9th KCSO
&
22nd ICCRTS

"Frontiers of C2"

Where are the Knowledge Systems?
Understanding obstacles to technology adoption

Track 10: Knowledge Systems for Coalition Operations
(Paper no: 76)

Jitu Patel and Peter Houghton

Defence Science and Technology Laboratory, UK

For any inquiries regarding this paper, email jmpatel@dstl.gov.uk.

Abstract

Command and Control (C2) aspects of military operations, though very complex, knowledge intensive and usually time bounded, tend to be carried out with limited use of command and decision support tools. While there have been isolated successes such as the Dynamic Analysis and Replanning Tool used during operation Desert Shield, routine adoption of knowledge systems have remained low. The problem is not with the availability of technology, as defence (both Governments and Industries) have invested significant effort in tool development over the years. This paper will discuss findings from an earlier study, which investigated factors that may be contributing to the lack of exploitation of knowledge systems, and present insights from recent experience working in a standing joint force headquarters. The paper will conclude with an agenda for future research that contributes to our understanding of how best to improve technology adoption.

Introduction

Just over two decades ago, the ARPA/Rome Laboratory Planning Initiative (ARPI) organised annual Integrated Feasibility Demonstrations (IFDs) to foster transitioning of advanced technology, particularly knowledge systems[1], into operational systems (Tate, 1996). The first IFD was the Dynamic Analysis and Replanning Tool (DART), which was used during Operation Desert Shield by the US Transportation Command to support deployment planning (Bienkowski and Edwards 1996). DART is an example of a successful technology transition, but unfortunately successes such as this are transient and not universal.

If one were to walk into a division or brigade headquarters today, one would typically see a few large screen displays and rows of functionally-arranged tables with laptops. Each of the laptops would be networked, and some may be able to project information on the large screens. A more detailed look at the laptops would reveal that they have a plethora of applications, centred around standard office automation tools, but with a few others intended to support planning and decision making. However, a closer and continued inspection of which of the applications were being used would reveal that only the office automation tools (e.g., word processing, spreadsheet and drawing tools) are routinely used; and, one would be hard pressed to find much evidence of the use of anything else. Indeed, it would be more like to find that military staffs are stooping over paper maps, with some huddled next to whiteboards or flip-charts. This leads to an obvious question, why in this "information age" do people still prefer to carry out many of the primary activities manually?

One might have expected that within Command and Control (C2) aspects of military operations, given that they are very complex, knowledge intensive and usually time bounded would require more extensive use of command and decision support tools. The problem appears not to be with the availability of technology, as Defence (both Governments and Industries) has invested significant funds and effort in tool development over the years. The aim of this paper is to therefore to discuss findings from studies that have tried to identify those factors that may be contributing to the lack of exploitation of the tools, and also to present some insights from observing Joint Exercises over the years

[1] Planning and Decision Support Tools

and from more recent experience working in a standing joint force headquarters. The paper will conclude with an agenda for future research that contributes to our understanding of how best to improve take-up of technology in headquarters.

Challenges to Technology Adoption

In 2007 UK MOD commissioned a study on the challenges of technology insertion and the impacts that technologies have had upon organisations. One of the objectives of the study, relevant to the subject of this paper, was to review the state-of-the-art research on challenges to technology adoption. The study conducted a comprehensive review of the relevant literature and interviewed a number of subject matter experts. The literature review showed that the success rate of integrating technology with the business goals of an organisation was surprisingly low i.e. less than 50%. From the perspective of technology adoption, organisational factors such as the management support and the organisation's appetite for change appear to play a significant role in whether the technology will be used or not (Dawson 2007).

Ewusi-Mensah and Przasnyski (1991) argued that the success of a technology insertion project is strongly influenced by the degree of senior management involvement and the level of end-user participation. Related to the former, there is evidence that technology change succeeds when an organisation has both an appropriate political environment and change-favouring norms and culture (Tolbert and Zucker 1983). On the contrary, organisational politics can significantly hinder change programmes. For example, managers and staff can become major hurdles to a technology change if they believe their jobs are at stake, or they will be giving up some of their authority and control. To impede implementation processes people have used non-cooperative tactics such as "keeping out of the way", "withholding vital information" and demonstrating "non-availability" (Keen 1981).

Along with organisational culture and climate, Nielsen (1994) has argued that technology acceptability is also determined by users' perception of the usefulness of the technology which includes factors such as: how easy it is to learn, whether there are intuitive interfaces, the degree of memorability, quick recovery from errors, and overall user satisfaction. There is also an applicable theory: the Unified Theory of Acceptance and Use of Technology' (UTAUT), which aims to explain user intentions to use technology as well as explaining subsequent usage behaviour. The theory holds that four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behaviour. Gender, age, experience, and 'voluntariness' of use are posited to mediate the impact of the four key constructs on usage intention and behaviour. (Venkatesh et al. 2003).

