Joint After Action Review Resource Library Open systems Architecture Approach

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ABSTRACT

The Solutions Group of US Joint Forces Command's Joint National Training Capability is developing a Joint After Action Review resource library (JAAR-RL) from Service GOTS tools. A successful business and technical approach of using resources of all four Services collaborating to build a new joint capability for use by all, a GOTS open source solution. Architectures within the Department of Defense (DoD) are created for a number of reasons. From a compliance perspective, the DoD is compelled by law and policy (i.e., Clinger-Cohen Act, Office of Management and Budget (OMB) Circular A-130) to develop architectures. From a practical perspective, experience has demonstrated that the management of large organizations employing sophisticated systems and technologies in pursuit of joint missions demands a structured, repeatable method for evaluating investments and investment alternatives, implementing organizational change, creating new systems, and deploying new technologies. Towards this end, the JAAR-RL Architecture and associated framework were developed as a guide for the integration of service AAR tool sets to satisfy Joint training needs.

The JAAR-RL provides the guidance and rules for integrating, representing, and understanding AAR tool sets based on a common denominator (framework) across Joint training sites and facilities. It provides Joint training stakeholders with insight into how to integrate the JAAR-RL into their training environments. The JAAR-RL architecture ensures that system descriptions can be compared and related across services, programs, mission areas, and ultimately, the enterprise, thus, establishing the foundation for analyses that supports decision-making processes throughout the DoD. This paper will describe the four points of architecture allowing the development of the Joint AAR Resource Library, and lessons learned from the use and production of disparate systems into one integrated homogeneous system.

ABOUT THE AUTHORS

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BACKGROUND

The Joint After Action Review Resource Library (JAAR-RL) architecture represents an architectural framework satisfying the requirements of the Joint AAR Functional Needs Analysis (FNA) specification. The functional definitions and their respective sub functions and communications structure does not reflect the design of the Joint AAR system but rather the functional composition required of a Joint AAR system. The design and development of the JAAR-RL is an effort of system engineering and integration using diverse COTS and GOTS hardware and software resources selected from the Functional Solutions Analysis (FSA). The integration development tasks are accomplished under JFCOM laboratories and integration facilities. These efforts are separate and distinct from any operational joint training exercises. The open architecture of the JAAR-RL enables integration of Service specific capabilities. The JAAR-RL is not a new software development program; the JAAR is program which integrates existing Service tool sets to satisfy Joint training needs related to after action review. When delivered to training sites, the JAAR-RL is tailored in specific operational context each site's Joint training needs. This paper discusses how acquisition processes and architecture were successfully applied to bring a stakeholder focus of integration to the JAAR-RL.

Relationship to JCIDS

The JAAR-RL was developed by following the JCIDS process as a guide for acquisition. The approach was to define the requirements through a functional needs analysis of existing AAR capabilities, then identify functional solutions from existing Service AAR tool sets. These solutions are then integrated operationally, and systematically, through common technical standards. This approach ensures Service tool sets are aligned and integrated as JAAR-RL components in context to specific architectural use cases that are the system functions developed during the function needs analysis.

Functional Needs Analysis

A functional needs analysis was conducted to identify gaps between Service/Cross-Service training and Joint training related to after action review. In this context Service/Cross-Service training is differentiated from Joint training by the tasks and associated measures used to evaluate and/or assess the training audience (Joint vs. Service). The FNA resulted in a set of AAR system functions or operational activities and the respective system requirements related to those functions/activities. The requirements of those functions represent measures of performance for the JAAR. The JAAR-RL is assessed by site/exercise personnel in context to their Joint training needs. Assessment tables for each system function are found in the JAAR System Verification Review Specification (SVRS).

Functional Solutions Analysis

Following the FNA the JAAR-RL assessment tables were used to assess existing AAR systems and programs for inclusion for increment 1 of the JAAR-RL. From over one hundred and fifty AAR systems and programs, a select group of programs were chosen based on high ratings from assessment tables of the specific system functions. The evaluation of mature technologies using JCIDS process represents the first phase of integration applied to the JAAR-RL.

Figure 1 depicts the current set of programs that have been integrated within the JAAR-RL across increments one and two.

