Adapting Current UK Military TNA Guidelines to Analyse Collective, Command and Control Training Requirements for the Royal Artillery

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ABSTRACT

The UK MoD identified a lack of opportunity to exercise the collective, command and control (C^2) procedures for the Royal Artillery Commanding Officer and his Indirect Fire System (IFS) formation staff at Brigade level. A Training Needs Analysis (TNA) was conducted to identify the cognitive and behavioural training requirements of collective, C^2 procedures and to recommend the most cost effective training option to meet the identified training need. Current Ministry of Defence (MoD) guidelines describe TNA methodologies which are predominantly designed to identify individual, Human-Machine-Interface training requirements. This paper describes the application of the TNA methodology to identify and analyse the collective, Human-Human Interface training requirements involved in the performance of Indirect Fire C^2 procedures.

The adopted operational task analysis methodology, identified the cognitive and behavioural tasks performed by each individual within the target audience to achieve each IFS collective training standard. In addition the analysis captured the C^2 process as a flow of information communicated between the target audience and the associated senders and recipients of information. The Knowledge, Skills and Attitudes Analysis and Fidelity Analysis methodologies were adapted to analyse the properties of the Human-Human Interfaces, which would require replication in the training environment. The output of the fidelity analysis informed the analysis of the manpower requirements needed to support an IFS exercise.

ABOUT THE AUTHORS

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INTRODUCTION

The Royal Artillery Commanding Officer (CO) and his Indirect Fire System (IFS) formation staff, have limited opportunity to exercise collective, command and control (C^2) procedures at Brigade level. This was recognised by the UK MoD and underpinned the requirement for an analysis of C^2 training needs for a Royal Artillery Future Indirect Fire System Trainer.

The MoD defines Indirect Fire as, 'Fire delivered at a target which cannot be seen by the aimer'. The components of the IFS include Surveillance and Target Acquisition, a Command Control Communication and Computation System, the Weapon platform, Munitions and Logistics.

A Training Needs Analysis (TNA) was conducted to identify the collective C^2 IFS training requirement and to recommend the most cost effective training option to meet the identified training need. It was assumed that the target audience was capable of performing individual duties prior to undergoing collective training. The TNA focused on an identification and analysis of the individual-team tasks and interactions required of individuals, to co-ordinate their behaviour, during the conduct of a collective C^2 IFS exercise.

Overview of the Military TNA Process

The Systems Approach to Training commences with the identification and analysis of the training requirement, prior to the design, conduct and evaluation of training. A TNA is conducted to analyse the training requirement.

The MoD defines a TNA as the 'identification of training requirements and the most cost effective means of meeting those requirements'. The process comprises a Scoping Study, an Operational Task Analysis (OTA), a Training Gap Analysis (TGA), a Training Options Analysis (TOA), a Final Report and a Post Project Evaluation (PPE).

At the start of a TNA, the Scoping Study defines the TNA parameters, processes and resources to be utilised in the conduct of the TNA. The operational training requirement is analysed during the OTA; the TGA analyses the gap between current training and the new training requirement; the TOA analyses the cost effectiveness of training solutions and these phases are summarised in a Final report. Following the completion of the TNA, a PPE assesses the processes utilised in the conduct of the TNA and the validity of the recommendations.

Aim

Current UK military guidance for the conduct of TNAs focus upon the conduct of TNAs in support of equipment acquisition. As a result, military TNA methodologies are suited particularly to an analysis of individual, Human Machine Interface (HMI) training requirements and not necessarily to those of a cognitive, decision-making nature.

The aim of this paper, therefore, is to demonstrate how current military TNA guidance can be enhanced, to address collective C^2 training requirements using processes typically applied during Early Human Factors Analysis (EHFA) (e.g., Human-Human Interface analysis, Goal directed task analysis). Specific consideration is given to describing how analysis methodologies were modified during the OTA and TGA to address the requirements of the IFS TNA. Media analysis processes are beyond the scope of the paper.

OPERATIONAL TASK ANALYSIS

This section describes the composition of the target audience, the development of the Operational Task Lists (OTLs) and presents a description of OTA components, which were modified for the IFS TNA.

