IDENTIFYING AND ADDRESSING ISSUES IN COALITION NETWORK CENTRIC OPERATIONS USING DISTRIBUTED SIMULATION

Martin R. Stytz, Ph.D.
Institute for Defense Analyses
Calculated Insight
Washington, DC
(407) 497-4407, (703) 338-2997
mstytz@att.net

Sheila B. Banks, Ph.D.
Calculated Insight

Orlando, Fl 32828
(407) 353-0566
sbanks@calculated-insight.com

ABSTRACT

The nature of warfare has been dramatically altered. In the past, "traditional" armed conflict was characterized by large forces on both sides, whose behaviour was driven largely by doctrine developed over relatively long periods of time. However, the pace of change in all aspects of life, especially technology, continues to accelerate and the pace of change makes it exceedingly difficult to exploit technologies to their fullest, which is especially important given the changing philosophy for military operations. Current military operations are often small scale, asymmetric conflicts and operations other than war. The important features in the current operational environment are the lack of doctrine describing adversarial behaviour, doctrine for guiding allied behaviour, and doctrine for exploiting new technologies. In this environment, the understanding of small team and group behaviour, advantageous use of technologies, and the need for more realistic and complete behaviour models is increasing critical. These three capabilities can address a variety of military operational needs, including commander decision aids, mission rehearsal and analysis of non-traditional operational missions, as well as the development of synthetic agents for virtual simulation and training environments for individuals, small teams, and groups of military operators. To support the research, development, and validation of the necessary models to make these desired capabilities a reality, a multi-national effort aimed at acquiring an improved understanding of human behaviour and the sharing of the modelling results across nations is required. A virtual institute is one possible and clearly reasonable option to pursue for addressing the problems associated with developing an increased number of higher fidelity human behavior models for a variety of military operational and simulation uses. The development of a virtual institute for research in human behaviour representation will enable the multi-national cooperation necessary for modelling human behaviour needed to address the three issues outlined above. In this paper, we examine the impact that the change in warfare paradigms must have on the world of simulation. We focus particularly on the impact that this change must have on computer-generated actors as well as the new demands that will be placed upon them, both in the portrayal of friendly and enemy combatant forces and in the use of new technologies. Clearly, these solutions will build upon much work performed before, but work performed in isolation and without an international component. The solutions that must be developed will draw upon this prior experience as well as results in the fields of human behavior modeling, cultural modeling, modeling of adversarial decision making, and modeling of operations other than war. The virtual institute is a capability that can be exploited to insure that the US and its coalition partners correctly model friendly small units and enemy activity within network-centric oriented simulations used for a variety of purposes ranging from training to acquisition.

1. INTRODUCTION[1]

The US military is in the midst of a massive change in the philosophy, approach, and technologies used for warfare by virtue of its adoption of a network centric approach to warfare. In this approach to warfare, information technologies are exploited to the maximum extent in order to increase the effectiveness and efficiency of all military operations. To leverage information technologies to the desired degree requires that information move from sensors to operators as well as between all humans involved in all aspects of military operations with unprecedented speed, accuracy, and security so that the information is both trustworthy and arrives wherever it is needed when it is needed. Simply achieving the required velocity, veracity, and security for information within a national joint operations network in order to attain a network centric

[1] The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of Defense or the US Government.

operational capability poses a number of technical challenges. The challenges include providing sufficient bandwidth to meet the additional communication burden, securing information, and routing the information in a timely manner between information producers and consumers. In a coalition environment, the impediments to achieving network centric operational capabilities are magnified and the impediments to network centricity are increased by individual national information releasability policies, technology differences, and cultural differences; all of which combine to reduce the velocity of information through the coalition's information grid.

In a coalition network centric operation, releasibility policies pose multiple challenges to the network centric operational environment. These challenges include releasibility restrictions that are not uniform across the coalition and vary from partner to partner and indeed vary based upon the partners that are communicating. Also, even information that can be released to a coalition partner may have additional restrictions that limit the coalition partner's individuals and organizations that can access the information. A more daunting challenge than releasibility restrictions arises from differences in technology between coalition partners that affect information exchange. The technology differences are due to a number of factors, including differences in allocation of communication spectrum, differences in communication devices, and differences in data distribution. In addition, and as a compounding factor, some coalition partners may produce information that has been better protected than other partners due to the information assurance policies and practices employed by the different coalition members. Hence, not only is there a substantial technical challenge that must be overcome when data flows from partner to partner, but its trustworthiness and risk of compromise changes as is moves from partner to partner as well. However, in our opinion, the greatest challenge that must be addressed in coalition network centric operations arises from cultural differences between the coalition partners.

