The History Of The Joint Theater Level Simulation (JTLS) 1982 to 1998

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In September of 1981, Professor Samuel H. Parry, of the Operations Research Department at the Naval Postgraduate School (NPS), was invited by the commander of the newly created U.S. Readiness Command (USREDCOM), General Donald Starry, to visit the USREDCOM Headquarters in Tampa, Florida. The primary purpose of the visit was to review USREDCOM's capability to conduct joint operation plan evaluations, and advise General Starry on his options to improve the staff's ability to conduct analysis of joint operational planning. From the initial visit in the fall of 1981, the project went from upgrading an existing air and land combat model, to the design, development, testing, fielding and coordinated improvement of the Joint Theater Level Simulation (JTLS). The purpose of this paper is to summarize the history of JTLS from its beginnings at USREDCOM to late 1998.

Discussions between USREDCOM and NPS resulted in the development of a Contingency Planning Institute at NPS with Professor Parry as advisor. The first task assigned to the Institute became known as the REDCOM Contingency Planning Task. This task started with the investigation of existing interactive theater level models. Meetings between NPS, Vector Research (VRI), the Army War College (AWC), and Lawrence Livermore National Laboratory (LLNL) were held to consider the efficacy of using currently available combat models to satisfy USREDCOM's needs. The following models were considered and evaluated as part of this NPS study:

1. Vector - this model was developed by VRI and was a non-interactive model.

2. Janus - this model was developed by LLNL and was primarily used to evaluate the employment of tactical nuclear weapons. It also considered conventional force-on-force combat.

3. Warfare Environment Simulator (WES) - this model was developed by the Naval Ocean Systems Center (NOSC) in San Diego. NPS students helped with the development and testing of WES.

4. McClintic Theater Model (MTM) - this model was developed by Mr. Fred McClintic, a staff member at the AWC. MTM was an interactive theater model, which concentrated on the representation of ground combat. It did have a rudimentary representation of air combat but no representation of naval combat. The model was written in FORTRAN.

Professor Parry's conclusion was that there was no existing war game or analysis tool, developed in enough detail, to model the complete spectrum of joint warfare in a coordinated manner. Professor Parry noted that there were a few good starts at developing analysis tools, which modeled the interactions of both air and land, but these existing models were only a few years old and were not robust enough to handle the complexities required to conduct a full operation plan evaluation. Furthermore, none of the existing models attempted to include the naval and amphibious aspects of joint operation plans.

Professor Parry concluded that MTM had the best chance of being modified to meet USREDCOM's needs. MTM was selected because it was an easy to follow, well-organized, program that had numerous simplifying assumptions. Its major advantage was that it was a working model. Its most notable disadvantage was a rudimentary air module that, for example, allowed a squadron of aircraft to conduct only a single mission at a time.

Based on Professor Parry's report to USREDCOM, a contract was let, in April of 1982, to the Jet Propulsion Laboratory (JPL) and a subcontract to ROLANDS & ASSOCIATES Corporation (R&A) to upgrade MTM. The goal of this initial JPL contract was to upgrade the MTM air module by allowing numerous missions to fly from a single squadron. In the process of accomplishing this task, JPL was to analyze the overall MTM structure and determine whether it was robust enough to continue improving MTM to meet the analysis needs of the USREDCOM staff. The contract culminated in what has been referred to as the Summer Feasibility Demonstration (SFD) in the summer of 1982.

R&A was a small firm of three people at this time. The owners of the company had both taught at the NPS and had worked in simulation and modeling during their military careers. Approximately 20,000 new lines of FORTRAN code were produced for MTM in three months. The modifications were accomplished using a Digital Equipment Corporation (DEC) VAX 11/780 at NPS. The demonstration was accomplished on a Honeywell 6070 at the Army War College. No testing was ever accomplished on the Honeywell machine prior to the SFD.

The SFD demonstrated the upgraded MTM program using a partial USREDCOM operational plan (OPLAN). There were a number of problems during the feasibility demonstration involving: system software, hardware, the weather, electrical problems, execution speed, and the availability of terrain and map data. However, the concept proved to be successful. Not only was the development of a model representing joint operations feasible, but the approach used to accomplish the task had much merit. The development of a prototype, in a short period of time, helped focus the USREDCOM staff on the capabilities and potential use of such a system.

