Technical Evaluation Report

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1.0 INTRODUCTION AND BACKGROUND

1.1 Introduction

There is a need within NATO to co-ordinate complex operations across nations, service branches (land/sea/air) and echelons of command (tactical/operational/strategic). A common operational picture (COP) ***is said*** to provide a shared understanding of the battlespace to improve responsiveness and decision dominance. Note the qualification "***is said***." The workshop brought forward careful distinctions in the use of this terminology, without changing the operational intent. Visualisation technologies offer means to establish the COP and to aid commanders in transitioning their focus across echelons of command responsibility. New technologies allow flexible display of geographic and non-geographic information in ways that assist users in drawing out new understanding of the residual data. The intent is to establish an integrated visualisation environment where commanders and staffs can gain a shared understanding of changing conditions in their areas of responsibility.

1.2 Background

This workshop was sponsored by the NATO RTO group, IST-021/RTG-007 ("Multimedia Visualisation of Massive Military Datasets"), whose objective is to examine and evaluate visualisation tools and techniques and to identify "lessons learned" for future development. This workshop was a logical follow-on to previous workshop IST-036/RWS-005, "Massive Military Data Fusion and Visualisation: Users Talk With Developers" held in Halden, Norway in September 2002. This workshop focused on the application of visualisation technologies to provide more effective COP for a wide variety of users.

1.3 Theme

This workshop had three integrated themes: Military Applications, Human Factors and Technology. Integration of these themes is inescapable. The military application of visualisation technologies is overly simplistic and misleading until the human factors related to comprehension and understanding are considered.

2.0 PURPOSE AND SCOPE

The purpose of this workshop was to provide critical exchange between users, technologists and developers to generate sufficient guidance for future military visualisation and COP development. Treating the COP as a **specific** visualisation application identifies the scope of the workshop and is a significant leap forward from previous workshops that dealt with "Visualisation of Massive Military Datasets" in more general and

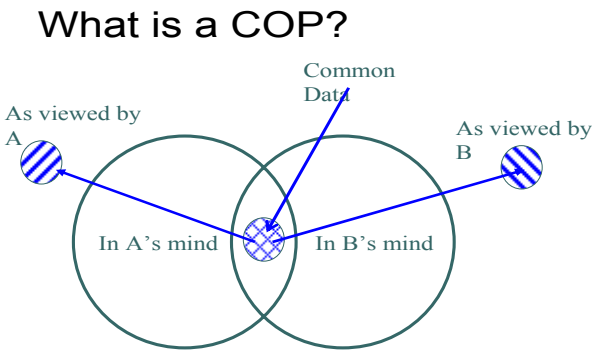
component of COP, rather than as a separate topic. This workshop was organized to bring forward very specific application needs and promising technologies that addressed specific issues in aiding human understanding.

