Train as You Fight: SINCE – the Key Enabler

"Lessons Learned from Recent SINCE Experimentation"

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ABSTRACT

*US and Germany are conducting three R&D experiments under Simulation and C2 **In**formation Systems **C**onnectivity **E**xperimentation (SINCE) Project. These efforts enable real-time information exchange, and coupling between combat simulation systems and command control (C2) information systems as needed to support the conduct of International Warfighter Experiments. Key SINCE enablers' are the C2Sim Proxy Service/Server and the Web-based C2 Collaboration Portal (WCP). The C2Sim Proxy Service is used by both the US and the Germany to link national simulation systems with national C2 systems. Interoperability between US and GE C2 systems is implemented using the Multilateral Interoperability Program (MIP) standard. Interoperability between US and German Combat simulation systems is implemented using High Level Architecture (HLA) standard. The WCP is being developed by the US and jointly tested by both sides to support both collaborative exchange of continuous planning information and display of the Coalition Common Operational Picture (CCOP).*

Initial SINCE capabilities were successfully demonstrated during Experiment 1a in November 2003 at WTD 81, Germany, with over thirty technical and military participants. The demonstration included real-time information exchange between the US and German C2 Systems and Simulation Systems. Significant technical capabilities demonstrated in this experiment are: (1) Automatic initialization of diverse systems and demonstration that they all displayed the same Operational Picture, (2) Simulated Blue and Red Force movement and position updates generated in either the US or German simulation systems could be published and viewed in real-time, (3) coalition force collaborative planning and force synchronization activities could be conducted via use of the WCP. Participating US and German military users agreed that the Experiment 1a had successfully demonstrated the linking of real C2 and M&S systems and opening the potential for future use of real-world Warfighter C2 systems in simulation-based training exercises. The SINCE Operational

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Experiment 1B was conducted during 12 through 23 July 04 at the 35th ID Combat Training Center (CTC) Facilities located near Ft. Leavenworth KS. A slightly enhanced and reconfigured version of the SINCE Experiment 1a environment was implemented to support this experiment.

In this paper we will present more details on the technical environment implemented to support these recent experiments and also discuss the lessons learned associated with their conduct. These SINCE experiments followed, adopted and adapted a code of best practice approach for experimentation. The compromises and trade-offs made to establish a balance between (a) development of an infrastructure that supports both the current and future planned experiments, compared with (b) just implementing an experimental configuration used for conduct of a specific experiment, will be discussed. An integral part of the solution was the establishment of the methodology by which the various information architectures would be harmonized within federations and across federations. Additionally some insights into the operational lessons learned from the conduct of these experiments will also be presented and discussed.

The innovative technical and operational interoperability capabilities that SINCE is implementing and demonstrating represent a significant step forward in coupling Warfighter C2 systems and combat simulation systems. SINCE has demonstrated essential capabilities needed to support simulation-based coalition force military training, and mission rehearsal activities, thereby enabling users to train with the same C2 systems they fight with.

1.0 SINCE PROGRAM OVERVIEW

As indicated in Figure 1 below, the major thrust of the SINCE program form a US perspective is focused on providing future Army Transformation, 2010 Objective Force and Future Combat System (FCS)

