USING HIGH LEVEL ARCHITECTURE (HLA) FOR INTEGRATING WEAPONS ANALYSIS LETHALITY TOOL SET (WALTS) WITH LIVE FLIGHT RANGES AND VIRTUAL SIMULATORS

Jerry Szulinski
Defense Threat Reduction Agency / Cubic Defense Systems, Inc.
Alexandria, VA

Abstract:
Accurate three-dimensional pre- and post-strike target visualization tools, such as the Defense Threat Reduction Agency's (DTRA) Weapons Analysis Lethality Tool Set (WALTS), provide a valuable addition to mission planning, the battle damage assessment (BDA) process, training, simulations and mission rehearsal. When struck, the 3D target models are dynamically repolygonized in near-real time using physics codes describing the weapon-target interactions. These models are then rendered for user inspection on the WALTS viewer or are passed to other rendering systems using the HLA methodology for further environment interaction.

Live Range data, when treated as a HLA federate, drives WALTS and, in return, WALTS provides for an enhanced after-action review and restrike/no-restrike training capability. Additionally, simulated weapons scoring can be used to quantify student performance during training and mission rehearsal. Finally, the HLA concepts allow for range objects and interactions, including the targets, to be visible to other federates. These federates can be other simulations or they can be display systems with varying levels of fidelity.

Another place for rendering these damaged targets is in the "out the window" scene of a virtual simulator. Virtual simulators are no longer limited to using pre-defined "damage states," i.e. 25%, 50% damaged, etc. Realistic damage visualization not only allows for an immediate and accurate feedback, but it also allows instructors to make restrike/no-restrike decisions on the fly while students are still immersed in their simulation. Mission rehearsal is one particular instance where this type of decision making becomes critical as the physics based weapon effects calculations guide us towards creating a more realistic and accurate synthetic environment.

HLA provides a good exchange mechanism for this type of integrated simulation. The WALTS federate can participate with a single virtual simulator federate, Live Range federate or as a part of a greater federation with several different types of federates: live, virtual and/or constructive.

Author Biographical Sketches:
JERRY SZULINSKI is a senior software engineer with the Cubic Defense Systems. He is responsible for the design and implementation of the TACTS/ACTS Live Range HLA gateway (EXACTS) and its integration with the physics based weapon effects server (WALTS). He is currently working on distributed visualization methods for HLA federates from various Live Ranges and virtual and constructive simulations. Throughout his 12 years in the simulation arena, Mr. Szulinski has provided technical team leadership in real-time and networked simulation software design and development. While at Lockheed Martin, he also developed and conducted numerous demonstrations to both domestic and international customers as well as provided technical input for a number of proposals. Mr. Szulinski is a graduate of Embry-Riddle Aero. Univ. with a degree in Aeronautical Engineering.

JON D. NEASHAM, Director, Special Engineering Programs , CUBIC Defense Systems. With more than 21 years of technical weapons experience, Mr. Neasham is a proven Program Manager (PM) and Weapons Technical Analyst currently supporting DTRA as the PM for the WALTS Contract. Mr. Neasham has been responsible for the integration of validated weapons algorithms into three programs capable of modeling and simulating hard target and underground facilities. Mr. Neasham's experience includes over ten years directing and supporting the Strategic Systems Program Office in the development of the TRIDENT series weapons systems. He supported modeling and simulation of components of the weapons system, live fire test, operation demonstrations, and R&D.

Mr. WALTER H. ZIMMERS, Chief, WMD Assessment and Analysis Center Counterproliferation Support and Operations Directorate, Defense Threat Reduction Agency. Under his leadership, DTRA's *WMD Assessment and Analysis Center* provides direct support for high-profile events, "real-world" operations and direct support to tactical planners and weaponeers in order to maximize mission effectiveness and minimize collateral effects.

USING HIGH LEVEL ARCHITECTURE (HLA) FOR INTEGRATING WEAPONS ANALYSIS LETHALITY TOOL SET (WALTS) WITH LIVE FLIGHT RANGES AND VIRTUAL SIMULATORS

Jerry Szulinski
Defense Threat Reduction Agency / Cubic Defense Systems, Inc.
Alexandria, VA

INTRODUCTION

Current day considerations dictate the necessity of incorporating greater modeling and simulation into Department of Defense (DoD) environments including acquisition, testing and training. The environmental, population and political impacts are shaping the requirements to train across broader mission and geographical areas. The demonstrations and negative media attention given to the Vieques Gunnery Range are excellent examples of these concerns. Couple these concerns with the requirements to fight in urban and other non-traditional environments including potential use of weapons of mass destruction necessitate the use of modeling and simulation tools to enhance training and testing. Until recently, training supported by modeling and simulation (M&S) was limited to the use of Aggregate Level Simulation Protocol (ALSP) and Distributed Interactive Simulation (DIS) systems, which had significant limitations in regard to integration of training and testing. With the advent of HLA, more live, virtual and constructive integration is possible. The Defense Threat Reduction Agency (DTRA) with its Weapons Analysis Lethality Tool Set (WALTS) is attempting to provide higher fidelity tools to support warfighter requirements across a broader range from acquisition to testing to training to battlefield preparation.

