# Getting cognitive requirements for system design right

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## ABSTRACT

Recently, the Ministry of Defence (MOD) updated guidance on the application of human factors in system acquisition. During that process, a number of gaps were identified. The aim of this study was to address one of the gaps by providing the MOD with a generic process that would allow them to: determine the cognitive capabilities required for accurate system operation; and measure the current cognitive capabilities of a proposed user group to inform the design or selection of any military system. Building on an analysis of cognitive literature, and an understanding of military tasks, a framework was derived for the classification of cognitive abilities. By combining the framework with guidance and best practice, a simple process for deriving and incorporating cognitive requirements into military system development was created. This process extends the current standardised approach, providing a holistic approach to human factors in system design.

#### **KEYWORDS**

Human factors integration, system design, cognitive requirements

## Introduction

As more and more military roles rely on information exchange and time-critical decisions that require personnel to filter large datasets, cognitive abilities and skills have become increasingly important, especially as the nature of roles vary so that the cognitive demands are quite different between different roles and tasks (Labbe, 1998). The development of more complex, safety-critical systems for the military, requiring increased cognitive engagement from users, has highlighted the need to be able to define the human cognitive capabilities in greater detail. Traditional target audience descriptions (TADs) have emphasised physical characteristics and there has been little guidance on how to address cognitive, or mental abilities and skills.

The need for a process, together with the lack of available best practice from within the military domain and other industries, highlighted the requirement for the MOD to understand how to incorporate cognitive abilities and skills into a TAD in a structured way. This process would support the characterisation of the population who are most likely to fulfil a role and understanding of how system design can be tailored to make best use of the target population's cognitive abilities and skills.

#### Aim

The aim of this study was to provide the MOD with a generic process that would allow them to determine the cognitive capabilities required for accurate system operation, and measure the cognitive capabilities of a proposed user group to inform the design, or selection, of any military system.

# Approach

The approach combined established knowledge, guidance and best practice in cognitive psychology, psychological measurement and military system/task design. Throughout the research, the focus was on developing a pragmatic solution that would take a user-centred approach to system development and complement the existing concept, assessment, demonstration, manufacture, inservice, disposal cycle (CADMID) and the MOD human factors integration (HFI) processes. This is illustrated in Figure 1. Establishing key cognitive abilities through a review of cognitive literature in relation to military tasks grounded the process in theory and the appropriate context. The identification of relevant established psychological tests supported the measurement of cognitive capability.



Figure 1: Approach to development of a process for defining cognitive capabilities

# Output

# Cognitive requirements for military systems

A review of the cognitive psychology literature was sufficient to identify an appropriate set of cognitive abilities and skills. The cognitive abilities identified during the review covered basic abilities, such as memory, to more complex skills that comprise a number of abilities such as decision making.

The cognitive aspects of military tasks were identified by reviewing task analyses from previous projects, which covered a variety of roles across the Royal Navy, Army and Royal Air Force. The tasks included command and control, engineering tasks, piloting, navigating, visual search and threat evaluation among others. The tasks were defined by a number of characteristics, including sensory input, object and pattern recognition, knowledge, communication and decision making.

The cognitive abilities and skills found in the literature were refined in light of military task requirements, resulting in a set of cognitive abilities and skills that could be meaningfully used within the military, specifically for equipment procurement. These were:

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- Attention
- Memory
- Visual perception
- Other senses perception
- Verbal communication
- Listening
- Mechanical reasoning
- Spatial reasoning
- Numerical reasoning
- Verbal reasoning
- Decision making

For each ability and skill, a practical and usable definition for application to system design was developed. These formed the basis of a cognitive framework for use in the cognitive capability definition process.

Suitable psychological tests were suggested for each of the abilities and skills identified in the cognitive framework using the criteria of current availability, ease of application, reliability and validity. These tests were found using the British Psychological Society's (BPS) Psychological Testing Centre. In two cases, 'other senses perception' and 'verbal communication', no tests could be found which met these criteria.

# Cognitive capability definition process

A process was developed that permits the typical cognitive abilities of a user group to be meaningfully described in a TAD. The derivation of the process was based on the application of knowledge gained in this research and good practice, aligned with existing practices in the MOD HFI process. The process was refined and enhanced by human factors practitioners, occupational psychologists and qualified BPS Test users experienced in working in the military domain, in the context of two case studies. These were: enhancement of a command system for the principal warfare officer role; and provision of a new capability to support a team operating a ground-based munition system.

The user-centred cognitive capability definition process was designed to be simple for a military procurement team to implement with support from suitably qualified and experienced (SQEP) human factors and BPS Test user personnel. It was intended to integrate well with typical military procurement and human factors processes, and, like other long-term procurement activities, be iterative and conducted to a level of detail appropriate to the stage and scale of procurement. SQEP personnel are required to be involved, as implementation requires judgement to be exercised, particularly in relation to the data collection methods utilised and level of detail of information gathered at each application.



Figure 2: User-centred cognitive capability definition process

Figure 2 provides a high-level representation of the process proposed to integrate cognitive elements into the TAD process. The output of which is referred to as the TAD-Cognitive (TAD-C).

Step one uses the concept of employment, user requirements and task descriptions to establish the cognitive abilities and skills that are required for successful execution of the tasks using the proposed system. Cognitive elements are then prioritised based on importance, frequency and difficulty. The cognitive framework questionnaire was developed to aid designers in the prioritisation of cognitive elements.

Step two uses the outputs of step one as well as data collected using the identified suitable psychological testing methods, in order to establish the range of ability and skill levels in the intended user group, for each cognitive element required for the task. These ranges will provide the design envelope for system designer, being the basis for the cognitive elements of people related requirements.

Step three completes the process and provides an actionable output to designers by articulating the people related requirements, based on the cognitive capabilities of the intended user group and publishes these as a TAD-C appropriate to the level of maturity of the system being developed.

## **Conclusion and impact**

The TAD-C process provides a robust and flexible approach to considering how people's abilities and skills should inform system design. Cognitive abilities and skills can be identified with reference to the cognitive framework and defined through utilisation of cognitive ability testing tailored to suit small and large programmes. The inclusion of a step to derive requirements goes beyond what is currently provided in a TAD, but would ensure that the output of future TADs, covering all aspects of the TAD not just the TAD-C, would be directly useful during the concept and assessment phases of the CADMID cycle.

## References

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