Realtime Initialization of Planning and Analysis Simulations Based on C4ISR System Data

2002 Command and Control Research and Technology Symposium (CCTRS)

Modeling and Simulation Track

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Abstract

Simulations have been used during exercises within analysis and planning cells for much of the past decade. However, the usefulness of such simulations is dependent on the ability to rapidly enter data from the tactical picture into the simulation, for use as a starting point for running analyses. Current methods for pulling in such C4ISR data rely on manual data entry that can introduce errors and take significant time to accomplish. This paper discusses an approach that allows automated initialization of simulations that takes advantage of an existing High Level Architecture (HLA) Runtime Infrastructure (RTI) interface within the Global Command and Control System (GCCS).

During the Navy's Global 2001 wargaming exercise, this approach was used to rapidly initialize the Naval Simulation System (NSS) for use in performing Course of Action (COA) analysis in the Naval Forces (NAVFOR) cell. The introduction of an automated feed from GCCS not only reduced the initialization time required for NSS, but also allowed analysts to evaluate more complex scenarios with larger track groups. A similar approach using the same GCCS HLA interface was successfully demonstrated with the Integrated Theater Engagement Model (ITEM) as part of exercise RSOI in April 02 for United States Forces Korea (USFK).

1.0 Background

Increasingly, simulations are being used during military exercises and operations by the planning and analysis staffs to conduct analysis. Different commands rely on a variety of simulation applications for this purpose. Among the simulation systems currently used to support such analysis are ITEM, NSS, THUNDER, and the Tactical Warfare (TACWAR) simulation.

One of the biggest drawbacks to using such simulations for planning and COA analysis is the inability to readily load data from C4ISR systems into such tools, without the need for manual data entry. This creates long delay times to initialize the simulation and generates data errors through a manual entry process. In many cases, the C4ISR system is not collocated in the cells where the analysis is being performed, complicating the problem even further.

Over the past decade considerable strides have been made in the automation of C4ISR and simulation interfaces. So why does this disconnect exist in data initialization of simulations from

C4ISR systems? The primary reason is that C4ISR-Simulation interface advances have focused primarily on the problem of *stimulating* C4ISR systems with content provided by simulations as part of command post training exercises. While not trivial, this problem has been largely solved through the design of message generators that provide the required content in the appropriate format of the C4ISR system. It has not been necessary to make modifications to the C4ISR system itself - almost all of the changes to improve C4ISR-Simulation interoperability have occurred on the side of the simulation system.

Once the simulation messages are received at the C4ISR system, they are parsed and the content is loaded into the system database, as it would be with an actual C4ISR message. The retrieval of this data, for purposes of initializing an analysis simulation ***does*** require that the C4ISR system be modified in order to be able to extract this data and use it in a simulation. For the most part, C4ISR systems have been unwilling to make such modifications, in part because their configuration management is tightly controlled to ensure that no unnecessary software processes are loaded onto the system that could lead to problems in operating such "go-to-war" systems.

2.0 Approach

While the problem of stimulating C4ISR systems from simulations has been largely solved, it has led to the development of literally hundreds of C4ISR-simulation interfaces. Many of these interfaces replicate functionality between systems – for example, each interface has its own unique message generator capability built in, even though similar formats are generated across the many interfaces (VMF, USMTF, Link 16, etc.). The large number of such interfaces is costly to maintain and has led to an increased effort within the services and DoD to standardize C4ISR-simulation interfaces where possible. Therefore, any approach to addressing the inverse problem of simulation initialization from C4ISR system data should take advantage of C4ISR and simulation standards to the greatest degree possible. This means leveraging common architecture solutions of the Defense Information Infrastructure Common Operating Environment (DII COE) and the High Level Architecture (HLA).

Secondly, the approach to initialization should be "data driven" and not "message driven". The goal of rapid initialization is to take the perceived state of the operation as it exists in the C4ISR system and transfer it as quickly as possible into the simulation. A message-based solution that requires the simulation to parse, correlate, and properly interpret C4ISR messages places an additional burden of processing on that simulation and replicates a function already being handled by the C4ISR system. A more direct approach would be to transfer the data that comprises the correlated picture in the C4ISR system directly to the simulation.

The initialization solution has to be straightforward to implement. As the target audience for simulation support tools is the military planner and analyst, C4ISR-to-simulation solutions must be built so that they can be easily implemented. If the solution requires a large support footprint of contractors it cannot be implemented in a warfighting environment. Ideally, such solutions could be used directly by the user as part of their normal interactions with their C4ISR system.

Finally, the solution has to fit into the constraints of the exercise or operational setting. The introduction of a complex system of hardware and software will generally not be tolerated in an operational setting where space is at a premium. Also, such complex solutions have a larger probability of failure that could impact other operational systems, which is why they are usually discouraged on an operational network.

3.0 GCCS Ambassador

Luckily, one of the key components to address automated initialization already existed at the time this work was undertaken. As part of previous C4ISR-Simulation interoperability experiments, the Naval Research Laboratory (NRL) had already developed a GCCS HLA-compliant interface (known as the "GCCS Ambassador") that allowed simulation data to be sent via the RTI and deposited into the GCCS Track Database Manager (TDBM). This interface was originally developed to work with the Joint Theater Level Simulation (JTLS), an aggregate-level simulation of air, ground, and sea operations used primarily by the Joint Warfighting Center (JWFC) in Joint training exercises. Details of this federation can be found in [Nielsen *et al*., 1998].

