Integration of OneSAF Objective System into Existing Virtual Programs

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ABSTRACT

One of the key short-term objectives of the Synthetic Environment Core Architecture and Integration (SE Core A&I) program is integrating the U.S. Army's OneSAF Objective System (OOS) into the Close Combat Tactical Trainer (CCTT) and Aviation Combined Arms Trainer (AVCATT). To accomplish this, SE Core A&I must bridge conceptual, programmatic, and technology gaps between the impacted programs. SE Core's OOS integration activities will provide valuable lessons-learned regarding the transition of established, stable legacy systems to new, common technologies that are not specialized to their needs. This paper will focus on the technical and practical issues and successes to date with OOS integration into CCTT and AVCATT. Specific, detailed examples will be cited to illustrate the key lessons-learned, including transition from constructive to virtual needs, updates to OOS' Synthetic Natural Environment (SNE), transition of legacy models to a new architecture, impacts to fair-fight, and the spider web of impacts and dependencies reaching into other system components. Upcoming technical activities required to complete OOS integration will be described in detail, along with potential solutions.

ABOUT THE AUTHORS

Peggy Hughley has over 11 years of experience in modeling and simulation applications, with a specific focus on modeling behaviors, digitization and graphical interfaces. Ms. Hughley has worked with CGF applications within the CCTT and OneSAF Objective System. Ms. Hughley has been involved in large programs and smaller efforts filling roles such as software developer and team lead. Ms. Hughley has authored or co-authored three conference papers and many technical reports. Ms. Hughley is currently a team member on the SE Core A&I project.

Jon Watkins has over 15 years of experience in modeling and simulation applications, with a specific focus on terrain databases, terrain services, and entity-level movement control algorithms. Mr. Watkins has worked with the CGF terrain formats and/or services for SIMNET, ModSAF (now OTB), CCTT, WARSIM, and OneSAF Objective System. Mr. Watkins has authored or co-authored nine conference papers and many technical reports. In 2004, Mr. Watkins formed Dignitas Technologies, a consulting firm, and is now a team member on multiple projects. On SE Core A&I, Mr. Watkins leads the SNE portion of OOS Integration into CCTT and AVCATT.

Jim Moerk has over 8 years of experience in modeling and simulation applications, with a specific focus on modeling behaviors, digitization and interoperability. Mr. Moerk has worked with CGF applications within the OneSAF Testbed, CCTT, and OneSAF Objective System. Mr. Moerk has co-authored one conference paper and many technical reports. Mr. Moerk is currently a team member on the SE Core Architecture and Integration project. Mr. Moerk leads both the Interoperability and C4I Integration efforts for SE Core A&I.

Angela Chang has over 16 years of experience in modeling and simulation applications. Ms. Chang has worked as a project/systems lead engineer supporting the Navy and U.S. Army on numerous highly complex military simulations. Ms. Chang has spent the last eight years working in the constructive domain. Until recently, Ms. Chang worked with CGF applications within the OneSAF Objective System program. Ms. Chang is currently a team member on the PEO STRI SE Core Architecture and Integration team.

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INTRODUCTION

The primary objective of the Synthetic Environment Core Architecture and Integration (SE Core A&I) program is integrating OneSAF Objective System (OOS, or "OneSAF") into the Close Combat Tactical Trainer (CCTT) and Aviation Combined Arms Trainer (AVCATT). To accomplish this, SE Core A&I must bridge conceptual, programmatic, and technology gaps between the impacted programs. For OOS to be successfully integrated, attention must be paid to how the simulation components work together to meet the training needs of the legacy systems. To meet this objective, the first nine months of the SE Core A&I project were dedicated to an analysis of the AVCATT and CCTT simulations. The analysis was used primarily to define the boundaries for the integration, e.g. which components of CCTT and AVCATT would be impacted and how. An additional purpose was to determine the capabilities of CCTT and AVCATT in comparison to those in OOS. The areas of reuse or overlap from each of the systems were defined. The maturity of each of the components of the systems was considered as well as the CVCs (Common Virtual Components) being developed by another task on the SE Core project. Future and current development on the programs was also considered to ensure that functionality of the systems was not lost as they evolved.

The results of this analysis were documented in the Integration Approaches document. Functional Integration Approaches defined the best technical solution for the integration by subject areas such as models, synthetic natural environment, dynamic terrain, voice communications, C4I communications, and user interfaces. Component Integration Approaches provided a description of how each component of the AVCATT and CCTT systems would be modified, and which parts of OOS would be reused. The reports and approaches were reviewed by all three impacted systems. Comments and issues on the reports and approaches were incorporated into the final report.

SE Core also hosted and continues to host numerous technical interchange meetings (TIMs) with other programs such as the Army's Future Combat System (FCS) and Common Gunnery Architecture (CGA). These provide a means to exchange functionality, knowledge, and lessons learned with other programs that are reusing OOS. The exchange minimizes duplication of efforts and ensures that we do not try something that has been proven unsuccessful by another program. This information allows SE Core developers more time to do tasks that are specific to virtual simulation needs.