Factors Affecting Adoption

In 2014 Dstl commissioned a more focussed study to understand why technology utilisation, particularly of command and decision support tools, has remained at such a low level. The aim was to investigate factors that might be contributing to the lack of exploitation of the intended utility of command support tools. The study was conducted by a multidisciplinary

team, drawn from Industry and Academia that used a combination of case studies, stakeholder interviews, literature reviews, and existing trials data to generate and integrate insights (Jaya-Ratnam et al. 2014).

The data was collected from interviews, and subsequent analysis categorised barriers to tool utilization in terms of common themes and issues as shown in Table 1 below.

Theme	*Description*
REQUIREMENTS	Issues that indicate that User requirement for the tool (or function it is supporting) may not have been fully understood or realised during acquisition.
DESIGN	Issues with the tool related to poor consideration of human factors and usability in the software and/or hardware design, e.g. usability, error management, physical ergonomics, accessibility from workstation
PERSONNEL	Issues associated with User characteristics, noting that each tool can have a range of different users – operators, commanders, maintainers, etc.
IMPLEMENTATION	Issues that could have been avoided through improved implementation and management of change, e.g. timing, senior champions, understanding benefits
TRAINING	Issues with training and education requirements, course content, timing or availability, e.g. refresher training, access to theatre tools on exercises.
SUPPORTABILITY	Issues associated with the need for improved or increased technical support, e.g. database mangers, computer expertise or maintenance once in-service.

Table 1: Data categorisation themes[2]

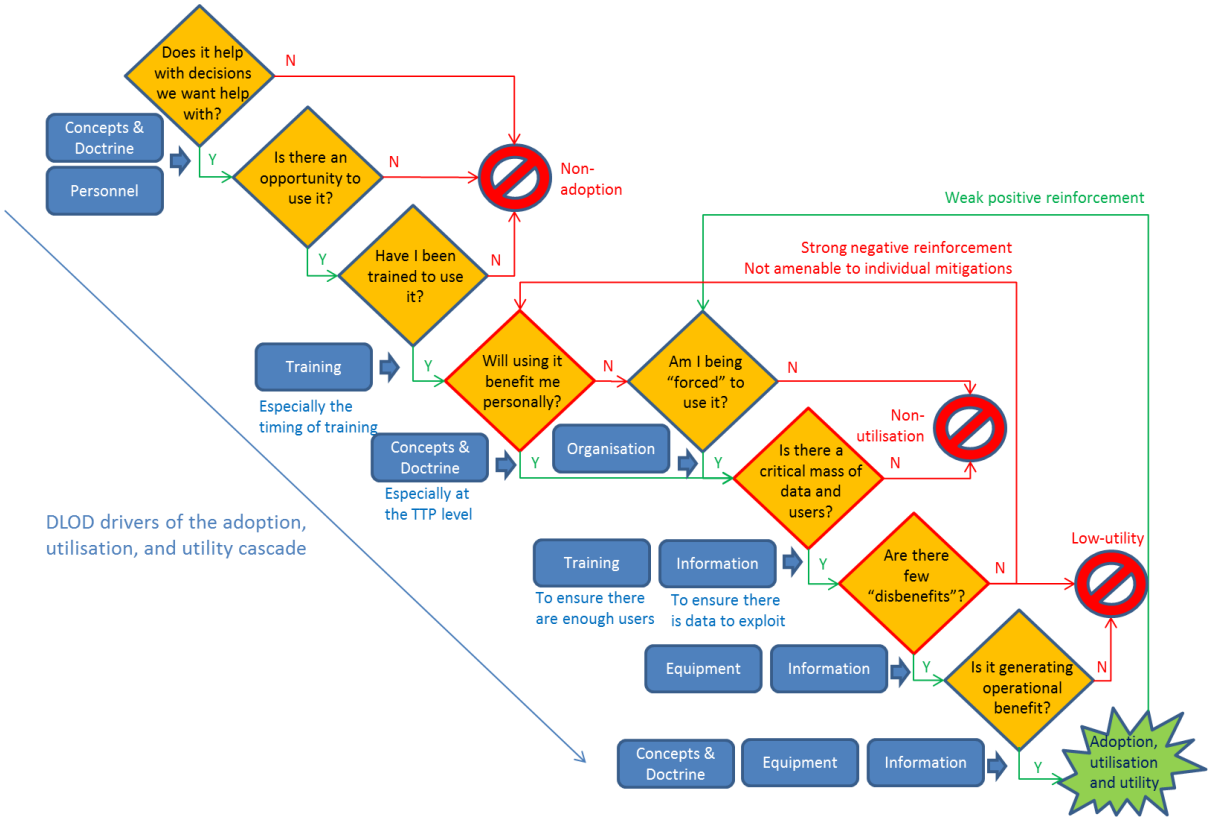

Figure 1: Decision tool adoption, utilisation and utility "cascade"[3]

[2] Reprinted from Jaya-Ratnam et al. (2014 p. 10), with permission of DIEMconsulting Ltd.