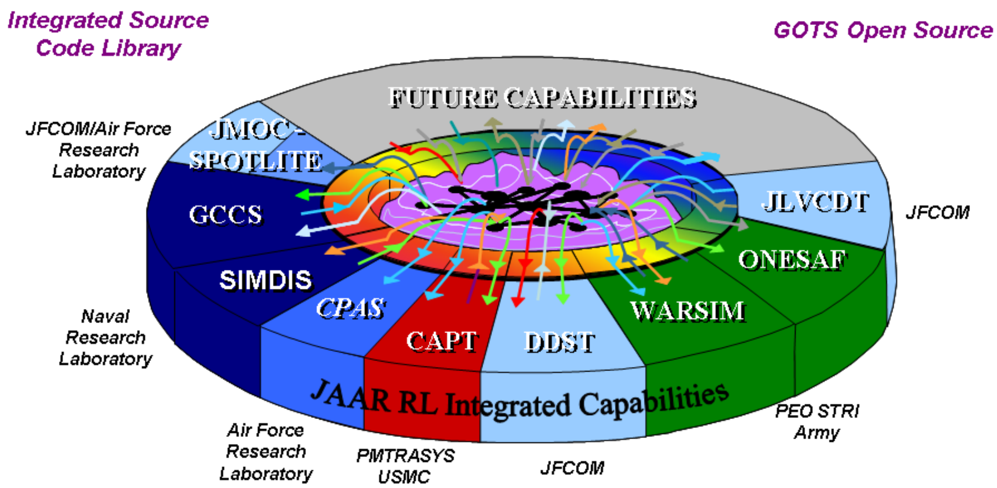

Figure 1. Joint After Action Review – Resource Library

- OneSAF AAR – The OneSAF AAR was selected based on ratings on the Reports functions as well as for the system architecture which was adopted as a starting point for the architecture of the JAAR-RL.

- RMT/DCS (CAPT) – The Combined Arms Planning Tool (CAPT) was selected based on ratings of planning functions. The CAPT tool includes a Tactical Plan Evaluator rules engine which is used to identify conflicts between battlefield elements such as fires and maneuver.

- WARSIM Data Collector – The WARSIM data collector was selected based on ratings of MOP/MOE, Data Retrieval, and Data Distribution functions. The WARSIM data collector provides a flexible framework for collecting simulation data from any HLA FOM into a common data model for after action review.

- DDST – The Distributed Decision Support Tool is a runtime analysis/adjudication workstation that provides access to JAAR-RL reports & products for AAR Analysts.

- GCCS Live C2/C4 Data Collection & Analysis – GCCS provides for track data collection from instrumented platforms, synthetic forces, and sensors/radars.

- SIMDIS 3D Visualization – SIMDIS provides 3D visualization of track and TENA data for the JAAR. It functions in real-time as well as replay modes of operation.

- JMOC (increment 2) – The Joint Measurement Operations Controller (JMOC) is a customized version of the SPOTLITE application for use within the JAAR-RL architecture. JMOC allows observer measures to be captured digitally and reviewed for use in AAR and other post exercise analysis.

- CPAS (increment 2) – The C2 Performance Assessment System is used to assess performance of the dynamic targeting cells. CPAS collects performance data for assessment from the Automated Deep Operations Coordination System (ADOCS).

These AAR tool sets and technologies were initially integrated through the four points of integration being technological standards for Protocols (HLA, DIS, TENA, etc), database (ODBC/SQL), Queries, and AAR Product (Media and other OLE Files).

Four Points of Integration

As a first step in aligning reused AAR tool sets from increment 1, the concept of four points of integration was established. These four points of integration are depicted in Figure 2. This concept arose as a common pattern of integration shared across AAR tool sets, ensuring the strengths of each tool set could be integrated in an appropriate technological context of the JAAR-RL.

