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"Analysis and planning using THE HTA TOOL"

C2 Assessment Tools and Metrics, Multi-national Endeavors, Organizational Issues

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Analysis and planning using THE HTA TOOL

Abstract

At the 12th ICCRTS, an approach to agile planning was presented (Farmilo, Whitworth and Hone, 2007), that made use of the planning function in THE HTA TOOL – a freeware task analysis tool developed at Cranfield University. The capability of the tool has now been extended so as to provide the ability to handle high-level analyses of complex operations, such as multi-force or multinational. Different forces (and/or different nationalities) can be color-coded so that individual patterns of actions, tasks, or responsibilities, can be easily identified, traced throughout the analysis, and related to other force components. A second extension to the tool has enabled the non-availability of particular assets to restrict the scope of the planning function in a way that indicates the relative merits of these assets. The proposed use is not intended to replace existing tools designed for detailed planning, but the paper will discuss the direct benefits of using this type of computerized application, look at examples of mission planning and how these utilize the additional features of the tool.

Keywords: task analysis, HTA, mission planning, coalition operations, multi-force, multinational, color-coding, task allocation, C2 tools

Introduction

Military and peace-keeping operations are no longer conducted by single services or a single national force. They are increasingly "joint" down to the tactical level and likely to be conducted within a coalition or alliance such as NATO (Blais, Galvin and Hieb, 2007). Coalitions pose many challenges for the multinational force commander. The increased level of communication adds a new level of complexity to operations, in terms of consistency and dissemination of information, cultural influences, allocation of responsibility and, perhaps most importantly, to command and control.

Hierarchical Task Analysis (HTA) is a technique which can be used to model any situation with a hierarchical structure, such as an organization (chain of command) or operation. Until recently there have been no software-based tools to aid the HTA practitioner in the conduct of an analysis. The Human Factors Integration Defence Technology Centre (HFI-DTC) have drawn on their expertise to develop THE HTA TOOL, a software application to facilitate the construction of a computerized HTA. This paper discusses the ways in which the tool can support the analysis of complex operations, such as multi-force or multinational.

Hierarchical Task Analysis

Hierarchical Task Analysis is a recognized method for describing a task in terms of a hierarchy of operations and plans based on structure chart notation. HTA is generally recognized to have been formalized by Annett and Duncan (1967) although it originates from the beginning of the 20th century. An example HTA is shown in Figure 1 (please note this is a simple example usually discussed for training purposes).