During the SFD, JPL presented their conclusions on MTM to General Starry, the AWC, and the Army Concepts Analysis Agency (CAA). These conclusions primarily stressed that the FORTRAN language restrictions associated with MTM would cause problems in the future and that any further improvement to MTM was not advisable. The structure of MTM and the requirements associated with the model were appropriate for the needs of the USREDCOM staff, but its potential for the future was limited because of the host computer system and the non-dynamic memory capabilities associated with the FORTRAN language.

A follow-on contract was let after the SFD to JPL to begin development of a new interactive joint combat model. The funding for the contract came from USREDCOM, AWC, and CAA. Each agency had its own goals and requirements for this new model. USREDCOM was primarily interested in an OPLAN evaluation tool, AWC was primarily interested in a training tool for its students, and CAA was interested in analyzing various force structure alternatives.

The model was to be developed on the DEC VAX computer system using DEC's virtual memory operating system, VMS. Because of this decision, a REDCOM-NPS Memorandum of Agreement (MOA) was negotiated and signed in late 1982. REDCOM provided a VAX 11-780 to NPS to be located in their secure computing facility plus annual maintenance funds for the machine. NPS, in return, agreed to allow the contractor (R&A) use of the computer and the secure computing facility for the model development.

JPL and R&A conducted a complete requirements study and developed a conceptual design from January to April 1983 for what became JTLS. The detailed design specifications were briefed in April and approved near the end of May. REDCOM, AWC, and CAA each had their own set of requirements. Some of these requirements were conflicting and some were supportive of one another. There were three basic requirements to which each agency agreed. These requirements became the backbone of the conceptual design. These requirements were:

1. The combat model was to be data driven. This meant there was to be no data included in the code. All model logic was to operate from the data entered into the database. The model was not to be limited to hardware and combat systems, which were currently in the inventory. The represented systems and their capabilities had to be defined as part of the database.

2. The system was to be a single language system. The desire was not to mix computer languages in the newly developed model. Mixed computer language systems required a larger maintenance staff and was viewed as undesirable. Although it was not decided at the SFD, SIMSCRIPT II.5 was strongly suggested as the language of choice because of its proven record in building combat models at NPS. As a result of the requirements study, the decision was made to in fact use SIMSCRIPT. Both AWC and CAA were familiar with SIMSCRIPT and were sold on its flexibility and capability to reduce development time.

3. The system was to be optimized for use on the selected computer system. The concept behind this requirement was that a single program, which would properly model all elements of a joint operation, had to be written efficiently. Joint operations was a complicated concept; therefore, the model written to represent all major facets of joint operations was expected to have processing time problems. If the system was developed specifically for the selected computer system, a minimal amount of processing time would be spent interfacing with that computer system. This would leave more processing time available to increase model fidelity.

Once the requirements were completed, the time between project start and the first full user acceptance test was less than 1 year. JPL was responsible for the overall project management and management of the development of a program to help prepare the large database associated with JTLS and the program required to act as the interface between the players and the combat model. R&A was responsible for the development and coding of the combat model, the total JTLS interface specifications, a program that verified the logical consistency of the data, and a series of software tools that were needed to run and organize the operation of the entire war game system on the VAX computer.

R&A engineers designed and wrote the Combat Events Program (CEP) portion of JTLS from June to September 1983. The actual coding started on a VMS VAX 11-780 in the NPS Computer Science Department. The first running code was delivered the Tuesday after Labor Day, 1983. This initial JTLS version included Ground, Supply, Intelligence, Air, and a little Navy. JPL with REDCOM present conducted a one week integration and basic functionality test. It was not an easy test environment in which to work. There was no player interface program available nor was there any graphical output. JPL had to rely on a small test program written by R&A to enter orders into the system. This small program did not refer to game objects by name, but rather by their memory pointer. The temporary order entry process was prone to error to say the least, but it allowed for the demonstration and testing of the CEP. Given the short development time, it is obvious that some problems were found, but the basic model functions worked.

