Using Service Flagship Simulations for Joint Training

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ABSTRACT

USJFCOM and the Joint Training Integration and Evaluation Center (JTIEC) conducted a study to identify what Service capabilities were available - currently or in the near term (5-year) pipeline - that could provide additional and/or a more cost effective Joint capability. The study assessed the additional operating costs associated with using these capabilities, and examined what federation architecture(s) would best support their employment.

The paper will discuss the findings of the first phase of the study. The study recommended development of a single, unified constructive architecture that leverages Service flagship simulations and the best features of existing federations, and the next steps required to achieve these goals.

ABOUT THE AUTHORS

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STUDY PURPOSE AND APPROACH

Purpose

The United States Joint Forces Command's (USJFCOM) Joint Training Directorate and Joint Warfighting Center (J7/JWFC), is facing declining research, development, test and evaluation funding, while the demand for both USJFCOM supported training and simulation capabilities is growing as our nation and our allies face an increasing range of threats.

USJFCOM currently develops two simulations, the Joint Theater Level Simulation (JTLS), and the Joint Conflict and Tactical Simulation (JCATS). USJFCOM does not always use its simulations alone in an exercise. Instead, USJFCOM often uses a federation of simulations that provide additional capabilities than those provided by JTLS or JCATS. This federation, called the Joint Live, Virtual, and Constructive federation (JLVC) is also managed by USJFCOM. In addition to the JLVC, one other federation is often used for Joint Training. This federation managed by the US Army and is called the Joint Land Component Constructive Training Capability – Multi-Resolution Federation (JLCCTC-MRF).

Some of the simulations that USJFCOM currently uses within JLVC are being retired. Additionally, in some cases, the Services have their own "Flagship" simulations that USJFCOM does not currently employ. The purpose of this study is first to identify what Service capabilities are or will be available that could provide additional and/or a more cost effective Joint capability. Assuming there are such capabilities available, the study is to assess the additional development and operating costs associated with using these capabilities, and identify what federation architecture(s) would best support their employment.

Training Paradigm and Study Direction

There are two ends of the training paradigm spectrum. At one extreme lies the Master Scenario Events List (MSEL)-driven and simulation supported (MDSS) paradigm. Features of this paradigm include:

- The exercise follows a predetermined script - not what is predicted by simulations.
- The simulations are used strictly for visualization (e.g., unmanned aerial vehicle feeds), to feed the common operational picture, and to generate messages for battle command systems and role players.
- The OPFOR and BLUFOR role players cooperate to ensure the exercises stays on script, reconstituting forces and otherwise previewing and modifying simulation results and C2 feeds prior to their delivery to the training audience.

At the other end of the spectrum lies the outcome based and competitive (OBC) paradigm which has these characteristics:

- Training audience decisions are translated into simulation orders and the simulation computes the outcome of the exercise based on those orders.
- There is a competitive OPFOR that reacts to, and attempts to defeat, training audience behavior.

While the exercises supported by the constructive simulations described in this study are never conducted exclusively at one end of the spectrum or the other, Joint exercises are largely MDSS, while Army, USMC and Navy largely follow the OBC paradigm, and Air Force exercises lean towards one end or the other or are a hybrid, depending on the exercise.

The study team quickly concluded that answering the question of whether Service simulations can effectively

be leveraged for Joint training depends on the answer to the question of whether USJFCOM will continue to lean towards the MDSS mode, or whether they would change to more OBC exercises in the future. The answer to the training paradigm question is not for this study to draw – it is USJFCOM's decision. Furthermore the answer may not be one or the other but rather that USJFCOM needs the ability to operate at both ends of the spectrum - or in the middle - depending on training audience, theater, the type of operation, or any of a host of contributing factors.

USJFCOM directed that the study team assume for the purpose of the study that there is a need for OBC training exercises and use of Service simulations to support them.

Study Approach

USJFCOM and the Joint Training, Integration and Evaluation Center (JTIEC) jointly funded the study. The study period of performance was deliberately short - February to October 2008.

MITRE executed the study with a core study team and consultants from within MITRE who have relevant experience with JMRM, JLVC, JLCCTC, the service simulations, and the technology and architectures used to build federations.

The Flagship Integrated Product Team (IPT) ensured that all stakeholders had input and review over the study. The IPT included the MITRE team, as well as representatives from USJFCOM and all of the Services, who were responsible to provide input to the study team, arrange for visits to observe exercises and to solicit technical information, and to review and debate emerging results. The JTIEC served as facilitator of the IPT meetings. Table 1 captures IPT membership.

The broad and iterative steps in the study were as follows:

- Develop an understanding of JFCOM supported Joint exercises, current simulation usage and needs
- Assess use of Service simulations for Joint training and identify architecture options
- Assess development[1] and operations costs of current Joint capabilities and alternative architectures

[1] Midway through the study, the IPT deferred the task of capturing development costs to a follow-on study, if at that time collection of that information is deemed relevant.

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Table 1 Flagship IPT Membership

The pool of Service simulations was constrained to those both ***planned and funded*** to be available in the near term, 5-year time horizon. This is an important assumption because developers can (arguably) alter simulations to do just about anything, given enough dollars, time, and operating resources.

The IPT was unanimous in its belief that the study collected and analyzed an enormous body of information heretofore held only piecemeal by the participating organizations and not organized into a DoD enterprise view. However, there are details still in debate by the IPT membership, details that time did not permit exhaustive resolution, details that have changed since they were examined by the study team, and probably some capabilities that should be included in the study that were overlooked. The study team, with sometimes-lively debate and input from the IPT, has done its best to integrate the information into a cohesive and balanced view of a complex and rapidly evolving problem space.

[2] Air Force Agency For Modeling and Simulation
[3] Program Executive Office, Simulation, Training and Instrumentation
[4] National Simulation Center
[5] Navy Warfare Development Command
[6] United States Navy Fleet Forces Command
[7] Program Manager for Training Systems
[8] Training and Education Command

CURRENT AND PLANNED CAPABILITIES

JLVC

JLVC (Figure 1) is an entity level federation. USJFCOM manages JLVC and uses the federation for Tier 3 and, increasingly, Tier 2 exercises and for multi-Tier exercises involving both.[9] USJFCOM may use only a subset of the federation, depending on the exercise requirements. As shown by the legend, the Services are the primary developers for many of the components. JLVC uses its own custom federation object model and federation policies, derived from the Real Time Platform Reference (RPR) FOM v2.