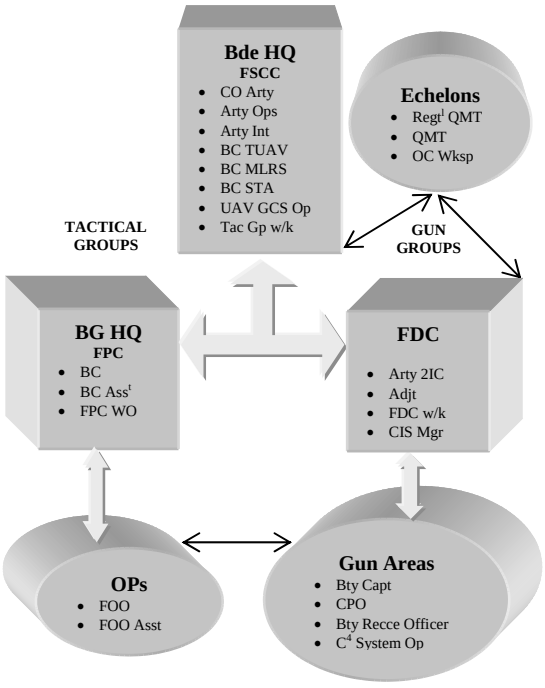
Target Audience Description

To deliver an Indirect Fire capability, a close support artillery regiment deploys a Tactical Group and a Gun Group within a Brigade formation. To define who from these groups will comprise the target audience, the selection criteria to apply is if they perform a key C^2 function at Brigade level. This results in a target audience of 24 roles from within a close support field artillery regiment (refer Figure 1). The Tactical Group target audience component comprises:

1. CO and personnel within the Fire Support Co-ordination Cell (FSCC) who deploy at Brigade level;
2. Battery Commanders (BCs) and personnel within the Fire Planning Cell (FPC) who deploy at Battle Group level;
3. Forward Observation Officer (FOO) parties who deploy at company/squadron level.

The target audience from the Gun Group consists of personnel within the Fire Direction Centre (FDC), the Ammunition Control Point and the Gun Batteries.

Figure 1. Schematic of C^2 Target Audience



The training system resulting from the TNA's findings will address the training needs of the target audience, but in doing so it is necessary for the TNA to identify precisely those personnel who will interface with the target audience to provide and receive information that supports the conduct of C^2 operations by the target audience. In other words, the TNA must identify the High Level Exercise Controllers (HICONs) and the Low Level Exercise Controllers (LOCONs).

OTL Development

In developing the OTLs, the aim was to identify all the C^2 tasks undertaken by the target audience. In an HMI focused TNA, Hierarchical Task Analysis (HTA) is undertaken to identify the operators' behavioural tasks. For example, observable actions are identified e.g. Switch on, Push, Press etc. It was recognised that the language and format of the HTA methodology, typically used during equipment based TNAs, was not suitable to identify and represent the cognitive and dynamic nature of C^2 operations. Examples of cognitive tasks include non-observable, mental actions e.g. Decide, Judge, Analyse etc.

OTL Structure

An OTL structure and supporting taxonomies were developed which would prompt:

1. A description of collective and individual-team tasks that were relevant to the target audience;
2. Use of language to describe both the behavioural and cognitive activities associated with C2 operations;
3. An identification of the inputs required to initiate the conduct of the collective task and outputs – thus representing the communication flow between the target audience and the HICON/LOCON interfaces.

The structure was informed by the results taken from a review of the literature on Cognitive Task Analysis (CTA) techniques, team training analysis methodologies and C^2 competencies. Articles reviewed highlighted the role of decision-making and communication networks in the performance of collective, C^2 tasks.

An extract from the OTL is presented at Table 1. The Royal Artillery's Collective Training Standards (CTSs) were used as a framework to identify the collective tasks. The generated OTLs would identify how each individual contributed to the performance of a CTS and who the individual requires to interface with. Table 1 demonstrates that for CTS number 2.1.A.2 'Co-ordinate fire support' CO Arty receives an input or a

trigger to perform a task from the Brigade Commander (Bde Comd), he performs his tasks, (ref 1.1 -1.3), to achieve the CTS and finalises the task by directing the Ops Officer.

Table 1. Example of the OTL Structure

Level of Task	Description
CTS	2.1.A.2 Co-ordinate fire support
CTS Input	Receive course of action from Bde Comd
Individual Tasks	1. Establish priorities for fire support
	1.1 Take decisions on changing priorities
	1.2 Re-allocate ammunition as necessary
	1.3 Allocate CO's reserve ammunition
CTS Output	Give Ops Officer priorities for allocation of resources

Methodology
Questionnaires were developed and interviews were conducted with current Artillery target audience representatives to collect the OTL data. The Artillery Subject Matter Experts (SMEs) were requested to identify the cognitive and behavioural tasks they would perform in order to achieve each CTS, who they would require to communicate with in order to perform their tasks and the task input and output.

The raw OTL data was analysed to ensure each task was written as a clear and concise statement, ordered hierarchically and there was consistency in terminology within and between individual task lists.

