RAPID INTEGRATION OF LARGE SCALE DISTRIBUTED SYNTHETIC ENVIRONMENTS

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ABSTRACT

The imperative to build large-scale synthetic environments has been driven by the increasing operational tempo experienced by nations due to political instabilities in many world regions simultaneously. One of the main problems faced by the services and national agencies is the need to compose an environment in time to meet a training, rehearsal or analysis need. During 2001 the US Joint Forces Command proposed the development of a prototype Joint Battle Space Environment (JBE) to encourage discussion as well as provide a baseline vision to the IITSEC community on where and how these environments should develop. An unexpected side effect of the integration of the many models and C4I systems for the prototype was the need to rapidly configure such a system and to demonstrate it live to a critical audience. This paper examines the experience and poses a number of issues that were highlighted by the first iteration of the JBE.

ABOUT THE AUTHORS

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INTRODUCTION

Modeling and simulation (M&S) techniques and technologies have been used extensively by military forces world wide to provide effective training over the past decade. These technologies have evolved over the years from a combination of physical model and computer assisted event adjudication, to standalone complete constructive simulation environments such as JANUS [1] that require little physical augmentation for terrain or for models.

As M&S technology has become more widely accepted there has been a realization that distributed simulation environments will provide additional utility through:

- Anywhere training.
- Distributed computational load management.
- Hybrid (combinations of live, virtual and constructive) environments that provide greater fidelity to the trainee or team.

There is also a realization that this technology also has application in the areas of acquisition, experimentation, analysis and mission rehearsal. Each of these application areas has its own unique requirements regarding accuracy and fidelity.

WHERE ARE WE NOW?

The large financial investment in simulation systems over the past decade and in many cases the stove piped development of service specific (Army, Navy (Marines) and Air Force) models has generated inter and intra-service contention regarding the advancement of the technology and its scalability and supportability into the future, whilst recognizing a reluctance to decommission systems that have been widely accepted and are embedded in the service training environments. This has initiated and will perpetuate the development of a common architecture to facilitate meaningful communication between these systems to obtain additional utility as an interim step to the next generation of modeling and simulation (M&S) technology, possibly involving composable object based technologies. This is a systems approach now being called M&S composability theory.

The High Level Architecture (HLA) [2] is an example of the implementation of such an architecture. Unfortunately, HLA is not a panacea and will not address model specific issues that fall back to verification and validation techniques as well as incompatibilities between the different model algorithms that are the subject of common environment adjudication. In other words, how do you provide a fair play environment amongst systems that attempt to mix stochastic and deterministic events, let alone the myriad of other issues (terrain, environment representation etc) that exist?

In recent years the United States Joint Forces Command (USJFCOM), started to examine how large scale synthetic environments could be implemented from both a practical (what exists today) and from a theoretical standpoint (where should we be) in order to develop a conceptual roadmap to evolve a persistent, on demand model driven environment for the future. This was captured in the Joint Battlespace Environment (JBE) vision:

> "*An on-demand, integrated environmental and operational battlespace, able to selectively accommodate different functional applications at varying levels of detail using common components*."
>
> **J7 USJFCOM 2001**

The aim of this paper is to examine the rapid integration and the ongoing construction of a large-scale synthetic environment and to suggest improvements to the development process.

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WHY BUILD LARGE SCALE HETEROGENEOUS ENVIRONMENTS?

For many years the Department of Defense (DoD) has struggled with providing the best possible environment for training whilst competing with budgetary cutbacks, increased operational tempo, changes in posture and increased complexity in operations (no longer the cold war attrition based focus).

In an effort to manage change, the use of modeling and simulation has become pervasive throughout the Defense community and is touching all facets of the military culture:

There have been many examples of single service attempts to generate holistic synthetic environments such as the Army Synthetic Theatre of War (STOW) and the USAF Joint Synthetic Battlespace (JSB), however these have been truly stove piped endeavors that have not been fully adopted on an inter-service basis. Rather a competitive approach has evolved that is driven by program interest, cultural and doctrinal divides, and specific-to-service requirements.

The recent move to form the US Joint Forces Command (USJFCOM) and the emerging and evolving role the USJFCOM is taking (in particular the homeland security requirements) has placed increased pressure on the Joint community to take a leadership role to mold doctrine and to integrate the single service capabilities into a more efficient and effective force multiplier.

