OneSAF: A Product Line Approach to Simulation Development

Robert L. Wittman Jr.
MITRE CORPORATION
3504 Lake Lynda Drive, Suite 155
Orlando, FL 32817
407-208-1320 x225
rwittman@mitre.org

Cynthia T. Harrison
U.S Army Simulation, Training and Instrumentation Command (STRICOM)
12350 Research Parkway Orlando, FL 32826
407-384-3845
cindy_harrison@stricom.army.mil

Keywords: OneSAF, Computer Generated Forces (CGF), Semi Automated Forces (SAF), Product Line Development, Product Line Architecture

ABSTRACT: *One Semi-Automated Forces (OneSAF) is the United States (U.S.) Army's next generation simulation system being developed to provide an integral simulation service to the Advanced Concepts and Requirements (ACR), Training, Exercises, and Military Operations (TEMO), and Research, Development, and Acquisition (RDA) domains. With requirements ranging from closed-form analytical support to command level human in the loop training, OneSAF will be an HLA compliant entity level simulation. OneSAF will provide simulation of individual battlefield components such as soldiers, tanks, and helicopters through aggregate units, to the Brigade level, operating in either a completely automated mode or under the control of the training audience via their organic command and control systems or role players using a OneSAF Graphical User Interface (GUI). Simulation entities, units, behaviors, and the synthetic environment will be composable to provide the greatest flexibility to the user in rapidly meeting the scenario requirements for a simulation event. Composition will allow not only ordinary task organizations to be defined with doctrinally correct behaviors and ordinary equipment sensor combinations, but will also support new concepts in combining equipment and sensor pairs as well as new equipment and behavior combinations. These ambitious requirements force a new tactic in simulation development. This paper describes the innovative Product Line approach the U.S. Army's Simulation, Training and Instrumentation Command (STRICOM) is using to manage the OneSAF development. In doing so it details the combination of Military subject matter experts and organizations, processes, and technologies that went into the development of the OneSAF concept and the integrated repository that houses the OneSAF operational and technical requirements, government directed reuse requirements, and the Product Line Architecture Framework (PLAF).*

1 Introduction

The One Semi-Automated Forces (OneSAF) Objective System is the United States (U.S.) Army's next generation, composable, entity based simulation system. It is being developed to provide an integral simulation service to the Advanced Concepts and Requirements (ACR), Training, Exercises, and Military Operations (TEMO), and Research, Development, and Acquisition (RDA) domains. With requirements ranging from closed-form analytical support to command level human

in the loop training, OneSAF will be a High Level Architecture (HLA) compliant entity level simulation providing a common solution for a broad range of user requirements. In order to realize this vision an innovative product line management and development approach has been selected.

The primary purpose of this paper is to describe the organizations, the foundational technical products, and the technologies enabling OneSAF to pursue this product line solution.

1.1 Background

The OneSAF concept originated in January 1996 following an extensive study that came to the conclusion that the Army was caught in a wasteful spending cycle, making identical or similar enhancements to legacy simulations across three different user domains.

Furthermore, it was determined that none of the existing legacy simulations were capable of being extended to provide comprehensive support of emerging Army functional requirements and technical standards.

Realizing this, the Army decided the best approach for overcoming the problems associated with the multitude of aging simulations was to create a single general-purpose entity level simulation. This solution relies on using lessons learned from successful simulation projects like the Modular Semi-Automated Forces (ModSAF) simulation, and the Close Combat Tactical Trainer (CCTT) SAF. [6]

In May of 1997 the Deputy Commanding General (DCG), Training and Doctrine Command (TRADOC) approved the Mission Needs Statement (MNS) for OneSAF which stated [7]:

"*The need for OneSAF capabilities is not a response to a specific warfighting threat against the force; the need is driven by the guidance to reduce duplication of M&S investments, foster interoperability and reuse across M&S domains, and meet the M&S requirements of the future force.*"

Shortly thereafter, a Cross-Domain Integrated Concept Team was established to design a simulation acquisition strategy, draft a program management plan, and begin harmonizing user requirements. This effort has evolved over the past 4 years and is now culminating in contracts being awarded for development of the OneSAF Product Line Architecture and the various composable products and components.

2 Army Community Involvement

The Army had a monumental task in coordinating the various user domains, the combat developer, and the acquisition community in order to create a single operational and technical vision for OneSAF. This section describes the various Army organizations that have been involved in OneSAF program since its inception. We begin with an introduction to the three user domains in order to provide the necessary insight into their roles within the OneSAF program. This is followed by a description of TRADOC and STRICOM and their role in the OneSAF acquisition. Finally, the organizational constructs that have evolved during the OneSAF concept formulation and initial contracting phases are explained.