OOS integration requires a resolution to several key challenges. One key to success for OOS integration is bridging the gaps between OOS' fundamentally constructive capability and virtual simulation system needs, including the specialized needs of CCTT and AVCATT. Another challenge arises due to the fact that all three programs are still in development. SE Core began in April 2005 while OOS did not have its official Government Acceptance Test (GAT) until June 2006 with its first post-GAT release coming in August 2006. While SE Core was trying to integrate OneSAF into CCTT and AVCATT, there were many known problems that OneSAF was in the process of correcting - some of which required architectural changes. Examples of this include updates to the interoperability component, the data model, and the model compositions. These issues are being mitigated by close communication with OneSAF management and developers.

The remainder of the paper focuses on describing current work completed and, as of this writing, planned through November 2006 followed by various areas that need to be addressed in the future. As CCTT, AVCATT, and OOS evolve, we fully expect plans to evolve in concert. Similarly, the extent and type of interactions between the programs ebbs and flows based upon various inter- and intra-program deadlines that come and go. The technical successes are described in light current plans and objectives.

TECHNICAL SUCCESSES

SE Core's OOS integration activities will provide valuable lessons-learned regarding the transition of established, stable legacy systems to new, common technologies that are not specialized to their needs.
The following sections describe technical and practical issues and successes to date with OOS integration into CCTT and AVCATT, which can serve as useful lessons-learned for future SE Core efforts.

Synthetic Natural Environment

Synthetic Natural Environment (SNE) provides an excellent example of why "replacement" of the CCTT and AVCATT Semi-Automated Forces (SAFs) is not a straightforward swap of one application for another. Both CCTT and AVCATT share SNE services between SAF and manned modules applications. For example, AVCATT manned modules use the same line-of-sight algorithm as AVCATT SAF, while CCTT manned modules and CCTT SAF use the same collision detection and height of terrain calculations. This approach helps to assure fair-fight and correlation of results between manned simulators and SAF entities. Similarly, SNE efforts are heavily impacted by the underlying terrain databases. The existing CCTT and AVCATT visual databases are expected to remain much the same throughout SE Core A&I's integration efforts. As a result, some mechanism must be found to convert between the conceptually very different terrain database formats used in CCTT and AVCATT versus OOS.

Example Differences in SNE Services

Significant differences exist between the as-built capabilities of CCTT and AVCATT as compared to OOS for SNE services and design. Selected differences are discussed here to illustrate the issues SE Core A&I are working through.

The concept and design of the SNE *service layers* for CCTT, AVCATT, and OOS vary significantly. At one extreme, CCTT's terrain databases are tightly encapsulated and hidden within a few functional areas. For example, CCTT's environment subsystem provides answers to functional questions only, not access to underlying SNE data. At the other extreme, OOS' Environment Runtime Component (ERC) services have a minimal semantic and geometric understanding of feature data as defined by the OOS Environment Data Model (EDM). ERC users in OOS directly query and receive data, especially feature data, and operate on it natively. In short, OOS' ERC emphasizes "get data" type operations, while CCTT and AVCATT tend to emphasize "get results." This difference has generally resulted in SE Core adding services centralized within OOS' ERC. This will support reuse across virtual components (e.g. SAF versus manned module), but also will provide more centralized maintenance and code modifications.

OOS's *database representation* is heavily data-driven, through an EDM, providing much greater flexibility for database format and feature content changes than CCTT or AVCATT can support. CCTT and AVCATT SAF use database formats that categorize features into limited bins based upon interaction and visual representation. While the OOS mechanism is far more flexible, the actual EDM instantiation in use for terrain data is overly complex. CCTT and AVCATT database formats are heavily compressed at the representation level, whereas OTF is not. This results in a significant size difference (increase) when using OTF, in return for cleaner, more understandable data structures and on-disk representations.

OOS is based upon true round earth global *coordinate systems*. CCTT is limited by Universal Transverse Mercator (UTM, a "flat earth" projected coordinate system). AVCATT uses a hybrid of these approaches called Global Coordinate System (GCS) for SAF and SNE processing.

ERC's *implementation language* is C++, but OOS accesses this C++ through the Java™ Native Interface (JNI). CCTT's SNE services are written in Ada. AVCATT's comparable services are primarily in C (with some Ada).

ERC Integration into Non-SAF Components

OOS' ERC is being integrated into the CCTT and AVCATT manned simulators, thereby allowing SNE services to be shared in CCTT/AVCATT modules alongside the integrated OOS capability. The overall ERC Integration approach is to leave in place the current interfaces to the extent possible, but change the "body" of the implementation such that it calls ERC. For example, AVCATT's "Environmental Interrogator" interface for line-of-sight will be left in place. Under the covers, code is being added to allow the line-of-sight (LOS) call to go to either the legacy service (libCTDB) or the new service (ERC). Similarly, CCTT environment subsystem interface remains the same, but the Ada bodies are being altered to call either the original service or the new ERC-based service.