A DoD goal is to have a DoD-wide M&S capability that can provide readily available, operationally valid environments for use by DoD components to train jointly, develop doctrine and tactics, formulate operational plans, and assess war fighting situations. Furthermore, its goal is to support technology assessment, system upgrades, prototypes and full scale development, and force structuring. The DoD vision is that common use of these synthetic environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these M&S environments are to be constructed from affordable, reusable components, inter-operating through open systems architecture.

The DoD M&S Master Plan (DoD 5000.59-P, October 1995) called for a "Common Technical Framework for Modeling & Simulation to be developed." The Common Technical Framework includes the HLA, Conceptual Models of the Mission Space (CMMS), and Data Standardization (DS). The Common Technical Framework, and specifically the HLA, represents one of the highest priority efforts within the DoD modeling and simulation community at this time.

WALTS BACKGROUND

DTRA continues to develop analytic tools and products that embody its extensive knowledge base of weapons effects/consequences. The Agency also participates in training, doctrine development, and assessment of war fighting situations through DOD-wide distributed M&S activities. Expressing its commitment to supporting these multi-agency activities, DTRA has been dedicated to converting extant or in-development weapons effects tools to achieve HLA compliance certification, constructing localized M&S weapons effects capabilities, and participating in linkage of

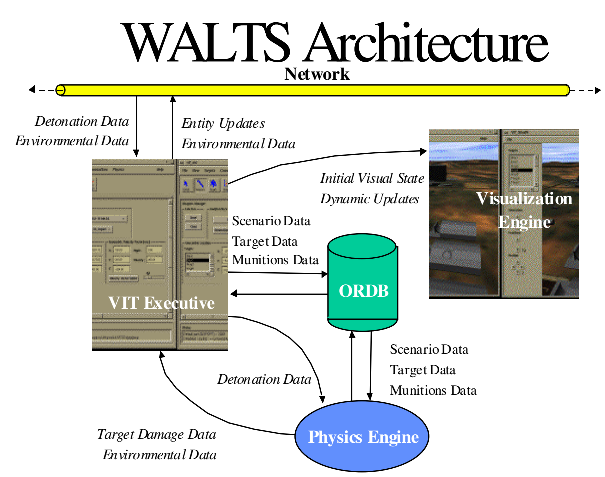


Figure 1. Simplified WALTS Architecture

geographically and organizationally distinct capabilities that support such simulations.

Accurate three-dimensional pre- and post-strike target visualization tools, such as WALTS, provide a valuable addition to mission planning, the BDA process, training, simulations and mission rehearsal. When struck, the 3D target models are dynamically re-polygonized in near-real time using physics codes describing the weapon-target interactions. These models are then rendered for user inspection on the WALTS viewer or can be passed to other rendering systems using the HLA methodology for further environment interaction. Optimized algorithms used in WALTS calculate cratering, penetration, internal/external blast, first order fragmentation, overpressure, temperature damage, in-structure shock, ground shock, equipment fault fragility, expulsion and down wind propagation of potential toxic contaminants. Additionally, sensor signatures and selected sensor views are currently being incorporated into WALTS. Several tools are being developed to rapidly place new entities and modify physical properties interactively. WALTS is capable of cumulative and dynamic damage updates.

WALTS Architecture

WALTS is a distributed M&S simulation developed to aid in the processing of weapons effects, and it is made up of several C/C++ modules (see Figure 1):

- The Physics Engine is composed of optimized physics based algorithms;
- The Executive module provides the interface between individual modules and the applications on a distributed system;
- The Object Oriented Relational Database internally specifies the physical target makeup;
- The Visualization Module used for locally displaying the results.

Currently, the executive and other modules are hosted on a Silicon Graphics computer but the source code is being ported to other systems including Linux and Sun Os.

The following WALTS functionality is accessible from the Executive or an HLA network:

- Defining and managing scenarios and target sets;
- Invoking protocols for distributed processing (i.e. Shared Overlay Manager for a COMPASS mission planning session, the DIS packet server for communications in a DIS environment, or the Run Time Infrastructure for participation in an HLA federation) or for standalone "what-if" analysis;
- Starting/stopping the Physics Engine;
- Starting/stopping the Visualization Module;
- Selecting weapons, fuses and impact conditions for detonations originated locally.

The Executive or an HLA federate filter network traffic and pass munitions detonation data to the Physics Engine, which calculates the appropriate effects. The Physics Engine passes damage and environmental information back to the Executive, which updates the Visualization Module and provides protocol-driven updates over the network. The physics process models are run in the Physics Engine based on impact conditions received from the Executive.

Live Range Driving WALTS

Live Range data, when treated as an HLA federate, drives WALTS, and, in return, WALTS provides for an enhanced after-action review and restrike/no-restrike training capability (see Figure 2). Additionally, simulated weapons scoring can be used to quantify warfighter performance. Furthermore, the HLA concepts allow for range objects and interactions, as well as the targets, to be visible to other federates. These federates can be other simulations, or they can be display systems with varying levels of fidelity.

