JTLS Air Improvements 2007 To 2016

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1.0 Introduction

The Joint Theater Level Simulation (JTLS) started development in 1983 as a joint project supported by the:

- U.S. Readiness Command (REDCOM), which has become the U.S. Central Command. REDCOM was interested in developing a system for Operational Plan Analysis and for Exercise Support.
- The U.S. Army War College. The War College was interested primarily in Exercise Support.
- The U.S. Army Concepts Analysis Agency (CAA)). CAA was primarily interested in a combat system evaluation tool.

Because JTLS roots are based in evaluation and analysis, it was important that the basic system design support results that could easily be justified and tracked. This implied a single, well integrated model where cause and effect relationships were well defined.

Over the years many systems have moved away from the single integrated model concept to a federation of models. There are advantages and disadvantages to each system structure, but JTLS has maintained its single integrated system design primarily because this construct results in lower costs to develop, maintain, test, and use. In addition, Project Management and the Development Team have steadfastly insisted that JTLS not lose its evaluation and analysis capabilities. The single integrated model approach allows an analyst to establish the needed cause and effects relationships for a proper evaluation. By definition, the establishment of such cause and effect relationships is not possible for a non-time constrained federation of models.

The primary design philosophy of JTLS is to be a “jack-of-all-trades” model. This philosophy results in JTLS representing almost every important military process within the single integrated model; albeit, not in as much detail as a single purpose model within a federation would be able to represent. As computers have become more powerful, JTLS has been able to improve the detail and representation of each of the important military processes, but by no means could the Development Team begin to indicate that it is as detailed a representation possible for a single purpose model that belongs to a federation.

Finally JTLS has been a model of firsts from the very beginning. The Development Team is proud that JTLS has been in the forefront of the improvement of military modeling and simulation. The JTLS “firsts” include:

- The first completed automated joint model.
- The first model to have a graphics system in which icons were overlayed on a real-world map image. This was called the GraphOver system. Since those early days, we have improved graphics and have recently moved to using official 2525C symbology for all icons.
- The first model to be built on the Digital Equipment Corporation (DEC) VAX/VMS system which became the computer standard for all military laboratories. We migrated long ago from the DEC VAX/VMS system, and transitioned easily from this original computer system, to Sun Unix systems, to RedHat Linux systems, and currently operate on 64-bit Linux based server systems. JTLS executes routinely on cloud-based and virtual systems.
- The first model to represent more that three sides. JTLS has the ability to represent up to 10 sides and an unlimited number of factions within the sides allowing the representation of the concepts and intricacies of real-world alliances and competing political goals.
- The first model to move to an XML file-based user defined interface. No programming is required to add new data variables to the database development system, to create new orders for the model, or to develop new data summary displays. Each of these capabilities are defined by XML files which the JTLS softwares reads and automatically implements. Given that JTLS has a relatively small development budget the Design Team has moved to automatic code generation for many non-modeling procedures based on the XML data.
- The first model to become web-enabled. JTLS is web-enabled from database development, to model execution, and continues through the JTLS delivered post-game After Action Review (AAR) capability.
- The first exercise support model that represents world-wide joint operations with supporting terrain.

JTLS may be considered a “legacy” model, but it is one of the very few models that has kept abreast of the technology throughout its life cycle. The purpose of this paper is to summarize the important improvements that have been made to JTLS since it became a web-enabled model in 2005.

2.0 Improvement Summary

2.1 Terrain

As most readers know, JTLS utilized a hexagon terrain system that limited combat and intelligence collection to a maximum 2000 Nautical Mile (NM) by 2000 NM play box.

Movement of ships and air missions could be represented worldwide, but operations were limited to the theater play box. Although decision makers could never verbalize their objections to the hexagon play box, it was viewed as old-fashioned and limiting. For this reason, development funds for the last two years have concentrated on the removal of the hexagon terrain representation and moving JTLS from a theater model to a global model. These improvements make JTLS extremely suitable for not only for theater exercise support, but more strategic world-wide force allocation evaluations.

This section summarizes the new JTLS terrain model and explains how JTLS manages to represent its combat capabilities anywhere in the world.