2.1 Advanced Concept Requirements Domain (ACR)

The ACR domain is under the direction of the TRADOC Analysis Center (TRAC). This community is primarily interested in the analytical application of modeling and simulation. Their intended uses of OneSAF include the following:

- To explore new and advanced concepts with respect to equipment, organizations, doctrine, and operational environments,
- To develop and evaluate tactics and Operational Plans for organizations at Brigade and below,
- To create data that can be used as input to other closed form analytic simulations, and
- To provide training associated with a specific location prior to real-world deployments. [7]

2.2 Training Exercise and Military Operations Domain (TEMO)

This domain is led by TRADOC's National Simulation Center (NSC) located in Ft. Leavenworth, KS. Their focus for OneSAF includes

- Unit training – OneSAF will be used as a simulation driver for round out forces,
- Unit commander and staff training at battalion and below in a training exercise, workshop, or seminar environment,
- Unit Division commander refresher training, and
- As a mechanism to link live, virtual, and constructive Synthetic Theater Of War like environments. [7]

2.3 Research Development and Acquisition Domain (RDA)

The U.S. Army Materiel Systems Analysis Activity (AMSAA) leads the RDA domain with the primary purpose of Simulation Based Acquisition (SBA). They operate out of the Aberdeen Proving Grounds in Maryland and expect to use OneSAF in support of

- Weapon systems development and product improvement using appropriate military settings and context,
- Technical development, test, and evaluation support for Army modernization objectives, and
- Communications design and laydown experiments. [7]

2.4 TRADOC Program Office, OneSAF (TPO OneSAF)

TPO OneSAF is the Combat Developer for OneSAF and is responsible for development of the OneSAF Operational Requirements Document (ORD) [7]. The TPO OneSAF has made significant contributions in defining specific cross-domain requirements with support from the RDA, ACR, and TEMO user communities.

2.5 Simulation, Training and Instrumentation Command (STRICOM)

STRICOM serves as the Materiel Developer for OneSAF. The Commander of STRICOM was delegated as the Milestone Decision Authority (MDA) for OneSAF by the Army Material Command in May of 2000 concurrent with the official standup within STRICOM of the Product Manager OneSAF (PM OneSAF) office. STRICOM/PM OneSAF has been and continues to be the focal point for all OneSAF concept exploration efforts and development contracts. As OneSAF transitions out of concept exploration STRICOM will use its existing STRICOM Omnibus Contract (STOC) as the vehicle to access the simulation and software development expertise to create OneSAF. PM OneSAF also provides the coordination function to ensure the User Domains remain involved in the contracting and simulation development process.

2.6 OneSAF Overarching Integrated Product Team (OIPT)

The fundamental purpose of the OIPT is to ensure the OneSAF program understands and is responsive to the strategic guidance of the MDA. In a nutshell, the MDA decides whether the OneSAF program is meeting its cost, schedule, and performance requirements and should continue to receive funding. The OIPT also has a range of senior management responsibilities from coordinating the various OneSAF activities to acting as an independent watchdog for cost, schedule and performance and providing these insights back to the MDA. The group is led by an MDA designee and is made up of representatives from the OneSAF Program Office, the TRADOC Project Office (TPO), the Army Model and Simulation Office (AMSO), the ACR domain, the RDA domain, and the TEMO domain. [8]

In order to meet its objectives, the OIPT created three subordinate IPTs: the requirements IPT, the OneSAF Testbed Baseline (OTB) IPT, and the Architecture IPT.

The Requirements IPT was focused on capturing OneSAF requirements across all domains and assessing them for commonality and variability. This group maintains the MNS and the Operational Requirements Document (ORD) in addition to recommending specific requirement prioritization to the OIPT.

The OTB IPT controls the OTB development process. This includes tracking and scheduling of user requirements, verifying the user feedback process is executing smoothly, and ensuring new and relevant technologies are integrated into the OTB.

These two IPTs are important in their own right. However, the remainder of this paper concentrates on the products of the Architecture IPT as this group has provided the technical underpinnings of the OneSAF development process.

2.7 OneSAF Architecture Integrated Product Team (A-IPT)

The OneSAF A-IPT was chartered, in support of the OIPT, in April of 1999 under the leadership of the OneSAF Chief Engineer [9]. Primary membership includes representatives from the OneSAF TPO, the ACR, RDA, and TEMO domains, as well as support from the MITRE Corporation. At inception, the team's primary responsibility was to develop a Product Line Architecture Framework to support and bound the OneSAF procurement process. In doing so the group performed various experiments and concept explorations to assess and understand the OneSAF architectural driving requirements such as scalability, distributed simulation, and optimistic and conservative time management schemes. The group actively developed products during the period of April 1999 through December of 2000.

The products and technology involved will be discussed in later sections but the primary contributions of the Architecture team include the Product Line Architecture Framework (PLAF), the Technical Requirements Document (TRD), the Operational Concept Document (OCD), and the Reuse Direction and Guidance (RDG) Document. All of these products are housed and controlled in what is termed the OneSAF Electronic Information Environment.

2.8 Web Based OneSAF Electronic Information Environment

All of the relevant government OneSAF information is available electronically through the OneSAF Web Site (www.onesaf.org). This website was initiated to serve as the repository for both the OneSAF Objective System and the OTB. Both public and private (user account/password) access are supported. It is intended to be the one stop-shopping site for OneSAF relevant data. The private website, in addition to offering web based search and information access also provides interactive chat collaboration tools and A-IPT meeting notes and briefings. At the heart of the private section is the OneSAF Electronic Information Environment built upon the commercially available Dynamic Object Oriented Requirements System (DOORS). [16] The logical layout of the DOORS repository is shown in figure 2.1. It holds all of the current government generated products and will eventually hold the contractor developed specifications and designs. In addition DOORS is used to hold the traceability mappings from architecture and design specifications and other development artifacts back to the operational requirements.

