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NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

RTO MEETING PROCEEDINGS 50

Multimedia Visualization of Massive Military Datasets

(Atelier OTAN sur la visualisation multimédia d'ensembles massifs de données militaires)

Papers presented at the RTO Information Systems Technology Panel (IST) Workshop held in Quebec, Canada, 6-9 June 2000.

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Multimedia Visualization of Massive Military Datasets

(RTO MP-050 / IST-020)

Executive Summary

The workshop IST-020/RWS-002 “Multimedia Visualisation of Massive Military Datasets” was held at the Defence Research Establishment Valcartier, near Quebec, Canada, June 6-9, 2000, under the responsibility of Task Group IST-013/RTG-002.

Military operations today depend heavily on the C4ISR (Command Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance) framework. Unfortunately many military systems make it difficult for users to understand the information available in the massive amount of data that flows from the various intelligence sources.

Users may not be able to use the systems to extract the information they need from the data, or they may not be able to create effective displays that allow them to visualise it. Potential information sources may be ignored, or not well used, because techniques for extracting information are deficient. As a consequence, users of many current systems discard much data unassessed. Inability to access, assimilate and exploit all the available information may lead to reduction in the effectiveness of strategic and tactical actions, both in simulation and training and in actual operation.

In the workshop, “visualisation” was taken to mean what it does in everyday language—“seeing” in one’s head a situation and its possible development. Effective visualisation requires users to interact closely with presentations that need not be graphical, or even necessarily visual, but might also be auditory or even haptic (i.e. using active touch).

New technologies and data sources now envisaged will require radically improved ways for allowing users to interact with data. Interaction is critical, but at present information is usually presented to commanders, analysts and executives as a passive situation display. Indeed, the term “visualisation” is sometimes used to mean the presentation of information on a display in graphical form.

Solutions to these problems can seldom be bought off-the shelf, but require research and development. The military needs, however, may not be the same as those that drive academic research or commercial development, and researchers and developers may not often be aware of what problems military users face.

The workshop participants were drawn from all three communities: military serving officers, system developers, and visualisation research scientists. The workshop was intended to bring these three communities together, so that the developers and researchers could improve their understanding of the problems faced by the military, and the military could appreciate some of the possibilities afforded by known visualisation technology.

The workshop was not intended either to present completed solutions to the military or for the military to present specifications and official requirements to the researchers and developers, though instances of either would be welcomed. Rather, it was intended to lead to improvements in the future orientation of visualisation research and development in the military context.

Before the workshop, participants were asked to suggest problematic issues that might be expected to highlight military or research areas to the possible benefit of all three communities. During the workshop, 28 separate presentations were made in seven sessions. Each session treated a theme, and concluded with an extended discussion of the theme developed in the presentations.

Two sessions were devoted to visualisation of operations, for air, land, and sea operations, as well as in peacekeeping. Exemplary applications, some of them fielded, were illustrated, as were facets of

research bearing on the problems. Related to these was a session on visualisation for Command, including logistics planning, and planning for air and land operations.

A different thread concerned Information Operations, the control of computer networks and the identification of intrusions. Some presentations concerned methods of visualising the contents of a collection of documents and the relations among them.

The proceedings here include most of the presentations in Microsoft PowerPoint form, with short textual abstracts. Many of the presentations were followed by discussions, of which recorders made brief notes of key points raised. These notes are usually in the form of bullet lists rather than texts. The same is true of the longer session discussions on the general themes of the sessions.

It is hoped that the presentations made at this workshop, and their reproduction here, may help to bring closer the researchers and developers of visualisation technology on the one hand and the military users of that technology on the other.

Atelier OTAN sur la visualisation multimédia d’ensembles massifs de données militaires

(RTO MP-050 / IST-020)

Synthèse

L’atelier IST-020/RWS-002 sur “La visualisation multimédia d’ensembles massifs de données militaires” a été organisé à l’Etablissement de recherche pour la défense Valcartier, à Québec, au Canada, du 6 au 9 juin 2000, sous la responsabilité du groupe de travail IST-013/RTG-002.

Les opérations militaires d’aujourd’hui dépendent dans une large mesure du cadre C4IST (commandement, contrôle, communications, informatique, renseignement, surveillance et reconnaissance). Malheureusement, bon nombre de systèmes militaires pose des difficultés pour l’utilisateur qui souhaite acquérir une compréhension pratique des informations correspondant à ses besoins immédiats, informations qui existent pourtant dans les masses énormes de données transmises par les différentes sources de renseignements.

Soit l’utilisateur ne peut utiliser le système pour extraire des données les informations dont il a besoin, soit il ne lui est pas possible de créer des affichages adéquats, lui permettant de les visualiser. Des sources possibles d’information peuvent être ignorées, ou bien mal exploitées, parce que les techniques d’extraction d’information sont défectueuses. Par conséquent, de nombreux utilisateurs de systèmes courants suppriment des données sans les évaluer. L’incapacité d’accéder à l’ensemble des informations disponibles, de les assimiler et de les exploiter, peut avoir pour effet de réduire l’efficacité d’actions stratégiques et tactiques, tant en ce qui concerne la simulation et l’entraînement que pour les opérations elles-mêmes.

Aux fins de l’atelier, le terme “visualisation” à été défini comme dans le langage courant, c’est à dire comme la capacité de “voir” mentalement une situation donnée et son évolution possible. Pour être efficace, la visualisation exige une interaction étroite entre l’utilisateur et les présentations, qui n’est pas forcement graphique, ni visuelle, mais qui peut être auditive et même haptique (c’est à dire au toucher actif).

Les nouvelles technologies et les nouvelles sources de données actuellement envisagées nécessiteront des moyens radicalement différents d’interaction entre l’utilisateur et les données. Si l’interaction est essentielle, à présent l’information est présentée aux chefs militaires, aux analystes et aux décideurs sous forme d’un affichage passif de la situation. En effet, le terme “visualisation” est parfois utilisé pour signifier la présentation d’une information sur un affichage sous forme graphique.

Les solutions de ces problèmes se trouvent rarement dans le commerce; elles sont normalement le fruit d’efforts de recherche et développement. Cependant, les besoins militaires peuvent être différents de ceux qui animent la recherche académique ou le développement commercial, et les chercheurs et développeurs ne sont pas forcément au courant des problèmes auxquels les militaires sont confrontés.

Les participants à l’atelier représentaient les trois principaux groupes d’intéressés, à savoir : des cadres militaires en activité, des développeurs de systèmes, et des chercheurs en visualisation. L’atelier a eu pour objectif de rassembler ces trois communautés, pour permettre aux chercheurs et aux développeurs de mieux comprendre les problèmes rencontrés par les militaires, et aux militaires d’apprécier quelques unes des possibilités offertes par les technologies de visualisation confirmées (reconnues ?).

L’atelier n’avait pas pour objectif de présenter aux militaires des solutions définitives, ou de présenter aux chercheurs et aux développeurs des spécifications et des besoins officiels, bien que de tels échanges aient été encouragés. L’intention était plutôt d’améliorer l’orientation future de la recherche et du développement en visualisation dans un contexte militaire.

Avant l'ouverture de l'atelier, il avait été demandé aux participants de signaler aux organisateurs la nature des problèmes qu'ils avaient pu rencontrer, ceci afin de mieux cerner les domaines militaires et les domaines de recherche susceptibles de profiter aux trois communautés. En tout, 28 communications ont été présentées lors des 7 sessions de l'atelier. Chaque session a traité un thème et a été conclue par une discussion des sujets développés lors des présentations.

Deux sessions ont été consacrées à la visualisation des opérations aériennes, maritimes et terrestres, ainsi qu'au maintien de la paix. Des exemples d'applications, dont certaines sont en service, ont été présentées, ainsi que divers aspects de certains travaux de recherches connexes. Une session a également été organisée sur la visualisation pour le commandement, y compris la planification de la logistique et des opérations aériennes et terrestres.

Un autre thème concernait les informations, le contrôle des réseaux informatiques et l'identification d'intrusions. Un certain nombre de présentations portaient sur des méthodes permettant de visualiser le contenu de documents et les relations entre eux.

Le compte rendu inclut la majorité des présentations, sous forme Microsoft PowerPoint, accompagnées de résumés succincts. De nombreuses présentations ont été suivies de discussions, dont les points clés ont été notés par les rapporteurs. En général, ces notes sont rédigées en style télégraphique. Les notes sur les discussions approfondies concernant les grands thèmes des différentes sessions sont rédigées de la même façon.

Il faut espérer que les communications présentées lors de cet atelier, telles que reproduites ici, permettront de rapprocher les chercheurs et les développeurs de technologies de visualisation d'un côté, et les utilisateurs militaires de ces technologies de l'autre.

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Classifying Applications and Issues Critical to Visualization of Massive Military Multimedia Datasets

Keynote Address

W.B. Cunningham
P.O. Box 2412, Poquosow, VA 23662
United States

Good morning, ladies and gentlemen.

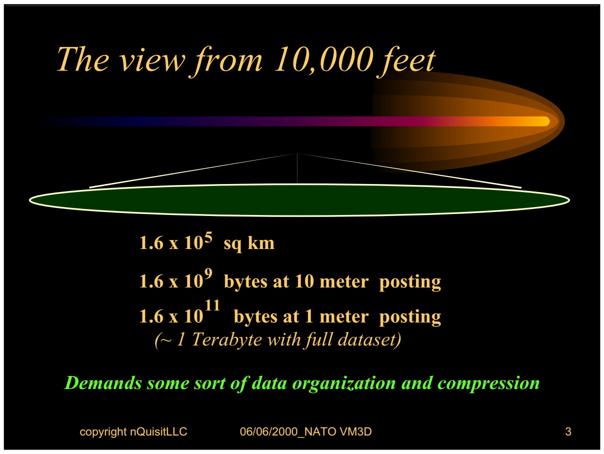
I find this experience somewhat daunting. While it is a great honor to be a keynote speaker, I've observed that most keynote speakers are very senior or famous people who utter profound statements about the forum at hand, and then leave while the audience is still pondering what was said. Remaining as a participant in these proceedings will provide you the opportunity to return fire. That should be fun.

The title shown here is a mouthful, requiring some explanation. The format for this workshop entails juxtaposition of a number complex operational problems, all plagued by massive data sets that invite visualization as a means of treating the problem. Hopefully, insights into one problem will carry over into solutions for other problems. With this in mind, I thought it useful to classify problems and specific issues in terms of common characteristics. This is not intended as a definitive listing, but rather a convenient way of focusing our thoughts.Looking at the agenda, one may well ask why we are here.

Each of these problems could easily be the focus of a panel discussion in whatever forum is appropriate to its domain, or perhaps a discussion in a general analytic symposium. The answer is simply stated, but difficult to carry out.

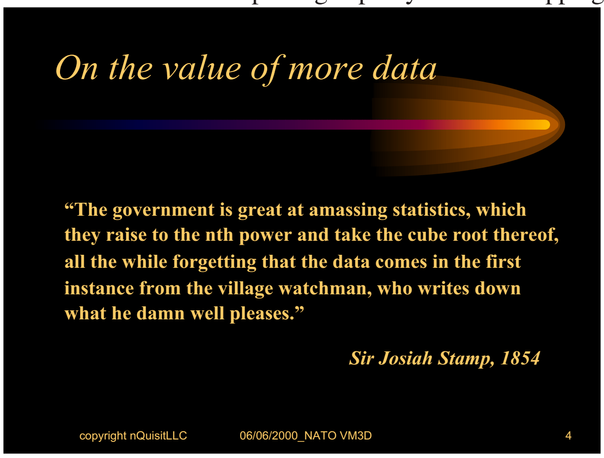
Real problems in the real world tend to be pretty complex, with no two problems exactly alike. Canned solutions and expert systems are a good start, but real problems typically require human adaptability and hence human understanding of both the problem and its context. Considerable art has developed surrounding each problem domain and considerable technology has been applied to each. What seems to be missing is coupling the machine assistance to the human artisan to take advantage of each. This is the role of visualization, the business of organizing large amounts of data and transferring the data and its organization into the heads of expert users who then visualize their problem space in more effective ways.

A simple example will provide a quick



understanding of why visualization strategies are important.

When I asked what a keynote speech should cover, I was told "The view from 10,000 feet." Well, using the standard smooth earth model for line-of-sight, we see that approximately 160,000 square kilometers are visable from that altitude. Ten meter posting is pretty detailed mapping,



Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

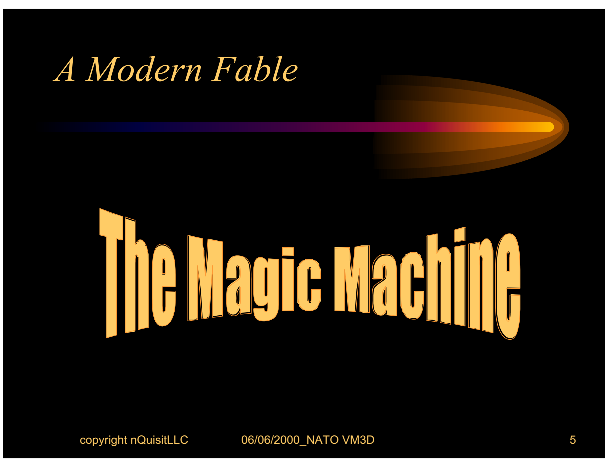
but todays technology is leading us toward one meter posting. Even at one byte, we would encounter approximately a sixth of a terabyte from that altitude. It's not at all hard to imagine a data set well in excess of a terabyte. And some people would like 10 meter posting, leading us to wonder what they would do with the data if they had it.

Statistical approaches are well known ways of dealing with massive data sets. The entire concept is to reduce huge quantities of raw data to a few parameters that are said to represent the whole population.

But by their very nature, statistical approaches mask what is going on in the real world from which the data arise. In particular, statistical approaches do not lend themselses to drilling down into an ongoing process or in understanding the interaction between components of an ongoing process.

The issue of ongoing processes is important, for it implies that the data set is open. That precludes defining a probability measure without imposing some severely limiting assumptions. Further, the statistics of rare events are very difficult to define because rare events are frequently misreported or misrepresented.

Before television, an Inuit native would have no reason to have seen a Bengal tiger. An actual tiger spotted in the Arctic is more likely to be reported as a striped polar bear, the report being dismissed as impossible. Visualization techniques have the virtue of not necessarily suppressing anomalous reports such these. In fact, one may very well visualize a striped polar bear and conclude that something resembling a tiger has been seen.



This fable is a long story about a man who enters the Brussels railroad station, buying a ticket to Munich, glancing at the departure display and proceeding to Track 13 where he encounters a machine advertizing "Personal data, 1 Euro."

He inserts the Euro coin and a multimedia display proceeds to tell him his name, height, weight, that he has just been posted from NATO headquarters to the German Signal School and that he is waiting at Track 13 for his train to Munich.. For more data, insert another Euro.

Curiosity aroused, he inserts another coin and receives a complete dump of his school records, from primary school onward and is told he is waiting at Track 13 for his train to Munich. For more data, insert another Euro.

Inserting his last Euro, he receives his complete medical records, including dental X-Rays, and is told he is waiting at Track 13 for his train to Munich. For more data, insert another Euro.

So, he wanders off to get more coins and returns to insert another Euro. At this point, the machine repeats all the previous data and tells him that he has missed the train to Munich that has just left from Track 18.

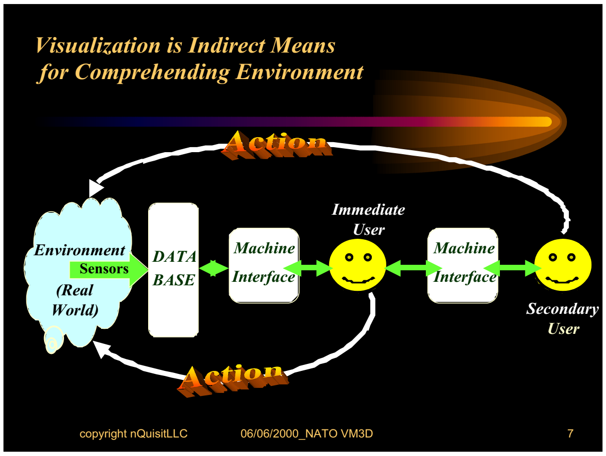
This is an old joke, dating from at least as far back as 1947. At that date, the magic machine seemed truly magic. We can build that machine today! But we can't guarantee the machine will produce the truly relevant data, namely that the individual is waiting at the wrong platform. The example is humorous, but the matter of extracting important information from a flood of data is serious business.

There is a tendancy to ascribe the term "visualization" to all manner of graphic displays or to claim that various automated system are capable of digesting great quantities of data and then displaying simple truths about what the data represent.

Visualization is a mental process that takes place in the head of the data recipient. The visualization may or may not reflect what the data purports to represent. Like beauty, visualization is in the eye of the beholder. It's important to note that different persons receiving the same graphic or multimedia display are capable of significantly different interpretations of the data.

The next slide is a deliberate expansion of the HAT model used by this panel. The same features can be found within the HAT model, but this diagram highlights important features that are frequently overlooked or assumed away.

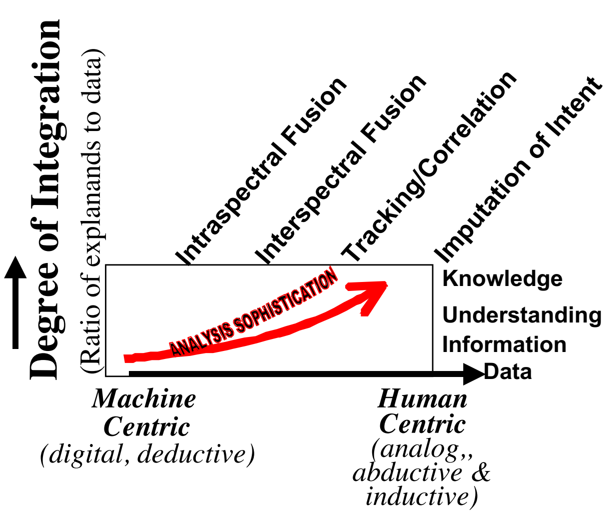
1. The "problem" to be solved involves some process in the real world that we attempt to represent by sensory data. It does not start with the sensors! We are all



prisoners in Plato's Cave looking at shadows of what is going on outside. We can only understand the real process through the data received. If the process is fairly well understood from previous experience, then the sensors can report representative data. However, if the process is not previously understood, there is a good chance that the data will bias subsequent comprehension because it overrepresents or underrepresents various aspects of the real process. In problem solving, one must always question how well the data represents the real situation.

2. There are always at least two users of the same data, and more frequently two or more users of overlapping similar but nonidentical data sets. The primary user may be senior or junior to the secondary users. Either may provide context for the other, depending on the problem and the situation. The important point is that there are always at least two individuals dealing with the same problem, each with their own context and obligations. Thus, their visualization of the data and interaction with it will be entirely different.

3. The data changes as a result both natural change in the real world process or as a consequence of actions taken the users to influence that process. If the problem is real, then its solution must involve action in the real world. Sensors that monitor the actions do not provide the same data as



sensors that monitor the real world consequences of the action.

This graphic does not reduce well for the notes page, but its meaning should be fairly clear.

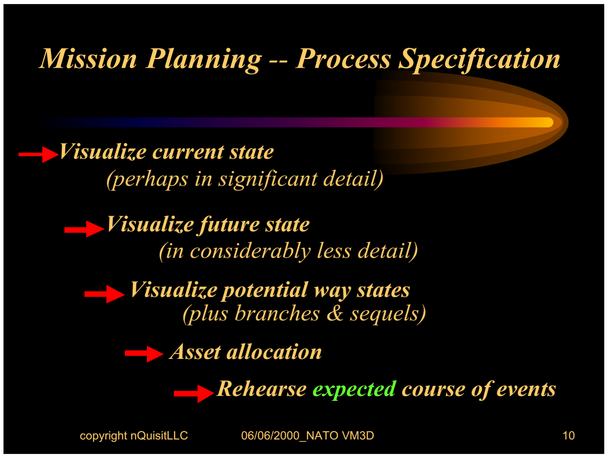
The lower left represents a regime of data oversupply, accompanied by an undersupply of explanation or interpretation. At the onset, it isn't clear whether or not the data reflect the same phenomenon. To borrow from the fable of the three blind men and the elephant, it isn't initially clear whether the data reflect multiple species, multiple samples of the same species, or multiple samples of the same beast that may later be inferred to be be a representative example of the entire species. Machines are great for sorting out these elementary questions before flooding the user with raw data. However, machinesbecome less and less useful as we proceed to the upper right of the figure. Here, the human is required to add interpretation and synthesis. The upper right is where vizualization within the human comes to the fore.

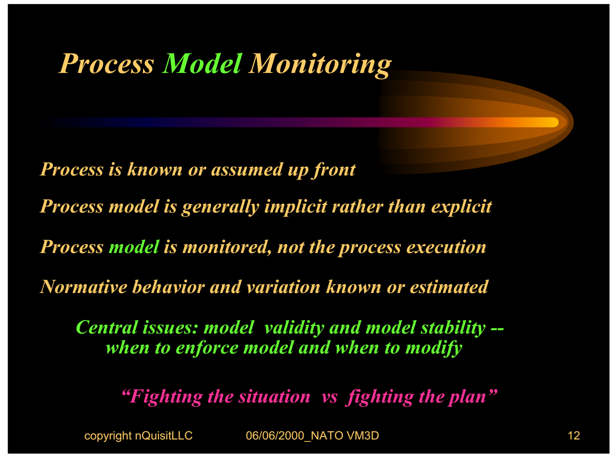
The challenge for visualization technology is to assist the human in his/her movement from a purely deductive thought process to the more creative abductive and inductive processes. This is the only way the human can cope with the complexity of the real world without insisting on an exhaustive data set, further complicating the data reduction problem.

Turning now to the nature of visualization applications, the nextslide lists a preliminary set of distinctly different problem categories. This list is not intended to be exhaustive and can certainly be refined. The real purpose is to group together the salient features of each problem type.

Mission Planning could go by several names. The intent here is to present the key points about deliberate mission planning. The process being specified is the organizational process defined by the plan.

Visualization plays a key role. The commander's current understanding, or model, of the real world is codified and used to establish context for all that follows. The samemodel is extrapolated into models of future states. The





staff fleshes out the commander's initial guidance. Planning addresses asset allocation to achieve goals in accordance with the model that is assumed to remain valid throughout. Some variation is allowed, and even planned for; but all within the scope of the original model. The strength of this approach is that it propagates the commander's initial understanding of the situation as the basis for all planning, providing order in the face of potential confusion. It's weakness is that it depends entirely on a good initial estimate of the situation.

A very large number of stated military applications fit this category. There are many details with which to contend, and visualization is helpful.

Mission execution is with respect to the deliberate mission plan and marks the distiction between command and staff problem solving modalities. The essential role of the staff in problems of this sort is to make the plan work. The process being monitored is the planned process, not necessarily thereal world process that cannot be seen directly. Said differently, the plan provides the context in which all subsequent data are interpreted.

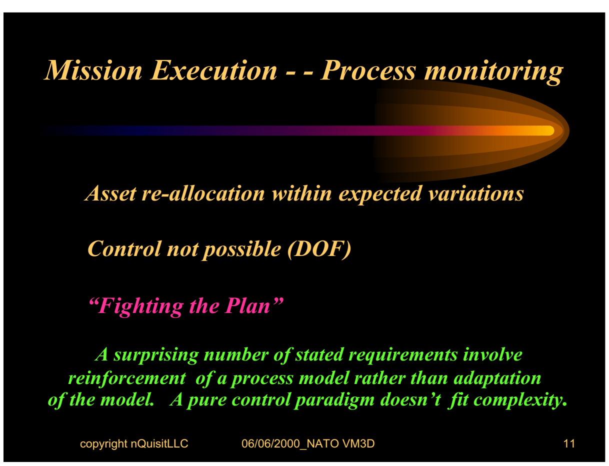
Control is exercized by asset reallocation, all within expected norms. A very large number of stated problems fit this category. Solutions are straightforward if the initial situation estimate is reasonably valid. This approach has a solid success record for conventional engagements between conventional forces. The results begin to degrade rapidly as the real situation departs from the plan.

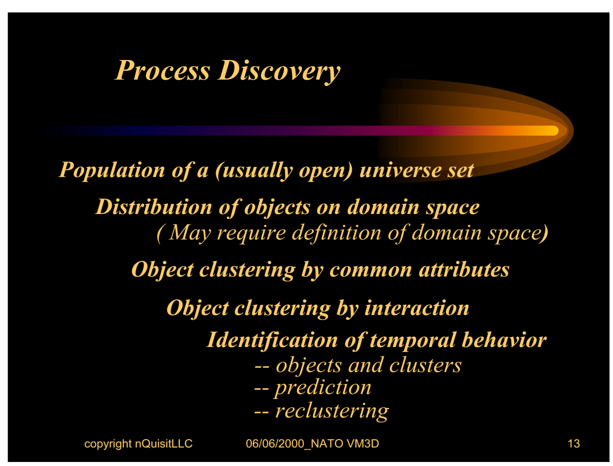
Process Model Monitoring refers to the commander's model of the real world process, not the organizational process set in motion by the deliberate plan.