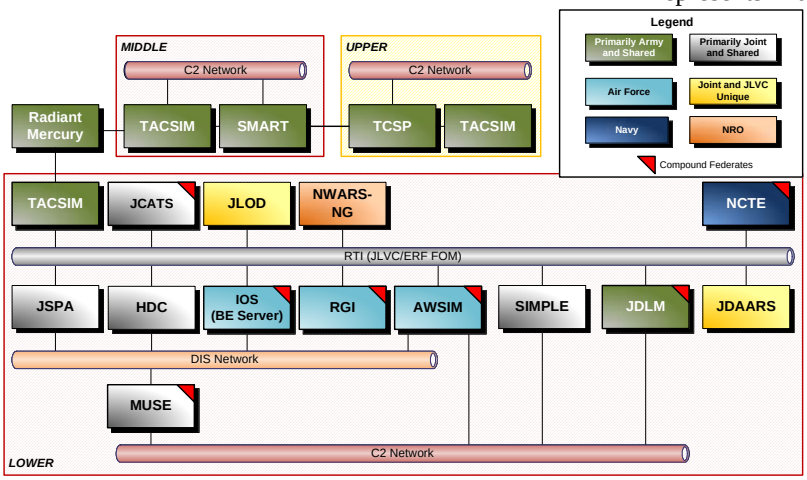

Figure 1 JLVC Federation Architecture

In the JLVC, JCATS models the ground and amphibious forces and is the de facto Army and Marine Corps entity level simulation until the Army's OneSAF simulation is in use[10].

The Air and Space and Cyberspace Constructive Environment (ASCCE) represents Air Force assets in the JLVC. ASCCE includes the Air Warfare Simulation (AWSIM), which depicts air force assets including aircraft, cruise missiles, surface-to-air missiles, and air bases and the Runtime Interface (RTI) GENIS Interface (RGI), which is the primary graphical user interface for AWSIM. It also includes the Information Operations Suite (Air and Space Constructive Environment (ACE)- Information Operations Simulations (IOS) / Basic Encyclopedia (BE) Server which, in JLVC, represents the Air Force intelligence assets.[11] Not depicted in the JLVC federation architecture are other components within ASCCE that interact directly with AWSIM and are not JLVC federates. The primary supporting components include an Air Force logistics model and interfaces to Air Force battle command systems.

The Navy Continuous Training Environment (NCTE) is a federation consisting of multiple copies of the Joint Semi-Automated Forces (JSAF) simulation, which represents Navy surface, subsurface, and air assets, along with supporting components such as Navy intelligence simulations and interfaces to Navy battle command systems. From the JLVC perspective, NCTE appears as a single federate, because the NCTE federation interoperates with its own Federation Object Model and federation policies and RTI via a single bridge to the JLVC.

NCTE operates only at the classification levels of US SECRET or higher, reflecting the classification of the JSAF models of anti-submarine warfare. This has architectural implications for NCTE in a federation supporting a coalition exercise. Also, the generic architecture shown in Figure 2 is somewhat misleading since NCTE cannot be run in the lowest enclave of a three enclave federation (assuming the lowest enclave is unclassified or releasable to a coalition partner).

Joint Deployment Logistics Model (JDLM) feeds the Battle Command Sustainment Support (BCS3) and models certain Army logistics functions, to include maintenance, medical, in–transit visibility, supply and convoy operations. In JLVC, JDLM also models convoy attrition, movement, and force protection.

The National Reconnaissance Office develops the National Wargaming System – Next Generation (NWARS-NG), which models National Electronic Signals Intelligence (ELINT) and National Imagery Intelligence (IMINT). In the JLVC, NWARS-NG operates at the US SECRET level of classification.

The Tactical Intelligence Simulation (TACSIM) models Army tactical sensors and National ELINT.

[9] When the staff functions as an Unified Combatant Command (UCC, formerly known as COCOM), the exercise is a Tier 1 exercise. A Tier 2 exercise involves a staff operating as a Joint Task Force (JTF) headquarters, and a Tier 3 exercise involves staffs operating as one or more component commander (Air, Land, Maritime or Special Operations).

[10] The Army plans to use OneSAF instead of JCATS when OneSAF is ready. The Marines Corps will make a decision once OneSAF is ready.

[11] The BE Server function is only used in JLCCTC-MRF.

TACSIM also models National IMINT but at a lower fidelity than NWARS-NG. The TACSIM system includes TACSIM, SMART, TCSP, and Radiant Mercury, which collectively provide guards and interfaces to allow TACSIM to operate at up to two different levels of classification in an exercise with up to three enclaves. TACSIM is being retired.

USJFCOM develops the Joint Low Overhead Driver (JLOD), a relatively new federate. Right now JLOD represents masses or crowds, such as might appear in a refugee evacuation. In the long term, USJFCOM plans for JLOD to represent Service functions in exercises where the Service is not a key player, but with significantly less labor and computer overhead. JLOD may also have a future role in irregular warfare.

USJFCOM also develops the Simulation to C4I Interchange Module for Plans, Logistics and Exercises (SIMPLE) (the JLVC interface to Army battle command systems), the HLA to DIS Convertor (HDC), the Joint Simulation Protocol Analyzer (JSPA), and the Joint Deployment After Action Review System (JDAARS). USJFCOM provided the study team with the following priorities for JLVC in the next five years.

- Reduce the footprint and improve USJFCOM's ability to provide Master Scenario Events List MDSS exercises
- Develop tools to build more coherent federation databases faster such as Joint Training Data Services (JTDS)
- Develop MSEL tools to inject MSELs directly into the simulations
- Allow JLOD, rather than Service simulations, to round out the battlefield when the Service in question is not a focus.
- JWFC is considering moving towards outcome based training in the future but the timeline is unspecified.

