Multinational Information Sharing and Collaborative Planning Limited Objective Experiments

C2 Experimentation

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Abstract

This paper describes Multinational Collaboration and Information Sharing Limited Objective Experiment (LOEs) that examine multinational aspects of joint command and control concepts at the US Joint Forces Command (USJFCOM). LOEs are designed to be both exploratory and structured, so there is an element of discovery that is extremely useful. LOEs also examine assertions made by joint concepts.

The LOE was completed in November 2001 and focused on collaborative planning with multinational partners planning a rapid decisive operation when planning time is short. The LOE compared courses of action (COAs) developed using traditional planning with COAs developed using integrated planning. Australia, Germany, United Kingdom, and United States formed traditional and integrated planning staffs, which were formed into independent planning teams linked through a secure global network. The two planning teams were presented with identical situations and background information, and using identical collaboration software asked to develop COAs in the allotted time.

Senior subject matter experts from participating nations evaluated COAs for suitability, completeness, and accuracy to determine which process, traditional or integrated, produced a superior plan when planning time was short. Evaluations were blind since evaluators knew neither the process used nor the lead nation.

Introduction

This paper presents an experimentation method the U.S. Joint Forces Command Joint Futures Laboratory (JFL) in Suffolk, Virginia, is using to conduct Multinational Information Sharing and Collaboration Limited Objective Experiments (LOEs) over the next three years. The focus of the paper is on the first LOE, which examined distributed multinational collaboration.

The Multinational Information Sharing and Collaborative Planning LOE series is the first JFL initiative with multinational partners and is intended to define and refine the multinational aspects of the Knowledge and Command & Control (C2) elements of the Rapid Decisive Operations (RDO) concept in the 2010-2020 timeframe. As the name implies, these LOEs explore information sharing and collaboration during RDO with coalition partners, albeit in a limited venue. Information sharing and collaboration are key enablers of the Knowledge and C2 elements, which are prerequisites for the third RDO element, Operations, as shown in figure 1.

Multinational LOEs are designed to be both discovery events and structured experiments. Since LOEs are in one sense pilot efforts for the larger more complex events that follow, there is an element of discovery, which can be both positive or negative but extremely useful regardless. It is far better to discover flaws in a small venue when corrections are easier rather than a large public event where correction is difficult if not impossible. In other words, the LOE is a very useful risk mitigation instrument for the major field

experiments. Reduced resource requirements when compared to the larger experiments and greater scientific control with fewer degrees of freedom also make LOEs attractive. The Multinational LOEs are also structured to assess capabilities. Data collection and proper measures quantify the value of information sharing and collaboration under different conditions.

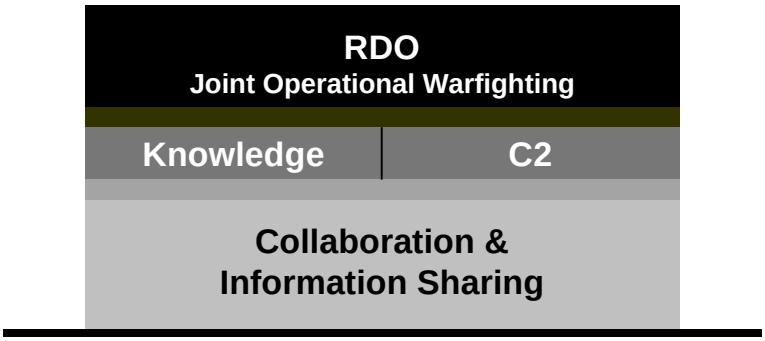


Figure 1. RDO Enablers: Information Sharing and Collaboration

RDO and the Operational Net Assessment

A critical product in planning RDO is the Operational Net Assessment (ONA) that provides the essential foundation for effects-based operations. ONA is a continuously updated analysis of adversary capabilities focused on the effect of a limited number of coalition courses of action (COAs). It is supported by all coalition collection assets and analytical expertise and addresses not only the adversary's war fighting ability, but also the strategic and operational context that supports it. Examining political, military, economic, social, and infrastructure (PMESI) systems and their interactions is the start to understanding how best to execute RDO.

The analysis and subsequent understanding of the nature, structure, and vulnerabilities of adversarial elements identify the critical nodes and centers of gravity in the adversary's "system of systems." ONA is dynamically updated to support an ongoing planning process for each selected contingency. ONA utility extends from peacetime interaction with potential adversaries through the conduct of rapid decisive military operations. Given the level of understanding provided by the ONA, RDO planners, assisted by decision support tools, can identify appropriate "defeat mechanisms," the body and sequence of means to upset the adversary's coherency, and coerce him to actions that are favorable to national and coalition interests. The objective is to provide the decision makers with a current analysis of the adversary's capabilities and vulnerabilities, as well as an array of effects-based options that can be applied to adversary courses of action as they are identified.