This imperative has driven the development of the Joint Battlespace Environment (JBE). The JBE is an evolving distributed modeling and simulation architecture that will provide a persistent training and analysis environment based on a best of breed approach across all service programs. The objective is to develop an architecture that will allow "on demand" plug and play training, analysis or experimentation whilst reducing cost, maintenance and complexity of operation. The environment must be "war-fighter focused" and responsive to rapid planning and deployment requirements. This will eventually be fully realized by the formation of the Joint National Training Capability (JNTC) of which the JBE is the synthetic component only.

During 2001 the United States Joint Forces Command (USJFCOM) established an initiative to develop a framework that is supportive of constructing large scale synthetic environments for the purposes of better meeting the requirements that Joint and coalition war-fighting environments have perpetuated through recent events. This initiative was formally named the JBE.

The JBE charter was:

"Explore distributed simulation activities that need to be advanced by DoD to define and move out on the way ahead in mixing live, virtual, and constructive applications in the Joint and combined environment that support current and future operations."

USJFCOM J7

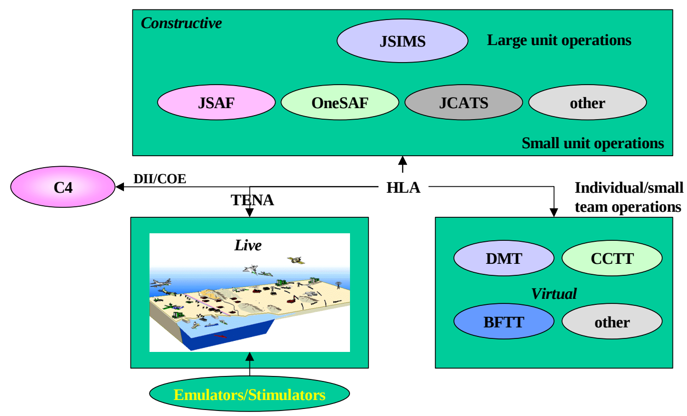

Figure1. JBE Near Term Picture.

The near term architecture of the JBE can be seen in figure 1. The diagram illustrates that the environment does not necessarily terminate in the M&S world rather it will have connectivity to both live systems through the Test and Training Enabling Architecture (TENA) and also to real world C4I systems such as the Global Command and Control System (GCCS). Locations for models and systems are not constrained to local geographic areas, rather they could be national or international.

TECHNICAL CHALLENGES

The state of military M&S technology and the stove piped single service approach to model development created a range of technical challenges for the development and eventual sustainment of a JBE as per the vision statement. These challenges were:

- To reduce event preparation time from months to hours/days to meet operational tempo.
- To create a shared, persistent and on-demand battlespace.
- Streamline the database building process.
- Improving standards/data formats.
- Support greater multi-level resolution environments (aggregation/dis-aggregation).
- Improve intelligent agents (semi-automated forces, intelligent tutors).
- Improve two-way interoperability with C4 systems.
- Streamline synchronization of live, virtual and constructive elements.

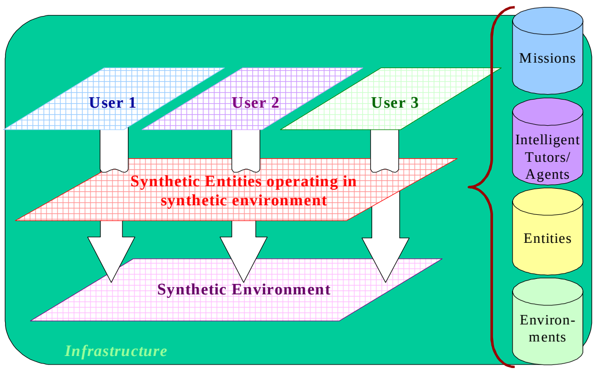

Figure 2. Representation of where the JBE Long-Term Vision.

The aforementioned technical challenges can be met in the near term through iterations of system improvements, however the long term (figure 2) will require a new architecture capable of composing an environment that can not only operate as intended but be verified and validated as suitable for the purpose intended.