Jaya-Ratnam et al. (2014) found that the identified themes could be viewed as steps in a cascade of development activities: Adoption – whether it is brought into "service", Utilisation – whether users actually try to use it, and Utility – whether users gain a benefit, as shown in Figure 1 above. This cascade diagram has the potential to be a useful aid, in the form of prompting questions about necessary factors to consider along the development path of getting a tool successfully implemented and exploited. For example, the following are some issues that those attempting to acquire and implement a decision support tool must address:

- *Usefulness* - decision tools are more likely to be adopted if they carry out mundane and mechanistic aspects of a task, such as automatic capture of data/information, and leave the deeper sense-making and decision making to the human.
- *Access* – the tool is accessible as and when required.
- *Benefits and Dis-benefits* – users' perception about the tool, beneficial or negative (i.e., dis-benefits). It was found that identified dis-benefits have greater negative impact on utility than meeting the requirements on benefit.
- *Training* – Users are adequately trained just before use (to ensure there is no skill fade). The assumption is that the tool is mature; otherwise, it would be ignored because of "dis-benefits" due to poor experience of bad design.
- *User Group* – There needs to be a critical mass of users and data to ensure there is material constantly being created and updated for exploitation. This should be supported by a User forum where users can go for help and support.

The study findings suggest that there is no clear and obvious relationship between benefit and adoption. However, there is a relationship between the level of negatives (i.e., dis-benefits) and non-adoption; adoption and utilisation was negatively correlated to level of "reported negatives". This means that a current focus on equipment programmes of attempting to identify and verify requirements for improvement in decision making is not sufficient. It is also necessary to set requirements for any new system to not increase any "dis-benefits" for the user, which would then lead to non-adoption.

User Needs – Understanding the Requirements

From what we have observed over numerous years at UK Joint Exercises, and in particular from close observation of staff working at the UK's Standing Joint Force Headquarters during 2016, staffs appear to prefer manual methods for information processing rather than exploiting the existing decision and planning support tools[4]. Whilst "ease of use" and "training" is partially the cause, they do not fully explain the reluctance to use the tools. We found in addition, the following two other factors that seem to influence persistent use of tools within a headquarters.

[3] Reprinted from Jaya-Ratnam et al. (2014 p. 17), with permission of DIEMconsulting Ltd.

[4] It appears that staff fall back on their experience of having no tools when they were Troop, Platoon and Battle Group Commanders.

Opportunity to Practise

One of the defining characteristics of a formation level headquarters is that there is a constant churn of staff every couple of years[5]. Furthermore, during Exercises, the headquarters numbers surge two to three fold due to augmentation[6]. While it is possible to ensure all staffs are trained before joining the headquarters, it is often the case that they do not get sufficient time to practise use of the tools intended to aid them. There are a number of reasons for this which includes:

- The battle rhythm - while the headquarters is in barracks its focus tends to be on administrative tasks and on refining deployment rather than on improving planning and decision making skills and competencies. It is quite normal to find that the primary opportunity for staffs to practise key HQ processes and use of tools are during exercise preparation and execution. However, during preparation stages the augmentees may not be present, and during execution, the core staff to augmentee ratio may be 1:2+. The end result is that the functional team leader tends towards the lowest common denominator and will choose not use any tool support (particularly if he/she is not an expert user and/or the tool is not intuitive).
- Lack of facility - even when time to practise is made available, the headquarters may not have a ready access to a facility to practise HQ processes using the tools (Patel and Patterson, 2017). Indeed, as noted above, the only time the headquarters has the opportunity to practise is during Exercises, which are focussed on assessing headquarters' competence and not on learning the tools of the trade. Hence, it is not uncommon to see staff conducting their work manually, as this is perceived to be by far the least risky option.

Scope and Functionality

Decision and Planning Tools are typically designed to support specific functions (e.g., TOPFAS[7] in the case of military planning). Unfortunately, such tools have implicit and inbuilt assumptions on the ways of operating and these are frequently not easily adapted to new or different thinking and concepts. They also tend to impose a significant training burden and due to tool complexity and infrequent training cycles the staffs suffer from skills fade. Therefore, this factor again contributes to a lack of tool use.