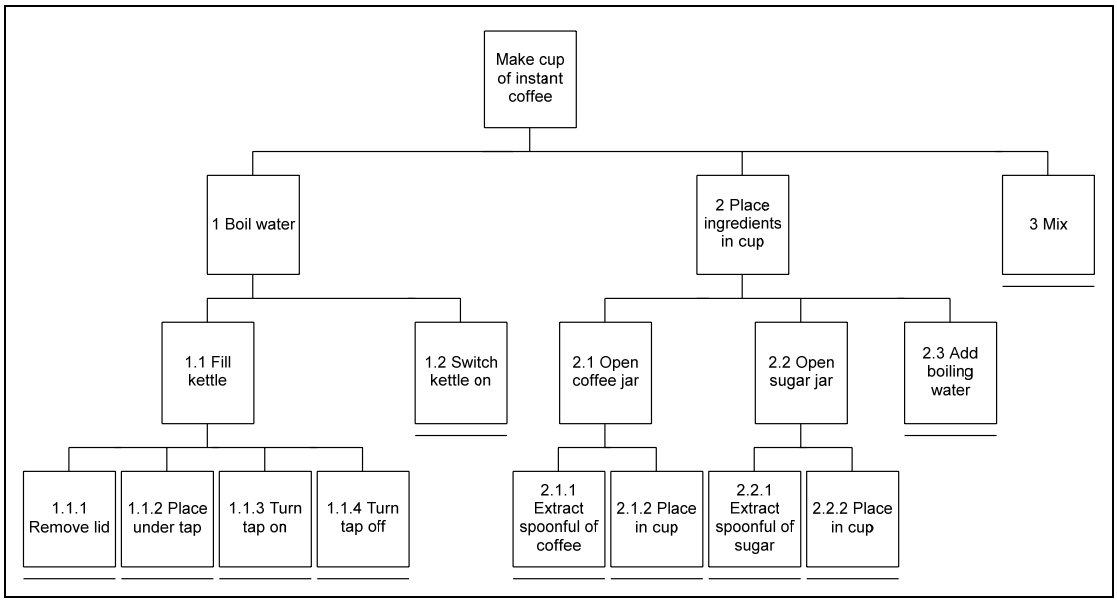

Figure 1. Example Hierarchical Task Analysis

The HTA technique involves recursively breaking down an overall goal, such as “Make cup of instant coffee”, into a sequence of sub-components (“boil water”, “place ingredients in cup”, “mix”), then decomposing those further until it is not possible to break down the cognitive or psychomotor activity any more, or to a point where additional decomposition is not considered useful for the application. This methodology has implementations in a wide range of fields from the simple (as above) to complex and safety critical systems. Indeed, Salmon, Stanton, Walker and Green (2004) reference a number of domains in which HTA has been applied, including the process control, and power generation industries, emergency services, civil aviation, retail, as well as military. It also parallels the software engineering approach of hierarchical decomposition.

One of the main advantages of HTA is that it is a simple concept, easy to learn and use. The hierarchical approach allows the analyst to concentrate on specific, more complex or important, aspects of the overall task. It is also a very powerful technique because it can be used in a variety of domains (see above), and forms the basis of many other assessments and task analysis methodologies, e.g. DIF (Difficulty, Importance,

Frequency) analysis, KSA (Knowledge, Skills and Attitudes) analysis, communication analysis and OPSs (Operational Performance Statements) (Hone and Stanton 2004).

However, there are some drawbacks to "hardcopy" HTAs: they can become particularly large and unwieldy for any non-trivial situation, and they are difficult to maintain - making alterations is a slow manual process and may require the re-creation of the whole analysis. It is also difficult to ensure an analysis does not contain errors (an HTA is only as good as the analyst who created it) and accounts for unforeseen eventualities, particularly as there is no uniform format to HTA and collaboration between analysts requires all to be present. Hone and Stanton (2004) also suggest that there is a need to increase the awareness and usage of HTA within the Armed Forces where it is not currently mandated and utilization often involves sub-contracting if a major analysis is required.

THE HTA TOOL

HTAs have traditionally been performed on paper or whiteboard, and later input into a computer as a record of the analysis or to be printed, often using any software package of the user's choosing (such as a spreadsheet) without specific consideration for future analysis (Hone and Stanton, 2004). Hone and Stanton report Microsoft Excel as the application of choice for data entry, but this is for representation only, and does not help in the conduct of the analysis. THE HTA TOOL was developed in response to a growing need for the computerization of the actual HTA process, from initial analysis through to potential modifications and reporting. It was developed non-commercially under the auspices of the Human Factors Integration-Defence Technology Centre (HFI-DTC), a Ministry of Defence (MoD) initiative, and is widely (and freely) available through a number of channels.

The original aim of the research was to produce a prototype tool which could support the range of HTA applications, and notably to create a tool to assist a user in analyzing and decomposing a task for training purposes. THE HTA TOOL was engineered following the Rapid Application Development (RAD) model at Cranfield University (Defence Academy campus), distributed to the MoD for critique in 2005, before being made available for public release, both in the UK and Internationally. It has been used by a number of multi-national corporations, for many applications beyond its original intentions, and with great success.