JBE Core Characteristics

To facilitate a JBE as a capability it must have certain characteristics, such as:

- **Persistent** - (long lasting, available, well structured and stable);
- **Configuration Managed** – (well understood, controlled, reliable);
- **Flexible** – (adaptable, reconfigurable whilst maintaining integrity);
- **High Availability** – (on demand, accessible from any permissible access point);
- **Integrated** – (holistic comprising live, virtual and constructive as well as advanced distributed learning);
- **Realistic** – (capable of replicating environmental, socio-political, economic, policy and human behavior at varying levels of fidelity);
- **Efficient** – (cost effective, well managed and planned);
- **Effective** – (measurable against defined metrics, tasks, standards and performance requirements);
- **Enduring** - (high up time, capable of withstanding increases in requirements such as entity count and performance);
- **Scalable** – (must be capable of scaling as required to meet unforeseen requirements);
- **Distributed** – (Train anywhere including coalition and US inter-continental requirements);
- **Evolutionary** – (Must be capable of evolving as the needs of the war-fighting community change); and
- **Verified and Validated** - (must be demonstrated as fit for purpose and correct by subject matter experts). This is a minimum requirement.

If done correctly the JBE will complement the single service M&S programs and become the glue that binds capability whilst providing the direction necessary to allow cost reduction and reduced development cycles. It should, where necessary, take into account where commercial off the shelf (COTS) systems can fill requirements and where modified COTS or special purpose systems are truly justified.

JBE Common Services

The JBE as a persistent environment would need a range of common services to ensure coherence and stability. This can be thought of as an example analogue to the OSI model provided for data communications (Figure 3). These common services could be thought of as:

- **Event Planning System (EPS) Layer** – a service layer that will allow for scheduling (including ad-hoc requirements) of resources (simulations and systems) as well as operators (war-fighters) to generate fit for purpose environment on demand. This is a presentation level layer

- **Simulation Scenario Development & Management Layer** – Using Open standards such as XML (Extensible Markup Language) and XMI, provide a distributed interface that will provide data entry, planning and validation services that span the chosen models for the environment.
- **Simulation Management Layer** – a service layer that will permit the coordination of computing and communications resources whilst monitoring the integrity and stability of the environment. Verification of component compositions to provide the required level of interoperability and robustness would tank place at this layer.
- **Simulation Components –** The simulations and systems that are integrated to generate the environment required to stimulate the active Battlefield Operating Systems (BOS) and the staff.
- **Simulation Services –** A service layer that ties the simulations together through advanced distributed simulation technologies and routed communications protocols on a well-designed and defined wide area network. This layer should also manage and arbitrate on quality of service (QOS) issues.
- **Data Transportation & Collection** – a service layer that provides a holistic view of the exercise or experiment calibrated to pre-determined qualitative and quantitative metrics linked to Joint Mission Essential Task Lists (JMETLs), tasks, conditions and standards and integrated with published doctrine.

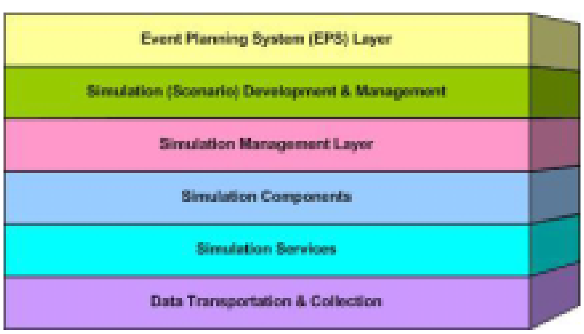

Figure 3. Open Systems Model for Large Scale Distributed Environments.

The provision of these common services helps to define the difference between an adhoc assembly of federated systems and the establishment of a stable coherent and manageable environment. The first of these services to be shown for the JBE was the Event Planning System (EPS) prototype. This was instantiated as a Macromedia FLASH web interface with a remote database serving the application through HTTP requests.

BUILDING A RAPID PROTOYPE WITH JUST IN TIME PLANNING

JBE Prototype Planning

The requirement to demonstrate the type of capability that a JBE would provide made it necessary that planning should be conducted throughout the 2001 calendar year with all interested parties in attendance. It was decided that the United States Air Force (USAF) would take the lead for the demonstration (as they would also be the lead service for the 2001 I/ITSEC conference). The lead service would determine the theme and scenarios for the demonstration. This had a significant impact on the configuration of models and systems that would be used to build the JBE prototype. The rotation of services each year at I/ITSEC would influence the theme and scenario design in future years as well.