For all aspects of ERC Integration, SE Core's implementation will allow the old and new services to be swapped out. For example, if stability or performance issues arise with the ERC Integration capabilities, it will be possible to execute with the legacy terrain services and terrain database. This swappable capability will be eliminated once sufficient surrounding functionality (e.g. dynamic terrain) is available and ERC specialization is completed.

For CCTT, common SNE services are being used throughout the system, reaching beyond the SAF and manned simulator. For example, the CCTT after action review (AAR) station uses the same height of terrain algorithm to keep the free-fly eyepoint above the terrain skin. These services have been addressed through ERC reuse and can also be swapped between legacy or ERC implementations.

Refinement of SNE Services

To CCTT and AVCATT, the Computer Generated Forces (CGF) is of secondary importance. The human-in-the-loop (HITL), and particularly what the HITL sees, is what matters most for training. This requires detailed "realism" refinement within CGF specific to features, visuals, how the manned simulators operate (i.e. fair-fight), etc. For example, prepared fighting positions in CCTT are not an abstract concept. In a virtual environment SAF entities must find these fighting positions, verify that they can accurately path-plan to the entrance, line the vehicle up with the entrance before proceeding down the ramp, move down the ramp slowly, and then recognize the difference between covered and defilade positions (for fighting positions that have these). Supporting algorithms like line-of-sight and collision detection must fully support the visual (and therefore geometric) implications of a vehicle being in a hole. It is this type of specialized interaction that stands out as requiring more complex, specialized solutions in the virtual domain.

These issues will follow two patterns. First, for services that are needed for correlation or fair-fight, centralization will be required to assure the same result given the same input. This supports integration of ERC into the manned simulators. Second, services in general, but particularly feature interactions, must be updated to meet full virtual functionality and fidelity, including the "appearance" of the right functionality when viewed on a visual system.

Database Generation Capabilities

Long-term, SE Core A&I will rely on a sister SE Core Program (Database Virtual Environment Development, or DVED) to build virtual simulation databases. Each legacy terrain database format that is retained after OOS integration will have to be supported through this future process.

In the interim, SE Core A&I has conducted limited conversions of existing CCTT and AVCATT databases into OOS' Objective Terrain Format and has generated new databases using the same source as comparable CCTT and AVCATT databases. These converted datasets have been useful in testing system functionality, e.g. providing more complex datasets and allowing testing of OOS within a virtual (i.e. a visualized) environment.

The main area of concern for database generation is OOS' approach of publishing a format, then allowing multiple vendors to meet the format requirements. The difficulty with this approach is the need for data to be represented not just in the right bits and bytes, but also in a way that supports simulation requirements and semantics. For example, the OOS EDM provides for a feature called "steep slope." At present, database producers will presumably only populate that feature type if source data includes such a feature (i.e. they never do). In reality, the steep slope feature should be placed everywhere that a ground polygon, or contiguous set of ground polygons, exceed a particular slope characteristic. This feature could then be used at run-time to allow obstacle avoidance algorithms to avoid steep terrain. Unfortunately, this type of relationship (steep terrain derives steep slope) is not captured in the EDM or in the database format. Thus, a key capability is lost. SE Core's sister program, DVED, will help resolve issues such as this by centralizing database production.

Test Capabilities

SE Core A&I has focused on test capabilities throughout its SNE integration activities. SE Core has extended existing, or created new, test tools to support correlation testing across systems, visualize SNE geometry databases and services, etc. For example, SE Core A&I extended a WARSIM test application to allow its use within OOS and for virtual services. This allowed direct visualization of OOS' OTF databases, visualization of collision detection and line-of-sight results, etc. SE Core's developed test capabilities have been provided back to multiple programs.

Similarly, a CCTT test tool called GIDGET was extended to allow services to be invoked through CCTT and OOS' ERC at the same time, graphically hi-lighting differences in functional results that could signal database miscorrelation or functionality differences.

Automated (non-graphical) test utilities were also created to support the comparison of millions of invocations of legacy services and ERC, supporting exhaustive performance and functionality testing. This provides a strong mechanism to discover minor implementation differences in legacy versus new services.

Protocol. The utilization ranges from simple concepts, such as entity state, to more complicated sequences, such as system initialization and interactions between virtual entities and manned simulators.