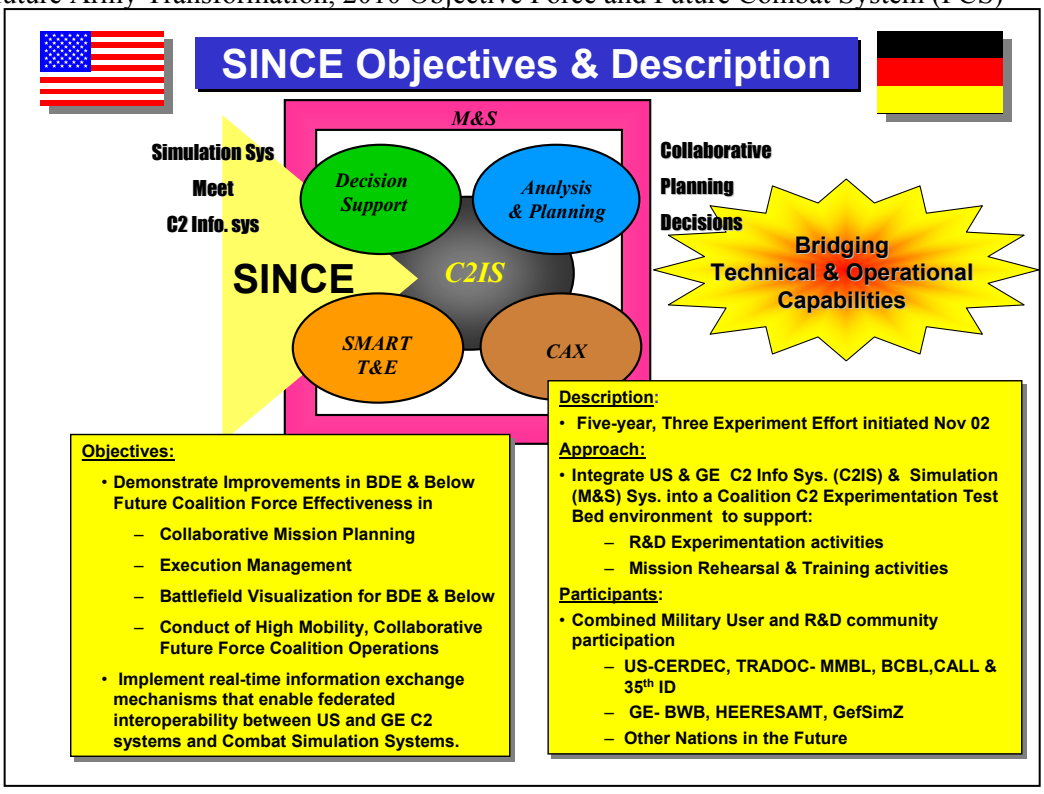

Figure 1: SINCE Objectives and Goals

Commanders with enhanced capabilities to conduct and coordinate collaborative military mission planning, execution monitoring, re-planning and mission management activities in support of combined Army and joint coalition force operations. Essential goals for the SINCE effort are demonstrating improved means for visualizing the coalition battle space and providing the capability to perform real-time collaboration and information exchange with coalition partners during the conduct of mobile operations. During the conduct of US/GE SINCE experimentation activities the US expects to harmonize evolving US Army Mission Planning, Execution Monitoring and Battle Management Decision Support Tools so that they can better support coalition operations. We also expect to demonstrate new and more affordable means for achieving interoperability between US Objective Force/FCS and GE C2IS and those of our coalition partners. In the execution of SINCE both the US and Germany are integrating and using M&S technologies to facilitate/support the planning, re-planning, execution monitoring and management of complex joint and combined coalition missions/operations.

From a military perspective, as illustrated by Figure 2 below, SINCE is helping the US and Germany to improve military capabilities that are essential to transformation of their forces to what is needed in the future. The future threats to the security of our countries are well known. Actual missions have shown us the importance of multinational and joint combined operations, especially on tactical level. New concepts have to be developed and proven out via experimentation in accordance with the guidance of the CD&E process. Our soldiers must be trained, as they have to fight especially as NCW becomes reality. In SINCE we do not talk about interoperability, we produce interoperability!

These are the most important reasons why US General Byrnes and General Dietrich, Vice Chief of Staff of the GE Army, tasked us to continue the SINCE project. They want to be updated regularly!

Figure 2: Program Focus

2.0 SINCE IMPLEMENTATION APPROACH

As depicted in Figure 3 below, SINCE has implemented three interfaces to support our experimentation activities. Two of these interfaces are technical interoperability interfaces, i.e.- the MIP C2IEDM for information exchange between C2 systems and HLA RTI for information exchange between Combat Simulation systems. The third interface we refer to as a Collaborative Operational Interface and is focused on how soldiers actually understand and use information during the conduct of collaborative planning and battle execution management activities. This operational interoperability interface is implemented as a Web-based C2 Collaboration Portal that is designed around a digitized XML and Battle Management Language representation of an OPORD and OPLAN. As you can see from the Experimentation Test Bed Implementation diagram illustrated in Figure 3, both US and Germany have implemented national versions of the C2Sim Proxy Server that manages the flow of information between simulation systems and C2 systems and also adapts/translates data generated by simulation systems into a form acceptable by C2 systems vice versa.