In order to establish a configuration baseline for the JBE it was necessary to determine the type of scenarios that would be demonstrated. It was decided early on that the scenario themes would be:

- Air Superiority – Mainly Air-to-Air engagements requiring air, sea and ground threats/targets.
- Time Critical Targeting (TCT) – requiring a concentration on air to ground engagements.

In the Air Superiority portion of the scenario, several aircraft (F15s, F18s, and F22s) supported by AWSIM, JSAF, and various simulator cockpits engage enemy SU27 aircraft supported by much of the same simulation models. The TCT portion of the scenario showcased the air units destroying the ground units (provided by JIMM) upon receiving notification of their location by the nearby JSTARS aircraft.

Script Development

The development of a well-structured script would provide the structure required to establish firm test criteria. This was done in tabular format, with event descriptions at pre-determined time intervals. The flow of the scenario was tightly controlled and this provided an artificial sense of order. In reality an exercise could not be this well defined and hence more issues would arise due to unseen faults caused by untested interactions and events not to mention inherent randomness in the simulation models.

Equipment Tracking and Physical Layout
From an early stage in the integration process the booth numbers to be applied at the I/ITSEC conference were placed at each station to ensure that integration in the Joint Training Analysis and Simulation Center (JTASC) test bay would not cause confusion when the environment was stripped down, packed up and moved to the Orlando convention center.

This would prove valuable later as at least one third of the thirty staff and engineers present during testing were replaced during the movement of equipment.

Federation Monitoring and Recording
It is essential that federation monitoring and recording tools are available. There are a number of companies that provide such tools. It is simply important to have a good understanding of the capabilities of such tools and to be able to effectively employ them during test and integration. Visual representations of the Federation provide queues that can flag problems as they start to arise.

Network Monitoring
The network as established became complex very quickly and although the entity count was limited to approximately 300 at its peak this was not an effective measure of network traffic loading. A better measure of network loading would be transactions per second.

Interoperability Issues (RTI selection)
This selection issue is easily resolved but can also be the greatest contention point to the formation of any federation. It is acknowledged that there are at least five different RTIs being used on a routine basis. Within those five are a countless number of version variations. It is essential that selection be made early to permit time for model developers and maintainers to prepare properly for test and integration. Late selection will raise the technical risk exponentially.

The JBE did not employ many of the services available such as time and data distribution management. Any persistent instantiation of a future JBE would probably take these into account. The RTI chosen for the integration of the JBE prototype was the vanilla **RTI 1.3 NGv4**.

Federation Development (FEDEP) Process

The requirement to bring together a range of simulation and C4I systems together from geographically dispersed locations (with engineers and programmers that had not worked together previously) made it difficult to gain any momentum in planning the federation design. This was due to a number of factors including the different stages of testing at each location and the lack of inter-model knowledge. Engineers were generally very knowledgeable where their own model was concerned, however it was obvious during integration that some of the assumptions made regarding other models (that appeared on face value to be reasonable) were in fact wrong and required adjustment in order for the federation to work correctly. Figure 4 from [4] shows the FEDEP, which is elaborated for the JBE in the following sub-sections.

Define Federation Objectives
In this instance program objectives were vague and at a very high level. The intent was to demonstrate a capability rather than accomplish a specific task in a domain such as training, acquisition etc. Available resources were also not known or at the very least unstable.

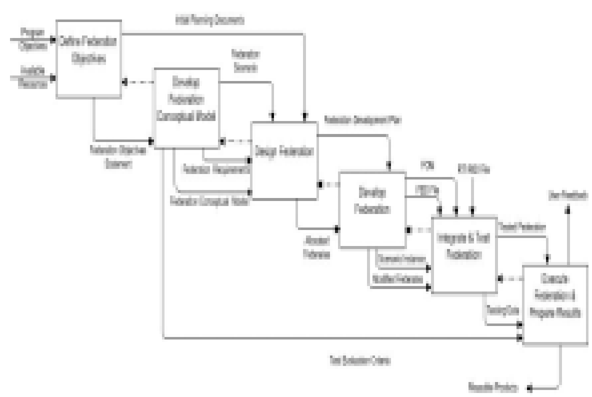

Figure 4. The Established Federation Development (FEDEP) Process [4]

Responsibility for acquisition of finance, equipment and personnel was unclear from the outset and this in turn raised the risk level for the prototype demonstration. It was this inability to define what the available resources were that forced the development of the federation to be built around a small stable nucleus of systems that were known to work together (JSAF, MARCI, UAVSim, GCCS, C2PC, MLST3). The objective was to extend the federation from this nucleus through pair-wise integration. This required each new system to be individually federated. By doing this fault identification became simpler as RTI compatibility issues could be corrected first (such as incorrect FED or RID file versions).

