paucity of data, Whitney et al conducted a controlled experiment comparing training performance of simulation-based counter-IED training on VBS2 with the traditional Rehearsal of Concept ‘sandpit’ drill training. They designed a cross-over study, so that the combination of the two types of training could also be evaluated. The findings of the study show that there were no significant differences in the training outcomes for the two types of training. Self report measures suggested that the soldiers actually preferred the Rehearsal of Concept ‘sandpit’ drill training over VBS2. Whitney et al argue that there is merit in both types of training and that together they offer a more comprehensive approach, reinforcing the learning from the other medium, whilst each has distinct advantages over the other.

Cahillane and Morin (Skills retention in a complex battlefield management system) argue that skill retention is a significant issue for the operation of complex military systems. They report anecdotal evidence that suggest there is a particular problem for digital systems that require personnel to recall long step sequences. The problem is exacerbated when those sequences are not regularly rehearsed and practiced. As there can be a delay between training and deployment, there is concern that personnel may not be able to perform to the required standard when initially in theatre. Estimates on the amount of skill degradation vary between ten to fifty percent, depending upon a variety of factors including the nature of the training, the type of task and the elapsed time. Poor system design is also like to be a major contributor [5]. The study reported in this paper sought to assess skill fade on a digital battlefield management system at three week intervals over nine weeks. Despite this only being a pilot study with a limited number of military participants and low statistical power, the results do show that skill degradation occurred quite markedly over a relatively short amount of time for those who received level one training. The study also showed that, although there was some degradation for those that received level two training, this was not quite as marked.

CONCLUSIONS FOR BATTLEFIELD TECHNOLOGY

Rapid advances in technology are increasing the potential contribution that battlefield technologies can make to modern day defence activities. Although there is great potential for such technologies to enable more efficient performance, the literature is littered with examples of how mismatches between man and technology have hindered performance, in extreme cases to the extent to which multiple lives were lost. The discipline of Human Factors provides the theories and methods required to support the design and implementation of efficient battlefield technologies. Despite this and many success stories, it is apparent that the uptake of Human Factors principles during battlefield technology design efforts is still limited. It is the intention of this special issue to not only provide a snapshot of Human Factors research in the area of battlefield technology design, evaluation and implementation, but also to demonstrate how our discipline can contribute to the acquisition and deployment of more efficient and effective battlefield technologies.

This overview of the special issue has therefore sought to highlight some of the benefits of incorporating Human Factors in the procurement and design of, and training in, Battlefield Technology, as well as some of the warnings of what could happen if Human Factors is not considered. Human Factors is neither an optional extra, nor a bolt on, rather it has to be integrated into the design and development of Battlefield Technology. Some take home messages have been drawn from the papers, as a summary of Human Factors in Battlefield Technology, as follows:

- maintain flexibility in the procurement process to ensure joint optimisation of both the technical and social systems;
- use methods that promoted early adoption of Human Factors in the design and development process;
- question the need for digitisation or technological intervention and don't build digital/technological systems for their own sake;
- ensure that digital systems and new technologies capitalise on, and support, established ways of working;
- integrate new tools into contemporary approaches and products;
- develop insights into distributed cognition, situation awareness and sensemaking to better understand the nature of military work;
- analyse the system at the appropriate level for the intervention;
- conduct formal evaluation of Human Factors methods in order to select the most appropriate for use in battlefield technology design and evaluation;
- conduct controlled experiments where possible to gauge benefits of an intervention;
- consider merits of combined media training; and
- be aware that skill degradation can occur over a relative, short amount of time.

In conclusion, it is hoped that the reader of this special issue will leave having new regard and respect for the role of Human Factors and be an advocate of the approach in their next Battlefield Technology Project.

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