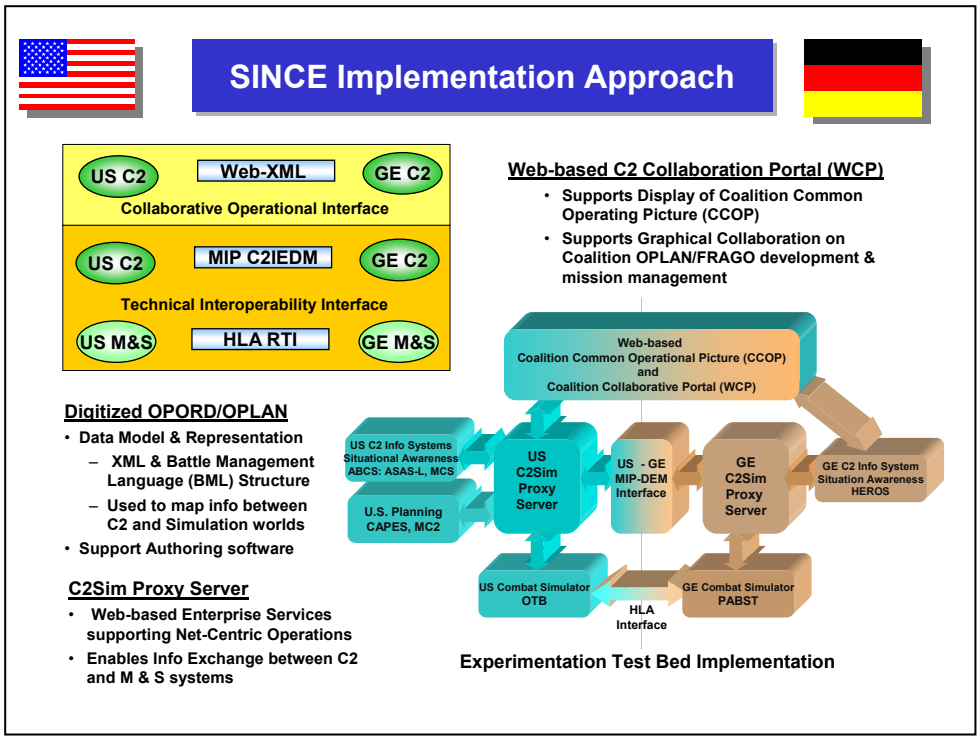

Figure 3: Implementation Approach

Figure 4 depicts the concept architecture and data exchange interfaces of the US C2Sim Proxy Server. In order to emulate the network-centric environment that future forces, US & coalition will operate in, the US C2Sim Proxy Server is internally implemented as a loose federation of external enterprise system interface ports and data adaptor/translation services. These system/data adaptor services are Web-based service request oriented agents/clients. Each of these data adaptor services automatically maps information received from an external system's unique format & data representation into a common digitized OPORD/OPLAN XML-based representation and vice versa. Thus information exchange between two external systems consists mapping into and out of a common XML representation, and the connection of new system/software interfaces to the US C2Sim proxy sever reduces to a "1" to "n" solution, rather than the usual "n" to "n" situation. Control and

flow of information exchange between these external system interfaces is internally implemented in the US C2Sim Proxy Server via a rule-based Publish and Subscribe data exchange mechanism. Each system and its information exchange interface attached to the C2Sim Proxy Server federation is registered with the proxy server's Information Manager/Discovery Service which is responsible for managing and controlling the flow of information between ports/ users in accordance with a prescribed set of information exchange rights and distribution rules. Additionally within the proxy server we have also implemented select set of information aggregation & filtering services, which are currently used to smooth and reduce the flow rates of information exchange between simulation systems and C2 systems. Within the US C2Sim Proxy Server, two persistent data repositories are maintained to support the functionality of the proxy server and also maintain a log/history of the transactions processed during the conduct of a SINCE experiment. All experiment state change information is stored in a MIP C2IEDM database/server. All XML OPORD/OPLAN/FRAGO information exchanges are stored on a Web-Portal server/repository. The C2Sim Web-Portal and MIP C2IEDM servers are linked together and automatically push and pull information as needed between them.

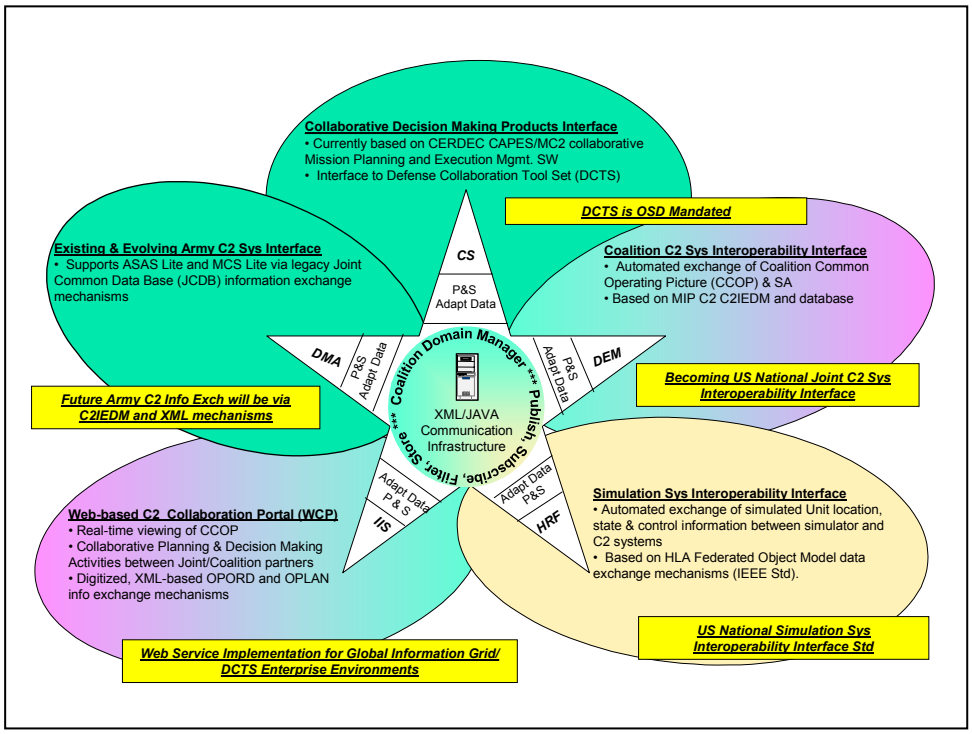

Figure 4: US C2Sim Proxy Server Implementation

The equivalent German C2-Sim Proxy Server in its current implementation primarily addresses only the exchange from information from the German PABST simulator with the German HEROS C2 System. It too, however, takes information received from the simulator and maps that information into an appropriate XML representation, which is subsequently used to generate AdatP3 messages that the HEROS C2 system can understand.

3.0 THE WEB C2 COLLABORATION PORTAL

All of the other information exchange interoperability interfaces implemented under the SINCE program basically facilitate technical interoperability between connect systems. The Web C2 Collaboration Portal and associated web server are focused on "Operational Interoperability Issues", - that is how the military user visualizes and understands an evolving operational situation and how he can effectively collaborate with his coalition partner in developing plans and concepts of operation during the conduct of a coalition operation. As depicted in Figure 5, the Web C2 Collaboration Portal allows the user to see the evolving Coalition Common Operating Picture (COP) and also view from different perspectives of digitized versions (i.e.- man and machine-readable representations) of OPORD, OPLAN and FRAGOs.

