The Quest for Effective Interoperability - Issues in Achieving a Naval Coalition Force Virtual Combat System

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Abstract

Over the last few years, experiences in naval coalition force activities have indicated a considerable shortfall in interoperability between participants. This has been detrimental to their overall capability and reduced their effectiveness. The problems are associated not only with the technical differences between the participating platforms but also with the lack of understanding of how to 'function' as a network centric coalition task force. The latter being caused by the limited experience of working in such an environment, due to their limited occurrence, and also the cost of running any large scale exercises to address the basic problems. A collaborative venture has been underway for 18 months between UK and US naval research groups where an encrypted link is being used for the network connectivity to provide a suitable research environment to investigate the problems. The objective is to address such areas as data requirements, management and filtering along with the necessary control strategies essential for effective interoperability in a networked coalition force. As well as gaining experience in areas that can be transferred onto operational systems, the four year program should provide some yardstick for measurement of interoperability and whether there is an improvement in technical capability or, perhaps, show that coalition force activity is primarily a political requirement.

Background

Experiences in the Gulf War and during the Kosovo conflict have highlighted the problems of multi-nation naval task forces working together in an efficient co-ordinated way. Even though each participating member has some level of technological support at the communications and combat system level, the level for communications and data exchange has been that of manual transfer of paper copies or joint presence of representatives from each unit in one physical location. The problem has been the inability of these systems to exchange meaningful information arising partially due to the differing technologies which are present in the participating platforms but also to the different ways in which data is interpreted and the meaning of the information generated from it. Expressions such as 'drowning in data and starved of information' and the

comment that 'knowledge superiority requires information with the appropriate latency and fidelity' are the basic statements on the problem and these have been made by those who were in charge during the conflicts mentioned such as Admiral Stone, Naval Task Force Commander off Kosovo.

There has been an increased emphasis on the adoption of a Network Centric approach and information integration in military task forces with both the platform level and task force command requiring a fused view of the joint "battle space", the term which has now replaced "battle field" as more representative of the environment in which the operations take place. As was pointed out by US Admiral Jay Johnson the move to Network Centric Warfare is a fundamental shift away from platform-centric thinking. It will require changes to organisational structures and doctrine that will lead to the development of new tactics and operational procedures. The need for effective battle force interoperability and painful experiences in the area, have given rise to US initiatives such as the Distributed Engineering Plant (DEP) but they are basically addressing single nation issues in the area, between systems of comparable technologies with similar command structures and the same interpretation of data into information. The need to operate effectively as part of a coalition force will require some modification of long held notions about command and control, particularly the principle of the unity of command and the ability not only to send out data but to transform it into meaningful information. The need is for delivery of the right amount of the right information to the right place at the right time in the right format in a network-centric warfare environment to increase the effectiveness of the participating units.

Recently, as part of an information exchange between the US staff at what is now NAVSEA Newport and researchers at the new UK MoD organisation, DSTL at the Land Based Test Site in Portsmouth, consideration has been given to how best to address the problems at the multi-national level. The simple answer of bringing representative vessels of both nations together to carry out an exercise and hoping to resolve the numerous problems was never on, mainly due to the cost of using the actual operational platforms (the estimated combined costs using actual platforms exceeds $500,000 per day). Thus, the approach adopted derives from prior experiences and investments by both countries in the technologies adopted in support of Open System Architectures, Interoperability Test-beds, and Naval Combat System Engineering in such programmes as the New Attack Submarine (NSSN CIT & WAIF) and UK CSTDF/POST/CSI research programmes with the opportunity being taken to join their respective test beds via an appropriate encrypted link.

This is allowing us, using basic commercial communications and the necessary encryption equipment, to experiment with two combat systems exchanging data using a common scenario under controlled conditions. While, from the operational point of view our scenario is slightly unusual, the likelihood of a US submarine and a UK surface vessel jointly prosecuting a mission is remote, it does provide for a set of conditions which are very relevant to the coalition network situation. The data transfers will not be continuous and the tactical pictures on the two systems will be considerably different, which is exactly the situation that any new vessel joining a coalition task force network

would encounter. The work so far has concentrated on the establishment of the basic capability in terms of the network and the support software with both commercial products and DoD tools being evaluated in the software area.

Support Tools

One of the tools used during the first stage of the collaboration has been Odyssey Collaborative System (OCS). This product derived from investments by ONR. It supports applications that make use of interactive video conferencing, and as our collaboration required an extensive amount of video teleconferencing connectivity this was an obvious tool to try. To facilitate the assessment of Odyssey the UK and US sides agreed that the US side would install the Server-side while the UK installed the Client-side of Odyssey. The installation was a non-trivial task. The initial installation was attempted on a Windows NT4 machine but was troublesome so after advice from our US colleagues an attempt was made to install on Windows 2000, which the US had been successful in achieving. This also failed, so NT4 was attempted again and after much lower level tweaking of the configuration and batch files it succeeded this time. With the UK side being the client to the US's server the geographical split then brought the physical networking infrastructure to the fore. After further liasing with US counterparts, the US Odyssey client came up to a level at which we could start using the tool.