This problem solving approach marks the difference between commanders and staff, and between experts and journeymen in nonmilitary situations. Given a complex situation, the expert seeks to know more about the situation where the nonexpert typically seeks to know more about the available solution set.

The central issue is whether the initial model of the real world remains sufficiently valid or whether significant revision is appropriate.

There is a significant data handling issue associated with this approach. The commander wants undistorted raw data to assess the goodness of his model. The sheer volume of the data encourages the staff to filter or compress data for the commander. The great difficulty is that the staff filtering process must be performed with respect to the original context and situation estimate, introducing significant bias as situation departs from the expected. Visualization technology can provide a great service to the commander by entertaining a huge glut of data without intoducing bias. This, in turn, provides a means for the commander to supply new context

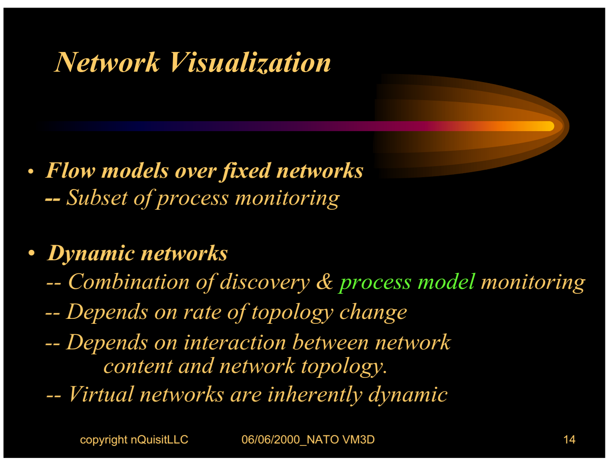




for the subordinates and staff who must not interpret data differently.

Again, the process being discovered is that process unfolding in the real world. In a purely theoretical case, the problem would be solved ex nihilo. In actual practice, prior experience drives what data is collected and how it is organized.

The key feature is that the problem solver knows the answer is unknown and is in a purely investigative mode. This can occur when previous answers have been proven wrong, or when the situation is entirely new or emerging. It is not possible to treat the data without imposing some organizational scheme, choosing a paradigm that may very well bias results. A good investigator will entertain multiple interpretations as long as possible and is willing to revise paradigm when warranted. The role of visualization technology is to allow parallel consideration of multiple possible interpretations, and to help the user make useful associations between seemingly unrelated data.



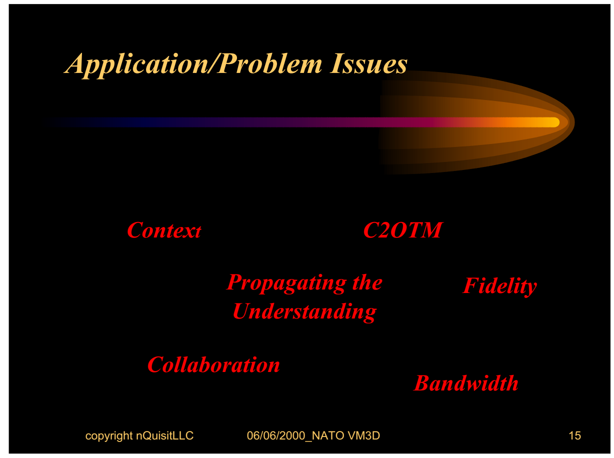
Networks lend themselves to graphic displays and have become a major consumer of visualization technology. Actually, network monitoring can be reclassified as belonging to problem types discussed previously.

Flow models over fixed networks are really examples of process execution monitoring, quickly highlighting nodes or arcs whose behavior is outside outside expected variation. These models lend themselves drill-down detail of intranodal processes, providing a connection between component level excursions and macro network behavior.

Flow models of networks with changing topology are truly exciting, providing insight into very complex self organizing processes. This is particularly true where thereis interaction between the network content and the network topology. Problems of this sort contain elements of both process discovery and process model monitoring.

Thie next slide simply lists a series of issues that apply to all the problem types discussed so far.

Perhaps the most central issue to understand is the



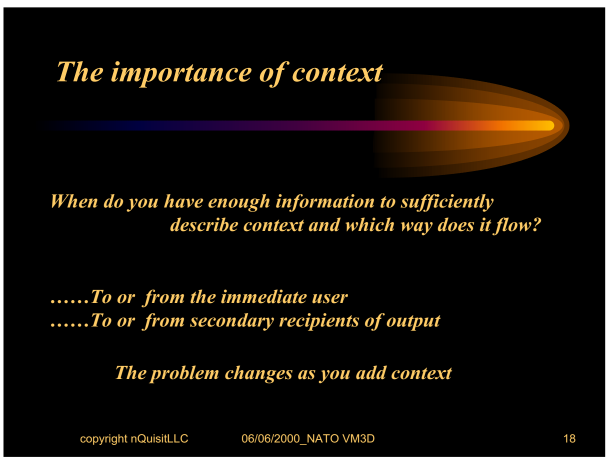
requirement to propagate understanding and context between users, remembering that immediate user may be subordinate, superior or peer to secondary or tertiary users. Direction of flow may reverse several times, depending on the situation. An information flow network model is always an interesting study, but most models don't account for the very different use of the information at each node.

It is traditional to separate analysis tools from production/communication tools, but that view just confuses what must happen. The act of shaping data for communication to another person requires synthesis and refinement of one's own ideas, and thus becomes part of the analytic process. The simplest example is thedifficulty, having arrived at great insight in some matter, of conveying to another why this is important to them.

The next slide is a static representation of the difficulty of receiving data when being jarred around in a moving vehicle. No matter what image stabilization or aural presentation techniques are used, the human's receptive bandwidth is radically reduced. Massive data reduction techniques are required.

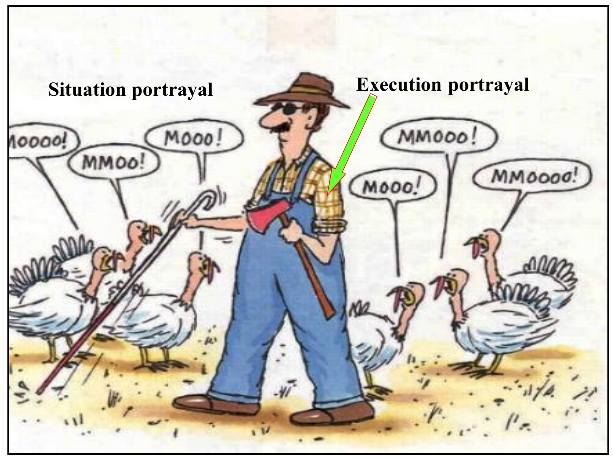
It's hard to overemphasize the importance of context. Context provides the background against which the next piece of data is interpreted. Depending on the situation, the problem

may be to provide sufficient context for other users or to interpret data with respect to received context. Even ex nihilo discovery problems generate their own context. The most significant point about context is that the problem changes as context is added.



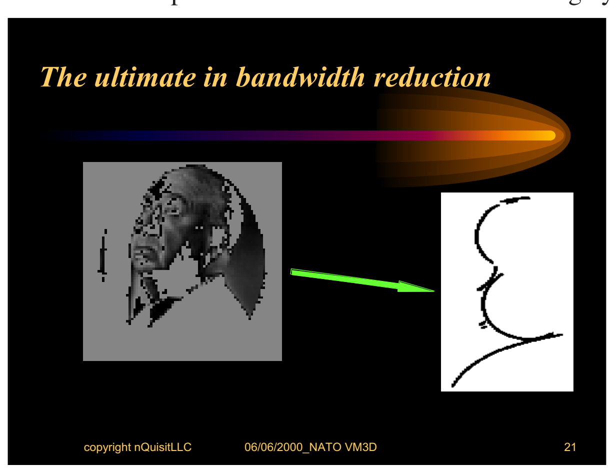
Communication from one person to another requires the sender to place the information in a form that is easily digested by the recipient. There is always some distortion in this process, significantly mitigated by iterative exchange. The real problem occurs when abstract conceptual or

qualitative information is transferred. The sender must search for metaphors that make sense to the recipient, and sometimes deliberate distortion must be added to get the point across. So, how do you know when distortion is beneficial and how much is permitted? Consider how news used to be reported, dry and outwardly factual (discounting covert content editing). The entertainment industry has become highly skilled at communicating abstract concepts, **as seen by the sender**. But the entertainment industry is geared to creating a desired impression in the audience, not the communication of fact. When the news media adopts entertainment tools to improve its communication effectiveness, it runs the risk of distorting the original content.



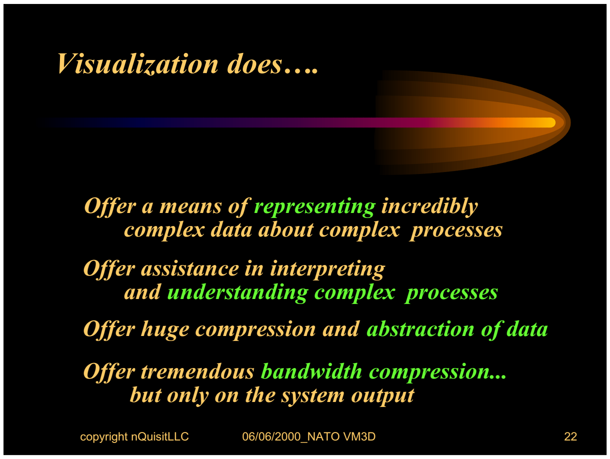
Here is an example of deliberate distortion of context intended to cause misinterpretation of any data received through the cane. Perfectly justifiable, from the turkeys' point of view.

Visualization techniques offer great bandwidth reduction, once the answer is known. There is a tendancy to think of visualization exclusively in terms of graphic displays and then argue over the bandwidth required to transmit the displays. In actual practice, the bandwidth required to assemble massive data sets is far greater than the bandwidth required to transmit essential conclusions. Caricature is a wonderful example. Practitioners of this artform are highly



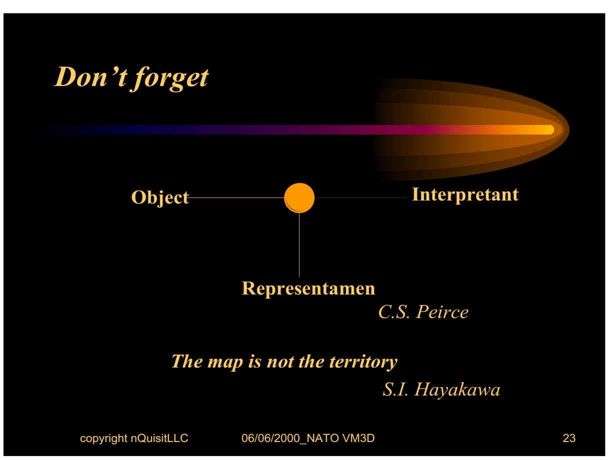
skilled at extracting both physical and personality characteristics and converting them to line drawings requiring very few bytes. These sketches quickly become iconic representations of very complex individuals.

Earlier, I spoke of things that visualization was not. Here is a list of things that visualization does. All contain the verb "offer' because there is no guarantee that any will happen automatically.



It is important to understand these potential results, each of which is an abstract concept. In all cases the data represent a second hand view of some process. When the process is complex, the data is usually also complex. And so the problem becomes one of adequate representation of the data itself, a secondary representation. If the mind can conjure up a connection between the secondary representation and a model of the real world, then visualization becomes the mechanism for comprehending the external process. And when that process is finally understood, great abstraction of the data is possible — leading to tremendous bandwidth reduction in subsequent portrayal.

Those not familiar with the writing of Charles Sanders Peirce are missing very important concepts in problem solving. His logic of discovery really does explain how data is manipulated in the mind to form new understanding. His existential graphs, shown here, show an irreduceable triadic relationship between an object, its representation, and the interpretation of that representation. Visualization results from the assembly of many representations into a cohesive interpretation.



But one more time, visualization is about how the mind represents and interprets data about external events. That is not the same thing as knowing the events directly. We hope the data maps into a faithful representation, but we must always understand that the map is not the territory.

Finally, some processes are very difficult to visualize while they are ongoing. Available data describe events as they occur, but do little to link events with each other or to depict the consequence of an event. The cumulation of consequences requires time to build up. Try to visualize feeding a baby without looking at this picture. All sorts of images come to mind, but not necessarily one of a very happy child presiding over what looks likeit may have been a disputed battlefield.

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Welcome, Objectives, Aims

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Introduction

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Visualising the Electronic Order of Battle

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The Problem

The Electronic Order of Battle (EOB) details all known combinations of emitters and platforms in a particular Area of Responsibility, for both Blue and Red force data. On today's modern battlefield an EOB can present a very complex and potentially confusing picture to the war fighter. Consequently, some method of presenting the EOB in a format readily assimilated by operators amongst the myriad data presented to them during pre-mission briefings is required. It is believed that visualisation techniques could be used to enhance the presentation of EOBs and assist operators to better understand and retain the data presented.

The PowerPoint presentation comprises two parts: a brief description of how an EOB is produced and then a brief on how EOBs are currently presented.

EOB Production at the CFEWC

The EOB is produced from the Canadian Forces Electronic Warfare Database (CFEWDB) which holds data on emitters, platforms, threat systems, and signatures, amongst other things. When it is decided to deploy assets into a particular theatre of operations a particular Area of Responsibility will be allocated and an EOB generated for that Area of Responsibility.

Data is extracted from the CFEWDB based on various source products linked to the Area of Responsibility of interest and the EOB for that Area of Responsibility. The data thus extracted is used in the programming of mission libraries for the particular EW systems to be deployed into the Area of Responsibility. However, the mission libraries are only as accurate as the available data allows. Therefore, there is the facility to feedback data on emitters encountered in theatre to the mission library production stage for rapid reprogramming of systems, and to the EOB so that it might be updated to reflect the current emitter situation in theatre.

In this way the EOB is continually updated by the original source products and feedback from the Area of Responsibility.

Presenting the EOB

Traditionally, the EOB has been presented to the operator in the form of paper based products, sometimes comprising large volumes of bound reports, and PowerPoint style presentations. This method required the operator to keep notes and rely on marked up maps and their memory to be aware of threats in their Area of Responsibility.

Currently, the EOB can be presented in the form of PDF files and simple electronic maps, which cuts down on the amount of paper involved but is far from an ideal system.

Work is ongoing into adopting interactive desktop GIS and browser based GIS linked to live database feeds, such as the CFEWDB. This approach gives a near real-time picture of the EOB for the Area of Responsibility to the operator.

Superimposing 3-D representations of missile engagement zones onto the GIS picture contributes to understanding the threat scenario because 'no go' areas which the Blue weapons platform should avoid become clearly defined. However, in the case of complex, interlocking and overlapping missile engagement zones it becomes very difficult to distinguish a 'safe passage' through the threat.

Perhaps a future system of presenting the EOB visually will utilise a fully interactive 3-D environment whereby the operator could 'fly' the mission in virtual reality.

Conclusion

The EOB for any particular Area of Responsibility is likely to present a highly complex picture to the operator. Currently, the EOB is presented in the form of paper reports and simple electronic maps, although work is ongoing in using a desktop GIS environment to present the EOB in a more readily assimilated form.

Paradoxically adding 3-D representations of missile engagement zones both enhances and complicates the GIS picture. The problem is how do we present the EOB data to the operator in a meaningful yet readily understandable and retainable form?

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Visualising the Status of On-going Air Operations

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Air tasking orders are issued in context. Consistency with the master air defence plan (MADP) and the airspace coordination plan (ACP) is necessary. Moreover, there is a complex of actors and stakeholders that include—but are not limited to—the following:

- Joint task force (JTF) air operations
- Airspace control authority (ACA)
- Joint force air component commander (JFACC)
- Area air defence commander (AADC)

In large scale operations, there may be as many as 4000 sorties, and 2000 separate missions in a day, involving

- Fixed wing aircraft [from the Air Force, Navy, Marine Corps, Coalition]
- Helicopters, artillery, rocket systems [from the Army]
- Cruise missiles [air and sea launched]

To be useful during operations, a visual rendering must help planners and controllers (16-20 operators) to deconflict in real time, and must present the whole plan after completion so as to be readily comprehended by commanders and staff. Clearly a simple spreadsheet will not suffice for the required operations picture.

Defensive visual renderings require different grain for different purposes—simple coverage maps over a wide area will suffice for command and planning, while smaller-area records of surveillance and acquisitions and are needed for post mission analysis.

Visualisation VCR

A suggestion is the video cassette recorder (VCR) as a metaphor. Conceived to record missions as planned (in animated and computer-generated fashion) for preview, playback, pause, fast forward/rewind, and freeze frame at selected times.

For Post Mission Analysis, also using the VCR metaphor, the suggestion is to record missions as executed (combat ops), including the replans, diverts, and scrambles.

Summary

Obviously, a visual presentaiton must satisfy the user (not the technologist) and help him or her to control the overall information content and select the appropriate subset to understand the situation and make informed decisions. Can this be accomplished? Some of the familiar PoerPoint charts are useful, but there needs to be more and better means to visualise them from real planning data, in real data bases for planning, replanning, and analyzing.

Can it be done?—perhaps the "VCR" can help.

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Visualising the Status of On-going Air Operations

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Discussion – Paper 3

A suggestion for improvement was to use software that would allow you to overlay different vies on the 3D display.

Level of detail was discussed. It would be valuable to be able to customize the level of detail for the end user.

Collision detection has been implemented.

Scalability is a concern. GIS compression software may be an asset.

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The Electronic Battle Box

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ABSTRACT

The Electronic Battle Box is an integrated suite of planning and decision-aid tools specially designed to facilitate Canadian Armed Force Officers during their training and during their tasks of preparing and conducting military operations. It is the result of a collaborative effort between the Defence Research Establishment Valcartier, the Directorate of Army Doctrine (DAD), the Directorate of Land Requirements (DLR), the G4 staff of 1Cdn Div HQ and CGI Information and Management Consultants Inc.

Distributed on CD-ROM, the Electronic Battle Box contains efficient and user-friendly tools that significantly reduce the planning time for military operations and ensure staff officers a better focus on significant tasks. Among the tools are an OrBat Browser and an Equipment Browser allowing to view and edit military organizations, a Task Browser providing facilities to prepare plans using Gantt charts, a Logistic Planner allowing to estimate supply requirements applying complex calculations, and Road, Air and Rail Movement Planners. EBB also provides staff officers with a large set of doctrinal documents in an electronic format. This paper provides an overview of the various tools of the Electronic Battle Box.

1. INTRODUCTION

Modern Armed Forces are highly polyvalent and mobile organizations that are involved, on the national as well as international scene, on a wide variety of operations, including armed conflicts, peace making and peace keeping, humanitary relief and aid to civil authorities missions. These operations require important planning efforts from military staff officers: Mission analysis, development of courses of action (including determining resources requirements), decision or course of action selection, plan development. These activities require from staff officers a good knowledge of the doctrine, military organizations and equipment characteristics. They also necessitate familiarity with a wide variety of complex calculation formulas (found in staff officers' handbooks) used to determine logistic, supply and construction requirements.

Although certain computerized planning tools are in used in the Canadian Forces, these tools only support partly the operation planning process. A large portion of the planning work is done manually or with generic tools (e.g. MS Office suite) poorly adapted to the tasks to be performed. Moreover, the planning process requires good synchronization between various staff officers, but sometimes information sharing is difficult and some tasks are duplicated.

The Electronic Battle Box (EBB) has been developed to provide automated facilities to support the planning process. EBB is an integrated collection of staff data and software planning tools used in the Canadian Army. The name "battle box" refers to the suitcase in which the army troops put the various Staff Officer's Handbooks (SOH) and Field Manuals when they deploy their tactical command posts. The Electronic Battle Box was developed with a purpose of providing a digital version of the various documents and software tools implementing the various military planning calculations found in field manuals. The logo of the suite (Fig. 1) represents the battle box (suitcase) turned into a computer monitor.

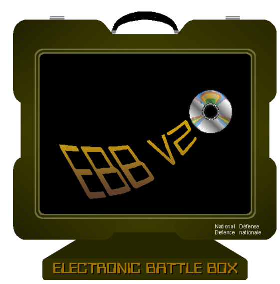

Figure 1 - EBB Logo

The Electronic Battle Box was developed as a cooperative effort between the Directorate of Army Doctrine (DAD), the Directorate of Land Requirements (DLR), the G4 staff of 1Cdn Div HQ and the Defence Research Establishment Valcartier (DREV), with the applications being developed by CGI Information and Management Consultants Inc. The development of the tools followed two years of R&D conducted at DREV on the exploration of advanced command and control concepts, in a project known as Chameleon. The aim of the EBB is to provide commanders and staff with common electronic reference material staff data, and planning tools for use within a command post. The tools have been deployed throughout the Canadian Army and are used in staff colleges. The Australian Department of Defence has also acquired the software to be used as part of the Army Battlefield Command Support System.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

2. IMPLEMENTATION APPROACH

The EBB suite has been developed on the Windows 95 / Windows NT platform using Borland Delphi 3.0 Rapid Application Development environment and Paradox Database v7.0. The suite of tools is integrated in a way similar to the MS Office suite and the user interface is based on the MS Office metaphors (e.g. Binder and HCI widgets). Import / export facilities between EBB and MS Office are also provided. The tools have been implemented to be used in a single-user mode. However, export facilities have been implemented to enable the user to exchange Orbats, Plans or Logistic Calculations with other users.

The tools are designed to help the user as much as possible. Highly graphical and user-friendly interfaces have been implemented; complex calculations have been automated and integrated to efficient and productive tools; electronic versions of doctrinal and staff officer's handbooks facilitate the search for information; in many tools, wizards provide the user with a step-by-step walk through on the use of the tools; a full-featured and multimedia on-line help provides the user with useful information both on the tools and on the planning process. Finally, the user interface of all tools is available in either French or English according to the user preference.

Each of the tools is briefly described in the following paragraphs.

3. THE EBB BINDER

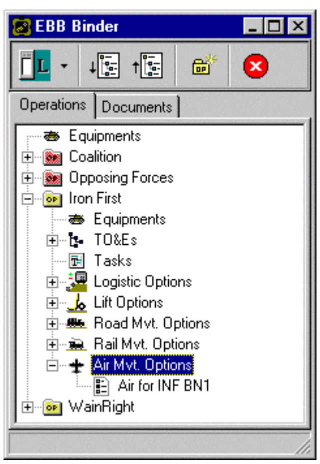

Figure 2 - The EBB Binder

The EBB Binder provides access to all the browsers, planning tools and read-only doctrinal data. In addition, users are able to commence the creation and manipulation of operations. Other reference documents are grouped into the Binder for ease of access. The Binder can also be used to exchange operation-related information between users. Figure 2 provides an example of the EBB Binder.

4. THE EQUIPMENT BROWSER

The Equipment Browser (Fig. 3) may be used to create, modify, delete, or view all the information related to doctrinal document. The equipment includes vehicles, trailers, shelters, weapons, ammunition, aircraft, EW assets, communications equipment, generators, engineer equipment and medical equipment.

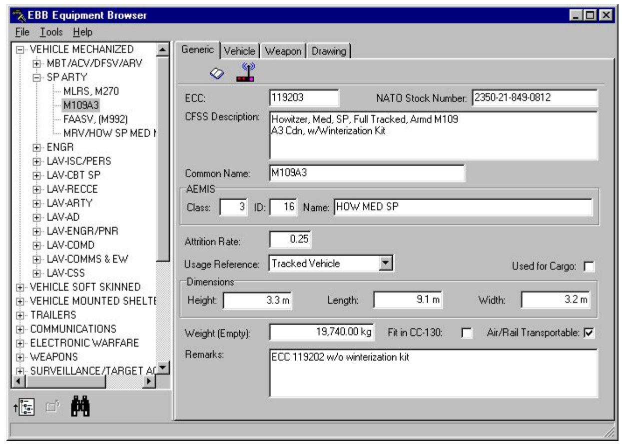

Figure 3 – The Equipment Browser

Among the main features of the Equipment Browser are the following:

- Equipment is divided into categories and presented using a tree view;
- For each equipment selected, the user can view various types of information: generic, vehicle characteristics, weapons and ammo for this equipment and equipment drawings with legends;
- The user can do a search on equipment names;
- Various equipment characteristics are used in the logistic and movement calculations.

5. THE ORBAT BROWSER

The OrBat Browser allows users to create, modify and display all the information relating to doctrinal OrBats. OrBats may be created from scratch, or by copying elements from existing OrBats. Equipment and Personnel can also be assigned to new organizational structures.

The OrBat Browser has a large number of interesting capabilities:

- The OrBat is presented both using a tree view and an Organization chart representation.