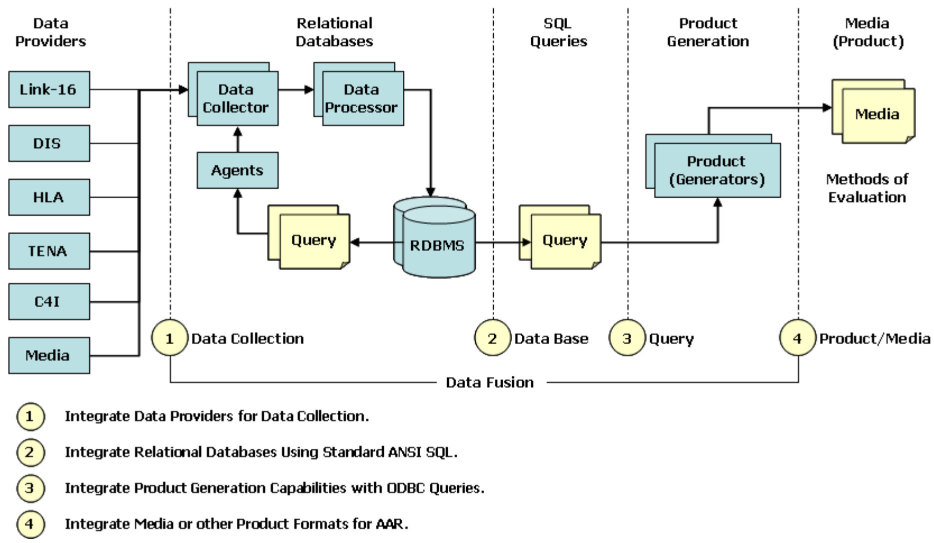

Figure 2. Four Points of (technical) Integration

(2) Data Collection – This point of integration involves using middleware applications and/or gateways to collect data from standard protocols. That data is then processed into a relational database.

(3) Data Base – This point of integration involves publishing collected data from a relational database through technical standards of ODBC and SQL.

(4) Query – This point of integration involves delivering queries as ODBC record sets or comma delimited files to product generators such as reporting or replay components.

(5) Product/Media – This point of integration involves the publication and sharing of AAR products through media, such as video, OLE documents (excel charts, tables, etc), and other formats to include chat.

These four points of technological integration represent the second phase of integration for the JAAR-RL. They ensure AAR tool sets can be integrated in context of their individual strengths of data collection, data base, query, and/or products/media through common technological standards.

INTEGRATION FRAMEWORK

Following this second phase of integration, the JAAR-RL was evaluated in context to operational Joint exercises using the assessment tables produced from the JCIDS process. This evaluation resulted in requirements for alignment of AAR components by common system functions (operational activities). That evaluation led to a third phase of integration at the system level. This integration consolidated graphical user interfaces and synchronized state of JAAR-RL components to include data collection, time management, etc. As the JAAR-RL is delivered to stakeholders, the system is configured to meet their operational and architectural needs. This operational context of integration represents the forth phase of integration for the JAAR. This integration cycle is repeated as additional AAR tool sets are integrated with the JAAR-RL and delivered to Joint stakeholders. This cycle represents the Integration Framework for the JAAR-RL.

Because the JAAR-RL is built upon the integration of service tool sets, the JAAR-RL Architecture was developed to provide Joint training stakeholders with a road map for how to integrate the JAAR-RL into their training environments. Under the JAAR-RL four phases of integration are brought to bear for each service AAR tool set that is included in the JAAR-RL. These phases are:

(1) Evaluation – Candidate tools are evaluated by the JAAR-RL assessment tables. Tools meeting high marks in one ore more functions are selected for integration within the JAAR-RL.

(2) Technological Standards Integration – Initial integration is conducted by aligning tools with the JAAR-RL four points of integration (protocol, database, query, and AAR product). System Integration – Once the basic technological integration has been completed, tools are integrated as the system

level as components of one or more workstations. For example, as a data collector or a replay component.

(3) Systems Integration – This phase of integration is accomplished by consolidating system functions on specific operational nodes of the JAAR-RL. This results in the integration of common capabilities under a consolidated user interface.

(4) Operational Integration – When deliveries of the JAAR-RL are made, the AAR requirements for a Joint training site/exercise are evaluated. That evaluation results in a unique JAAR-RL configuration that is delivered in specific context to the operational training needs of the site/exercise.

It was decided to apply concepts of the DoD Architectural Framework (DODAF) to the architectural specification of the JAAR-RL. The graphical products and associated descriptions were developed as abstractions of the system. As recommended by the software engineering institute (SEI), these products were developed to reflect:

- A vehicle for communication among stakeholders.
- The manifestation of the earliest design decisions.
- A reusable, transferable abstraction of a system.

The following sections provide an overview of the JAAR-RL DODAF products/views.

OPERATIONAL VIEW

The Operational View (OV) was developed to describe the tasks and activities necessary to successfully perform operational activities for Joint after action review. OV descriptions are useful for facilitating actions and assessments related to the integration of JAAR-RL components within existing Joint training facilities and architectures.

Operational Concept (OV-1)

The OV-1 describes the JAAR capability, operational nodes (see OV-2 definition) and interesting or unique aspects of operations related to integration with the JAAR-RL. It provides a description of the interactions between the JAAR-RL architecture and the Joint training/AAR environment.