The federation objectives statement was based on the USAF Joint Synthetic Battlespace (JSB) intent and was very informal. The initial planning documents attempted to define an architecture that would be capable of the following:

- Constructive simulation (including Semi-automated forces).
- Man in the loop simulation (cockpit simulation and Naval warship simulator).
- Virtual (Stealth viewer).
- C4I (GCCS).

Develop Federation Conceptual Model

The team had a great deal of difficulty deciding on the scope of the initial scenarios and was therefore reluctant to commit to scripts. This caused a "*chicken and egg*" problem, as no agreement on scenarios would be met until a stable baseline of models was identified and a stable list of models would not be agreed on until a stable scenario was derived. This cycle was broken by defining an in principle scenario and then apportioning the entity requirements to the available models. It was readily identified that many of the models such as JSAF were capable of modeling a range of weapon systems and could therefore be used to manage the risk of a simulation system being withdrawn.

It is also important to point out that after decision had been made regarding which RTI version to use for the federation it was also quickly decided to minimize risk by using a federation file (FED file) that had already been proven during Exercise MC02 testing. This decision provided the team with a common baseline to work from and sped the integration process up considerably. An example of the federation classes supported in the Fed file is shown as table 1.

When developing the federation it became necessary to view the federation from a range of perspectives. An excellent way of understanding the structure of the federation (and its interoperability with other systems such as gateways and C4I systems) from a message perspective was to develop a dependency chart (Table 2). It was used to map out the federation from a perspective other than as a function of network structure. This allowed a better understanding of expected interactions than could be achieved by staring at a network diagram.

Design Federation

The true design of the federation was at best adhoc due to the constant removal and reintroduction of a variety of federates. The decision was to remain flexible regarding the choice of federates and to focus on the scenario intent rather than the capabilities of each model or system.

The dependency chart (Table 2) was also used to stabilize the changing environment by providing a snapshot of the federation that could be validated during testing. This became useful by matching interaction by simulation against the FOM.

Develop Federation

The logistics of moving equipment and personnel to the test bay location required that models and equipment would arrive at different times and in some cases days. There for the introduction of new systems and the requirement to build models from source code on borrowed equipment also meant that decisions on operating system platform were left also to the last minute.

CLASS 1	CLASS 2	CLASS 3	CLASS 4
BaseEntity (S)	Aggregate (PS)		
	DataLinkTrk (PS)		
	EnvironmentalEntity (PS)		
	PhysicalEntity (S)	CulturalFeature (PS)	DestroyedBridge (PS)
		Lifeform (S)	Human (PS)
		Munition (PS)	
		Platform (S)	Aircraft (PS)
			AmphibiousVehicle (PS)
			GroundVehicle (PS)
			Missile (PS)
			MultiDomainPlatform (PS)
			Spacecraft (PS)
			SubmersibleVessel (PS)
			SurfaceVessel (PS)
		Radio (PS)	
		Sensor (PS)	
		Supplies (PS)	
	TADILA (PS)		
	TADILJ (PS)		
	Track (PS)		
CarrierAircraftState (PS)			
CarrierWeaponState (PS)			
EmbeddedSystem (N)	Designator (PS)		
	EmitterSystem (PS)		
	IFF (PS)		
	RadioTransmitter (PS)		
EmitterBeam (S)	JammerBeam (PS)		
	RadarBeam (PS)		
Engineering (N)	Lanes (PS)		
	Markers (PS)		
	Minefields (PS)		
	Mines (PS)		
EntityBasedCell (PS)			
Manager_1 (PS)	Federate (PS)		
	Federation (PS)		

Table 1. Federation Classes Supported.