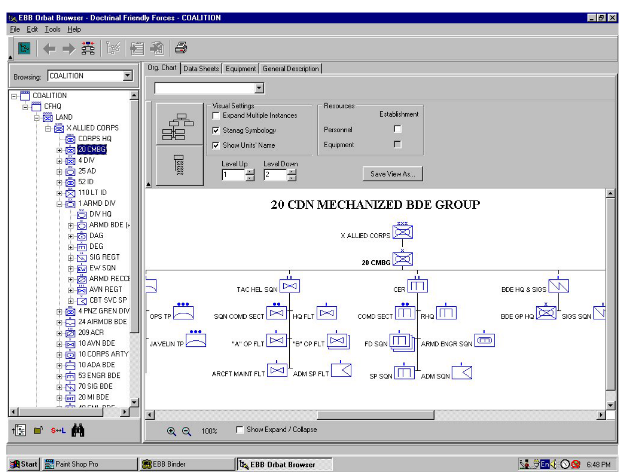

Figure 4 – The OrBat Browser (STANAG 2525 Symbology)

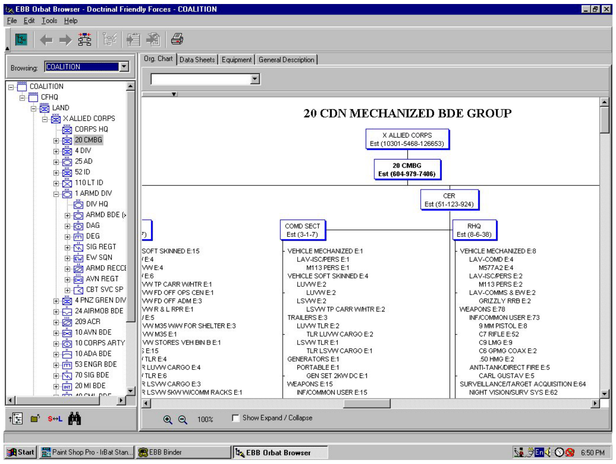

Figure 5 – The OrBat Browser (Equipment List)

- The user can customize the Org Chart representation, for example by presenting unit information using APP6 or STANAG 2525 symbology (Fig. 4) or without the symbology but with lists of equipment (Fig. 5). The user can display the number of levels as desired, display the Org Chart in four different layouts and maximize the viewing area by showing only the Org Chart. The Org Charts can be exported to the clipboard then imported into MS Word or MS PowerPoint.
- The user can create a new OrBat simply by importing an existing one and doing a drag and drop of the needed formations or units. The user can then easily readjust the personnel quantities and the list of equipment.
- Tables of Organizations and Equipment can be presented in a spreadsheet format. Both establishment and actual quantities can be presented. The user can customize the spreadsheet display by collapsing or expanding both rows and columns and interestingly, this can be exported to MS Excel.

6. THE TASK BROWSER

The Task Browser (Fig. 6) is used to plan tasks,

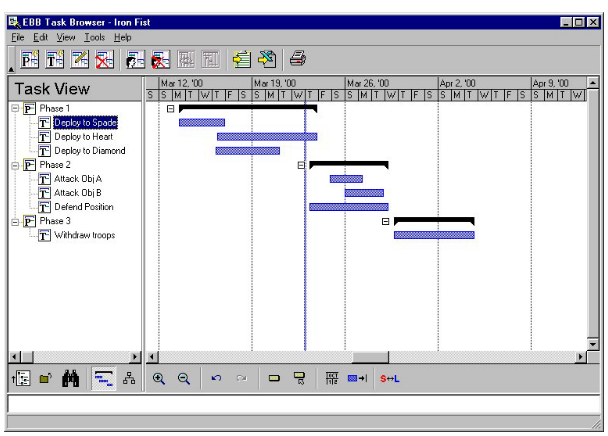

Figure 6 – The Task Browser

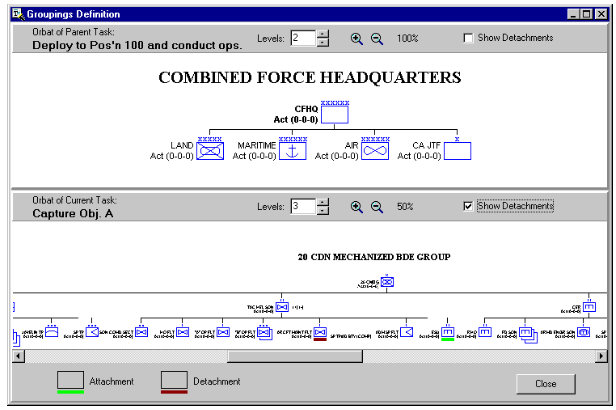

Figure 7 – Groupings Definition

which are grouped into phases, and to visually represent them as a Gantt chart. The browser allows for the assignment of a specific unit in the defined OrBat to a particular task. It also allows for the tactical grouping of units associated with specific tasks (Fig. 7). These groupings are subsequently used in the calculations for logistic support.

When defining phases and tasks, the user can set various parameter that will be used in the calculations. For example, based on the climatic conditions (e.g. arctic, tropical), he can set different food consumption requirements. Based on the type of tasks (e.g. attack or defend), the user can also set different ammunition consumption rates and different attrition rates.

For the Gantt chart representation, the user can select two modes of display: the first mode is to display the tasks on the left and show on the Gantt chart which units are involved on each task; the second mode is to display the OrBat on the left and show on the Gantt chart the various tasks the units are doing. The user can adjust the task duration graphically and move tasks on the Gantt chart. When doing so, the software will warn the user if a unit is committed to two tasks during the same period. The granularity of the time scale in the Gantt chart is automatically adjusted as the user zooms in or zooms out. The user can also plan in absolute mode or in relative mode (e.g. D-days, H-hours).

7. THE LOGISTIC PLANNER

The Logistic Planner calculates the supply needs for the selected units in order to accomplish their specific tasks. It computes the number of pallets required to transport the supplies. These calculated staff checks can then be manually adjusted to consider contingencies. Figure 8 shows an example of the ammunition, Petroleum-Oil-Lubricants and Subsistence requirements for a certain logistic option.

The Logistic Planner relieves the user from complex calculations. The calculations are based on formulas found in staff officers' handbooks and take into account various parameters: the tasks parameter set (e.g. climatic conditions, attrition rates), the resources (personnel and equipment) for

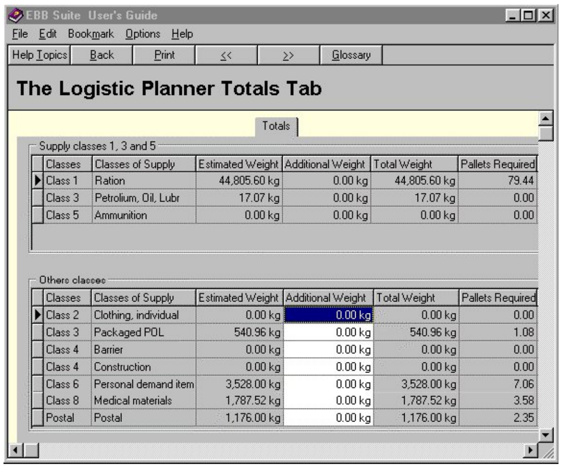

Figure 8 – The Logistic Planner

the units carrying each task, the equipment consumption (e.g. POL, ammunitions), the tasks duration.

8. THE LIFT PLANNER

The Lift Planner helps determine the number of vehicles required to move all the supplies calculated by the Logistic Planner and compares this to the number of vehicles available in the tasked units. It uses the list of equipment assigned to the units selected to carry the supplies. An equipment must respect four conditions to be considered: it must be marked as cargo; it must have a NATO pallet capacity greater than zero; its empty weight must be specified; and either its maximum weight on road or in cross country must be specified.

The tool presents the user with a surplus/lack indicator. The surplus/lack information is the difference between the equipment transportation capacity and the quantity of supply to transport, in terms of weight and number of pallets. Thus, a negative number indicates a lack of equipment to transport all the supplies.

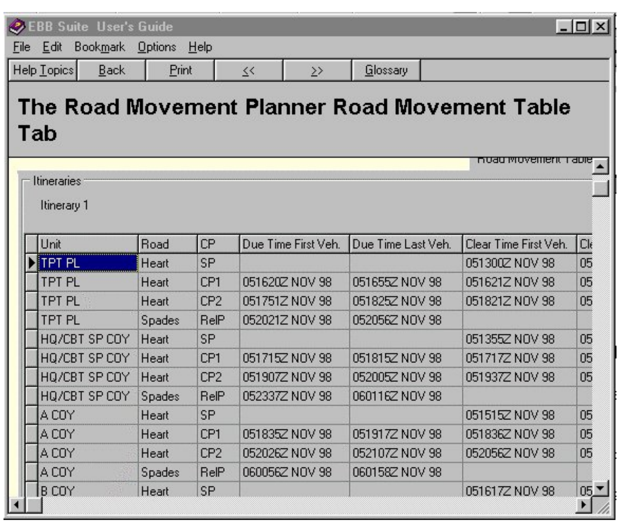

Figure 9 – Example of a Road Movement Table

9. THE ROAD MOVEMENT PLANNER

The Road Movement Planner provides the user with a detailed road movement schedule in the form of a road movement table. This tool can also be used for dumping planning.

Although this version of the tool does not use an electronic map background or a geographic information system, the Road Movement Planner allows the user to provide information on a road network with distances and the type of roads, then to specify itineraries. Parameters can be set for road movement by day or night and various road movement options can be calculated.

Orders of march can be defined for a set of units and its fleet of vehicles. The movement schedule for each vehicle can then be computed (Fig. 9). It should be noted however that the tool does not resolve the schedule synchronization of two road itineraries merging at a junction point.

10. THE AIR MOVEMENT PLANNER

The Air Movement Planner calculates the number of aircraft required to transport the units' personnel, equipment and/or supplies. It is designed to give an estimate of the required number of aircraft based on weight and volume considerations and should not be considered as a detailed aircraft-loading tool.

11. THE RAIL MOVEMENT PLANNER

The Rail Movement Planner provides solutions for loading a train depending on the number and type of train cars available, the equipment to load and some other criteria set to the users' preferences. It performs this function iteratively, creating and evaluating options until a good solution is obtained. Unit cohesiveness is maintained.

The Rail Movement Planner is implemented using genetic algorithms. On each iteration, a new set of solutions is generated. The user can view these solutions graphically, with an indication of the various sets of train cars used and of the vehicle(s) loaded on each train car (Fig. 10). Each solution is weighted according to their fitness, for example considering the number of vehicles left on the dock or the total number of

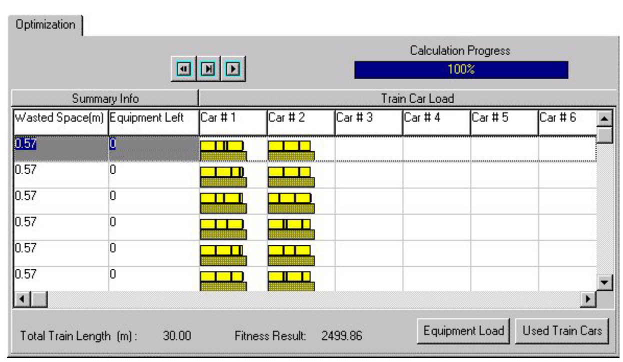

Figure 10 – Example of the Rail Movement Planner

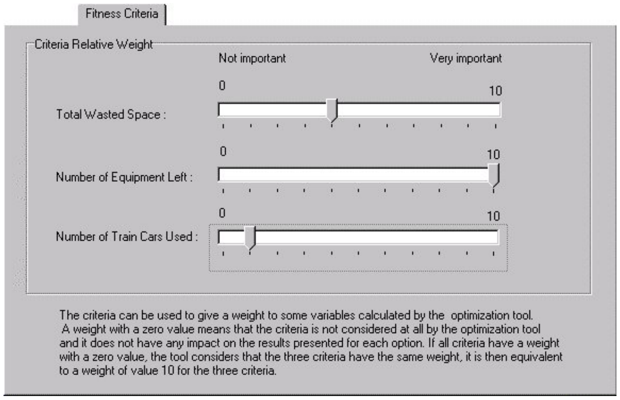

Figure 11 – Gauges for setting user priorities (weighting factors)

meters of unused space on the train cars. The user can establish his priorities when determining the fitness values (Fig. 11). The good solutions are used to create the new generations of solutions. Three techniques are used as part of the genetic algorithms: clone copies of good solutions are created, mutation of good solutions are computed or two good solutions (two good parents) are used to create a new solution (child). Genetic algorithms are very good when ones want to take into account multiple constraints. It allows to generate rapidly a good solution, but not necessarily the optimal solution.

12. CONCLUSION

The Electronic Battle Box is an efficient set of planning tools for the Armed Forces. It has tangible benefits for military staff officers. First it diminish considerably the time required for various planning tasks. Certain tasks that used to require 12 hours to carry out can now be done within an hour with EBB. Moreover, as the tools are integrated in a coherent suite and as the complex calculations have been automated, the risk for errors is significantly reduced. Finally, staff officers can now focus on essential military planning activities rather than on clerical work.

The manual planning process brings so much constraints that one sole planning option is often considered and this is seldom optimal. EBB tools allow to consider various options, perform some ‘what-if’ scenarios, and select the best option. EBB also provides facilities to share the results of some options with other staff officers, diminishing duplication of work and ensuring a better coordination. In the next version of EBB, a multi-user architecture will be implemented so that users can even have a better interaction in a collaborative mode.

Finally, staff officers in military training centers and staff colleges are better equipped to provide training on military doctrine and the operation planning process. They can better rely on information technology, prepare and reuse more easily military scenarios and exercises (including OrBats) and can focus on the real training objectives. Having access to a central repository of doctrinal data on a compact and easily accessed medium (the doctrinal documents on EBB CD-ROM) also facilitates the task of the training staff.

Footnotes

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Keywords: Planning, Decision-Aids, Logistics, Road Movement, Air Movement, Rail Movement. OrBat, Graphical User Interfaces, Command and Control

Discussion – Paper 4

This appeared to be a very good tool for entering and maintaining data, but not so good for creating executive summaries or reporting. It is effective at the strategic level.

Suggestions for improvements included:
- direct link to manuals or URL
- Use visualisation for reporting.
- Hyperbolic trees

Potential commercial uses could be displaying organizational charts, and resource and task planning. (i.e. police, fire departments)

Visualisation tools could be used to highlight aspects of the org, for example, weaknesses in the organization.

Issues of Visualisation in Peacekeeping Operations

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1. The Users

Commanders of multinational peacekeeping forces and leaders of small units in the field have related but different problems, many of which might be alleviated if they had access to displays of data relating to the various political and individuals with whom they are required to interact.

1.1 Technological support

There are at least two classes of technological support systems—support for fixed or mobile HQ operations, and support for officers in the field.

Support for HQ operations can be based on standard office-quality displays, databases, and communication systems. Support for officers in the field may be limited to hand-held devices (like Palm Pilots, for example) that have little display real-estate, small internal memories, and low-bandwidth communications, though it is conceivable that in the future, even field officers may be provided with non-intrusive head-mounted displays.

These two levels of support must be matched with the kinds of things Commanders (including logistics officers and other HQ personnel) and Field Officers need to know.

2. The Problem

Many independent groups are usually active in an area in which peacekeepers are deployed. Belligerents may not be cooperative; Non-Governmental Organizations (NGOs) may have overlapping self-determined areas of interest; formally allied peacekeeping forces may have different structures and national interests. Civilians need to be protected, and possibly housed and fed.

How does a commander at a high or low level determine with whom to interact, and in what manner?

How does a soldier in the field determine what to do when confronted with an unexpected situation?

2.1 Problems relating to Belligerents

2.1.1 (Commander's view)

A commander needs to be able to communicate with both belligerent parties, both to ascertain how they view the existing situation and each other, and to keep them informed of the intentions of the peacekeeping forces. Difficult and dangerous situations may occur if a harmlessly intended action is viewed as provocative or other than even-handed by either party. This need to communicate may be affected by the commander's lack of knowledge about the parties.

1. *Who's in charge here?* One or both of the opposing parties may have no defined command structure. The peacekeeping commander must determine who has the moral authority to ensure that agreements are made and kept.

2. *Where are the main communication channels?* Who in each of the belligerent parties is likely to be providing the "responsible authorities" with the data and advice on which they will base their actions?

3. *Who do they trust?* Which allies among the peacekeeping forces, and which NGOs do the belligerents trust and which do they mistrust?

4. *What are their social or religious taboos?* What should I avoid doing if I am to gain and retain the trust of the parties?

2.1.2 (Field Officer's view)

The Field officer is accompanied by a small number of soldiers, or may be alone. Rather than dealing with persons of authority among the belligerents, the Field officer may deal with individuals under orders, with individuals acting independently, or with organized or disorganized groups who are acting with intent to provoke or are simply congregated with no immediate purpose.

1. *Who's in charge here?* A potentially threatening group or situation has been encountered. Who among those present should be addressed, and in what manner?

2. *Should this person be detained?* A person has been observed who may be under indictment from Den Haag. Is this person the one indicted, and is the situation appropriate to execute an arrest?

3. *What should be done about this construction?* A structure, such as a roadblock or a gun emplacement, has been encountered. Is it in the database of permitted structures? Is it within the scope of agreements? How should it be treated, and who should discuss the issue if there is one?

4. *What of my possible actions might be viewed as unnecessarily provocative?* Are there actions that in my culture would be appropriate for the situation that might here lead me into difficulty or danger?

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2.2 Problems relating to NGOs

2.2.1 Commander's view

It is normal to assume that any NGO in the field has the intention of helping the civilian population in some way, whether it be with medical assistance, food, housing, social support, or in some other way. However, in attempting to help, an NGO might well impede the work of the peacekeeping forces, or disturb each other's humanitarian operations. The peacekeeping commander normally has no authority over the operations of an NGO, but nevertheless may need to influence their operations by exerting moral authority, perhaps backed by the potential of requesting political authorisation to enforce some requirement.

The commander needs to know what the NGOs are attempting, how they are organized, and how they relate to the belligerents. An NGO whose work is confined to aiding one of the belligerents to the exclusion of the other may be seen by the other as provocative, if the peacekeeping forces do not in some way provide a countervailing assistance to the party ignored by the NGO.

1. *Who's in charge here?* How is this NGO structured? Is it a loose-knit collection of volunteers doing what they can, or are the workers tasked by some local or remote central authority?

2. *Who is doing what?* What is each NGO trying to do? There may be dozens or even hundreds of different organizations in the area. Overlaps and friction are likely. How does the commander determine what they are trying to do, and how can he/she maximize their effectiveness?

3. *How can the NGOs help the formal peacekeepers, and vice-versa?* Some tasks may be better done by NGOs than by the military, or vice-versa. How does the commander assess the balances?

2.2.2 Field Officer's view

The Field Officer encounters individual members of an NGO who are doing the job for which they came. But in the circumstances, what they are doing may appear to the field officer to be potentially dangerous to themselves or to others, or may overlap what ought to be the officer's own area of responsibility. To know how best to act, the officer needs to know at least a few facts of the situation.

1. *Who's in charge here?* A bunch of civilians is doing something. Who are they and who is in charge of them? Who should the officer deal with?

2. *Who is doing what?* Who are these people and is what they are doing likely to be helpful or damaging? what should be done to encourage or discourage them?

3. *How can the NGOs help the formal peacekeepers, and vice-versa?* Can the officer assist the NGO personnel on the ground in a difficult situation, perhaps physically, perhaps by acting as liaison to some other NGO? Can the local NGO personnel assist his/her forces in an assigned task?

2.3 Problems relating to Coalition units

Commander or Field Officer

The units of forces in the coalition from other nations should, in principle, be structured and tasked in a way known to the commander and to the field officer. But that information must reside somewhere, and the facts may well not match the formally defined structure.

1. *Who's in charge here?* What is the Order of Battle of the coalition units? Who is responsible for liaison and for the actions of those units?

2. *Who is doing what?* What are the responsibilities of the Coalition units, and how are they to be coordinated?

3. *What are the political objectives of the different allied elements?* Do some Coalition units favour one belligerent over the other? Are some NGOs more closely linked with some coalition elements than with others?

3. Problem Abstraction

Many of the problems listed above have in common that the key requirement is for the user to visualise ***relationships***.

The commander may need to visualise who talks to whom, who can authorise what kinds of action on the part of the belligerents or the NGOs, how civilian refugees relate to each other—who is likely to help whom, and who is likely to harm whom. Are there family relationships to consider?

The field officer may need to visualise the political relationships relating to an unexpected roadblock or an opportunistic encounter with a suspected war criminal.

How should relationships be displayed? Does the answer depend on the screen real-estate available?

3.1 Displaying Relationships

If there are only a few entities of interest, the existence of a relationship between two (or among three) may be shown by connecting lines between icons. This does not, however, allow the user to visualise the nature of the relationship.

The interesting relationships often centre around an individual or a place. This suggests that the representation may often have a “fisheye” quality, relationships being displayed in detail around the core individual or place, and more generally for more distant relationships.

Relationships come in many flavours. They often correspond to verbs. Verbs may be dynamic, suggesting that the display of such relationships might map best onto a dynamic display. Verbs (in English) often relate three entities in a particular way, which also suggests that relationship displays might normally be 3-way rather than linking just two entities. ***How?***

Most relationships are not symmetric. A *owns* B does not imply B *owns* A. Connecting lines—even lines with arrowheads—do not make the relationship intuitively obvious. When the relationship is triple (e.g. A *gives* B *to* C) the problem is worse.

Connecting lines also create problems when there are many entities with pairwise or triple relationships. In the real world, relationships are often visualised from common movement, colour, spatial relationship or other Gestalt factors. This suggests that not only intrinsically dynamic relationships may usefully be displayed through related movements on displays, but also asymmetric relationships may benefit from motion in the display.

Consider the problem of a field officer unexpectedly seeing a person who might be a war crimes suspect. Before making an arrest, the officer needs to know the ramifications of making or not making the arrest at that moment. The available display is on a hand-held device, but it must display relationships such as the political tensions and support systems around the person, the position of the person within the belligerent organization, and so forth. How? We do not know. Research is needed.

4. Conclusion

This paper has noted a few of the multitude of problems that face officers involved in peacekeeping, which is an increasingly important part of the activities of most militaries. It is asserted that the officers could be helped by the provision of displays that could show them some of the relationships among individuals and groups that may be encountered during the operations. These relationships are of several types. They may be symmetric or asymmetric, and may be bilateral, trulateral, or possibly even more complex. Little is known about how to display relationships, especially complex relationships within large numbers of individuals and groups. It is asserted that however the relationships are best displayed individually, the display of large sets is likely to depend on some kind of fish-eye view, in which the most detailed information concerns a central individual or group, with more distant relationships shown in less detail.

Note

1. The original specification of this problem was provided by C.A.McCann of the Defence and Civil Institute of Environmental Medicine, Box 2000, North York, Toronto, Ontario, Canada M3M 3B9.

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Support Concept for Creation and Use of Marine Doctrines - Problem Presentation

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Summary

The aim of this research project is the development of an ergonomic support concept for creation and use of marine doctrines.

Command and combat direction systems deal with decision making processes, which support operators in identification, classification and combat. These tasks can be optimised by means of variable parameters according to the situational environment. Special decision rules (*doctrines*) allow the value assignment to parameters according to specific events. Those rules allow the simplification of the operator interface and can influence significantly system behaviour.

The task of this research project is to optimise the tools required for handling and visualising doctrines and parameters rather than to develop doctrines in content. The user shall be relieved by the use of information processing and information presentation technologies. The effectiveness of the doctrine concept shall be assured.

Introduction/problem description

Modern command and combat direction systems (CDS) of marine platforms include decision making processes, which support the operator in identification, classification and combat. These processes regularly are not fixed instead can be optimised by means of variable parameters according to the situational environment, like e.g. threat and geography. Recent developments may help to avoid the manual and single step tuning of such parameters. Special decision rules (called “doctrines” in the CDS F124 (fregate 124)) allow the value assignment to complete parameter sets according to actual needs as determined by the CDS. Events, that trigger such doctrines, are freely definable within all the existing datasets of the system. For example, it is possible to define by means of doctrines that by entry in a defined marine area the combat of Quick Reaction Targets takes place automatically opposed to semi-automatically by exit of the area. Also the commencement of a Rule of Engagement could be a trigger event for a doctrine.

The control of radar systems can take place the same way. New developments, like APAR and SMART-L, include parameters adjustable by doctrines. Those sensors as well as a lot of other parameters influence complex processes. The understanding of the effect of changing parameter values partly requires profound system knowledge. Doctrines allow the simplification of the operator interface, e.g. the algorithms for acquisition, detection and combat of Sea Skimmers could be optimised by manual release of a doctrine “Sea Skimmer Defence” without the need of detailed knowledge by the operator onboard.

Consequently, doctrines can influence significantly system behaviour. Their application will be inevitable for control the multitude and complexity of parameters in order to make the CDS to an efficient field-tested system. It is the aim to condition the CDS that way that the operator is supported and relieved in time critical situations. This requires a thorough planning in definition and selection of doctrines guaranteed only by an ergonomic design of the handling of doctrines.

Problem constraints

A doctrine system will be introduced by the German Navy with the CDS F124 for the first time. The specifications and concepts of this system are the basis for this study. It is not the aim of this study to develop doctrines for F124 in content rather to optimise the tools required for handling and visualising doctrines and parameters. It is assumed that the development of doctrines will be basically performed by a special organisation staff ashore. Its task will be the definition of mission based scenario supported packages of doctrines and their validation by means of a simulation system. The tasks aboard will be the selection of required doctrines as well as a situation dependent adaptation/supplementation.