Experiences with Odyssey

As the UK side was set as the client it was always necessary to have the US side's server up and running before anything could be done. This was rarely if ever a problem. However, the responses from the server seemed to come at glacial speed. At some points during the OCS interaction the whole system would lock up and no responses could be got from the server. This may have been due to timeouts built into the system, but at the time there was no way of knowing. The situation invariably came about from the way in which interaction with Odyssey took place. One of the impressive features of Odyssey is the ability to create and define objects and rooms. In collaboration with our US colleagues a set of buildings was created to reflect platforms (frigates, submarines, etc.) and our respective labs. Within those rooms, subsidiary areas such as operations rooms, sonar rooms, lab rooms and so on were created into which documents could be made available and where virtual 'meetings' with people took place. It was hoped that it would be possible to 'move' around within these rooms, retrieve and view objects such as documents, and arrange private or public chats with team members determined to be 'present'. All of this interaction was to be carried out using Odyssey's point and click interface. The reality was, however, not initially encouraging.

The system response time was inadequate. For example, one would click on a room to 'teleport' oneself into it and it would be minutes before the room was updated to reflect one's presence in that room. After discussing with US counterparts who assured us they had had no similar problems, it was surmised that the problem must lie with the communications network to the US. This was indeed more than likely as was obvious from experiences using our network 'link' with other commercial products like NetMeeting. Closer examination revealed that the ISDN connection was inexplicably

dropping channels during the link-up. Another source of latency may also have been introduced by the network hardware. The problem was to then find a way of assessing Odyssey in the absence of reliably fast communications links.

It was decided to remove the need for networking in a geographically dispersed environment. A copy of the then latest Odyssey software for both the Client-side and the Server-side was installed on two different machines in the UK. The installation was eventually managed with one NT4 machine set as a client and another as the server. With this arrangement it was possible to get it working. It became possible to control the creating of rooms, which initially was only the preserve of the US's server side of Odyssey. The response from the system was very much improved and navigation relatively easy, moving from room to room, carrying out private conversations or open discussions.

Odyssey itself is a very comprehensive tool with many desirable features that are not readily available on many similar commercial packages. It is more of a 'virtual space' environment than merely a collaboration tool, the latter for our needs focusing more on knowledge management. Of the more impressive features is its user-customisability to reflect the geographical set-up of the environment where teams are located. This has the advantage of adding some realism, albeit limited. The virtual presence of other team members on screen and being able to notice their comings and goings has the effect of letting one know the possibility of instant problem or knowledge sharing. There are additional capabilities that would be desirable, but would appear to have been overlooked in the current version of the Odyssey system.

Document management is a vital part of working in teams. It is the main means by which plans are updated, revised and issued. Read and write permissions are good as controls on documents but other features are important. For example, it would be useful to have a way in which common documents being written could be controlled in such a way that the document can only be checked out by one person at a time, thus protecting them from being overwritten when two people work on the same document simultaneously. Additionally, facilitating the creation of private and public versions of documents would be an advantage. There are more document management features that are needed to ease collaborative work and we await the next revision of the tool.

Conclusions Regarding Odyssey
Odyssey has some excellent features as a tool but the experiences we have had so far indicate that its maturity is a still at a low level. Specific shortcomings can be summarized as follows:

1. It is rather a difficult tool to install. We had to dive into the internals, changing batch files and redirecting paths.

2. The response times suggest that a geographically dispersed team working collaboratively would have difficulty using some of its features that require higher bandwidth.

3   It is not really a collaborative tool but more of a virtual space environment where team members may be in the same time zone and therefore more dynamically interacting. Collaboration puts more emphasis on synchronisation of activities, avoiding duplication of effort when working on the same subject, and the management of information.

One suggestion that we would make is to investigate modular implementation of some of the features of the system, not unlike the way Enterprise Resource Planning (ERP) tools such as SAP are implemented, where a subset of the features can be selected. This is achieved, not merely by disabling a particular feature or module, but by not building it into the implemented system. This may have the advantage of simplifying and lightening the system as a whole.

Overall, the ideas behind the tool are very good and the tool would be suited to most activities in any collaborative environment, which requires representation of different 'locations', which, in our case, are naval platforms.