Unit	Software	BOOTH	MIL/CON	M/O/C	F16	F22	DDG-51	TBM+ SAM	Truck Convoy	JSTARS	…	UAV
NWDC	RTI Exec	1370	CON	OTHER								
JFCOM	JCATS	1276	CON	M&S								
JFCOM	JCATS Bridge	1276	CON	OTHER								
JFCOM	C2PC	1370	CON	C4I								
NWDC	JSAF	1370	CON	M&S								
NWDC	JSAF C4I GW	1370	CON	OTHER								
NWDC	WARCON	1370	CON	M&S								
BFTT	BFTT	1376	MIL	M&S								
NWDC	JSAF BFTT GW	1370	CON	M&S								
NWDC	GCCS-M	1370	CON	C4I								
NWDC	GISRC	1370	CON	C4I								
NWDC	UAVSIM	1370	MIL	M&S								
NWDC	MLST3 JSAF GW	1370	CON	OTHER								
NWDC	MLST-3	1370	CON	OTHER								
AF	AWSIM	736	CON	M&S								
AF	AWSIM DIS/HLA GW	736	CON	OTHER								
AF	JIMM	736	CON	C4I								
AF	STK	1302	CON	M&S								
AF	VBMS	470	CON	M&S								
AF	IDAL Cockpit	470	MIL	M&S								
AF	F22		MIL	M&S								

Table 2. Federation Dependency Chart

By this stage the federation was relatively stable in terms of an understanding of what would finally be provided. The scenarios were complete and stable. The scripts for the scenarios were complete and the test plan was well on its way to being finished.

To ensure the stability of all DIS to HLA gateways, they were base-lined, mirrored and provided by the staff from the Naval Warfare Development Center (NWDC) which greatly reduced risk. Each DIS Gateway was required to be set to a different DIS game to ensure that there was no contention or confusion on the network as there were many models that required translation such as F22, AWSim, Battle Force Tactical Trainer and JCATS.

Integrate & Test Federation

Table 3 shows an example spreadsheet used to access the success of various components of the federation.

Serial		Event	Pass/Fail
1		**Network Communications**	
	a	All simulations present and functioning as standalone	
	b	Databases configured (scenarios loaded)	
	c	Terrain files correct	
	d	Switches available and operating	
	e	TCP/IP configured and hosts discovered (Ping Test)	
	f	All simulations communicating on network	
2		**Establish Federation (Air Superiority and TCT are two separate Federations to be tested)**	
	a	RTI Exec up and running	
	b	JSAF Joins Federation	
	c	Gateways Join Federation	
	d	Each Federate for respective scenario joins Federation	
	e	Establish startup sequence for each federation	
3		**Scenario Interactions**	
	a	Verify F22 is seen in AWSIM	
	b	Verify Tracks reach GCCS-M (COP)	
	c	Verify Tracks reach C2PC (COP)	
	d	Verify DDG-51 (BFTT) is seen in JSAF	
	e	Verify each entity is seen and operates in accordance with the script	

Table 3. Example Success Criteria

All systems were connected to the same group of switches and one Class C subnet was used for the network. This was not the most elegant solution to managing network traffic. However, due to the short time frame available for integration it provided a level of confidence regarding the ability to minimize equipment incompatibility and to quickly separate network errors and faults from federation errors and faults.

The RTI chosen for the federation was an IEEE Specification compliant RTI developed by SAIC and provided under direction of the Defense Modeling and simulation Office (DMSO). This was RTI 1.3 NG Version 4. A reason for this decision apart from being provided with knowledgeable engineers on the RTI was the ability to monitor the federation through tools such as HLA Results and Control. This was done due to access to MOM data, and provided a quick response to federation faults and issues of polling or impending failure on the part of a federate. The RTI used also had an active RTI console window that allowed for quick response to issues. Dead Object Recycling Center (DORC) was used to remove aberrant federates upon failure during federation operation. This worked most of the time but not always.

Execute Federation & Compare Results

The execution of the federation was managed very closely. This required strict discipline to start up and shutdown of federates and the sequence. The sequence was an issue due to the behavior of some federates that burst traffic onto the network and starved the RTI form being able to respond. This was true of at least one federate that constantly flooded the RTI with requests. The issue was remedied through a code change, but this would not have been easily identified without strict management discipline.