The RDO concept, including ONA, is enabled by two knowledge and C2 concepts: Collaborative Information Environment (CIE) and the Standing Joint Force Headquarters

(SJFHQ). CIE provides shared awareness and enables concurrent collaborative planning using decision support tools. SJFHQ allows the commander to tailor his command and control organization to best respond to the situation. The Multinational LOEs address both supporting concepts.

The first Multinational LOE focused on CIE by comparing the "integrated" planning process embodied in CIE with a more "traditional" planning process. CIE asserts that integrated planning produces a product in less time that is superior to the product produced by traditional planning when planning times are short. To represent traditional planning, the Multinational LOE used a planning process adapted from the "Lead Nation Concept in Coalition Operations" prepared by the Doctrine, Plans and Procedures Multinational Interoperability Working Group (MIWG) of the Multinational Interoperability Council (MIC).

RDO ONA and Lead Nation processes are too large and complex to examine during a LOE, so a comparison of appropriate subsets of both planning processes was the object of the LOE. Therefore, the first Multinational LOE concentrated on developing a COA in response to a developing regional situation.

Multinational LOE Framework

The Multinational LOE used a series of operational vignettes to compare Lead Nation traditional planning with CIE integrated planning. Each participating nation formed two planning staffs, one traditional and one integrated. During each vignette, the traditional staffs formed a virtual traditional planning team, and the integrated staffs formed an integrated planning team. Each team was required to develop a COA within the allotted time in response to a developing situation. The COAs were the basis for post-LOE analysis. In other words, the products determined the superior process. The two planning processes are depicted in figure 2.

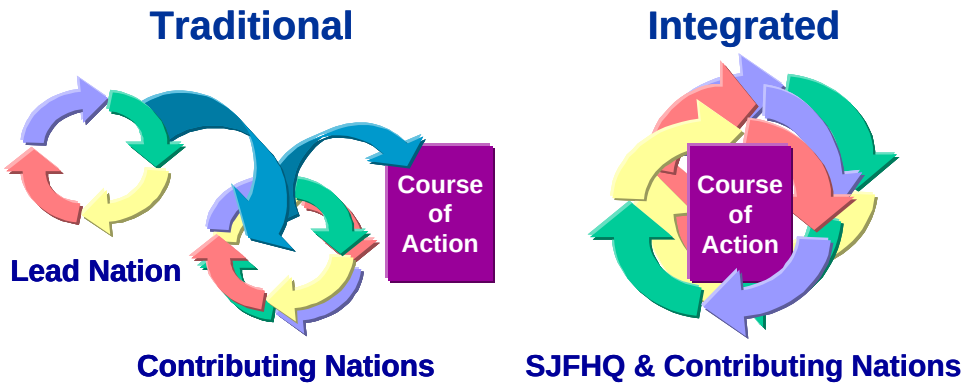


Figure 2. Multinational LOE Planning Processes

Under the Lead Nation planning process, one national staff was designated as the lead nation and responsible for establishing the C2 architecture and knowledge management procedures for developing the initial COA. The contributing national staffs iteratively reviewed and commented on the plan prepared under lead nation direction. The lead nation staff finalized the plan based on coalition nations staff inputs and comments.

Under the integrated process, one national staff was designated as the Standing Joint Force Headquarters (SJFHQ) and led the development of a COA through continuous interaction.

All operational vignettes were based on the same scenario, which was distributed to all participants prior to start of the LOE. Scenario supporting information, which included ONA items, was also provided to the participants. The scenario was not classified to keep the LOE administrative burden low. Participants were permitted to supplement the provided information with open source information obtained from the World Wide Web (WWW) during the vignettes. For this LOE, open source information was defined as information available through legal and ethical means, available to anyone, and not classified.

The Multinational LOE represented on a small scale and uncomplicated way the connectivity, information sharing, and collaboration mechanisms needed to conduct an ONA during RDO in the 2015 timeframe. The LOE focused on procedures that could enable coalition participation in an ONA. The Multinational LOE assumed virtual private workspaces where unique encryption and peer-to-peer communication and computation were commonplace.