Operational Aspects
Moving from the support side of our activities to the operational side of the collaboration, a common scenario has been generated to meet the needs of our investigation.   As indicated earlier, the scenario may not reflect the normal run of platform interactions, but it envisages a joint operation in response to terrorist activities and involves surface, subsurface and air units with the possibility to extend the action into other domains as needed in the future. The complexity of the operation is expandable but has been kept at a simplistic level at present while the problems of communications and synchronisation have been resolved between the sim/stim drivers that implement the scenario. The basic idea is that sensor data is being processed through the UK surface combat data fusion system and the output transmitted to the US subsurface unit at the appropriate times, and that the US platform is providing periodic sonar picture updates based on the same sim/stim program to enable the operational task to be executed. This raises several issues concerning the data, which is being exchanged.
The research work is addressing such issues as:
- data requirements
- data management and filtering
- data structures and content
- control strategies
- data servers vs. datalinks

Having establish the initial connectivity and the passing of tactical picture data, the major effort has moved on to investigate the formats and structure of information, the information architecture, and ways for both sides to reach an agreement on their interpretation of that information within their own environment. There is no point in exchanging data that adds no value. Early tests are being used to identify the basic levels that are acceptable to the two combat systems in terms of enhancing the system capability

by the introduction of new information, but at the same time not overloading it with useless (and potentially distracting) information. There will be several tests in this area to demonstrate the basic capabilities that will be required to support the more complex experiments.

In a more general subject area, it will be necessary to investigate the relationship between a subsurface platform and surface platform and the transfer of information between them. It will be necessary to investigate the use of current datalinks (Link-11 and Link-16) or other message formats and to consider whether the present operational procedures are acceptable in the new network-centric environment. It might be an appropriate time to consider how best to handle the coalition force information in this situation as distinct from the present data link scenarios. Although existing Link-11 and Link-16 include some subsurface message formats they have been used little to date and the possibility of developing some form of Coalition Data Server (CDS) is being considered.

Large scale information transfer involving submarines is likely to be performed on a spasmodic basis, enabled only when a submarine is in contact with a surface platform. The purpose of this area of research is to determine:

- The effect on the above water platform of integrating such spasmodic and time varying information from a submarine into the rest of its tactical picture involving organic and non-organic wide area non-real time information.

- The effect on the under water platform of integrating real time information into its picture and subsequent handling of that data in terms of staleness, predictions etc.

The effort here will build on the present set of experiments, looking at the types of information that could be exchanged and how this could be managed. The aim at this stage will be to compare particularly the pictures compiled in the relevant surface and subsurface platforms as time progresses without refresh. It will be attempted to determine whether the degree of drift between the actual and perceived positions outweighs the initial transfer of information and whether better staleness or prediction measures could be used to improve the pictures. It will also allow some assessment of the best options for interoperation between the surface and subsurface platforms in terms of the procedures covering such aspects as frequency of contact and amount and type of data exchanged.

The follow on from this is to provide the ability to investigate the remote use of sensors and weapons such as EW, sonar, torpedoes and missiles between coalition platforms, initially starting with the sub to surface link and then expanding to the different platforms in the network. The network at this stage should be capable of allowing land and air platforms to be integrated as part of the environment and the full coalition battle space scenario addressed building on the experience gained from the earlier investigations and experiments. It will also provide the ability to investigate the remote use of sensors and weapons such as radar, IR, EW, sonar, torpedoes and missiles between coalition platforms, initially starting with the sub to surface link and then expanding to the different platforms in the network. The concept here is that the network will provide the ability to decouple the specific sensor from the platform on which it resides and to make

it one of the sensors available on the task force network and accessible to anyone who has the necessary access to and need for a source of data. Not only does this enable the actual range over which a sensor's data is contributing to be significantly increased but it also means that participating platforms have access to the 'best' sensor available within the task force thereby increasing the quality of the data available.

It will, however, raise many questions of control and authority.

Once the US network has been extended to link to other US surface platform test bed facilities and the UK end has a similar extended capability, issues such as force data fusion across the coalition surface and subsurface platforms can be investigated. This opens up the possibility for investigating the factors mentioned earlier in the organisational and doctrine areas:

- The different operating characteristics of the UK and US navies,

- The different command structures.

- The different interpretation of data into information and understanding

- How to operate Network-Centric Command and Control

A further area for investigation will be extending the experiences gained from the investigations into the spasmodic type of interaction to see if any of the lessons learned can be used in setting set up the joining and leaving procedures for a platform and a force network in terms of what is required and how it is controlled.

And in conjunction with these issues the collaboration is looking at how to evaluate the effectiveness of such interoperability between combat systems and lay down some initial guidelines for how this type of coalition network might be operated, what the procedures are for joining and leaving a network-centric force and how to improve the capabilities of the platforms involved rather than just "drowning them in data". The results of the collaboration will help to move systems up through the information domain from the data level to the situation knowledge level and thereby increase the ability to understand and assess that situation.