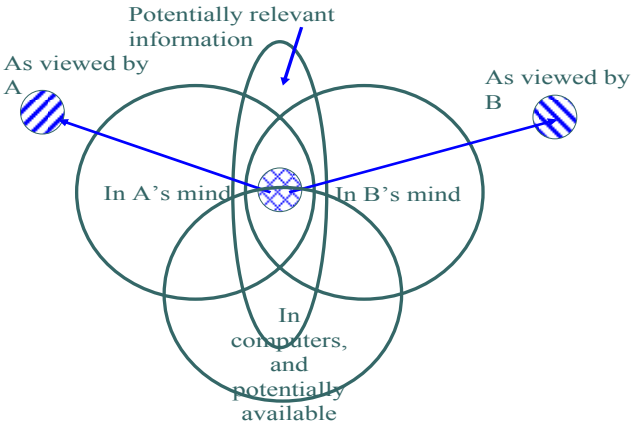
3.0 EVALUATION

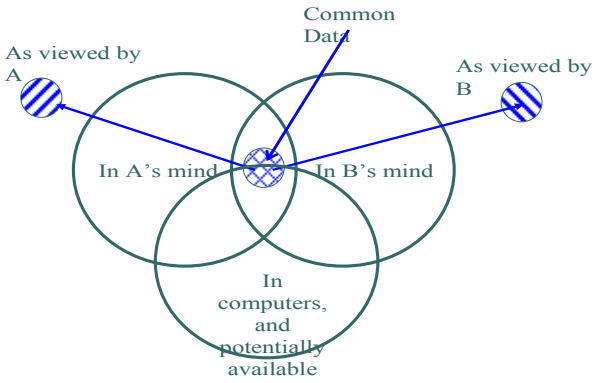
Overall, the combination of presentations, plenary discussion and working groups provided comprehensive and insightful coverage of COP issues, visualisation technologies and related human factors. Excellent organization, careful participant selection and the chairman's advance statement that participants were expected to attend for the entire agenda provided stimulating interchange throughout. The following points are particularly significant.

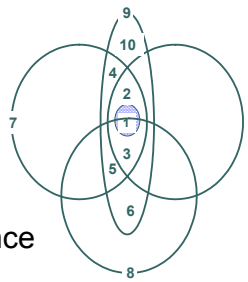
3.1 COP Terminology

There is clearly a discrepancy between the doctrinal declaration that COP is a "shared understanding" and the reality of different individuals from different backgrounds, nations and services arriving at non-identical interpretations of shared presentations of the same data. There is no difference, however, in the operational intent -- maximizing common understanding, resolving different interpretations where identified and in reducing confusion. The distinction between shared mental image and multiple mental images of shared data and presentation is more than technical nitpicking because of its impact on system design. The following Venn diagrams extracted from the report by Working Group 1 illustrate the point.









The goal is to reduce the difference between {1,2,3} and 9.

3.2 Users' Perspective

3.2.1 Immediate Need

There is a clear and urgent need for a common framework for construction of a NATO COP. The participants and details of future operations cannot be predicted, but ad hoc multinational military formations is a given and the COP must be generated for each situation. Adherence to a common framework will reduce operational delay and confusion. Detailed technical interoperability may follow, but the common framework must come first. In this respect, a "70% solution" is required immediately, rather than wait for a perfect solution that will never come.

3.2.2 Risk and Speed

Commanders make decisions under risk – that is their job. Uncertainty, potential consequences and shortness of time raise stress, promoting tunnel vision and reducing options. Very clearly, rapid understanding, including ambiguities, promotes better decisions and earlier decisions.

3.2.3 Fusion & Filtering vs. Anomalies

Commanders live on anomalies and outliers that are the harbingers of emerging changes, indications of incorrect or outdated assumptions and departures from expectations. Fusion is a data-centered process that tends to suppress anomalous data or warp it into conformance with previous experience. Staffs tend to do the same thing. And so the commander is faced with the need to synthesize a new understanding of the situation without being overwhelmed by too much data that, while relevant, masks the important anomalies. There is a constant tension between providing raw data and various forms of filtering (eliminating) data, aggregating data and suppressing clutter. This holds true for a **COP that must be decision-centered** rather than data-centered. Visualisation technologies must therefore support alerting to potential change, display uncertainty with a retrievable audit trail and provide indications of time required to resolve uncertainty vs. time by which decision is required.

3.3 Significant Technical Insights

3.3.1 2D vs. 3D

There were a number of revealing discussions regarding 2-dimensional vs. 3-dimensional displays, with very clear and different roles for each. 3D displays are egocentric and have great "gee whiz" appeal. They clearly help the view in understanding complex terrain. But these displays are not suited for measurements due to errors introduced in the generation of the display and by the human in interpretation of the display. 2D displays are exocentric and more suited to planning and extraction of measurements. Emerging technology that permits generation of 3D displays from non-stereoscopic 2D imagery appears extremely useful because it would permit alternate views while retaining registration between them. 3D imagery from synthetic aperture radar would provide a significant all-weather improvement in understanding changes in complex urban terrain brought about by military action or natural disaster.