Cultural differences give rise to challenges because, even if data is preserved, intact, trustworthy, and accessable to all partners, the differences in culture lead to differing interpretations of the data. These different interpretations can result in actions by the coalition partners that are not mutually supporting and hence undercut the network centric warfare paradigm. Therefore, in addition to insuring that data can move between partners in accordance with their policies, be accessable, remain secure, be trustworthy, and arrive in a timely manner within their own national network; the data presentation at each coalition partner must be customized and structured so that each coalition partner has an identical view of the battlespace. If this state for data exchange between coalition partners is not achieved, network centric operations among coalition partners will be difficult to conduct and the effectiveness of the coalition will be reduced. In our opinion, coalition data interchange issues are of such an important nature that they must be comprehensively addressed before the onset of operations. A distributed simulation environment, coupled with associated analyses and collaboration tools, is the best environment available to conduct the experiments and exercises needed to address coalition network centric operations and data interchange challenges. Our task is to define in more detail the policy, technical, and cultural challenges that must be addressed in order to enable coalition network centric operations. This paper describes our progress in addressing these challenges to date.

The remainder of this paper is organized as follows. Section Two presents a brief discussion of previous research that can be leveraged to address the research problem. Section Three presents a discussion of the requirements, parameters, and scope of the solutions to the policy, technological, and cultural challenges that are raised by coalition network centric operations and of the manner in which a virtual institute can be employed to address these issues. Section Four contains a brief summary of the paper and our suggestions for further research.

2. BACKGROUND: RESEARCH FOUNDATION AND OPERATIONAL CONCEPT FOR THE VIRTUAL INSTITUTE

Our approach to addressing the issues raised by coalition network centric operational issues involves the use of a virtual institute as the experimental testbed. A virtual institute is a distributed computing environment (that may include distributed virtual environments) used for hosting experiments, exercises, lectures, workshops, symposia and collaborations. The virtual institute can also be used for model development and sharing; for training; to aid in re-use of models and information; and to permit exploration of solutions to operational problems at a lower cost than is possible in the real world due to the difficulties inherent in operating and collaborating in real-life. The virtual institute concept was not developed in isolation or in a short period of time; instead, it was developed over several years as part of an international collaboration. The virtual institute concept was developed as part of a NATO activity, an Exploratory Team. tasked with

identifying technologies that could be used to economically address NATO research and interoperability issues. Exploratory Teams (ET) are established by the NATO Research and Technology Organization (RTO) when a RTO panel believes that a particular expertise is required to assist or advise that panel on the technical merit or feasibility of a specific proposal of a technical activity. To research the technical merit of using a virtual institute within NATO, an exploratory team (SAS-ET.V) was formed by the RTO Studies, Analysis, and Simulation (SAS) panel.

The topic and focus of the SAS-ET.V was derived from a previous NATO Long Term Scientific Study (LTSS/51) sponsored by the SAS panel. The purpose of an LTSS is to provide a report for use by NATO and the national authorities on the implications of technological developments to military operations over the next ten to fifteen years and to provide research planners with recommendations for research that can address/investigate the implications of projected technological developments. The recommendations presented by a LTSS identify the technology or technologies needed for a specific military task and the potential for development of the required technologies in the future. Of particular interest to our research, and addressed initially in the context of LTSS/51, was the highest priority recommendation to establish a NATO RTO exploratory team to investigate the feasibility and utility of assembling a virtual institute. Specifically, if implemented, the virtual institute was to be established for the purpose of modeling military-related individuals, teams, groups, platforms, and organizations in their performance of military operations and tasks. The virtual institute exploratory team's work included assessing the utility of a web-based clearing house of databases, models and model components, and developing modeling standards, and requirements to support multi-national research on human behavior modeling. The results of the work by LTSS/51 and its recommendation was presented to and approved by the SAS panel, which in turn established SAS-ET.V.