2.1.1 Grid Terrain System

JTLS represents terrain as layers of square latitude and longitude grids of various sizes. The basic terrain layer, called the World Layer, is a 10 degree by 10 degree array of grids 36 by 18 that covers the entire world. Although each grid is the same size in latitude and longitude, they obviously are not the same size when considering distance. These variations are managed within the JTLS algorithms.

From the World Layer, a database developer decides where more detailed terrain representation is required. In the middle of the ocean, less detail maybe required, while at the site of a planned amphibious assault a great deal of terrain detail may be desired. **Figure 1** shows an example of the gridded terrain. Note the larger grids in the open ocean.

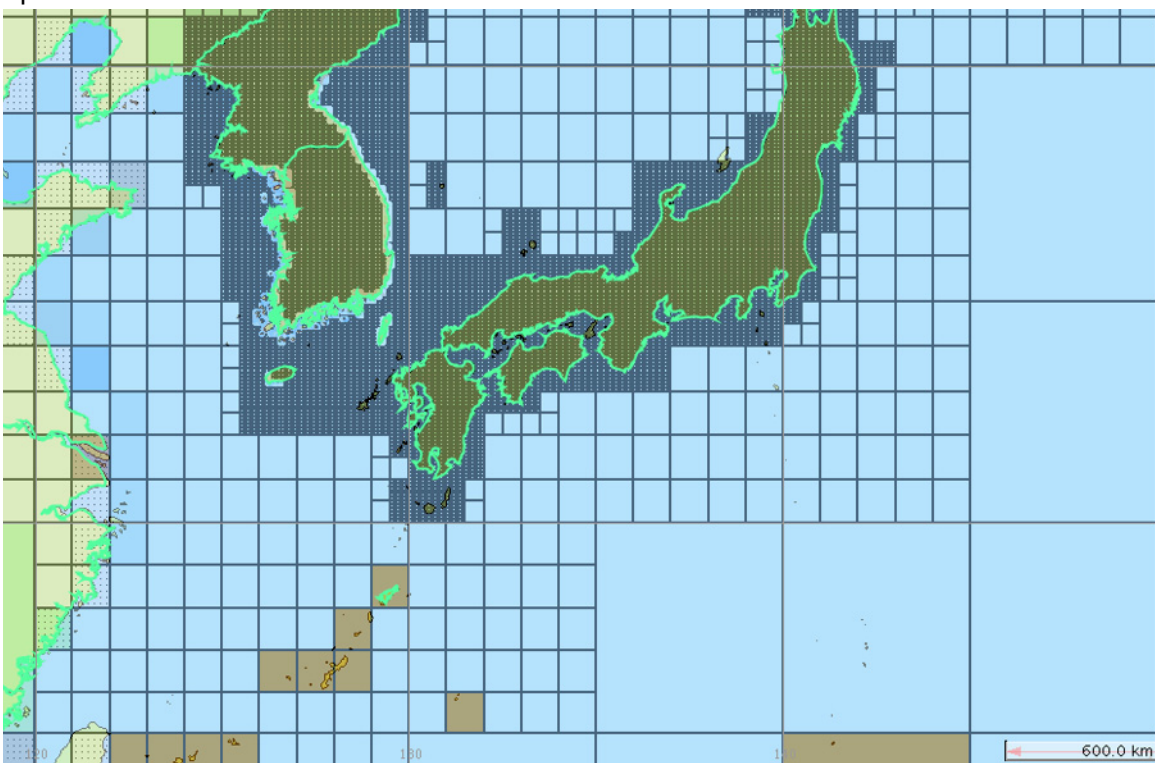

FIGURE 1. Terrain Grid Example 1

Figure 2 zooms into the terrain represented to show the increased detail around the coast line. Grids can be as small as 15 seconds by 15 seconds.