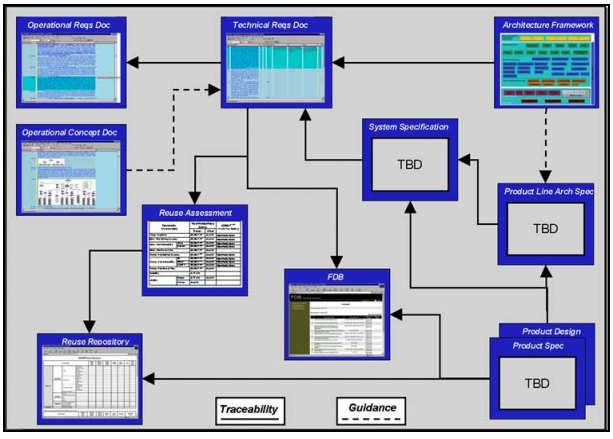

Figure 2.1, Electronic Information Environment Logical Layout

3 The OneSAF Technical Foundation

The A-IPT created a number of technical products between April 1999 and December 2000 with the goal of articulating the government's product line concepts and requirements to the modeling and simulation development community and other external organizations. These products supplement the OneSAF ORD and are intended to be used as direction and guidance in the development of the OneSAF Product Line. As mentioned earlier, the A-IPT products include the PLAF, TRD, OCD, and the RDG Document.

The intent of the government direction is to reduce cost and development timelines and increase overall system performance. Although other implementations can be generated it is incumbent on the contracting organization to present compelling evidence of substantial lifecycle savings in order to change the direction.

The PLAF is intended to identify basic products, components, and interfaces that support the entirety of the OneSAF requirements. It also relates a set of guiding principles for the product line based architecture. It is envisioned that the OneSAF Architecture and Integration contractor will revise and extend the PLAF to become the formal OneSAF Product Line Architecture Specification (PLAS) that fully specifies the architectural products, components, interfaces, and services.

Finally, the TRD and OCD are considered transitional products intended to provide tools for the Architecture and Integration contractor to construct the OneSAF Product Line Requirements Specification (PLRS) and the final Operational Concept Document (OCD).

3.1 Product Line Architecture Framework (PLAF)

The OneSAF Product Line Architecture Framework (PLAF) was developed over a period from mid 1999 through October 2000. For OneSAF the product line concept is driven by the need to support multiple user domains with a variety of end state uses. Thus the variability of a product ranges across several dimensions:

1) The type of supporting infrastructure (single processor hosted simulation to a distributed multi-processor, multi-host simulation),
2) The type of human interaction ranging from Human-in-the-loop (HITL) simulations for training

and mission rehearsal situations to closed form analytic uses of the simulation.

3) The use of specific applications, AAR, simulated entity composition, etc. for each user domain.

The initial software development process used in understanding the design impacts driven by the requirements was based on a tailored derivation of the Texel/Williams Software Development Process described in detail in [10]. This process describes a use case based approach intended to explain the objects and interactions starting at the user interaction level and ending with pure software representations. This process was modified and used only in the conceptual exploration phases, prior to contract award, to focus strictly on the OneSAF domain user's perspectives instead of internal software design. Together the products of this analysis (the End State Scenarios, Operational Architectures, OneSAF Use Cases, OneSAF Lifecycle, and User Categories) makeup the OneSAF Operational Concept Document (OCD). This initial analysis also laid the foundation for the products and components described within the OneSAF PLAF.

The PLAF is to be used to guide the definition of individual components, their services, and interfaces so that they can be independently developed and then combined to support a variety of products and system configurations. It is left to the OneSAF Architecture and Integration contractor to determine and provide appropriate definition to the extent to which the components and products can be combined dynamically, during run-time, or statically, during compile time.

The PLAF supports a hierarchical composition process to create specific system configurations to support the different user domains. A pictorial representation, taken from [11], is shown in figure 2.2. At the highest level products are combined to create the system configurations. The products are complete units of functionality such as an After Action Review product. Products themselves are made up of one or more components. Components are the elements that can be developed independently and therefore must have complete service and interface definitions along with a formal documented process for combining and ensuring that the overall performance requirements are met.

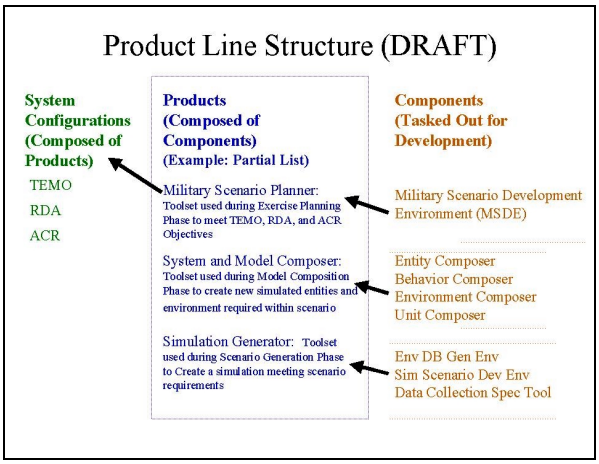

Figure 2.2, OneSAF Product Line Structure

Figure 2.3, again taken from [11], shows the initial breakout of system configurations, products, and components using a layering approach. The top block shows the end user configurations supporting the TEMO, RDA, and ACR domains. Next the product layer is given showing the products necessary to compose a complete system configuration. Under each product is a list of the components that need to be developed or harvested through reuse to support the product. There may be a number of "same name" components that are developed in order to support the variability of the OneSAF requirements. These components will need to be easily interchanged in order to support the end user system configurations.

