Technical Evaluation Report
Beyond Time and Space

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ABSTRACT

The title "Beyond Time and Space" allowed authors an open opportunity to interpret its meaning through their papers and presentations. The papers fell into four areas: 1) how experts can virtually be brought to where they are needed; 2) new tools for effecting time and space; 3) new processes for solving problems and creating designs; and 4) the possibilities and problems that virtual networks offer. Overall, the papers explored the ability of science and technology to compress time through the use of efficient tools to solve problems and create designs and shrink space through use of communication facilities that allow widely separated people to interact effectively. There were several themes that were present in more than one paper. Those themes included: collaboration between experts and novices, or experts from different fields; the human factors implications that result from changing processes; and the need for common mental models and understanding of terms. Understanding the implications of new capabilities that reach out over time and space will play an important role in setting a research agenda for the HFM community.

Keywords: Collaboration, Expertise, Digital Networks, Telemedicine, Telemaintenance

1.0 INTRODUCTION

The North Atlantic Treaty Organization (NATO) Science and Technology Organization (STO) Human Factors and Medicine (HFM) Panel organized and conducted a symposium entitled "Beyond Time and Space" on 14-16 October 2013. The symposium was held in Orlando, Florida USA. At the time of the symposium, the United States Government had partially shut down due to lack of fiscal appropriations. This prevented several key participants from attending. One of those not able to attend was the Technical Evaluator. I was asked shortly before the symposium to serve as the Technical Evaluator. This report reflects my reactions and conclusions resulting from the presentation of the papers at the symposium.

1.1 Background

The symposium's title "Beyond Time and Space" is open ended and open to interpretation. The presentations explored how science and technologies could allow people to compress time by enabling faster, more efficient performance and shrink space through modern communication capabilities that enable widely separated individuals to work together effectively.

1.2 Goals and Objectives

In his introductory remarks, Professor Flemisch, symposium co-chair, discussed the impact of time and space using as an example an archeological find of an early weapon. The carefully crafted spear (the oldest wooden

weapon found to date) when used by early man expanded the distance at which they could hunt and the type of prey they hunted. Innovation has had a similar impact on warfare. The gradual improvements in weaponry, transportation, and communications have spread out the battlefield to the point where a modern Infantry battalion can control an area that is many times larger than that controlled by an ancient Roman equivalent. Prof. Flemish pointed out the process of shrinking space and leveraging time continues to accelerate at a rapid rate. Symposium presentations discussed how new technology combined with new implementations affect military doctrine and outcomes. The introduction of radical new capabilities has implications beyond the capabilities themselves. DOTML PF stands for "Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities." Effective changes in any single area will lead to increased military capability, but that change will also affect the other elements of DOTML PF. For example, the introduction of a faster, more capable vehicle would require changes in doctrine, training, facilities, and perhaps the type of operator chosen. During the symposium we heard about new systems for conducting maintenance, command and control, and medical actions. How these systems will affect doctrine, organization, training, materiel, logistics, personnel and facilities, and what adjustments will need to be made to accommodate them, has yet to be determined. The presentations fall into four categories: 1) how experts can virtually be brought to where they are needed; 2) new tools for effecting time and space; 3) new processes for solving problems and creating designs; and 4) the possibilities and problems inherent in using virtual networks such as the internet. Understanding the implications of new capabilities that reach out over time and space will play an important role in setting a research agenda for the HFM community.

2.0 BRINGING EXPERTS VIRTUALLY TO WHERE THEY ARE NEEDED

Three presentations discussed methods for utilizing telepresence to bring experts located in their home country to the front lines of the battlefield, where they could assist repairmen, medical technicians, and corpsman. In this situation, deployed personnel would be trained to have general knowledge of a topic, but may not have the knowledge or experience to independently succeed in specific situations. Dr. Alexander's paper served as the basis for the further work reported by Prof. Schlick in his keynote address. The subject matter for Dr. Alexander and Prof. Schlick was telemaintenance; Dr. McVeigh used a similar approach regarding telemedicine.

Dr. Alexander's presentation discussed an experiment in which participants had access to information via audio, audio/visual, or direct communication with someone in the same room. The experiment involved a technician having access to an expert while the technician was conducting a maintenance action. Dr. Alexander reported that audio alone was inferior to audio/visual, but audio/visual and direct co-located communication showed comparable results. An interesting finding reported by Dr. Alexander was that the repairman often didn't stop to ask the expert for assistance and as a result in many cases got the process wrong. Dr. Alexander's finding served as support for the development of audio/visual media as an interface to support interactions between repairmen and experts in the research reported by Prof. Schlick.