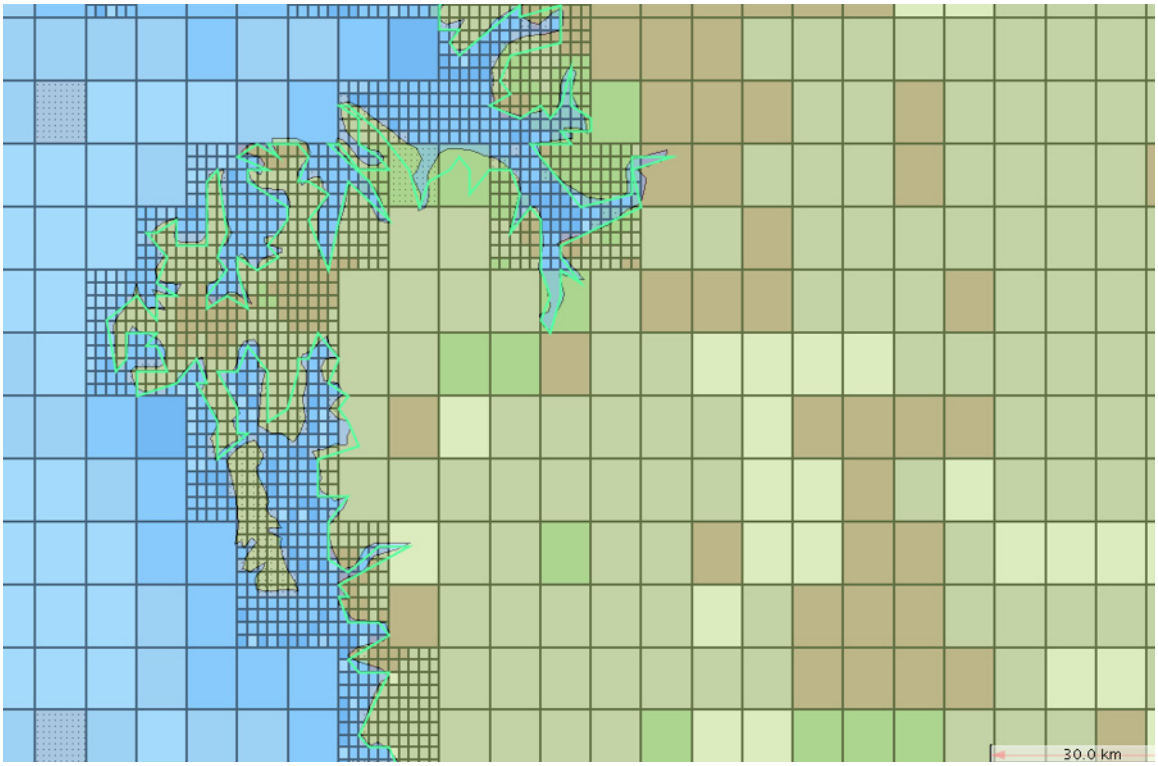

FIGURE 2. Terrain Grid Example 2

Naturally, the is no way to maintain a reasonable game speed if a user builds a terrain database with 15 seconds grids covering the earth's surface, but in numerous tests we have built several exercise terrain databases that meet the needs of the exercise with fewer grids than an equivalent capability using the old hexagon system. This is mainly because we only put the detail where it is absolutely necessary.

2.1.2 Movement Network Overlays

On top of this gridded terrain are a series of movement networks as describe in **Table 1**.

TABLE 1. Movement Networks

Type Network	Description
Road	Used by Ground units, convoys, and High Resolution Units (HRUs). For certain missions, such as Withdrawing from combat the road network is not considered; instead, the ground unit will move over the terrain grid. Users have the choice when submitting move orders that indicate whether the road network should or should not be considered.
Rail	Used by rail convoys.
River	Used by barge convoys and HRUs with small boats. The HRUs would use this network if they were conducting a river patrol for instance.

TABLE 1. Movement Networks

Type Network	Description
Air Corridors	Use by Air Missions, if the user has indicated they should be used based on the mission type. These air corridors have altitude limitations and are primarily used for civilian air traffic and logistics missions. For instance, movement on this network allows the Exercise Director to simulate an airliner leaving a planned flight path to get the exercise audience to investigate.
Sealanes	Used by Naval Units. As with the air corridors, realistic movement of civilian shipping can realistically be portrayed. Unlike air traffic that stays exactly on the network, shipping simply stays close to the shipping lanes for realistic Common Operational Picture (COP) representation.