Figure 3 depicts the operational concept of the JAAR-RL for supporting joint training, test & evaluation applications and stakeholders. Data is collected from LVC simulation systems and live/real world C2 systems to support a broad range of joint users and applications.

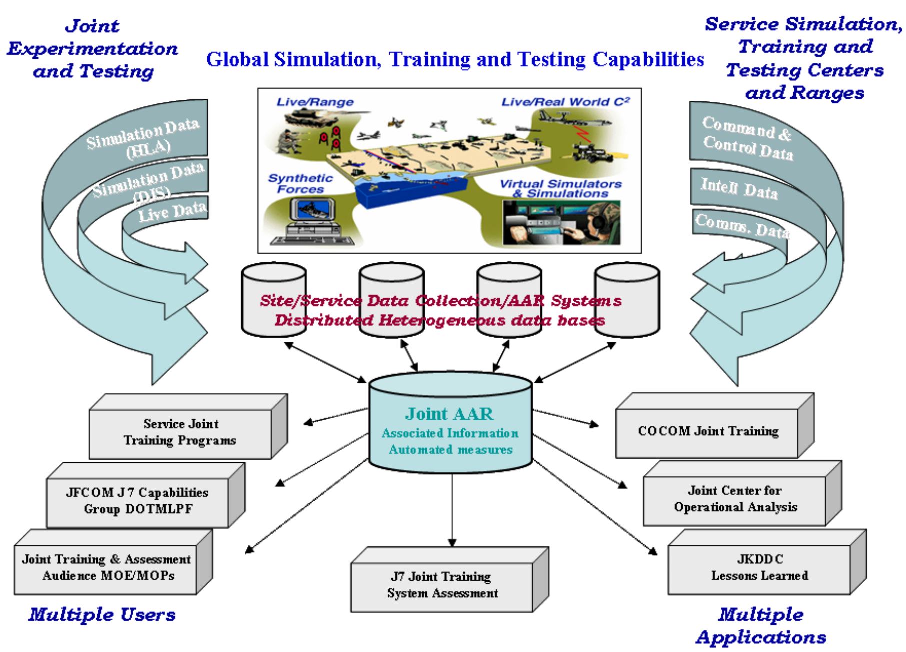

Figure 3. Operational Concept (OV-1)

The JAAR-RL interfaces to these systems in order to collect and fuse the exercise data into a common database. JAAR-RL tools and products are then used to analyze, filter, and display the data in formats that support the discovery and learning experience of after action review.

Operational Nodes (OV-2)

The Operational Node Connectivity Description (OV-2) is a composition hierarchy of operational nodes, connectivity and information exchanged between those nodes.

Figure 4 depicts the operational node connectivity provided for by the JAAR-RL. This view is applied to integrate the JAAR-RL in specific context to the tools and models used at each exercise site. This ensures the JAAR-RL does not replace systems (nodes) already in use; it integrates with them through common technical standards (DIS, HLA, TENA, etc).

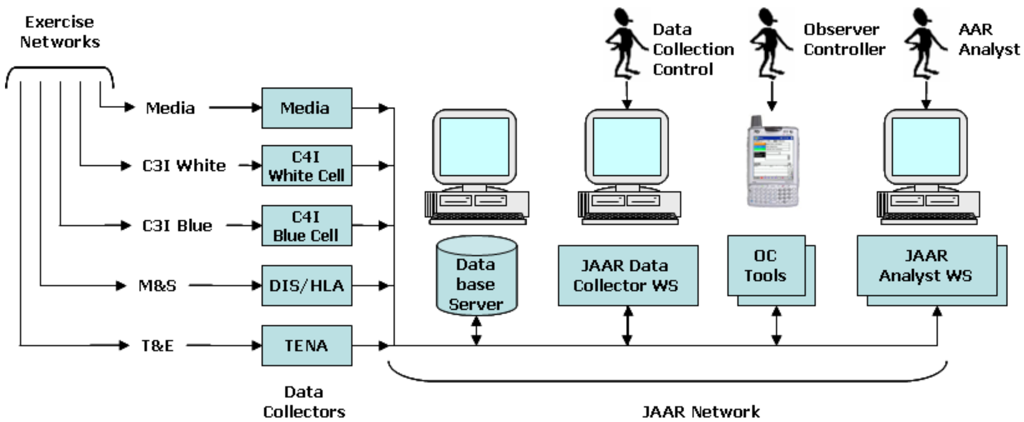

Figure 4. Operational Node Connectivity Diagram (OV-2)

- White Cell (C3I) – Operational protocols representing exercise ground truth for technical control.