3.3.2 Reducing Mental Transformations

One of the more useful concepts to emerge from discussion is that the ease of understanding a display is related to the number of mental transformations required by the user to generate his/her own interpretation and mental image. Display of multiple disparate data adds to the complexity of a presentation, offering a

significant challenge to both presenter and viewer. In principle, the required number of mental transformations would serve as an excellent performance metric for visualisation products – if there were a reliable way of determining them. Still, relative reduction in transformation complexity should provide a significant guideline. In this regard, pliable display techniques were demonstrated as a means of presenting great detail without losing context or reference to the larger picture.

3.3.3 Change Detection

Humans perform poorly at change detection, experts in particular. Confirmation bias is well known. While commanders may be more alert to change than others, individuals preparing data for presentation in the COP may not be at all sensitive. Furthermore, evidence of change may be buried in clutter. This is an area where machine assistance can be of great value.

3.3.4 Visualisation of Networks

Two working groups wrestled with issues concerning the visualisation of networks. It became clear that comprehension and understanding of very complex and disparate networks is an important requirement for conduct of network-centric warfare – to the extent that some networks must be considered part of a commander's battlespace (e.g., the social network of belligerents and sympathizers is critical to peacekeeping operations) and that specific networks are the battlespace for the specialists who must deal directly with them. Generalized visualisation tools are clearly lacking. Without such tools, many operational advantages will remain in jeopardy or go unrealized.

Visualisation techniques for ship navigation appear ready for immediate application and most appropriate for piloting in/around unfamiliar harbors – if the necessary data can be made available.

4.0 CONCLUSIONS

This workshop was especially productive, in large part because the general topic of visualisation of massive military datasets (techno speak) was focused on a clear application stated in operational terms, with sufficient user participation to retain the focus. The greatest value lies with the working group briefings and associated slides. One of the more encouraging aspects of this workshop was that participants retained the user's decision space as their point of reference, rather than descending into the technical minutia of the data or the mechanics of presentation. Curiously, the suggestion that visualisation of the information network supporting (or potentially supporting) a COP was rejected in several working groups as being too complicated or requiring NATO interoperability and standardization agreement, rather than treating such a network as the desired COP framework.

It seems very clear that the technologies necessary for visualisation of the COP are sufficiently mature to support development of prototype systems that would serve as a "70% solution." The human factors and the operational intent are well understood in general terms. As witnessed by the briefing slides on NATO COP support to the recent Olympics (made available to the workshop participants by NATO RTA), there is need for immediate improvement and it is entirely feasible.

5.0 RECOMMENDATIONS

Begin immediate development of candidate COP visualisation systems, explicitly designed for the "plug and play" nature of NATO formations. Use rapid prototyping techniques to both mature and grow the product.

The first step should be visualisation of the information network that would potentially support the COP. Assume a technology solution to interface issues rather than wait for standardization agreements. This actual development should not be a large NATO-wide project, at least in the initial stages. The nature of the project lends itself to a “skunk works” approach with a small team of users, developers, technologists and human factors specialists to define the initial goals and requirements. The developer should be a smaller firm or establishment experienced with rapid response to customer needs rather than a large military systems house. Scalability is a significant issue and should remain a primary design intent, even if the initial prototype cannot be scalable, but should follow that intention. User input and active participation at the colonel level is required to ensure breadth of coverage and appropriate treatment of multiple echelons.

Visualisation of networks is an important topic that warrants continued workshops, organized very much like the one reported here. Initially, there is a need to establish a generic framework and appropriate tools, and to identify a small number of very different applications with high payoff. Much attention is already focused on computer networks and it may be more productive to rely on the non-military efforts here, concentrating instead on purely military applications like logistics networks (both troop and materiel movement) and social networks associated with peacekeeping, intelligence gathering and humanitarian relief.