2.2 Current Operations

Since JTLS had its roots in Operational Plan Evaluation, the original capability design lacked flexibility in properly representing current operations and magically altering objects, especially air missions, to support exercise needs. Project Management directed the implementation of a considerable number of Engineering Change Proposals (ECPs) to correct these shortfalls over the last decade. **Table 2** summarizes these improvements.

TABLE 2. Current Operations Improvements

Improvement	Description
Combat System Maintenance	The model determines when things break and need to go into and out of maintenance. In addition, combat damage can cause systems, including aircraft and personnel to go into maintenance. Several factors affect the time needed to get the system out of maintenance. The controller has always had access to the data used to make the determination of which systems go into and how long it takes to repair the systems that are in maintenance. Improvements include was given full override control of system that are in maintenance. Thus a controller can now specifically add systems, such as aircraft to maintenance or take them out of maintenance overriding the time computed by the model. This capability is particularly useful when attempting to simulate fuel contamination. The Controller can manually place the aircraft into maintenance to simulate the mandatory engine checks after a fuel contamination event.
Dual Air-to-Air and Air-to-Ground Weapons	In previous versions, JTLS labeled a weapon as either and air-to-air weapon or an air-to-ground weapon. Aircraft mounted guns can be used in either mode. It is now possible to represent this dual use capability.
Air Mission Adjustments	In previous versions, JTLS had very little control over an air mission's capabilities after it launched. The trusted air player was given an order called the "Magic Air Ops" order to magically add or remove fuel, weapons, sensors, or jammers from a flying air mission, The user also has the ability to speed up or slow down the air mission even beyond the database specified capabilities of the aircraft in the air mission.

TABLE 2. Current Operations Improvements

Improvement	Description
Refuel Chits	In previous versions, the user had the ability to tell a tanker mission whom it was suppose to refuel, when the refueling should take place, and how much fuel should be transferred. The model was improved to fully manage and alter this information once entered into the system.
Better Flight Planning	The user now has a view and complete control of a mission's future flight plan. If the model automatically changes the mission's flight plan, for example sending the mission home when the mission loses too many aircraft, the old flight plan is still available and the user can override the models standard operating procedure decisions. The user can alter any portion of the flight plan from its alert base, to the targets it is designated to hit, and the amount of time that the mission should remain on station. In previous version, once a mission started to bingo, there was no way to turn it around and assign another task. This restriction has been completely removed.
Better Intercept Break-off Feedback	A mission can break off its current intercept for several reasons. Some example reasons are: running low on fuel, out of weapons, and the intercepted air mission no longer being represented in the game because its aircraft were killed. Users requested quick access to this information. This information is now available on the Air Mission Status board. In addition the Break Off order was improved to indicate whether the mission should never intercept the track or whether all own-side missions should never intercept the track again. This helps simulate the ability to intercept an unknown track and determine it is of no concern and can be ignored.
Manage Multi-Target Orders	When JTLS started development in 1983, a typical attack mission was given a single target and a single alternate target. Over the years capabilities and procedures for attack missions have changed drastically. It is not fairly typical to have several targets assigned to a single sortie. Each target assigned one or two of the missions weapons. In JTLS terms, this is a multi-target Attack Mission. When first implemented, the user had very little ability to alter the assigned multiple targets. Improvements have been made several times since 2006 to improve the flexibility of this capability within JTLS.
Controller Killing Theater Ballistic Missiles (TBM) and Cruise Missiles	In previous versions, JTLS had the ability for the Controller to magically kill aircraft in any mission to fulfill needed exercise objectives. The ability was added for the Controller to also magically kill Cruise and Ballistics Missiles.
Turn On/Off Air Mission Sensors	The player was given the ability to turn on and turn off individual sensors held by an air mission, This capability is normally used to represent malfunctioning hardware in support of exercise objectives.

2.3 General Air Representation Improvements

JTLS from its inception represented every major type of air mission task, but because real-world military operations have continued to evolve, Project Management directed the implementation of numerous ECPs to properly represent new strategies and tactics. **Table 3** summarizes these improvements.