OneSAF communicates in two different ways. It uses the Simulation Object Runtime Database (SORD) for its native communication. The SORD is a virtual database that supports a distributed simulation. In OneSAF, the Simulation Object Runtime Database (SORD) is implemented in three parts. The Object Database (ODB) provides the low-level capability to distribute objects and interactions across the network. The Runtime Data Model (RDM) defines the network objects and interactions used by OneSAF to represent and control the battlespace. The Object Database Manager (ODM) layer contains individual managers that represent rich objects and events used by tool and modeling clients. These managers map the rich objects and events into RDM objects and interactions that are distributed through the ODB. OneSAF communicates with the external systems through the use of interoperability adapters. The adapters translate data between external protocols and the OOS RDM view.

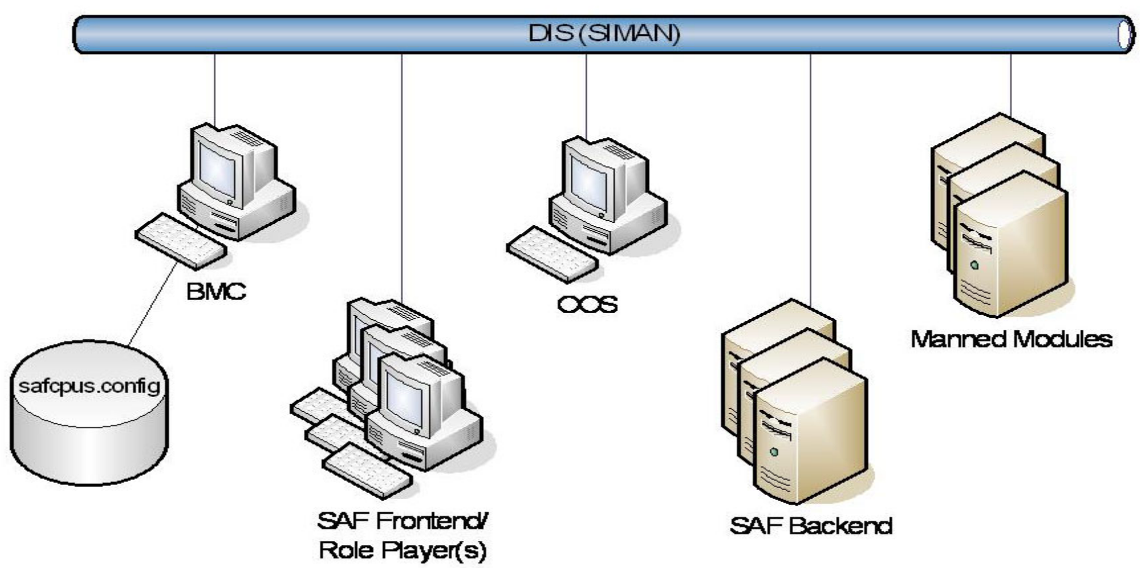

Figure 1: AVCATT/OOS Configuration

Interoperability

This section describes interoperability between OOS and the CCTT and AVCATT system separately, not CCTT/AVCATT interoperability. The CCTT and AVCATT systems both base interoperability between their respective virtual and constructive simulations on the Distributed Interactive Simulation (DIS) 2.04

Interoperability adapters currently supported include DIS, High Level Architecture (HLA), and Common Training and Instrumentation Architecture (CTIA). The SE Core A&I OOS Integration interoperability solution is based on the reuse of the OOS DIS Adapter.

Although the DIS standard has a well-defined structure for supported protocol data units (PDUs), CCTT and AVCATT do not strictly adhere to this specification in all instances. Some examples of these occurrences are enumeration values (especially Entity Type Record), sequences (Repair, Mount, Dismount, simulation management), and appearance (AVCATT uses unused bits to extend the DIS standard).

Both CCTT and AVCATT support centralized management and initialization of all simulation assets using DIS Simulation Management (SIMAN) PDUs. Much of the initialization is accomplished through the exchange of Action Request and Action Response PDU sequences. Neither the sequences nor the datum records contained in the Action Request PDUs are standardized between the systems. SE Core A&I needed to add the capability to respond to these system-specific initialization protocols within OneSAF.

Analysis of options for interoperability initially sought to identify a common DIS implementation to use among the three systems. These updates fall outside of the obvious scope of replacing the constructive simulation. This would likely have been technically feasible in the case of CCTT because a single DIS implementation is used throughout the system. However, this is not the case with AVCATT. AVCATT contains several different implementations of DIS, including COTS tools that would require modification in accordance with these protocol updates. A new solution was defined in order to reduce the programmatic and technical risks associated with the common enumeration set.

The current approach takes advantage of the configurability of the OneSAF Interoperability component. OOS provides an interoperability framework to allow for the communication with external systems using standard communication mechanisms. It provides a data-driven mechanism to configure the type of interoperability configuration to use. As mentioned above, examples of Interoperability Components currently provided by OOS include CTIA, HLA, and DIS. SE Core A&I focuses on the reuse of the OOS DIS Interoperability component to provide interoperability with both CCTT and AVCATT. The configurations of AVCATT and CCTT are shown in Figure 1 and Figure 2.