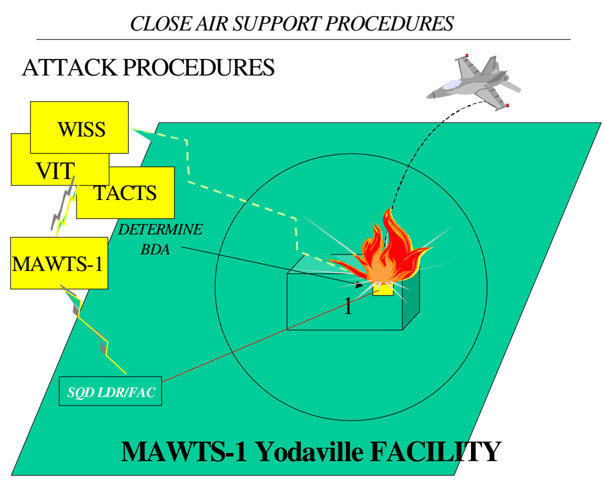


Figure 2. WALTS TACTS/ACMI Interaction

Virtual Simulators Driving WALTS

Another place for rendering these damaged targets is in the "out the window" scene of a virtual simulator. Virtual simulators are no longer limited to using pre-defined damaged "states", i.e. 25%, 50% damaged, etc. Realistic damage visualization not only allows for an immediate and accurate feedback, but it also allows instructors to make restrike/no-restrike decisions on the fly while students are still immersed in their simulation. Mission rehearsal is one particular instance where this type of decision making becomes critical as the physics based weapons effects calculations guide us towards creating a more realistic and accurate synthetic environment.

HLA provides a good exchange mechanism for this type of integrated simulation. The WALTS federate can participate with a single virtual simulator federate, Live Range federate or as a part of a greater federation with several different types of federates: live, virtual and/or constructive.

HIGH LEVEL ARCHITECTURE AND WALTS

HLA has been established as the simulation industry standard for simulation network communication. The Defense Modeling and Simulation Office (DMSO) assumed the lead role in overseeing the transition from the DIS protocol to the new HLA implementation. The HLA implementation centers around the Run Time Infrastructure (RTI) which provides the actual network communication between separate simulation nodes, called federates. The stability of the HLA implementation, the RTI, as a communication protocol is two fold. The first is the stability of the actual software, which, due to its widespread use, will remain well supported and will be continuously improved upon. The second is the stability stemming from the DMSO mandated use of this protocol for simulation networks.

Live Ranges, Virtual Simulators and WALTS

WALTS provides physics based weapon effects to federates allowing them to incorporate credible weapon effects results. Two such federates are Live Air Combat Ranges and Virtual Simulators. The HLA network interface for Live Ranges is being handled by the Entity Exchange Air Combat Tactical SOM (EXACTS) software. EXACTS is easily adapted to act as an HLA gateway for virtual simulators as well. It is a software application translating the range "static" data and real-time data gathered from the "active" participants. Range static data represents data such as the range name, location, controller name, etc. Active participants relate to any moving entities such as aircraft, land vehicles, ground troops, vessels, as well as dynamic weapons. EXACTS uses the HLA implementation's "publish" services to inform the RTI of those active entities as well as their static and dynamic attributes. Examples of entities' static data include vehicle type, driver name, call sign, tail number, on-board weapon definitions, weapon count, radar and radio configuration. Dynamic data includes position, velocities, weapon dynamics and other rapidly changing data.

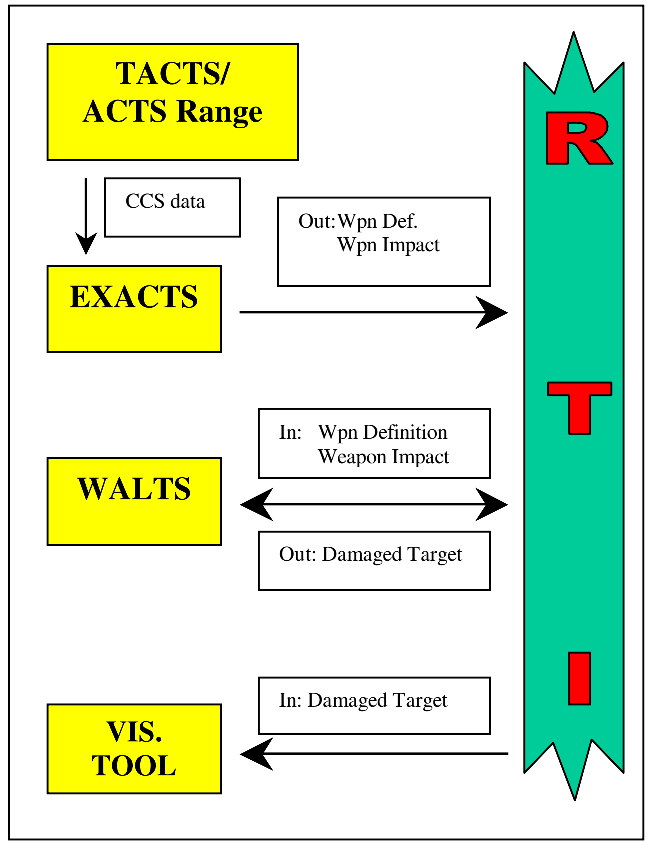


Figure 3. EXACTS And WALTS In A Simple Federation

In a simple example of a federation where WALTS would be a participant (see Figure 3), the Federation Object Model (FOM) would be mostly comprised of the WALTS Simulation Object Model (SOM). The weapon effects server is primarily interested in the weapon and its strike characteristics. Therefore, it requires the following minimum input:

- Weapon type (i.e. Mk82 bomb, Tomahawk missile, 3.5" rocket)
- Weapon characteristic (fuse setting)
- Weapon trajectory (impact point and direction)
- Weapon speed

The weapon impact data arrives via an HLA Interaction with a set of Parameters. Once the weapon effects server completes its calculations, the resulting data is broadcast onto the HLA network via an Object Class. This data, in turn, is subscribed to by a federate which is responsible for the graphical visualization of the results.