The objective of SAS-ET.V was two-fold. Firstly, SAS-ET.V was to advise the SAS panel and, through cooperation with other RTO panels, the RTO on the technical merit and feasibility of establishing a virtual institute within NATO. Secondly, the SAS-ET.V was to advise the SAS panel and the RTO on the feasibility of enabling multi-national research and development in human behavior modeling by using the virtual institute concept. The primary mechanism for presenting the assessments of these twin objectives to the SAS panel was an advisory report addressing the HBR virtual institute concept, its development, its implementation, and potential uses.

As envisioned by the exploratory team, the institute conducts multi-national research to address human behavior modeling needs within NATO. To retain maximum flexibility for experimental purposes while also insuring that research is focused on NATO needs and priorities, SAS-ET.V devised an organizational structure for the virtual institute. The backbone of the organizational structure of the virtual institute is provided by a relatively stable administrative component comprised of permanent NATO staff; whereas, the organizational structure and administration for specific purposes (experiment, exercise, workshop, symposia, tutorial, etc.) along with the specific country participants for the purpose would vary with each tasking. This concept for operations and the need for a flexible, fluid, dynamic organizational structure organization led to the organizational structure depicted in Figure 1.

The institute's organizational structure was designed so that each major component, or division, of the structure would correspond to a major area of research in HBR or to the institute's current support for a major exercise or activity. For example, one major area of human behavior representation research is organizational modeling, therefore the institute has a research division dedicated to HBR organizational research and within the division are found researchers from the nations that have interest in this research topic. Another major area of HBR research is cultural modeling, so the institute has a division dedicated to cultural modeling. When the institute is asked or tasked to provide support to a large activity, the institute would create a division dedicated to the support of the activity, the members of the division would be the HBR participants in the activity from the various nations involved in the activity. As currently envisioned, the research and activity support divisions of the institute would vary over time; their membership can change as necessary and divisions can be dissolved or formed as necessary. There would be four permanent components of the institute; the technical organization, administration, multinational control board, and the Virtual Institute operational executive. The technical organization would provide ongoing support to maintain the computer and database infrastructure for the institute as well as provide support for web access to institute resources. The administration component would support the control board and operational executive as well as provide administrative assistance to the divisions in the institute. The operational executive would provide oversight for the institute, set overall

research direction, establish policy, determine which exercises the institute would support, allocate institute resources, and handle all other day-to-day activities for the institute. The control board exists to provide multinational oversight to the activities of the operational executive as well as to provide broad guidance for institute activities.