The TDBM contains information on all correlated tracks that have been received by GCCS as either Over-the-Horizon Gold (OTH-G) or Link-16 messages or other types of sensor reports. The TDBM is the underlying database that provides data to the GCCS Common Operating Picture (COP). Figure 1 shows a graphical depiction of the interactions between the GCCS Ambassador, the RTI, the TDBM, and the COP all within a single GCCS hardware platform.

Because of its interface to the TDBM, the GCCS Ambassador can either write to, or read from, the TDBM based on data it either receives or sends across the RTI. This is exactly the type of automated interface that satisfies the rapid initialization criteria described in the previous section. However, in order to realize this interface it requires that a portion of the RTI process be able to execute on the GCCS hardware platform itself. While this could have implications for disrupting other GCCS processes, during demonstrations of previous work involving the JTLS-GCCS federation, no noticeable impact occurred to other GCCS processes as a result of running the RTI on the GCCS platform. Since then, the GCCS Ambassador has been extended to work with the Naval Simulation System (NSS) [Lutz *et al*., 1999] , and Pegasus federation [Layman *et al*., 2001] , without any noticeable impact on other GCCS processes.

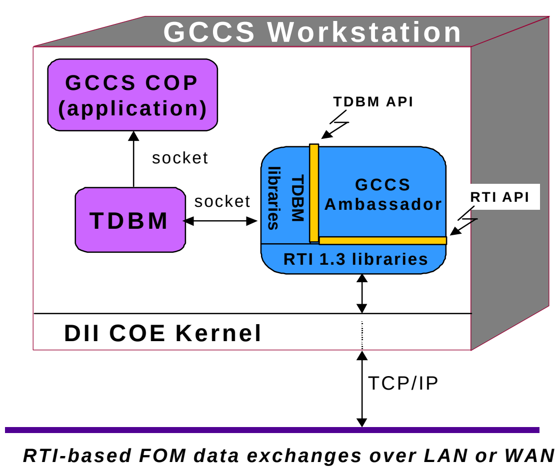

Figure 1. GCCS Ambassador Component Architecture [Lutz *et al*., 1999]

4.0 GCCS-NSS

During the execution of Navy's Global 2000 wargaming exercise, the previously mentioned limitations on initialization of COA simulations for analysis with manual inputs became apparent. NSS was used during Global 2000 in the White Cell, to help with COA analysis and exercise arbitration. In this mode, NSS users would manually input the initial location, speed, and heading information of unit tracks that were desired in the analysis. This approach would often take an hour or more, depending upon the number of units or tracks included in the scenario. Because of the amount of time required, and the difficulty in manually initializing NSS in this manner, COA scenarios were often of limited size and complexity, with typically no more than 20 tracks as part of the COA analysis.

4.1 GCCS-NSS Design

The key to fixing the initialization problem was in the recognition that the previous HLA work involving NSS and GCCS could be applied ***in reverse***. Because the GCCS RTI interface was tied directly to the TDBM, this allowed for ready access to the actual data elements that provided the operational view in the GCCS COP.

The RTI interface into GCCS provides access to all of the data elements in the TDBM. Therefore, the Federation Object Model (FOM) for NSS-GCCS is based heavily on the data elements in the TDBM. In fact, the original FOM that existed between GCCS and NSS that was used to populate the TDBM was re-used with very few alterations to initialize NSS.

Although air track data is available in the TDBM, it was decided not to publish or use this data as part of the federation execution. This decision was made, in part, because of the speed at which aircraft travel, they would quickly 'dead-reckon' out of the area. Combined with the fact that aircraft missions rely on dedicated launch and landing sites and perform relatively complex motion and operational plans, it did not make sense to pass this information over to NSS as part of the COA formulation. Even with the increase in speed in initializing NSS, by the time that multiple runs were performed and the data analyzed the ability to modify tasking associated with aircraft missions would not be possible.

One of the technical challenges addressed during implementation of this federation, was in handling differences in naming convention between NSS and GCCS. Prior to the initialization process, NSS had been "pre-loaded" with an exercise database that contained the Unit Order of Battle (UOB) and details on the capabilities of these units for the Global 2000 exercise. However, as the track data coming into GCCS is derived from a separate simulation that is driving the exercise, in most cases the GCCS data did not directly match what was in NSS. To resolve this mapping, NSS buffered the RTI data prior to forwarding it on to the simulation process and performed pair matching between this track data and its NSS database. NSS employed a mapping table that determined the default mapping from GCCS to NSS. For example, any GCCS track with a Threat value of "FRD" (friendly) would be mapped to the NSS "Blue" alliance. The user could either accept the mapping choices or individually change any mapping target. The mapping process involved associating a GCCS track with an NSS alliance (Blue, Red, White, etc.), an NSS force commander, an NSS asset class, and an NSS tactics table. The mapping function has a memory feature so that it remembers a mapping. For example, if the analyst maps GCCS Track T to the NSS set (Alliance A, Force Commander B, Name C, Asset Class D, Tactics Table E), then that mapping will be "remembered" and will be automatically displayed as the default the next time the analyst imports GCCS Track A.

