Hierarchical Task Analysis using a Synthetic Environment based on Close Air Support Missions

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Abstract

Hierarchical Task Analyses (HTAs) were conducted during a Military Judgement Panel (MJP) to capture the various tasks carried out by Forward Air Controllers (FACs) and Pilots, during Close Air Support operations. The analyses were derived from observations and post-operational interviews carried out during and immediately following simulated operational scenarios completed within a synthetic environment (SE), adapted from a gaming platform. The aim of the MJP was to validate the SE, evaluate the implementation of simulated Situational Awareness tools and Target Identification Devices (TID) to support FACs in the Combat Identification process, and contribute to the de-risking of a full experiment using the SE.

This paper summarises the methods employed to generate detailed task analyses of FACs and Pilots interacting within a novel SE environment, which provide a useful reference tool to aid future experimental design, fault analysis and best practice benchmarking.

Introduction

Combat Identification (CID) is a high priority for UK's military forces, both to support effective targeting of enemy forces and to prevent engagement of friendly forces and neutrals. A key component of the supporting research programme is the understanding of the human decision-making process which drives the identification of battlespace entities. Reference [1] outlines the main UK MOD research studies which have addressed the human factors issues for CID. Close Air Support (CAS) is a particular emphasis of the programme as it is an area where accurate targeting is essential. CAS is defined as air action against hostile forces that are in close proximity to friendly forces; for this reason there is some risk of friendly fire. A recent UK study interviewed UK Forward Air Controllers (FAC) and aircrew to derive a detailed understanding of the underlying elements that affect operators' decisions when involved in making decisions on weapons release in current air-to-ground operations [2]. This study recommended review and update of Standard Operating Procedures (SOPs) and team training to reduce misidentification of targets. The SE described in this paper has potential for both training of personnel and in development and assessment of new procedures.

A foundational element of the UK's Combat Identification research programme is the development of a model to represent the decision-making process. The work described in this paper is part of the validation and verification process for that model.

The Integrative Combat Identification Entity Relationship (INCIDER) Model

The INCIDER model was first developed in 2004 by the UK MOD's Defence Science and Technology Laboratory (Dstl). It is an operations research tool that predicts the outcome of encounters[1] for specific operational contexts (scenario vignettes). A number of Dstl reports provide the background and history of the model [3, 4, 5, 6]; reference [7] provides an open-source description of the work. A key feature of the development of INCIDER has been the use of an integrated analysis and experimentation programme to simultaneously develop model concepts and analysis tools whilst undertaking validation experimentation, and developing exploitation routes. This is represented in figure 1.

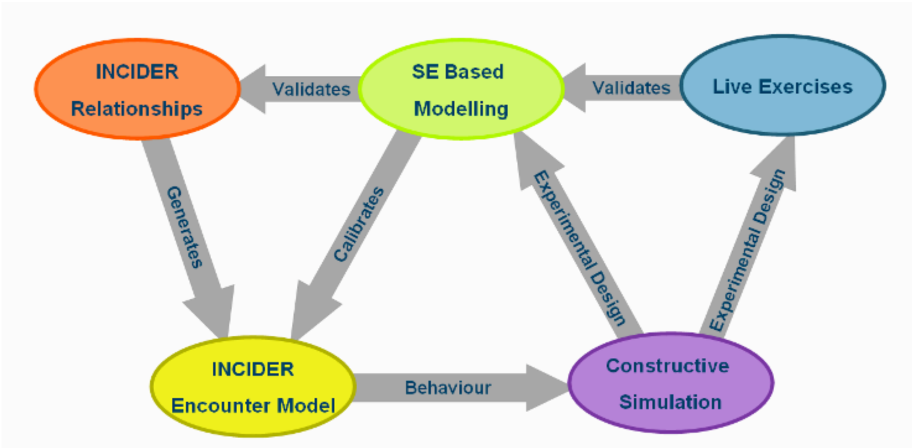

Figure 1: The INCIDER Integrated Analysis and Experimentation Programme

The Conceptual Model ("INCIDER Relationships" in figure 1) is a collection of factors (including human factors) that have an impact upon CID, together with their interrelationships. The Conceptual Model is used to develop the Encounter Model which represents CID encounters within specific operational contexts. SEs and live exercises[2] are used to calibrate and validate these models. Although the Encounter Model can be used stand-alone as an analysis tool, an additional strand of work is also attempting to use its concepts to drive the development of experimental constructive simulations.