TABLE 3. General Air Representation Improvements

Improvement	Description
Split Air Missions	JTLS now has the ability to split any air mission into two missions whether the mission is on the ground or flying. Once split, the user can alter the tasks and flight plan assigned to each new mission. Missions cannot be reemerged.
Better Model TLAM-E	The ability to represent the orbiting of cruise missiles and the redirection of these missile to alternate targets mid-flight were added to JTLS
Represent Blue Force Tracker	The representation of Blue Force Tracker was added to JTLS during this period. The location of any air mission with aircraft (helicopters) labeled in the database as Blue Force Tracker capable as automatically detected. No Air Search radar coverage is required.
Self Reporting Cruise Missiles	A new database attribute was added to the Cruise Missile object. This attribute indicates if the Cruise Missile is a self reporting mission. If set to YES, no Air Search radar coverage is required for the owning side to detect and track the location of the Cruise Missile.
Automatic IFF Assignment	Normally a mission gets its IFF Squawk codes from the ATO, but when operating within a coalition environment or with civilian aircraft, there is not always an available ATO. In these circumstances, the player can select to automatically assign IFF Squawk codes to missions. A block of squadron codes, such as 4000 to 4500 can be assigned to the Civilian side. When an aircraft launches, the model automatically assigns a squawk code to the mission if the aircraft have the proper Mode squawk equipment. When the mission lands the code is returned to the pool of available codes.
Enable / Disable Supply Consumption	Although, not specifically air related, this new capability was added to the Summary List because of its possible importance to easily running a given theater f deployment scenario over long periods. For example, consider the situation in which the first few days of a contingency plan should be exercised. After this initial period and exercise audience decisions are made, the model is to be run 30, 60, 90, or even 120 days forward to represent the movement of assets into the theater. In a real operational plan, sustainment of theater forces would need to be considered, but it is possible to ignore this and only evaluate the actual movement of forces into the theater. the The Controller has the ability to disable all supply consumption or sustainment requirements. The game can be run quickly ahead to get additional forces within the theater of operations. After that period, the consumption can be re-enabled, and Phase 2 of the exercise may realistically continue. As a side note, there is no reason to disable supply consumption during a long period run ahead, but the plan must then consider the movement of operational forces into the theater as well as sustainment requirements.
ATO-Translator	The JTLS ATO-Translator (ATO-T) has continued major development throughout this period. We have added the concept of Joint Desired Points of Impact (JDPI). We have also web-enabled the translator allowing our Interface Controllers to view the translated missions prior to entry into the game. In fact, a Web Hosted Interface Program (WHIP) operator has the ability to view the segment of the US MTF ATO message that generated the mission. This helps the operator verify any special instructions that were included withing the message.