Prof. Schlick's research made use of combining augmented and virtual reality technologies to allow an expert in a distant location to work cooperatively with repairmen in the field. There was an underlying philosophy that repairmen were taught general approaches to repairing systems and they could go to the expert for aid on specifics for a particular vehicle type. The prototype system's computer and communication capabilities were found to be adequate for the application. The visual interface proved to be the technology in need of improvement. Prof Schlick reported low acceptance of helmet mounted displays by German users and as a result they used smart phones for the visuals. The AR/VR system allowed experts to see what the repairman on site could see. Performance, workload and visual fatigue measures were collected in an evaluation where an AR/VR system was compared with a commercial off the shelf (COTS) video teleconferencing system. The experimental task was to change the cam shaft housing on an engine. The performance measure used was the

number of work steps completed in 10 minutes. Fourteen of eighteen participants completed more work steps in the AR/VR condition than the video teleconferencing condition. In addition, fewer and shorter communications occurred in the AR/VR condition.

If militaries adapt this method of performing maintenance, there are human issues beyond the performance of the maintenance tasks themselves that will need to be considered. For example, how would the underlying model affect personnel selection and training? Is there still growth from novice to expert when the novice always has access to an expert and is never trained on the specific knowledge possessed by experts? Given the need for experts with broad knowledge of specific vehicles, will it be necessary to train them differently than the repairmen? Will experts have to be brought into the military from trade schools at higher ranks?

Just as telemaintenance bridges time and space, so does telemedicine. As noted by Dr. McVeigh, telemedicine can take many forms; while its use is limited today, it is increasing. I was impressed with telemedicine's benefits, in particular that it enables increased access to specialty care. Many lessons learned from telemaintenance can be shared with telemedicine and vice versa. Some of the virtual technologies used by Prof. Schlick should have applications in the medical arena. Dr. McVeigh reported that there were over 1900 teleconsultations from theater on behavioral health issues. An interesting approach to getting potential patients familiar with their telebehavioral health options was funded by the US Army and developed by the Institute for Creative Technology (ICT). They created an application called "SimCoach." In SimCoach, service members interact with virtual humans (intelligent avatars). The virtual humans ask questions and make suggestions about available healthcare resources. The ICT found that many patients using "SimCoach" opened up more to the virtual human than a real person.

Dr. McVeigh pointed out the challenges and potential benefits of telemedicine. Legal liability and credentialing will probably be the most difficult challenges to overcome; while the benefits include avoiding hospital admission and an increase in availability of specialists to remote patients. The delivery mechanisms for telemedicine can be tablets, smart phones, and other devices that connect to communication networks. Dr. McVeigh also discussed the Netwarrior program which is using the Samsung Galaxy 2 with 3 levels of security.

The presentations by Prof. Schlick and Dr. McVeigh both used a concept that the US Army has called "Reach" - the ability to connect to an expert who is out of the war zone for help in completing a task. "Reach" was to be a capability inherent in the now defunct Future Combat System program. The use of smart phones for telemedicine and telemaintenance suggests that issuing them to service members needs to be considered further. A few years ago, the US Army was exploring whether or not to issue phones to soldiers. It never happened because of cost considerations. It seems the need for smart phones is still there but at present, service members will likely have to bring their own. More research is needed into the effectiveness of telemedicine and telemaintenance, as well as determining which methods and media are most likely to result in repairmen using their available expert appropriately.

3.0 NEW TOOLS FOR EFFECTING TIME AND SPACE

In addition to Dr. McVeigh's presentation, there were others on various aspects of telemedicine. LTC Thompson described the process by which requirements are generated and telemedicine systems developed. He concluded that gaps or needs can be filled with changes that are not new materiel or, as he said, "a bright shiny object." It is common knowledge that requirements generators too often request materiel solutions without adequately studying alternative approaches. LTC Thompson was the first to raise the problem of semantic interoperability. Semantic interoperability refers to the frequent lack of agreement between people from different fields about what terms mean. This can lead to big problems in telesystems as well as other military

communication. The US Army's "The Blueprint of the Battlefield" was created in the late 1980s to try to overcome semantic problems. It was designed to clearly define terms so they had a common meaning regardless of branch (infantry vs. field artillery) and battlefield operating systems. Ontologies depend on agreement on semantics. The need for agreement on definition of terms came up frequently in symposium presentations. One concern of LTC Thompson was that the technology transfer process isn't well organized and that within the S&T community there are a lot of science projects. This is not an unusual concern and brings up the philosophical question about the correct balance between exploratory basic research and applied research applications.

Papers by Mr. Jones, Ms. Pavliscsak, and Dr. Gilbert discussed issues in building and using tools that impact the quality of telemedical care and overcome distance / time issues.