- Blue Cell (C3I) – Operational protocols representing the perceived truth to the training audience.

- Modeling & Simulation (M&S) – HLA and DIS protocols publishing the simulated battle space for the exercise.

- Test and Evaluation (T&E) – TENA protocols publishing the live battle space for the exercise.

- Observer Controller (PDA) – PDA devices are used to collect structured observations for an exercise.

- Data Collection Control – Data Collection Control manages and controls exercise/system data collectors of T&E, M&S, and operational data.

Operational Activities (OV-5)

The OV-5 was shown in Figure 5 was developed to describe the activities that are normally conducted in the course of achieving the mission of after action review.

Within the JAAR-RL architecture this operational activity diagram is further decomposed within the architecture to reflect the specific system component hierarchies, timing and activity sequences which occur in support of each operational activity:

- Planning Activity – The after action review capability for an exercise is planned based on scenario content, Joint tasks, and the exercise architecture.

- Operator Interface Activity – The operator interface of the JAAR represents an integrated set of user interfaces focused to the needs of AAR Analyst and Exercise Control staff.

- Communications Activity – The communications function activity provide the joint AAR with the ability to retrieve tactical, operational and strategic information from various voice and data links in specific context to fused data.

- Real-Time Feedback Activity – The real-time feedback activity provides mechanisms to monitor and observe the exercise in progress. This activity supports roles of exercise and observer controllers.

- Data Fusion Activity – The data fusion activity associates relevant information from multiple sources related to individual events and entities.

- Data Retrieval Activity – The data retrieval activity obtains reference data from multiple sources including exercise data, doctrine, observations, etc.

- MOP/MOE Activity – The MOP/MOE activity provides measures for the assessment of Joint tasks in training exercises.

- Analysis Activity – The Analysis activity provides for the conduct of analyzing the sequence of actions, events, and performance of systems or subsystems related to the strategic, operational and tactical views of the Joint training exercises.

- Reports Activity – The reports activity provides summary and detail reports of entities, events and associated actions in context to situational details of those entities, events, and associated actions.

- Replay Activity – The replay activity provides the ability review fused data for specific events or actions in 2D/3D display as well as communications (audio and text).

- Collaboration Activity – Collaboration enables JAAR users to work together (collectively) in a distributed fashion in support of other activities.

- Data Distribution Activity – The data distribution activity provides efficient access to data in support of other activities from distributed or remote sites

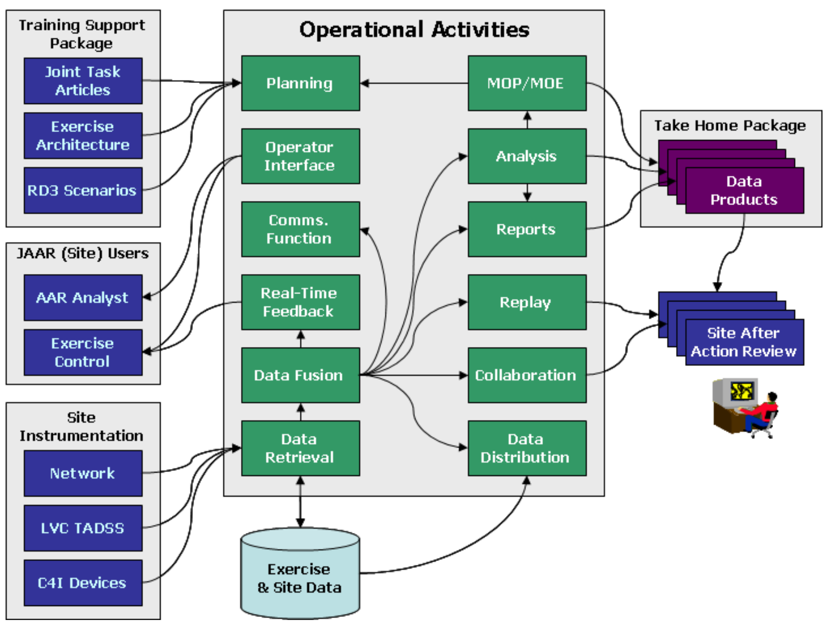

Figure 5. Operational Activity Diagram

SYSTEMS VIEW

The Systems View was developed to describe the systems and connections to those systems in context to the JAAR-RL. The SV is used for many purposes, including systems base lining, making decisions concerning ways to satisfy Joint training/AAR requirements, and evaluating interoperability improvements for site specific joint training environments. An SV addresses specific technologies and "systems." These technologies represent integration strategies with existing, emerging, planned, and conceptual Joint testing training solutions.