During this same period of time, a CACI employee working at JPL designed and started to create the Model Interface Program (MIP). Also, the JPL Image Processing Laboratory started to develop the methodology that created the terrain data.

JTLS development and testing continued throughout the remainder of 1983. Late in 1983, the VAX 11/780 was delivered to NPS and installed in the C3I lab. JTLS by now consisted of the Combat Events Program (CEP), a breadboard version of the MIP, and a program to verify the entries in the database called the REDCOM Scenario Verification Program (RSVP). The first JTLS database was called SOVEREIGN STATE. It was in a notional country centered at Bandar Abbas, since no actual terrain database existed for JTLS. R&A totally built the Scenario Initialization File (SIF) file and Terrain database by hand using the VAX EDT editor since the database development software was not completed.

JTLS development continued throughout 1984, where the major events were the validations. The first functional validation was held at NPS in February, with representatives of AWC, CAA, REDCOM, and CINCPAC all attending. By this time, JPL had delivered a basic MPP and the Scenario Preparation Program (SPP) written in C. Therefore it didn't take long to realize that the second basic JTLS requirement, a single computer language system, had its flaws. SIMSCRIPT had proven its usefulness as a simulation language. The fact that the CEP came so far in such a short time proved its worth. On the other had, for non-simulation tasks, there were more efficient languages available to implement the support software. The SPP was finally approved as written and JTLS became a two programming language system, although it took some effort for JPL to convince the project sponsors.

An acceptance test was held at the Army War College, after some modifications, followed by the first JTLS exercise. Exercise Yellow Breeches was held in October 1984 at the AWC. It was well received by the users, and was followed by the first JTLS Configuration Control Board (CCB) meeting. A large number of enhancements were requested. Specific requests included modification of the air, logistics, ground combat and intelligence modules, inclusion of post-processing capabilities, and the development of color graphics displays. Additional support was requested to assist in the development of various data bases to be used with the JTLS and to support JTLS installation for compilers and operating system software upgrades.

The JTLS project started planning for a graphical output system, in response to the CCB requirements. At this same time, JPL had started work on another REDCOM Task, the Joint Exercise Support System (JESS). The initial combat events program software and concepts used in JESS were taken directly from the JTLS CEP. However, a decision was made to keep the JTLS and JESS projects separate because of the different level of combat that was being addressed. On the other hand, due to the close relationship between JESS and JTLS, the color graphical display system being developed for JESS was selected as the color graphical display system to be used by JTLS[1].

This graphics system used a state-of-the-art capability that merged video display and graphical display technologies. Pictures of real maps, at various levels of resolution, were taken and placed on a laser disk. In 1984 these disks were the size of a 33 1/3 RPM record. The laser disks held thousands of images. Software was developed to access the images and display them on a high resolution television monitor. You could move from image-to-image in all directions and then zoom in or out to images of the various map resolutions. The software then accessed the location of JTLS game objects and drew icons to represent these objects over the displayed video pictures. The hardware, called the GraphOver, was built by Interactive Television Company.

The following year, 1985, the Modern Aids to Planning Program (MAPP) came into being. Along with it came the transition of the JTLS program from USREDCOM to the Joint Analysis Directorate (JAD) which later became JCS/J-8. In the Fall of 1985, the original MAPP Integration contract was awarded sole source to SYSCON Corporation. JTLS Version 1.3 was demonstrated at the June MAPP conference at NPS. JTLS was officially brought under the MAPP as of September 1985.

Early in 1985, preparation began for JTLS support of the Warrior Preparation Center (WPC) exercise Determined Warrior 85. This exercise was held at the WPC in December, using JTLS Version 1.3+. A direct result of the two week long exercise was the development of the ASCII checkpoint capability. A model must have the capability to recover quickly from a software crash during an exercise. During Determined Warrior 85, JTLS had a checkpoint capability but it was a memory checkpoint capability developed especially for the SIMSCRIPT compiler on the VAX computer system. Since it was a memory checkpoint, it was not possible to change code and then restart the model from a saved position. An ASCII checkpoint capability means that the current game state of all objects was to be saved to ASCII text files. If needed, CEP code could be changed and then the model restarted by reading in the ASCII text data files.