Another configuration issue for Global 2001 was the requirement to work with the Navy variant of GCCS, or GCCS-Maritime (GCCS-M). GCCS-M only runs under the HP environment, but there is no version of the RTI that can run under HPUX. This problem was addressed through the use of the auto-forwarding function within GCCS-M. Messages were generated by the C4I Gateway, an OTH-Gold message generator linked with the Joint Semi-Automated Forces (JSAF) simulation, and sent to GCCS-M where they were auto-forwarded to a GCCS machine. The GCCS machine was configured to run Sun Solaris, allowing it to run both the GCCS Ambassador and RTI process. This auto-forwarded data was then consolidated on the TDBM on the GCCS Sun machine and sent via the RTI to NSS. A diagram showing the configuration of processes for this exercise is shown in Figure 2. The technical details surrounding this implementation can be found in [Prochnow *et al*., 2001]

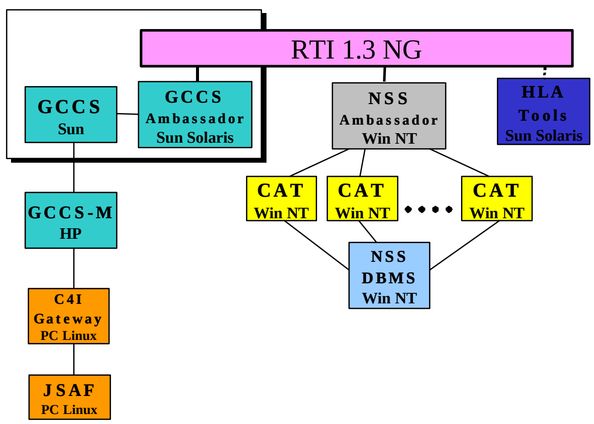

Figure 2: Simulation Architecture for Global 2001 [Prochnow *et al*., 2001].

An interesting operational challenge in using the GCCS-NSS interface was in dealing with "unknown" (identified as neither Blue or Red forces) tracks in the GCCS COP. Such tracks often arise, due to insufficient information received from various data sources that feed the COP. In such instances, unknown tracks in GCCS are transmitted are assigned a value of "unknown" to the "threat" attribute, as they are transmitted to NSS across the RTI. Upon receipt in NSS, they may be assigned an alliance and some sort of general tactics, depending on the nature of the COA that is to be conducted (worst case, or optimal case).

4.2 Implementation in Global 01

During Global 2001, the role of NSS expanded beyond the traditional Red and White Cell support, to provide COA analysis support to the Blue Cell or the NAVFOR Commander. In this role, the ability to rapidly initialize an NSS study using the GCCS Ambassador and provide timely results was key to supporting NAVFOR planners and decision-makers. Unlike previous wargames, the analyses were more robust and used a larger number of tracks (typically over five hundred) which more accurately represented the relatively complex COP.

During the wargame, the NAVFOR Commander would typically direct his staff to consider various options, including use of specific platforms (ships/aircraft), movement of assets, or specific actions against the enemy (such as electronic attack). As the staff developed COAs to consider, the NSS operators/planners would liaison with the NAVFOR staff to determine which general COAs were being considered, pass that information verbally to the NSS operator, who would then use the GCCS Ambassador to pull in COP tracks for the area of interest. This process was so responsive that before long, rather than having to request information from planners to initiate COA studies, NSS operators found that the staff/planners would come to them, asking for a COA analysis. Additionally, by formulating COAs so that they could be simulated and studied with an analytic decision aid like NSS, the details of COAs under consideration were more clearly specified.

The use of the GCCS Ambassador allowed the NSS operator to quickly pass track data to NSS, setup appropriate tactics and communications, conduct multiple Monte-Carlo runs, and provide more timely results to planners and decision-makers. As a result, NSS operator workload was significantly reduced and in most cases NSS COA analysis results were available and presented to decision-makers in time to affect the selection of a particular COA. In many cases, after the NSS operator had built the COA (setting up appropriate tactics) the GCCS COP would refresh NSS one last time – allowing the most accurate picture of the current situation to be used in initializing the COA.

Since less time was spent on manually inputting track data, more time was available to consider additional COAs or refinements to COAs or for planners to ask questions like, “What if I moved this ship here?” or “What if we denied the Red Force's use of this airfield/aircraft?” It should be noted that the use of NSS in this context was not a substitute for sound military judgment. NSS was used as COA decision ***aid***, which provided decision-makers with a better understanding of the underlying factors contributing to a COA outcome and more confidence in the likely success of a decided-upon COA.

Some interesting operational lessons were identified through the use of the GCCS-NSS linkage. One of these was the importance of communication and coordination between the planner/decision-maker and NSS operator. During the exercise, it was quickly realized that the COA initialization process could be inefficient if key elements or details of a COA being considered were not passed to the NSS operator. In some cases, salient information in the COA was omitted during the setup only to be discovered several hours later after multiple runs had been performed. Inputting the missing detail was usually straightforward, but required the multiple COA runs to be performed again. The solution to this problem was to review a standardized COA analysis study checklist prior to run execution. This checklist included such information such as: Scenario Name, Description, Start Time / Duration, What If / Excursions, Blue/Red/White Assets (including Type, Number, Weapons, Sensors, Location, Mission, ROE / Tactics), and results or questions to be answered.