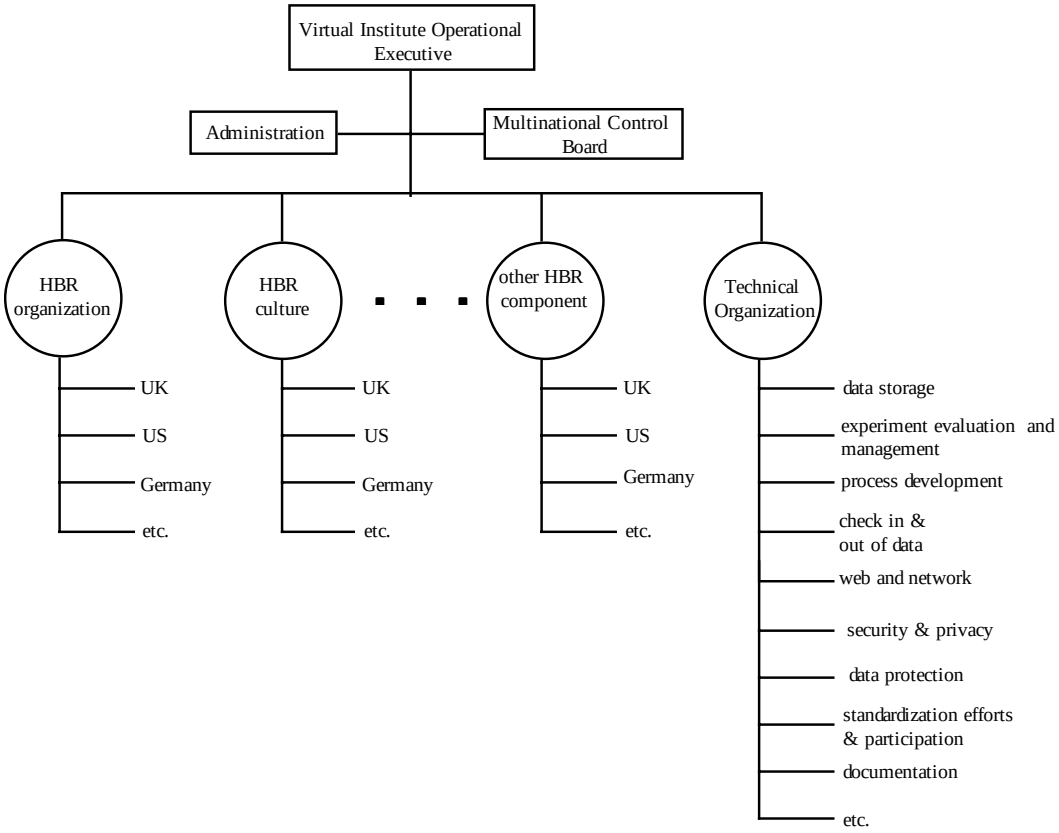

Figure 1: Virtual Institute Structure and Organization

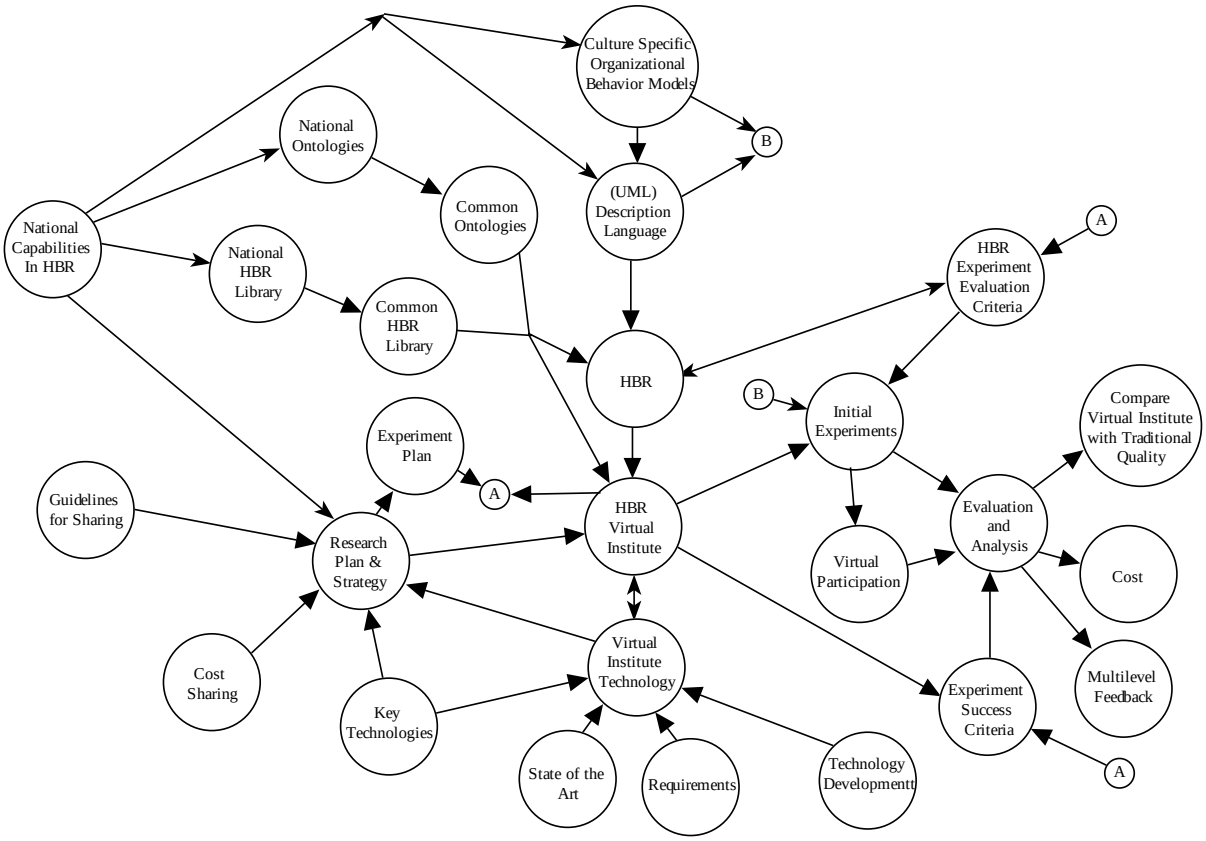

Figure 2: HBR Virtual Institute Research Activity Process Flow

To maximize the effectiveness of the virtual institute organization and insure that all worthy concepts for using the virtual institute would be considered, the exploratory team developed an initial process for formulating, assessing, conducting, and evaluating the results of virtual institute activities. The operational concept for the virtual institute is based upon a four-phase approach to using the institute, as shown in Figure 2. The first phase consists of defining/specifying the experiment, identifying any supporting/enabling technologies, identification/solicitation of participating nations, and developing a research plan. The second phase consists of steps designed to integrate the activity into the virtual institute and its resources, determining the required outcomes for the activity, and assessing the activity in relation to the state of the art to determine the value of the activity and insure that it is a worthwhile use of virtual institute resources. The third phase consists of prototype execution of the proposed activity and assessment of the criteria for success of the activity. The fourth phase consists of execution of the activity and assessment of the results.

The recommendations of the exploratory team were accepted by NATO and a research task group (RTG) was formed by the SAS panel. The RTG, SAS-053, is tasked to finalize the operational concept for the institute, to deliver a prototype-quality virtual institute capability, and to involve the virtual institute in experiments and exercises in order to be able to assess the utility of the virtual institute concept and inform NATO about the desirability of continuing work in this direction. Based upon results to date, current plans are for NATO to incorporate the virtual institute as part of the NATO organization, probably within RTO, in the 2007 timeframe.

3. USING THE VIRTUAL INSTITUTE TO ADDRESS NETWORK CENTRIC ISSUES

Based upon the research and the knowledge to be gleaned from the limited multi-national coalition experiments performed to date, some issues to be considered when simulating coalition network centric warfare (NCW) and network centric operations are evident. As the foundation for our argument for broadened and frequent multi-national experiments lies the insight that there is more to technological surprise than the mere invention of a new technology. To achieve technological surprise also requires the effective employment of the new technology in appropriate

circumstances. It is in this second, employment phase that the virtual institute can play a major role in enabling more effective coalition operations. Fundamentally, distributed simulations need to be used to go far beyond current theory and identify the key technical and cultural issues that must be addressed if NCW is to work for the US and is to work in a coalition. The virtual institute can aid in this effort. The following discussion presents a few of the areas of investigation for network centric operations that the virtual institute can be used to address. While space does not permit us to discuss all of the uses of the institute, we hope that the discussion highlights the flexibility of the institute and its inherent capability for addressing a wide variety of network-centric issues.