Geographically dispersed nodes were connected through gateways to a wide area network (WAN) for the first Multinational LOE. Each node also had a local area network (LAN) linking workstations at staff positions. The first Multinational LOE used the Combined Federated Battle Laboratory Network (CFBLNet), a WAN dedicated to supporting year-round experimentation involving the combined research labs of CFBL[1] members. The U.S. node, which included the U.S. staff and the main element of the LOE Control Cell, was located at the U.S. Joint Forces Command Joint Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) Battle Center (JBC) in Suffolk, Virginia. Other participating national staffs were located at the following locations:

- Australia – Defence Science & Technology Organisation (DSTO) C3 Research Centre, Fern Hill Park
- Germany – Bundeswehr Operations Command, Potsdam
- United Kingdom – Defence Science & Technology Laboratory, Portsdown West.

[1] NATO through the NATO Consultation, Command and Control Agency (NC3A) and the Combined Communications Electronics Board (CCEB) whose membership includes Australia, New Zealand, Canada, United Kingdom and the United States.

The LOE was managed during execution by a distributed virtual control cell that was linked via the CFBLNet. The main component of the control cell was located at the JBC in Suffolk, Virginia. The control cell had a representative at each nation's participation point. The control cell was responsible for the setup, execution, and data collection. The control cell was also responsible for coordinating with CFBLNet operations staff to resolve network difficulties. Figure 3 depicts the Multinational LOE network topology.

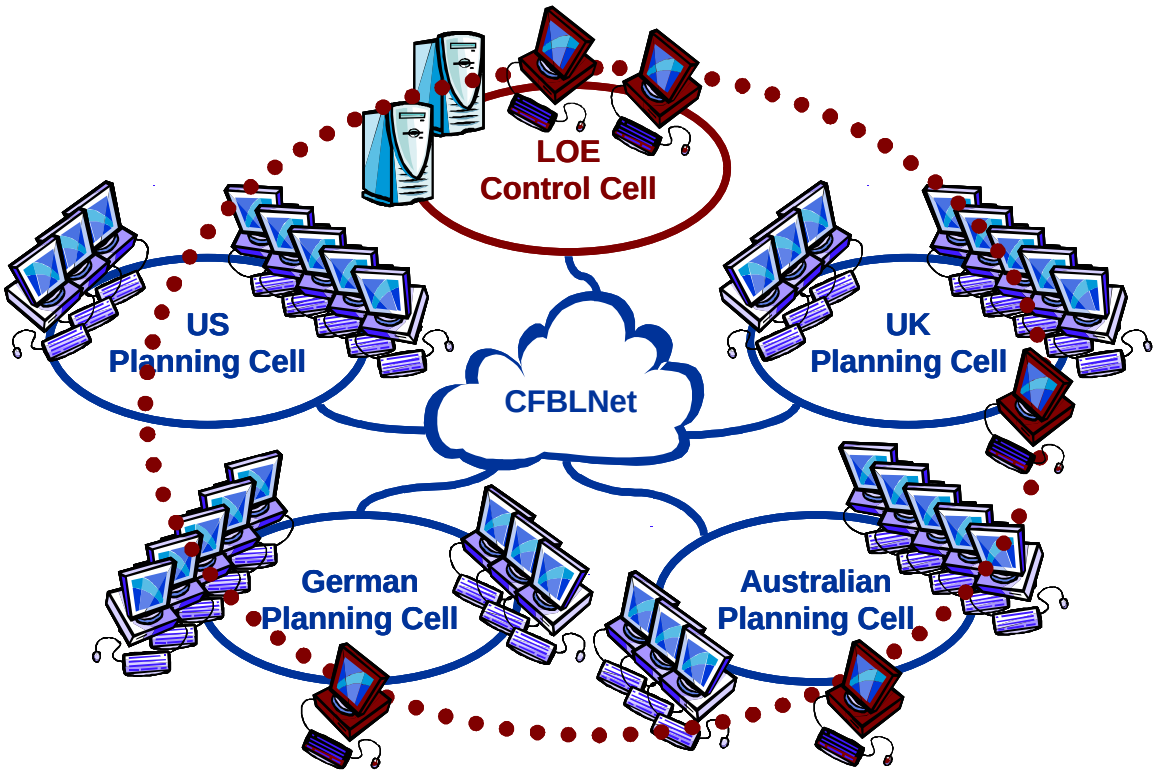


Figure 3. Multinational LOE Operational Topology

Multinational LOE Collaboration Tools

The focus of the first Multinational LOE was on distributed collaboration among the participants. The following functions were available to all participants for collaboration and information sharing:

- File distribution
- Text and voice chat (broadcast and point to point)
- Electronic message distribution
- Interactive notepad and drawing board.