Another unforeseen consequence of using the GCCS-NSS application was that hundreds of tracks could now be “pulled into” NSS immediately, which increased the size and complexity of the scenarios being evaluated. In some cases, the limitations on computer processing coupled with the need to run multiple replications to form a valid statistical sample, required long execution times – sometimes overnight. A potential solution to this problem would be to export the GCCS

COP data to a “reachback” analysis center, where adequate computing power is present. Such resources as the high performance computers located at Maui, Hawaii, may have the sufficient processing power to serve COA analysis needs for an entire theater. More discussion of “reachback” potential for this technology is contained in Section 7.2.

While the availability of GCCS COP data significantly improved initialization time and accuracy, it was still necessary for the NSS operator to manually “fill in” enemy intentions and estimate the locations of unobserved (but known to exist) units, such as submarines. This requirement added to the operator workload and increased the amount of time that it took to run an analysis and provide results to decision-makers. The use of additional C4ISR data sources, beyond the GCCS COP, could help to improve the completeness of the initialization (see Section 7.1).

With the improving use of simulation aids, such as NSS, during the planning and analysis portions of military operations, it is likely that there will a migration away from analyst-based support towards more direct use by fleet operators. As a result, it will be critically important to train these fleet operators and planners to accurately use and realistically interpret the results from these types of analytic decision aids.

A final operational consideration for the future will be in dealing with the real world problem of track latency. Since the GCCS COP was artificially generated using the JSAF, none of the track reports were significantly delayed. If used in an operational environment where GCCS tracks might be delayed by minutes or hours, it may be necessary to filter or discard tracks that did not meet specified criteria for timeliness or updates.

4.3 Implementation in NORWESTPAC Exercise 02

During March 02, the GCCS-NSS application was used during the Navy's NORWESTPAC exercise at NWC, in Newport, RI. The use of the federation, prior to the start of the exercise, allowed the base game scenario in NSS to be constructed in a single day - a process that typically takes an entire week. In addition to reducing the initial scenario development time down to a single day, the execution of simulation runs during the exercise was done in under an hour. This base scenario involved over 700 tracks that were updated periodically over 3 days of game play. The federation was up continuously for all three days with only minor hiccups that were very apparent and easily recovered from.

While NSS was not used directly in this exercise for COA development and analysis, the use of the GCCS-NSS linkage highlighted another important capability of this federation. During this exercise the GCCS Reconstruction Logger (or "Recon" tool) was used, allowing for the capture of all track data corresponding to OTH-Gold messages received by GCCS. The recording of this information, along with the use of NSS, allows for simplified post exercise analysis. At the end of this exercise, the Recon data was sent to CINCPACFLT for their post-game analysis efforts and to serve as baseline data for other studies that they are conducting. CINCPACFLT recently completed installation of the GCCS-NSS capability at their location, so that they will be able to initialize NSS for analysis runs based on the same set of data that was used in the NORWESTPAC exercise.

5.0 GCCS-ITEM

During a visit to United States Forces Korea (USFK) in February 2001, personnel from the Defense Modeling and Simulation Office (DMSO) held discussions with the USFK planning and analysis cells to attempt to determine what M&S shortfalls they were experiencing. The most critical issue that was brought up in the discussion was the need to "***feed the planning and analysis cells with GCCS data to aid in the development of courses of action during the exercise***." The simulation application used most widely by the USFK warfighter analysts is the Integrated Theater Engagement Model (ITEM). As this model had already developed an HLA interface, it was felt that extension of the work involving GCCS-NSS for GCCS-ITEM could be a straightforward solution to the GCCS data distribution issues for planning and analysis.

After coordination with the Defense Threat Reduction Agency (DTRA), the proponent for the ITEM model, a task to replicate the capabilities of GCCS-NSS using ITEM was initiated over the summer of 2001. The goals of this task were to develop a GCCS-ITEM automated initialization capability that could be used on a trial basis as part of exercise Reception, Staging, Onward-Movement and Integration (RSOI) in April 02, with full implementation planned for exercise Ulchi Focus Lens (UFL) 2002.

5.1 GCCS-ITEM Design

Because the data available via the RTI from GCCS is relatively fixed (based on the data elements in the TDBM), most of the modifications that were necessary to the federation were done on the ITEM side - not on the GCCS side. Many of the technical issues resolved during implementation with NSS were carried over and applied for the ITEM model. This included the development of a GUI that allowed for pairwise matching of track names with database object names, and the use of a similar set of procedures for initialization. In addition, the ITEM user associates GCCS tracks with ITEM objects though a *correlation* process, and then performs *synchronization* to place newly correlated data into the ITEM database.

As modifications to the ITEM HLA interface were made to accommodate the reception of track data, a test federate was provided to the ITEM development team (SAIC) to use during component testing. The Simulation Integration Test Harness (SITH) is a component developed by the MITRE Corporation that allows easy emulation of other federates during the development process, as a way to test federates under development without the need for the actual set of federates to be in place. This component was provided to SAIC for development testing in San Diego, long before the more formal integration events took place. The use of the tool allowed the SAIC team to stimulate their ITEM model with expected GCCS track attributes based on the FOM, long before they actually participated in the first integration event.

5.2 Implementation in RSOI 02

The use of GCCS-ITEM in RSOI 02 was to be limited to a technical demonstration in order to test run the application in an operational setting. Thus, the focus was on verifying the technical capabilities of the federation in the USFK environment and not on use as a COA analysis tool during the exercise.