The SV is a set of graphical and textual products that describes system resources providing for functions of Joint AAR. These system views support operational activities and facilitate information exchange among operational nodes.

Systems Interface Description (SV-1)

The JAAR-RL architecture provides a context for the integration of service AAR tool sets in support of Joint training needs. Where the JAAR-RL architecture identifies integration strategies of service AAR tool sets at the three levels of Operational, System, and Technological Standards, the SV-1 represents the strategy for integrating service tool sets at the Systems level.

There are two Interface Descriptions for the JAAR-RL:

- Inter-nodal Interface Description – A view depicting the interfaces between internal (JAAR) nodes and external nodes.
- Intra-nodal Interface Description – A view depicting the interfaces between internal (JAAR) nodes used to distribute data across components of the JAAR.

The inter-nodal view shown in Figure 6 organizes interfaces into three categories, user functions, JAAR functions, and exercise functions.

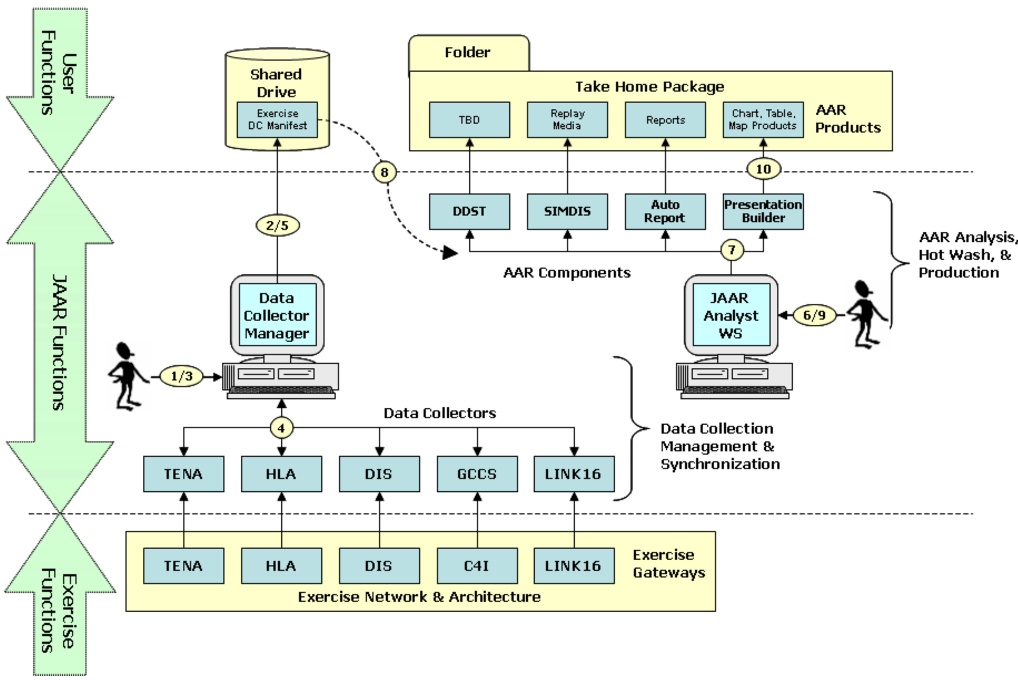

Figure 6. Inter-nodal System-System Interfaces

User functions represent media and other products that are generated using the JAAR components and applied to exercise objectives for AAR. JAAR Functions represent the JAAR software and hardware assets made up of integrated service AAR tool sets. Exercise functions represent the exercise network and architecture that is a context of JAAR-RL integration. The exercise network and architecture publish exercise data over networks to the JAAR-RL.

The intra-view is reflective of the four points of integration as shown in Figure 2. The Data Collector workstation encompasses integration points 1 and 2. The Analyst workstation encompasses integration points 2 and 4.

The systems views of the JAAR-RL are stakeholder driven. User needs of the JAAR drive the capabilities (solutions) to be integrated. The selection of Service tool sets drives the selection of solutions. Together these needs and solutions drive systems evolution of the JAAR-RL.

Systems Evolution Description (SV-8)

The SV-8 captures the evolution plans describing how the JAAR-RL architecture will evolve in future builds and increments. This view ensures stakeholders understand the future opportunities for integration with the JAAR-RL.