Coalition Data server

As has been pointed out, any task force battle group or coalition force naval operation requires coordinated communication among diverse platforms and integration of information assets for success. Additionally, the requirement is for naval combat systems of diverse manufacture, providing different views of the battle space with different levels of confidence and capability, to interact effectively and flexibly as a system of systems for effective mission accomplishment.

The coalition needs expressed above distils to an initial aim, which is to transfer data between heterogeneous platforms with the minimum of the human intervention required for the information exchange. The proposal is to adopt a flexible architecture to facilitate current as well as future requirements, and the eXtensible Markup Language (XML) provides a way that facilitates one machine's applications to interact with another using a common human readable data format. The intention is to build a prototype CDS to

incorporate US and UK coalition applications by building XML parsers and generators for each application and to use the Servers as the bridge (translator) between coalition data and application specific data with an interactive Java CDS viewer with read and write capability. The basic aim is to show the ability of the CDS to make data available to a remote platform.

When using XML, it is possible for a system to receive XML-tagged data from another system, and the other can receive XML-tagged data from the first. Neither of them needs to know how the other's system is organized. If another partner or supplier teams up with the network, there is no need to write code to exchange data with their system. They are simply required to follow the document rules defined in the schema.

One of the early tasks has been to standardize on a schema to define coalition data content. An XML schema defines what tags can go in your document, what tags can contain other tags, the number and sequence of the tags, the attributes the tags can have, and optionally, the values those attributes can have. To achieve this, the data requirements of current US / UK applications have been examined. The initial sample of data messages has yielded a schema, which, although not complete, serves the purposes for exploring the concepts identified above.

Effectiveness of Joint/Coalition Forces

In parallel with the research identified above, a major activity during this work must be the identification of measures of effectiveness for joint/coalition force activities. While it may be possible to exchange information, it is essential that there is some means of assessing the effectiveness of what is being achieved. This will need to take into consideration both the national and joint/coalition requirements and to what level the coalition platform systems will be integrated into a task force unit. It will of necessity not only address the technical issues, but also will have to deal with the command and doctrinal issues that will arise.

Summary

The adoption of an early integration testing approach in the development of complex systems has proven to be a success. In fact, the U. S. Navy has since embarked on the establishment of a Distributed Engineering Plant (DEP) and a Collaborative Engineering Environment (CEE) modelled on their Wide Area Integration Facility (WAIF) experiences. From an architectural perspective, the development issues and the operational issues are seen to have much in common where test and integration are concerned. This approach is now being employed at the joint/coalition force level and the avoidance of operational problems achievable as a result of adopting such an approach is substantial.

Taken in its broadest view, interoperability is more than just connectivity and communications. Its import goes beyond just command and planning activities to embrace real time sensor data integration among collaborating platforms. In a real sense the objective is a virtual combat system that spans platforms. The drive for interoperable combat systems is a natural consequence of the increasing emphasis on information warfare, of the increasing reliance on joint and coalition forces to achieve military

objectives, of the increasing reliance on commercial technologies, and on the decreasing defense acquisition and research and development budgets. Needing or desiring interoperability is not the same as achieving it however. There remains much to do to bring about the interoperable combat systems needed for success in the era of network-centric operations and information warfare.

As we seek to manage an information landscape that is more comprehensive and diverse each day, it is important to guard against the technological imperative to do things merely because we can. Access to all information all of the time is not the optimal design objective for combat systems. It is not even desirable. We must also guard against the tendency to confuse technology with engineering. Proper use of technology requires that we engineer our systems with careful attention to architectural issues. There remains plenty of work to do. A near-term list might include:

> Identifying the consequences of interfacing systems designed to different architectural standards
> Developing measures of architectural openness
> Overcoming obstacles to wide-area distribution of time critical sensor-to-shooter loops
> Determining the extent of necessary commonality in deployed information infrastructure
> Understanding and coping with terminological and training barriers to interoperable coalition force combat systems
> Identification of an appropriate Combat System Interface Profile to support interoperability
> Developing criteria for managing the information landscape

The bottom line objective in the search for combat systems that are both operable and interoperable must never be lost sight of: providing the right amount of the right information to the right place at the right time in the right format.

The experience so far from the first phase has validated the basic tenet that the problems under investigation are not simple. In order for two similar, yet fundamentally dissimilar, systems to work together a common understanding is required of the terminology and ways in which tasks are carried out. The learning curve is steep and progress at times seems slow, but at least the problems are being identified and resolved before the real platforms, and the related costs that would incur, are involved.