In order to conduct operational testing of the GCCS-ITEM design during RSOI 02, a great deal of technical development was completed by DMSO (project sponsor), MITRE (integration and test), NRL (GCCS Ambassador developer), and SAIC (ITEM developer) prior to the exercise. Working with Operations Analysis Branch (OAB), USFK, the design team began building the same data transfer functionality into GCCS-ITEM as had been previously demonstrated with GCCS-NSS. During the course of building the GCCS-ITEM linkage, the design team began coordinating with the USFK J6 to provide the necessary security documentation to physically connect ITEM with the GCCS COP. Coordination with the J6 required the design team to resolve several physical and technical security issues in accordance with the procedures outlined in the Defense Information Technology Security Certification and Accreditation Process (DITSCAP). A critical step in this process was the submission of a System Security Authorization Agreement (SSAA) for the certification and accreditation of the GCCS-ITEM linkage from the GCCS COP through the federation directly to ITEM. For RSOI, the SSAA was not processed and therefore an interim technical solution was required that met all the security requirements of the J6. Due to the efforts by MITRE, an interim authority was granted to operate the GCCS-ITEM system via an "air gap" (see Figure 3). This air gap allowed for the manual transfer for the COP track information from GCCS to the GCCS-ITEM ambassador system. With this solution, the design team could execute the GCCS-ITEM design testing during RSOI with an interim security approval. The entire system setup was assessed to be level 1 security (low risk).

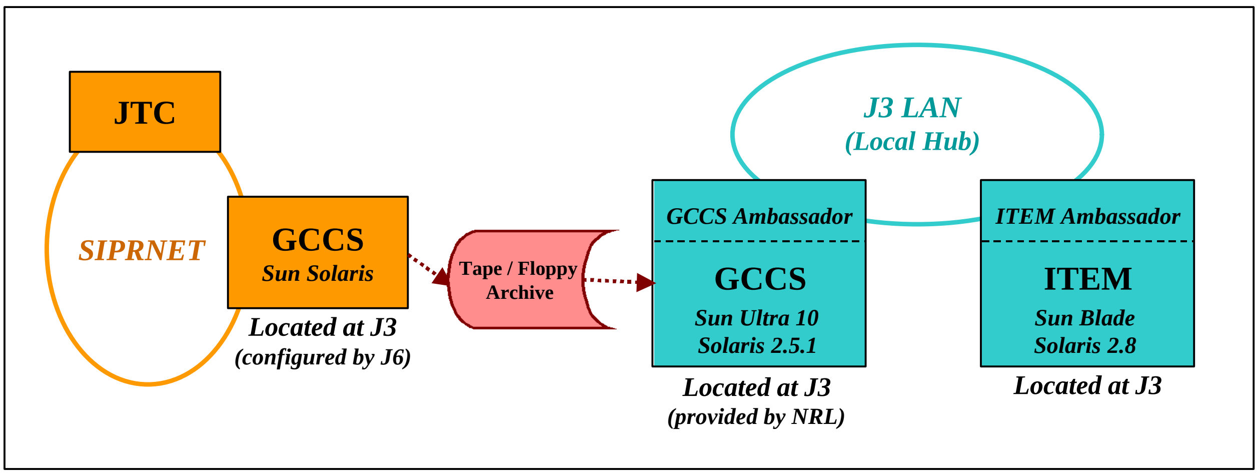

Figure 3. Simulation Architecture for RSOI 2002.

As described in detail with the GCCS-NSS design the capability of linking analytical models to the current operational situation greatly improves the wargaming potential of any warfighting staff. Since virtually all the Combined Forces Command (CFC) wargaming is conducted with analytical models the ITEM-GCCS design will become a staff multiplier. As demonstrated with the GCCS-NSS work there are some immediate benefits to this process that were validated during RSOI:

1. Immediate upload of the COP tracks into the analytical model reduces the time required to "fat finger" or manually enter the data. The time saved not only allows for more opportunities to conduct COA analysis but it also avoids information latency. In the previous manual procedure, by the time an analyst loaded the data, some of the information may be so obsolete that it made any subsequent analysis invalid.

2. The automated system of uploading the data avoids mistakes that inevitably occur when manually entering data.
3. The utility of ITEM as an analytical tool is greatly enhanced by the quick refresh of current data. Currently, ITEM is used as a stand-alone analytical tool used in deliberate planning and not within the context of a model assisted wargame for the theater staff. Because ITEM has the potential of uploading all the component data (Air, Ground, Maritime, and Special Operations Forces) quickly from the GCCS COP the USFK planners will soon explore the utility of ITEM as an interactive wargaming tool for COA development.

The GCCS-ITEM design also highlighted other critical needs in the CFC automated planning efforts. CFC is currently working to provide the Ground Component Command (GCC) with a collaborative planning tool to conduct wargaming over a classified distributive network. This tool, developed at The US Army Communications Electronics Command (CECOM), is known as the Combined Arms Planning and Execution-Monitoring Systems (CAPES) and is a variant on the Battlefield Planning and Visualization (BPV) and DAVINCI planning tools already demonstrated during USFK exercises. As the command struggles to develop its collaborative planning tools there appears to be a definite need to synchronize the distributed wargaming sites. It became obvious to the CFC staff that a C4ISR-Simulation realtime initialization capability, like the one provide by GCCS-ITEM, would be required for any collaborative planning and wargaming process.