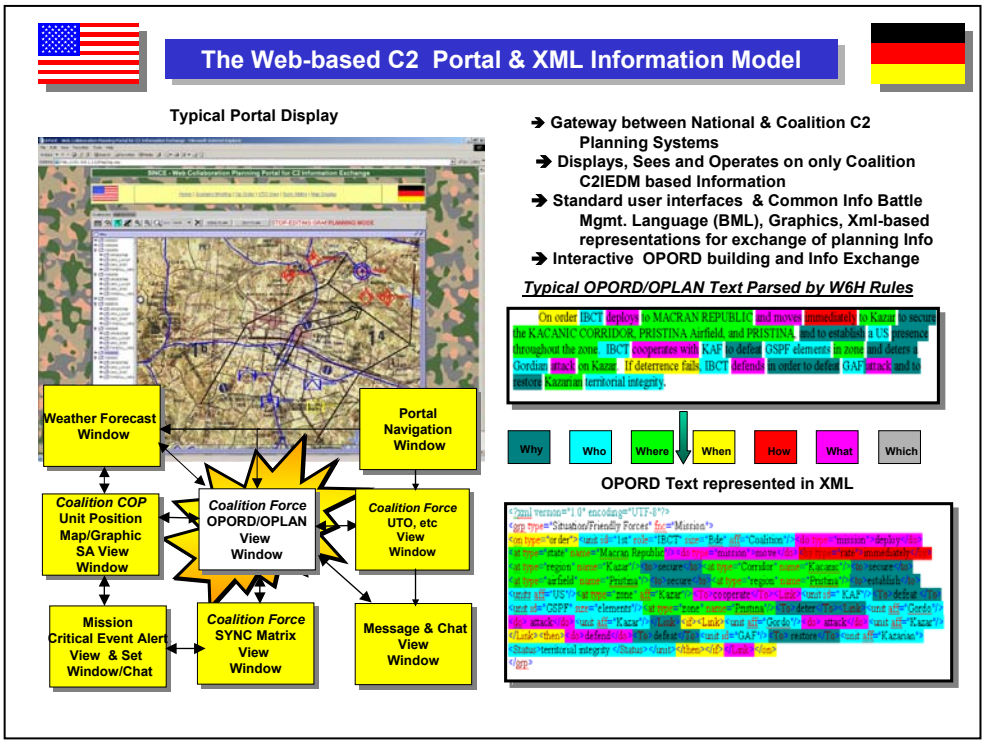

Figure 5: Different views of the Web C2 Collaboration Portal iew of the Web C2 Collaboration Portal

Additionally as indicated in Figure 6, a coalition user can via a graphical point and click interface, develop OPORD, OPLAN or FRAGO unit task assignments that are easily understood by all, and can also be viewed in an appropriate man and machine-readable "who, what, where, when, why, which and how" unit task breakdown that can further tweaked and annotated as necessary to assure successful execution.

During the conduct of the SINCE Experiment 1b(Operational), both the US and German military users conducting the operational portion of the experiment became extremely proficient at using the Web C2 Collaboration Portal graphical point and click planning information exchange tools for developing and coordination their OPLANs and FRAGOs. All had extremely high praise for the collaboration capabilities provided by the portal and recommended additional enhancement and evolution of the WCP for future transition and use with national C2 systems.