The collaboration environment had to be intuitive and easy to use. The assumption was that LOE participants came from several organizations, had not worked together before, and were not familiar with the concepts being examined. The LOE was about comparing two approaches to developing COAs, not learning a new tool set. There was some

indoctrination and orientation on the collaboration tools prior to the LOE, but more emphasis was placed on familiarization vignettes to permit the participants to become comfortable with concept processes that were used during the LOE. The week prior to the LOE concentrated on tool set familiarization and short work-up vignettes to exercise the participants on the processes used during the LOE.

Commercial-Off-The-Shelf (COTS) products made up the collaboration tool set. The main collaboration tool was Groove, a peer-to-peer (P2P) collaboration tool developed by Groove Networks (www.groove.net). Groove lets users work in protected spaces, known as shared spaces, for sharing information and collaboration. Any change made in a shared space is automatically distributed to all members of the space. Collaboration in the space can be in the form of voice and text chat, threaded discussions, file sharing, sketch boards, outline sharing, and the like. The collaboration can be either synchronous or asynchronous. Changes to the shared spaces, known as "deltas," are distributed to the Groove clients of all members of the shared space in the order in which they were created. This is an attractive feature because causality is preserved in the shared space if the computer clocks are synchronized. Figure 4 is a Groove shared space similar to those used during the LOE.

Multinational LOE Conduct

The Multinational LOE consisted of eight operations-other-than war (OOTW) vignettes conducted over a two-week period where small planning staffs from participating nations formed distributed virtual planning teams and tasked to develop COAs in a relatively short period of time. Each nation had two planning staffs participating in each vignette, one traditional and one integrated. The traditional staffs for the traditional planning team, and the integrated staffs formed the integrated planning team. The traditional team planned based on the Lead Nation concept, and the integrated team used the CIE-SJFHQ concepts. For each vignette, one nation was designated lead nation for the traditional approach, and another nation was designated as the SJFHQ for the integrated approach. Each participating nation was designated lead nation twice during the LOE. The U.S. staff served as the SJFHQ for most of the vignettes since they were previously trained in the integrated approach and other national staffs could "observe" prior to assuming the SJFHQ role. All national staffs were presented with an operational situation disclosure and commander's intent at the beginning of each vignette and tasked to develop a COA. During actual operations, a planning staff would develop several COAs, but to keep the LOE manageable, only one COA is developed by each staff.

The lead nation was required to establish a C2 architecture and information management process to develop a COA in response to the tasking and coordinate national staffs interaction and approval. The lead nation modified the COA as agreed amongst the staffs and submitted the final plan to the LOE control cell. The SJFHQ nation continuously interacts with the other national staffs and develops an agreed COA, which is submitted to the LOE control cell when consensus is reach among the national staffs.