"Black Box" Design in the WALTS' SOM

The Object Class and Interaction based interface allows for a design approach conducive to interoperability. Each federate requires specific input and can produce specific output. These characteristics can be defined in abstract without necessarily knowing what other federates will be present. The emphasis is on data and its encapsulation rather than on individual federation members. This allows for easier interoperability with other simulations. Thus, it is less costly and integrated more quickly than when trying to tie a number of different players each with a distinct communication protocol.

As indicated in the previous section, WALTS utilizes very specific and minimal input to process weapon impacts. Should there be a need, other federates can also define target locations and characteristics. However, these are not necessary for the weapon effects server to operate. In fact, part of the design approach includes specifying default values and an ability to define data locally as much as possible in order to be able to operate with a wide range of federates. This design creates a "black box" implementation since it does not rely on any one or a group of particular federates to be able to provide all of its necessary input or to be able to process its output.

In a simple federation (see Figure 3), the only WALTS' output in which other federates would be interested is the visual representation of the damaged ground targets. In more complex federations, however, other federates might be interested in more details, such as fragmentation patterns or the pressures and temperatures on a room by room basis for the struck targets. Once again, this information is in the SOM and available to any federate wishing to subscribe to it.

Using HLA for Subsystem Communication

The WALTS SOM actually encompasses two subsystems, which communicate through the RTI allowing for load distribution. The federates have the option of running on the same server node, or they can be distributed across multiple platforms. This fact is worth mentioning even though it is entirely transparent to other federates in the federation.

A similar approach is used for the EXACTS SOM. What in the past might have been closely coupled subsystems can now be separate federates on an HLA network. For example, the real-time aircraft data published by EXACTS can be subscribed to by a visualization federate similar to an Advanced Display and Debrief System (ADDS). This HLA based display system, with its open architecture, can easily display entities generated by other federates (real, virtual or constructive). Such an approach is particularly useful when connecting to a single weapon physics server or a range from multiple remote locations (see Figure 4).

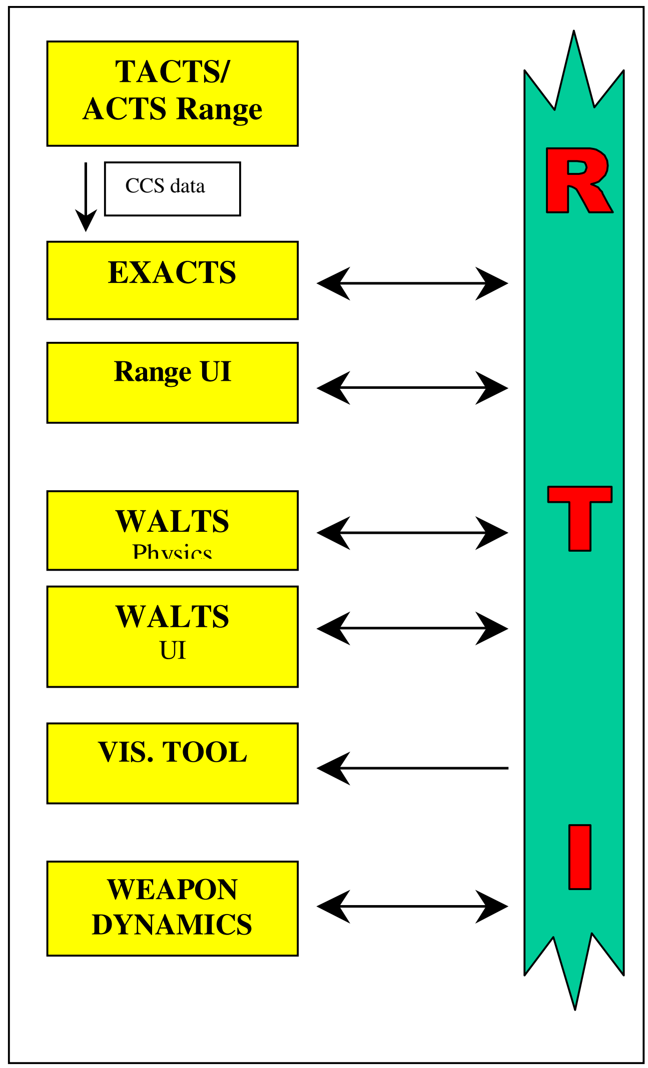


Figure 4. Subsystems Using HLA For Communication

Furthermore, with the weapon dynamics being fed into the RTI, it is possible for other federates to assume weapon ownership. Therefore, if another, more accurate, weapon dynamics federate is available, it can assume responsibility for the weapon trajectories and feed the weapon impact information back to the RTI, which in turn will be retrieved by the WALTS federate.

The benefits of this approach have to be balanced with the added RTI overhead resulting from it. This approach is good for applications where the added overhead is either minimal, or where there is a potential for using another, higher fidelity, federate in place of the local subsystem.