TABLE 3. General Air Representation Improvements

Improvement	Description
ATO-Generator	JTLS comes with a full functioning, web-enabled ATO-Generator (ATO-G). The ATO-G supports Attack missions, alert and orbiting Offensive Air support missions, post-strike reconnaissance missions, Electronic Combat missions, Suppression of Enemy Air Defense Missions (SEAD), alert and orbiting Defensive Counter Air Missions, and Air Refueling missions. The ATO-G supports the creation of Mission Packages. This is done by entering the commander guidance concerning, the role of dual-role capable squadrons, allocating available resources, and prioritizing types of targets. The ATO-G access the current perception of the enemy forces and creates an appropriate ATO. The ATO-G automatically submits the orders to the game and generates a legal US MTF ATO message that can be loaded into either NATO's Integrated Command and Control (ICC) system or the US Theater Battle Management Core System (TBMCS). The exercise audience can then track the ATO in the same manner they would if the ATO had been created by the Air Operations Center (AOC) manually. Note that currently the ATO-G does not generate AWACS mission, a shortfall that will hopefully be corrected sometime after the initial JTLS 5.0 is delivered. The ATO-G also does not allocate assets to the various mobility missions. There are currently no plans to improve the ATO-G for this purpose.
ATO-Viewer	A new WHIP component called the ATO-Viewer (ATO-V) was added. The user can view all air missions in a time-line format similar to the time-line within TBMCS.
Strategic Airlift (SAL) Mission	Added the Strategic Airlift Mission to JTLS. This allows moving Unit Line Number (ULN) assets into the theater of operations. This allows for actually simulating a full Time Phased Force Deployment Data (TPFDD) plan for a theater of deployment or theater evacuation.
Alert Logistics Missions	The only missions that JTLS could not properly represent were alert logistics missions. This problem has been corrected in JTLS 5.0. With JTLS 5.0, the Design Team believes that all missions that can normally occur within a real-world ATO, can be properly modeled within JTLS.
Improve BE Representation	JTLS Development Team has spent consider time and effort to improve the generation of intelligence messages. The model has added the concept of Basic Encyclopedia (BE) facility representation. History of collected data is maintained for these facilities, so intelligence reports can not only report current status of targets within a BE facility but changes to that status.
IIPR Messages	Along with the improvements to the BE Facility representation is the generation of properly formated and realistic IIR messages. The JS/J7 Intelligence Team has worked closely with the JTLS Development Team and they are currently extremely happy with the IIR generation process.
Better TBM Air Defense Interdiction	Improved the representation of Air Defense Interdiction of Theater Ballistic Missiles (TBMs). In previous versions, ADA sites could only interdict terminal TBMs. JTLS now represents a parabolic TBM flight path and interdiction is allowed based on ADA capabilities throughout the flight path.

TABLE 3. General Air Representation Improvements

Improvement	Description
WHIP MSEND Capability	It is now possible to build a single order and have the order submitted to the game while increment an order parameter. For example, the user can build a single Orbiting DCA mission, and have the order submitted 6 times, while incrementing the time on station parameter by 4 hours. Thus with a single order, you could set up a CAP station for an entire 24 hour period. This makes the job of OPFOR personnel fairly easy.
Special Interest Flags	JTLS added the capability to set special interest flags for a mission. The meaning of these special interest flags are classified, but are needed by TBMCS.
Civilian Air Order	Added a new Civilian Air Mission order, in which the user simply enters the Aircraft Type, ICAO of embarkation, the ICAO of debarkation and the time of takeoff. The model automatically insures the correct aircraft are available and fly as designated. This allows for data mining of a real-world commercial time table schedule to support realistic situational force air traffic. JTLS is delivered with a tool that takes a data mined spreadsheet and converts it into the new Civilian Air Orders.
WHIP Internationalization	JTLS WHIP interface is designed for full internationalization. Thus everything associated with a WHIP can be displayed in any desired language. Naturally some effort needs to be allocated to creating and maintaining the translation files needed, but an editor is provided to make this capability easy to manage.
Message Delivery Program	Improvements were made to the JTLS Message Deliver Program (MDP). This allows for the automatic delivery of selected messages to e-mail addresses and files in a specific directories on the server. One typical use of the MDP is to save all Mission Reports (MISREPs) in a single directory or to e-mail all Initial Imagery Reports (IIRs) to the intelligence response cell for review before sending the message onto the exercise audience.
VFR Squawk Not Hard-coded	In previous versions, if an air mission was Mode 3 capable and no Mode 3 was assigned, the model automatically assigned the VFR code 1200. This is not true in all parts of the world. The VFR default squawk was added to the database.
DSA Collection Modes	In JTLS, Direct Search Areas (DSA) are constructed to match the collection deck of the Exercise Audience intelligence staff. JTLS has several tools to automatically input this collection deck into the model. The collection deck normally indicates what type of sensor the exercise audience wants assigned to collect the information. JTLS was improved to add and enforce the desired collection mode for a DSA
Satellite Service	JTLS is delivered with a Satellite Service which computes the orbital track of a satellite. The satellite can collect imagery, Infra-Red (IR) detections, Electronic Intelligence (ELINT), and Communications Intelligence (COMINT), JTLS does not represent interdiction of satellites. This is done through magic Controller action.

2.4 Links To C4I Systems

JTLS is used by the United States and over 20 of its coalition partners worldwide. This means that JTLS needs to be flexible enough to link to not only US real-world Command, Control, Communication, Computer Information (C4I) systems, but the

various C4I systems used by all of its partners. The JTLS Development Team takes pride in the fact that the system structure allows any user to easily get information out of the system and to submit orders to the system.