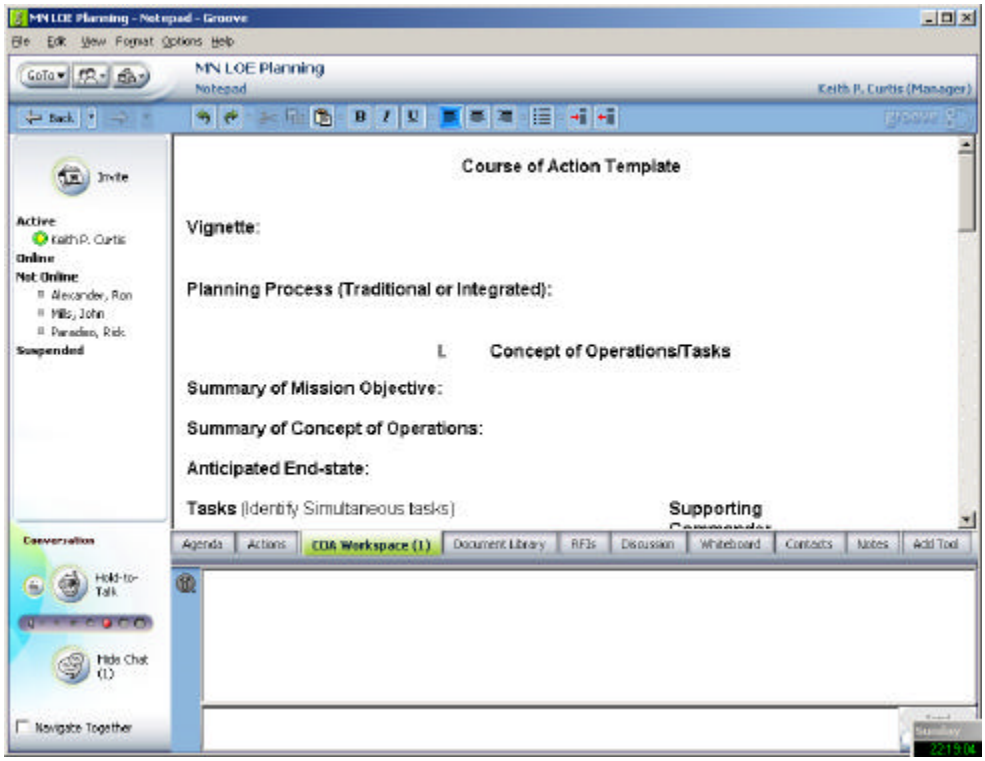


Figure 4. Sample Groove Shared Space

The planning staffs were comprised of individuals with military experience that included operational planning and analysis. A notional staff had a leader, one or two planners, and one or two analysts. The staffs were kept intentionally small to keep personnel resource demands reasonable. When a national staff is the lead nation or SJFHQ, the staff consists of a leader, two planners, and two analysts. When a national staff was a contributor, the staff consisted of a leader, one planner, and one analyst. When a nation was the traditional lead, it was a contributing nation for SJFHQ. When a nation was SJFHQ, it was a contributing nation for Lead Nation. Thus for any vignette, a nation provide eight individuals if they were Lead Nation or SJFHQ and six individuals otherwise.

All national staffs had equal access to collaboration tools, scenario information, and vignette disclosures. During each vignette, the integrated planning team worked in three functional shared spaces: plans, intelligence, and logistics. The traditional national staffs each had separate shared spaces, and the Lead Nation had to decide how information was shared across the traditional spaces.

The control cell used the same collaboration software for coordination as the LOE participants. This simplified the software configuration gave the control cell a private control space for coordination yet permitted the control cell to observe participant collaboration during the vignette. Prior to the start of a vignette, the control cell would create all the shared spaces needed for the vignette, ensure all background and scenario

information was available in the spaces, and verify that all participants had access to the shared spaces. During the vignettes, the control cell distributed scenario events, like intelligence reports, to all participants on both teams by instant text messages so there was no bias towards any team organization.

During the conduct of a vignette, the distributed members of the control cell monitored activity at their location and used the control space to coordinate as necessary, usually by text or voice chat. The CFBLNet operations staff also had access to the control shared space to facilitate coordination when network problems arose. This was important since the Groove software required connectivity to synchronize shared spaces in each Groove client, the collaboration software application that resided on the computer of each participant. Figure 5 shows the Groove shared spaces in use during the LOE.

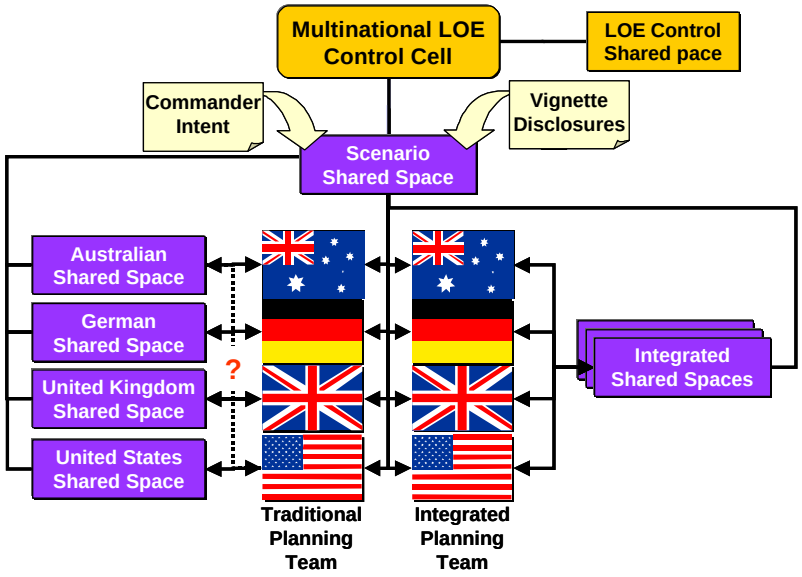
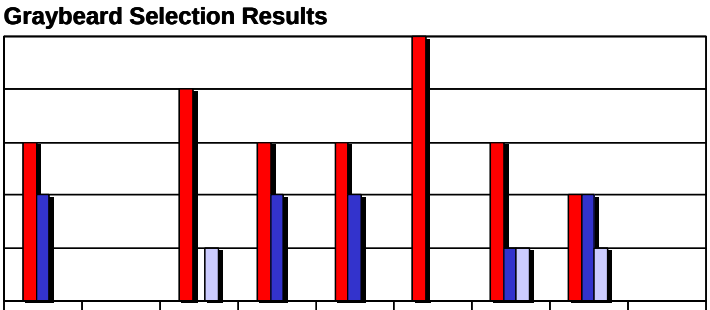