Necessity and purpose of the research:

It is a big chance for developers and for users to support mission planing as well as mission execution of battle ships by means of doctrines. The CDS F124 will have about 600 parameters and about 5000 situational data at its disposal,

Paper presented at the RTO IST Workshop on “Multimedia Visualization of Massive Military Datasets”, held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

which could be used as building blocks for doctrines. The amount of producible and useful doctrines is practically unlimited and is solely dependent by the system resources. Furthermore, any doctrine might trigger any other doctrine. The variety of combinatorial options as well as the knowledge and the understanding of these complex correlations picture a problem for developers of doctrines and for users onboard.

Beside the use of a doctrine-database filled by the navy there shall be an option to input and edit own doctrines as well as to change parameters onboard. That might yield to problems in consistency and conflicts that have to be avoided absolutely. As far as specified there will be no intelligence in the doctrine editor F124 for proof of consistency. So far, products developed in the scope of the CDS F124 often show the insufficiency that the requirements regarding an ergonomic user interface (clarity, transparency, short operating sequences) remained unconsidered.

Reasons are among others missing knowledge of tactical operational backgrounds, development of system components that belong together under various contracts and time pressure in product development in order to hold the deadlines. It has always been required to bring in tactical-operational knowledge by navy developers in order to produce an application-suited design of the human-machine interface. The doctrine concept F124 is a novel planning instrument with no experience neither in industry nor in the navy.

Task contents

Aim of the research project is the development of an ergonomic support concept for creation and use of marine doctrines. The user shall be relieved by the use of information processing and information presentation technologies and the effectiveness of the doctrine concept shall be assured.

The problem areas to be covered in this project are:

- Creation of doctrines (overview and access to doctrine modules, edit functions)
- Management of doctrines (doctrine database, sorting functions, search functions, select functions, transparency, i.e. "How can the user recognise the impact of a defined doctrine?")
- Doctrine handling in use (adaptation of predefined doctrines to a tactical situation, status overview, manual triggers, general application concept: selection of many alternative doctrines or creation of derivatives of a generic structure?)
- Conflict between doctrine controlled and manual parameter setting (avoidance of contradictory actions)
- Consistency of active doctrines (avoidance of contradictory actions)

Task schedule:

1) In cooperation with the navy exemplary doctrines shall be selected or formulated, effective in areas like sensor control, identification, classification and combat. The examples ought to cover the complete spectrum of doctrine application, i.e. beside the setting of parameter values the following doctrine actions/triggers are to be considered: "Operator Notification", "Doctrine Activation", "Operator Input" and "Time".
2) On the basis of this representative cross-section a support concept for the work with doctrines shall developed, that serves doctrine developers as well as users. Possible weaknesses of the doctrine concept F124 as well as arrangements for their elimination ought to be presented.
3) Realisation proposals are to be designed by means of a prototyping tool and exemplary demonstrated.

References:

Task description for the study: "Support concept for creation and use of doctrines", F¸ M III, BMVg. (Navy Forces Staff, department III, German Department of Defence)

Discussion – Paper 6

- Support concept for creation and use of marine doctrines
- How do we structure the rules in order to have the right information available at the right time?
- Several thousand rules (marine doctrines) determine the tasks of the staff of a military ship has to perform.
- Knowledge acquisition
- Coding, editing, inserting structuring and visualizing the rules and inference results
- Artificial intelligence
- Visualisation of rules, actions, missions, relations between rules

Discussion:

Major facets of discovery
How to construct, hypothesis generation
The faster you do that, the more alternatives you can obtain
How do you use old rules to create new rules?
Stress factor kicks in when you're running out of time and the user doesn't want to introduce or consider a new alternative.

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The Surveillance Picture Visualisation and Display

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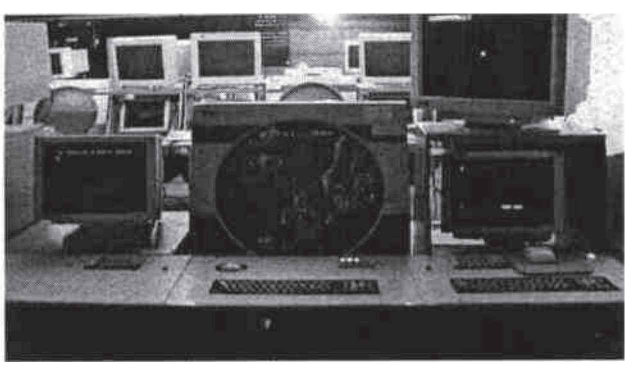
Summary: The aim of this paper is to outline some of the work carried out at DERA Malvem about visualisation and display issues associated with the surveillance picture. It will describe some of the current surveillance pictures in use in NATO, outline the application of symbology in the air picture, and then describe how visualisation can help the identification officer.

The Operations Room: The first figure below depicts the operations room, in which the operations process has remained largely unchanged for over 50 years.

Operations Room from 1940s

The UK operations room, responsible for producing the surveillance picture, is shown in the second figure. It is comprised of a 4-colour picture display with tote information on tabular display screens. It was designed in the 1970s during the Cold War, developed in the 1980s, and introduced into service during the mid 1990s, and was effectively obsolete by 2000. However it is regarded as state of the art by many countries who use systems more akin to the first figure.



RAF Ops Room 2000 ICCS

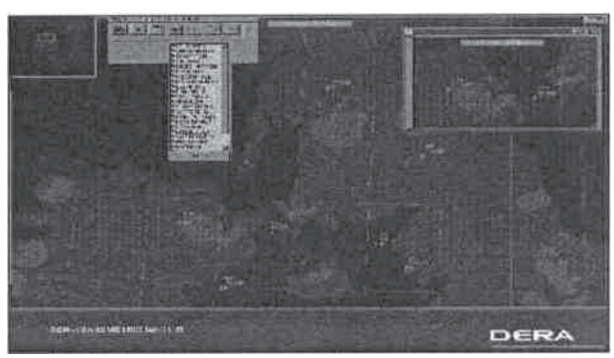
However there are still serious issues concerning the new system:

- The system relies on the user spending up to ten minutes customising the display to suit their own preferences.
- Visualisation tools such as air routes are not individually selectable, so the user is presenting with all the information.
- Limited choice of colour in the display
- Information presented in large tables can obscure changes in the data.
- The operator currently has to switch the display between selected areas.

A current prototype developed by DERA illustrates a more practical approach to the HCI design. It consists of a large map, accompanied by two smaller inset maps, which aid navigation around the map, without losing the visibility of the data.

Subsets of the data may be displayed or hidden by use **of** a pull down list. The colour scheme used in this prototype highlights data that is applicable to the current user's role. Other data, not applicable to the role, is also presented but is dimmed so that it does not distract the **usr.**

Symbology: The key to operational success in all fields of air operations is situation awareness, and the aim of symbology is to assist the operator achieving this situational



Future Surveillance HCI

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awareness. It is difficult to quantify how situational awareness is achieved; in its simplest form on a surveillance picture it is the ability of the operator to scan the picture and get a feeling of the relative disposition of forces and their location. The use of a well-conceived symbology can make this task significantly easier.

In order to develop a symbology set the following need to be considered:

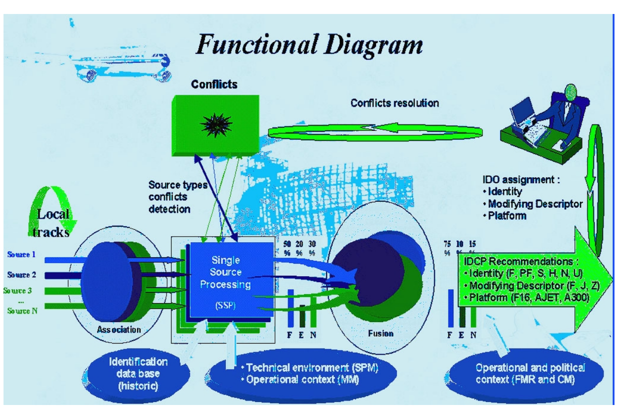
- Examine me standards, track categories and the definitions of what constitutes a track.
- Determine the structure of the symbol. This structure can either reflect the category of the track eg a hostile tack could be seen as 'h'. Alternatively the track could represent the platform type eg small aircraft symbol for a fighter, large for a transport ac etc.
- Add appropriate colours, shapes to give us the common symbology set.
- Add explanatory detail, e.g. track identifiers, direction of track, number of aircraft, etc.

There is confusion in the use of symbology in general and Air C2 systems specifically,

- Clarity in the use of Categories and Identities.
- Emergence of a de facto standard (e.g. on the E-3 aircraft) that does not align with any of the current NATO standards.
- Loss in the value of data that is translated between systems.
- No adoption of recognised colour groups in relation to Category

Visualisation in air target Identification through data fusion. Most aircraft identification is carried out without the clear picture on the left. Even if you see an aircraft with the mark 1 eyeball it may be at a distance, in bad weather or in a difficult profile.

The reality is that the identification operator may only have a plot or a track on the screen that has been initiated form one or several different data sources. Often these sources may not have been fused, and manual correlation has to be carried out.

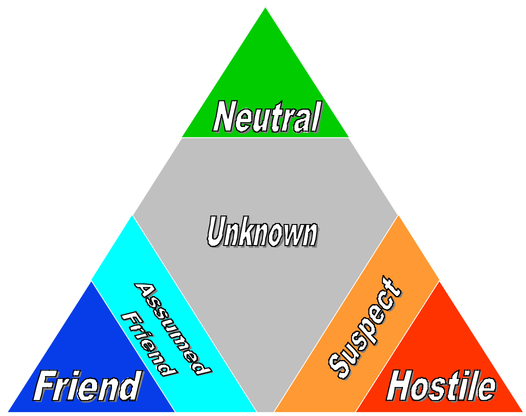


Identification Data Combining Process

A fully fused system can provide the operator with visual aids to target identification from a number of data sources. The diagram below illustrates the process whereby data from the sources is used to produce a recommendation based on the identification data combining process (IDCP).

Visual cues are provided to the operator in both anautomatic and manual processes. By selecting a data source the operator can view the system-generated probabilities of identification allegiance. Here the system probabilities are critical a define exactly where the dot will appear, in a system based upon the concept illustrated below.

This whole area of data fusion, IDCP and visualisation aids for the operators has been tested by Nato operators in a simulated exercise in France.



The Allegiance Triangle

While there was much discussion on the setting of the IDCP factors, the comments from the operators on the visualisation aspects of the system were most favourable:

- Air picture displays need to reflect available visualisation technologies.
- There needs to be a commonality of visual data presented to the operator (symbols, colours etc)
- New technologies such as data fusion will bring greater visualisation possibilities such as IDCP and the Allegiance Triangle.
- Internet and Intranet technologies should be integrated into the operator's workspace.

Discussion – Paper 7

Current and future air picture tech
Symbology
Data fusion

Current UK system problems?
We live in the dark, do we need to?
Dumb system – takes a long time to get the system back up after crashes, could there be a swipe card?
Limits to visualisation tools
Colour discrimination
Hidden info
Single display

2003 – use of color and transparency to highlight map
Call up displays of interest – weather for example

Objects must be displayed in real time

Symbology used to assist the operator in achieving situation understanding
Symbology set, standardized, labeling
Currently there is loss in the value of data when it is translated between systems, use of symbology not consistent with NATO standards

Need to standardize categories, colors, symbols

Need electronic online visual assistant
- Intelligence and tactics
- Simulation
- Manning
- Help

Need air picture displays
Need commonality

Speed up procurement procedures
Video conferencing and passing screen shots

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Discussion – Operations Visualisation I

Use of
- color
- overlays
- amount of detail
- multiple vs single displays

Visualising dynamic relationships

Use of COTS components

Need to react to a situation in terms of the static background, or context

Computing systems good at answering the questions you ask, not necessarily the answer you want to know.

Temporal relationship

Dynamic situation and data

Scalability

Varying level of detail

Tend to put all the information we know into a visualisation, especially when we're not sure what we want to know. Use visualisation to help us see what we need to know, even if we're not sure what that is. Danger of information overload, which instead of clarifying complicates. Varying levels of detail on display can help prevent info overload while still maintaining valuable info

Using level of detail to indicate the difference between general to specific

Context sensitive
    Surveillance/control
    What can be controlled
    What can be observed

Drill down
Reactive

Ambient visualisation

Speech
Anomalies in sound
3D audio
generic vs learned capabilities
Noticing something different in the environment, be it through sight, sound, or other form of input that the user notices.
Machine learns how to best present information to a specific user, neural network.
The visualisation becomes an extension of the person

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Environmental Visualization for Sonar Tactical Decision Aids

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The coverage and timeliness of environmental data is improving significantly. New analytical acoustical models offer increased resolution and greater accuracy. PC computing platforms are orders of magnitude faster. There is a need to turn a moderately slow environment assessment into a rapid environment assessment.

Given near-complete environmental data and faster more accurate models, DERA recently posed the question of how can these capabilities be harnessed to improve the performance of ASW sonar operations and tactical decision making. How would this environmental data be displayed? Visualization is one tool that can be beneficial in presenting and exploiting the environmental picture.

Visualization is a valuable tool anywhere there are large amounts of data, and/or multi-dimensional data, and/or the need for context and focus, and most importantly, where ever people need to be in the loop.

Interactive 2D and 3D visualizations allow people to see more data, more quickly with more comprehension. Situation awareness, and decision-making processes can benefit from combining data, graphics and interaction. Understanding is increased, tasks are completed more quickly, critical data and analytical resources are fully used, confidence is increased and decisions are improved.

Visualization is a tool for enhancing human performance especially when decisions are not black and white. "ASW is a thinking man's war" with many changing conditions and situations. Visualization can be an external cognitive aid. It can help provide greater understanding of sonar conditions and sensor effectiveness. The need is great. *"Submarines live in the underwater environment all the time while surface ships are there only a little time."* Surface ships need greater insight into the underwater environment, how it affects their performance and any opportunities for improving their performance. In ASW operations, the environment has significant tactical consequences. Environmental factors are influential in many command decisions. Command wants to know, "Where am I going to acquire the target? And from how far away?"

During the course of a project sponsored by DERA, a number of design concepts were developed that show how interactive 2-D and 3-D linked visualizations can address some of these ASW requirements.

A user interface framework was developed with several display elements, including: environmental view, acoustic analyzer, thumbnails view, and a key plan view. This framework allows acoustic model data to be viewed in context with the related environmental factors, for the purpose of making timely, informed tactical decisions.

These display elements are linked. Changes in one view can affect, and be seen, in the other views. For example, changing slice depth in one view causes an update in the other views too. Tightly coupled interactions enhance user comprehension of related complex factors. "What if" analysis is supported via tightly coupled interactions. For example, a user can change the FOM setting and instantly see the impact on ranges in all views.

An isosurface is used to show the acoustic volume in the acoustic analyzer view. The isosurface works by taking a discrete value from the user and creating a "shell" composed by connecting all of the instances of that value in a volume. An isosurface traces the path or paths of a single threshold value in three dimensional data space and displays them using one or more surfaces. This is used to create a shell indicating, for example, the placement of a specific confidence volume within a larger volume of seawater, as well as other volumetric propagation loss properties.

The Thumbnails component is a comparison tool designed to visualize, store and recall the relation between acoustic property surfaces at different parameter settings. The shape and size of the surface will be different based on the parameter settings; and this component provides a graphical representation of the surfaces to allow for a quick visual comparison between them.

The designs discussed here were targeted for implementation using the highest end Windows / Intel / graphics accelerator platform possible. These capabilities can be implemented in Java, in order to provide platform flexibility, and would require using a commercial off the shelf toolkit.

The visualization design goals included maximizing readability, useability, with a clear insightful display that uses natural visual paradigms.

The visualization supports the visual fusion of different data in the same display.

These design concepts are presented in this NATO forum for review, and with the intention of generating discussion and suggestions for improvement.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 8

The multiple views are an asset. The display shows multiple levels of command and the reasons for decisions.

Suggestions for improvement:

- Currently only one sensor is used, could multiple sensors be deployed?
- Ability to toggle aspects on and off and show transparency
- Show how a sound ray might be bent in the sea

If there is a sub in location X, how do you decide where to place the sensors?

- Not readily covered

How do the ASW people feel about this?

- The users have been involved in the development cycle through interviews, display updates, and reviews.

Validation and quantification processes are underway.

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Joint Air Command Laboratory

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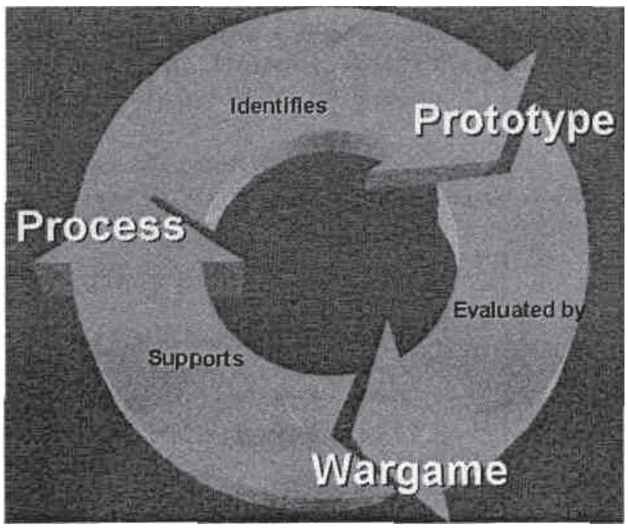
Summary: This paper will describe the concepts behind the development of the JASPA prototype, within the Joint Air Command laboratory (JACL) at DERA Malvem.

The JACL: The JACL was established in 1997 to give the customers (including the operational community) a single focus - an identity that they could turn to for information on all Air C2 issues.

The belief underpinning a great deal of the work of the JACL is that Command is about the process - it is not about technology. Technology doesn't win wars - people make decisions and people win wars.

To support this notion the work based at the JACL undergoes a cyclical nature: understand the operational process, develop the prototypes, expose the prototypes to a near real-time exercise involving operational staff, and where necessary, revise the process and prototypes.



The 3-stage process of the JACL

Military Background: Military operations today depend heavily on the C^4ISR (Command Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance) framework. This involves the collection, dissemination, processing and interpretation of large volumes of data and information. As battlefield operations become increasingly complex there is an increasing burden for commanders/operations room personnel to act as information assimilators and overseers. There is a need for a revolution in the presentation of the necessary information. This is particularly important in the context of the increasing likelihood of joint and/or combined operations, where the larger tactical picture is of fundamental importance to the operation planner and controller.

An accepted model of 'conduct' is the OODA (Observe, Orient, Decide, and Act) cycle. Previous research has tended to concentrate on the *"decide"* and *"act"* stages of this cycle. Research is required to address the *"observe"* and *"orient"* stages of the OODA cycle so that assessment of the actions (e.g. battle damage to targets, mission reports, enemy actions) can be fed into the early stages of the next cycle. For example, if a mission was launched to destroy a bridge the commander will need to know:

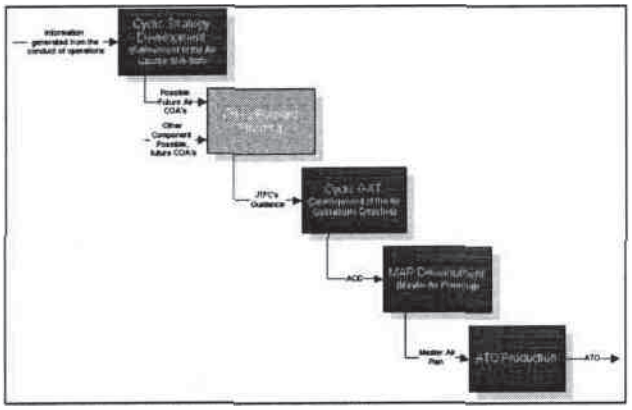
- whether the bridge was hit, and which parts of the bridge was disabled
- does the mission need to be repeated
- impacts for and against a repeat mission
- all targets missed with, with target priority/importance.

Visualisation of the battlespace will assist the battle commander to project ahead from the orientation stage to decision making. UK enemy forces currently undergo manually the OODA loop every 24 hours. There is, tlicicl'ore, an urgent need to be able to assess automatically not only the success or failure of missions, but also to monitor continuously the detail of missions and logistics in a ready and efficient manner, i.e. complete the OODA cycle in a short time.

Such rapid mission assessment would provide an advantage over the enemy for mission planning and decision making as greater visibility of the battlespace will allow the commander to optimise his own cycle and possibly allow him to make more opportunistic decisions, based upon previous actions.

The process. A technology gap was identified by consulting the models that the JACL produced in order to understand the processes used to exercise command and control of air operations in a joint environment. The diagram below depicts a "scene" extracted from the models. It illustrates the data sources used by the Strategy Cell to refine their understanding of the enemy and the tasks that they have been given to achieve: both of these together are used to develop possible courses of action for the next cycle. The development of the courses of action is an iterative process that takes input from the other components. The selected courses of action are submitted to the JFACC for his approval

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

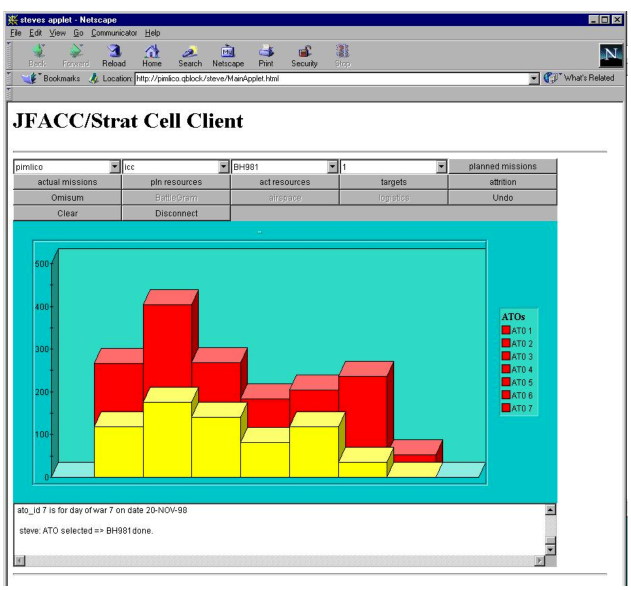


Extract from the JACL process models

JASPA: During early 1999 de-risking work was started on the visualisation of large datasets from Air Battle Planning Systems. This investigated likely technologies and methods of extracting large amounts of data from a variety of databases, processing me data and displaying the results in a user definable format by the use of a drag and drop interface. A user interface was implemented which enabled the operator to display the database data in 2-D and 3-D in a web browser; this enabled the data to be visualised on a variety of platforms and operating systems. The Figure below illustrates a method of applying data visualisation.

In this first iteration of the JASPA prototype the operator initially selects the type of data, the name of the Webserver plus the name of the database instance. A series of buttons corresponding to database SQL queries may be selected to produce a graphical representation of the data.

As the project widened its scope with interfaces to different databases and planning systems it became apparent that some method of systems to announce their presence and clients to discover what systems were available was needed



Planned missions plotted against actual missions

A distributed computing environment was developed that supported a registry lookup service; interface services were built to different systems linked in to then-database. The service once started would announce its presence on the network and register itself, clients wishing to use such a service could then locate it, and the service is uploaded to the client and is then available to perform tasks. Once the connection is made, the lookup service is not involved in any of the resulting interactions between that client and that service. The diagram below offers a representation of how this federation may operate

The initial responses from the operational community have been positive and supportive of the work. Further research is required to create flexible user interfaces, navigation tools and search methods appropriate to each type of operator and task. In addition, the tailoring of the visualisation system based on human capabilities of perception and information processing poses further challenges. With the involvement of psychologists from the Centre for Human Studies (CHS), it is intended to investigate the process of decision making from an information visualisation perspective

JiniTechnology. Jini is a set ofAPIs and network protocols, the technology is built on top of the Java application environment. It uses core Java functionality to provide a reliable, portable and simple-to-use distributed computing model, it enables networks of devices and software services to be assembled into working groups known as *federations of services* without the intervention of system administrators. The operator needs no knowledge of what services are available, or where they are located, as the list of available services is always up to date. All that the **operator** requires is a Java enabled web browser.

Discussion – Paper 9

Command in CAOC

- Joint Air Command Laboratory (Steve McQueen)
- Problems
    - Combat assessment
    - Reduce 72 hour ATO cycle
    - Distributed HCI
    - Data hiding
    - Reduce decision making cycle
    - Problems in using 2D data in 3D graph
- Approach - Process, prototype, wargame
- Notional ATO cycle
- Produced series of detailed process models
- Exercise Brilliant Force
    - Color coding to provide objective summary using dots
- UK JFHQ
    - Series of more traditional charts to show infor such as projected aircraft attrition
    - Tasked sorties
- Research
    - Campaign combat info management for future command
    - Tech infrastructure –access to distributed homogeneous data
- JASPA Visualisation
    - Customizable charts – buttons allow different information to be introduced into a 3D bar chart showing ATOs, number of sorties (planned vs actual)
    - Will be using In3D for future work
- Interested in Jini technology

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Joint Operations Picture

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The Problem

- The ability to give the commander at the Strategic / Operational level the appropriate amount of situational awareness in order to facilitate understanding to aid the command process.
- The total set of information, in whatever form, which is a managed and validated view of the history, current situation and future plans for all components of an operation.
- Right information, right form, right time!

What is it?