The first half of 1986 for JTLS involved a major clean up of the code, with only two significant enhancements completed: the ASCII checkpoint capability and a prototype Post Processor. The Determined Warrior 86 exercise was held at WPC in July and was a very successful exercise. Not a single model crash occurred during the two week event.

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[1] JESS is part of the JFCOM/JWFC Joint Training Confederation. It is now called the Corps Battle Simulation (CBS). R.J. Roland, October 2002

The year 1987 saw an increase in JTLS work, not only in code development but also in the development of the JTLS documentation suite. The first Data Requirements Manual and Database Preparation Manual, upon which work had been started in the Fall of 1986, were delivered in the Spring. JTLS Version 1.6 underwent successful JCS/J-8 testing at SYSCON in Washington, and was subsequently delivered. This version included model upgrades for Naval and Amphibious operations.

Design meetings were held in the Spring of 1987 to discuss model enhancements and plan for the Fall JTLS CCB meeting in Washington. These meetings included R&A, Martin Marietta, and other government personnel, and included design discussions for the new JTLS Information Management Terminal (IMT).

The 1987 JTLS CCB was held in August in Georgetown. This was the first CCB that was held with two Design/Support Activities present (SYSCON and R&A). By this time, the numbers of user requests for more model capability had increased significantly. SYSCON presented a design for two major JTLS system improvements. The first was a new Scenario Development System (SDS), which was designed to replace the originally developed SPP. The new SDS was to use a large, commercially available, relational database management system called Ingres. The original design for the IMT was also presented by SYSCON and also relied on Ingres for its operation. The implementation plan for JTLS Version 1.7 was agreed upon, and the development of specific detailed designs for version 1.7 began shortly thereafter.

Early in 1988, a decision was made to split JTLS 1.7 into two releases. JTLS Version 1.65 was scheduled for release in the Fall specifically to support US European Command (EUCOM) exercise requirements. Two of the major changes to be included were to allow units of opposite color in the same hex and to provide the ability to create air mission packages other than for air-to-ground attack. In October, JTLS Version 1.65 was delivered and immediately used in the first EUCOM JTLS exercise.

Also in 1988, R&A was asked to accept an expanded role in JTLS development. In addition to being responsible for the combat modeling, and maintenance and upgrade of the JTLS CEP, R&A became the integration agent for the model. This support was arranged by JCS/J-8, through a Martin Marietta Energy Systems contract with the Oak Ridge National Laboratory. Later in the year, responsibility for JTLS moved from J-8 to the Joint Warfare Center (JWC) located at Hurlburt Field, Florida.

In December of 1988, JTLS 1.65A was delivered as a maintenance release that included fixes to STRs from the EUCOM exercise. This release also included the first real graphics checkpoint. Up until this point, the program written to access the current location and strength of game objects and display this information on the GraphOver operated by accessing a DEC VAX specific construct called a “Global Section”. A “Global Section” was a reserved section of disk space, which could be accessed by several independent processes. The CEP wrote the current state of game objects to the “Global Section”, and the process feeding the GraphOver read this information from the “Global Section”. Each time the CEP stopped, the “Global Section” would be lost. When the model was re-started, the “Global Section” had to be re-populated. This took some processing time. The new graphics checkpoint capability eliminated this re-initialization procedure and significantly improved overall model performance.

R&A spent the majority of 1989, correcting reported code errors, restructuring the JTLS Scenario Verification Program (SVP) and adding new capabilities to the model. A design of an Air Tasking Order - Generator (ATO-G) was completed. JTLS Version 1.65B was released in July. Later in the year, under a contract from EUCOM, upgrades were made to the model's logistics shipment capabilities. These improvements included the introduction of barges, railroad networks, and pipelines into JTLS.

By early 1990, a Beta version of the new Ingres-based SDS was delivered by SYSCON to the government. The Ingres-based IMT project was abandoned. Ingres could not keep up with the JTLS transaction load required to maintain the design goal of 6-to-1 game speeds. In its place, R&A designed a Shared Memory IMT that obtained its information from the CEP maintained "Global Section". By June a beta version of the IMT was delivered for initial government testing.