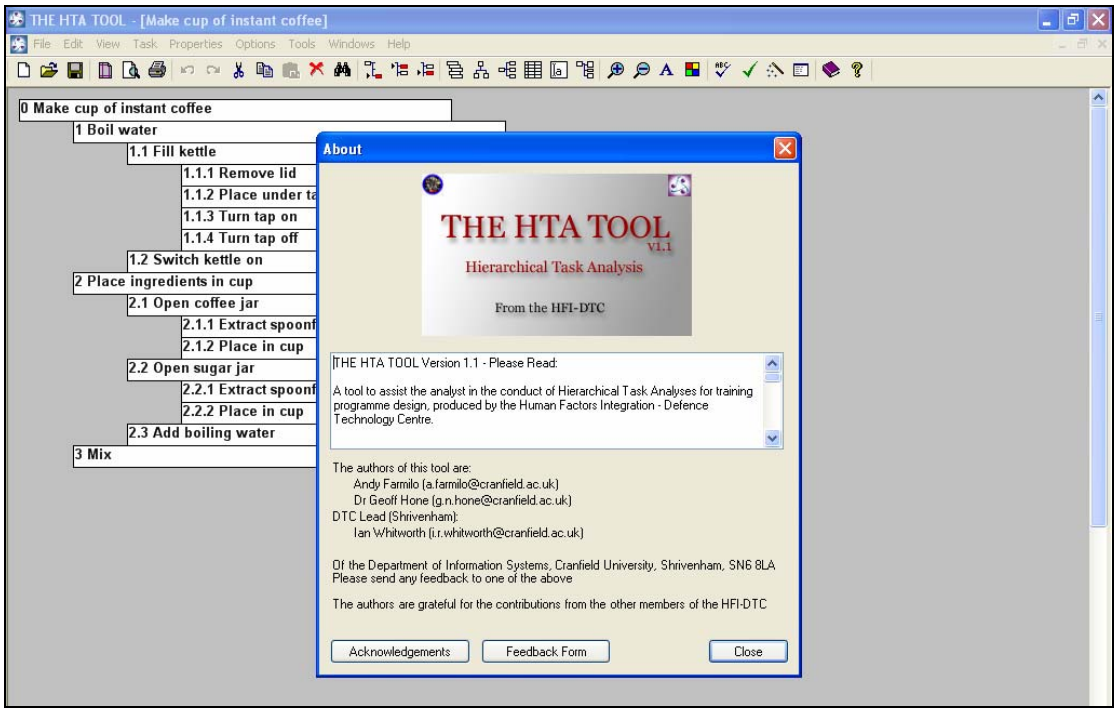

Figure 2. Screenshot of THE HTA TOOL

There are several advantages to using a computerized version of HTA as opposed to the traditional "hardcopy" method. The most obvious of these is the simplicity in making changes to task names, or indeed more comprehensive adjustments to the entire structure. A software tool also reduces the impact of the previously mentioned disadvantages of HTA: a) the plans facility of the tool allows for a number of ordering styles and for unlimited description (i.e. not restricted by the size of your drawing chart); b) having an electronic version of an analysis facilitates faster modification, greater collaboration between analysts, a standard, clear format for validation and verification, and THE HTA TOOL also has a built-in checker to highlight common structural mistakes.

In the 21st century our lives revolve around technology and computers. Computerized systems have endless power to offer if properly combined with human knowledge and expertise. Software can then help people do their jobs, quicker and more efficiently. THE HTA TOOL is one such software application which has been designed to improve the usability and usefulness of hierarchical task analysis. The tool is in use internationally on a diverse range of projects. For example, a major defense contractor (BAE Systems) is using THE HTA TOOL for air mission planning for the Euro-Fighter Typhoon.

Plans and Conditional Planning

With any type of mission planner there is a need for flexibility (Sakamoto, 2006) and to produce accurate results under time-pressure (Thunholm, 2006). A mission planner in the Command and Control system should also account for the uncertainty inherent in the operational execution of the missions. At this point an application like THE HTA TOOL becomes very powerful. It has an easy to use, intuitive interface, and changes can be made on-the-fly and, with the right network, disseminated around the chain of command in seconds.

The tool also facilitates a degree of uncertainty in the initial design phase by the construction of task plans. A plan can be described for any "parent" task in a hierarchy and expresses the order, timing and pre-conditions of "child" operations. There are built-in functions to produce plans automatically, or to highlight where a plan has not been included. Additionally, the plans system allows a considerable amount of customization, including a simple-to-follow plan builder using common order styles, such as linear and parallel, and provision for an analyst to provide a textual description for particularly complex situations (Figure 3). The plans system also allows selection from the standard text and symbol notation types, as recommended by Shepherd (Shepherd, 2001).