The scripted nature of the scenarios provided an artificial sense of stability. By adhering strictly to scheduled events there was an opportunity to develop work arounds to serious federation problems that would otherwise have required in-depth addressing at a configuration control board post the JBE demonstration.

It should also be noted that the scripted nature of scenario testing enabled many faults to be rectified across the federation quickly allowing stability to be iteratively improved.

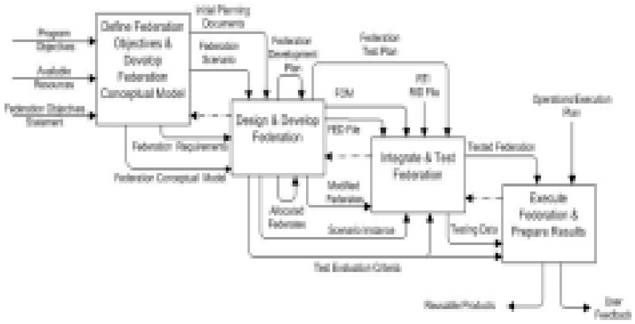

Figure 5. The actual FEDEP Process as applied to JBE.

As can be seen at figure 5 the FEDEP process was compressed. This was in part due to the short time duration and adhoc nature of the environment that was to be integrated. The scenario documents were therefore the core of the test plan and provided the success criteria according to events.

In essence the process became such that just in time (JIT) integration was possible with manageable risk. Federates were added almost daily to the federation and right up until the last demonstration on the I/ITSEC show floor with the inclusion of the Immersive Common Operational Picture (ICOP) by VRCO.

LESSONS LEARNED

The Experience gained during 2001 was invaluable to the planning of future large-scale federation demonstrations. The following key points provide insight into recommendations for the next JBE prototype.

Institutional training

All of the participants that attended the integration effort had their own perspectives on what was to be achieved and any limitations on success. It was not until the systems were integrated and exercised that the team came to understand the overall scheme of a JBE environment. It is imperative that a common view of the JBE be exercised and taught. This includes the ability to cross train on simulations and systems.

Many times during the JTASC integration and again on transfer to the IITSEC demonstration site operators were changed and staff returned to their home units. This happened in some instance without replacement. A risk reduction technique was the just in time cross training of remaining members, this increased work load and stress on some participants who at times were operating up to three systems simultaneously.

Configuration Management

It became apparent at the outset of planning for the JBE that each of the simulations and systems to be integrated were at varying stages of development. There are two levels of configuration management that will need to be applied to future demonstrations and in time the real JBE architecture. The first is the individual program changes to each simulation under the control of single service sponsors; the second and also important level is the recognition of what impact a change will make on the development of the JBE. The two requirements are linked and have a range of implications that extend beyond the scope of this paper.

Exercise Portal

During the JBE planning, communication was primarily performed via routine weekly teleconferences with stakeholders. This was done once for the USAF Joint Synthetic Battle Space team and also for the Joint Battle Space Environment (JBE) team. The result was two sets of priorities, problems that were not necessarily recognized by both groups and additional wasted planning time.

In order for the next iteration of the JBE to be effective it is suggested that an exercise portal be established to act as both a communications medium, a link to the common services that the JBE would consist of (such as the Event Planning system (EPS)) and a common repository for documents critical to the success and evolution of the JBE. This could be achieved in a number of ways:

- Internet portal or website – This was started for the 2001 demonstration but did not eventuate due to lack of time and resources. The website requires a host or sponsor agency, adequate resources for update and maintenance and would be the focal point for development of the concept. This would need a range of services beyond simply posting information, as it would be used in an email reflector role as a discussion medium for group-wise resolution of issues and concerns.

- Use of groupware such as Lotus Notes or Groove [5] – Not every one on the team will have access to Lotus Notes nor will permissions in the Lotus Notes access control lists of the various institutions or units allow for the required communication. Groove however is free and quite effective for both real-time and non real-time communication. The suggestion would be to apply groove to the problem as the web portal is being scoped designed and built.

Staff Early

Uncertainty over who was to staff each simulation and system or whether anyone would be available to staff a particular system added to the exacerbation of the JBE planning team. The increase in uncertainty added a significant level of risk to the demonstration and could have guaranteed certain failure. Institutions that agree to participate in the demonstration must make best efforts to identify key players and to resource both travel and subsistence for those individuals.