It is frequently assumed within the Systems Procurement Community that functional areas within a headquarters can work independently. This is far from the truth. Headquarters, particularly the effective ones, provide a more coherent C2 capability where there is a more seamless dissemination of relevant information within the HQ. There are also robust and effective interfaces vertically (i.e., to higher and lower headquarters) and with external organisations. Thus, specialist functional tools that do not support a more integrated HQ

[5] The duration may be shorter or longer for some staff. Typically the change would be at different periods during the year and either Service or rank based.

[6] Augmentees may have the training and experience of tools, however this is not guaranteed. Also, what is quite common is that they would join the headquarters just before the start of an Exercise with little or no opportunity to practise the processes and/or tools with their new team members.

[7] Tools for Operational Planning Functional Area Services (TOPFAS) is an integrated set of collaborative planning and decision support tools developed by NATO Communication Information Agency.

operation, and do not support coherent information dissemination between teams, will tend to be avoided. Instead, those that tend to be adopted are those that support generic functions such as information management, dissemination and sharing. However, even here, it is not given that such tools will be adopted and exploited, unless they are configured and used in a consistent manner across the headquarters. This frequently requires a skill sets that a military HQ does not have in abundance.

Planning and decision making is a collaborative activity involving staffs from across the various branches within an individual headquarters, as well as with other headquarters and external partner organisations. Staffs will therefore tend to favour those tools that are common across all of the potential collaborators. Thus, there is a tendency is to fall back, either completely on manual approaches (paper, maps, drawings, physical meetings and notebooks etc.) or on the lowest denominator technology such as office applications. Even these then tend to be used in a lowest common denominator manner i.e. with only a minimal level of functionality actually being used.

Conclusion

Over the last two decades a significant amount of research and development effort has gone into creation of knowledge systems (i.e., planning and decision support tools) in an attempt to improve the effectiveness of staff working in headquarters. Unfortunately, very few of these tools have been adopted. Getting the requirements right, and having a strong user involvement from the start, will both improve the chances of success. However, as noted above, there are many other factors that need to be attended to before tool adoption becomes more widespread. As noted previously in the successful example of tool adoption success:

> "Transportation planners readily accepted DART because they had helped define the initial prototype capabilities, refine the prototype into the operations systems, and analyse elapsed planning and analysis times to quantitatively identify the major sources of improvement." (Bienkowski and Edwards 1996, p 37).

Our more recent studies suggest that organisational and cultural factors also play an important role in technology adoption, and that this can be undermined by perception of dis-benefits. Observations of headquarters working suggest that many of the tools have been developed without clear understanding of the user needs and how the tools will be utilised within a headquarters. From the research perspective, there are two fundamental questions to be addressed:

- From a cost benefit and effectiveness perspective, would it be better to educate and help command staff continually practise new problem-solving and thinking skills instead of making large investments in technology-driven decision support tools?
- Should there be a different balance between investing in both education and tool development, where there is a shift of the balance away from technology via the use of much lighter weight, but more adaptable tools? If so, what would these tools look like and how would they be developed? Finally, what would the education and training to go with these tools be, and how would it be developed and sustained?

References

Bienkowski M. and G. Edwards G. (1996). Demonstrating the Operational Feasibility of New Technologies: The ARPI IFDs in Tate, A. (Ed.) *Advanced Planning Technology: Technological Achievements of the APRA/Rome Laboratory Planning Initiative*, AAAI Press, Menlo Park, California, 35-42.

Dawson B. (2007). *The Impact of Technology Insertion on Organisations*, HFIDTC/2/12.2.1/1.

Ewusi-Mensah, K. and Przasnyski, Z. (1994). Factors contributing to one abandonment of information systems development projects. *Journal of Information Technology, 9, 185-201*.

Jaya-Ratnam D., Fletcher G., Smith T. & Schraagen J. (2014). *Final Report, TIN 3.092 C2 Concepts Task 1: Inadequate utility of command and decision support tools*, UC-DHCSTC_1386917_H_T3_092_1/002.

Keen, P. (1981). Information Systems and Organisational Change, *Communications of the ACM,* 24, 24-33.

Nielsen, J. (1994). *Usability Engineering*, Morgan Kaufmann Publishers.

Patel J. & Patterson G. (2017). Headquarters Maturity Model: An approach to optimising a HQ for operational advantage. *Paper submitted to the 22nd International Command and Control Research and Technology Symposium*, Los Angeles.

Tate, A. (Ed.) (1996) *Advanced Planning Technology: Technological Achievements of the APRA/Rome Laboratory Planning Initiative*, AAAI Press, Menlo Park, California.

Tolbert, P. and Zucker, L. (1983). 'Institutional Sources of Change in the Formal Structure of Organisations: The Diffusion of Civil Service Reform, 1880-1935'. *Administrative Science Quarterly*, 2, 22-39.

Venkatesh, V., Morris, M.G., Davis, G.B., and Davis, F.D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27, 425-478.