The Military Judgement Panel Objectives

The principal objectives of the Military Judgement Panel (MJP) using the SE were: to validate the synthetic environment and associated scenarios; and to explore the implementation of Situational Awareness (SA) and Target Identification Device (TID) tools within simulated scenarios for experimentation. Although, not a principal aim, the opportunity arose to use observation and interview techniques to elicit the required information to create a detailed Hierarchical Task Analysis (HTA) of a Pilot and FAC operating within the SE.

This activity was used to further validate the representation of Close Air Support (CAS) for air-to-ground encounters within the INCIDER model. Additionally, the HTA was further reviewed to refine an experimental design proposal for further experimentation in this area during 2008/9.

[1] INCIDER defines an encounter as being the process of a single decision maker detecting, recognising and identifying an unknown object or entity in the battlespace, within a specific scenario.
[2] Such as the Coalition Combat ID Advanced Concept Technology Demonstrator (ACTD) exercises URGENT QUEST and BOLD QUEST.

Four military Subject Matter Experts (SMEs) supported the MJP: one Royal Air Force pilot, two Forward Air-Controllers (1 RAF, 1 Territorial Army Royal Artillery) and one Royal Artillery Mortar Fire Controller.

Experimental Procedure and Lay-out

The MJP was run over two days over which time three scenarios were run. The first scenario was essentially used as baseline training for the participants and so on data from scenarios 2 and 3 were analysed. This scenario was used for familiarisation in using the SE, thus reducing this as a confounding variable within the data collected.

To fulfil the aims of the MJP, Scenarios 2 and 3 were each run twice. The initial runs were used to verify the SE, to evaluate the implementation of simulated SA tools and TID to support FACs in the CID process, and to contribute to the de-risking of a future full experiment using the SE. Once the SE was verified, the re-runs were used for data collection to develop the HTAs. This paper will only describe the development of the HTAs.

The experiment used two workstations: one representing the pilot, the other the FAC. The Synthetic Environment used was the Forward Air Controller Synthetic Environment (FACSE) which is based on the commercial game 'Lock-On$_{TM}$'[3].

For each scenario run all data were time-stamped from the commencement of the trial. The FACs/Pilots were given free rein to complete the 'briefed' task of detecting, identifying and prosecuting a hostile target within the SE. The trial ran until such time that a target had been identified, tracked and prosecuted; in essence until completion of the 'kill chain'.

After each session the observer analyst notes were used to guide the open-ended questions asked of the operators in order to generate a much clearer understanding of what occurred during a scenario and why.

The laboratory set-up is detailed within figure 2. Both the Pilot and FAC workstations were accommodated within the same laboratory. Open microphone communications were installed to allow communication between the FAC and Pilot, exercise controller and data recording operator. The open communications ensured that the various players and controllers remained synchronised and any technical problems could be recorded and dealt with during scenario runs. All verbal communications were recorded for further offline analysis.

[3] Lock-On was developed by the Fighter Collection which is an organisation based at Duxford Airfield in the UK (www.fighter-collection.com). FACSE is a training aid developed in conjunction with HVR Consulting (www.hvr-csl.co.uk).