The staff identified must be well managed to ensure that the occurrence of changes to critical team members during the change of venues is minimized or stopped. Now that one JBE demonstration has occurred there is a degree of common knowledge amongst team members that should be leveraged if the next demonstration is to improve upon the last.

Common Team

Following on from the point to staff early is the need to have experience kept within the team. The complexity of the integration demands this if the JBE is to develop and grow from year to year.

The integration will move from adhoc coordination to a well structured and systematized process over time if a corporate memory is kept within the team.

Federation Management

The successful integration of the simulations via HLA is not in itself sufficient to ensure success. The scenarios to be run at the demonstrations require a combination of scripting and coordination to ensure that key points are brought out during the presentation component.

This requires a dedicated federation manager who would be responsible for the linking of the script to the simulation environment and ensuring that events occurred at the correct time and were accurately represented.

Elegant Network Design

Much credence is given to the question, “How many entities were run in the environment”. In essence this statement does not mean anything. A 100 MB Fast Ethernet backbone can be broken by as few as 200 entities, given the number of discrete event interactions that occur (either due to intended detection and engagement issues or due to abhorrent simulation behavior). Some simulations fed out a great deal of spurious un-necessary data onto the network through poor design or by virtue of the characteristics of their operation. The data rate of some simulation systems had to be calibrated in order to not swamp the network.

The IITSEC show network contractors provided an unmanaged switch as the central communications point for the network. This was barely acceptable and caused switches to be cascaded on the network (not a good practice). The network needs to be carefully designed and effort put into resourcing a dedicated network team. Reliance on the IITSEC show contractor is not recommended.

Verification and Validation Issues

In reality the combination of simulations provided an environment that could not be sensibly verified or validated. This was due to the range of different algorithms and techniques used to represent weapon systems. Allocation of damage states, representation of events and calculation of parameters were varied across the federation and therefore the best that could be said for interactions was that they appeared on face value to make sense.

Faults & Rectification

Software change forms were issued to all team members with strict direction to document all faults and rectifications. This required close scrutiny as the temptation was constantly there to make a quick fix and to move on without recording any detail. It is estimated that recorded faults were representative of 30% of actual faults and issues. Management reviews in the mornings and evenings each day were employed to bring the team together to air issues and concerns. This proved to be the best method of determining corrective actions whilst keeping the federation (and the federation team) stable and the integration progressing towards successful completion.

CONCLUSION

The development of any complex federation is a complex issue from a range of perspectives, being:

- Network view.
- Federation view.
- Scenario View.

Therefore, it is necessary to be as methodical as possible to ensure that the integration process proceeds as smoothly as possible. Many answers to questions and issues regarding access to resources and tools must be achieved early in the process.

This is also true of rapid integration tasks such as the JBE. It was not an intention to conduct just in time integration of the systems involved, however that was the end effect. It demonstrated what could be achieved by compressing the federation development process and by making maximum use and reuse of existing products such as a valid and tested federation file. It was evident at the integration meetings that the Fomerama did not achieve its desired outcome with the USAF JSB environment as the people present did not have sufficient depth of understanding of each others models to effectively communicate issues such as damage state, attribute types, data formats etc. There were far too many assumptions made that were at best inaccurate.

For this reason it is essential that a rigid management regime be put in place to ensure team communication during any integration task. This can be done through morning and afternoon conferences to bring out faults and to resolve issues on a team basis. On many occasions private assumptions were quickly dispelled through group interaction. Hand in hand with communication is strict and careful documentation of faults and resolutions so that this can be reintroduced into model configuration control environments post integration. The day-to-day configuration management process through management of file updates and strict adherence to routine also reduced risk significantly.

The JBE federation progressively improved in stability and ease of management the longer it was in place. If the environment had been left in place for a month longer it is expected that each of the models would have benefited significantly from continued test and interaction with other systems.

The realization also is that the reality of bringing together such a range of legacy systems also generates an enormous problem with verification and validation. It is unlikely that such a complex federation of models could be verified or validated due to design heritage issues.

The JBE proto-federation demonstration was an excellent example of applying systems engineering principles to the development of a complex simulation network, however it is not the type of environment suitable for the types of use suggested by the USJFCOM. There is a great deal of research into composable simulation environments that needs to be done before a fit for use accreditation could be reasonable given.

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