- Not just the geo-spatial situational awareness picture
- Information centric and includes facilities for information retrieval, linking and management as well as database interaction
- Dynamic by phase of operation, level in command and role/function
- The JOP is not just technology it requires an information culture, standards, procedures, a diversity of information sources and an infrastructure.

Key Purposes

- Enable individual and collective awareness of operational situation
- Enable individuals/groups to share/compare/contrast their views
- More effective means of communicating operation information
- Enable individuals/groups to model/represent the operation with combined knowledge and perception

Functional Requirements

- HCI
- Searching capability
- Information assurance
- Aggregation
- Data replication/synchronization
- Ownership
- Lifecycle
- Time stamp
- Archiving, Backup and recovery

Profiling

- **Profile**
  - security
- **Use of Digital sigs/PKI**
- **Managed Access-control & Capabilities Environment (MACE)**
  - function
  - command level
  - personnel preferences - language e.t.c.
- **Information Broker**
  - ability to change user profile
  - suggest more information

Future Issues

- **Summarisation**
  - between command levels
  - between cells
  - over various sources of information
  - truth maintenance
- **Certainty**
  - representing uncertainty - sliding scale?
  - aggregation of weightings
  - degradation of data - fading?
- **Alerting**
  - track changes
  - communication problems
  - alerting mechanisms

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 10

Can you overlay images on the graph?

- Yes, but it is a controllable option.

Is there an overview to show an inventory of available information?

- Not at present, but it could be done.

How well does it interface with other systems?

- It is designed to look for information from other sources.

Collaborative aspects at different levels of command: Is there a common update so all levels get the most recent data?

- For group work there can be shared information in the individual wants to publish it, at a given security level.

Battlespace Visualisation

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In the interests of readability and understandability, it is RTO policy to publish PowerPoint presentations only when accompanied by supporting text. There are instances however, when the provision of such supporting text is not possible hence at the time of publishing, no accompanying text was available for the following PowerPoint presentation.

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Discussion – Paper 11

One problem with people "doing visualisation" is that they are not artists and designers. They are not visually literate. But we have thousands of years of experience in getting messages across visually. When you are developing a presentation, you should develop it for the presentation device.

> *He seems to be saying that visualisation is a process of taking data and presenting it in a visual display--mmt*

Talking on the phone is different from face-to-face, because of the lack of visual cues.

One other problem is realism. [Jacobson: Perhaps 'solidity' rather than "realism"?] Realism is not necessarily good, especially if one wants to represent concepts. It can be distracting. [Kuchta: Realism is not exactitude.]

Representing uncertainty and inconsistency is problematic.

Conversely, the data may be exact, but the representation makes it seem not so (e.g. colour scales).

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Paper and computers are different media. There is an analogy with early movies, which where treated as like recorded theatre. Computers allow animation, but most animation is not done well by visualisation technologists

Consider the interaction, which is the main difference between computers and paper.--mmt.

The organization of information is critical.
[Hines: There is a problem with giving the commander something that is too advanced for him to use]
[Kuchta: The user doesn't have an image, but a concept; or, the user wants the other person to get a concept]
[Wright: Sophisticated does not mean complex; simplicity does not mean impoverished.

Pictures are inexact, and words can be more precise.

Recall always the back-and-forth aspect of information transfer interactions--in other words, language. --mmt.

Visualizing Logistics

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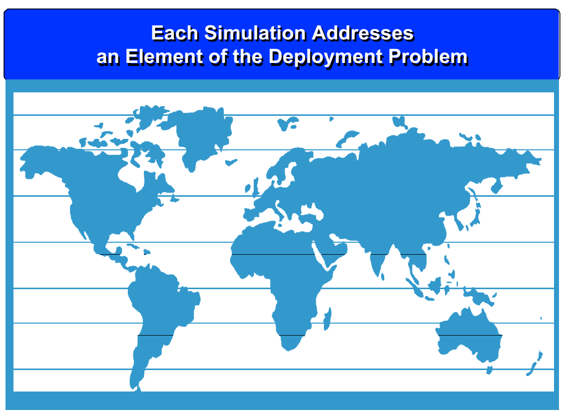
Logistics processes can be divided into two categories: deployment and sustainment. Both categories generate huge and dynamic datasets that are difficult to comprehend without visualization products. My remarks will address deployment because that is where Argonne National Lab has placed its greatest effort with the simulations shown here.

Deployment can be viewed as a network flow conducted sequentially in three distinct stages, each of which generates its own oversupply of data to comprehend. The three stages consist of gathering or marshalling the force from its predeployment locations to ports of debarkation, movement of the force from ports of embarkation to ports of debarkation and then movement of the force from of debarkation to where needed. Simplistically, this can be called fan-in, transport and fan-out. All three stages are active simultaneously in a fully launched deployment, requiring reuse of assets and steady flow through transfer nodes.



Units are moved according to a detailed plan called the Theater Prioritized Force Deployment List, or TPFDL. This sort of planning assures elements needed arrive in the order needed, e.g., stevedores precede ground transport. Each small unit consists of many piece-parts that must be accumulated and loaded for ground movement to port. That transport and loading format is typically different than normal movement in combat and certainly different than that required for intra-theater transport. Thus, the many piece-parts may have to be repackaged at each transport change node. Each of these introduces a different set of delays and thus a massive dataset that ultimately represents the whole process.

Very complex process models have accumulated for each type of unit, each type of transport and the transfer at each of the major transfer nodes [including home station]. These drive the constructive simulations. Note that these process models are dependent on a very large database and are sufficiently complex that real life anomalies in the process or process input data are far more apparent in the cumulative effects than when observed directly.

An example may illustrate the importance of comprehending the net cumulative effect. Suppose two ships are intended to load simultaneously at the same port, but the crane loading one of them is out of service for half a day hours causing delay in loading one of the ships. This may delay sailing of that ship and alter the sequence in which their cargos arrive, conceivably delaying the shipment of forklifts intended to unload the dock area at the destination. A subsequent sea movement model may show that a tidal window has been missed, exacerbating the delay. The forklifts may be critical for other shipments arriving from other ports of debarkation, and so on.

The ELIST constructive simulation develops the time-phased movement of forces from origins to destinations over this infrastructure network to determine how long the movements would take and to identify the potential bottlenecks. Flow is constricted by constraints imposed by the infrastructure (capacities of roads and rail links, nodes) and by the movements of assets available over time.

The kinds of information one can get out of the model include statistics on link utilization and asset utilization over time, and the arrival times of all units to destinations, shown here with comparison with the required arrival times

The final slide begins to show the purpose and extent of force projection modeling. Remember that each of the simulations is the aggregation of many process models. Currently, visualization of results is confined to macro unit flow. The complexity of the simulations makes them very useful for planning, but entirely cumbersome for execution. It would be highly beneficial to visualize the overall flow in a way that tied back to the source of observed perturbations, and did so with machine execution speeds that would support near real time management of available assets under changing conditions.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 12

Analytic engines could be used to automate logistic planning when it is a rule-based system. Although automation does not appear to be a priority for the services, many companies are utilizing planning tools for daily planning cycles that are similar and may be useful

Many similarities in logistic planning and mission planning. It may be useful to allow the operator to make the decisions as he knows the domain. For example, the Master Battle Planner shows the user the consequences and the operator makes the decisions.

If the system is very rule based, would it be enough to know if there are deviations from the plan. The visualisation could concentrate on the context to demonstrate what is happening and if changes are needed. It sounds like a control model. You need the data on what is actually happening in order to make the changes that will then affect other operations and situations.

Often the things that go wrong are really unexpected. For example, an engineering company all gets sick with an unidentified ailment and is unable to bridge a flooded river.

Discussion – Operations Visualisation II

A user needs to see varying levels of detail. Fisheye views may facilitate this, however, going into the fisheye requires the dimension of the expansion to be specified. A user should be able to get more information if they want to.

A sense of persistence of background is important. The background information should not be continually dumped on the user, instead a story line should be created.

The visual metaphor must be considered. The metaphors are often derived from or relate to the people, tasks, and data that are obtained from the user. The metaphors are derived from the people doing the tasks. In developing systems, metaphors that the customer already uses are often implemented. New presentations of the same metaphor or completely new metaphors imply learning and can be useful. Once a metaphor has been chosen, it must be tested to see where it leads.

It's important to know the information requirements. Cognitive task analyses can help in identifying the decision space, the information requirements for those decisions, and thus, the visualization requirements.

Flexibility is important in dealing with different people. Interaction between the user and the computer in creating the presentation could allow the user to customize the display and chose how they would like the information presented to them. Not all commanders want to see the same thing. What's important is that the critical information is communicated. The user can then chose how they can best extract that data.

Allow the user to "talk" to the data. Don't expect that people with different devices will interact with the data in the same way. The quality of the communication is what is important. Try to probe the use to ensure they received the message.

How the data is presented can influence how it is interpreted. Scientists like to say they are giving just the facts, while the entertainment and news communities presents facts in a context intended to lead to a conclusion. It is important to know if you are telling a story or inferring a story. In a case where a decision needs to be made based on fact alone, it is important to transmit the data without interpretation or corruption. If a commander wants to communicate a decision to a subordinated, the purpose of the presentation is not to allow the subordinates to come to their own conclusion, but to effectively communicate the decision.

"Facts" are a property of the medium as well as of the data. To understand how this works is critical. And also to remember that humans are not linear receivers. The general might get the facts, but what matters is how they integrate with the context that affects the consequences of the facts. How the facts are represented depends on the target audience. There may be a presumption of common background. The story line is important in at least some domains, not least because it allows a "fact" to exist, as well as to affect its implications.

Colour may be best used as a qualitative variable. May be very useful for reinforcing qualities.

The miltiary tends to value the stability of methods. Commercial enterprises are in stable environments, the military are not. The military support environment must be more robust against external perturbation. The presentations over the last two days have talked about situations in which most of the time the user is in a "stable" state, but anomalies of kinds requiring innovation are important.

In all three (McCann, Kaster, Cunningham) the underlying issues seem very similar.

What happens when the computer has the intuition? As humans co-evolve with their tools it becomes less clear as to where the discovery comes from. The computer may have the bulk of the experience, and the most accurate memory. The computer is another assistant. the level of trust in the assistant will determine how extensively you evaluate whether it was a good intuition and the need to check its reasoning.

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Visualisation for the Command Post of the Future

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With the permission of Ward Page, CPOF Program Manager

Command Post of the Future: Introduction

The command post of the future (CPOF) is a DARPA program with several objectives:

(1) to increase the speed and quality of command decisions by means of

- Faster recognition and better understanding of changing battlefield situations
- faster and more complete exploration of available courses of action.

(2)Provide more effective dissemination of commands

- COA capture for dissemination of commander's intent
- Status and capability feedback from deployed operators

(3) Enable smaller, more mobile and agile command structures

- More mobile, distributed command element
- Smaller support tail & reduced deployment requirements

The CPof provides tailored visual renderings to assist immediate understanding

- Match user's cognitive model
- Portray uncertainties;
- Match the user's functional role
- Accommodate the user's background & preferences

We performed a set of limited objective experiments concerning CPOF.

Command Post of Today—Limitations

The characteristics of the current command post include:

- 60+ Workstations, 100+ people
- People are flooded by individual data streams
- Disjointed data systems; fragmented pictures of the battlefield
- No portrayal of uncertainties, inconsistencies or unknowns
- Requires too many people, too much communication

Some consequences are:

- Disjointed systems can cause negative situational awareness
- Increased time to comprehend the significance of information
- Incomplete, inaccurate understanding of the battlefield
- Delayed decisions while waiting for more data, understanding

Command Post of the Future—Operational Impact

Increased Operational Tempo will necessitate

- Faster recognition and better understanding of significant battlefield changes;
- Faster and more complete exploration of available courses of action; and
- More rapid and more accurate dissemination of commands

Smaller, More Mobile Command Structures also imply.

- Fewer staff members;
- Smaller support trail & reduced deployment requirements; and
- More mobile, distributed command organizations

The CPof also anticipates an Increased Span of Control

Results of the Experiments:

Tailored visualizations improved Situation Awareness in measures

- CPOF strongest in complex situations
- CPOF strongest in force-on-force situations
- CPOF strongest in understanding adversary's situation
- Different Strengths Emerged from Alternative CPOF technologies

Time Issues and Others

- Some changes due to control scores getting worse rather than CPOF scores greatly improving
- Time appeared to help in case where visualization technique introduced new concept
- Longer viewing time did not always result in higher scores
- CPOF Technologies generated better situation awareness, particularly in complex situations.
- CPOF Technologies provided better situation awareness than Control, prompted and unprompted, in Force-on-Force situations

Summary

- CPOF technologies had a significant impact on performance as measured.
- CPOF experimental approach captures the strengths and weaknesses
- CPOF technologies appear to improve subjects' overall Situation Awareness compared to traditional methods
- CPOF experimental approach captures strengths and weaknesses of each treatment

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 13

Visualisation for the Command Post of the Future

- Problems
  - Support increased operational tempo
  - Smaller more mobile command structures
  - Increase speed and quality of command decisions
  - Tailored visualizations
  - Needs to be decision-centered

Bill Wright (Visual Insights)

- Command post today
  - 60+ workstations 100+ people
  - disjoint data systems, fragmented pictures
- CPOF Experiments
  - Experimental structures (battle lab students –40, Aces 8-15)
  - Known scenarios (asymmetric, Guerilla, Urban disaster, Peace Keeping, sustained operations
  - Use of control displays
  - Users could not interact with displays
  - Studied approaches based on the amount of time available
- LOE-1
  - DARPA Limited Objective Experiment
  - 3 cases being tested with 2 visualisation solutions and one control
  - force on force
  - insurgency
- D-Day Blob
  - 3 dimensional terrain
  - blobs showing deployment
  - thickness of line represents strength of force
  - diameter of blobs shows range of weapons
- Haiti Sit4B –5 Critical events (Visual Insights)
  - Set of text reports on situation
  - Time space and event view on 2D map
  - Show observed events in regions
- Treatment B
  - Used 2D map with integrated charts icons and drill down to charts

- Significant Findings
  - Visualizations generated better situation awareness
  - Visualizations very large improvement in complex situations
  - Blobs better than color coding
  - Drill down method found better than everything on one screen
  - More time helped only in more complex situations
- How is situation awareness defined? –complex definition defined by CPOF

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Performance Measurement for Visualisation

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Summary:
Key problems with extant visualisation systems for command and control are outlined. A systematic research program investigating five key issues relevant to C2 information visualisation is proposed. The outcome of this work should help to improve our understanding of those factors that make C2 visualisation more effective.

Military command and control (C2) is a complex process: many variables need to be monitored by many people; decisions must be made quickly; stress levels are high given time pressure and life or death consequences. The aim of command or battlefield visualisation software is to display pertinent information in comprehensible form to the commander or command team, so that they can make accurate and timely decisions, ultimately making our forces more effective than enemy forces.

However, despite the widespread development and implementation of command visualisation technology , it is unclear whether such technology actually improves the effectiveness of military forces, or even the command team itself. Command visualisation algorithms, engines, and techniques are being developed at a rapid rate, but the assessment of the approaches is sadly lacking. This is also the case for software more generally (Landauer, 1995, 1997). Although usability methods have increasingly been used to detect and fix more serious software problems (e.g., Nielsen, 1993), the study that compares performance with a new system to an old system (which may be an old computer system, or a pre-existing method not relying on computers) is rare. Does our new technological development really improve the situation or complicate it? The apparent benefit of the new system can be overshadowed by occasional problems or errors that overwhelm the benefits (Landauer, 1997).

It is in some ways not surprising that measurement methods have not been applied to C2 visualisation. Valid measurement involving human behavior in a real-world context is always problematic. In the similarly complex nuclear engineering domain for example, there is little agreement on how human performance should be measured (Voss, 1997). Voss notes that the IEEE Std 845 document (Evaluation of Man-Machine Performance, IEEE, 1988) neglects to specify those types of human performance that are important and necessary to measure in nuclear engineering. Similar problems in specifying appropriate performance measures are likely in C2 visualisation.

What is the system? In addition, it is important that when assessing human performance with a computer, both human and computer are considered as parts of the system. Traditional information-processing approaches have emphasized the human in isolation from computer, or have viewed the situation in static form, ignoring the impact of dynamic control on the human-computer system. In contrast, system designers tend to think of the system as the box on the desktop—forgetting for a moment that for the "system" to do anything useful a human must issue a command and inspect the result, and therefore a complete account of the system must include the human.

All these maxims are especially true in the visualisation domain, where the emphasis has traditionally been on the machine (particularly display software), not on

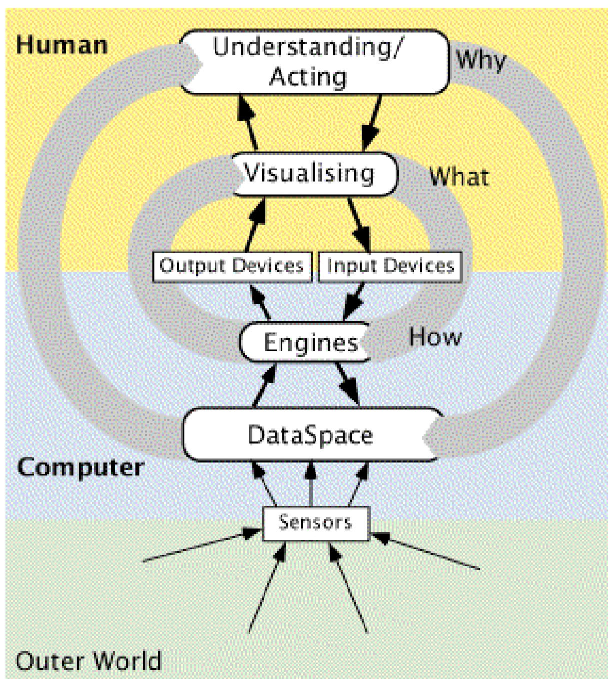

Figure 1. NATO IST-05 Reference Model for Visualisation.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

the person. As noted earlier, algorithms and engines are being developed at a rapid pace, but evaluation is lacking. The entire system—including the human—must be considered. To reflect this, the control loop approach represented in Figure 1 is espoused (The IST-05 Reference Model; NATO IST-05, 1999). The Reference Model makes clear that "visualisation" does not refer to displays on a computer screen, but rather to a human activity augmented by such displays. Displaying complex data in a task-relevant way shifts the processing burden to the computer and away from the human, but ultimately, the visualisation must take place in the user's mind, or the display software has not been successful.

When one considers the military C2 context additional concerns become evident. Meister (1989) describes the concept of indeterminacy, or more formally, a determinacy-indeterminacy continuum. In a highly deterministic system inputs (to the user) are usually unambiguous and require little analysis. In contrast, indeterminate systems reflect considerable stimulus ambiguity and uncertainty. Military systems in wartime represent an indeterminate system (Meister, 1989). Any command visualisation situation will therefore reflect this ambiguity. Meister also notes that adversaries are a source of uncertainty because they strive to conceal their actions. This type of uncertainty is not present in supervisory control situations, in contrast.

Thus, it is clear there is a need for a systematic research program investigating factors affecting the effectiveness of C2 visualisation systems.

Proposed research program. The purpose of the proposed work is to develop a command visualisation testbed based on empirical principles, and to develop test protocols by conducting experiments based on relevant military tasks. This testbed and the planned experiments will provide a capability to investigate whether future proposed visualisation algorithms, constructs, and display concepts are consistent with human perception and cognition and whether they improve command decision making.

1. Frame of reference and visual momentum. Various visual momentum (Woods, 1984) techniques are available to allow commanders to transition between or "drill down" and then to "roll up" data with other data of similar types or at different levels (Roth et al. 1997), and their utility will be tested for individual and group displays. A related problem is disorientation or becoming lost when transitioning from one format to another. Use of landmarks in strategic locations and other techniques in development by Vinson (1999) will be tested experimentally.

2. Perceptual bias and reference points. Human judgments of the geometric volumes and areas that are commonly used to depict quantitative values in 3D data representations in statistical graphs and maps are biased (Hollands & Dyre, in press). The use of perspective rendering in 3D displays can also lead to bias. The selection of physical continua to code specific variables and the perceptual biases that result will be examined. In addition, the potential utility of reference points to reduce judgement error in command visualisation systems will be investigated.

3. Modeling mental operations. Follette and Hollands (2000) propose that two factors affect quantitative judgments with graphs: (1) the number of operations necessary; (2) the effectiveness of the perceptual features used as input for the operations. This model requires validation with more complex, dynamic displays as used in command systems. The model also needs to be cross-validated by measurement of eye movements using an eyetracker. A set of experiments is planned to test the predictions of the mental operations framework in command visualisation and cross-validate it using eye movement data.

4. Preattentive processing. When searching a field of symbols on a visual display certain symbols tend to "pop out" or be more salient. This research (e.g., Treisman & Gelade, 1980; Healey et al., 1995) has suggested that target detection and symbol grouping can be made more efficient and reduce attentional demand when pop out occurs. Experiments are planned that will investigate the relations among the perceptual dimensions used in C2 displays with respect to pop out. A better understanding of this relationship should enable the development of display mappings appropriate for different contexts. The eyetracker will provide an understanding of how displays are scanned and how much information in a display can be perceived "at a glance".

5. Mapping data to perceptual continua. Display designers often assign conceptual variables (e.g., vessel co-ordinates, number of torpedoes in task group, radar propagation characteristics) to perceptual dimensions (position, size, shape, colour saturation, colour hue, brightness, etc.) in an arbitrary way. However, perceptual dimensions have specific properties. Some perceptual dimensions are effective for depicting quantitative relationships, others only for order information, still others display only nominal (i.e., categorical) information well (Bertin, 1983; Cleveland, 1985; Wickens & Hollands, 2000). A systematic research program will investigate the effectiveness of various data-display mappings and determine the most effective mapping(s) from the conceptual to the perceptual for command visualisation.

Conclusions. Key problems with extant visualisation systems for command and control were outlined. A systematic research program investigating five key issues relevant to C2 information visualisation was proposed. The outcome of this work should help to improve our understanding of those factors that make C2 visualisation more effective.

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Footnotes

Discussion – Paper 14

Command Visualisation

- Problems
  - Users cannot use engines to extract info from data
  - Need to arrange data in the right way for particular tasks
  - Measurement – what do we measure and how do we interpret these measures
  - Need for multiple views

Justin Hollands (DCIEM HCI Group):--

- Measurement important – cannot measure everything
- Example given from Challenger crash showing visualisation of O ring data
  - Temperature vs O ring damage (source E Tufte(1997. Visual Explanations) chart
- DARPA not doing sand table any more
- Multiple view and task dependency
  - Multiple formats
  - Must ease transitions between views
- Info vis is human's capacity to utilize effectively the output from the computer to understand the data.
  - Relies on human capacity
  - Why just computer – could be paper, sound
  - Artifact, process, or result?
- Command visualization testbed
  - To create effective command visualization platform based on empirical performance data captured
  - CTA used to determine type of info should be presented when
- What are we measuring?
  - Error magnitude, signal detection measures (sensitivity and bias)
  - Response time
  - Subjective measures (preferences, situation awareness, workload
- Visual momentum techniques (continuously available global views, gradual transitions, brushing)
- Perceptual measures

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The Master Battle Planner

G. Richardson

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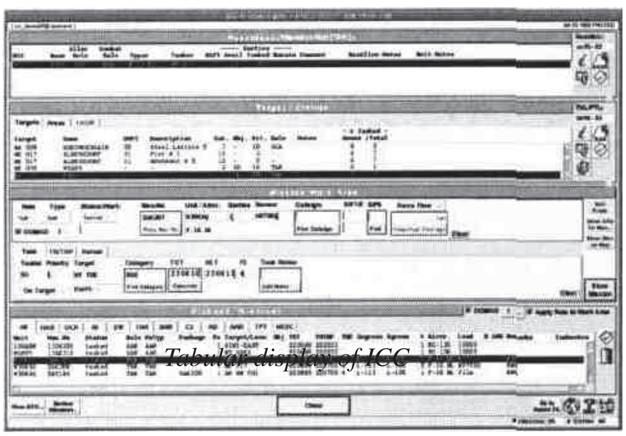
Summary: The development of the MBP commenced as an investigation into novel HCIs, and has now been extended as a tool for Master Air Attack Plan production. As the system is PC-based, minimal support is required and campaign planning can literally commence using a laptop in transit to the operational theatre.

Introduction: The Master Battle Planner (MBP) is a prototype developed by DERA as a result of a study into the operational process of the UK CAOC. A technology gap was identified and the MBP was developed to replace a manual procedure in developing the Master Air Attack Plan

Existing air battle planning systems, CTAPS/TBMCS and ICC, were implemented on Unix platforms, and make use of commercial relational databases. An example of an ICC display is given below.