LIVE AIR COMBAT RANGES

Instrumented ranges provide a unique opportunity for the utilization of M&S enhancements previously only selectively available. These live ranges include aircraft "TOP-GUN" air combat ranges, which can use M&S to improve range limited live or inert ordnance air-to-ground combat maneuvers. Current Air Combat Maneuvering Instrumentation (ACMI) ranges are multi-lateral fixed ranges with geographic limitations. Mountains, population centers, and bounding air routes are some of these limitations. Although limited, they provide an excellent first path for developing an integrated live, virtual and constructive battlespace environment. Rangeless air combat systems provide the "next generation of air combat training systems." ACMI requires a fixed training range with elaborate ground-based infrastructure, including expensive communication towers. Aircraft have to fly within the boundaries of that range and in line of sight of the towers for their actions to be tracked and recorded. Rangeless systems however, are completely portable. They package the tracking technology into a pod carried on the wing of a fighter plane. This means the combat training flights can be flown anywhere where there is suitable airspace, even at sea. They are not tied to a fixed range. The electronics in these "smart" pods are able to record the simulated firing of weapons and calculate weapons flyouts, hits and misses. They capture all of the aircraft's actions, including position information obtained from Global Positioning System.

Live Range Simulation

When a pilot initiates a simulated weapons fire, the aircraft's weapons control system signals the pod, which picks the target, ground or air, and simulates launch of the selected weapon. If targeting another aircraft, the simulation determines if a hit was scored, and the opposing aircraft, as well as the initiating aircraft, are notified of the results of the engagement. When conducting a strike against a ground target, on the other hand, the simulation determines the impact point of the weapon and passes that information via the RTI to the WALTS federate for the BDA. WALTS in turn feeds its findings back onto the RTI for other federates to subscribe to.

Post Action Review

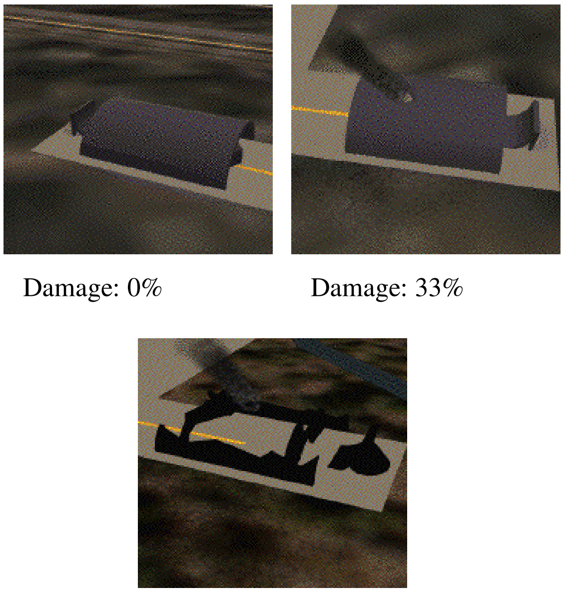
Currently, once pilots return to the ground, stored information is downloaded into a computer for playback. Pilots and instructors can see what actually happened. The information can also be transmitted to the ground during the training mission, if desired, so that the instructors and safety officers can monitor the mission in real-time. By using computer-generated three-dimensional graphics and text, a display unit can replay all flight dynamics and profiles of all participating aircraft, weapons events, and the outcomes of each engagement. Using this real-time down link and the RTI, the additional capabilities of WALTS-like systems can be utilized not only to enhance training and mission rehearsal but also to insert the live entities into virtual and constructive simulations. Instead of spending hours trying to recreate what pilots did, it is possible to let it run in real time and to record all range interactions. After action simulations can also allow pilots to change history. By allowing the use of simulated weapon launches and hits, it is then possible to show what would have happened if a different weapon had been used, or if the weapon had been fired from a different range.

VIRTUAL SIMULATORS

Unlike Live Ranges, computer generated synthetic environments allow virtual simulators greater flexibility in training in various parts of the world, perhaps otherwise inaccessible. Three-dimensional computer visualization plays an important role in this virtual world immersion. Simulator designers rely not only on vehicle instrumentation but primarily on the visual queues of the out the window (OTW) scenes to represent credible virtual worlds, such as desert, mountains, coastal regions, etc. Trainees can also learn and rehearse missions conducted in specific urban areas, airfields, and other locations build in "virtual reality."

Pre-Defined Damage States

While the ease of reconfiguring the virtual worlds is one of the major assets of virtual simulators, it is also one of its challenges. Most simulators still lack the benefit of dynamic, physics based calculations of weapon effects. In the old scheme of things, these are illustrated with "damage states" (see Figure 5). These are simply discriminate states corresponding to some pre-set degrees of damage.



Damage: 0% Damage: 33%

Damage: 90%

Figure 5. Discrete, Pre-Defined Damage States

These "damage states" are represented with pre-built 3D computer models to be substituted into the OTW scene as some criteria are met. For instance, when firing with a 3.5 inch rocket and hitting a target within a certain radius of its center, the simulation computer would display a 30% damaged model. On the other hand, when firing with a more potent weapon, perhaps a more damaged model would be substituted.