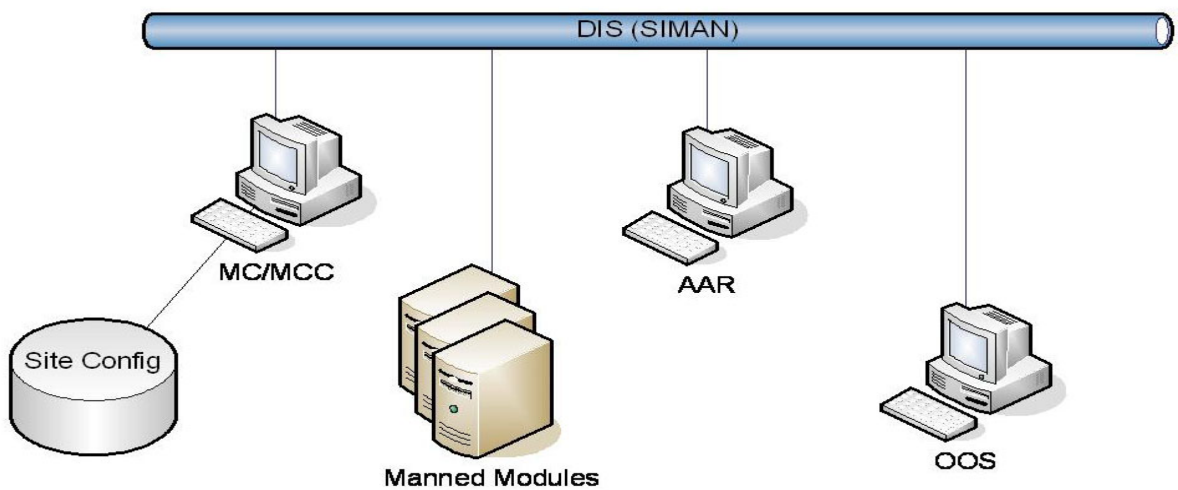

Figure 2: CCTT/OOS Configuration

The initial interoperability development relied heavily upon gateways to support basic interoperability. Each entity's representation remained unchanged internally to CCTT, AVCATT, and OOS. Gateways were used to translate between each system's native entity representation and the appropriate SE Core A&I representation. Gateways were also used to eliminate several remaining issues commonly encountered during system interoperability to include terrain correlation and broadcast/multicast DIS network traffic conversion.

OOS DIS Interoperability Component

The DIS Interoperability component allows for the specification of separate DIS Cores. Each DIS Core represents a specific dialect of the DIS protocol. A separate XML file is used to define the properties of each supported DIS Core. The DIS Core XML file specifies the classes that will be instantiated for PDU processing by the DIS Interoperability Component. Each DIS Core may have separate PDU definitions, PDU translators, and Event Handlers. SE Core A&I has created specific DIS Core definitions for both the CCTT and AVCATT DIS dialects. New PDU classes were created for each system to support the specific structure of PDU.

Enumeration Sets
Scripts were developed to automatically harvest enumeration name value pairs from the legacy systems and output them in the format required by OOS. In addition, the models team identified mappings between CCTT and AVCATT entities and supplies. Scripts were developed to generate mappings between the CCTT and AVCATT DIS values and the OOS values. This is important because development (especially new entities) is continuing on all three programs. Scripts can be re-run with minimal effort to support mapping to the current state.

Event Handlers
The DIS Core class loads all event handlers specified in the XML configuration file. Each event handler registers for interest in specific event types. New event handler classes were created to separately manage the CCTT-specific AVCATT-specific initialization sequences in OOS. The handlers create the correct PDU class and manage state mappings between the external system (CCTT or AVCATT) and OneSAF. Incoming DIS events cause the handler to request the appropriate actions from the OOS Simulation Engine.

Some of the interactions that occur between the legacy systems and OneSAF are listed below.

- Load and initialize a scenario based on PDU exchange between the Simulation Controller and OOS
- Process Start/Resume PDU to start the exercise after initialization or to resume from pause, or restart
- Interoperability with Entity State, Fire, Detonation, and Mount/Dismount PDUs
- Process Stop/Freeze PDU to stop the exercise or to pause, or restart
- Store/Restore Checkpoints upon receipt of the appropriate Action Request PDU
- Centralized reporting of OOS status

Demonstrations of interoperability and simulation control interactions have occurred at each stage. The interactions to complete this task need to be hardened so that OneSAF and the legacy SAFs can co-exist in the same exercise. These efforts have been included in the plan for the completion of the OOS integration.

Models

Models consist of physical, organizational, and behavior models. CCTT, AVCATT, and OOS were analyzed to determine the capabilities and differences in these three areas.