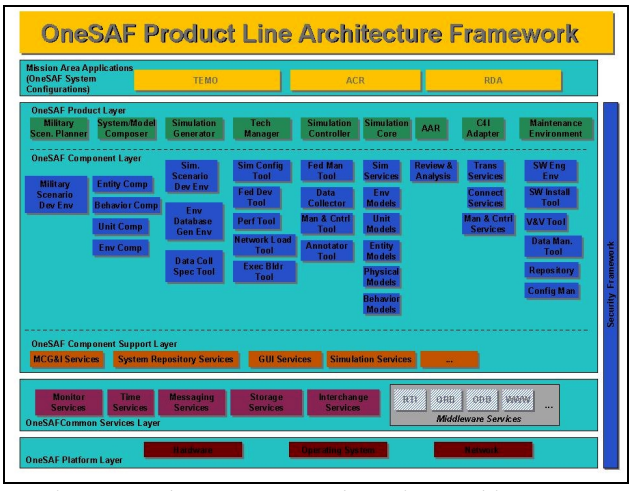

Figure 2.3, the OneSAF Product Line Architecture Framework

This section defines the current set of Products and the components that can be composed by the user to create OneSAF system configurations that are suitable for any particular use case. The descriptions provided here are consistent with those contained within the OneSAF TRD but are presented as high level summaries. The

TRD provides the detailed requirements for each of the identified PLAF Products and Components [12].

3.1.1 Military Scenario Planner Product

The Military Scenario Planner supports the definition of a Military Scenario Specification in eXtensible Markup Language (XML) that will be used in future simulation events. It provides a GUI-based mechanism for selection of force structure, overlays, and control measures that bound the scenario. It may also use operational graphics generated by organic C4I systems. It is a goal of this product to be able to produce military scenarios that can be shared by multiple simulations (e.g., WARSIM and COMBAT^{XXI}). The Military Scenario Development Environment (MSDE) Component is the single component within the Military Scenario Planner.

3.1.2 Model & System Composer Product

The Model & System Composer Product supports the creation of a composite entity, behavior, or environmental element from a collection of primitive components. Metadata associated with each primitive constrains the process in the creation of allowable constructs. At a system level, the composer supports the creation of tailored applications from desired software modules or artifacts. The components within this product are briefly described below:

The Entity Composer will provide the capability to construct entities like tanks from supporting constructs like tracks, turrets, guns, etc. Information describing the new entity can then be entered within the entity composer tool. The entity composer will also allow behaviors and physical models to be bound to specific entities.

The **Unit Composer** will provide the capability to construct military units (organizations) from other unit constructs. Information describing the new unit can then be entered within the unit composer tool. The unit composer will also allow behaviors to be bound to specific units.

The **Behavior Composer** will provide the capability to construct complex behaviors from other primitive behavior types. Complex behaviors, along with their relevant metadata, will be specified in an XML based Behavior Specification Language. Information describing the new behavior can then be entered within the behavior composer tool.

The **OneSAF Environment Composer** will provide the user the capability to compose the synthetic environment to include, but not limited to, geographic location, terrain representation and resolution, feature representation and resolution, atmospheric effects representation and resolution, bathymetric representation and resolution, etc.

The **OneSAF System Composer** will provide the user the capability to compose and tailor the product line products and components to create a specific system configuration (create combat simulation from high resolution entities/units, configure executive to run as fast as possible, repeatable mode, etc.).

3.1.3 Simulation Generator Product

The OneSAF Simulation Generator Product provides a GUI-based mechanism for the selection of the appropriate terrain and environmental information, forces, factional relationships, non-combatant organizations, data collection information and other elements necessary to capture the requirements of the scenario at execution. The selection process is supported by the examination of metadata describing each element. The Generator uses the XML Military Scenario Specification created by the MSDE component as a basis for extension. The Simulation Generator supports association of synthetic entities with map based control measures and temporal order execution sequences. The Simulation Scenario Specification is stored in an XML-based format for further processing by the Technical Manager Product. The Components within this Product are briefly described below:

The **OneSAF Simulation Scenario Development Environment**(SSDE) provides the GUI-based mechanism for the selection of the appropriate forces, factional relationships, non-combatant organizations, and other elements necessary to capture the requirements of the scenario at execution. It updates the Simulation Scenario Specification with this additional data.

The **OneSAF Environment Database Generation Environment**(EDGE) Component provides the GUI-based mechanism for the selection of the appropriate terrain and environmental data necessary to capture the requirements of the scenario at execution. It updates the Simulation Scenario Specification with this additional data.

The **OneSAF Data Collection Specification Tool** (DCST) will allow the user to identify the data items of interest for collection during simulation execution. It

updates the Simulation Scenario Specification with this additional data.