3.1 Cultural Issues

Clearly, one of the key differences in how each nation will employ network-centric operational capabilities arises from their national culture and experiences. Therefore, as a preparatory activity to understanding the network centric issues that must be addressed in a coalition operation, background experimentation must be undertaken to determine differences between US and coalition member military cultures and national cultures. These differences must then be encoded in a knowledge base that is used to control the operation of the computer generated actors and operational milieu for the environment. This set of preliminary experiments would also help to address the problem of socialization and trust development between coalition members. Trust development and socialization are important aspects of successful coalition operations, but are also very difficult to achieve. A coalition may work very hard to cooperate but there are still culture differences to overcome and there are also misunderstandings due to word usage and custom. The virtual institute can be used to address these issues in a repeatable manner that also permits improvements in the process and widespread re-use of effective techniques.

The current data indicate that socialization between coalition members (simply put, getting to know and understand each other) is crucial to coalition success. Based upon experience and the limited research performed to date, socialization between coalition members is difficult and time consuming to achieve. Currently, socialization is accomplished by conducting joint exercises in the real-world and participating in joint training at various times in a military career and occurs as a result of many conversations that, in bulk, permit a degree of confidence and trust to be built among coalition partners as well as permit development of an understanding of other cultures. Because coalition partners will vary, current socialization approaches do not scale to operate effectively within a short time period. Therefore, simulation environments within the virtual institute must portray the behavior of potential coalition allies with a sufficient degree of fidelity so that socialization and accommodation as well as a degree of mutual understanding can be achieved via simulation environment experiences. However, this problem is a difficult one because there are not only cultural differences to be overcome but also misunderstandings due to word usage and customs. Unfortunately, it is not clear which knowledge about other cultures is most crucial to an operation or to an effective coalition action. Experimentation within the virtual institute should help to answer these questions. We believe that, when accompanied by proper analysis, simulation exercises among coalition potential partners on a regular basis within the virtual institute would accelerate the socialization process.