Assumptions
The analysis effort was based on multiple assumptions. One assumption was that analysis of the as-built systems was a better source of input than the original documentation such as the Software Requirements Specifications (SRSs) and the Combat Instruction Sets (CISs), due to the amount of development that has occurred since the initial delivery of the systems. Another important assumption was that CCTT would be used primarily for ground analysis and AVCATT would be used primarily for air and air defense analysis. This was due to the fact that those were the key purposes for development for those systems. Most ground updates for AVCATT, other than air defense involved developing targets so the CCTT solution is sufficient for that purpose. Changes made to ground models were checked to ensure that capabilities required for training were not lost. The assumption also limited the AVCATT analysis to the modifications made to the OneSAF Test Bed (OTB) baseline to create AVCATT's SAF. An additional assumption was that the analysis of the OOS models would focus on Medium Resolution Models since these were developed based on the CCTT and OTB models. Utilizing these assumptions allowed SE Core to focus on the areas that were most important to CCTT and AVCATT and minimize the effort required to analyze the systems.

Physical Models
The approaches for physical models between the three systems are mostly similar. The models show similarities in their execution thread of control (mainly periodic), they are parametric in nature, and most can trace their algorithms back to valid sources and data. Since the legacy for each of the models is the same (AMSAA, WES, ERDC), the algorithms, data, and control strategy are very similar. In fact

CCTT SAF, DI SAF, and AVCATT SAF were algorithm, model, and data reuse sources for OOS.

Some of the main differences are rooted in implementation or architecture. For example, the control strategy can be different between the various systems, ranging from a waypoint mobility control approach to a direction/speed approach to a combination of both. However, all three systems are similar in that intermediate behaviors control the execution of the models in the simulation space so this difference is muted unless the decision is to implement direct code reuse where each part is reused from different systems. A second major difference in the systems is the set of physical models that are implemented. For example, CCTT included deployable models directly in the mobility model that contained it in the limited set of entities that CCTT supports. While this works for the limited scope of CCTT, this approach would not work for a composable system. So, while at the close level of a line-by-line comparison, the physical models will seem to have major differences, the composition approach separates these capabilities and further partitions dissimilar components.

Since the systems have differing structures, SE Core's analysis focused on whether OOS had the same capabilities as those provided by CCTT and AVCATT. The analysis determined that OOS did not have an Infrared (IR) Seeker Sensor or a Longbow Fire Control Radar and the FWA and RWA mobility models were not sufficient for training in AVCATT. The deficient models were discussed with OneSAF, and they had already planned to improve the models. The requirements of the model for AVCATT were forwarded to OneSAF for incorporation via the OneSAF User Feedback Queue. The missing models were added to the SE Core development plan. The creation of the new physical models in OneSAF will be a software development activity. The addition of the model to a component and an entity will be an XML file change made using the OneSAF Component and Entity Composers, due to the composability of OneSAF.

Organizational Models

Organizational models represent the entity and unit models of the systems. The analysis of these models included determining the set of entities and units supported by AVCATT, CCTT, and OneSAF. The lists were filtered based on the assumptions from above.

The legacy entities were mapped to OneSAF entities based on the entity types assigned to them. In some cases, this resulted in multiple matches. The initial approach compared the components of the legacy entity and determined the closest match in OOS. The missing components were then investigated to determine if they had been replaced by newer technologies. Any other missing components were added to the OOS entity and saved in the SE Core composition area. Based on the results of this pass, SE Core determined that OOS entities were sufficient to meet the general training needs of the legacy systems. Subsequent passes mapped legacy entities to OOS entities and any mappings with multiple results were resolved by the OneSAF developer of the compositions. Incorporation of this lesson-learned allowed SE Core to increase the output of the entities provided. This activity was added to the SE Core development plan for all of the legacy entities.

This analysis also enabled the identification of overriding changes such as AVCATT adding laser designators to all of the ground units in OTB. The addition of the components to the appropriate entities was also made to the planned activities for SE Core.

A similar process was used to determine the appropriate set of unit models needed. The unit organizations that mapped to legacy units were harvested from OneSAF. The OneSAF entities will be replaced with the entities defined by SE Core. This reuse will be further aided by the use of the Unit Bulk Loader developed by OneSAF. The bulk loader imports Excel® spreadsheets and converts them to OneSAF unit compositions. Scripts are being developed to replace the OneSAF entities with the SE Core entity set and to generate the units. Units unsupported by OneSAF will be added to the spreadsheets using the organizations expressed in the legacy systems using the SE Core entity set. The generation of the units has been added to the planned activities for SE Core.

Behavior Models

Behavior models consist of two categories. One type interacts with the physical models and the environment, called controllers, while the other consists of the interactions between the entities and units according to doctrine, which are referred to as the doctrinal behaviors. Both types of behavior models need to be addressed to ensure that the resulting behaviors support the training needs of the legacy systems.