Identification of Standards

It was apparent that the C^2 tasks do not lend themselves to being assigned fixed, objective standards, e.g. Issue Fire Plan within 15 minutes. Therefore an interview was conducted with an SME from Divisional HQ to determine performance criteria for each task. Consequently, standards were identified which were more subjective in nature than those assigned to behavioural tasks. Table 2 demonstrates an example of a performance criteria. In addition, the correct procedures for supporting each task were identified by referring to Artillery Reference Documentation which listed the procedures.

Table 2. Example of a Performance Criteria

Task	Direct the production of deployment orders
Performance Criteria	Provide sufficient detail to allow assets to optimize their capabilities whilst maintaining availability.

Operational Task Statement

Following the identification of standards, the identification of conditions, the conduct of Difficulty, Importance and Frequency analysis and the production of the Operational Task Statement did not differ from MoD guidelines.

TRAINING GAP ANALYSIS

The scope of this section will include a description of the methodology used to identify Knowledge, Skills and Attitudes (KSA), Fidelity Analysis and an analysis of IFS Exercise Manpower Requirements.

KSA Analysis

The objective of this analysis was to identify the KSA associated with each CTS decomposed during the OTA. It was assumed that the target audience was competent in their individual roles and possessed the required physical skills to operate the IFS equipment prior to receiving collective C^2 training. The analysis therefore identified KSAs which were required to support the collective performance of each CTS.

KSA Definition
Knowledge was defined as the acquisition and retention of principles, theories, procedures or concepts.

Skills were defined as abilities and are predominantly mental in nature for C^2 tasks. Mental skills refer to the cognitive activity where the human receives, filters and processes knowledge and information.

The definition of attitudes adopted in the TNA was influenced by the definition coined by Rosenburg and Hovland (1960). Rosenburg and Hovland define an attitude as, 'Predispositions to respond to some class of stimuli with certain classes of response.' The authors propose a three-component view of attitudes comprising cognitive, behavioural and affective components. Cognitive components refer to what you

believe or what opinions you hold, behavioural components refer to the display of overt actions and affective components refer to evaluative feelings and preferences. The attitudes identified for the CTS tasks are predominantly behavioural and affective, and imply that an individual has preferences to perform certain behaviours or displays an acceptance to perform the required behaviours.

Table 3. An Extract from the C2 IFS KSA Analysis

Knowledge Elements	**Definition**
Tactical Situation	Knowledge of the battlespace that allows the team to predict the outcome of its own actions and forecast the actions of the enemy.
Influence of own role on team performance	Knowledge of the implications of individual actions on the performance of other team members.
Others competence	Knowledge of others strengths, weaknesses and experience levels and impact on the team objectives.
Skill Elements	**Definition**
Process incomplete or inaccurate information	Ability to support the decision making process by drawing workable conclusions from an evolving information flow at times suited to the tempo of operations, regardless of the completeness of the data.
Co-ordinate with other IFS teams	Ability to share and transfer data across the battlespace to improve the synergy of the IFS.
Implement time management strategies	Ability to manage workload within time constraints.
Communicate clearly and concisely	Ability to convey your meaning unambiguously and in a timely manner.
Maintain composure in chaotic environment	Ability to prioritise and think clearly in conditions where confusing signals from multiple sources distract the efforts of achieving goals.
Attitude Elements	**Definition**
Trust other team members	Accept the need to delegate autonomous action to subordinate without excessive and time-consuming checks.
Co-operate with other team members	Accept the need to work with others to achieve a team objective.
Seek advice and suggestions from others	Accept the need to request advice and knowledge from other team members.

Methodology

The KSA required for each member of the target audience to co-ordinate their behaviour collectively, to perform each CTS, was discussed with an SME. This process included reference to generic definitions of effective teamwork, (e.g. co-operation, co-ordination, communication, situational awareness, workload management). These definitions were discussed with an SME and contextualized given a specific requirement of C^2 IFS procedures. An extract of the KSAs identified during this analysis are presented at Table 3

Fidelity Analysis

The objective of Fidelity Analysis is to determine the appropriate Physical, Functional and Environmental Fidelity factors, reflecting the degree of realism each task requires to permit effective training. In an equipment based TNA the fidelity factors focus upon aspects of the HMI which require replication in the training environment. Analysis of the Human-Equipment fidelity requirements were outside the scope of the TNA and it was assumed that the functionality of the equipment in the training solution will be capable of supporting the identified tasks.

The focus of the fidelity analysis for this cognitive based TNA was based upon those aspects of the Human-Human Interface, rather than the HMI, which need to be replicated to support the performance of IFS C^2 tasks.