TECHNOLOGICAL VIEW

The Technological View was developed to describe the set of rules governing the arrangement, interaction, and interdependence of system components. The TV provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. The TV includes a collection of the technical standards that govern systems and system elements for the JAAR-RL integration architecture.

Technical Standards Profile (TV-1)

The technical standards profile is a listing of standards that apply to Systems and Services View elements of the JAAR-RL. The scope of standards includes formats, protocols, and middleware applications.

Table 1 summarizes the technical standards that are applied during second phase of integration for the JAAR-RL, technical standards integration.

Table 1: Middleware and Gateway Standards

Standards Area	Standards	Tool Sets						
		WARSIM Data Collector	JLVCDT	JDT	GCCS	PostgreSQL	DDST, SIMDIS, OneSAF	CPAS, JMOC
Live Range	TENA		Read/Write	Read/Write	Read			
Synthetic Forces	HLA	Read	Read/Write	Read/Write				
	DIS		Read/Write	Read/Write				
Command & Control	LINK		Read	Read/Write	Read			
	OTH GOLD			TBD	Read			
	USMTF			TBD	Read			
	VMF			TBD	Read			
	TACFIRE / GDU			TBD	Read			
Data Base	SQL	Read/Write			Write	Server	Read	Read/Write
	ODBC	Read/Write			Write	Server	Read	Read/Write
Document Formats	OLE, Video, Audio						Read/Write	
	Chat				Read		Read	Read

The technical standards profile of the JAAR-RL identifies standards used to integrate stakeholder training sites with the JAAR-RL as well as integrate Service tool sets as components within the JAAR-RL.

JAAR-RL ARCHITECTURE FRAMEWORK

The works of Paul Clements et al. (2002, 2003) on the SEI series on software architectures was used to develop the JAAR Architectural Framework. The JAAR-RL Framework shown in Figure 7 represents a modular view of architectural layers. These layers include:

- Operational Layer – The Operational defines the operational AAR use case scenarios or activities supported by the JAAR.
- Product Layer – The Product Layer is related to the Systems Layer through classes of functional AAR Products. These products represent consolidated or integrated systems of the JAAR-RL.
- Systems Layer – The Systems Layer identifies the software assets that make up the JAAR Resource Library. Each asset represents an instance of one or more AAR Products or capabilities.
- Technical Support Layer – The Technical Support Layer identifies the gateways and middleware applications that integrate the Systems with the Technical Standards.
- Technical Standards Layer – The Technical Standards Layer identifies the standards and network protocols supported under the JAAR-RL.

Understanding how these layers relate enables a stakeholder to understand how integration is to be achieved for:

- New Technology (technical standards layer and technical support layer)
- New Service Tool Sets (Systems Layer)
- New AAR Products and capabilities (Product layer)
- New JAAR users and Joint training capabilities (Operational Layer)

This framework brings together three of the four phases of integration into a single context enabling a stakeholder to understand how the JAAR-RL integrates operationally through systems and systematically through technical standards.