Evaluation of the specific controllers of the legacy systems and comparison to the OneSAF controllers independently is complex, due to the differing architectures of the systems. It was determined that the best approach to compare the controllers was through execution of the doctrinal behaviors. This approach allowed all aspects of the controllers to be exercised. This analysis was included in the plan to analyze and develop the doctrinal behavior set for SE Core.

To provide the doctrinal behaviors available in the legacy systems, it was determined that the only behaviors supported would be those used to support training. The initial approach involved running the behavior in the legacy system and documenting the activities and the interactions within the units and with the other entities. The developer then determined a similar or closely matching behavior in OneSAF. If one was found, updates were made to the OneSAF behavior composition and stored in the SE Core area. If one was not found, then the developer created a new behavior composition using the available OneSAF primitives. It was determined that in some cases a primitive was not available. In this case the SE Core developer coded a new primitive using the OneSAF architecture. Unfortunately, the effort required for this approach would not allow the entire model set to be completed within the SE Core period of performance.

The approach was altered and now involves consulting with subject matter experts from the legacy systems to determine whether the available OneSAF behaviors were sufficient to meet the training needs of their perspective system. This is the current approach that has been added to the planned activities for SE Core.

FUTURE WORK

Most work to date has consisted of determining the boundaries of the system changes and defining what the legacy systems will look like after the integration. The initial approaches to complete the integration have been established. Efforts have begun to integrate OneSAF as the SAF/CGF component of CCTT and AVCATT. Examples of areas to be addressed as integration proceeds are captured below.

Synthetic Natural Environment

Initial SNE development has focused on integration of OOS' ERC into manned simulators, extending ERC services, converting and creating complex terrain datasets, and extending test capabilities.

The upcoming year will focus primarily on integrating the very different dynamic environment capabilities of CCTT, AVCATT, and OOS. Additional effort will be directed toward refinement and specialization of complex CGF services like obstacle avoidance. In addition, coordination with the SE Core DVED program will be critical for developing OTF databases that match CCTT and AVCATT visuals while supporting necessarily functionality.

Interoperability/Simulation Management

There are several minor simulation management activities to continue through the next several builds to complete the interoperability of AVCATT, CCTT, and OneSAF. Currently, CCTT centralized asset management reports the status of individual nodes using DIS. The OOS architecture is defined to support a zero-or-more interoperability component, each translating between any single external simulation and OOS. Several approaches have been identified to overcome this difference and will be further analyzed by SE Core A&I.

Support will be added to the appropriate DIS Core for the remaining virtual/constructive interactions. These interactions include the following PDUs:

For AVCATT:

- Collision
- Resupply
- Emissions, Laser Designation, Identify Friend or Foe (IFF)
- Communications
- AVCATT Stealth control PDU

For CCTT:

- Mount/Dismount
- Resupply
- Repair
- Emissions, Laser Designator

Scenario Generation

The scenario generation capabilities between AVCATT and CCTT are very different. AVCATT generates scenarios using the SAF front-end component while CCTT has multiple options for scenario generation. The file format of the scenario is also different in each of the systems and translation of the existing scenario files should also be addressed. Since OOS is also being incorporated into CCTT, the scenario generation between the systems will be similar. Thus, if upgrades are done for generating scenarios on either AVCATT or CCTT, they could be shared between the programs. The integration will be able to support running legacy and OOS nodes concurrently so the ability to generate scenario files for all systems must remain.

Scenario Translation

Because OOS will form the basis of AVCATT and CCTT's future CGF functionality, it is inevitable that pre-existing exercise files that were in any way specific to CCTT or AVCATT will require some kind of mapping or translation if they are to be used with OOS. For example, pre-existing behaviors or unit types may not be found in the same form within OOS. The need to translate scenario files is important, but it is very unlikely that this mapping will be fully automated, at least for behaviors. Other areas, such as overlay symbols and location data, will be more amenable to automated translation.

AVCATT Scenarios

The basic AVCATT scenario generation approach will be altered to allow the generation of scenarios in either OOS or AVCATT systems as part of the SE Core A&I effort. The CGF and Manned Modules will still generate their scenario files separately. The CGF scenario generation will provide a switch between the current AVCATT SAF Graphical User Interfaces (GUIs) and the OOS GUIs- specifically the Management and Control Tool (MCT). The impact of this change is that the initialization of the scenario from the BMC will require updates so that the scenario files are extracted from the correct locations for the scenario files.

CCTT Scenarios

The CCTT scenario generation approach is more complicated that the AVCATT solution. CCTT allows scenario generation from the SAF workstation, the Master Control Console (MCC), and also through a separate tool, CCTT Exercise Initialization Tool (CEIT). The CEIT scenario files are a different format from the other two means, so they will be addressed separately.