Fidelity Categories
The definition and composition of Functional and Environmental Fidelity categories did not differ significantly from MoD guidelines. The Functional Fidelity category included the replication of the Format, Content and Response rate of information and the Environmental Fidelity category included the replication of Sound, Motion and Ambience. It was the Physical Fidelity category which was modified the most, from MoD guidelines, to suit the nature of IFS C^2 tasks, especially with regard to the communicative aspects. This category included the following elements:

1. **Communication modes.** How important is face to face, radio or written modes of communication to the performance of the task?
2. **Location.** How important is the co-location of individuals to the performance of the tasks?

Methodology
Fidelity Analysis was conducted for all tasks in consultation with an SME. The SME was required to assess each task against the Physical, Functional and Environmental Fidelity categories on a 4-point rating scale in accordance with MoD guidelines.

Output
It was concluded from the Fidelity Analysis that the replication of the Functional Fidelity aspects was highly important to the performance of IFS C^2 tasks. As already stated the communication of information is a key aspect of C^2 tasks, therefore it was important to replicate the format, content and response rate of C^2 information communicated within the IFS. Functional Fidelity was rated as highly important for all of the IFS tasks.

The replication of Environmental Fidelity factors was rated as being of low/medium importance to the performance of IFS C^2 tasks. It was acknowledged that although the replication of Battlefield noise had an impact upon the realism of the training environment, it had little impact on training. Motion was not required to be replicated as the majority of C^2 duties are performed whilst stationary and the replication of ambience was perceived to have little impact on training.

The assessment of the Physical Fidelity factors were more bespoke to each IFS task, owing to the differences in communication properties between tasks. The analysis identified the delivery means of the information input and output and whether the sender or receiver would be able to be represented as a HICON or a LOCON function within the resultant training system. If a one-way flow of information is required, then it was assumed that the sender and receiver could be a human or synthetic HICON or a LOCON, however if a two-way flow of information or interaction is required, then it was assumed that the sender or receiver would be required to take part in an IFS exercise. In addition it was identified whether the sender, processor and receiver of information are required to be co-located to perform the task and was rated as yes, no or either.

IFS Exercise Manpower Requirements

This section will describe how the data captured during the identification of OTLs and the fidelity analysis was used to inform the manpower requirements needed to support an IFS exercise. The scope of the manpower analysis included the analysis of HICON, LOCON and Exercise Controller (EXCON) requirements.

Methodology
Using the OTA and outputs of the Fidelity Analysis a set of communication flow diagrams were developed to represent the senders of information to the target audience and the recipients of information from the target audience.

SME review of the communication flow diagram was undertaken with the following objectives:

1. Classify each sender and receiver as a HICON or a LOCON to an IFS exercise, depending on their hierarchical position in a Brigade formation.
2. Assess whether the individual performing each HICON or LOCON input was required to attend in person to support an IFS exercise.
3. Identify the competence, experience and rank levels required to carry out each HICON or LOCON input and their potential availability to do so.
4. Assess whether the HICON or LOCON function could be performed by a more junior individual (A substitute) and identify the most appropriate individual to represent a group input (A representative).

Following the identification of the HICON and LOCON inputs, the SME was requested to analyse whether the information provided by each HICON and LOCON could be synthetically modelled, or whether the suggested individual was required to be present (i.e. a human input).

Following the identification of which HICON and LOCON inputs were required to attend an IFS exercise, interviews were conducted with an SME to recommend the EXCON manpower required to support an IFS exercise. It was assumed that EXCONs would be required to control an IFS exercise, brief and debrief the IFS Command Team and HICONs/LOCONs and to maintain the consistency of control standards within and between exercises. EXCONs were recommended who had specific artillery expertise and training delivery expertise.

DISCUSSION

The aim of this paper was to demonstrate how current military TNA guidance, which is equipment focussed, can be enhanced to address collective C^2 training requirements. The project demonstrated the effectiveness of modifying a generic equipment based TNA methodology to suit the specific requirements of a collective training TNA. The C^2 aspects of the IFS tasks were identified by integrating the language and formats typically used by CTA into the OTLs. This resulted in an identification of the cognitive, decision making tasks undertaken during C^2 operations and representation of the flow of information between co-located and distributed teams.

TNA is a process by which the data collected in the initial stages of a TNA informs subsequent phases, therefore in the application of a TNA methodology, it is imperative that the data collected in the initial stages of the TNA informs later data requirements. The integration of inputs and outputs of information in the OTLs and their source enabled this data to be utilised to inform the fidelity analysis and the analysis of HICON and LOCON manpower inputs. This enabled a comprehensive analysis of manpower required to support an IFS exercise.

CONCLUSIONS

With the careful development of Operational Task Lists to enable them to be fully representative of cognitive, C^2 operational functions, the current UK military TNA methodology for individual training can be successfully adapted to meet the requirements of collective and team training analyses.

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