Figure 5. Groove Shared Spaces for Multinational LOE Vignettes

Findings

Senior subject matter experts or "graybeards" from participating nations evaluated the two COAs produced during each vignette using three basic criteria: suitability, completeness, and accuracy. Suitability was determined by comparing the COA to commander intent and the operational situation presented in vignette disclosure. Completeness was determined by establishing how well the COA responded to commander intent and considered information presented in the vignette disclosure. Accuracy was determined by comparing the information contained in the COA with information available to the planning teams. These criteria served as the basis for selecting which process produced a superior plan when the planning time is short.

Upon completion of the LOE, the COAs were packaged along with scenario information, commander intent, and disclosures for each vignette. The graybeards from Australia, Germany, and the United States reviewed the COAs independently using the three criteria. The graybeards did not know what process produced a particular COA nor did they know which nation led the COA development. The graybeard evaluations showed that the integrated process produced a superior plan a majority of the time. The results are presented in figure 6.



Vignette	1st	2nd *	3rd	4th	5th	6th	7th	8th	Total
Integrated	3	-	4	3	3	5	3	2	23
Traditional	2	-	-	2	2	-	1	2	9
No Preference	-	-	1	-	-	-	1	1	3

* Vignette 2 terminated early because of technical problems

Figure 6. Graybeard Evaluation Results

Two vignettes were unanimous in favor of the integrated process. The vote was three to one in one vignette, three to two in three vignettes in favor of the integrated process, and a two to two tie in one vignette. While the results appear to be in overwhelming favor of the integrated process, because of the small sample size, there is only statistical significance in the two unanimous vignettes. The graybeards found the COA quality very close as evidenced by three evaluations classified as “no preference.” A detailed review of the graybeard evaluations revealed no clear trend that explained the selections. The following are factors that merit further investigation:

- The integrated process may be better suited to OOTW
- The integrated team had the advantage of training prior to the LOE and the process remained stable throughout the LOE
- The integrated team was better organized to retain corporate knowledge and take advantage of previous planning efforts.

Collaboration Infrastructure Performance

The CFBLNet permitted the Multinational LOE to be conducted in a distributed global manner, allowing nations to participate “at home” from their own facilities. By taking

advantage of the CFBLNet and the available national facilities, there was considerable saving in travel costs. Having a point of participation (POP) located in each nation also facilitated the availability of national staff to participate in the LOE. Doing the first LOE distributed over a global wide area network was a risk. CFBLNet successfully supporting the Joint Warrior Interoperability Demonstration (JWID) 2001 earlier in the year and substantial technical support available in each participating nation and at critical nodes were risk reducers. Critical nodes included the Defense Information Systems Agency (DISA) Advanced Information Technology Services Joint Program Office (AITS-JPO) and NATO Consultation, Command and Control Agency (NC3A). NC3A was a key node on CFBLNet for the German POP in Potsdam, which did not exist during JWID 2001. The German POP at Potsdam was linked through NC3A to the CFBLNet at RAF Molesworth, UK.

Three stress tests with all POPs were conducted to insure that the use of Groove over CFBLNet for collaboration could support the MN LOE. Of particular concern was the German POP, linked to the CFBLNet by commercial Integrated Services Digital Network (ISDN) dial-up lines through NC3A. Initially, the connection to Germany had 512 kilobits per second (Kbps) of bandwidth from RAF Molesworth to NC3A and 256 Kbps from NC3A to Potsdam. However testing showed 1 megabit per second (Mbps) from RAF Molesworth to NC3A and 512 Kbps from NC3A to Potsdam were needed to reduce latency to an acceptable level. From the US, CFBLNet provided 512 Kbps to Australia, 1.5 Mbps to Canada, and 2 Mbps to the UK.