JLCCTC MRF-C

The JLCCTC MRF Corps Battle Simulation Centric (JLCCTC MRF-C) federation (Figure 2) is based on the Army's current aggregate ground model, the Corps Battle Simulation (CBS). MRF-C is used for the Multi Tier (2 and 3) Operation Iraqi Freedom Rotation MRX and also for Army Division and Corps Warfighter exercises. MRF-C uses its own custom federation object model and federation policies, based upon the Joint Training Confederation Aggregate Level Simulation Protocol interface control documents and federation rules.

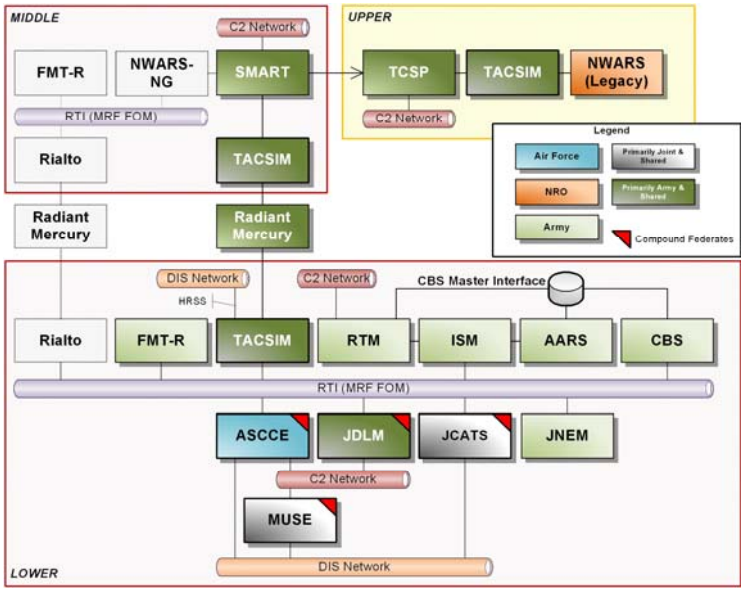

Figure 2 JLCCTC MRF-C Version 5

The Joint Training Transformation Initiative Plus Korea (JTTI+K) (Figure 3), adds missile defense, maritime play, and Republic of Korea (ROK) simulations and tools. JTTI+K is used for the Joint / Coalition Tier 3 Korea exercises Yama Sakura, Key Resolve, and Ulchi Freedom Guardian.

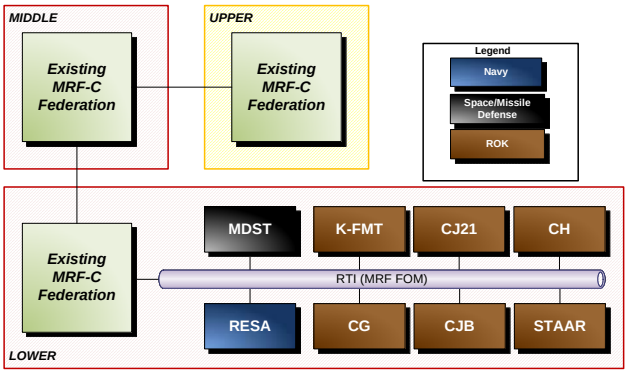

Figure 3 JTTI+K Version 5

CBS primarily represents units as battalions and companies and represents the ground battle, except for in the JCATS area of interest. JCATS is responsible to assume control of CBS entities in specified geographic areas of interest and fight the entity battle within JCATS until the unit is handed back. JCATS is also responsible to exchange indirect fires with CBS's aggregate ground forces and with ASCCE's air forces.

In MRF-C, ASCCE is used to represent Air Force assets and to interface to Air Force battle command systems in any exercise where there is an Air Force training audience.

In MRF-C, ACE-IOS / BE Server serves an additional function not used in JLVC – the common representation of fixed sites, or BE Server. The BE Server is used to reconcile and provide a single view of fixed sites such as bridges or buildings that are modeled in more than one simulation.

The Runtime Manager (RTM) provides an interface between CBS and the Army Battle Command System (ABCS) components, except for Battle Command Support Sustainment System (BCS3) and All Source Analysis System (ASAS).

The Joint Non-Kinetic Effects Model (JNEM) models the responses of civilians in relation to explicit Blue force (BLUFOR) action such as neighborhood patrols or damage to a civilian facility. Favorable civilian reaction benefits the BLUFOR – for example it may trigger increased flow of intelligence data. Unfavorable civilian reaction triggers undesirable responses such as an increase in hostile activity by civilians.

Independent Stimulation Module (ISM) is responsible to monitor changes in civilian satisfaction as computed by JNEM, and provide appropriate feedback to role players and training audience via email. ISM also can inject scripted events (such as Improvised Explosive Device (IED) explosions) into the battlespace.

JDLM feeds BCS3 and models certain Army logistics functions, to include maintenance, medical, in–transit visibility, supply and convoy operations.

Use of TACSIM in MRF-C is functionally equivalent to its use in JLVC.

The Federation Management Tool Reloaded (FMT-R) monitors and controls technical operations.

Rialto is a two-way, HLA-compliant wrapper around a Radiant Mercury guard that allows two federations in two security enclaves to interoperate both technically and functionally. Currently, the down data is limited to data required for technical federation operations such as save or resign or time management functions.

Additional JTTI+K components include:

- Research Evaluation and Systems Analysis (RESA) (developed by Space and Naval Warfare Systems Command (SPAWAR)) was at one time the sanctioned Navy constructive simulation. While it is no longer supported by the Navy, it is still used in Korea to represent US Navy assets.
- MDST (US Space and Missile Command) is used in JTTI+K to represent tactical ballistic missile (TBM) early warning and send the TRAP/TIBS feed to the training audience.
- Chang Jo 21(CJ21) is the ROK ground force simulation, Chang Gong (CG) is the ROK air force simulation, Cheong Hae (CH) is the ROK naval simulation, and Cheon Ja Bong (CJB) is the ROK marine corps-equivalent simulation.
- System for Theater Level After Action Review (STAAR) is the AAR tool used in JTTI+K.
- K-FMT is a Hangul version of the FMT-R.