3.1.4 Technical Manager Product

The OneSAF Technical Manager Product will provide GUI-based mechanisms and the services to support exercise configuration and setup. The components within this product are briefly described below:

The **OneSAF Simulation Executable Builder** parses the XML Simulation Scenario Specification and provides the user tools to partition the scenario into sub-elements and build required executables. The Simulation Executable Builder extends the scenario specification by embedding a partitioning scheme and executable assignments.

The **OneSAF Simulation Configuration Tool**(SCT) will provide a GUI-based mechanism for the configuration of hosts and networks that will participate in a OneSAF execution. The SCT will use the XML Simulation Scenario Specifications to guide assignment of software to appropriate computational hosts. The SCT downloads required executables that are built by the Simulation Executable Builder to the hosts and hands control over to the Simulation Control Product.

The **OneSAF Federation Development Tool** will provide a GUI-based mechanism for supporting the HLA federation development process. This tool shall support OneSAF Simulation Object Model (SOM) to Federation Object Model (FOM) mapping in support of federation execution.

The **OneSAF Performance Modeling Tool** will provide a GUI-based mechanism to predict runtime performance of a particular OneSAF scenario via a simulation of OneSAF execution.

The **OneSAF Blaster/Network Loader Tool** will provide a GUI-based mechanism to assess network performance and capacity to support a OneSAF execution. The Blaster/Network Loader Tool will provide applications for benchmarking absolute performance for network comparisons. In addition, for a given network layout the Blaster/Network Loader tool shall provide utilities for estimating network resource requirements for a given scenario.

3.1.5 Simulation Core Product

The OneSAF Simulation Core Product will provide the foundational OneSAF simulation services/executive and core modeling capabilities and shall provide a GUI to monitor and control these services. The simulation services include, but are not limited to, time and event management, random number generation and stream services, probability distribution library services, RTI interface services, standalone single computer simulation implementation services and distributed simulation services, environmental models, unit models, entity models, etc. The modeling capabilities include modeling of Units, Entities, Behaviors, Physical Models, and the Environment. The components within this product are briefly described below:

The **OneSAF Simulation Core Services** shall include, but are not limited to, time and event management, random number generation and stream services, probability distribution library services, RTI interface services, standalone single computer simulation implementation services and distributed simulation services, etc.

The **OneSAF Environment Models** comprise those environmental models, both dynamic and static, that are built in support of the OneSAF requirements set.

The **OneSAF Unit Models** comprise the military organizational or unit models developed in support of the OneSAF requirements set. The unit is defined as a component of a military, paramilitary, quasi-military (guerilla or terrorist cell, etc.), governmental or other organizational hierarchy. Traditional military units are organized by echelon (e.g., brigade, battalion, company, platoon, squad, team/crew, and individual) with well-established command and control structures. Paramilitary and quasi-military units may cooperate through more dynamic or ad-hoc relationship structures. The OneSAF Unit Models provide the runtime representation of the Units identified within the Simulation Scenario Specification.

The **OneSAF Entity Models** are comprised of Command Entities or Basic Entities. A Command Entity is the physical representation of the command node (squad/platoon/company command posts and battalion Tactical Attack Center (TAC) and Tactical Operations Center (TOC), civilian leader, etc) within the simulation and the associated command decision making capability. A Basic Entity is a system that can be modeled and/or represented within the synthetic environment and that can express observable behavior. An entity may be a life form (e.g., human, military working dog) or a platform (e.g., tank, helicopter). The OneSAF Entity Models provide the runtime representation of the Entities identified within the Simulation Scenario Specification.

The **OneSAF Behavior Models** provide the runtime modeling of the cognitive aspect of Units and Entities and utilize the XML based behaviors that have been composed for each of the scenario's Units and Entities.

The **OneSAF Physical models** provide the mathematical representation of combat systems and their interactions with the environment and other entities. Physical models may be represented at multiple levels of fidelity as defined by the TRD.

3.1.6 Simulation Controller Product

The Simulation Controller Product provides all controlling mechanisms, displays, and devices for interacting with OneSAF during runtime. These displays shall include map-based (PVD) representation of terrain database including unit and platform locations, overlays, and supporting contextual information for simulation execution. Simulation Control will provide controls for interacting with and directing behavior of battlefield entities represented in OneSAF. In addition, the Simulation Control Product monitors the simulation performance during execution and can dynamically shutdown and restart executables as necessary. The components within this product are briefly described below:

The **OneSAF Management and Control Services** are those necessary to view and control the simulated entities as a technical controller, battlemaster/senior controller, puckster, analyst, or (Low Overhead Driver) LOD user.

The **OneSAF Federation Management Tool** shall provide mechanisms to monitor and control OneSAF Federations.

The **OneSAF Data Collector** provides the services to collect and store all of the data identified within the XML based Data Collection Specification created by the Data Collection Specification Tool.

The **OneSAF Annotator** will provide an observer/controller or other remote user the ability to record electronic form based data entry regarding the simulation event to support AAR and Analysis activities. It is envisioned that this will be implemented in a Personal Digital Assistant (PDA)-based application.

3.1.7 OneSAF C4I Adapter Product

The OneSAF C4I Adapter provides bi-directional translation, connection, and control and monitoring of information flowing between real-world C4I systems and OneSAF. The components within this product are briefly described below:

The **OneSAF Monitor and Control GUI Services** will provide mechanisms to monitor and control the C4I adapter settings as well as manage, control, or modify the data flowing between the C4I system and OneSAF.