The stress tests were also designed to determine if the Groove collaboration software would perform as advertised. The MN LOE planning team used Groove on the Internet as the planning space for the LOE with numerous participants from all participating nations with good success. Groove had not been tested in an environment where up to 50 Groove clients would be synchronized concurrently over a network with single paths to the POPs.

The three stress tests and two pre-LOE training vignette sessions led the MN LOE planning team to believe that Groove and the CFBLNet as configured for the LOE were sufficient to support the eight vignettes scheduled for the two-week period, 5-16 November 2001.

The performance of the collaboration software over a global wide area network was an experiment in itself. The LOE was designed to examine the implementation of a multinational force headquarters planning an RDO and not the technical infrastructure supporting the LOE. However, because Groove was a relatively new collaboration product built on the P2P concept, there was understandable interest on the part of the participating nations.

The CFBLNet was generally reliable except the link from RAF Molesworth to Potsdam, the extension to the CFBLNet put in place for the Multinational LOE. The link to Postdam was made up of separate ISDN lines each with 64 Kbps of bandwidth. For example, the link from NC3A to Potsdam consisted of eight ISDN lines. The lines were running Internet Protocol (IP) over Asynchronous Transfer Mode (ATM) so there was

overhead which meant the usable bandwidth was less than 64 Kbps. There were frequent problems with lines disconnecting and having to be redialed. On several occasions during LOE vignettes the link to Postdam went completely down when commercial providers performed unannounced maintenance.

When the German POP would go down, Groove clients at all other POPs would have to re-send deltas generated while the German POP was down. The glut of deltas severely affected throughput, especially from Australia to Germany. There was no way to purge the backlog of deltas in Groove other than to "uninvite" a client from a shared space, remove the shared space from the client, and then invite the client to the same space, a clumsy workaround at best. Figure 7 shows bandwidth used during a portion of the LOE.

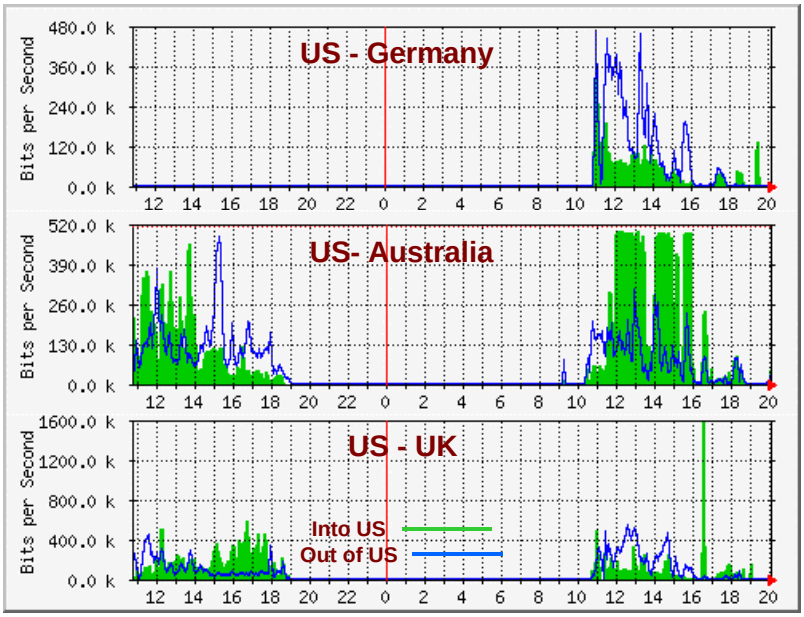


Figure 7. CFBLNet Performance

The graphs represent throughput on CFBLNet in and out of the US for two vignettes. The activity on the left of the upper band shows the lost of connectivity to Germany during a vignette with throughput between the other nations well within available bandwidth. On the right is the network activity associated with the subsequent vignette. Here network activity is normal with the exception of the Australia, where Groove clients were re-sending deltas that were not delivered previously.

The use of a Network Time Protocol (NTP) is important when using Groove as the collaboration tool. Groove not only insures that shared spaces are synchronized on all clients, it delivers deltas in the order created. If Groove client computers clocks are not synchronized, deltas will not be delivered in the order they were created. For example, if computer A shows a clock time of 8:00 and computer B shows a clock time of 8:05, any deltas created by computer A will appear in the shared space on computer B five minutes

before they were created, since Groove uses the delta timestamp to maintain chronological order. This ordering is most notable in text chat and can be confusing, especially if users are responding to questions. For the LOE, different clock synchronization solutions were used. German and UK computers were synchronized to an Internet site providing GMT. Australian computers were synchronized to a router at the JBC set to Greenwich Mean Time (GMT). The latter worked well until the JBC router lost power and reverted to a time that set Australian computer clocks back seven hours. When the router was reset back to GMT, Australian Groove clients began re-sending seven hours of deltas. An important lesson relearned is that computer clock synchronization is critical in a distributed collaboration environment.