In November 1990 US Atlantic Command (LANTCOM) held their first JTLS exercise, Spartan Base 90. They used the pre-released version of JTLS 1.7. In the Spring of 1991, Version 1.7 was released with the new "shared memory" IMT. It also included the railroad, barge, pipeline, and port unit functions designed for and paid for by EUCOM. This release introduced the ability to attach and detach units and provided fixes to all the STRs resulting from the Spartan Base 90 exercise.

During 1991, JWC started their own internal development project. This was called Enhanced JTLS, or E-JTLS. Its major improvement was the ability to execute JTLS on a remote basis. The system was designed to have the CEP execute at one site and have the players entering orders from remote locations. R&A continued working on functional changes to JTLS throughout the remainder of 1991. These changes include Special Operation Forces (SOF) representation and submarines. For all practical purposes, there were two independent versions of JTLS, JTLS 1.8 and E-JTLS. A tape with the initial JTLS 1.8 was shipped to the government for testing in July.

In 1992, the JWC JTLS team completed in-house pre-release functional and local area network testing for JTLS 1.8. By this time, WPC had integrated the R&A version of JTLS and the JWC E-JTLS version. JTLS 1.8 was officially released in March of 1992.

JTLS 1.8 also included an adjunct program, called the Monitor Program, designed and written by JWC support personnel. The program was designed to monitor network resources during a simulation exercise. The major job of the Monitor program was to help coordinate the JTLS checkpoint procedure. The JTLS Model Interface Program (MIP) took its own checkpoints to keep track of the orders it had, the orders which had been sent, and the messages which were currently in the MIP's message queue. Each player was required to enter a command, called "READY", to indicate the player was indeed ready to have a checkpoint taken. The CEP checkpoint would not start, and therefore the game could not continue, until all MIP checkpoints were completed. In a non-distributed mode, it was not easy to get all players to enter the "READY" command. In the distributed mode, it was almost impossible. The monitor program graphically displayed which MIP's had entered the "READY" command and which players had not done so. Technical Control could then easily determine which MIP needed to perform the "READY" command.

The June 1992 CCB was held at JWC. At that CCB, the JTLS project manager, LTC Kevin Brandt, U.S. Army, proposed and received approval for several major decisions that drastically altered the direction of JTLS. The CCB decided to take two major steps in the improvement of JTLS: coalition warfare, which was the ability to represent more than two sides in the conflict situation; and to move to an open system architecture. This new version was to be released in June 1995 and called JTLS 2.0.

The plans to move to an open architecture ended the third of the original three basic design requirements of JTLS, to optimize the program to efficiently operate on the selected computer system. JTLS had continued its development on the DEC VAX. This led to several problems. First, there were procurement issues. The selected operating system VAX/VMS was proprietary to the Digital Equipment Corporation. JTLS used many of its unique features, such as the "Global Section" concept. The model had to run on DEC equipment. That did not leave any room for competition and pricing alternatives. Second, DEC was not keeping up with the capability of the fast changing computer market. There were many faster and cheaper machines available, but these machines could not be used. Finally, an organization could not adopt the JTLS model without requiring the purchase of significant hardware. The open system architecture concept solved all of these problems.

In November of 1992, Exercise Spartan Base 92 was held at LANTCOM. Spartan Base 92 was the first real exercise failure for JTLS. To say the exercise was a failure could, to this day, be considered an understatement. The exercise almost resulted in the end of the JTLS project. This exercise was a serious stress test for the new distributed capability of JTLS since the interprocess communication was extensive. From this lowest point, JWC and the JTLS development team learned some extremely important lessons. These lessons have provided the framework on which JWC continues to this day to manage the JTLS project and to run a JTLS CAX. Among the lessons learned were:

1. Do not use code unless it has been thoroughly stress tested. Although the CEP had been tested, there was never any major stress test conducted by JWC prior to using the distributed version of JTLS 1.8. Code errors plagued the exercise from the start. Minutes before the exercise was to begin, a major error was found in the CEP. It had to be brought down, corrected and restarted. The situation didn't improve much over the course of the exercise. The model experienced on the average 2 crashes per day.