An additional complicating factor in coalition network centric operations is that the different cultures involved in an operation implies that each coalition member evaluates information about the battlespace in a different manner. As a result, technologies are needed to insure that coalition members have a common mental model of the battlespace across cultures. At this time, limited multi-national simulation experience indicates that different cultures/militaries use different information to make decisions when faced with the same situation. However, each nation and culture purports to make use of identical information in its decision making process. Addressing this seeming contradiction by using the virtual institute will allow us to determine the priority for the information that has to flow into each coalition partner from all other partners in order to insure that congruent decisions are made when presented with a common situation. The virtual institute can be used to aid in developing operational procedures and policies that account for the fact of the differences and thereby make allowances for them. Additionally, the NCW field requires investigation into the factors that influence cross-cultural development of a common understanding of the battlespace and of the actions to be performed within it, which is another area of research that the virtual institute can support.

3.2 Cybersecurity Issues

The virtual institute can serve several purposes in the area of information assurance and cybersecurity for coalitions. We have identified a few areas, which we will briefly describe here. For example, in support of the twin issues of trust establishment and coalition member socialization, the virtual institute can be used to help coalition members to rapidly arrive at a common understanding of the coalition members' and coalition's information security capabilities, information security operations capabilities, and NCW capabilities. In addition, coupled with these needs is the need for automated techniques to test coalition partners' key information technology interfaces for their security and data interoperability and security properties; these tests will serve to give each partner confidence in the ability of other coalition partners ability to protect data and to provide data that is accurate and uncorrupted. Furthermore, to enable proper operation between coalition partners, they must be able to achieve synchronization on information speed/velocity between coalition members because each force has its own natural operations tempo and natural information velocity within its national information technology infrastructure. The virtual institute can aid in these efforts because it can present coalition members with standard sets of scenarios designed to elicit the needed information in a cultural-neutral manner.

Another important issue related to cybersecurity and information exchange between coalition partners that can be addressed within the virtual institute is an issue that arises after the coalition members have achieved a high degree of operational integration and coordination. As the coalition partners increase their degree of operational effectiveness, their reliance upon network resources to retain this high degree of operational effectiveness increases. However, this degree of coalition operational effectiveness can be degraded if the network is attacked and, subsequently, confidence in NCW resources and capabilities starts to decrease. The degradation can pose a problem for coalition NCW operations. We can use the virtual institute to determine how different cultures respond to this circumstance and, thereby, prepare procedures for it and develop doctrine to allow coalition partners to deal with this eventuality. In addition, in the virtual institute we can also determine if/when the network connectivity should be terminated and the likely operational and psychological effect of doing so.

3.3 Information Movement and Battlespace Understanding

Another way in which the virtual institute can be of help in improving coalition network centric operations is to aid in identifying technologies and procedures that are needed to insure that coalition members have a common, coherent mental model of the battlespace. The virtual institute can be used to investigate the cultural factors that influence the formation of a common (or at least congruent) operational picture of the battlespace and how those factors vary across cultures. At this point in time, another useful employment of the virtual institute would be to use it to identify the key technical and cultural issues that must be addressed if NCW is to succeed for the US and its coalition partners. The experiments must identify the type of communication ability that is needed in terms of bandwidth, security, redundancy, flexibility, and content. The experiments must also determine how to conduct rapid, flexible, and fluid multinational operations while also securely exchanging data among the coalition and preserving each nation's NCW capabilities and information technology infrastructure.

Another issue that can be addressed using the virtual institute is for the acquisition of information between different military cultures and command structures. Currently, it is not clear how to insure that information flow and exchange activities can be structured so that all parties that need the information receive it in a timely manner and that crucial information receives the priority and the attention that it deserves when being transferred to a coalition partner. Activities within the virtual institute can be used to achieve a common understanding of coalition members' information operations capabilities, information security capabilities, information security operations capabilities, NCW capabilities, and information technology maturity. Proper prioritization will insure that each partner has the right information that the partner needs at the right time in order to act upon the information at hand in a way that is consistent with their culture and decision-making style.