Dynamic, Physics Based Weapon Effects

Using a representative damage state might not be sufficient when striving for increased scene and simulation realism. Working in conjunction with a WALTS server and using HLA implementation as a communication platform, it is now possible for virtual simulators to introduce more realistic weapon effects to their dynamic 3D computer generated scenes. The simulator or some other federate still calculates weapon dynamics, but then it passes the detonation details to the weapon effects server. WALTS uses the validated physics based calculations to come up with the weapon detonation dynamics and then re-polygonize the target model.

Once the polygons of the newly damaged target are generated, the photo-texture is automatically re-applied. The model is then transferred to the graphics engine for rendering in the OTW scene. Until recently, this type of calculation was reserved for static display but can now be done with WALTS in near real-time with results viewed in the simulator within seconds.

Benefits of Both Approaches

There are distinct pros and cons to both approaches of handling the weapon effects in virtual simulators (see Table 1). A few things are worth noting. On one hand, the calculations necessary for determining which pre-programmed damage state to render are relatively simple, but, on the other hand, not very realistic. Because the pre-programmed models are exactly that: pre-programmed, the 3D graphics engineers can take their time to make them look as "realistic" as possible; however, they will not be accurate. In other words, they can look as a damaged target would, but their appearance will not be based on the actual weapon to target interaction. The only way to achieve that is to perform the physics calculations once the weapon strikes the target.

It is possible, for instance, to painstakingly construct an elaborate 3D model of a damaged target. It can show charred shreds of concrete hanging by the re-bar and electrical cables. However, this is not feasible in real applications. The problem arises when a simulated weapon impacts the target at the opposite end of the building from what has been arbitrarily pre-modeled.

	Damage states	Physics based
Model substitution speed	X	X
Model appearance	Perhaps	
Model accuracy		X
Scalability		X
DTRA's support		X
Web-based Mission Replay	Probably not	X
Web-based Damage Analysis		X

Table 1. Benefits Of Using Pre-Programmed "Damage States" Vs. "Physics Based" Weapon Effects In Virtual Simulators

When using the reach-back capability of the WALTS server, one can rely on DTRA's continuous research in the field of weapon effects. WALTS is continuously updated with the latest data as weapons and their variants are developed and researched. Remote client usage of the DTRA's server is also monitored to ensure continuous high level of performance.

The local WALTS server can also be scaled according to the number and complexity of potential targets. The type of server needed is also determined by the anticipated number of simultaneous weapon hits to be processed as well as potential weapons used and their characteristics.

Additional features offered by WALTS are high fidelity mission replay and damage analysis capabilities. Both of these features can be accessed from a web-based browser such as Microsoft Internet Explorer or Netscape Navigator. Trainees can review their completed training sessions any time in the future, even after they go back to their units. They can review their tactical moves, weapon launches, weapon strikes, the damaged targets and blast propagation data all in a dynamic 3D virtual environment. Even though their moves are recorded, the scene is generated in real-time to permit dynamic viewpoint positioning. This allows the scene to be viewed from any angle.