Mr. Jones discussed tools developed to aid in Cognitive Behavioral Therapy. The tools monitor stress indicators and provide feedback allowing patients to be more aware of their own behavior. With this information, the patient and therapist can better understand triggers that induce stress and anxiety. The system provides information and reminders which influence therapy outcomes. It's an ambitious project that provides possibilities for many other applications in a wide range of fields. Acceptance and effectiveness are key issues, as well as knowing that the right symptoms are being tracked and how they effect the therapeutic outcomes.

Ms. Pavliscsac's mCARE system had similarities with the Cognitive Behavioral Therapy tools discussed above. mCARE is a tool for maintaining communication with multiple patients. It has proved to be an effective tool for keeping in touch with numerous patients in a way that was acceptable to them. Systems such as mCARE could have a variety of other potential applications. How information is presented to users is key to success, and design options are worthy of continued research.

Dr. Gilbert discussed issues that are preventing unmanned casualty evacuation from being a viable evacuation option. A key policy decision, according to Dr. Gilbert, is when it is appropriate to use an unmanned evacuation system. He said that they should only be used when it was unsafe for standard evacuation methods. Given the degree of danger that would preclude the use of standard evacuation methods, the patient would have to be severely injured before the use of unmanned evacuation systems would be considered. There are human factors and ethical issues, but when there's no other way to save a life, an unmanned solution should be acceptable as a last resort. The technology to perform unmanned evacuations is here, but human factors and ethical issues are standing in the way of implementation. A question that Dr. Gilbert raised as being an important factor in allowing for unmanned evacuation, is what do medics do while they are riding with patients on medical evacuation helicopters? A definitive answer to this question may contribute to key policy discussions on implementation of unmanned evacuation systems.

Capt. Apse spoke about the difficulty of managing information in the digital age. Information can easily overwhelm users to the point where they cannot find what they need. Semantic tagging is an organizing method for knowledge; it can turn taxonomies of information into ontologies of knowledge. As previously mentioned, semantics is a key component of the tele-process and having agreed upon definitions is vital. Capt. Apse pointed out that telemedicine needs to share information at all levels. C2 systems are also hierarchical. Capt. Apse proposed that collaborative tagging could evolve into a ubiquitous information sharing method whereby individuals who use the system produce semantic tags, and a coordinator controls the standard use of vocabulary. As computer networks expand, the need for better methods of organizing information will clearly be needed.

4.0 NEW PROCESSES FOR SOLVING PROBLEMS AND CREATING DESIGNS

Design of revolutionary new systems and tools cannot be left to chance. Mr. Fouse and Prof. Flemisch presented approaches to system design that allowed the designer to explore a range of possibilities and eliminate those that

weren't appropriate. Virtual prototyping and facilitated exploring of a problem space provide powerful tools for evaluating design alternatives and solving multi-dimensional problems.

Mr. Fouse's keynote address discussed the power of virtual prototyping. In the process, he described how alternative ideas for a new system can be tried out in software within a proscribed concept of operations (CONOPS). The results of playing out CONOPS-driven scenarios provides insights into the effectiveness of a design concept. The co-evolution of technology and CONOPS through experimentation allows both the design and its CONOPS to be vetted under conditions that will likely be encountered when the system is fielded. Mr. Fouse mentioned the need for an effective and systematic method of measuring mission effectiveness and system performance. Human systems design was a key focus of the presentation, which discussed current efforts to develop evaluation tools, effective ways to measure human performance as it relates to mission effectiveness and system performance measures. MANPRINT is the systematic consideration of human factors, training, personnel and safety issues in system design. MANPRINT needs to be introduced in Mr. Fouse's process. This would ensure that virtual prototyping would also benefit the human dimension in system design. Design and development of the Command Post of the Future (CPOF) was used as an example of a system that went through the co-evolution development process. The result is a tool that can be used to effect time and space. Design and development occurred collaboratively with designers and system users working together. Collaboration was another theme that was an important part of this presentation and others. The dynamics of that collaboration need further study. Mr. Fouse concluded that the success of the process he described is dependent on having users or subject matter experts (SMEs) who have a concept of what the future looks like. CPOF has proven to be an effective C2 tool that commanders use to great effect, shrinking preparation time and allowing for operations over a dispersed area.

Prof. Flemisch presented a different approach to designing new systems that meet the needs of users. The "Exploroscope" is his concept for providing designers with the space and capabilities to explore design alternatives. Simulation tools, Wizard of Oz techniques, toys, and theatrical approaches that aid design in a playful way are the keys to trying out and evaluating concepts. Prof. Flemisch also stressed the need for agreement over terms and development of mental models that are shared across disciplines. Coming to consensus is clearly important to the design process, yet how consensus is reached is unclear. Who decides when an idea is worth further effort or that it's time to move on to something else? Who assigns the roles when conducting a Wizard of Oz exercise, or the theatrical approach? As mentioned above, the process of collaboration between designers and users need further definition.