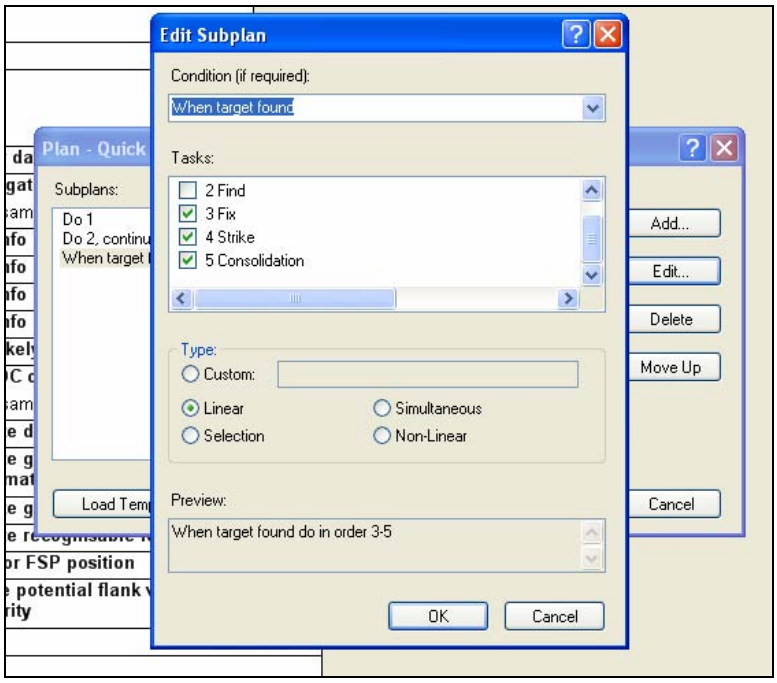

Figure 3. THE HTA TOOL Plan Builder

This part of the tool has recently been extended in response to a need to utilize its potential for supporting decision-making. It is now possible to indicate the non-availability of particular assets to restrict the scope of the planning function in a way that reveals the relative merits of those assets. A conditional item (see the "Condition (if required)" box in figure 3 above), such as, "If air support is available then" do the selected tasks, can be entered into a sub-plan. Depending on whether this condition is met it seems sensible to reveal or hide the resulting set of tasks accordingly. Currently, if the condition is not met (false) then the tasks are grayed out in each of the views as shown in figure 4, although it would be very simple to hide that part of the analysis completely. This allows the analyst, or decision maker, to concentrate only on those tasks that are still available/required.

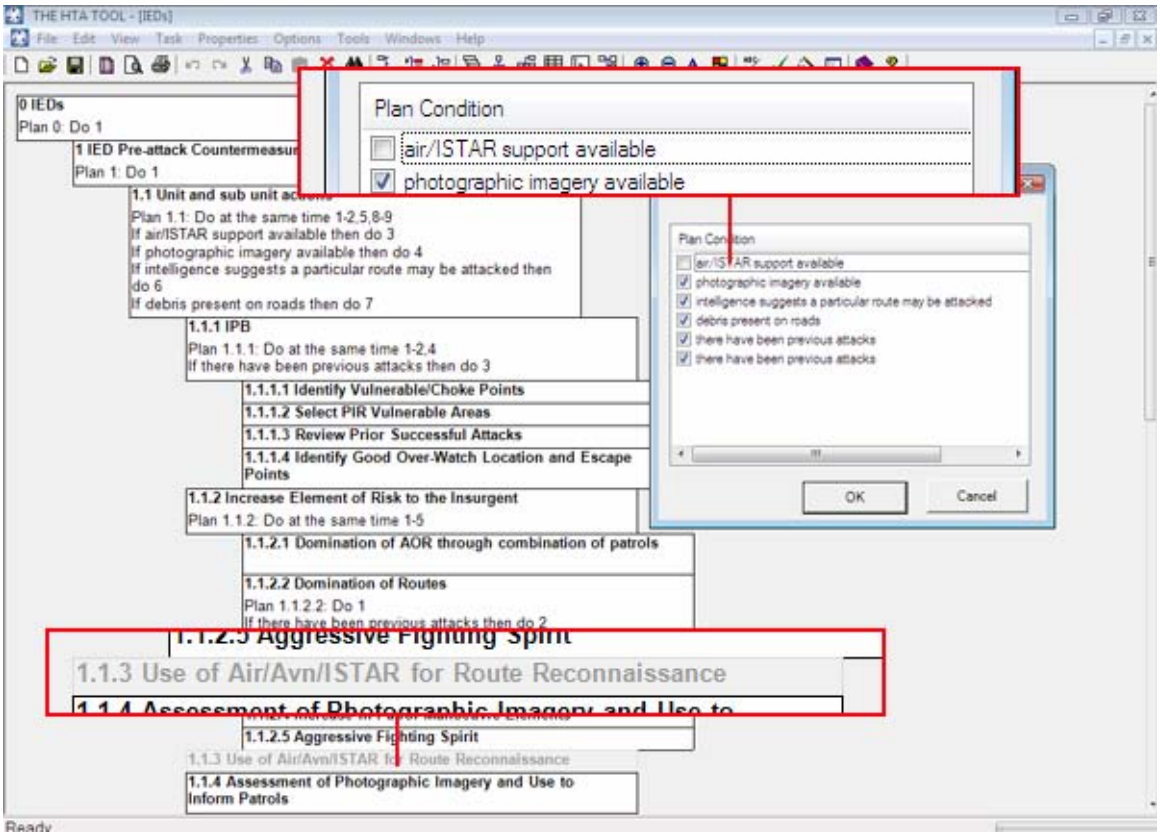

Figure 4. Example of Conditional Plans

In Figure 4 the condition of "air/ISTAR support available" is un-checked which means that there is no support available, therefore the corresponding task in the hierarchy – "Use of air support for route reconnaissance" – is not applicable and, therefore, displayed in gray. This particular feature, along with the tool itself, is being considered for use on an Improvised Explosive Device (IED) threat training and support program for Non Government Organizations (NGOs).