The **OneSAF Translation Services** will provide two way translation services that translate internal OneSAF formats to C4I formats and vice versa. These translations may include and are not limited to voice, binary, human readable, and database formats.

The **OneSAF Connection Services** will provide a mechanism to connect the Adapter to specific C4I systems using inherent C4I protocols and physical connection mechanisms. These may include but are not limited to serial communication lines, Ethernet, wireless communications, etc.

3.1.8 After Action Review (AAR) Product

The OneSAF After Action Review Product will support graphical review, analysis and presentation of all data collected during the OneSAF execution. The toolset shall support mining of collected data to construct Measures of Effectiveness (MOEs)/Measures of Performance (MOPs) and analytical charts and graphs as well as allowing data export to Commercial Off The Shelf Software (COTS) Office Automation and analytical review tools. The Analysis and Review component is the sole component within this product.

3.1.9 Maintenance Environment Product

The OneSAF Maintenance Environment Product provides an integrated environment to manage all data and artifacts associated with the OneSAF Product Line. These tools shall span the software development lifecycle, from requirements engineering to software maintenance. The Components within this Product are briefly described below:

The **OneSAF Configuration Management Utilities** will support the configuration management and maintenance of all data within the repository.

The **OneSAF System Accounting Utilities** will support management of user accounts and privileges.

The **OneSAF System Asset Management Utilities** will support the setup and management of network assets that include, but are not limited to, communications links, processing nodes, peripheral devices, etc.

The **OneSAF System Distribution Services** will support the distribution of the OneSAF system and product lines to the user sites.

The **OneSAF Information Security Utilities** will assist the user in management of classified information in the Repository.

The **OneSAF Data Harvesting and Translation** utilities will support the harvesting and automated translation of data sources commonly used in legacy systems into common data standards and formats to be used within the OneSAF Product Line Architecture Specification.

The **OneSAF Software Engineering Environment** will provide tools to support product line and software analysis, software requirements traceability, software design, software coding, software debugging, software testing, and software configuration management and revision control.

The **OneSAF Software Installation Tool** will provide a "wizard like" install tool to automate the software installation process. This component will verify minimum system hardware and software requirements are met. These requirements will include things like CPU Version, available disk space, Operating System Version, existence of necessary supporting software, etc.

The **OneSAF Online Help and Tutorials** utilities will support the definition and use of context sensitive help and on-line tutorial capabilities.

The **OneSAF Verification and Validation Tool** will provide user access to data confirming that the software development process is being followed. This data includes but is not limited to requirements traceability, coding standard adherence proof, internal software documentation standard adherence proof, Application Programmer's Interface (API) standard adherence proof, etc. The OneSAF Verification and Validation Tool will also provide data aiding in the validation of the models against real-world data. This data may be provided through software instrumentation techniques or other data creation and access methods.

The **OneSAF Data Management Tool** will provide mechanisms to access, review, modify, archive, and analyze data within the OneSAF Repository.

The **OneSAF Repository** will accommodate all OneSAF data and information. The repository must accommodate, at a minimum, the following types of data: system and software documentation, system and software source code and executable code, system and software product configuration data and change history, any metadata necessary to support simulation composition activities, scenario data, simulation execution data, simulation execution performance metrics, results of analysis performed on simulation data, after action review data, etc.

3.2 Technical Requirements Document (TRD)

The TRD is the companion document to the PLAF. It provides the technical requirements for the PLAF products and components and is traceable back to the ORD [12]. The TRD evolved throughout the duration of the A-IPTs existence. The first step in the TRD's development was to transform the structure of ORD based requirements into independent "shall" requirements. This included deriving requirements, based on information gained during concept exploration, to add a level of richness to the ORD requirements. Again the user domains were involved throughout this process. Next, the TRD paragraphs or modules as they are called in DOORS were categorized or grouped into the products within the Product Line Architecture Framework (PLAF).

3.3 Operational Concept Document (OCD)

Work on the OCD also began in December of 1999 and ran through December of 2000 [13]. The OCD is not a single document; instead it is a collection of several analysis artifacts:

- End State Scenarios: seven from the ACR domain, two from the RDA domain, and six from the TEMO domain,
- Four representative Operational Architectures,
- A set of OneSAF use cases – a representative set from each domain,
- A OneSAF exercise lifecycle overview, and
- The set of OneSAF user categories.

The types of information contained in each one of the products reflects the culmination of various meetings and workshops held by the A-IPT.

The End State Scenarios represent the types of military operations that have to be represented in OneSAF to meet the domains' OneSAF requirements. They include the military plans, orders, units involved, and the various behaviors of the units.

The four representative operation architectures: 1) COA Doctrine and Combat Development Tool, 2) Leader and Staff Training – Seminar Driver, 3) Material Development Tool, and 4) Seamless Training Exercise Driver contain the simulation configuration requirements for each of the representative uses of OneSAF. The four operational architectures attempt to show the variations in computer, network, and personnel that must be supported by the OneSAF system.

The Operational Use Cases show how OneSAF will be used within each domain. The complete set of use cases set the boundaries for the OneSAF system. The use cases from each domain are roughly based on the OneSAF Lifecycle.