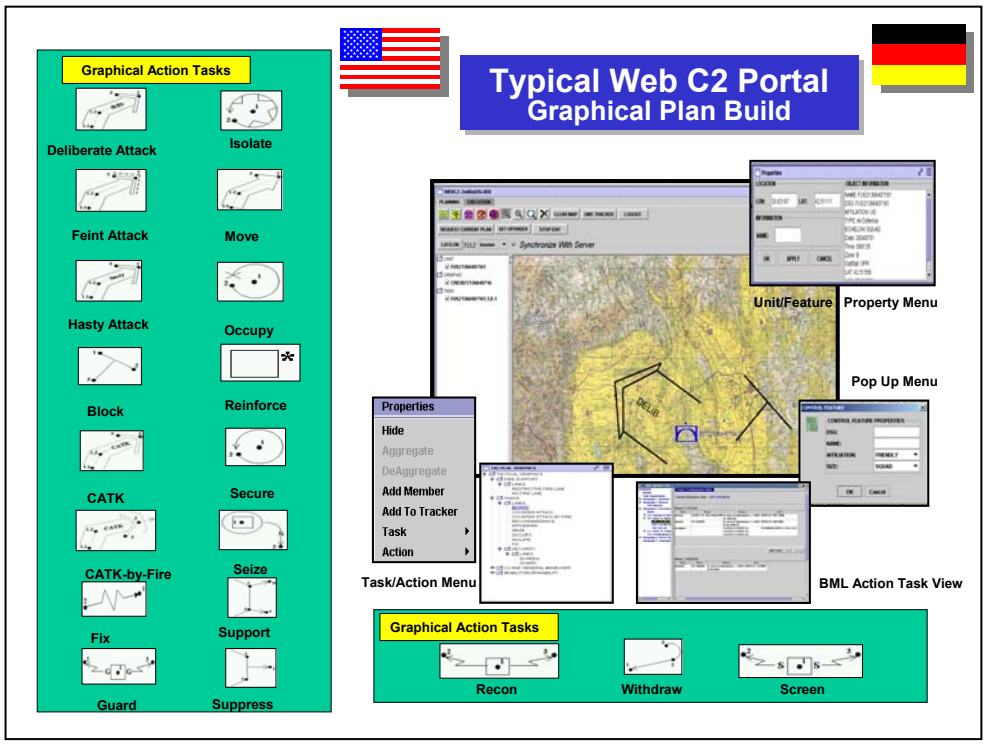

Figure 6: Web C2 Collaboration Portal Planning Interface

4.0 THE SINCE EXPERIMENT 1B (OPERATIONAL)

Figure 7 depicts the notional layout for the SINCE Experimentation Test Bed. We have connected real C2 systems into appropriate Brigade level HICON and Battalion level TOC configurations. To emphasize the Train-as-You-Fight paradigm these are manned by real troops, on real C2 systems, conducting real planning tasks and coordination activities against a simulated coalition force operation. All the movement, shooting etc. occurs in the simulation world. Figure 8 indicates all of the different C2 and Combat Simulations systems connected and playing together in some capacity in the SINCE 1b Experiment. As you can see, there are 24 computer systems connected in the SINCE Experiment Test Bed, playing different roles. The systems indicated on the pale yellow background represent the core systems used to implement the US portion of the experimentation facility. The systems on the pale green background represent the core German systems playing in the experiment. The systems on the pale blue background represent other US joint/legacy systems with which we demonstrated connectivity and information exchange capabilities. More detail on the roles these systems played in the experiment and their interconnection is provided in Figure 9. Figure 9 represents the actual physical layout of the experimentation facility that we implemented to conduct the experiment and which we to demonstrate the capabilities of the SINCE program to 43 visitors attending our SINCE VIP Day on 22 July 04.