The ROK and US land, air and maritime simulations are fully interoperable for basic combat functions, with the exception that there is no close combat interface between CBS, CJ21 and CJB.

MRF-C is being retired in favor of a Warfighter Simulation (WARSIM)-centric version, MRF-W. MRF-W will be fielded for use in Army and Joint exercises in Version 6 in 2010, at which time MRF-C will no longer be used for those purposes. MRF-W will be upgraded and fielded for use in very high intensity exercises by 2012, after which time MRF-C / JTTI+K will not be used at all.

OTHER SERVICE FLAGSHIP SIMULATIONS

The Air Force and Navy Flagship simulation systems, ASCCE and NCTE, respectively, are already used for joint training as part of the JLVC, as is the current de facto Marine and Army entity simulation, JCATS. Not currently in use are the next generation Army aggregate and entity simulations, WARSIM and One Semi-Automated Forces (OneSAF), and the Marine aggregate simulation, the Marine Corps' Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulation (MTWS).

ONESAF

OneSAF will replace JCATS as the entity ground model of choice for the Army and possibly for the USMC. OneSAF passed its last constructive training test, but not all needed functionality for Army constructive training has been built or tested. As a result, OneSAF is not currently validated for training within the US Army.

In 2011 and 2012, OneSAF plans to develop additional capability to address known functional gaps, integrate into JLCCTC, and harden for exercise use so that OneSAF will be ready for training no later than 2013.

JLCCTC Entity Resolution Federation (ERF)

ERF is used for Army Brigade and below training. ERF shares an architecture, FOM and federation policies with JLVC. ERF differs from JLVC in that it does not include the Navy and Air Force components, and it adds components needed for Army training.

JLCCTC MRF-W

JLCCTC MRF-W will replace MRF-C using WARSIM as the aggregate ground model in lieu of CBS and WARSIM Intelligence Module (WIM) as the Army and National Intelligence model in lieu of TACSIM and NWARS. MRF-W is being developed and integrated in an evolutionary fashion in three versions - 5, 5.5 and 6. All versions will undergo user testing but only Version 6 will be fielded.

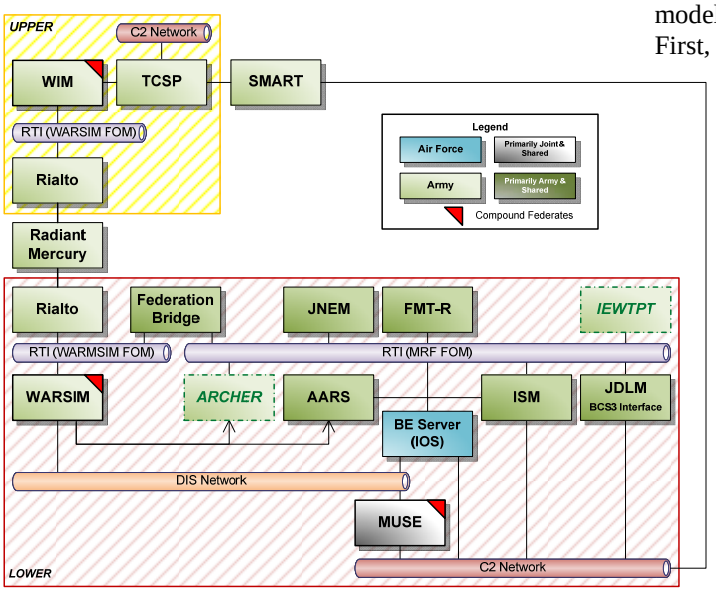

Figure 4 MRF-W Version 5

Figure 4 depicts three federations that together make up MRF-W v5. The first federation, in the lower enclave on the right, runs an RTI using the same MRF FOM used in MRF-C. From the perspective of the RTI running the MRF FOM, WARSIM appears as a single federate – the Federation Bridge. However, like NCTE, WARSIM is itself a federation – in fact in Version 5 it is two federations - a lower enclave where the ground game and other federates operate, and an upper enclave where an SCI level version of the WIM operates. The WARSIM federations use the WARSIM FOM. The WARSIM compound component in Figure 4 looks like Figure 5 when expanded.

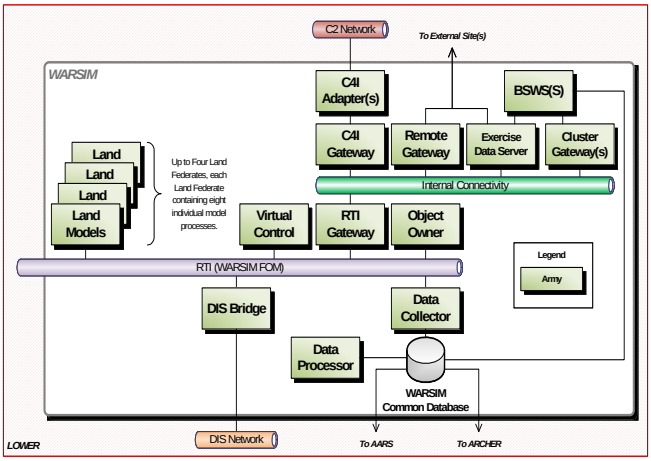

Figure 5 Details of a WARSIM Federation

In MRF-W, the WARSIM land models replace the land models provided by CBS in MRF-C. WARSIM land models are different from CBS in three key regards. First, the physical presence of units is modeled at an echelon lower than CBS – typically at the platoon level. Secondly, WARSIM includes models of behaviors of the units that allow their semi-autonomous behavior and that allow them to automatically adjust behaviors as the situation changes. Finally, WARSIM combat algorithms do not use the Lanchester equations used by CBS that calculate force-on force attrition over time using differential equations. Instead WARSIM computes individual vehicle and person sensing and shooter pairings.

MRF-W Version 5 includes interfaces to the ISM, JNEM, AARS, FMT-R, Rialto / Radiant Mercury and Multiple Unified Simulation Environment (MUSE) components that directly mirror functionality in MRF-C and, for the most part, reuses those interfaces. An exception to interface reuse is that AARS collects data via the CBS Master interface in MRF-C and from the Data Collector in MRF-W.