In the final analysis, when CFBLNet was stable, Groove performed well. Voice chat, the feature most susceptible to bandwidth, had low latency even between Australia and Germany, the path with the least bandwidth and the most "hops" as shown in the figure 8.

Figure 8. CFBLNet Bandwidth for Multinational LOE

Figure 9 depicts the overall reliability of the CFBLNet during the LOE. The only recurring problems were with the ISDN dial-up lines between RAF Molesworth, NC3A, and Potsdam. Other problems over the course of the LOE were a JBC power failure that took down a router, ATM multi-point signaling and crypto sync problems at NC3A, and an intermittent Open Shortest Path First (OSPF) routing problem in the US. AITS-JPO and NC3A technical staff worked quickly to resolve problems when they arose. The link to Potsdam was a case of what was feasible within the time available. The use of leased commercial dial-up lines was the only available solution for the LOE. A more permanent solution is needed if the German POP is to remain in Potsdam for future experiments.

The MN LOE was the first USJFCOM Joint Futures Lab's multinational effort. It was unique since it was a focused discovery experiment structured to examine a specific aspect of the RDO concept, distributed planning with multinational partners. The LOE was also pilot event in that it attempted a global distributed experiment linking sites that had never been linked using a relatively new commercial collaboration tool and approach. The MN LOE also took an innovative approach for controlling the experiment by relying on a distributed virtual control cell in lieu of the more traditional centralized approach. Finally, the MN LOE served as a venue for focused research on topics of national interest. Follow-on LOEs will benefit from the management insights gained during MN LOE I.

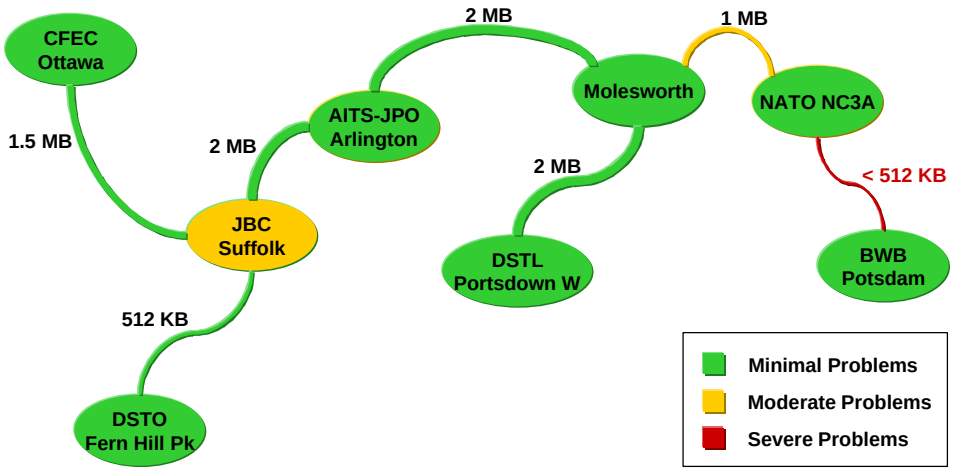


Figure 9. Multinational LOE Network Reliability

Summary

This paper detailed an approach for experimenting with multinational information sharing and collaboration. The goal was to establish a venue for exploring concepts and technologies that will permit coalition partners to plan and execute rapidly in the future. The experiments, known as LOEs, are intended to be both discovery events as well as structured experiments in partnership with nations that could become coalition partners with the United States in the future.

The U.S. Joint Forces Command Joint Futures Lab developed the RDO Concept as a way to deal with future adversaries in an expeditious manner. It is unlikely that the U.S. forces would act unilaterally against an adversary, so it is important that the RDO Concept include provisions for coalition partners.

The key to successful RDO is a robust ONA, and the key to a robust ONA is shared awareness, collaboration, and a command and control organization tailored to the mission. The way towards developing a robust ONA must include experiments with potential coalition partners.

The Multinational LOEs are the first in a series of stepping stones towards understanding how to share information and collaborate with coalition partners effectively during RDO in the future when planning time is short, defining how coalition partners integrate into RDO Command and Control, and serving as pilot efforts to integrate coalition partners in future large field experiments.