The OneSAF Lifecycle was created by looking at processes used by legacy systems, interviewing Subject Matter Experts, and reviewing the ORD and the HLA Federation Development Process (FEDEP). The OneSAF Lifecycle, as summarized from [13], is described by the following 10 phases:

1. **Event Planning**: Operational objectives are identified and broken down into specific functional requirements. This phase normally lasts several months in duration and requires a significant amount of collaboration between event planners.
2. **Database Development**: The necessary environmental, unit, behavior, and equipment databases are determined. Datasets are investigated to identify those that can be reused, those that can be created through modification, and those that need to be created from scratch.
3. **Software Development**: Software is developed based on the results of the Database Development Phase investigation.
4. **Model Composition**: Models are generated using the model composition tools within OneSAF.
5. **Scenario Generation**: All software based representations required to execute the event are selected and parameterized.
6. **Simulation Configuration**: The software is allocated to computational hosts and the simulation network is designed based upon event performance requirements.
7. **Systems Test and Verification**: The simulation is run in a trial mode to see if it executes as planned and meets performance requirements.
8. **Simulation Execution**: The simulation event is executed.
9. **Post-Execution Analysis/After Action Review**: Data collected during exercise execution is analyzed and fed to the participants in analytical form or in a hotwash training forum. This can occur during and after exercise execution.
10. **Archival**: All collected data is archived for easy retrieval and analysis.

The final piece of the OCD is the User Category List. This list is intended to identify the critical roles played by users of OneSAF. This information will be used to create appropriate GUIs allowing access to the functions necessary for each user type. The list of User Categories, extracted from [13], is provided below:

1. **Software Developer** - Responsible for the creation of a specific software artifact.
2. **Model Composer** - Responsible for the creation of a composite entity/behavior/unit from a set of existing primitives or other composites. This process includes changing parametric data and the selection of appropriate fidelity within the physical models.
3. **Database Developer** - Responsible for the development of databases in support of a simulation event
4. **Scenario Developer** - Responsible for operational planning and development of the forces and environment for the execution of a simulation event.
5. **Configuration Manager** - Responsible for performing version control and management of all aspects of the baseline product.
6. **Data Manager** - Responsible for organization and classification of data supporting an execution of the simulation.
7. **System Administrator** – Super-User, responsible for the successful operation of the OneSAF system.
8. **Technical Controller** - Responsible for the set up, configuration, monitoring, use, and maintenance of the assets supporting the simulation execution.
9. **Observer/Controller** - Responsible for evaluation of the training audience and recording of appropriate events/observations.
10. **Puckster/Training Audience** - Responsible for controlling SAF entities during execution of a scenario.

11. **Analyst** - Responsible for planning, preparation, conduct, and analysis of the simulation event.
12. **LOD User** - Non-technical user with limited set of tools to tailor and run a predefined scenario.
13. **Model Validator** - Domain Subject Matter Expert (SME) responsible for validation of the models.

3.4 Reuse Direction and Guidance (RDG)

During the spring of 2000, the A-IPT performed a reuse assessment to identify opportunities to leverage developmental artifacts from existing programs. The reuse assessment resulted in the RDG document and a supporting reuse repository [14]. The RDG is directly traceable into the appropriate products within the reuse repository that reference complete fielded and developmental products from numerous programs including WARSIM, CCTT, COMBAT^{XXI}, and the OTB. As new reuse opportunities are identified and as existing baselines mature documentation and other supporting artifacts will be collected and added to the repository. The intent of the reuse repository is to provide the OneSAF contractors with the government's authoritative expectations for product reuse. The reuse definitions went through a number of iterations and initially considered knowledge acquisition/ requirements, design, and code reuse. With the specific type of reuse being categorized by the product being reused. Another level was associated with the completeness in which a reused product satisfied an existing OneSAF requirement. From complete satisfaction at the product level, to partial satisfaction, to simple algorithmic reuse. The following final definitions are provided within the OneSAF RDG document [14]:

"*Directed Reuse: The contractor is directed to reuse the identified product as a starting point for OneSAF development. Substantial life cycle cost benefits must be demonstrated in order to propose a different starting point."*

"Recommended Reuse: The contractor is directed to consider the reuse of the identified products as a starting point for OneSAF development. Life cycle benefits of using products should be shown along with proposed starting point."

The directed reuse analysis began with the team looking at products nominated within each domain and the reuse criteria defined by the A-IPT. The members then were assigned specific products to assess. The assessment centered on meeting the functional requirements as stated within the ORD and TRD. The four-step assessment process is as follows:

1. Identify a specific functional area like C4I interfaces,
2. Produce a basic statement of the requirements,
3. Analyze specific products based on the requirements, and
4. Tag the product as directed, recommended, or not to be reused, and provide commentary as needed.

In all, there are approximately 30 items categorized as government directed reuse and 6 as recommended reuse. The basic layout for each reuse assessment is shown below.