MRF-W Version 5 also includes an interface to BCS3 via the JDLM BCS3 Interface, which allows WARSIM logistics models to be used, rather than JDLM models. This mode of operation is needed for Army or Joint exercises where a full up Army logistics training

audience is not present and the "lighter" and lower-overhead WARSIM models are sufficient.

MRF-W Version 5 also includes a partial interface to the ASCCE / BE Server fixed site capability that allows damage to fixed sites by WARSIM to be reflected at the MUSE. In Version 5 WARSIM could only damage but not repair fixed sites.

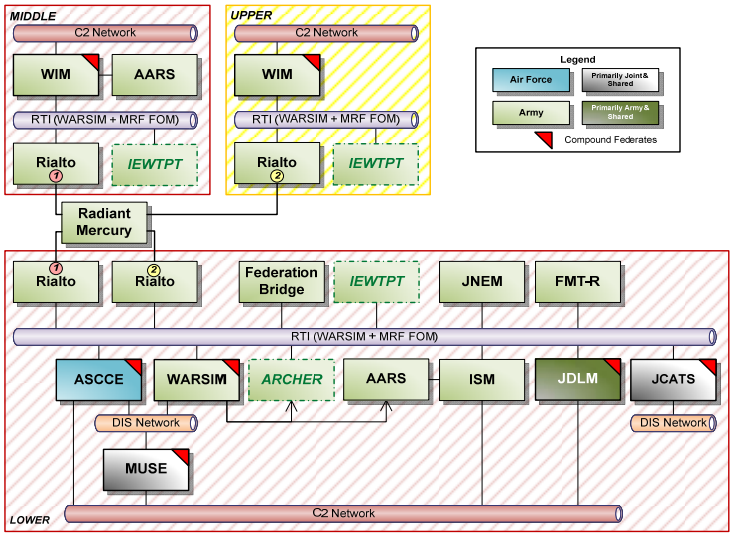

Figure 6 MRF-W Version 6.0

MRF-W Version 6 (Figure 6), will provide full functional equivalence to MRF-C, but not to the JTTI+K. As shown in the diagram, MRF-W Version 6 adds a third enclave with both US SECRET and SCI intelligence models, has full interoperability to ASCCE / BE Server, and includes JCATS. It also will include a switchable capability to use full JDLM logistics models or the JDLM BCS3 Interface with WARSIM logistics models and interfaces to Archer (a BCTP AAR tool) and the Army's Intelligence Electronic Warfare Tactical Proficiency Trainer (IEWTPT).

A key architectural change planned – pending ongoing proof of concept analysis and experimentation – is to merge the MRF and WARSIM FOMs into a super-FOM to reduce the number of federations. HLA Data Distribution Management (DDM) services or RTI sender side filtering would be used to optimize distribution of the merged data - allowing WARSIM-FOM data to be sent only to the WARSIM federates that understand it and, likewise, MRF-FOM data to be sent only to the MRF federates.

Other enhancements planned but not explicitly depicted include an interface to Distributed Common Ground System (DCGS-A), improved stability and performance, enhancements to irregular warfare and intelligence, scalability to Corps (from Division in Version 5), select simulation "down data" through Rialto and Radiant Mercury, and resolution of functional problems identified in Version 5.

Objective JLCCTC (JLCCTC-O)

JLCCTC-O (Figure 7) is the end state capability planned by the Army in 2012. The Army will no longer support multiple architectures for MRF and ERF, or have a need for simultaneous support of legacy (MRF-C) and evolving future (MRF-W) federations. Instead there will be one JLCCTC that uses one architecture that allows for use of WARSIM, OneSAF, or both simultaneously in a multi-resolution mode.

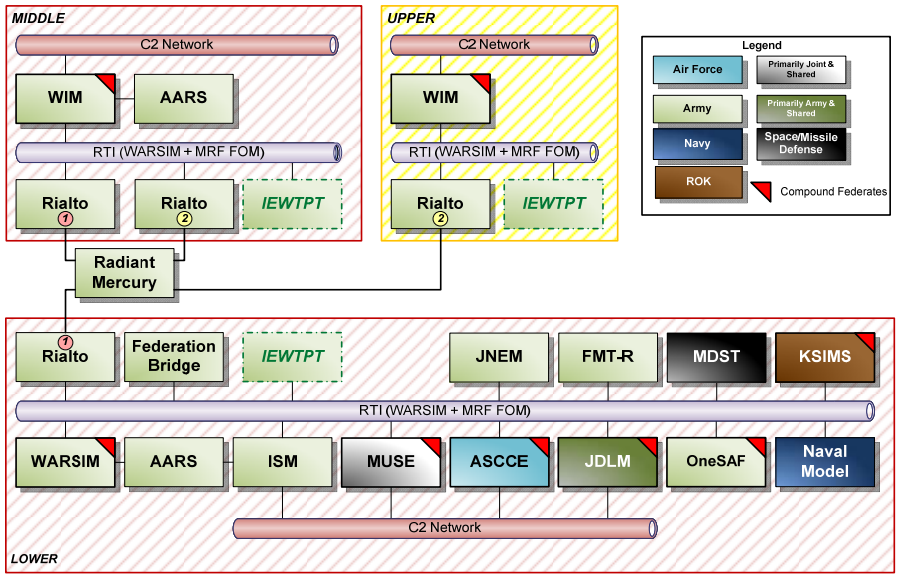

Figure 7 JLCCTC-O 2012

In addition to replacing separate ERF and MRF federations, JLCCTC-O 2012 will replace JCATS with

OneSAF, migrate MUSE to HLA, and provide scalability to echelons above Corps. Also, it will add the JTTI+K capability. Unknowns in this latter enhancement are what model will be used to represent US Naval forces and whether the ROK models will operate on the other side of a ROK only enclave, as is being discussed by the ROKs and KBSC.

MCFED

The Marine Corps Federation (MCFED) includes MTWS, JCATS, and the Shadow UAV simulator. Like JMRM and JLCCTC-MRF, MCFED uses JCATS to focus on high resolution tactical objectives within a larger operational scenario being played in MTWS.