Another issue that can be investigated within a virtual institute environment is the impedance mismatch between the velocity of information flow among and between coalition partners. Currently, this issue arises because the various coalition partners have different information technology capabilities, different capabilities for sharing information among their own national forces, and different capabilities and policies for information

interchange with coalition partners. Each coalition partner has its own natural operations tempo and natural information velocity within its national information technology infrastructure. As a result, within a network-centric operational environment there is no one simple solution for information interchange among coalition partners that will allow them to synchronize their information flows and equally exploit all available information. Instead, each coalition partner will have to be presented with a customized set of information at its own pace from its partners. This customized set allows each of the partners to form as nearly an identical common operational picture as possible given the technology and interchange limitations but also insures that important information reaches all coalition partners rapidly and with proper emphasis. The magnitude of the problem is increased because all of these adaptations must be made in a manner that allows the coalition to maximize the effectiveness and contribution of each partner. Experimentation within a virtual institute to determine the appropriate means for addressing this issue is clearly indicated.

A further issue that can be assessed within the virtual institute is the determination of the number of separate communication channels that are needed within a coalition. This issue arises from the need to support the broad scope and volume of communication between and among coalition partners in a network centric operational environment. The variety of channels would support communication between commanders, between staff elements, and provide other peer-to-peer communication of various priorities among the coalition. However, even the approximate number of channels or rules for determining the required number is unknown. Indeed, the mix of data, voice, and video channels is unknown as are the number of needed unicast and multicast channels required for a given mix of coalition partners and world circumstances. This information can be determined for a variety of circumstances using the virtual institute. A corollary need that has been identified is a need to develop a model for the value of information flows within a coalition that accounts for velocity of information, information half-life, chokepoints on information that arise from policy issues, security differences, command structure differences, NCW capability differences, and the impact of information latency. In this situation as well, the virtual institute can play a role and support activities designed to address these issues.

3.4 Commander Support

A final, but nonetheless, important illustrative use of the virtual institute is to support commanders engaged in operational activities. We believe that the virtual institute can serve a further use during coalition operations by providing a real-time simulation of coalition partners so that the commander of the coalition forces can determine if plans and intent are clear. The correct execution of the simulated plan within the virtual institute would demonstrate that cultural and language barriers have been overcome and that the plans, orders, and intent are clear in regards to each coalition member's culture. Simply stated, if the result of the simulation matches the desired plan outcome and the commander's intent, then the corresponding orders can be issued since the commander would know that the order is culturally clear. This approach can also be used to compare the unfolding of real-world operations to the simulated execution of the plan to determine if there is a plan or cultural communication failure. We do not claim that this list of activities that can be conducted by the virtual institute in support of coalition network centric operations is exhaustive, but it should serve to illustrate the breadth of activities that can be supported and the value of a virtual institute for the investigation of coalition network centric operational issues.

4. SUMMARY

Coalition network-centric operations are a crucial component of future military operations but their success and efficiency is by no means guaranteed. We believe that a virtual institute and its attendant capabilities, as outlined in this paper, are a powerful technique for assuring success. As we have seen, the challenges of coalition operations that the virtual institute can address arise from a number of sources, including differences in equipment, differences in training, differences in culture, and differences in tactics. In the light of the commitment made by the US to achieving a network-centric operational capability coupled with the increasing frequency of coalition operations, the need to understand and manage the effect of cultural differences on coalition operations is increasingly important. While the solution(s) to the challenges posed by cultural differences among coalition partners are not yet evident, the scope and breadth of the challenges need to be clarified and explored. The virtual institute offers an ideal vehicle for performing these tasks within a multi-national setting. In this

paper we have examined some of the coalition NCW issues that can be addressed using the virtual institute in order to achieve effective and efficient coalition operations. Clearly, the virtual institute has the potential to permit the exploration of the spectrum of alternatives and factors, both human and cultural, that affect command and control, operations, intelligence, logistics, and the remainder of the entire, complex mileau of coalition military operations. In order to come to grips with the broad scope of issues to be addressed, it is clear that the time has come to conduct regular experiments with likely coalition partners and start the process of identifying and resolving the issues that regular, broad coalition level distributed simulations will uncover. The virtual institute offers an effective means for identifying and addressing issues that arise during coalition network centric operations.

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