- ***Functional Area****: Direct reference to TRD.*
- ***Basic Statement of Requirements****: Requirements extracted from TRD.*
- ***Products Considered****: Listing of the products that were considered by the A-IPT members for reuse*
- ***Directed Reuse****: Specific products the government has selected for directed reuse*
- ***Recommended Reuse****: Specific products the government has selected for recommended reuse.*
- ***Additional Commentary****: Additional comments giving rationale or additional detail behind the direction or recommendation.*

4 International Community Collaboration Activities

4.1 Organizational Relationships

Since 1997, the OneSAF program has sought out and actively participated with international organizations in the refinement of OneSAF requirements and concepts. OneSAF has worked specifically with UK Defence Evaluation and Research Agency (DERA) under an established UK-US Information Exchange Agreement [15] to perform collaborative research and development into next generation simulation concepts. The OneSAF program is currently supporting the establishment of a modeling and simulation working group as part of the Australian, British, Canadian, and American (ABCA) Standardization Program [17] with the goal of expanding our opportunities for collaboration to include the appropriate Canadian and Australian defense organizations. Initial steps have been taken with these organizations to identify common objectives and opportunities for collaboration but the specifics of these arrangements are still in the early discussion phases.

4.2 Early Technical Transition

The OneSAF program has inserted concepts into the Product Line approach that not only support the interoperability and early use of the program by the U.S. Army community, but support the early use of OneSAF by the international community as well. These concepts support the transition of the international community from their current ModSAF applications to the appropriate internationally releasable OneSAF version by providing data/scenario harvesting tools that convert ModSAF related data and scenarios into the OneSAF XML based Scenario Specification Language. In addition, OneSAF will also provide an early capability to define unique service/country scenarios (unit structures, entities, etc.) and unique service/country unit and entity behaviors (both BLUFOR and OPFOR) by providing early access to the toolset supporting the OneSAF XML based Scenario Specification Language and Behavioral Specification Language.

5 Summary

In summary, the OneSAF program will provide the U.S. Army with substantial lifecycle savings by significantly reducing redundant SAF software development and evolution efforts, increasing interoperability and reusing products across the SAF user community, and by using leading edge product line architecture and design techniques to provide a modular, composable system that will support Army requirements into the future. To support this the Army leadership including STRICOM, the TPO, and the Army user domains: ACR, RDA, TEMO have collaborated to provide a series of products which convey the Government's OneSAF requirements and product line concepts to our industry partners and other external organizations.

6 References

[1] Bosch, Jan: "Design &Use of Software Architectures: Adopting and evolving a product-line approach", Addison-Wesley, 2000.

[2] OneSAF Architecture-IPT: "Near Term Schedule", Architecture-IPT Meeting Products, Dec. 6, 1999.

[3] OneSAF Architecture-IPT: "OneSAF Object Model Development Briefing", Architecture-IPT Meeting Products, December 6, 1999.

[4] OneSAF Architecture-IPT: "OneSAF Reuse Assessment", Architecture-IPT Meeting Products, December 6, 1999.

[5] Harrison, Cindy: "OneSAF Architecture R&D Plan", 13 April 1999.

[6] "One Semi-Automated Forces (OneSAF) Mission Needs Statement (MNS)", approved May 1997.

[7] "One Semi-Automated Forces (OneSAF) Operational Requirements Document (ORD) Version 1.1", 14 January 2000, Final Draft. (http://www.onesaf.org/public1safdocs.html).

[8] OneSAF OIPT: "ONE SEMI-AUTOMATED FORCES (OneSAF) Overarching integrated Product Team (OIPT) Charter".

[9] OneSAF Architecture-IPT: "One Semi-Automated Forces (OneSAF) Architecture Integrated Product Team (IPT) Charter", April 1999.

[10] Texel, Putnam P. and Williams, Charles B.: "Use Cases Combined with Booch/OMT/UML: Process and Products", Prentice Hall, 1997.

[11] STRICOM: One Semi-Automated Forces (One-SAF) Product Line Architecture Framework (PLAF), October 31, 2000.

[12] STRICOM: "One Semi-Automated Forces (OneSAF) Technical Requirements Document (TRD)", DOORS Electronic Information Environment, October 31, 2000.

[13] STRICOM: "One Semi-Automated Forces (OneSAF) Operational Concept Document (OCD)", DOORS Electronic Information Environment, October 31, 2000.

[14] STRICOM: "One Semi-Automated Forces (OneSAF) Reuse Direction and Guidance (RDG) DOORS Module", DOORS Electronic Information Environment, October 31, 2000.

[15] IEA-UK-A-A-97-1543, "UK-US Information Exchange Memorandum of Understanding, Annex Concerning Modeling and Simulation Technologies", 1997.

[16] DOORS, A Telelogic Product: http://www2.telelogic.com/doors.

[17] Australian, British, Canadian, and American (ABCA) Standardization Program, http://www.abca.hqda.pentagon.mil.

Author Biographies

ROBERT L. WITTMAN JR. currently works for the MITRE Corporation supporting the OneSAF program. He has been part of the U.S. DoD M&S community since 1990. During that time he has provided simulation engineering support to the Joint Staff J-8, JWFC, JSIMS, and STRICOM. He holds a Bachelor of Science in Computer Science from Washington State University, a Master of Science in Software Engineering from the University of West Florida, and is currently enrolled in the Industrial Engineering Ph.D. program at the University of Central Florida.

CYNTHIA T. HARRISON currently works for the U.S. Army STRICOM as the Chief Engineer for the OneSAF Program. Since 1985, she has had a wide

variety of experience in the Live, Constructive, and Virtual simulation domains for the Army and Navy. Ms. Harrison holds Bachelor and Master of Science degrees in Computer Science from the University of Central Florida.