Tabular display of ICC

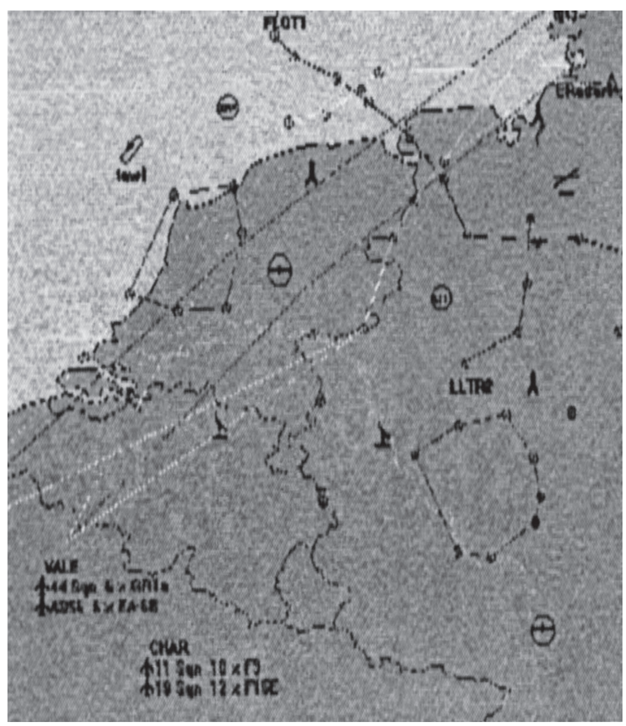
Unfortunately the display presented to the planner has tended to mimic the layout of these database tables, i.e. rows of textual information. This can lead to a number of serious problems:

- A large table means that navigating through the data is a difficult task as the number of rows and columns can exceed the space available on the screen.
- Some data can also be difficult to understand, e.g. a latitude/longitude displayed as an alphanumeric string contains no contextual value.
- Entering data into a table is a change from the process of manually drawing the plan with Chinagraph pens. The planner has been forced to modify the process to suit the tool, rather than the tool support the process.

The development of the MBP prototype investigated methods of improving the user interface. It was implemented as a map based system onto which planners could drag and drop representations of assets, airbases, targets, air units, etc. Missions are planned by dragging an air unit from an airbase onto a target, in the same manner that files can be moved between directories in Windows Explorer. As far as possible the system was designed to have the look and feel of a standard PC application.

By reducing the fidelity of information, e.g. the characlenslics of aircraft and airbases, the need for a large database was removed. This, plus the intuitive design of the user interface means that the lead-time in populating a scenario for a given operation can be drastically reduced

A PC implementation also drastically reduces the hardware costs of the system. Whereas CTAPS/TBMCS require a minimum of 9 Unix servers supporting any number of Unix workstations, plus software licences for databases and graphics applications, the MBP can run on a single standard PC, or laptop, with the Windows operating system.



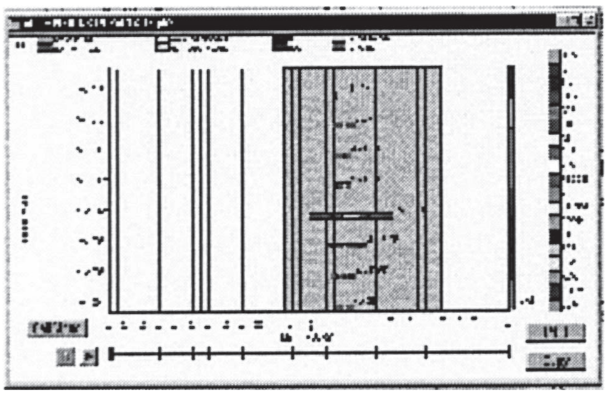
Direct interaction with map-based plan

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Master Air Attack Plan (MAAP) Production: The principal aim widiin an MAAP production organisation is to achieve the objectives defined by a higher authority by creating a plan which makes the most effective use of the available resources against the nominated targets.

The Master Battle Planner (MBP) provides a graphical and highly intuitive method for visualising the battle scenario and developing the MAAP. The planner is continuously immersed in the battle scenario and this provides a high degree of situation awareness. MBP is designed to be very flexible, and can be used in a standalone mode or in conjunction with more complex planning systems.

Battle Scenario Visualisation: MBP provides the



Direct interaction with mission timings

planner with facilities to establish *the* battle scenario with an intuitive toolset. MBP provides a map-based approach to planning which allows visualisation of the entire battle scenario. It supports interrogation and modification of all objects by interaction with them on the displayed map or in other data views including Gantt charts, histograms, etc.

During the planning of the campaign the planner must ensure that the planned assets have been co-ordinated, so that, for example, a fighter or bomber rendezvous at the correct time and place with a tanker. One of the data views provided to the planner is a Gantt chart, shown below, depicting the planned schedule. Individual items can be manipulated within the Gantt chart?

Some assets, e.g. a tanker, have vertical bars stamped on the schedule, which represent the time on station. This assists the planner in aligning the receiving asset to the tanker so that tanking time on the receiver can be aligned with the tankers' time on station.

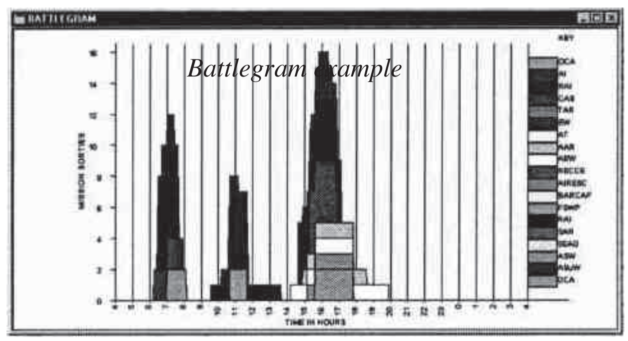
Previewer: MBP allows the planner to perform a "sanity check" on the plan by providing a preview capability. As the plan is constructed the plan can be "animated" to show the flow of the plan, assets are shown to take off from the bases, follow the planned route and return to base.

This will show, for example, that the tanker is on station when the fighter arrives, or that assets do not fly near

Previewing the map-based plan

an enemy SAM site before the planned TLAM cruise missile has destroyed the SAM.

Battlegram: Also included within the MBP is the ability to view the planned missions as a Battlegram. This allows the planner to view the flow of the battle as a number of sorties planned against a period of time - the 24 hour ATO period. The Battlegram will highlight any gaps in the plan, e.g. gaps in CAP or AEW coverage.



Battlegram example

MBP does not contain any artificial intelligence to indicate to the planner that mistakes in scheduling, like those outlined above, have been included in a plan. The intelligence is contained within the planner creating me plan, rather than the tool. However, some simple rules have been implemented to assist the planner, e.g. to warn the planner when they have overtasked a unit.

Exercises and operational evaluations, in the UK and as part of NATO and coalition exercises, have shown that the MBP is an invaluable aid to improving situation awareness and reducing plan development time. When projected onto a touch sensitive display, the MBP is a perfect focus for teamwork. An additional benefit is that the MBP system provides an excellent means of briefing the plan to the Commander, saving time and reducing the IT support required.

Discussion - Paper 15

The MBP is releasable to TTCP and NATO on written request, naming a point of contact. The Demo presented showed how a mission could be created, and assessed with the MBP. The display shows whether the mission as described is feasible. There are thus interactions implicit in an underlying database. One can create packages of missions, which generates cross-checking. Movies of missions can let humans see potential problems. Asset allocation is shown, with over tasking alerts.

The software does not currently interface with other tools, however, one can get data into it form other databases. It uses a flat file, not a database, and can be set up quickly in new situations.

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Visualisation of Heterogeneous Military Data in Geographical Information Systems

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Discussion – Paper 16

Visualisation of Heterogeneous Military Data in GIS

- Annette Kaster (Germany)
- Problems
    - Heterogeneous information environment
    - Variety of task requirements must be supported
    - Different user needs
    - Need to provide military situation display
    - New approaches for visualization tool development -Use of component ware
    - Model View Controller concepts for building next generation visualization systems
    - Window management needs to be studied
    - Consistent user interface principles need to be applied
- VDI 5005 model framework
    - For evaluation of visualization solutions
    - User model, application model
    - Competence support, flexibility

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

- xIRIS
  - Multi window, multi layer technique
  - Image view
  - Open system architecture
  - Visualization to geo-reference data
  - Dynamic situation display

Discussion – Visualisation for Command

- Measurement
    - CPOF experimentation preliminary and needs further development
- Large Screen Displays
    - Indicators as to the effectiveness of large screen displays
    - Sernof Displays at Ft Leavenworth – virtual wall where can display your display for sharing
    - DREV large screen display
    - Use of wearable head mounted displays
    - Seem to be driven by what we can do rather than what makes sense
    - Large screen displays typically not used – used in a movie format. NASA has had some success
    - Collaborative shared workspace
    - Need keeper of large screen – what should be provided for common understanding
    - Use large screen for aggregated view
    - Not just one display – series of displays
- What about small displays like palm pilots?
    - Problems cited with evaluation undertaken with Marines
    - Content must change for the particular displays
    - Should look at what will work on small displays and then think about large displays
    - Will make people think closely about what absolutely needs to be displayed
- Enabling technologies
    - Collaborative working
    - Information workspace –rooms metaphor
    - Technology fast moving and so level of maturity in terms of users use of info technology will always be behind what is possible
- Customization of information for particular needs
    - Commanders need generic overviews

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A Proposed Reference Model Framework for the Application of Computer-Based Visualisation Approaches

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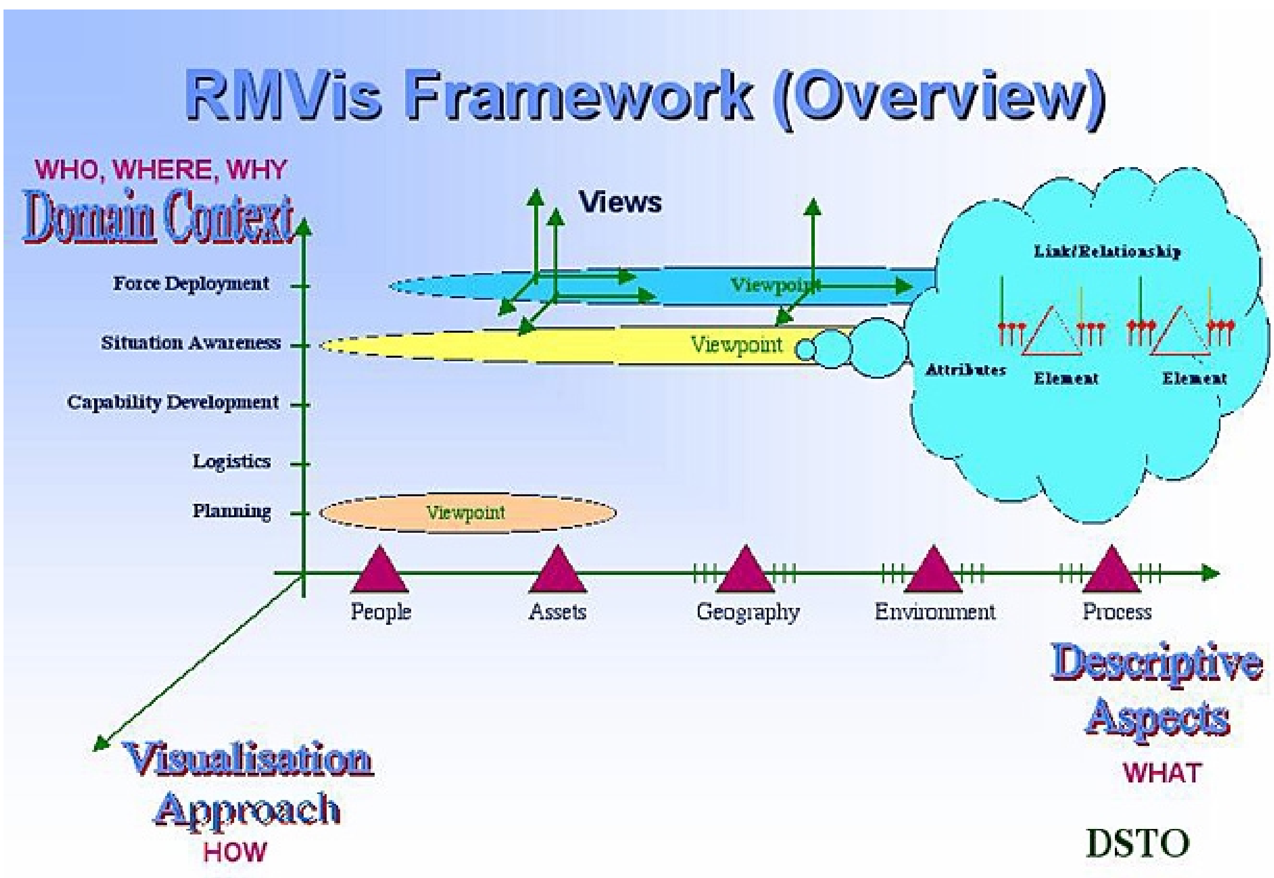
This presentation provides an overview of a reference model framwork (called RM-Vis) being developed by the TTCP Action Group on Information Visulaisation to provide the foundations for the various survey and analysis activities being undertaken by the group. A key feature of the framework is that it helps characterise visualisation solutions in terms of trhei context of use, the visual representation and enhancement techniques used, an key features of tool support provided such as user interactions, and deployment support. Initial tool support has been developed and is being used for the characterisation, identification, and showcasing of visualisation solutions in the C3I domain.

Various taxonomies and models have been proposed to support the characterisation of visualisation approaches. However, most have focused on defining visualisation tools in terms of the types of data that can be visualised or specific techniques such as interaction modes, and particular domains of interest to the authgors, such as software visualisation.

For example, it is rare to find taxonomies which characterise visualisation approaches in terms of specific tasks that need to be performed by users (i.e. the domain context) or the types of things that need to be described (descriptive aspects). One exception is the IST-05 Reference Model for Visualisation developed by the NATO group RTO IST-013/RTG-002. This model sets the context for computer-based visualisation by considering the why, what, and how of visualisation.

The "why" relates to the needs of the human in terms of the tasks being undertaken (e.g. understanding, acting). The "what" refers to what information in the dataspace is important in terms of the visualisation process (i.e. what needs to be described and what data are avaiolable to provide this description). The model refers to the "how" as being the engines (e.g. computer support) that allows humans to access, manipulate, and display the data.



Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Although the model provides the high-level context of visualisation, it does not providee the mechanisms for more detailed definition and analysis of visualisation domains and approaches. The RM-Vis framework described in this presentation attempts to provide this more detailed perspective.

RM-Vis is a generic framework which can be customised for specific domains of interest and requirements. It does not presuppose particular taxonomies or models. For example, TTCP is interested in characterising visualisation approaches for a broad range of C3I activities. An instance of the reference model (RM-Vis(C3I)) has been set up to support this work. Similarly, instances of the refernece model could be set up to support activities in other domains such as software engineering or air traffic control. The framework is flexible, in that it can support as spectrum of characterisation activities from coarse to fine grain (i.e. is down to the characterisation of approaches for particular tasks and individuals).

As shown in the Figure, RM-Vis has three key dimensions:

1. The **Domain Context** is a model which defines the focus for the application of visualisation approaches (i.e. *where* visualisation approaches will be applied. A domain context can be generated from existing enterprise models and tailored for the particular application of the reference model. For example, investigations into the application of visualisation in air operations might define the domain context in terms of the tasks and roles that need to be supported (perhaps based on a pre-existing order of battle model).
2. **Descriptive Aspects** (DA) Define *what* needs to be described for particular domain contexts. For example, DAs could be defined in terms of the various elements (or things) that are of importance, the relationships between those elements and particular attributes which describe the elements and relationships.
3 The Visualisation Approach dimension defines how the required information can be provided through computer-based visualisation. Approaches are characterised in terms of the visual representations used (e.g. graphs, charts, maps), visuals enhancements (e.g. use of overlays, distortion, animation), interaction (direct manipulation, drag and drop, etc.), and deployment techniques such as intelligent user support and enterprise integration.

Other features of the framework are defined in this dimension substrate. A **Viewpoint** is a model of what needs to be described for particular domain contexts. The framework distinguishes what needs to be described from what will be described. For example, an Operations Officer in an Air Defence domain may require information on the status of fighter and tanker aircraft to support decisions relating to a task “assign air assets”. Various visualisation approaches could be used to provide the information required for this viewpoint.

A **View** is the definition of the visualisation approach used to support the requirements of one or more Viewpoints. The Viewpoint might be supported by one or more integrated Views. In the Air Defence example, the Viewpoint requirements might be met by two integrated Views: one showing the location of air assets on a map, and the other showingg a Gantt chart of flight tiomes and fuel loadings.

Effectiveness is considered as a supplementary dimension of the framework. We argue that the effectiveness of particular approaches can only be considered in terms of their context of use.

Initial tool support has been developed for RM-Vis to allow for the characterisation of visualisation approaches in various domain contexts. The tools support the incremental development of taxonomies for aspects such as Visual Representation, Enhnacement, and Interaction Techniques.

Querying mechanisms support the answering of questions such as “What visual representation techniques are used by tools developed by the TTCP participating nations to support intelligence analysis activities in joint littoral operations?

Showcasing features allows users to quickly assess screenshots, animations, or videos showing the use of various visualisation approaches as implemented in particular Views.

Support is also provided for capturing, managing, and viewing effectiveness evaluation results.

RM-Vis is itself currently being evaluated as part of the work being done by TTCP AGVis which is characterising the use of visualisation approaches in C3I domains, particularly in terms of how these approaches could be used to support coalition operations. Additional validation is being done as part of a research activity which is assembling a more generalised knowledge base of some 180 key visualisation approaches that are available commercially or formthe basis of research prototypes developed by the research commuunity.

Discussion – Paper 17

A Proposed Reference Model Framework for the Application of Computer Based Visualisation Approaches.

It is important to measure the effectiveness of visualisation solutions. Very little of this happens at the moment.

Effectiveness in this context means the application of a specific visualisation approach within a particular domain context and for a particular viewpoint

Measurements at the moment focus on the character of the tool and do not look at the effectiveness of that tool within different domain contexts. RMVis is a proposed framework to enable the measurement of this effectiveness.

To enable the measurement of the effectiveness of these tools it is important to understand the dimensions that are being measured:

- Domain Context – who will use it, where will they use it and why do they use it. Sit aware, capability areas (can include cognitive tasks)
- Descriptive aspects – why and what we are doing here people, assets Geography Environment Processes
- Visualisation approach – integrated and multiple views. Visual representation, The enhancement techniques (distortion), Interaction (brushing techniques) Deployment (cost effectiveness of visualisation)

This Ref model can be tailored for different uses.

RMVis is a proposed framework that focuses on the applications of these within domains.

In the spirit of sharing information and knowledge the TTCP AGVis Group is creating a database of visualisation tools and solutions, each country will be responsible for adding their own tools/solutions to this database. They hope to set the direction that TTCP goes within the visualisation field as well as influencing individual country visualisation solutions.

Audience discussion:

1. Will the database be available for others to use?

   Yes and the group are interested in collaboration – if participants want their work registered within it then go to their panel member.

2. Is it possible to get a description of the framework?

   They are awaiting authorisation from TTCP to publish this information on their web site. If people require it sooner then email Rudi.

3. Within the effectiveness rating is there any measurement about how much support it gives to decision making? How are they calculating this measurement?

   There are many ideas about how to proceed within this difficult area of assessing how effective a visualisation solution is. The group would welcome help and guidance on how best to proceed.

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Data Mining and Concept Clustering in Determining the Nature of a Network Attack

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Information Assurance for Information Warfare [IA/IW] is defined as, "information operations that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality, and non-repudiation. Information assurance includes providing for restoration of information systems by incorporating protection, detection, and reaction capabilities. (DODD S-3600.1)

Information Assurance is necessary to provide commanders with the capability to defend information flows required to execute assigned missions in both peacetime and crisis/contingency. This is a 365-day-a year Information Assurance for daily operations and business at all levels, and to integrate it's provision into Operations planning and execution.

The functional state-of-the-art in Information Assurance is analogous to air-traffic control—operators continually scanning networks for signs of attack. This obviously needs improvement. reports of successful and feared-successful attacks appear with increasing frequency.

"Russian Hackers Steal US Weapons Secrets"

"American officials believe Russia may have stolen some of the nation's most sensitive military secrets, including weapons guidance systems and naval intelligence codes, in a concerted espionage offensive that investigators have called operation Moonlight Maze.

This was so sophisticated and well co-ordinated that security experts trying to build ramparts against further incursions believe America may be losing the world's first 'cyber war'.

(Interview with Mr. John Hamre,
Deputy Secretary of Defense)
London Sunday Times, 25 July 1999

TTCP TP-11 have mounted an IA project. The first year demonstrated Successful exchange of intrusion event data between Australian Shape-Vector and Rome Labs [AFRL]'s $EPIC^2$ prototypes

The USAF Enterprise Defence project is intended to develop the next-generation enterprise defence framework for AF Modicums and aerospace expeditionary forces (AEF), providing situational assessment and decision support, simultaneously improving the information overload problem for network defenders, provide a consistent visual environment for information portrayal, fusing information assurance (IA) and network management data into a common enterprise picture (CEP). A further intent is to empower the MAJCOM to validate and influence present and future technology so it suitable for transition into NMS/BIP and other acquisition programs

The Air Force has embarked on a project to develop the next-generation enterprise defence framework for AF MAJCOMs and Aerospace Expeditionary Forces (AEF), including situational assessment & decision support;

1. Reduce network defenders' information overload;
2. Provide a consistent visual environment for information portrayal ;
3. Fuse information assurance (IA) and network management data into a common enterprise picture (CEP); and to
4. Empower the MAJCOM to validate and influence present and future technology so it suitable for transition into NMS/BIP and other acquisition programs.

Several programs are under way to address these priorities. The presentation slides show several of these in considerable detail. There remain important potential problems for data fusion engines to solve:

- Identifying low, slow mapping and probing attempts. Sensor data grows quickly and it is difficult to store, problems with storage and retrieval; the current plan is to utilize a trend database that saves suspicious events and compressing other data.
- Acquiring knowledge from domain experts for data analysis. Some data gathering has been done but the information has not been readily available.
- Data correlation between sensors and events in real-time is needed in order to identify attacks and reduce false alarms. Throughput (for real time operation) is biggest problem. The current plan is to Implement "rules" in native code
- Goal-seeking to determine the purpose of an attack. [This will require a flexible, backward chaining capability.]
- Better rule/filter deconfliction are needed between components. That is, there is a need to ensure that filtering/rules do not conflict with each other and that a filter does not block data needed by a rule.
- Better data mining tools and techniques are needed to identify new attack signatures
- Modification of KB knowledge space must be made possible by non-KB experts, or their information and experience will be lost.
- Threat profile/identification extrapolation—this is needed to face future, potential threats and attacks.
- Machine learning algorithms are needed to enable the system to anticipate analysts "next move"

Technology assessment can examine new applications' functional goals and structures, identify the cognitively demanding aspects of decision makers' tasks, analyze work domain constraints and task context, support team decision making and co-ordination, and support software design.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 18

Data Mining and Concept Clustering in Determining the Nature of a Network Attack

Commonly most effort within the Information Assurance (IA) arena has been focused at finding the attack signature but protection, detection and reaction all need to be visualised.

As humans and machines are tuned in to see specific patterns there is a need to visualise data/information in different ways to see odd or unusual patterns. The results of one visualisation should then be able to be added into another visualisation giving the user another chance to gain more understanding from the data.

Within network management very little work has been done on the correlation between the cyber and the real world in an operational environment. It is important to do this in order to show the way that the availability of the communications network (both blue and red) could affect the operation.

In order to do this the operations communications structure has to be mapped. This includes both the hardware and how networks are connected to each other e.g. via other countries networks (whether civil or military) for both the blue and red forces. It also needs to highlight the capacity and real structure of the red theatre communication links and how they can be effected.

The aim is to fuse IA and network management into a common enterprise picture.

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IRONMAN V 1.5 — Network Management Environment

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The recognition of the importance of defensive capabilities against intrusion into enterprise networks has increased over the past decade. Governments around the world have become aware, sometimes dramatically, that their internet-based information and support systems are subject to intrusion and compromise. Within industry, proprietary corporate information is accessible through the intranet-to-internet gateways. Although firewalls, encryption and other existing techniques have provided some protection, they have also provided restrictions on corporate use of the internet resource and have not fully succeeded in preventing intrusions.

Numerous excellent commercial and academic efforts have resulted in vulnerability scanning, intrusion detection and network management applications and products.

Unfortunately, only a few of these are efficient or scaleable in very large heterogeneous enterprise environments and none provide a comprehensive management environment .

IRONMAN is a system which is being developed and used to integrate academic and commercial tools providing network discovery/scanning, intrusion detection and management capabilities. Added to these tools (and enhancements to them) are a data visualization environment, modeling, analysis and reasoning tools, and a policy management framework. It is a prototype environment designed to provide interactive management of networks and network components and services. Interaction is provided through a VRML 2.0 3D virtual environment and through additional extended controls such as forms and dialog boxes. VRML 2.0 provides a framework for dynamic visualization of information and systems.

The IRONMAN modeling framework uses an underlying ontological framework which supports a wide variety of reasoning tools to provide for policy based modeling, analysis and control. Through indigenous capabilities and the integration of third-party commercial and custom applications, IRONMAN provides both passive monitoring and active probing of networks and their components.

IRONMAN uses a virtual common data repository model for all information sources. This provides for integration of existing databases and new associative information servers and can support collaborative workspaces.

IRONMAN is based on existing software, hardware and networking standards wherever possible and is currently implemented as a layered client-server architecture. The primary client host is a WWW browser (e.g. Netscape) and the servers primarily use the CGI (Common Gateway Interface) model. The design provides for integration of mobile and transportable agents.