As with a Live Range, in a virtual simulator training

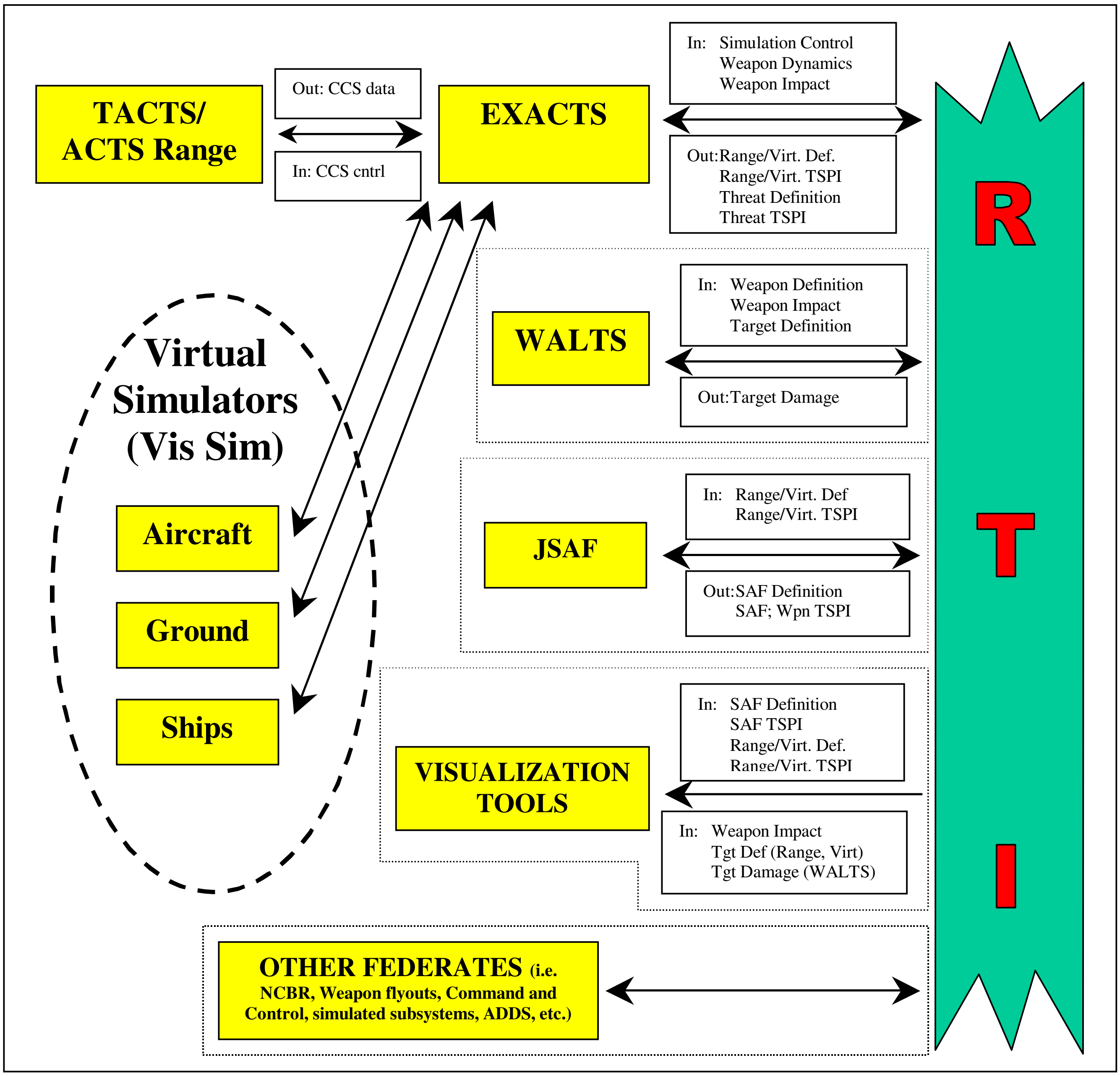


Figure 6. Complex federation

scenario there is a need for a post-action debrief. WALTS provides an added benefit of a realistic BDA, which is based on the physics of the weapon/target interaction. This, combined with the after action replay capabilities and the blast propagation data, offers a more meaningful post-action review with reliable and quantitative scoring of the simulated weapon drops and a capability for restrike/no-restrike decision making process training.

Mission Rehearsal

Another important area of virtual simulation training where realistic weapon effects are needed is mission rehearsal. It is extremely important to know not just what the real target properties are but also how these targets will react when subjected to available weapons. The physics based calculations during mission rehearsal can influence the mission planning itself, particularly when combined with accurate intelligence of target structural makeup. This training can lead to weapon, route or attack method changes. It is also an excellent source for restrike/no restrike rehearsal.

SIMULATION OBJECT MODEL (SOM) DESIGN CONSIDERATIONS

SOM Core

EXACTS plays a central role in tying the Live Ranges and Virtual Simulators to the federation. The EXACTS SOM has been developed to primarily encompass data gathered by a typical Live Range System. The Navy Tactical Aircrew Combat Training System (TACTS) and the Air Force Air Combat Training System (ACTS) have been used as a basis for the design. The HLA Object Classes are constructed in such a way as to reflect the TACTS/ACTS objects, such as mission, aircraft, threat, target and weapons data (see Table 2).

EXACTS HLA OBJECT CLASSES	
CCS_Aircraft	CCS_Laser
CCS_Threat	CCS_LowActivityPtpnt
CCS_Weapon	CCS_ADU
CCS_Target	CCS_RangeStatus
CCS_Mission	CCS_RangeTime
CCS_LGBomb	CCS_UHFRadio

Table 2. EXACTS HLA Object Classes

All of the data received in TACTS/ACMI CCS messages are passed through HLA Object Class Attributes. These CCS messages are then packaged into their appropriate HLA Object Class Attributes and sent onto the RTI. A single HLA Object Class can therefore handle multiple CCS messages so long as they pertain to the same object. The CCS_Aircraft HLA Object Class for example, handles four different CCS messages (see Table 3).

EXACTS CCS_Aircraft Object Attributes	
Sim_Source	PilotYaw
ID	Mach
Type	IndicatedAirspeed
Position	RateOfClimb
Velocity	Inventory
Orientation	TD_RadarAzimuth
AngleOfAttack	TD_RadarElevation
AngleOfSideslip	TD_IR_SeekerAzimuth
NormalAcceleration	TD_IR_SeekerElevation
TrueAirspeed	PulseRepFreqTone
Weapon	DirFindingElev
Loadout	DirFindingAzimuth
Mission_ID	OptDive_ClimbAng
Color	OptAC_Target
Pod_ID	WeaponSelected
EW_Designator	RadarMode
All	LGB_Designated
MissionCode	CounterMeasure
LogicalPlayer	Onboard_Jamming_Status
TailNumber	Initial_Status
CallSign	Chaff_Emp
Pilot	Flare_Emp
G_limit	Exp_Jamming_Emp
AOA_limit	Chaff_Rockt_Emp
IAS_limit	Chaff_Inv
SPCM_Pod_Type	Flare_Inv
AC_Group	Exp_Jammer_Inv
Descent_limit	Chaff_Rckt_Inv
Range_Number	Qualitative_Descriptor_1
IR_Tone	Qualitative_Descriptor_2
Interrogator	LaserStatus
ITRACE	LaserTarget_ID
Dive_Climb_Angle	

Table 3. EXACTS CCS_Aircraft Object Attributes

EXACTS HLA Interaction Classes	
WeaponLaunch	WeaponTargetImpact

Table 4. EXACTS HLA Interaction Classes

In some cases, the Live Range objects also trigger HLA interactions, such as in the case of weapon launches and impacts (see Table 4). For example, a laser-guided bomb is tracked as an Object Class until it is calculated to have impacted a target or terrain. At this point, the event is published as an interaction. This is done to distinguish the "state" of a weapon as opposed to the "event" of a weapon impact. These concepts are processed differently depending on which federates are subscribing to the data.