The original MCC implementation treated the scenario generation capability as near-wholesale reuse from the PVD and SAF Workstation (SAF WS) developers, thereby making this capability logically separable from the rest of the MCC implementation. The MCC will also allow generation of scenarios for either CCTT or OOS by allowing the user to choose which scenario to generate. The resultant scenario generation capability will be functionally equivalent to software running on the new SAF front-end. This capability allows the CCTT users to utilize existing scenarios while incorporating the OOS functionality.

The OOS-based planning capability already supports running under the Windows® operating system. In the past, this was a significant factor in CCTT because it had separate planning capabilities for on-site and off-site planning. An advantage for CCTT is that they will be able to use OOS as another option for off-site planning. Adopting the OOS planning capability as the CCTT off-site planner would offer the following benefits:

- Off-site planner could be used to develop a "ready to execute" scenario file
- Separate off-site planner is eliminated, reducing maintenance cost

The scenario generation capabilities of the MCT will be upgraded to include the manned modules. OneSAF provides the ability to add a unit to a scenario and specify the leader of a unit to be externally simulated. This functionality requires enhancements to support additional entities and/or independent entities to be externally simulated and associated with a specific manned simulator. This requires minor upgrades for the definition and control of the information but the impacts on AVCATT manned modules initialization may require additional updates.

An advantage is that the full use of OOS for scenario planning would result in direct compatibility with AVCATT's CGF once integration is complete.

C4I

Digital messaging in OneSAF requires enhancements to support the needs of CCTT and AVCATT. The approach includes reuse of the existing Common C4I Adapter. The adapter will be updated to translate between OOS C2DM protocol and the CCTT and AVCATT protocols. The adapter communications interface will also be enhanced to send and receive DIS signal and transmitter PDUs with the encoded tactical messages. Additional updates are required to configure the adapter to run on the same box at each OOS node. Since digital messages are sent via PDUs, effort will be spent to eliminate duplicate messages on nodes that have SORD and DIS interfaces. Any digital messages required by CCTT and AVCATT that are not currently in OnSAF will be identified and added. Additional behaviors may be required to support any added messages. AVCATT now also supports Joint Variable Message Format (JVMF) digital messages. The implications from this will need to be determined and may require additional effort.

Graphical User Interfaces

OOS GUIs have many differences, especially the overall SAF control workstations and associated specialized windows. The work for this area will be focused on adding functionality that is available in AVCATT and CCTT but not included in the OneSAF MCT. The identification and prioritization of this functionality was performed with available users of the AVCATT and CCTT systems. An example is an editor for IFF (Identify Friendly/Foe) will be recreated on the MCT based on the one available in AVCATT. Additional control measures will be included such as air corridors, aviation checkpoints, fortifications, holding areas, and improved fighting positions.

Communication interfaces will be added to allow for the definition of frequency presets and the assignment of radios to specific simulation entities.

OneSAF supports the concept of privileges for user types. This functionality will be augmented to provide simulation access, which is limited based on the specific user type. The privilege settings will be based on the current access provided in the legacy systems. The accesses have already been determined and reviewed for accuracy. The overall look and feel of the SAF varies between the systems. Updates will be made to the PVD on the MCT so that it looks more like a paper map. OneSAF uses skins to alter the color schemes of the GUIs. Additional skins will be added to more closely mirror the color schemes of the legacy SAFs.

Addressing Overarching Virtual Needs

Virtual training environments require additional fidelity and performance functionality that are not necessarily needed in a constructive simulation. An entire development build has been dedicated to testing, identifying issues, and improving core system functionality. One area that will be addressed is fair-fight between the manned simulators and the SAF entities. This effort is necessary so the trainees are not able to readily identify the SAF entities and the SAF entities perform as expected so that training is not diminished. Another area that will be addressed is performance of the system. Responsiveness of the user interfaces is critical for the facilitators of the exercise to modify the exercise to meet the training objectives.

CONCLUSION

The SE Core A&I OOS Integration task has made significant initial progress towards a successful integration of the OneSAF Objective System into the AVCATT and CCTT simulation systems. Up-front analysis has generated integration approaches and encouraged detailed technical exchanges with CCTT, AVCATT, and OOS. Implementation progress has been made in the areas of Simulation Management, Interoperability, Synthetic Natural Environment, and Models. An initial demonstration showed OOS running advanced behaviors within CCTT and AVCATT. In each system, OOS was initialized using that system's native simulation management protocol, and viewed on that program's visualization platform. Such demonstrations indicate early progress toward OOS working within a CCTT and AVCATT context, while also providing new capabilities such as modern behaviors.

The SE Core A&I team continues to work with the CCTT, AVCATT, and OneSAF programs to ensure that the needs of the legacy systems are met while working within the architecture and commonality defined by OOS. The SE Core A&I government and contractor team are also refining integration activities to assure that OOS integration provides the greatest value to the CCTT and AVCATT programs upon completion.

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