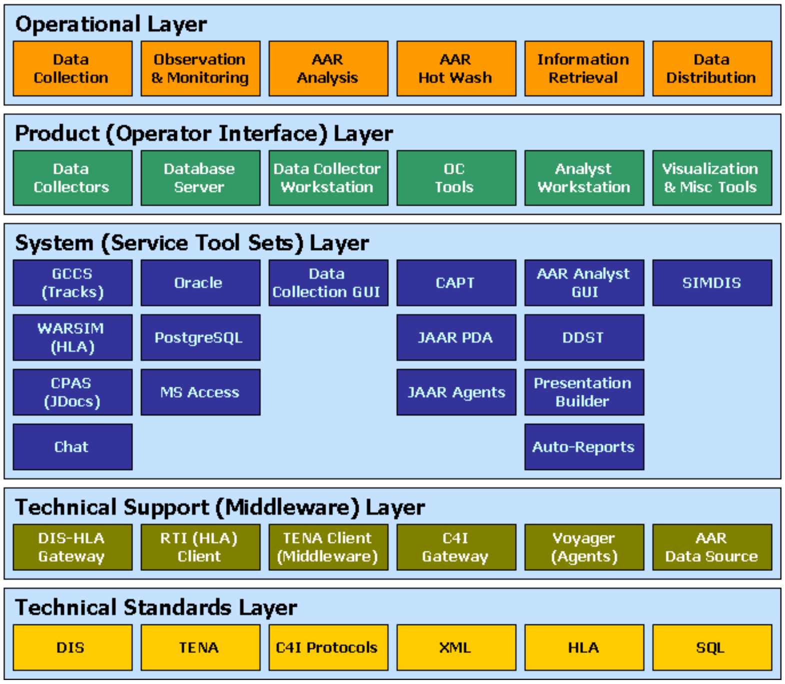

Figure 7. JAAR-RL Architectural Framework

LESSONS LEARNED

The SEI (2006) has evaluated the JCIDS framework as still a waterfall process. In context to new software (technology) development that can be a problem as it requires an accurate vision into the future nature of a system's implementation. In case of the JAAR the JCIDS process is used to inform decisions on the selection of those best of breeds tool sets based on known current functional needs.

Integration and reuse in contrast to new software development can succeed quite well, but there are challenges. Under the JAAR-RL integration occurs in a distributed environment. Jessica Lipnack and Jeffrey Stamps (1997) found that struggles in technical leadership, notions of competition for work share, lack of trust, and cultural incompatibility between teams can disrupt any distributed team. Integration and reuse demand the architecture be flexible and adapt to common constructs that exist across the reused components. Yet, architecture must come first if integration is to be effective and team synergy is to be maintained; reference Paul E. McMahon (2001). The solution of these two seemingly opposing forces was found in a top-down bottom-up approach to the JAAR-RL Architecture. The operational and all views represent the top-down reality of the operational context the JAAR-RL must integrate to. The technological standards views represent the bottom-up reality of interoperability and integration as it applies to AAR. The system views evolve or adapt to suit the top-down bottom-up approach to developing the JAAR-RL. The system views will continue to evolve into the future as additional capabilities are integrated with the JAAR.

The views of the DODAF provide a common context of understanding to a broad scope of stakeholders. A balance must be achieved in terms of the level of detail specified in the architecture; too much detail leads to maintenance problems; too little does not provide a common understanding for your stakeholders. Unique and interesting concepts such as the four points of integration provide cohesion across the views of the architecture.

In the context of reuse and integration, architecture must adapt to fit the needs of the systems being integrated. This necessity does not conflict with operational or technological views of the DODAF. The impact is principally in context to the systems views. The longer system view decisions can be deferred, the more informed architectural decisions become. Under the JAAR these decisions are made as patterns of integration are identified; where two or more components are integrated into the same context. Integration frame works can be used in context to these patterns to ensure repeatable means of integration.

CONCLUSIONS

Formal process and architecture have led to the success of the JAAR. JCIDS was used as an acquisition process for developing JAAR-RL requirements and system functions being the functional needs. Functional solutions were then selected for reuse based on those needs. Architecture provided the context for integration. The Four Points of Integration provided an immediate context for integration of Service tool sets. This context proved to be a universal concept shared by all AAR systems. This common context provided a means for relating requirements, system functions, and selected (reuse) components directly to the architecture. It represents a universal concept of integration that is readily understood by all stakeholders.

Acquisition processes and architecture take time and resources to develop. Commitment to process and architecture brings integrity to the program. With integrity comes the trust from your stakeholders.

The use of software agents and middleware applications under the JAAR-RL provided a service oriented approach for integration. This approach combined with the four points of integration has demonstrated a proven level flexibility and scalability for integration of AAR systems.

Integration does not push aside the programs that are selected for reuse. Integration builds upon those base programs as a foundation of reuse. This includes software, architecture, and documentation.

Architecture provides a common understanding as an abstraction of the system. It does not answer all questions stakeholders might have; it does enable stakeholders to ask all the right questions the first time.

The DODAF is not a cook book for architectures. It takes some time to apply this framework to any architecture. We found it to be important to specify operational and technological views first. Then develop system views of the architecture as understandings and concepts evolve.

ACKNOWLEDGEMENTS

Without common architectural frameworks and acquisition processes the JAAR-RL architecture would not exist. We are pleased to acknowledge the United States Department of Defense for DoD Architectural Framework and the Joint Capabilities Integration Development System of acquisition requirements and evaluation criteria.

Without academia we would not have recognized the need to tailor and extend the DODAF to focus on software reuse and integration activities. We are pleased to acknowledge Carnegie Mellon and the Software Engineering Institute for their publications on software architectures and product lines.

Without stakeholders no architecture can succeed. We are pleased to acknowledge the efforts of the JAAR-RL team, contributing programs, users, and customers for their efforts to provide capabilities, feedback and improvements to the JAAR-RL.

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