The IRONMAN functional architecture has seven main functional areas:

- acquisition :- this is the set of functions used to obtain data from elements of the system. The functions are provided by scanners, intrusion detection systems, SNMP, sniffers, and other various applications;
- control :- this set of functions is used to change some aspect of the system being managed or IRONMAN parameters and configuration;
- representation :- the representation functions deal with the syntactic and semantic forms of data and information related to a managed system and where and how data and information is stored and accessed;
- presentation :- the set of functions which deal with how data and information is structured and displayed to the user and the means of interacting with the data and with the system which the data represents;
- analysis :- the set of functions which process the available data to generate subsets, feature sets, statistical characteristics, etc.; and
- decision :- the set of functions which process data to provide a set of branch points which can be acted on using control functions.

Information Operations (IO) concepts are being actively explored by a number of organisations including Departments of the Government of Canada. The defensive aspect of IO is supported by IRONMAN concepts and facilities. However, IRONMAN should contribute fully to attack facilities and scenarios that are needed to stress test information technology systems presently deployed as well as those facilities that will be deployed in the near future as part of an information system architecture.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Discussion – Paper 19

IRONMAN V1.5 – Network Management Environment

<u>Ironman – Network Surveillance Infrastructure</u>

Most work within network security deals with preparing for what could happen rather than sitting back and monitoring the traffic (looking at what is happening). Changes within the information security arena are happening quickly and the infrastructure has to be able to reflect these changes.

Within a network there are a large number of nodes to protect including large numbers of protocols, ports, services and applications. Ironman sits in a network management environment and provides visual and oral sensory stimuli allowing the user a view of both the traffic on the network as well as the systems that are being protected.

It provides the user the ability to define a policy region within 3d space allowing the user to easily see if certain nodes have not implemented the policy correctly. Ironman also fuses and manages sensors as well as analyzing, collecting and storing data, giving the user a variety of ways of viewing it. It aids the user in capturing highly transient events such as port scanning by different machines over time. Scenario generation and detection, risk analysis etc. can be modeled within this environment.

Research in this area has thrown up a number of questions:

Is familiarity or efficiency better within visualisation?
Is visual literacy something that is learnt? If so is it the skill of the writer or that of the reader that is important?
When a system is first presented, then changed at a later date how confusing is it to the user? How much does a user imprint on the first visualisation?

Audience discussion:

1. Have the displays within Ironman been evaluated?

   No formal evaluation has happened, though a prototype system is being installed within the Information Operations team at DREO and feedback is expected on the system. Further evaluation on the visualisation will be happening within the next year. It is important to keep the correct balance between what is possible with visualisation technology and what is the sensible visualisation to use. Sets of trial ideas are needed to test what is possible to do – what are the limits etc.

2. Measuring the user response to the Ironman environment.

The user is encouraged to navigate through Ironman, though it is difficult to find a way of measuring how people navigate through virtual space.

Identifying Enterprise Intrusion

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Discussion – Paper 20

Bill Wright—scalability problem, data mining—finding the very few problems that really represent attacks
Dealing with False positives
MIT Bottleneck ID technique—try to characterize normal information flows of the enterprise, rather than characterize what attack would look like
Objection that still have false positives
Bayesian or neural models to distinguish between what is really unusual and what is normal traffic
Sharing the raw data in intrusion detection not done—trust the partner to perform their part of the interpretation correctly
Taxonomy (Kunar-session chair) problems with large data sets?
Milan—says uses an ontology approach
Seems to be some confusion w.r.t. use of terms “visualisation” vs. “taxonomy” vs. “ontology”
Portals—customized interfaces
Use one window to access all types of information/applications

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Discussion – Network Visualisation

Filtering at the human level seems to be important

Data mining, algorithmic approaches.
Sensors don't have a broad enough view of what's going on
Attacks don't just happen, sensors don't have perception in order to filter important information

Instead of looking at anomalies, looking at what characterizes the normal working situation.

Only a few ways to become a root user on a UNIX system. Instead of tracking all uses, if you look at tracking only when a user becomes a root user through means other than the prescribed, it can automatically be seen as suspect.

Hard to profile users. It's hard to say what's normal behavior and what's not. Could result in many false positives.

Slow and wide attacks. How are nations sharing information for visualisation. Can't share low level data, too much, what abstraction are they using, passing ontologies as well?
Currently there isn't that much interoperability. Very difficult to share. Distributed visualisation dependent on classification of information. Classic problem with coalition operations, you may have a very good picture but note everyone may be able to see what you're seeing and then miss the details that are important. Political decision – what to make available. Technical – language, common tools and fundamental structures. How do we translate our survival skills developed in this world into the new automated space.

Humans have limited attention. Issue of false alarms – number may not be as important as how difficult they are to deal with. If you are not used to the environment, you may not notice abnormal events.

If you have a tool to identify normal and abnormal events you can apply them to each other.

Auto correlation to highlight significant events

Consistent visual environment – if they know your algorithm, or display, it can make it easier to hack, and may limit your visualisation

If you had all the data it would avoid the possibility of missing something from not having everything available, but would be a flood of data.

Consistency, coherence, and coverage

Visual environment needs to be molded to the tasks that the user has to perform.

Expert systems – cost and performance important

Could it all be one huge neural net?

Taxonomies, how do you address it, and how do you approach it in terms of search engine capabilities in order to retrieve it?

Can a taxonomy be defined when you don't know enough about the domain. Perhaps ontologies are better, as they are meant to evolve. No ontological model will ever be complete. Ensure that the ontology is not written in stone and can be flexible. A problem on this scale may not be able to be taken on at once.

But a framework model is important. Information and knowledge capture is imperative. Scalability is a consideration. Archiving and searching.

If we know how to find fingerprints we won't try to track every single event

Looking at relationships to manage data.

Portals – makes it easier to segment the information. Creates hierarchical views. Allows user to customize their presentation needs.

Portal – allows you to see any information you want through a single window, in the way you want to see it.

Defensive Information Warfare Branch Presentation

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Discussion – Paper 21

DISCUSSION AM 8 JUN 2000

The subjects were raised as a result of the presentations made by Chet Macaig about Information Operations. Answers by Chet unless otherwise annotated.

Q 1

The problem of detecting attacks of information systems is complicated by the number of false positives which have to be filtered by humans.

A

Sensors do not have a refined enough view to directly detect an attack. However, attacks have a purpose and therefore a sequence of events. It is this sequence that needs to be identified. MIT have developed Bottle neck verification techniques to do this, it looks at business flows and identifies anomalies within. An example of the ways in which in UNIX there are 2/3 authorised ways to go from normal to super user, any other method would be an anomaly. Key to identifying these may be the use of neural networks to ascribe a probability of the behaviour being divergent.

Q2 What sort of information was being shared.

A

Overall goal was to have a common visualisation by all 4 countries involved in the collaboration. Sharing was complex because o the lack of interoperability of visualisation tools. Auto correlation techniques used for RADAR target extraction has interesting possibilities in this new domain.

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Milan Kuchta added: Ontologies and data sharing within an international sphere has always been a politically difficult. The technology is not the whole problem. As we enter this new space we need to take with us the survival skills that have evolved and kept us safe in our normal environment. How we take these tools into the new space is the key question. Underlying approach analogous to biological evolution, we need to take our best weapons and then learn how to make them better, and fast! Forensics give another good example to learn from, they do not need to know everything about the criminal you only need a finger print.

Statement from Bill Wright: in investigating cellular telephone fraud visualisation techniques have been developed to identify deviant behaviour.

Q From the Chair: Have architectural Portals been investigated

A No

Then clarification on the definition of Portal as a single specific view.

A

Not customized visualisation but customisable visualisation is required. Similar to some of the internet tools e.g. YAHOO.

Lengthy discussion about Portals, semantics and transformations. Interaction through Portals must preserve the integrity of the information, not the data.

Visualizing Expert Networks

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Discussion – Paper 22

Given many emails
Visualisizing social relationships among people

Relates to Carol McCann and Annette Kaster's problems (naval shipkeeping and seakeeping rules)
Solution: suggest the artificial gravity picture, where the entities are the figures of icons in visual space.

N/X problem (getting people to disagree to get diffferent viewpoints) different from Carol's problem (getting people to get along)

Milan Kuchta—need to do more than just identify people.

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Using Data Compression to Increase the Bandwith of Existing Tactical Control System – Content Based Compression

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Introduction

The huge investment in military sensors has meant rapid growth in the quality, diversity and quantity of images collected by the variety of military image acquisition systems. This has outpaced existing transmission, storage and retrieval systems. The military requirements for low bandwidth/power, covert operation, high quality transmission for non co-operative imaging and huge data volumes place severe demands on current state-of-the-art technology. At present, effective and timely communication of large imagery is prohibitive. It is slow and it consumes large portions of available communications capacity. Yet the transmission of imagery is becoming an increasingly important and widespread requirement. It is believed that if information cannot be received or delivered in a reasonable time efficiently and effectively then it is pointless to collect it.

Images in their raw form contain vast amounts of data within which a smaller amount of information may be relevant to particular applications, e.g. tactical control, surveillance, target recognition, change detection, underwater mine hunting etc. There is an urgent military need for an 'intelligent' compression approach that will provide an efficient and effective means of transmitting, storing and managing images based on their 'informative' content. This need is apparent across the range of military environments, from beyond line of sight air communications to underwater communications, from intelligence analysis to covert surveillance as well as fixed and deployable command & control systems and tactical control system.

Intelligent Image Compression

The aim of the presentation was to show the benefits in applying the 'intelligent' image compression technique in military application. The idea is to use image understanding to structure the applied compression so as to ensure that the compression process does not corrupt the militarily 'important' information contained within the image, while still attaining high compression ratios. The system characteristics correspond to clearly identified military requirements and has been evaluated in this context.

Scientific and Technical Issues

Content Based Compression It is a novel approach that has been developed at the Defence Evaluation and Research Agency in which the informative content (e.g. the targets) in an image is preserved using lossless compression while the rest of the image is compressed lossily to gain compression ratio. The regions of interest/targets/informative content are identified/cued automatically.

This novel intelligent compression approach is radically different from all existing compression approaches (where images are compressed either losslessly or lossily across the whole image).

The precise gain in performance depends on the application and the informative content of the image. When compared with lossless compression it can provide the same degree of information with a smaller amount of data. When compared with lossy compression it can provide more information for a given amount of data. In general for still imagery the conventional lossy compression can achieve a significantly higher compression ratio (10:1 to 50:1 for still images with tolerable degradation artefacts) than lossless compression (3:1 at best). In this novel approach up to 290:1 compression ratio can be achieved without losing the ability to identify 'Possible' military activity.

Automated Region of Interest/Target Cueing Algorithms Region cueing provides the essential guidance for automatically applying lossless and lossy compression techniques judiciously and intelligently onto the regions/targets of interests and non-relevant background areas in the image respectively.

In this project four novel region cueing techniques for static imagery have been developed, namely:

- the H-V quadtree based approach;
- the approximate entropy approach;
- phase congruency;
- a fusion based approach.

The H-V quadtree based and the approximate entropy approaches are both general purpose cueing processes. General purpose cueing was developed to overcome the problem of the high variability of content in military imagery. Phase congruency is a novel general purpose technique that is suited to detecting information at finer detail than the other two, this approach shows very promising results but is not mature enough at this stage. The fusion approach was developed to fuse results from all three

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techniques so as to benefit from the best of each.

Evaluation showed that the assignment of these regions corresponds to the Photographic Interpreters' and Intelligence Analysts' perception of importance.

Video imagery The novel content based approach has also been applied in video imagery. Here the moving target/object is segmented and encoded losslessly, while the static background is compressed lossily using MPEG4. For the video sequence considered an 800:1 compression ratio has been achieved using this approach, c.f. the 50:1 to 200:1 normally achieved for video with tolerable degradation artefacts.

Visualisation of Performance Evaluation

The conventional approach to performance evaluation in image compression is simply to measure compression and signal-to-noise ratios. Application and user based assessment techniques were developed and used to evaluate both the compression and cueing processes. The assessment took into account subjective user evaluation criteria as well as objective criteria.

A novel visualisation approach was developed to show and explore the highly complex performance space taking into account both the subjective and objective measures.

Conclusion

It has been demonstrated that it is more effective to use the limited available communications capacity to transmit images which have been compressed using the intelligent Content Based Compression than current Standard techniques. In the cases of the imagery considered in this project the Content Based approach can achieve usable 290:1 compression, c.f. 3:1 for Standard lossless techniques and 50:1 for Standard lossy techniques.

It has been shown that the required and attainable compression characteristics and ratio are dependent upon the nature of the imagery and the military operational requirements.

The performance visualisation approach developed, which uses objective and subjective performance metrics, is of wide applicability in performance evaluation for military systems.

Discussion – Paper 23

Evaluation issues

Retrieval effectiveness
- Dynamic data source
- User oriented
- Task oriented
- Key word salience – interactive relevance rating

Summarization
- Targeted at the interests of the user
- Summaries first followed by full report

Visualisation
- Show the similarly, duplicate, topic trends
- Want to know inter-relationship

Value in exploiting open source information

Event Stream analysis

Content based video compression

Only concerned with compression ratio, they don't really care what data is preserved and what's been thrown out.

Loss-less still used for images that require detail analysis and or further processing where loss of data would be unacceptable

Preservation of information is very important in some applications.

Draw attention to area that is of interest, area of no consequence can be compressed to meet bandwidth requirements.

Image fusion – structurally combining images not gray scale

Manual annotation
- Outline particular area of interest in an image
- Identify areas that are of extreme interest

Phase congruency

Performance evaluation
Target detection performance
Performance visualisation

Difference between what is data and what is information

Advantage of preserving data in an image – allows you higher compression while maintaining more information

Important elements of generating an effective image, what are the heuristics?

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A Simple 3D Visual Text Retrieval Interface

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Abstract

3D visual text retrieval interfaces are currently a fringe topic of interest. This paper suggests that 3D visual interfaces are fringe topics because of the complexity and abstract nature of many of the previous attempts in this area. In order for 3D visual interfaces to become mainstream this paper proposes that they must be concrete in the metaphor they employ, simple to use, and appear familiar to the average web user. In a set of two prototypes, AutoViz and NetViz, an attempt is made to fulfill these requirements. The prototypes represent the query terms one plane and the documents in a second parallel plane. A spring system is used to cluster the terms and documents into a meaningful structure. Document profiles are displayed to the user as they move the mouse on top of document representations.

Keywords: information visualization, visual query languages, search interfaces, information retrieval.

1 Introduction

Very little work has been done on 3D visual search interfaces in the past. The reasons that work in this area has been stifled is two fold. First, many of the projects took as a primary focus the exploration within the result space. Exploration is a secondary function of a search interface. Examining the results for the needed document is the primary goal, only after the needed document is believed not to be in the results is exploring and interacting with the result space an issue. Basically, exploration is not something that the average user will do on a regular basis. Second, many visual interfaces are too complex, feature overloaded and overwhelming for the average user. For the average user simplicity and familiarity are important and all too often ignored.

The goal of this 3D visual search interface is to be concrete in its representations and simple in its layout mechanisms and interactions. In addition the interface is meant to interact with existing search engines. Thus unlike some other visualizations this project does not require a specially processed document database.

The two prototypes, NetViz and AutoViz, discussed in this paper are both preliminary explorations into this area. More work is needed.

2 Related Work

The most interesting 3D visual search interface is the Document Explorer [Fowler *et al*. 1996, Fowler *et al*. 1997]. It is very effective in showing the semantic relationships between various documents in a set through spatial arrangements. Unfortunately, its 3D spatial layout of the documents leads to the appearance of complexity. The majority of the documents in the visualization are obstructed by other documents in a sea of overlapping text. Also the visual information in the interface is spread over various windows and views suggesting to the average user thai the interface is very complex and difficult to leam.

Another interesting, though less flashy, information retrieval visualization is VQuery system [Jones 1998]. This system uses a direct manipulation interface based on Venn-like diagrams. In this system the user is able to create oval and associate then with particular terms. These ovals can then be placed in overlapping combination that imply specific Boolean search queries.

The interface described in this paper was developed independently of the two similar systems mentioned above.

3 Visualizing Search Results

The goals of this 3D visual search interface are concrete representations and simplicity. In a search there is two sets of data: the query and the results. The query in most text retrieval application is a set of terms. The results are usually a subset of total documents in the index.

3.1 Basic Layout

We chose to represent each of the terms in the query string by a sphere. A cylinder represents each of the documents in the results.

To make effective use of 3D space the terms and the documents are laid out in two parallel planes. The upper plane contains the terms while the lower plane contains the documents as shown in Fig. 1. This arrangement allows for an easy view of the whole topology of the results without excessive manipulation of the view.

Paper presented at the RTO IST Workshop on “Multimedia Visualization of Massive Military Datasets”, held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

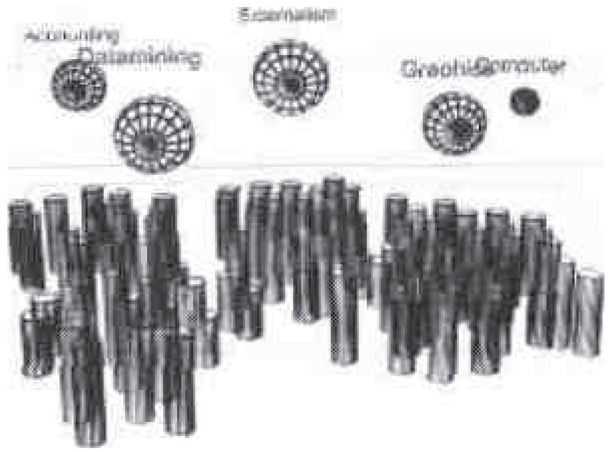

Figure 1. Schematic of the term and document planes used in visualizing search results.

Although not apparent in the schematic shown in Fig. 1 the documents will cluster underneath the terms that they contain. The clustering algorithm is an iterative energy minimizing spring system similar to Kamada and Kawai [Kamada and Kawai 1989]. The terms themselves are free to move as well and thus they will move into an arrangement such that terms that co-occur in the results will be located near each other. This results in a very Venn-like representation of the results as shown in Fig 2.

3.2 Use of Color and Proportion

Each of the terms has a brightness/intensity that is relative to the information content of that particular term. The information content of a term is greater the more rare a term is. In other words, terms that are more obscure have a more specific meaning and are thus more important in narrowing down the search space. The size of a term is also relative to its information content.

In the current prototypes all the terms are colored yellow. In the future with the help of a semantic word network it could be useful to color terms according to how separated they are in the word network. Thus related terms such as 'keyboard' and 'computer' would be have similar hues while the unrelated term 'car' would have a very dissimilar hue.

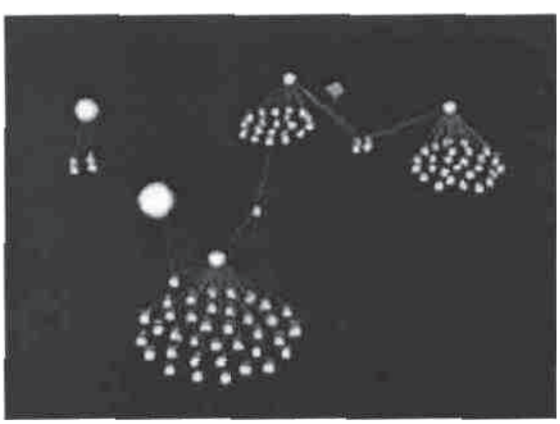

Figure 2. Auto Viz screen. A set of documents is clustered around a series of terms in a Venn diagram like fashion.

Documents are varying in brightness/intensity. This dimension of intensity is used to identify the most relevant documents in the topology. It is interesting to note that usually the most highly relevant results will be clustered in two or more locations. Only about half of the time will you have a single grouping that contains the most relevant documents. This grouping or relevant results is one or more clusters allows for the user to only inspect a few documents in each cluster to determine the trends and decide whether to continue exploring in that cluster.

4 The Use of Text in the Visualization

Since the visualization is intended to be used for text retrieval it is necessary that text be displayed within the interface. Strangely, it was our findings from user feedback, that the less text in the interface the better. It seems that text can quickly clutter the visualization and this adds to its perceived complexity. As mentioned earlier it seems that an increase in perceived complexity leads to fear in users attempting to leam how to use the interface.

4.1 Labeling of the Terms

The terms as represented by spheres in the upper plane are always labeled. This is the only instance of persistent text within the visualization. The reason that the terms are labeled and nothing else is the result of the fact that the terms serve as landmarks or a road map for the underlying clustered document topology.

The terms are labeled by text that is fixed in a location relative to the representative spheres but fixed in its orientation in terms of the viewer. Thus the term label as still being scaled based their distance from the viewer but their orientation will always be remain upright and lacing the viewer. The fixed viewer orientation of the text ensures that it is always readable.

The term labels are all the same color, typeface and font size. It was found that varying the colors of the labels only served to decrease their readability.

4.2 Labeling the Documents

Determining an effective method for displaying the titles and profiles of the documents proved to be challenging. The term profile refers to a document's title, URL, summary, size and date of addition into index. The requirements for the labeling of documents were (1) since the number of documents is huge only one document's profile should be visible at any one time (2) the user should be familiar with the format the document information is provided in (3) the user should easily be able to view the information from any document in the visualization.

The three methods of displaying a document's profile or title discussed in the following paragraphs all rely on the same document selection technique. The selection technique works as follows: as the user move their mouse on to a cylinder representing a document a timer will be set. If the timer expires and the user still has their mouse cursor on top of that particular document its profile will be displayed. This method allows for the user to easily move their mouse around the scene without triggering the display of any document profiles while at the same time allowing the user to rest the mouse cursor on a document and almost instantly get the profile. This is is a method similar to how ScreenTips are displayed in Microsoft Office'.

It should also be noted that in the visualizations in which a document is selected and its profile is displayed the associated terms in the visualization would also be highlighted. This is not very important when terms are connected by edges to documents as in the current prototypes (Fig. 2, Fig. 3) bui in future it is planned that there will be no edges visible (see Fig. 1).

4.2.1 Method one: situated document titles. The first method was simplistic and ineffective. The choice was made to have a documents label appear situated within the visualization. It was thought that this would be a nice way of spatially associating a label to a document. There are two major downsides to this usage of situated text. First, the document plane is quite dense with other documents and thus the situated document labels where easily obstructed. Second, there is not room for other text beside just a title within the visualization space.

4.2.2 Method two: relatively positioned overlays. In this method a semi transparent rectangle was overlaid on top of the visualization and then filled with formatted text. This allowed for a large amount of text to be clearly readable. The association between the text and document was very clear. The downside of this method was that the text had to be removed from the visualization as soon as the user moved the mouse off of the document they were inspecting. The reasons for this was simply that the text overlay usually obstructed the view of a number of documents that were located underneath it.

4.2.3 Method three: fixed position overlays. It was felt that it was advantageous to display a document's profile for as long as possible or at least until the user requested to view another document's profile. It was impossible to keep the profile on screen using the previous technique since many documents would be obstructed and thus the user would be prevented from inspecting them. In order get around the obstruction problem associated with the last technique it was suggested that the overlay be fixed to a particular non-obstructive location in the visualization. As visible in Fig. 3 the top left corner was chosen. This method worked quite well and it is the current method that is still in use.

The current method employs the use of a semi-transparent rectangle with white text. In the next version the overlay will be designed in order to mimic the document profiles seen in most search engines (for an example of a Go-ogle profile [Bin and Page, 1998] see Fig. 4). Thus a white background will be chosen, the title will be a bold hyper link, and the rest of the text information will be in a black font augmented by hyper links. Also along the side of the overlay a scroll bar will be present letting the user examine the documents in a serial fashion without selecting them from the 3D visualization. The usage of a profile that mimics a standard results from a 2ND search engine should aid users in understanding the 3D interface.

Latent Semantic Analysis
... Latent Semantic Analysis. Latent Semantic...
...techniques. Although Latent Semantic Anaysis has shown...
www.cs.brown.edu/courses/cs295-3/latentsemanticanalysis.html Cached • *4K* GoogleScout

Figure 4. A single document profile from the Google search engine.

This usage of a visual summary is meant to serve as a complementary technique to existing text summary.

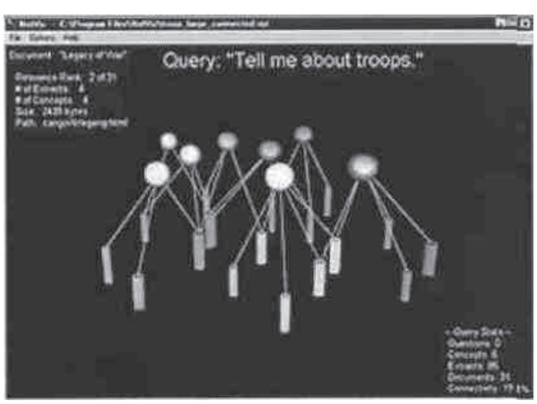

Figure 3. NetViz screen. A profile of a document is visible in the top left comer, the statistics on the search is visible in the bottom left corner.