JTLS is delivered with its own:

- Terrain Generation System
- Database Development System
- User Interface
- Programs to feed C4I System
- Programs to submit orders from C4I system
- Post-processor and After Action Review (AAR) system.

That being said, there is nothing that requires a customer to use the tools provided with JTLS. Any customer can create their own terrain generation system or their own program to feed their specific C4I system. The methodology to do so is well documented and can be accomplished by any reasonably competent programmer with only a few hours of training.

Still a basic premise of the JTLS system design is to provide a single well integrated combat model that can be used “out of the box” to meet the exercise needs of any user. For this reason, Project Management and global customers, such as NATO and Norway, have directed the implementation of a considerable number of ECPs to expand the capability of JTLS linking to real-world C4I systems. **Table 4** summarizes these improvements.

TABLE 4. Links to C4I Systems

Improvement	Description
ICC	JTLS links to NATO’s Integrated Command and Control (ICC) system. Air Tasking Orders (ATOs) are accepted by the JTLS ATO-T and updates to the information held in the ICC are provided by the JTLS Transactional Operation Interface (JTOI). JTLS has the ability to initialize the ICC database insuring that the JTLS scenario matches the ICC database.
TBMCS	JTLS links to the US Theater Battle Management Core System (TBMCS). ATOs are accepted by the JTLS ATO-T and updates to the information held in the ICC are provided by the JTLS Transactional Operation Interface (JTOI). JTLS has the ability to verify that the TBMCS database matches the JTLS scenario database.
NEC-CCIS	JTLS links to the Northern European Command - Command and Control Information System (NEC-CCIS). ATOs are accepted by the JTLS ATO-T and updates to the information held in the ICC are provided by the JTLS Transactional Operation Interface (JTOI). JTLS has the ability to initialize the NEC-CCIS database insuring that the JTLS scenario matches the ICC database.
GCCS	JTLS feeds both OTH-Gold and Link-16 TADIL J messages to the Global Command and Control System (GCCS).

TABLE 4. Links to C4I Systems

Improvement	Description
ADSI	The Air Defense System Integrator (ADSI) has been successfully linked and used with JTLS. Only Link-16 TADIL-J messages are sent to this system.
Link-16 Missile Warning Messages	JTLS supports the following Link-16 messages, 2.2, 2.3, 2.5, 3.0, 3.1, 3.2, 3.3, 3.6,7.0, 10.2, 13.2, 13.3, and 13.5. These messages include TBM warning messages.
TACELINT	JTLS generates Tactical Electronic Intelligence (TACELINT) messages. The service can send these messages directly to a real-world system or through a transfer mechanism for feeding systems on a higher classification network.
MUSE/AFSERS Link	Although not a C4I system, MUSE/AFSERS (Multiple Unified Simulation Environment/Air Force Synthetic Environment for Reconnaissance and Surveillance) system does generate Unmanned Aerial Vehicle (UAV) video for the exercise audience. JTLS has an efficient direct link to MUSE/ AFSERS, which the MUSE team agrees is more efficient, by several magnitudes, than its High Level Architecture (HLA) interface to the Joint Live Virtual Constructive (JLVC) federation link.

3.0 Conclusions

With the improvements discussed in this paper, it should be readily apparent that JTLS is a robust model that has continued to grow and improve since it started development as the first joint, completely automated, exercise support and combat plan evaluation system. Through all of these improvements, the basic JTLS system design has not changed. This speaks for its simple, flexible, and puissant architecture.

For example, within the last two years, well over 40 percent of the model code has been altered to support the removal of the hexagon terrain system, but very little of the support software (database development system, user interface, AAR, and C4I interface) needed to be changed, primarily because of our efficient system design construct and use of automtically generated code. For this reason, JTLS remains one of the most cost efficient models available for use in Computer Aided Exercises (CAX) from both the development and execution point of view.

Future plans include continuing the development and improvement of the system to meet the needs of the exercise support capabilities of the United States military and its coalition partners.