6.0 Near Term Plans

6.1 Near Term Exercise Applications

Due to the successful introduction and use of the GCCS-NSS federation during Global 2001, plans are underway to install NSS and the GCCS Ambassador onboard the USS CORONADO in support of a Joint Task Force Exercise (JTFEX) in late Spring 2002. The CORONADO will serve as command ship for Commander, U.S. THIRD Fleet, during this Abraham Lincoln Battle Group's (ALBG) JTFEX. The GCCS-NSS federation will be used in a similar way to the Global '01 application - allowing rapid initialization of NSS scenarios using the GCCS Ambassador to support COA analysis and decision-making. However, in this exercise, NSS will be used to support operations in a more realistic non-laboratory environment, potentially affecting the use and employment of actual physical assets. NSS will be used in direct support of the Joint Forces Maritime Component Commander (JFMCC) and plans are underway to provide additional support to the ALBG Commander and his Primary Warfare Commanders (PWC). While details are still being worked out, initial plans are to use the GCCS Ambassador onboard the CORONADO to pull in the GCCS COP and initialize NSS. This initialization will result in a baseline scenario within NSS that will be sent via SIPRNET email attachment, on request, to planners and decision-makers onboard the USS LINCOLN. The NSS operator, onboard the LINCOLN, will provide analyst support to the BG staff and planners. Only a single instance of the GCCS-NSS linkage will be required, resulting in the generation of two NSS scenarios that can be evaluated at different locations.

The GCCS-ITEM design will continue to be refined and USFK will pursue formal security approval in time for application in Ulchi Focus Lens (UFL) 2002 - thus eliminating the "air gap" requirement. During UFL 02, USFK plans to fully employ the GCCS-ITEM application as part of the COA process. SAIC is working to make the linking of COP tracks to designated objects more automated. It is expected that all these fixes will also be completed prior to UFL02. During the exercise the GCCS-ITEM design will enable the quick turn around of COA analysis required for the Naval Component Command (NCC) that has been lacking in previous exercises. The maritime analysis section of OAB will conduct most of this work. Additionally, it has been briefed to MG Miller, CJ3, that efforts would be made to test the feasibility of ITEM as a CFC wargaming tool for the theater staff. Because of the compressed timelines for COA development the GCCS-ITEM design will be critical for this effort. By quickly uploading current information from the COP, the theater staff will now be able to wargame COA's in a more responsive manner. It is expected that the design itself will function properly and that the major obstacle will be staff training on computer assisted wargaming and overall ITEM functionality.

6.2 DII COE

The Defense Information Infrastructure Common Operating Environment (DII COE, or just "COE") is a software environment that is configuration managed by the Defense Information Systems Agency (DISA) with the intent of promoting interoperability and re-use of major C4ISR software components on DoD systems. The use of the COE is mandated by DoD within the Joint Technical Architecture (JTA) [JTA, 2001], so that all C4ISR systems will have the assurance of running under a common configuration managed and tested environment. It is also intended to provide a common foundation of software that can be applied across a wide variety of end user applications so that individual C4ISR systems ("Mission Applications") do not have to develop functions that are already available in the COE.

As discussed previously, in applications such as GCCS-NSS and GCCS-ITEM it is essential that certain M&S applications (such as the HLA RTI) run on the same platform that the C4I system is operating on. While C4ISR system developers may be willing to employ such M&S components within a system as part of a demonstration or prototype effort, it is unlikely that such software will be fielded unless it is brought under the configuration management (CM) process of the C4ISR system. As the GCCS Ambassador and RTI have been shown to be useable across a range of simulation systems, it became a straightforward decision to pursue "segmenting" both components as part of the COE.

Recently, both the GCCS Ambassador and RTI have been modified in accordance with COE guidance to allow for submission to DISA and acceptance into the COE. This process is being coordinated through the COE Modeling and Simulation (M&S) Technical Working Group (TWG) which identifies M&S requirements for the COE and coordinates implementation of new M&S segments. Both the RTI and GCCS Ambassador are targeted initially for use as COE-compliant Mission Applications, under GCCS. The eventual goal is to submit a commercially developed version of the RTI into the COE 4.x baseline that can be downloaded as part of the COE software suite with other standard C4ISR applications. This should eventually lead to the ability to install the GCCS Ambassador and RTI directly on operational GCCS systems for use, rather than relying on the use of a separately configured Sun machine that receives forwarded OTH-G tracks.

6.3 Potential Enhancements

Among the enhancements under consideration for both NSS and ITEM are the transmission of overlay information, interpretation of C2 messages directly by the simulation, bi-directional transmission of data, and use of automated UOB tools for building the pre-application simulation database. All of these enhancements discussed in this section are still under evaluation, and will be implemented pending funding and prioritization by the organizations involved.

Overlay information includes graphic data that appears on map overlays - such as phase lines. This information can be readily generated within GCCS as part of the tactical picture and could be transmitted across the RTI with appropriate extensions to the FOM. This would allow for a more robust set of data from GCCS to be transmitted across for COA initialization.