NATO's Allied Command Transformation interact with a wide range of people on a myriad of requirements and issues. One of the methods used for developing responses to these requirements is the Imagination Center. Mr. Da Deppo's presentation discussed the Imagination Center. The center brings together experts from different disciplines to work collaboratively and solve problems for the future. The Imagination Center demonstrates NATO's willingness to try new ideas and consider the opinions of a wide range of experts; it is an open forum for experts to work collaboratively together. Mr. Da Deppo's talk raised questions about the nature of collaboration between individuals and the methods used to arrive at optimal solutions. Although there has been considerable research on collaboration, most of it lacks consideration on how chat, social networks, and teleconferencing foster or impede it. Are the dynamics of collaboration different in those mediums compared to face to face communication? The concept of developing trust between experts was raised as a factor that could contribute to better collaborations, resulting in better solutions. At the US Army Research Institute, an experiment was performed about ten years ago with colleagues at Defense R&D Canada that compared the performance of two groups of two-person teams. In one group, the team members were geographically separated (one team member in Orlando, one in Toronto) and in the other group, both team members were co-located in the same room in Orlando. For both groups, the teammates were immersed in a shared virtual environment and asked to perform tasks that required team work and coordination. An After Actions Report

(AAR) followed each scenario either over the phone for the distant teammates or in person for the co-located. The co-located teams consistently performed better after the first scenario, most likely due to the fact that they were able to interact freely along multiple dimensions, which fostered greater trust between the teammates and led to better team work. Understanding how trust plays a role in collaboration is a goal of future research.

5.0 DISTRIBUTED NETWORKS: OPPORTUNITIES AND POTENTIAL PROBLEMS

Chris Dibona's keynote address discussed the pros and cons of using the internet for telesystems for government purposes. His warning was clear that under stress, Governments will manipulate use of the internet for their own ends. He also discussed the availability of information and data that can do harm on the internet. Mr. DiBona raised the serious concern that there are no adequate ways to control information that shouldn't be readily available to those who could use it for no good. On the other hand, a number of the positive capabilities the internet offers were also raised, for example, the technologies that Google can deploy on the internet to help in times of emergency.

Dr. Burov and Mr. DiBona had similar messages. Both presentations discussed how society will need to operate in the information age and what are the advantages and disadvantages.

6.0 CONCLUSIONS

The symposium set out to explore the impact of new technologies and processes on the ability to work in a time efficient manner and collaborate effectively with others at distant locations. The ability of apprentice performers with limited knowledge of specific systems to reach back for assistance from a centrally located expert is an example of the efficient use of technology.

Examples of how this could work in both telemedicine and telemaintenance were presented. The capabilities of smart phones and tablets make this model of performing work applicable to many other fields as well. There are implications of this model beyond the technology that could easily be lost, thus careful consideration will have to be given to personnel and training policies to ensure that a sufficient supply of experts are available and that the technicians have a path for advancement and further training.

Examples were presented of tools that allow a therapist or other health care provider to keep track of and offer help to a number of dispersed individuals. Examples of how this could work in telemedicine with regard to behavioral therapy were shown. As were keeping track of and assessing the condition of patients. With these tools, one therapist or healthcare provider would have available the information needed to make informed decisions and help many patients. Today's research is just beginning to scratch the surface of the potential of these tools.

A third symposium theme discussed processes developed and implemented which foster system design through collaboration between system users and designers. In general, these methods would allow experts from different fields to effectively and efficiently work together to solve problems. Using teams of experts with different backgrounds is not a new idea, but having a structure that fosters collaboration is an important contribution. Expertise isn't the only criterion for being part of the process; intuition and creativity are equally important.

In order to work beyond time and space, there are a number of research issues that were repeatedly raised. The methods and tools necessary for effective collaboration was a central theme. The dynamics of collaboration between individuals could be very different depending on the skills of the individuals and the means they have to communicate. The capabilities and expertise of the collaborators, the medium of communication, and the goals of the collaboration can all be important factors.

Use of digital networks requires clear communication between the parties. Agreement on the meaning of terms is critical to developing a common understanding between collaborators and an ability to locate information and knowledge within databases. Given the rapid growth of information and knowledge, research is needed to determine optimal ways to develop shared understanding or mental models.

The need for multi-disciplinary collaboration was frequently mentioned. A user's perspective should influence a designer's concepts, and experts from multiple fields can contribute to solving multi-dimensional problems. How should the process of interaction between designer and user be controlled? The role of trust and other social interactions in fostering collaboration are also important research topics.

The ambiguous title "Beyond Time and Space" provided an opportunity to bring together ideas that may, on their surface, seem unrelated. The range of papers presented at the symposium identified areas for further study by NATO, such as the dynamics of collaboration in the digital age, developing better understanding of building consensus in semantics and mental models.