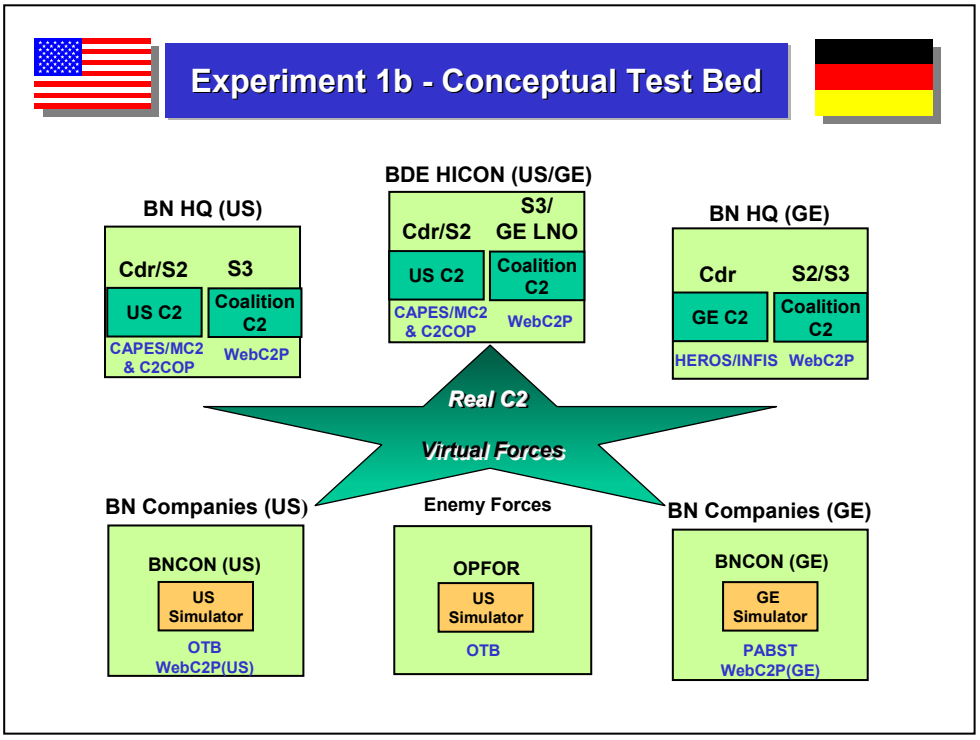

Figure 7: Conceptual Experiment 1B Test Bed Implementation

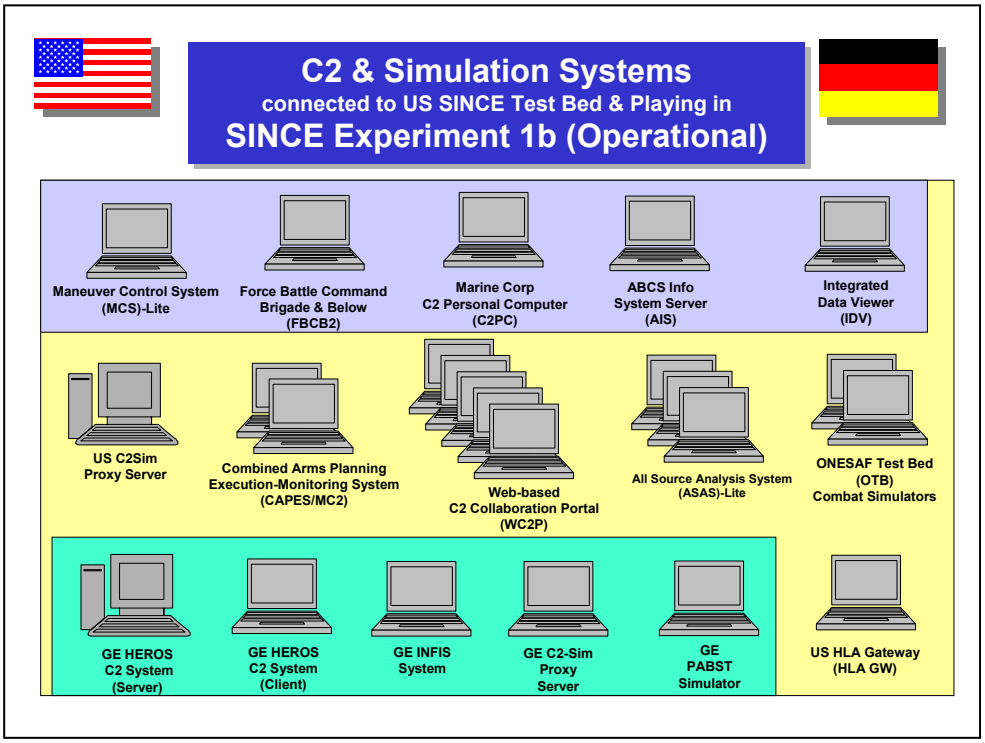

Figure 8: Actual Physical Experimentation Layout

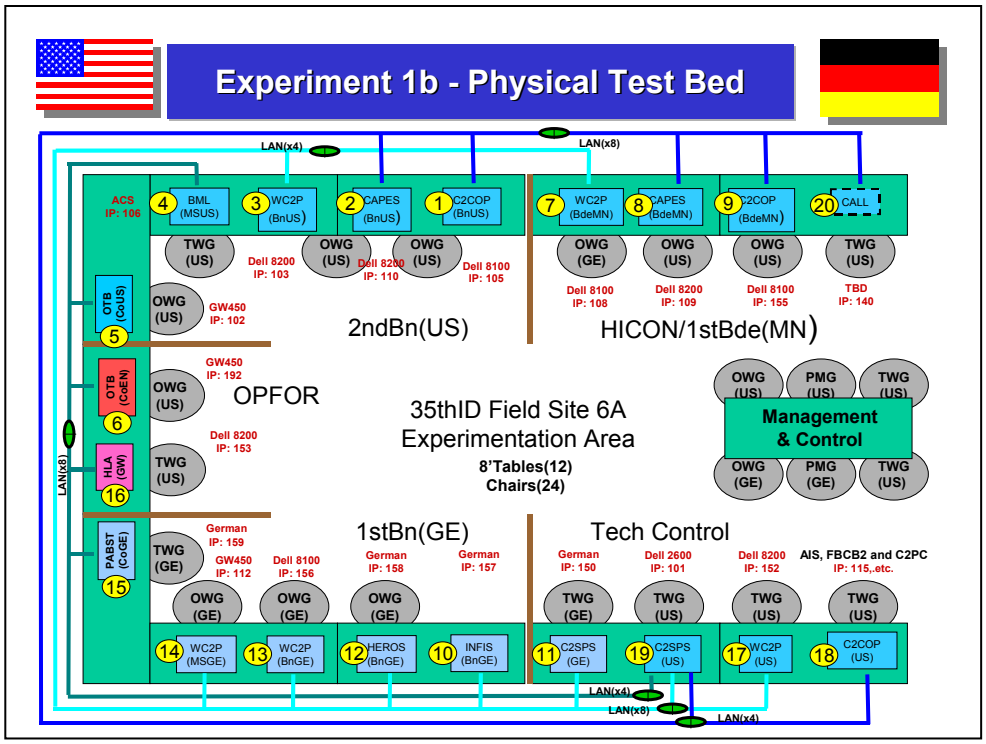

Figure 9 Physical Experiment 1b Test Bed Layout.

5.0 DISCUSSION OF EXPERIMENTATION ACTIVITIES AND RESULTS

Figure 10 provides a high level overview of both the technical and operational experimentation activities that were undertaken as part of two week, 12 –23 July 04, conduct period of SINCE Experiment 1b. As is indicated in Figure 10, the operational portions of the experiment were play out as vignettes of different aspects of a real coalition force operational scenario, sometimes scripted and other times completely ad hoc in nature. The prime objective of the SINCE Experiment 1b was to validate the technical and operation functionality of the SINCE experimentation test bed environment and assure it was ready to support more complete and comprehensive operational experimentation activities planned and scheduled for the SINCE 2 and 3 experiments.

5.1 Experimental Results and Lessons Learned

The experiment was conducted by repeating the standard operational cycle of the four fundamental phases inherent in any operation: a) Connect/Network, b) Initialize /Federate, c) Collaborate/Plan, and d) Interoperate/Execute. The first two phases were predominantly technical in nature and the second pair of phases was predominantly operational. In the Connect/Network phase we experimented using various protocols (e.g. unreliable UDP vs. reliable TCP/IP) network configurations (Single vs. Multiple LAN environment) and server host locations (Distributed vs. Centralized). In the Initialize/Federate phase, we experimented using three general publish and subscribe topics (Control, Plan and Execute) in which we experimented with varying the ground truth and observing the effects on the perceived truth. In this phase we were also able to experiment with initializing the MIP interface in two different ways: centralized vs. distributed. In the third phase, we enabled the user to experiment with multiple collaboration planning

sessions and multiple workspace SMIs. Finally in the forth phase, the user was able to monitor the current COP and determine when and how to switch back to collaborative re-planning.