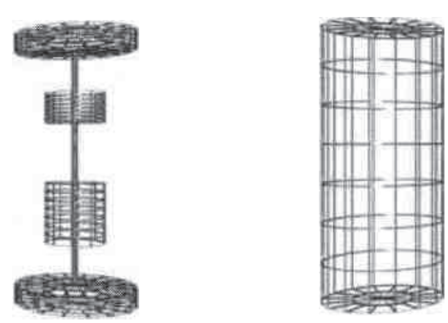

Figure 5. On the left is a "closed" document, on the right is an "open" document revealing the sections which are relevant to the query.

4.3 Previewing a Documents Contents

Many commercial search engines provide short text summaries of a document to allow the user to make a judgment on weather a particular results could be fruitful. These summaries can be extracted from the META tags, they can be the first 256 characters of the document, or they can be a piece or two of the text that contains some query terms.

Unfortunately, it is hard to judge a document based solely on the equivalent of one sentences of text no matter how well the particular words are chosen. A complementary technology to text summarization would be the visualization of the regions of a document that are related to each of the individual terms of the query. The visual depiction would allow the user to judge whether the terms where consistently co-located or not.

In staying with the theme of simplicity the information about the inira-document term locations are hidden from the user until the user requests further information. Only when a user selected a particular document in order to view the profile would the extra information become apparent. The selected document (i.e. the cylinder representing the document) "opens-up" and reveals the location of term usage (See Fig 5). This idea of graphically displaying the relevant pieces of text within a document is based on a somewhat related 2D project byEick[Eickl994].

5 Interaction Methods

5.*1 Adjusting the Relevance* ***Threshold***

When a search engine returns a set of results it will assign a uni-dimensional relevance factor to each element of the set. The relevance factor is generated based upon how well a document fulfills the query as a whole. Qualities such as the number of times a term is mentioned in a document, if a term appears in the title of a document, or a document has many incoming links influence the relevance factor.

AutoViz will display either the 1000 documents with the highest reputability or all the documents that fullill ai least partially the query—which ever is smaller.

The relevance threshold is a user-controlled scale that sets the minimum relevance that a document must meet in order to be displayed in the visualization. Once AutoViz has displayed all the documents, the user is then able to adjust the relevance threshold slider, in order to focus on only the most relevant documents (see Fig. 6 and Fig. 7).

5.2 Visualizing Multiple Queries

Assuming that the user does not get the result that they were looking for on the first query they will then have to somehow determine better more targeted queries to submit. This visual search interface allows for the submission of addition queries into the visualization. It will allow the user to comprehend the cross-query trends in the results.

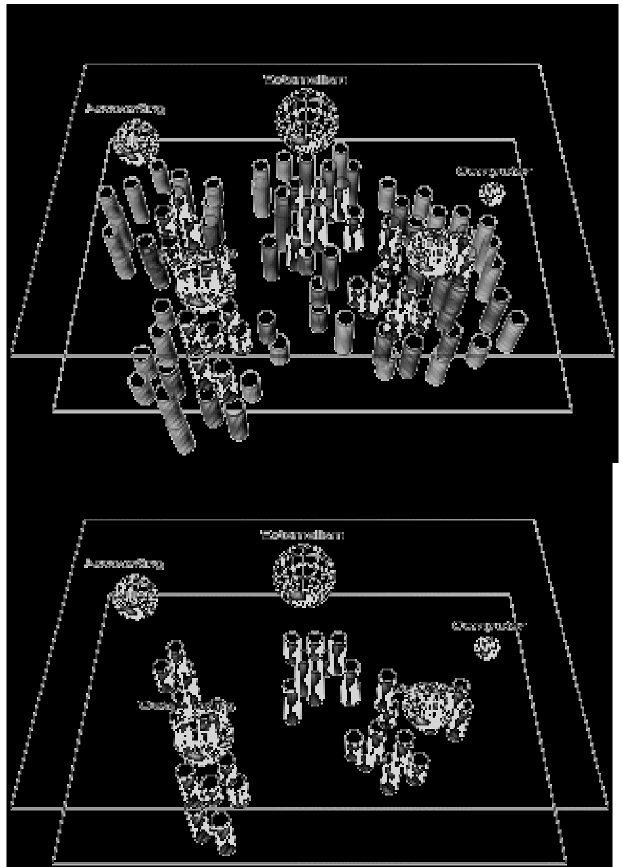

Figure 6. A depiction of showing the a low relevance threshold (top) and a high relevance threshold (bottom).

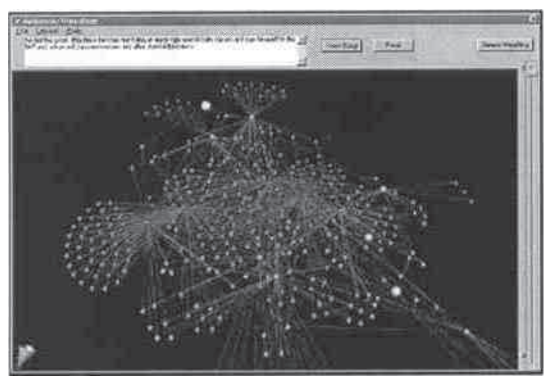

figure 7. AutoViz screen. The relevance threshold scale runs vertically along the right side of the window.

Sometimes a document may be slightly relevant to a series of queries but not highly relevant to any particular query. This ability to view trends across queries will allow the user to notice persistent results and examine them to determine if it is what they are looking for.

6 Acknowledgements

Thanks to NATO IST-05, IST-13 and the Canadian Department of Defence.

7 Conclusions

The prototypes and ideas discussed in this paper are all on a path leading to simpler visualization tools for aiding users in their searches for information. No longer should users be scare of a large number of search hits when they have access to an interface that can organize that information in an obvious and meaningful way.

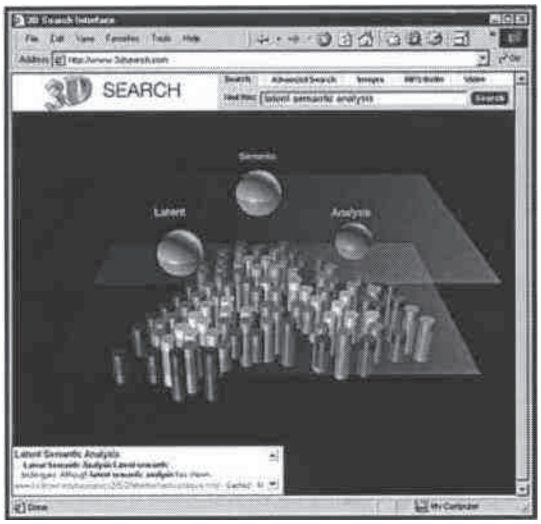

Figure 8. Artist's depiction of a future possible version of this visual search interface.

The next version of the interface may be implemented as a browser plug-in and could look like the depiction in figure 8.

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Discussion – Paper 24

- Can we come up with a graphical way of representing search results in a way that is superior to text only displays?

- Visualisation is good for specific knowledge

- 3 types of info retrieval process – binary, vector, probabilistic

It's difficult to formulate effective queries
- words don't have a 1:1 mapping to semantic concepts
- we have to go past words
- there are a huge number of documents on the internet

- Concrete representation of the query, data mining, and visual summaries, bridging the gaps between serial queries

- Widening/narrowing to get context

Characteristics of the Autoviz application:
- Visual document summaries
- Highlighting and extracting subsets
- Allows interactive extracting to demonstrate the relationships and associations

- Is the underlying engine is more critical than visualization? The engine is what gives you the results, but how the results are displayed may enhance your understanding and improve the results of the engine.

- Visualization is usually a fix for insufficient data mining algorithm techniques

- Intra result set clustering works in text only displays too

- It will be integrated into existing text search engines

- The metaphor of exploring information space it become more popular

Discussion – Maths and Techniques

Opportunity for data compression – recovering data from the black box
streaming of exercise log book – DERA commercial product

Looking to apply MBP in the medical field, with military medical records.

Event stream analysis uses simplistic symbolize to show true movement of red and blue forces. Stream massive amounts of data

Visualisation is a means to an end. Streamed data preserves temporal information, and delivers information in a stream instead of all at once. Element of anomaly detection because you may be able to predict expected movement and will be able to see deviation from the direction.

Event stream analysis can be used to display patterns and trends in the display.

Visualisation provides pattern recognition… good for decision-makers who have the experience to make the generalizations and can interpretation of data.

Visualisation is a tool, not the method.

Currency of data - archived data could be used as a benchmark for comparison but be careful of validity.

Data mining – what are the analytical tools used to analyse data? Is there a way to match up the analysis tools with the different types of problems?

Clustering
Correlation
Convolution
Statistical analysis

In the end it doesn't matter what the analytical engines are or do, it's how they impact the user or the human environment. Visualisation tools have to deliver information that allows the user to perform the tasks well. The people who will be using the tool are in the business of analysis, they still have to do the analysis, but these tools help the user focus in on areas, and making more efficient and effective analysis.

You need to put the users' hands into the visualisation. You can tell if a visualisation is intuitive by using it.

The importance of testing. What are we measuring the tool against? Requirements definite the process. Visualisation is usually not a requirement, but may have come up as a possible solution to a real problem.

Briefings are a necessity, and have huge amounts of data that they need to present effectively and timely. Need to compare preparation of briefs with the use of the tools to that of the "old" way. Hard to get the raw data, but definitely something they are trying to test.

Elastics.

Testing intuitive use of tool:

Here's the task
Here's the visualisation tool
Can you do the task without training or assistance?

Sometimes the visualisation doesn't need to be intuitive. It depends on the task. Sometimes if a task is difficult and complex, the interface may have to be the same, and can be learned by a user.

Important to have people, using real data, performing real tasks, and see how effectively they can perform them.

Often Vis tools are useful in tasks that need to be done quickly and effectively without training or time.

Evaluation – usable systems with out much training wanted by clients. Systems are being put together without much testing with the hope that it's effective. There is need to assess and measure visualisation tools

In R&D stage, use your creativity and freedom to develop the best tool you can…

Image Compression
Much support of the process.

Have to have some way of determining what are the areas of interest.

Out of the norm, something different
Cueing
Identifying and modeling normalities and then if there is something out of the norm it is something of interest

Simulation
Spatial information – can corrupt small details

Evaluation needs to be addressed.

Use of compressed image is important. Technology is great, must make sure that it is applicable to the task.

Sending intelligence + context to someone who can analyze it.

Assembly and Deployment of Enterprise Visualisation Solutions

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Discussion – Paper 25

Assembly and Deployment of Enterprise Visualisation Solutions

Research Program at DSTO in visualisation area
Differs from more traditional approaches
Several teams
Vis team combined with knowledge based team + another
Question: How can we provide infrastructure and support for particular domains

Looking at Vis. In C3I
Operational and strategic levels (little bit of tactical)
Domain solutions—analysis, how do we link into information management
Cost of deployment needs to be considered

Research Issues
Provision process—how things are deployed

InVision-new approach for computer-based vis. Resulting from research being conducted at DSTO
Key concepts

- Integrated component-based vis. Approach
- Model based visualisation
- M-V-C
- Allows a variety of information representations and views to be integrated
- Representational integration-putting together different representational forms into one visualisation—e.g., map + chart
- Knowledge-based deployment components

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Integration of components to build vis system

User Perspective

- Rich visualisation environment using COTS components (e.g, graphs charts)
- Topographic view
- Workspace—allows various views and representations to be combined and tailored to user roles
- Process/Workflow support
- Intelligent assistants—guiding the user
- Monitoring

Virtual machine question: java platform independent, yes addressing that

Development process iterative and evolutionary

Sensor Deployment

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Basic Question:

Why do users who **do not** want to be **flooded by data** want ever bigger screens on which to **display more data**?

It seems somewhat inconsistent for a commander to complain about the dataflood, while at the same time asking for screens that fill whole room walls, or for 3-D worktables that can present ever more data. Yet this is exactly what many commanders do. This presentation discusses the underlying factors that resolve the seeming inconsistency,

The Basic Question has two answers (both valid):

1. The more screen real estate, the more **context** of different kinds can be displayed for any item of focal interest.
2. Eyes **"flick"** more easily than screen data can be changed by interactive devices, meaning that both focus and context can be changed rapidly and consistently, with an easy return to the original focus and context once the information from the new place has been assimilated.

An eye-flick is the simplest kind of sensor redeployment. But it is like any other sensor redeployment in that it provides information about a new part of the environment, while losing the ability to gather information from the place the sensor observed before the redeploymnet. One always must balance gains and losses when redeploying sensors, but the gains and losses are not simply the gain of the new scene and the loss of the old.

One loss comes from the fact that the sensor is unusable during redeployment. Another loss comes from the resources needed to determine where the sensor should be moved, and to actually effect the move. In the case of the eye, it is often a peripherally observed movement or flash that tells you where to move the eye, and the eye itself is a lightweight sphere in a well lubricated environment, meaning that the movement can be quick and accurate, using few processing resources to determine the target of the move, little muscle power to effect the move, and little loss of observing time during the move.

In contrast to using an eye-flick, if the commander's display showed only the data relevant to the task at hand, sensor reedeployment would require some processing to determine what new data to select, attention to perform the selection, and substantial time-loss during the change. A very large display, then, if the content is appropriately configured, can allow the user to substitute a very easy eye-flick sensor redeployment for the more complex method of instructing the computer to display the data that are newly of interest.

Sensor Deployment

The example above contrasted the ease of an eye flick with the relative difficulty of obtaining the same change of seen data by asking the computer to change what is displayed on a small screen. Can either be equated with the redeployment of sensors on a battlefield? What can we legitimately call a sensor that can be redeployed?

A sensor is a device for bringing some aspect of the world into the range of a processor, whether the processor is a computer, a brain, or a burglar alarm. Any sensor sees only some of the available data at any one time, but if the data change slowly compared to the rate at which the sensor can be moved to a new part of the dataspace, then the data can be scanned and built into a larger picture. Alternatively, if a sensor with a wide field of view can detect a change in a part of the dataspace not seen by a focal sensor, then the focal sensor can be redeployed to examine that part of the dataspace more closely.

Dataspaces occur not only in the natural environment, but also inside computers, and dataspaces inside computers are the ones we have a problem visualising. To get the data into the brain requires

"engines" that select data, process it, and prepare it for presentation through display devices. The combination of an "engine" (selector or analyser) with a display device can be considered a sensor"that allows the human to see into a data space in a computer—to visualise what the data mean for the task at hand. So, "sensor deployment" can then be taken to apply to the control of the engines, directing them how to select the data, because there is too much to see all at once, how to process it, because it is unlikely to be in a useful form initially, and how to present it, because there are usually many possibilities for the presentation of the processed data.

When we are talking about visualising the natural environment, the only mechanism that intervenes between the environmental data and the brain is the senory mechanism such as the eye, the ear, the arm and hand—unless, of course, the hand is holding a probing stick or is manipulating some kind of tool. When the hand is holding a familiar stick or tool, it sometimes feels as though one's self extends to the probing tip, rather than ending where the skin meets the tool. Control of the stick is effortless and requires no diversion of attention from the task of visuaalising the environment the stick probes. This observation raises a question and a claim:

Question: Where do "I" find a boundary? At the skin? At the end of the "blind man's stick"?

Claim:

- If a sensor deployment needs specific "conscious" commands it is part of the outer world.
- If a sensor is deployed in its arena easily, intuitively, and "unconsciously" it is part of "you", and makes you feel you are in the data space.
- If you feel "in" the dataspace, you will visualise its implications better than if you "observe" the dataspace through an instrument that requires conscious manipulation.

Resources devoted to controlling the sensor are resources not available to interpret the data. If attention must be devoted

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

to the procedure for seeing a new part of the data, or for seeing the data in a new way, itthat attention cannot be addressed to the data. That is the fundamental reason why the large screen across which a user can flick the eyes is usually preferred to a small screen that shows all and only the data relevant to the task immediately at hand.

Interacting with the interface Versus Interacting with the data

When we use a computer display system to view data held in the computer, logically we have to interact through (and with) an interface. But it need not feel as if we do, any more than the blind man's stick feels like anything but an extension of the blind man's self. The feeling that the interface has disappeared, and we are interacting directly with the data, is sometimes called "transparency", but that term, evocative as it may be, is a bit misleading. Is the action of the steering wheel of a car "transparent"? It is not conscious, and does not demand attentional resources, but it is not "transparent". However, the driver does not think of interacting with the steering wheel so much as of interacting with the other traffic on the road, and with the intended route. The steering wheel requires no thought. Route-finding may, and interacting with the other traffic does.

The interface for deploying a sensor may be more complex than a steering wheel. A steering wheel controls the car in only one degree of freedom, whereas to identify useful data and to arrange for its display in an intuitively effective way may require many degrees of freedom. To some extent, then, the ideal of a "cognitively vanishing" interface can usually not be completely achieved for sensor deployment when the sensors are the""engines" of a visualisation system.

To approach the ideal (meaning to deploy a sensor easily and intuitively) one needs three things:

- To know where the sensor should look
- To know how to get it there
- To have the means to use this knowledge easily

To know where the sensor should go, there are different possibilities:

- Context (fisheye, multiple views, big screen): The new location may be visible within the displayed context of the original presentation. This is more likely to be true with large displays, in which sufficient display space is available for both the focal and the contextual data.
- Alert system (preprocessors): Autonomous processors analyze the dataspace, seeking out parts of it that satisfy predetermined criteria. When such a location is found, a subsidiary display may show where the intreresting data may exist, or if it is in the already displayed context, that location may be highlighted.
- Memory of the configuration of the data: If the user wants to observe a new part of the data for some reason based on interpretation of what has already been seen, rather than because of the actual characteristics of the data at the new location, the user's memory of the data structure may be able to guide the transition.

To know how to get it there, only two possibilities exist:

- Navigation through the dataspace, observing different data processed in a common way. The navigation may be continuous, in the sense that the data shown have a natural property of neighbourhood and that the displayed data progresses through neighbouring spaces. Alternatively, the navigation may be discrete, in that the focus of the presentation is moved abruptly from one part of the dataspace to another, without passing through intermediate regions of the data.
- Dimensional control: The same or different part of the dataspace may be viewed in a new way, either by changing the processing of the data before presentation, or by looking at different aspects of the same part of the dataspace. Of course, navigation and dimensional control can be used in conjunction.

To have the means to use this knowledge

- Effective input devices matched to the navigation requirements. Even if the user knows where to look in the dataspace, and how to get the sensor to look there, this knowledge is of no value if the input devices do not allow for the appropriate commands to the sensor. Precision of control is important, because if the sensor deployment is imprecise, it will require attention for the "correct" selection and processing to be achieved.

Navigation implies understanding the structure of the data, an understanding that can be achieved in several possible ways:

- The current presentation may display enough of the data to allow the structure to be understood.
- The presentaiton may use a metaphor to previously known data space (e.g. the office desktop…)
- Learning, training, exploration
- Subject matter expertise

You can't be'"in" the data unless you know how it fits together. But as the earlier discussion suggests, you can't be'"in" the data unless, without having to think about it, you know where the sensor should go, how to get it there, and you have input devices intuitively suited to commanding the sensor.

Precision of control is part of ease of control. Imprecise sensor deployment often means "conscious" deployment – and destroys the feeling of being "in" the data space. Attention devoted to correcting imprecise deployment is attention not given to the real task.

Where do "I" end? At the limit of where my control of sensor deployment is intuitive, "unconscious" and"**precise.**

Discussion – Paper 27

Sensor Deployment

IST-05 reference model

Inner loop

We want big screen real estate, but don't want to be overwhelmed by data
Answer: The more screen real estate, the more context of different kinds
Eyes flick more easily than screen data can be changed by interactive devices

Need alerting system to cue user to focus on certain presentation

Feeling of being immersed in data – sensor deployment – putting you fingers where you want to, looking where you want, having control over your interaction with the data

We have limited focal attention – 1 or 2 threads

A sensor is a device for bring some aspect of the world into the range of a processor

A sensor for a brain includes your eye looking at the data that was obtained by some other sensor and into your brain

Where do I find a boundary, at the skin? At the end of the blind man's stick?

Claim:

Where you begin to have to explicitly command the senses to do something is where "I" end. If a sensor is deployed in its arena easily, intuitively and unconsciously it is part of "you"..

Interacting with the interface vs interacting with the data

Important to remember the data is not the real thing. To deploy a sensor easily and intuitively one needs to know where is should go
Context
Alert system

to know how to get it there
navigation – continuous? Discrete? Menus good for discrete
- exploration of data spaces
- effectiveness of obtaining data from the system may have a lot to do with the input devices that allow the user to interact with the data
- implies understanding the structure of the data
- metaphor to previously know dataspace
- learing, training, exploration
- subject matter expertise
-

dimensional control

to have the means to use this knowledge easily

At the limit of where my control of sensor deployment is intuitive "unconscious" and precise

Precision of control is part of ease of control.
Imprecise sensor deployment often means "conscious" deployment – and destroys the feeling of being in the data space

Fuzzy skin – where the end of your conscious deployment is dynamic. Orchestra leader, for example—his "skin" encloses the orchestra in the sense that control and interaction is full, intuitive, and broadband [at least for music production, at least for the duration of the piece].

Perceptual control theory

Training and discovery

Pace of Change

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Discussion – Paper 28

Pace of Change: Can you Cope?
Speed vs. maneuverability
Greater field of view in US aircraft, although less man. Than Russian aircraft
Greater orient/visualisation
OODA loop

Lind ODOA, applies better outside air force conference
Visualisation solution does not work in every context

People see same thing differently

Ray Kurzweil—Braille, nanobots
Computing speed doubling every three months by 2020
Have to design future systems now, not current systems, b/c by the time they're built computing power has increased considerably

Quadrant one internal awareness
Quadrant two
Internal responsiveness
Quad 3
Responsiveness
Quad 4
External responsiveness
Wealth in innovation, not optimization
Balance between risk and effectiveness of innovation
People have values not organizations
Stop developing independently—develop a strategy for working group, take it to the brass

Paper presented at the RTO IST Workshop on "Multimedia Visualization of Massive Military Datasets", held in Quebec, Canada, 6-9 June 2000, and published in RTO-MP-050.

Leveraging collective wisdom to be more strategic and innovative
Institutional pride not seen in group---rather seeing institutional frustration
Managers of work rather than of people—be stewards evangelists of a combined effort

General Discussion on Aims and Workshop Wrap-up

IST-21 Aims

Seen many presentations focusing on technology.

Evaluation
- Who should decided what information is needed?

Need to work in cooperation and collaboration, jointly with the NATO group and friends.

Each group has it's own individual objective and deliverables and projects, but it is important to exploit each other's frameworks and strategies.
Value in a collaborative framework and strategies

Corner stones
- framework – what are we doing, strategies
- evaluation – is it working, how can we tell

Component based software and system architecture

Domain – roles – view points – evaluative needs

View points become the focus of the system roles

Framework provides basis for capturing roles and effectively obtaining objective of visualisation.

Take focus off developing specific technologies but provide guidance by defining strategies and objectives

Utilization of human potential… can it evolve with the technologies…

Art, science, and engineering.
Collaborative study of human and visualisation utilization

Objective of the group
- technical group to advise and contribute to the goals and aims of the level 2 group.
- Perspective of overall objectives needed
- User and underlying technology expert input essential
- Supported by individual nations

Clearly defined objectives
Need for user involvement, especially in terms of evaluation.

Workshop is an independent event. The purpose was to bring together the military personnel with the problems with experts and researchers to understand and share ideas, solutions, and areas of future work.

Objective of IST-21 must be clearly defined in order to provide focus and clarity. Innovation is essential.

Take from this Workshop an understanding of what is needed from a user perspective, as well as help define a coherent program of the next group.
Identify what problems still exist and help define what needs to be done. Allows the group to select a program of work and term of reference for future group.

Formal collaborative Workshop between NATO and TTCP tentatively planned in about 18 months. Understanding user requirements and evaluation possible topics.

Conference, invite NATO members, have workshop as subset of that – help to distribute the information to an extended audience.

Need for different levels of technical detail.

Venue has impact on the style of the meeting. Keeping numbers down may encourage discussion and development of relationships. But it's still important to pass that information around. Attempt to satisfy the needs of users, technologists, and research.

Applied research environment attempts to understand military situation and apply technology. Look for collaborative opportunities and draw on experience and expertise of other participants. Discussions had a tendency to move away from applied solutions or ideas towards conceptual ideas.

It is important to have a feedback mechanism.

Cannot do R&D in a military situation without having user feedback and involvement.

Extremely valuable week, but would be nice to see more people from the military side.

User interview and software design, development, and evaluation is a commonly excepted software engineering practice.

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Human computer interaction
Human factors engineering
Information operations
Information systems
Intrusion detection
Logistics planning
Man computer interface
Military applications
Military intelligence
Military requirements
Models
Multimedia
Peacekeeping
Quality visualization
Research management
Software development
Software engineering
Visualisation
Visualization

14. Abstract

The workshop IST-020/RWS-002 on Multimedia Visualisation of Massive Military Datasets was held at the Defence Research Establishment Valcartier, Quebec, Canada from 6-9 June 2000.

Five major themes were addressed in 28 presentations with extended discussion, in separate sessions entitled:

- Operations Visualisation
- Visualisation for Command
- Network Visualisation
- Data Fusion
- Maths and Techniques

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