Task Allocation

One feature of THE HTA TOOL which is perhaps not as widely utilized as it could be is the ability to perform task allocation. A method by which this can be achieved is color-coding. Each task can be allocated a different color-code which can correspond to an individual, team, military unit, service or even country. It has been shown that color-coding tasks is an excellent way to keep teams and individuals informed of their own roles and remove ambiguity (PR Newswire Europe, 2007). In addition to allocating responsibilities to people an analysis can be color-coded so that individual patterns of actions or tasks can be easily identified, traced throughout the analysis, and related to other force components.

An example of an analysis where the task allocation capabilities of the tool have proved a major benefit is in the review of a chemical incident at a remote farm. This scenario begins with a report of possible hazardous materials on a farm, and then additional information becomes available, e.g. reports of casualties, problems with labeling on hazardous materials etc. The exercise was designed to encourage experienced fire-fighters to consider risks arising from hazardous materials and the appropriate courses of action they would need to take, e.g. in terms of protective equipment, incident management and information seeking activities (Baber, Houghton, McMaster, Salmon, Stanton, Stewart and Walker, 2004).

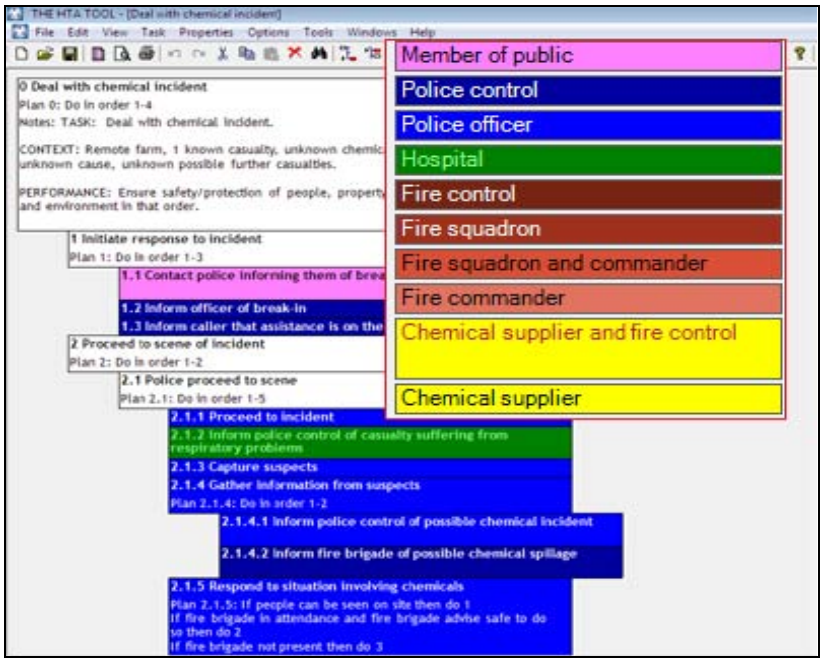

Figure 5. Chemical Incident example of color-coding

The chemical incident scenario involves the collaboration and coordination of four main agencies: police, hospital, fire and chemical response unit. From a timeline of events a hierarchical task analysis was generated including the following five main phases: initiate response to incident, perform initial incident assessment, chemical identification, chemical assessment, and resolve incident. For each of the phases tasks could be allocated against the various agencies, and this was achieved using THE HTA TOOL's color-coding facility, part of the resulting analysis is shown in Figure 5.

This scenario also makes extensive use of the tool's plan-generation feature. Following an analysis of a similar Fire Service-based incident, a Road Traffic Accident (RTA) involving a Chemical Tanker, the Fire Service Training College were said to have responded favorably to the concept of color-coding and planned to use the results in support of exercise training and debriefs (Baber, Houghton, McMaster, Salmon, Stanton, Stewart and Walker, 2004).