Through the use of dynamic memory allocation, the old 36 "High Activity Participant," or Aircraft, limit is also gone from the gateway. Now only the network and the RTI become the limiting factors for the amount of data that can be transported. While some federates might be interested in a small portion of data for each of the participating aircraft, others might be interested in all of the available aircraft data but from a limited number of participants. EXACTS allows for that type of scalability.

EXACTS can also be used as an HLA gateway for a variety of virtual simulators, especially where they use data similar to their Live counter parts. This allows for interoperability between the two types of training devices. The only addition necessary to the gateway is an interface to the simulator and its data formats.

Complex Federations

Another example of a federate potentially interested in the Live Range data and/or virtual simulator data is the category of visualization tools. Systems such as Joint Semi-Automated Forces (JSAF) can simply visualize the entities (aircraft, tanks, vessels, troops, etc.) or it can generate forces as well. More active federates, similar to the Advanced Debrief and Display System (ADDS) have the capability of sending commands to the participating entities. EXACTS and HLA can be used in a much broader exercise whereby such display systems could be utilized (see Figure 6). This example shows how all three types of simulation can be integrated in a seamless environment.

The primary purpose of the EXACTS software in this illustration is to act as a gateway for a Live Range system and several virtual simulators. It translates all real-time data into the "HLA format" and retrieves the User Interface / Simulation Control commands. In this configuration HLA (RTI) can integrate another federate, such as JSAF, which could assume ownership of weapons at launch time and calculate their trajectories. This capability is be particularly useful to legacy systems because it allows for virtual simulators and/or Live Range entities to "carry" and "fire" new and experimental weapons not modeled by them directly.

Virtual simulators can also display Live Range aircraft and targets in their own environment (radar, OTW displays) as well as other JSAF generated constructive entities. This greatly enhances the training and mission rehearsal realism by adding more variables.

Data Encapsulation

It is entirely transparent to the WALTS federate from where it receives data. In this example, WALTS might take input from several different sources. For instance, the target structural definition could come from within the federate itself, the weapon definition from a Live Range or a virtual simulator entity, whereas the weapon impact would come from a JSAF system or an entirely other federate processing the weapon dynamics. The consumption of the WALTS data would once again be spread out to several federates:

- 3D polygonal data (damaged target) to the virtual simulators
- percent damage indication to the JSAF system
- chem/bio expulsion data for the agent propagation simulation (i.e. DTRA's NCBR)
- blast propagation details to visualization software (perhaps web based)

Future Applications Integration

Multiple Integrated Laser Engagement System (MILES) 2000 using the data link integrated with ACMI/rangeless air systems can provide additional indirect and air to ground weapons effects not previously available for training. Future improvements to rangeless aircraft and ground tracking systems will significantly change training and mission rehearsal. Operational use of the US Army's new MILES 2000 tactical engagement simulation system began in October 1999, when the direct-fire, force-on-force training equipment was introduced at the Army's Ranger School at Ft. Benning, GA.

The laser-based training system closely replicates actual battlefield conditions by allowing soldiers to fire infrared impulses, rather than bullets, from the same weapons and vehicles that they would use in combat. It also accurately replicates the actual ranges and lethality of specific weapon systems as used in real combat.

Just like for live flight ranges, the WALTS, when integrated as an independent federate, can further enhance military operations training in urban environment (MOUT). In real combat situations, ground units have to deal with weapon fragmentation patterns upon detonation and chemical and biological agent release. None of those threats are handled very well in current training. WALTS and other similar federates can in the future provide valuable realism to the MOUT training scenarios. The training will include ground forces interacting with real and virtual fixed and rotary wing aircraft, ground vehicles and physics based weapons effects. This integrated environment will allow entities to interact with each other as federates thus providing a seamless, credible and more realistic training.

Conclusions

Live Ranges are coming under increased pressure, both political and financial, to reduce the number of live weapon drops. Virtual simulators are becoming more sophisticated, and their users expect a higher degree of realism and training value.

Helping to eliviate these problems EXACTS and WALTS are two leading DTRA products designed to bring Live Ranges and virtual simulators into the world of simulation interoperability and credible physics based weapons effects.

Both of these products fulfill the DoD M&S Master Plan calling for a "Common Technical Framework for Modeling & Simulation to be developed." They are constructed from affordable and reusable components, inter-operating through open systems architecture.

EXACTS SOM is designed to publish Live Ranges' and virtual simulators' data onto an HLA network. WALTS is a physics based weapon effects server, which can also be used on an HLA network. Combining the two reduces the need for Live Range weapon drops and adds unparalleled target damage realism and credibility to virtual simulators.

Additionally, the SOM allows for wide spread exercises where the live, virtual and constructive simulation play in a seamless integrated environment. Individual subsystem functions, when integrated as federates, can be taken over by other, more capable, federates. The existing subsystems can also be spread over multiple nodes allowing for physical separation and/or load balancing.