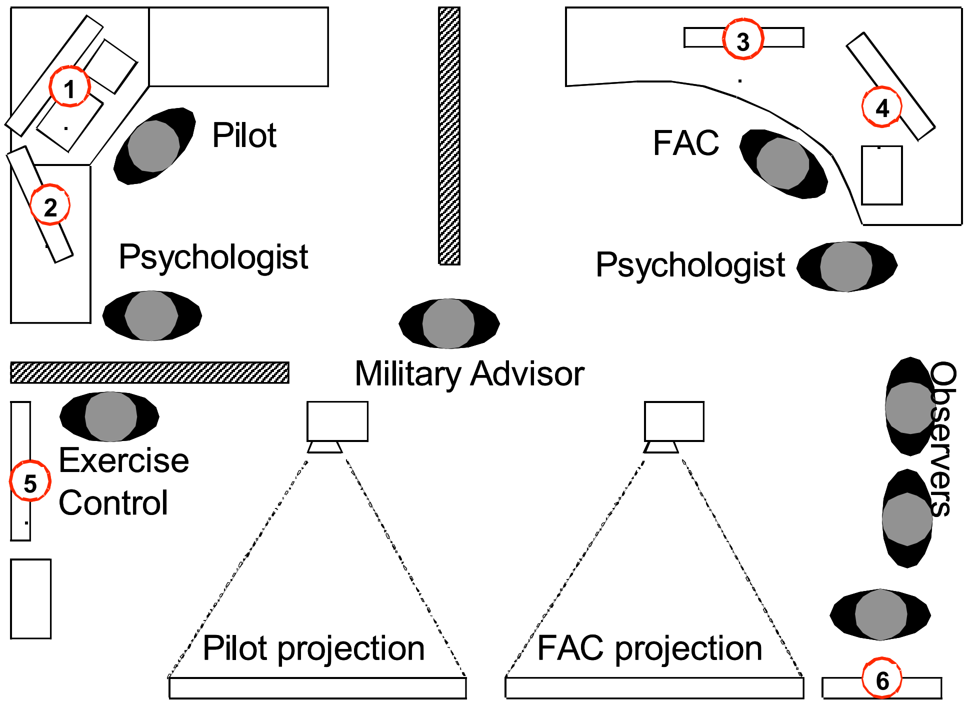

Figure 2: Laboratory Layout for Combat ID MJP

Key to Layout Interfaces:
1) Pilot workstation
2) Delayed Blue Force Situational Awareness pilot screen
3) FAC map / Blue Force SA screen.
4) FAC workstation
5) Observer workstation: SA control
6) Server workstation: voice communications recording

As indicated within figure 2, a psychologist/human factors observer was assigned to each of the FAC and Pilot to observe all actions and record outline communications in real time. Follow-up data collection involved post-scenario interviews with the FAC and pilot to ensure that a complete and clear record of actions and behaviours was recorded. This was further supplemented by analysis of the recorded verbal communications transcripts. A military adviser also observed the proceedings, specifically noting inconsistencies with standard procedures and any factors which affected the general realism of the SE.

The human factors observers used independent time recording to log actions and verbal communications to the nearest minute within the course of the scenario. This level of granularity was sufficient to provide an accurate record of what each of the operators did within the scenario and crucially to provide an outline structure from which to conduct a more detailed post-scenario interview with each of the operators in turn.

Post-Scenario Interviews

The post-scenario interviews were conducted using the human factors observer notes as a guideline. The FAC and Pilot were encouraged to provide sufficient detail within the post-scenario interviews to ensure a clear understanding of the tasks and events undertaken during the scenario, including the reasons why certain things occurred at specific time points. This semi-structured open-interview technique appears to provide an appropriate means to elicit the relevant details from the FAC and Pilot concerning the scenario; this is reinforced by the use of the same approach in Reference [2]. The human factors observers made notes of instances where workload seemed particularly high, any errors that were made and other points of note throughout the scenarios. These notes were used as prompts during the interviews to extract additional error or workload-focussed queries. This method is recommended for future MJPs and experiments.

Follow-up Analyses

A HTA was conducted using the data generated during the MJP [8]. Specifically the human factors observer notes and post-scenario interviews were used to create generic task analyses for the pilot and FAC respectively. Once draft diagrams had been prepared further verification was obtained through follow-up interviews with the Pilot and Forward Air Controller SMEs.