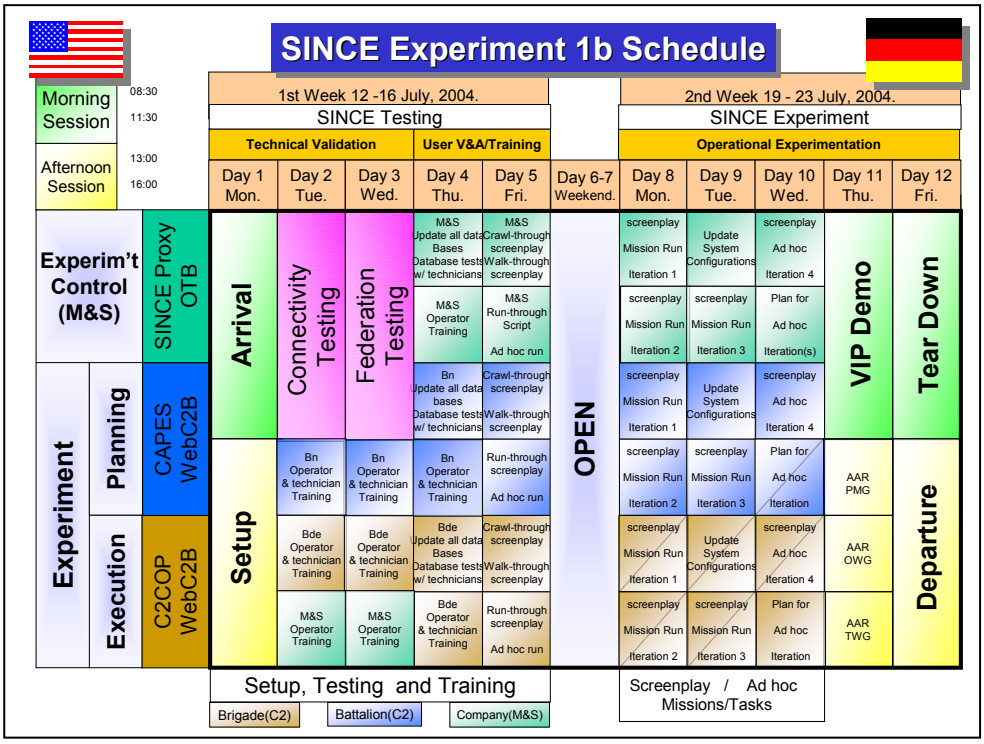

Figure 10: SINCE Experiment 1b Activities Schedule

5.1.1 Connect and Network

The network of over twenty computers was continuously monitored at the server level as well as at the client level. Although not a requirement, optimally, each coalition partner should be network-enabled with three separate networks (LANs): one for the National C2 COP/Plan IER, one for the shared coalition C2 COP/Plan IER and the third for M&S ground truth COP maintained by HLA RTI/RPR FOM IER. In SINCE Experiment 1a a single network connected the testbed and the phases were initiated sequentially, no real bandwidth/load issues were apparent. In SINCE Experiment 1b (SINCEx1b), the test bed was potentially enabled by three separate networks, however, only two networks were used due to a technical limitation: one for National US C2 COP/Plan IER and the other for accommodating the shared coalition C2 COP/Plan IER together with the M&S traffic. This combination proved useful only when the M&S traffic was run sequentially with the C2 traffic. When the two offered traffic types (C2 and M&S) were run concurrently/simultaneously as is required to simulate an operational environment, the C2 traffic became sporadic and unreliable at best. In future experiments as a minimum, each nation should be enabled with the three networks a) to preclude potentially network access conflicts between M&S ground truth COP IER and C2IER and b) to preclude potential network access and privilege conflicts between the National C2 IER and the Multinational C2 IER.

5.1.2 Federation and Initialization

In this phase the "publish and subscribe" mechanism of the US Proxy Server was configured using three topics: Control topic for initialization, Plan topic for collaboration and Execute Topic for interoperability. Once all federate servers and clients were interconnected, the M&S systems (OTB (US/blue), OTB (OPFOR/red), and PABST (GE/blue) were initialized first with the ground truth. It took a few seconds to consistently verify that the multinational M&S portrayed and accurately reflected each other's ground truth data. Subsequently, the C2 systems were initialized with the COP based upon the perceived truth as decided by the user. Typically this equated to all ground truth units minus a few OPFOR red units and was verified visually by the user at each C2 display. Since the M&S systems (OTB and PABST) were executing in real time, the M&S operators, performed manual magical moves to speed up the time at which SPOT reports would occur and demonstrated that indeed perceived truth was updated during execution with appropriate changes to the ground truth depending upon friendly proximity to enemy units.