To put the tool into a military context there is another example of its use by the Future Strategic Tanker Aircraft (FSTA) project within the UK Ministry of Defence (MoD). Part of the project involves modifying the flight deck of the basic platform to incorporate military modifications. As a result a thorough task analysis was conducted before undertaking too much design work to reassure the MoD that the solution was workable.

Initially this was completed using a Microsoft Excel spreadsheet, but this had a number of drawbacks including:

- The information was not presented in an easily understandable format and the effects of changes in one area could not be shown in other areas without manual intervention
- The task analysis was at a high level and used 25 pages of UK size A3 paper (approximately 11" x 16") to print out with text at about 6pt. The full analysis would have been even more difficult to handle
- When deciding how best to allocate new military tasks, there was no convenient way of including the workloads of the four possible crew members under the circumstances when the new task was relevant

At which point THE HTA TOOL was trialed as a purpose-built application for HTA and part of the resulting analysis is shown below (Figure 6), including the use of color-codes to indicate tasks allocated to individuals or a number of crew members:

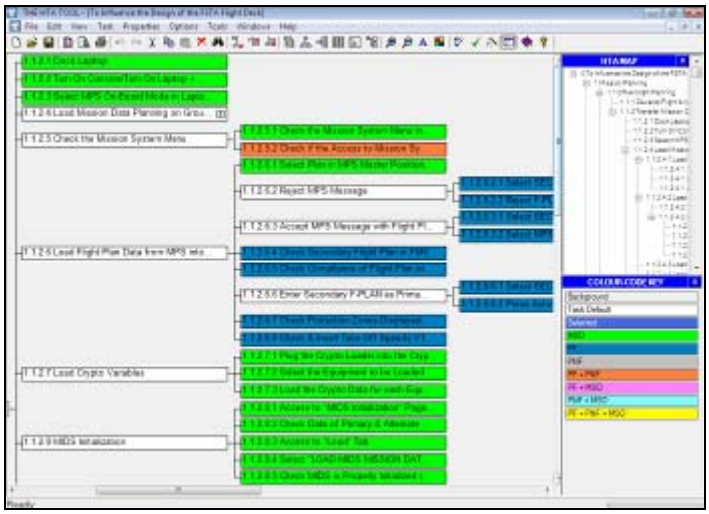

Figure 6. FSTA example use of color-coding

This analysis also goes one step further and defines additional properties for each task, such as for including further description on what the task involves and an assessment of workload. The ability to create properties provides another method of task allocation because you can create a text descriptor which identifies one or multiple actors, or alternatively define a selection list from which agents can be chosen and flagged if appropriate.

One drawback of the latest version of the tool is that only one color can be allocated to each task. From the extensive feedback received one of the suggestions for development is the ability for multiple color-codes to be associated with tasks, and perhaps the use of patterns or other forms of shading to differentiate between colors and subsequently allow the distinctions to still be visible if, for example, the analysis is printed in black and white.

Other Features and Developments

The tool boasts a number of advantages over traditional non-computerized methods. Initial analysis creation is simplified by the use of an Analysis Wizard which prompts the user for increasing levels of decomposition, one step at a time, as well as allowing quick selection of plans and an ability to load previously created sub-goal templates (custom-made sections of re-usable analysis). These could, for example, cover standard military tasks, the Mission Essential Task List (METL) comes to mind.

Any changes to the analysis result in an automatic update to the numbering system (in particular, and where appropriate, to the plans). The tool is designed to recognized graphical user interface (GUI) standards and has a familiar Microsoft Windows look and feel, including shortcut keys, menus and toolbar buttons. This enables a user to learn the tool's basic functions in a few hours. The analysis tree is easily modifiable, with the ability to insert, cut, copy and paste tasks at any level (with undo and redo options).

Hone and Stanton (2004) highlight that different analysts find different representations of an analysis more useful to them. As such, THE HTA TOOL supports all of the main visual representations of the decomposition, including indented list (Figure 2), vertical (Figure 1) and horizontal hierarchies, and tabular list. Using the latter an analysis can be extended using original or recommended techniques including DIF analysis. It is also possible to attach other information to tasks such as images - particularly useful for identification or clarification. When an agreed stopping point has been reached the analysis can be printed, with appropriate classification, or exported to a number of formats including XML (Extensible Markup Language), Vector Graphics metafile or Microsoft Excel.

Although the tool has many good features there is scope for development. The biggest potential improvement would be to increase the speed of the tool when a large number of properties are added or there are hundreds of tasks within an analysis. Enhancing this aspect of the tool would satisfy the needs of the majority of its current and future users. Furthermore, there may be advantages to developing a version of the software for hand-held computers such as PDAs, to provide changing, real-time operations information to commanders in the battlefield.