Simulation interoperability exists for:

- Object ownership transfer, allowing a switch between aggregate modeling in MTWS and detailed modeling in JCATS
- Indirect fire engagements
- Direct fire engagements (no ground-to-ground)
- Resupply

The USMC certified MCFED in May 2008, focusing on four universal joint task lists: amphibious operations, joint fires, close air support, and gain/maintain air superiority. The USMC is currently working with JFCOM to investigate putting MTWS into JLVC.

GROUND MODEL COMPARISON

USJFCOM explicitly asked that the study evaluate overhead costs of using different simulations. Since there are single solutions for Navy and Air Force simulations there is no comparison to be made for these services. However, Army next generation systems are on the verge of being fielded and consideration needs to be given as to if, when and how JFCOM uses them. Specifically, the timelines, architecture options, operating costs (manpower and computer overhead) and benefits of use relative to JCATS needs to be captured. Likewise, the USMC aggregate simulation of choice, MTWS, is not included in any federation now, so its costs and benefits need to be captured. Data about CBS, the Army's current - but soon to be retired - aggregate ground simulation is included as a point of reference.

WARSIM is programmed to be available as the primary ground model in MRF-W in 2010 and OneSAF in 2012. MTWS is available now. Use in a different architecture would require additional unfunded development and integration, pushing those timelines to the right. Similarly, MTWS can be used stand-alone or in MCFED today, but using it in a different architecture would require unplanned and unfunded development and integration.

	Companies controlled by One Role Player/Workstation																			Sim Servers	Entity Count	Max Size		Movement Group for			Realism of combat outcomes (important for OBC but not MDSS exercises)	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	⇒	30*	⇒	100**			Current	Planned	Entity	PLT	CO	Validation	Comment
JCATS Entity	1																			2 HP 8400 CHP	250K	DIV	DIV	x				
JCATS PLT					5																				x			LOS and range computed based on center of
JCATS CO															15											x		mass of aggregate while attrition based on
OneSAF Entity Control	1																			20 Dell670	30K v2.0 Test	BCT	BCT	x				Designed to operate here but not yet valildated
OneSAF CO Control					5																			x				Designed to operate here but not yet valildated
OneSAF BN Control										10														x				Not planned til 2012
CBS CO					5											⇒	30*	⇒	100**	1 Opteron	10K aggs and 360K entities	EAC	EAC			x		
WARSIM PLT w/o AB***	1																			1-4 Opteron	230K for BCT to 730K for EAC	BCT	EAC	x				Failed Army validation but undergoing
WARSIM PLT w/ AB					5					10														x				correction for 2010 - AB area in need of most
WARSIM CO					5																				x			work
WARSIM BN															15											x		Can operate at aggregation above level algorithms designed
MTWS												12								1-3 Linux servers	2000 units****	MEF	MEF			x		

* Very exoerienced operator

** OPFOR only

*** 1 AB = Automated behaviors

**** Generally companies but also some squads and special teams

KEY
Validated by Army
Potential for validation by Army in Flagship timeframe
Potntial for validation bt Army past Flagship timeframe
Used by JFCOM and failed validation by Army
Potential for use by JFCOM but not planned for validation by Army
Validated by USMC

Table 2 Operating Costs and Benefits

Table 2 compares the operating costs (manpower and computers) and benefits (scalability, granularity of forces, service validation) for JCATS, OneSAF, CBS (as point of reference), WARSIM and MTWS.

The first columns, labeled "Companies controlled by One Role Player / Workstation", give a relative metric on the numbers of role players needed to operate the models when used in various modes in an exercise. When JCATS is operated in entity mode – i.e., each vehicle or life form entity is independently managed by a role player - one role player can manage a company of entities. But when JCATS is operated in its so-called "aggregate mode" and the aggregation is done at the company level, one role player can manage 15 companies.

The "Sim Servers", "Entity Count" and "Max Size" columns show that, in all modes, JCATS runs on two HP 8400 common hardware platforms and it can represent up to 250,000 entities, or roughly a division sized exercise.

The "Movement Group" columns show how entity motion is portrayed. When JCATS is operated in entity mode, the individual vehicles and life forms have autonomous motion; when operated in aggregate mode, the motion of the group (platoon or company) is templated into a fixed formation. This can create situations where entities at the fringe of the center of mass of the aggregate fall off roads or go through buildings.

JCATS operated in entity model has been validated by the Army. When operated in aggregate mode, however, the model fails Army validation. This is basically because operating JCATS in aggregate mode means that it is being operated outside the bounds for which many of its algorithms are designed. For example, in aggregate mode, the line of sight (LOS) and shooter / target calculations are based on the location of the aggregate center of mass, while the outcomes are still computed on an entity-to-entity basis. This is an issue for the Army, which uses the OBC training paradigm, but is less of an issue in an exercise using the MDSS paradigm, where role payers are prepared to override simulation results to match a script anyway.

OneSAF forces currently can be controlled at the individual entity or the company level. By 2012, battalion control is planned. A significant difference between OneSAF and JCATS is that OneSAF provides so-called "automated behaviors"; software that translates orders by the role player at the company (and later battalion) level into behaviors at the individual platform level. The automated behaviors also allow the individual vehicles to react automatically to changes in their environment, independent of role player input. This latter function is what is meant by the term semi-automated force in the name OneSAF. The use of automated behaviors should give OneSAF an advantage over JCATS in two ways. Unlike JCATS aggregate mode, OneSAF automated behaviors allow greater span of control by an operator while both allowing individual vehicle autonomous motion and behavior, and also preserving validated behavior.

An important caveat to the above is that the automated behaviors in OneSAF have not yet been validated by the Army or by the USMC[12].

The major cost to the improved OneSAF capability will be hardware footprint. The OneSAF simulation nodes ran on 20 Dell 670s in the v2 test with approximately 30,000 entities meant to represent a typical Army Brigade Combat Team (BCT). The nodes were not operating at capacity at this test and no data is currently available on the maximum number of entities this suite could manage, nor on how many nodes could be added to extend the number of entities. However, OneSAF is only required by the Army to scale to a BCT sized exercise.