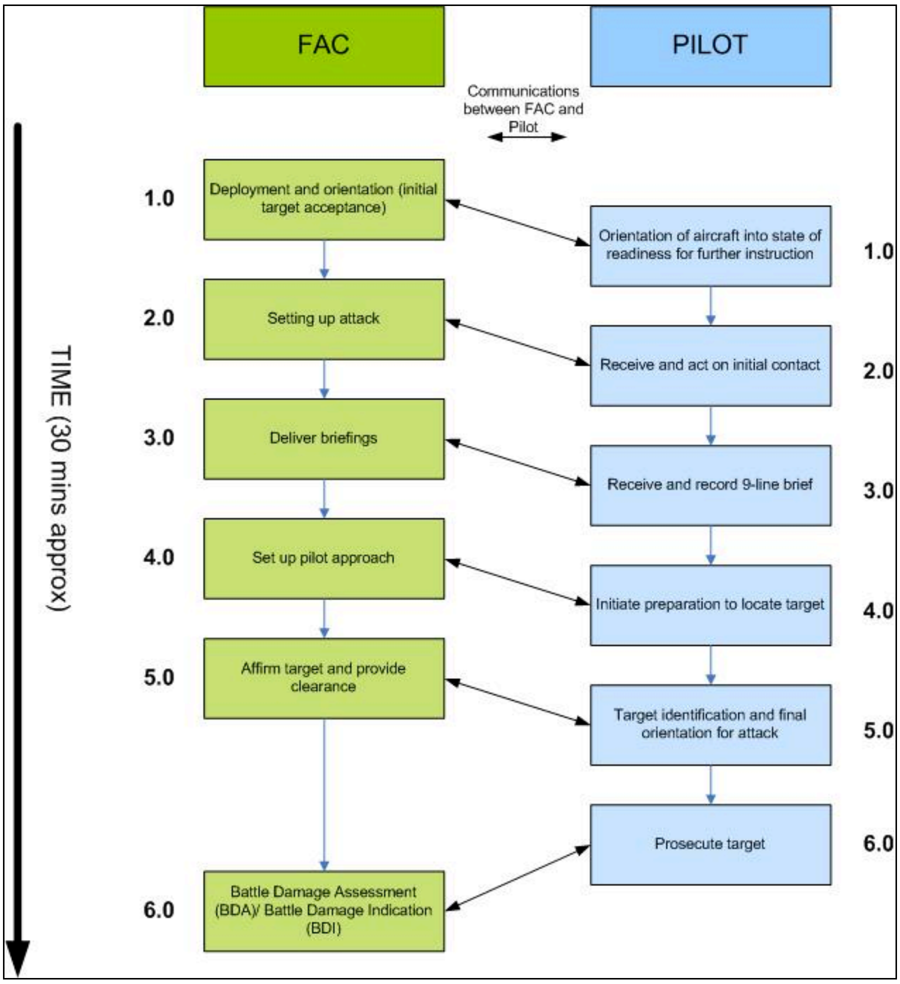

Figure 3: Summary Task Diagram for FAC-Pilot Tasks during a Generic Scenario with the Synthetic Environment

Figure 3 summarises the top level tasks for both the FAC and Pilot in parallel. Essentially the tasks are comprised of actions completed by the two operators (FAC and Pilot) and the communications between them. The component task boxes are numbered to reflect the general order of tasks. Some tasks are optional depending on scenario-specific circumstances. Other tasks may be skipped or perhaps completed at an earlier or later time point. The tasks detailed have been agreed with subject matter experts to be the minimum number of tasks to faithfully represent that required to prosecute a successful attack on a target within the synthetic environment employed during the Military Judgement Panel.

Results

Workload

The HTA diagrams can provide a useful means to identify those points where workload would hypothetically be higher, through discussion with an appropriate SME. In this case, for the FAC the highest workload tasks are tasks 2.0, 3.0 and 5.0. For the pilot tasks 3.0, 4.0, 5.0 and 6.0 are identified as being periods of highest workload. Using the task analysis diagrams a more comprehensive workload approximation could be made through further discussion with one or a number of SMEs. However, more appropriately, standardised measures of workload could be collected during scenario runs, using the diagrams as guidance for appropriate moments to capture the data, without interfering with the ongoing tasks.

Errors

Errors were not formally recorded during the MJP; however, where errors occurred, they were noted and discussed during the post-scenario wash-ups. Errors identified and recorded informally within the post-scenario interview transcripts were rare in the two scenarios analysed. The most notable error was when the FAC communicated incorrect attack approach information to the pilot (East-West instead of West-East). This error was corrected by the pilot without mention during the scenario, based on previously briefed knowledge. Where slight errors did occur they seemed to be corrected without resort to verbal clarification, and therefore were relatively difficult to detect. There were no blue-on-blue incidents recorded in any of the scenarios run, including the two scenarios used for the human factors analysis. A formal comparison of the task analysis with a formal fault tree may provide more useful information concerning the likely points where errors could be made and highlight methodological means to capture those errors and integrate this information into any post-scenario interviews.

Team Cognition

Although the HTA gives a greater understanding of cognitive tasks, there is a requirement to start to understand the social dimensions of team cognition. Currently the INCIDER model represents a single decision maker, the future need is to represent a team and identify Combat ID issues.

Blueprint to Support Experimental Design

The primary application of this HTA analysis is to support future experimental design. The comprehensive record of tasks and the formalised structure provides a useful framework from which to identify suitable dependent measures. The HTA can further provide a benchmark for subsequent comparison in terms of scenario. For example where a scenario does not require the use of 'units of measure' certain associated tasks will not be necessary.

The HTA can be interrogated to identify and select the key measures for comparison. The number of times the SA tool is used, or the number of communications required to prosecute a target, are two obvious candidates which may provide useful data. Through familiarity with the HTA the probable points at which these measures might be taken can be clearly and readily understood.

References

* The marked reports are available to TTCP participating nations via the third author of this paper.

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