Another area that warrants potential investigation for improvement is in the interpretation of C2 data directly by the simulation. In its current form, the GCCS initialization process is able to transact the "nouns" from GCCS and align this data with information in either NSS or ITEM. However, in order to execute a COA the "verbs" (i.e., orders, enemy intent, etc.) are required to be able to direct units to specific locations and provide them with the appropriate set of actions for engagement. Ideally, this could be done via the C4ISR system so that an NSS or ITEM operator would not have to input these orders into the simulation as part of the initialization process. Already, three sets of rudimentary commands from GCCS can be understood by NSS - a PIM track (Path of Intended Movement), Screen Kilo, and Whiskey Grid - had been implemented as part of the previous GCCS-NSS federation. However, to simplify the COA process for Global 2001, none of these were implemented during the exercise.

A bi-directional data flow would not only allow for the initialization of the simulation from the C4ISR system, but would allow for the playback and display of the simulation within the C4ISR system. This could have profound impact on the way in which planning information is distributed to various C4ISR systems. In fact, such a system could potentially reduce ambiguity in current text-based planning data.

Another areas that warrant investigation is the direct database build of a simulation, based on Unit Order Battle (UOB) information associated with the scenario. While the GCCS COA process allows for rapid "alignment" of the database elements in either NSS or ITEM, it does not address the problem of building the database from scratch, prior to exercise execution. The use of automated UOB tools may be one way to improve this process.

6.4 Application to Other Models

While any simulation that is HLA compliant could in theory derive data from GCCS in this manner, there are only a select few that are used in the execution of COA and deliberate planning applications that really need this capability. The Joint Warfare System (JWARS) is one of the simulations that is currently considering adopting this technology for use. As JWARS has a requirement specified in its Operations Requirements Document (ORD) for operating as a COA application [JWARS, 1998] in support of CINC analysis requirements, this type of initialization scheme may be well suited for it. JWARS has recently developed an HLA interface for use with other applications, which would provide a straightforward approach for implementation with the GCCS Ambassador.

7.0 Long Term Direction

7.1 Additional C4ISR Data Sources

While the GCCS COP provides a significant amount of information on enemy and friendly units, it does not contain several bits of data of interest to the analysis of COAs. Among the data sources that would be beneficial for inclusion in this federation are the Master Intelligence Database (MIDB), Status of Resources and Training Systems (SORTS), and Joint Operation Planning and Execution System (JOPES) data. Also, since GCCS is an aggregated view of the entire theater battle, it tends to lack certain detail that can be found in component data sources such as Theater Battle Management Core System (TBMCS), and the Joint Common Database (JCDB). Implementation of COA analysis at lower echelons may require finer resolution data that can only be found in these component C4ISR systems.

Over time, GCCS is planning to move to an Integrated Imagery and Intelligence (I3) architecture that will incorporate elements of the MIDB into its architecture. This information should in turn be available to the GCCS Ambassador for export to HLA-compliant simulations that are part of the COA initialization process. Recently, the Army TRADOC Analysis Center (TRAC) has developed an RTI interface to the JCDB that may provide a way of initializing applications from that data source. Other solutions for accessing MIDB and other C4ISR databases via the RTI are under investigation.

7.2 Reachback Applications

Analysis simulations have been used for years in a "reachback" mode where data from the Theater is typically forwarded to an analysis center for incorporation into a simulation that projects outcomes over the next hours or days. In most cases, the data that is transmitted back to CONUS sites consists of the daily CINC briefing, built in Powerpoint, and containing representative data on the current theater picture. For example, during UFL 00, analysts at the Army's Center for Army Analysis (CAA) used the daily CINC briefing to perform runs on their Concepts Evaluation Model [Read *et al*., 2001].

Extracting data from the CINC briefing and inputting it manually into CEM has many of the same problems as inputting the data into Theater analysis tools such as NSS and ITEM. A more efficient approach would be to export the C4ISR picture from Theater back to CONUS where the reachback analysis is to take place. Initialization of the simulation could then be done, on demand, in faster time and with fewer errors.

This approach has the advantage that different simulations that are HLA-compliant, could all tap into the same theater picture and run concurrent analysis. Different analysis centers could be focused on different portions of the operation - over the next several hours or over the next several days. Within a single location, multiple instantiations of the same model might be used to conduct multiple runs of a COA concurrently, in order to generate larger sample sizes of potential outcomes. This could be done simply by federating multiple versions of a model to the RTI to pull data, or by developing an architecture that provides a client/server approach similar to that discussed above for the GCCS-NSS application in Global 01.

7.3 Execution Monitoring

One of the most compelling ways in which the initialization capabilities discussed above could be exploited is via execution monitoring of operations. Once a simulation is "aligned" via the initialization scheme described above, and the appropriate operational plan (OPLAN) data is loaded, the simulation could be run in realtime and constantly compared to the C4I picture. The use of the RTI as the linkage between a C4ISR system and simulation allows for straightforward implementation of such a scheme. Once data has been used to initialize the simulation, the simulation would then publish data on state changes of its units as it runs. In fact, since the existing GCCS-ITEM/NSS FOM distinguishes object class by “Real” (published by GCCS) or “Simulated” (published by ITEM or NSS), it could be utilized readily for such a purpose. A monitoring federate attached to the RTI could easily track inconsistencies between the state of a unit within the simulation and the C4ISR system. Depending on the threshold set by the user (distance or time deviations) an alert could provide a commander with information on when a particular unit is "off plan"