Also of note at the v2 test is that the OneSAF entities were operated in mixed modes as follows:

- ~3600 CO controlled units, having a high computer requirement and low people requirement
- ~2000 PLT controlled units, having a medium computer requirement and medium people requirement
- ~24,000 Entity controlled units, having low computer requirement and high people requirement

CBS aggregate forces are generally represented and controlled at the company level although a given exercise will typically have a mix of battalions through platforms. A typical role player can control 5 BLUFOR companies and an experienced BCTP-type operator can control up to 30. In CBS, the opposing force (OPFOR) models are simpler than the models of BLUFOR – allowing an OPRFOR controller to manage as many as 100 OPFOR company-equivalent units.

In the largest exercise it supports (UFG), about 10,000 aggregate units are typically played. CBS can represent

[12] Battalion control, while planned, has not been demonstrated and will be very challenging.

individual platforms and small groups of people in template formations that vary with unit posture. While the entity mode is turned off in UFG exercises, the 10,000 aggregates translate into about 360,000 entities. CBS is routinely validated for use by the Army.

The span of control for a typical WARSIM operator when aggregation is at company or platoon level is the same as for a CBS operator - 5 BLUFOR companies – assuming that platoon aggregation includes automated behaviors. Automated behaviors in WARSIM have not yet been validated by the Army but the plan is to do so by 2010. A very experienced WARSIM operator can manage up to 10 BLUFOR units. WARSIM currently does not have simplified and easier to manage models for OPFOR so span of control for OPFOR models is the same as for BLUFOR. Increased span of control for OPFOR is planned for WARSIM in 2010.

Like some other models, WARSIM can be operated outside the design parameters of it algorithms. When units are aggregated to the battalion level, a controller should be able to manage 15 companies. The Army has no plans to validate this mode at this time. The WARSIM ground simulation itself runs on 1-4 Options, but the hardware footprint of WARSIM as a whole is significantly larger and is shown in Table 3.

are typically companies but which typically also includes some squads and special teams. This size exercise represents a Marine Expeditionary Force (MEF). MTWS can project template entities as well but the movement group is the size of the aggregate. MTWS is validated by the USMC.

STUDY FINDINGS AND CONCLUSIONS

Training Paradigm Choice Impacts Use of Service Simulations

MITRE concluded that if USJFCOM wishes to continue to use more of an MDSS paradigm, then Service simulations may not be the most cost-effective tools. If the intent is to have the exercise follow a detailed and prescriptive course, independent of how models predict the battlespace will change in reaction to training audience decisions, then USJFCOM should investigate tools that are not simulations at all, but rather "movie generators" that can create the needed feeds and visualizations based upon a fixed script. Service simulations can be - and are - used to produce this same effect, but with considerable overhead both on the part of running the simulations and overriding their sometimes unwanted outcomes.

MRF-W V5.5 WARSIM HARDWARE - 2 Enclave					
Type System	Platform	Low Enclave	High Enclave	Total	Comments
WARSIM Model #1	**Opteron4-L**	**1**	**0**	**1**	
WARSIM Model #2	**Opteron4-L**	**1**	**0**	**1**	
WARSIM Model #3	**Opteron4-L**	**1**	**0**	**1**	
WARSIM Model #4	**Opteron4-L**	**1**	**0**	**1**	
INTEL Model	**Opteron4-L**	**1**	**1**	**2**	
Federation Bridge	**Opteron4-L**	**1**	**0**	**1**	
ORACLE/NES	**Opteron4-L-D-A**	**1**	**1**	**2**	
Guard Interface	**Opteron2-L**	**0**	**1**	**1**	
Data Proc/Coll	**Opteron2-L**	**1**	**1**	**2**	
RTI Gateway	**Opteron2-L**	**1**	**1**	**2**	
DIS Bridge	Opteron2-L	1	0	1	Optional - Needed for MUSE Interface
Remote Gateway	Opteron2-W	1	0	1	Optional - Needed for Distributed/Forward Suites
C4I Gateway	Opteron2-W	1	0	1	Optional - Needed for Interfacing with C2 Training
C4I Adapter	Opteron2-W	2	0	2	Optional - 1 Adapter per TOC
DNS	**Opteron2-W-A**	**1**	**1**	**2**	
Virtual Contol	**CHP-1M**	**1**	**1**	**2**	
Exercise Data Server	**CHP-1M**	**1**	**1**	**2**	
RIALTO	**CHP-1M**	**1**	**1**	**2**	
Radiant Mercury	**Netra 44D**	**1**	**0**	**1**	May be upgrading this computer
Senior Control	**CHP-2M**	**1**	**1**	**2**	
System Consule	CHP-2M	1	1	2	Optional - Only needed if KVM is not used
Cluster Gateway	CHP-1M	1	0	1	Optiona - 1 Cluster per 20 BSWS
BSWS	CHP-2M	-	-	-	Depends on the Number of Role Players

Table 3 WARSIM Hardware Footprint

WARSIM has demonstrated scalability to BCT and will be validated at division scale by 2010, and EAC by 2012.

An MTWS operator can control 12 companies and MTWS can simulate up to 2,000 aggregate units which

However, if USJFCOM has a need for more OBC exercises, then validated Service M&S capabilities should be incorporated because Service M&S capabilities – when operated in the mode the Services validate - provide the fidelity required for OBC exercises.

Potential for a Unified Constructive Architecture

While today we do not have a single M&S approach that addresses all Joint training use cases using OBC, the study team and IPT concluded that a technical solution that uses Service constructive simulations in a single unified constructive architecture (UCA) is feasible and would:

- Address current use case gaps
- Cost money in the short term to modify simulations to adhere to the architecture
- Save money long term by reducing development and integration for multiple architectures
- Potentially shift exercise costs from planning to execution – the net difference needs to be assessed

Based upon this conclusion and USJFCOM's desire to further pursue the question of training paradigm (therefore leaving open the potential that Service simulations could be well leveraged), the IPT recommended that a Flagship Study Phase 2 be conducted. The purpose of this study would be to:

- Design a detailed UCA. This would include a paper design as well as experiments to validate the unified architecture assumptions. Much like the Phase 1 study involved the Service and Joint government user and developer representatives, Phase 2 would include their technical representatives to ensure the design captures the needs of all of the stakeholders.
- Build a roadmap and business case for the architecture and change in simulation employment to help weigh the costs and benefits.
- Formalize a future management and collaboration structure to govern a unified constructive architecture.