5.1.3 Collaborate and Plan

Each operational cell, HICON BDE (MN), and subordinates BN (US), and BN (GE) established workspaces for maintaining configuration management over their planning session as well as workspaces for viewing and providing feedback to their two collaboration partners. This capability was well received by the user and additional overlay needs/requirements were established for future experiments. These features include:

- Overlay/merge own plan on/with current COP
- Overlay/merge feedback on own plan
- Overlay/compare own plan with peer, superior or subordinate plan updates

Another important flexibility was established from the process of getting the plan approved as an OPORD for execution. The superior unit (HICON) commander reserves the right to approve not only his OPORD but also that of his subordinates. This will depend upon the level of experience and training of the subordinate commanders. With high level of experience and confidence in the subordinates, the HICON will let subordinate commanders approve their own plans as OPORDs for execution.

5.1.4 Execute and Interoperate

In this phase, C2 situation awareness (SA) of the current situation was maintained by the simulation systems, which published friendly heartbeat in the form of position reports and reported on enemy units using SPOT reports. In this phase we experimented with different algorithms for aggregation using center-of-mass and elapsed-time-since-last-report and update frequency. These algorithms proved effective in eliminating the jitter that would otherwise occur when viewing the current situation. Another important finding had to do with reconciling differences in the terrain environments between the C2 raster maps and the M&S feature maps. Since the map sources were different and the terrain had significant amount of rivers and roads, planned routes based upon raster maps seldom-matched route feature available in the simulator terrain database. It was essential therefore for the M&S operators to adjust movement of platforms IAW the intended terrain feature data. Otherwise, vehicles would be stuck at various obstacles not foreseen in the raster map of the C2 system. It is not clear from the current experiment to what extent a higher fidelity C2 raster map, such as available from CJMTK map server, required by the user for higher fidelity planning may resolve such discrepancies. This will be investigated in future experiments.

6.0 CONCLUSIONS AND SUMMARY

Overall, the US and German SINCE team considers the conduct of SINCE Experiment 1b a success. While some technical integration problems were experienced resulting from increase in the scale test bed scale and introduction new capabilities above those tested during out Nov 03 experimentation in Gredig Germany, none of these problems were show stopper or of major issue. Future SINCE experiments will have more pre-experiment integration testing.

According to the US-GE SINCE agreement, three experiments are scheduled, as depicted in Figure 11, over a five-year period. Between the experiments a spiral development following a build-a-little/ test-a-little methodology takes place. Experiment 1, the combination of 1a and 1b, was intended to be the proof of concept and validation of meeting the user requirements as well as demonstration of the initial proxy functionality. Experiments 2 and 3 will be based on scenarios of growing complexity and will show additional functions to support military user demands. The technology of coupling M&S systems with C2 systems and the requirement of collaborative mission planning and execution instruments are certainly not unique to demands of the Army. This is why joint aspects and systems are being incorporated starting with Experiment 2. Eventually – with respect to the international composition of today's coalition forces – other nations will be invited to participate in Experiments 2 and 3. The SINCE architecture will allow them to very efficiently join the federation. There is a mutual understanding within and beyond the SINCE community that the focus of the program is to lay the foundations necessary to support an International Warfighter Experiment in the year 2007.

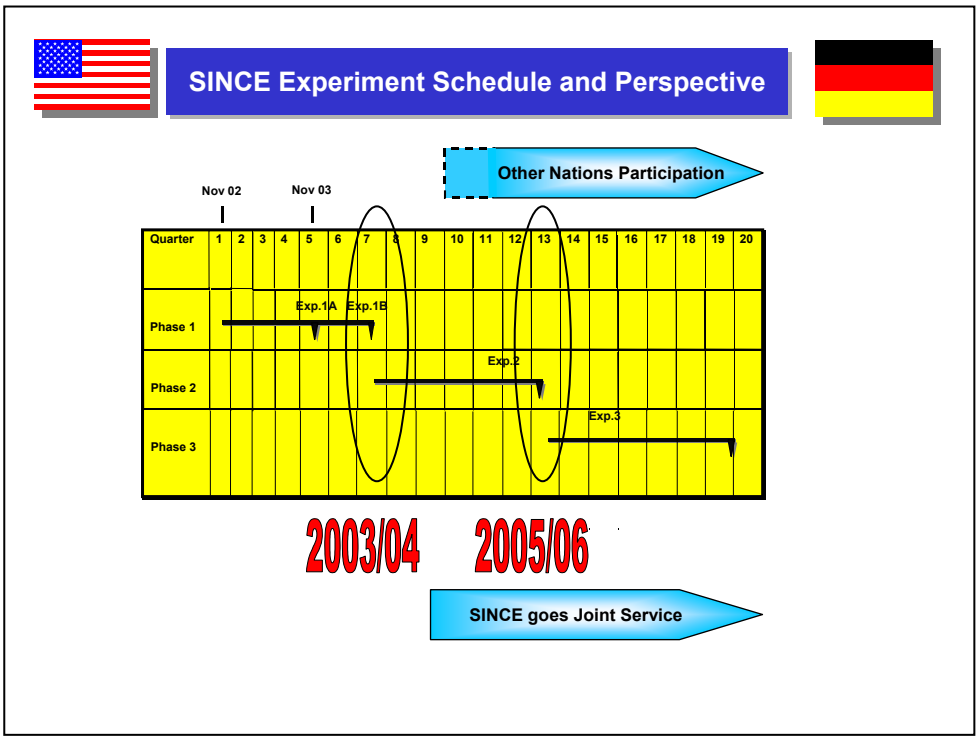

Figure 11: SINCE Experimentation Schedule

ACKNOWLEDGEMENTS

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