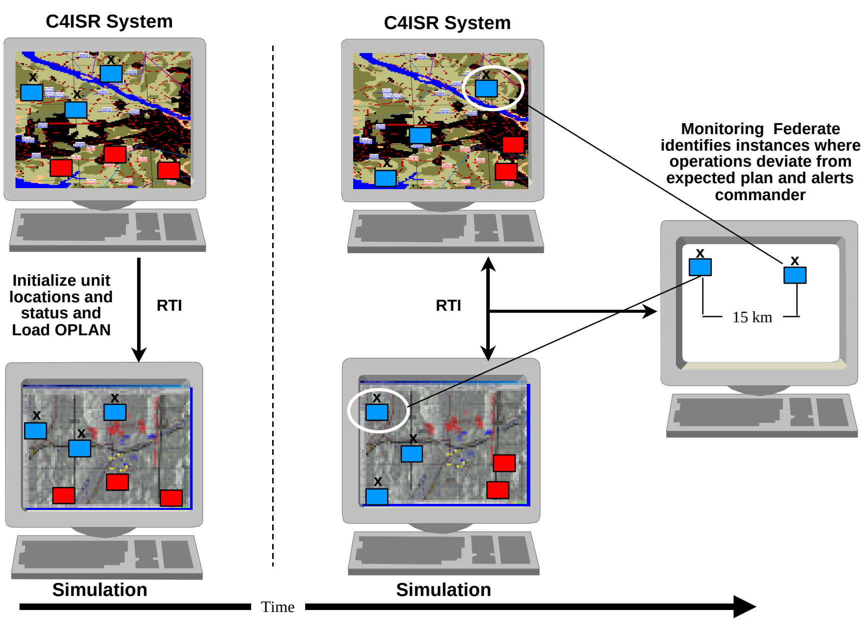

Figure 4. Potential Execution Monitoring Application.

The use of such a capability would not only have implications for ensuring that Blue forces remain synchronized, but could also alert planners to instances when Red forces deviate from the expected tactics that underlie the OPLAN.

One of the most interesting aspects of such a system would not just be the alert capabilities that it could provide, but an eventual capability to determine what the impacts of such deviations are within the OPLAN. In such cases, an additional simulation could be federated with the applications mentioned above and run in a faster than realtime mode to perform projections based on the deviations seen across the system. This could eventually help commanders to determine whether or not deviations in unit location or delays are important enough to warrant retasking, and could also identify opportunities to deviate from the OPLAN to take advantage of the evolving operational picture.

7.4 Collaborative Planning

While current uses of the GCCS-ITEM and GCCS-NSS applications are focused on COA analysis, there is no reason why the basic components of this technology could not be applied during the planning phases of operations. In particular, this technology could have significant impact during crisis action planning - where no OPLAN currently exists and the current C4ISR picture rapidly transferred into a simulation could enable faster generation and analysis of a crisis action plan. In military conflicts such as operations other than war (OOTW) and military operations in urban terrain (MOUT), where crisis action planning performed more, such a capability could prove invaluable. One possible solution here would be to pursue a GCCS initialization capability with the Joint Conflict and Tactical Simulation (JCATS), a simulation tailored for analysis and training of OOTW and MOUT missions. JCATS HLA interface may make such a solution straightforward to implement.

The rapid transfer of C4ISR data to a simulation used in planning could also greatly benefit the refinement of existing OPLANS. By initializing a theater-level simulation and then federating other more detailed simulations (such as signal models, intelligence models, and logistics models), the impact of the OPLAN on detailed functions can be determined ahead of time. The use of the C4ISR system feed to obtain the latest information on friendly and enemy posture to refine the OPLAN, could be a tremendous asset in operational planning.

7.5 Joint Experimentation

Because of the potential to improve the C2 decision process, a potential venue for use of this technology is in joint and service experimentation events. In addition to the major joint experiments such as Millennium Challenge 02, JFCOM also hosts a series of Limited Objective Experiments (LOEs) that are smaller in scale and more focused. Such events could be ideal for experimenting with rapid COA initialization techniques.

8.0 Summary

The application of the GCCS-NSS and GCCS-ITEM automated initialization schemes is an important step in improving the utility of M&S in operations planning, analysis, and execution monitoring. The operational utility of faster initialization of these models, along with more accurate transfer of data has been demonstrated in exercises such as Global 2001 and RSOI '02. The use of standards such at the HLA and DII COE have contributed directly to implementing a solution for data transfer between C4ISR and simulation systems that is straightforward to implement, and readily extensible.

Once the foundation has been laid of moving data from C4I systems into simulation analysis tools, we will be able to take advantage of new M&S techniques and applications that can provide the warfighter with decision support aids in prosecuting the battle. Solving the data transfer problem is a key part of enabling the employment of execution monitoring applications, collaborative planning tools, and reachback applications for the warfighter. Together, such tools will help us achieve the vision of Transformation and Information Superiority documented in Joint Vision 2020.

9.0 Acknowledgements

The authors wish to acknowledge the support of the Defense Modeling and Simulation Office (DMSO), and model sponsoring organizations of NSS (OPNAV N6M), and ITEM (DTRA). In addition, we would like to thank the willing participation of user sites involved in adopting these applications, including the Naval Warfare College (NWC), CINCPACFLT N64, SPAWAR PMW-153, and USFK. Finally, we would like to thank the contributions of individuals from the integration and development teams including MITRE, SAIC, NRL, and Metron, Inc.

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