The results of the Phase 2 study would then be used to decide the future direction – conduct of the study does not imply preordained answers to either the training paradigm question or the question of whether a unified UCA should be pursued.

Architecture Pros and Cons

The pros and cons of the primary extant architectures – JLVC and JLCCTC – and the proposed UCA are listed below. Strong points are indicated with an upward facing arrow. Diamonds are open issues for which solutions are being developed. Downward arrows indicate major shortcomings. "Cat paws" show open issues that are independent of the architecture chosen.

JLVC strengths and weaknesses are that JLVC:

- Uses an architecture that is the emerging community choice for LVC interoperability
- Includes Navy and Air Force and today's de facto Army and Marine Corps entity simulations
- While JLVC can support large scale exercises the methods used are not those validated by the Army.
- Does not include the ROK simulations
- Does not currently include the Marine Corps' service simulation (MTWS).

JLCCTC, on the other hand:

- Provides realistic representations for high intensity, large scale, ground intense scenarios and has the best span of control for ground model operators if realistic outcomes are a criteria for ground play
- Includes the ROK simulations
- Also does not include the Marine Corps' service simulation (MTWS).
- Is missing the Navy-endorsed simulation (JSAF); and the need for ROK model interoperability poses a significant security challenge if the Navy model can only operate at US SECRET
- Does not enable virtual or live given its current development path

A notable disconnect between JLVC and JLCCTC is that

- The Army's next generation entity simulation (OneSAF) is targeted to interoperate with JLCCTC and not JLVC, meaning JLVC remains dependent on JCATS unless a course correction is made on some axis.

Under a unified constructive architecture

- Simulations would not have to maintain multiple baselines for multiple architectures
- Hardware and operator expertise would be common and shareable
- Independent development of similar capabilities would be avoided
- Most shortcomings of both JLVC and JLCCTC would be addressed
- Current development plans would likely be disrupted
- A new short term bill for services simulations to adapt would be presented
- There would be an increased cost of coordination

- The autonomy of USJFCOM in JLVC and of the Air Force and Army in JLCCTC could be impacted

Finally, there are three major architecture–independent open issues

- Given the state of guard down data, US SECRET Navy models cannot interoperate with coalition simulations to anywhere near the same level that the current US models that can run at Releasable to the Republic of Korea (REL-ROK) do – currently all cross model combat interactions except ground-ground direct fire or close combat are supported.
- Close combat between ground models when one or more of the models is aggregate and different attrition approaches are used is an expensive proposition that may never yield satisfactorily realistic results, at least for an OBC paradigm.
- While the Army's next generation aggregate, entity and intelligence models will share common and dynamic representations of terrain and weather to address environment-related fair fight issues, other models will continue to have different views unless they too use these services. Conversion to use of the services could be costly.

Other Findings

Other study findings that will influence when and if USJFCOM can leverage Service simulations and /or retire their own include:

- The Army's next generation entity simulation (OneSAF) is not planned for first Army use within the 5-year planning horizon of this study. This means that USJFCOM, the Marine Corps and the Army all will still need to depend on JCATS until at least 2012.
- In the JLVC, ACE-IOS can fill in for the Army's retiring intelligence simulation (TACSIM) at low cost. WIM has more capability but will cost more to integrate and will have a larger footprint – its incorporation would be more cost effective if it were part of a package with WARSIM.
- Steps are being taken now to integrate MTWS into the JLVC. This activity should be coordinated with the development of the UCA - and vice versa - to ensure both that USMC model requirements are addressed in the UCA and also that work done to bring MTWS into the JLVC now is reusable later in the context of the broader UCA.
- The Army has made and continues to make a sizable investment in tools (JNEM and ISM) to represent irregular warfare. These tools do not meet USJFCOM requirements as is, and USJFCOM is preparing to develop their own capability. USJFCOM and the Army should collaborate to determine if the existing tools could be molded to meet USJFCOM needs.

Way Ahead

USJFCOM and JTIEC have co-funded the second phase of this study to be executed from March to September 2009. As a first use case, the study team is evaluating how a UCA could support US Korea Command (USKORCOM) constructive training requirements. Within the context, team is assessing architecture options for MRF and KSIMS to integrate with the JLVC.

Final Thoughts Going Forward

During this study, the Services and Joint communities stepped back to take a DoD enterprise perspective of simulation-based training. This is very encouraging, as organizations can leverage other existing capabilities through such an enterprise approach. While this has previously been seen in small pockets at the working level, it had not been explicitly directed in recent times until this study.

At the same time, it is important to recognize that there are tradeoffs between the benefits of collaboration and the cost of coordination. Collaboration may lead to software reuse and improved interoperability, but in some cases, this may be wasted effort if systems are not designed to or needed to operate with other systems. It is also a political reality that individual organizations are funded for a specific purpose; and coordination with other organizations, while beneficial for the DoD in general, may not help an organization to meet its specific objectives. Collectively, it seems the community has recently erred on the side of too much avoidance of the costs of coordination.

As a result of this study, organizations have gained a clearer understanding of other ongoing activities that can have a direct impact on their work. This study raised and captured many local issues. A collective decision on whether we pursue a unified architecture or multiple architectures, and whether there is one management body or multiple management bodies that converge periodically, will drive what issues need to be addressed and when. Even if the specific path recommended by this report is not followed, continued communications between the relevant DoD modeling and simulation organizations would still be fruitful.

The individual organizations will be able to make more informed, cost-effective decisions by furthering the close coordination that occurred during this study.

The study team has endeavored to make impartial and informed assessments. However, it is impossible for the authors of this report to have all the data or knowledge that the Flagship IPT collectively brings. Therefore, continued coordination and collaboration is necessary to exploit the IPT's collective expertise.

REFERENCES

Simulation Interoperability Standards Organization (SISO) Real-time Platform Reference FOM, Version 2 Draft 17