The current version facilitates the allocation of timings to each task, and these can utilize the allocated plans to calculate an overall expected time to complete. Figure 7 provides an example of this technique. Here, tasks A, B and C are carried out in parallel (see the plan for task 1), so the time required for task 1 is the largest of its sub-tasks, which is 6 hours. Whereas, tasks D, E and F are to be sequential so to find the total time required for task 2 you must sum the times for all its sub-tasks, which is 12 hours. As tasks 1 and 2 are also due to occur in sequence the total time required for the Overall Activity is 6 + 12 = 18 hours.

This method can provide a quick way of estimating how long it will take to complete a military operation, for example. But it is not easy to see where the timings have originated, or visualize how the operation is organized.

Super-ordinate	Task	Time to Complete (hrs)	Total Time Required (hrs)
0	**Overall Activity** Plan 0: Do in order 1-2		18
1	**Tasks done in parallel** Plan 1: Do at the same time 1-3		6
1.1	**Task A**	5	5
1.2	**Task B**	6	6
1.3	**Task C**	3	3
2	**Tasks done in sequence** Plan 2: Do in order 1-3		12
2.1	**Task D**	4	4
2.2	**Task E**	1	1
2.3	**Task F**	7	7

Figure 7. Example of Timings

One of the alternative diagrammatic views in THE HTA TOOL would help with the latter. But from the extensive collection of feedback a common suggestion for improvement to the tool has been to develop a flow charting view, which utilizes the plans system to display tasks as they would occur in chronological order. Examples of this concept are shown in Figures 8 and 9. This would be even more useful, for coalition operations in particular, if it could be shown which roles were currently utilized on each task along a timeline. It would then be possible to see which assets are available at a certain time and which are in high demand, or even meant to be “in two places at once”!

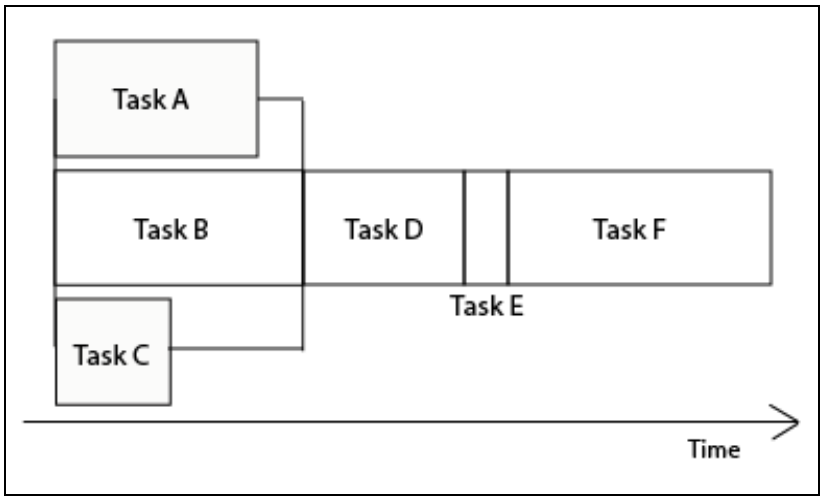

Figure 8. Example Timeline-based Flow Chart

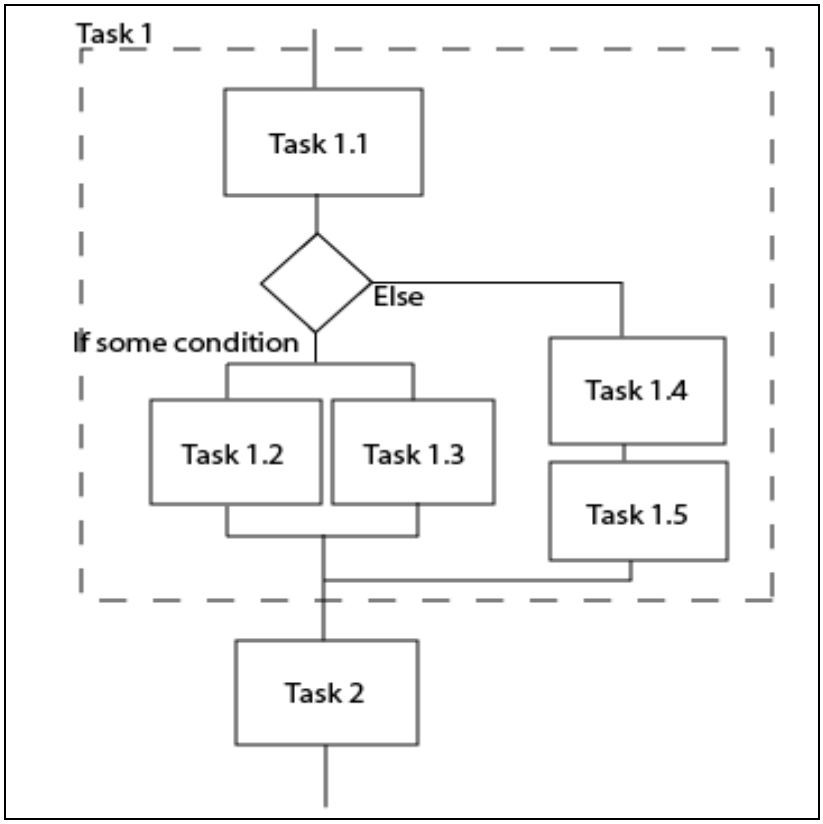

Figure 9. Traditional Flow Chart style with Hierarchy

Conclusion

Multinational operations are important. In contemporary theory, they offer international legitimacy while allowing the nation to capitalize on the various strengths of a unified effort (MacInnis, 2006). But the doctrinal, cultural, logistic and other differences between nations and organizations makes short-term coalition efforts very difficult to plan. MacInnis suggests that the best way to overcome the difficulties associated with coalitions would be a thorough and accurate mission analysis conducted by the multinational force commander and his staff (MacInnis, 2006). It has been shown that THE HTA TOOL is a viable support for this because it has the functionality, such as colour-coding and plans, to facilitate task analysis and allocation at all levels. Indeed it has already been utilized in this way by current users. The tool also has the advantages of being easy to maintain or modify an analysis with automatic updates including task plans. These are characteristics that could make it suitable for implementation in an agile, time-critical environment.

The intention is to continue developing THE HTA TOOL with multi-force and multi-national implementations in mind. This could include extending the color-coding feature of the tool to allow tasks to be allocated multiple codes. Other modifications which would be beneficial include either a flow chart or time-line based view of an analysis, particularly if the activities being performed by each role as time progresses could be viewed. Closer integration between tasks and plans, and cross-linkage between tasks would improve the tool. There may also be potential for collaboration with other planning tools and methods.

References

Blais, C., K. Galvin, and M. Hieb. 2007. Coalition Battle Management Language (C-BML) Study Group Report. Paper presented at the 12th International Command and Control Research and Technology Symposium, June 19-21, in Newport, RI

Annett, J. and K.D. Duncan. 1967. Task Analysis and Training Design. *Occupational Psychology*, 41, 211-221

Baber, C., R.J. Houghton, R. McMaster, P. Salmon, N.A. Stanton, R.J. Stewart, G. Walker. 2004. *Work Package 1.1.1 - Field Studies in the Emergency Services*. Human Factors Integration Defence Technology Centre

Farmilo, A., G.N. Hone and I.R. Whitworth. 2007. Using THE HTA TOOL for Agile Mission Planning. Paper presented at the 12th International Command and Control Research and Technology Symposium, June 19-21, in Newport, RI

Hone, G.N. and N. Stanton. 2004. *HTA: The development and use of tools for Hierarchical Task Analysis in the Armed Forces and elsewhere*. Human Factors Integration Defence Technology Centre

MacInnis, D. 2006. *Coalition Operations: Planning Considerations for the Good and the Bad*. Naval War College, Newport, RI

PR Newswire Europe. 2007. *Wasting Time on 'Pink' work? New colour coding system helps work teams redefine their roles*. http://www.prnewswire.co.uk/cgi/news/release?id=36500 Accessed 2007-11-23

Sakamoto, P. 2006. *UAV Mission Planning Under Uncertainty*. Alfred P Sloan School of Management, Massachusetts Institute of Technology (MIT)

Salmon, P., N.A. Stanton, G. Walker and D. Green. 2004. *Hierarchical Task Analysis Software Tool: Software specification recommendations*. Human Factors Integration Defence Technology Centre

Shepherd, A. 2001. *Hierarchical Task Analysis*. London: Taylor & Francis

Thunholm, P. 2006. A New Model for Tactical Mission Planning for the Swedish Armed Forces. Paper presented at the 2006 Command and Control Research and Technology Symposium, June 20-22, San Diego, CA