2. Hold several database tests prior to the exercise. LANTCOM insisted on building the database themselves. They had a single database test approximately three weeks before the exercise. During this test, major sections of data were missing. For example, most of the target database had not been built, and was not available for testing. Major database changes were being made up until two hours before the exercise. Although establishing a database cutoff date is advisable, it is seldom practical. Major database changes after the last database test is completed must be avoided.

3. Establish reliable communications. The CEP was executed from the computer center at LANTCOM on the Norfolk Naval Station. The players were across town at the Naval Amphibious Base. The communications lines between the model and the players were very unreliable. As soon as communications were lost, the system had to be re-initialized so the players could get a full and current status of the model.

4. Keep the exercise audience separate from the model. The exercise audience was on the same open floor as the players entering orders into the model. They could hear and knew of every problem that was being encountered by the model. Given this environment, it was impossible to keep an air of realism for the exercise audience. Since then, in all exercises, there is no mention of the model to the exercise audience. Although they know a model is being used, a great deal of effort is expended to insure that no reference to the model is made when relaying information concerning the status of their forces or the results of their planned operations.

5. Don't let people sit on your computers. Although, we now look at this lesson with a smile, at the time it was not funny. Not once, but twice, during the exercise, someone sat on the computer and accidentally knocked the system power switch. The computer system was turned off and all data lost. In this situation, there was no choice but to restart the model from the last checkpoint and replay the game. The requirement to insure there is adequate room for all computer equipment and technical personnel is now high on the CAX location site survey check list.

JTLS was literally saved because of the forward looking approach of the June 1992 CCB. There were no other interactive combat models, which represented more than two game sides, and the coalition warfare design required the ability to play up to ten sides and multiple factions within each side.

By the Spring of 1993, JTLS was scheduled to be used for several major exercises in the immediate future. Coalition warfare was desired for these exercises. Because of the immediate importance of fielding a coalition warfare capability, the decision was made to separate the coalition warfare change from the open system architecture change. JTLS with coalition warfare was to be called JTLS 1.85 and the open system architecture version of JTLS remained as JTLS 2.0.

The first delivery of coalition warfare came in 1993 as part of Version 1.8B. This release included, for example, the concept of multiple runways for an airbase, and multiple airbases using the same runway.

In late January of 1994, JTLS was the exercise driver for Keen Edge, a coordinated exercise involving the Japanese Defense Agency and US Forces. This was the first exercise in which the coalition warfare was effectively demonstrated. It was extremely successful and provided the first real test of JTLS 1.85. The exercise was described in articles in DEFENSE NEWS as a "... breakthrough in simulation technology..."

JTLS Version 1.85, the coalition warfare release, was officially delivered in April of 1994. JTLS 1.85 constituted a major functional enhancement of the JTLS system. Besides the ability to represent up to 10 sides, other significant functional upgrades in this release included: input of location permitted in Military Grid; aircraft were allowed to recover at a squadron different from their home squadron; addition of air mission loads that include weapons, sensors, jammers, and fuel; enabling improved Battle Damage Assessment; and some capability to represent drop tanks. In addition, the Graphical Input And Control (GIAC), written by Los Alamos National Laboratory, was delivered in a demonstration graphical output mode. The GIAC was being considered, in the open system architecture design, as the replacement for the JTLS video laser disk graphics GraphOver system.

In September of 1994, JWC moved to Ft. Monroe, VA, and became the Joint Warfighting Center (JWFC) commanded by Major General Joe Redden. In November of that year R&A hosted the JTLS CCB in Monterey. The attending organizations included Australia, Warrior Preparation Center, Supreme Headquarters Allied Powers Europe (SHAPE) Technical Center, US Pacific Command (PACOM), Special Operations Command (SOCOM), MITRE, JWFC, DISA (as the Configuration Management agent), EUCOM, SPACECOM, Los Alamos National Labs. and SOF Simulation Center at Ft. Bragg, North Carolina.

During 1995, the JTLS team provided support for three major exercises: Keen Edge (Japan), Internal Look (Central Command), and Cobra Gold (Thailand). Two new versions were released, JTLS Version 1.85A and Version 1.85B. Some of the more significant enhancements to the model made during the year involved the air module. For example, the Manual Pair option was introduced, allowing the player to specify what mission a particular interceptor will engage. Also, the capability to specify a special Weapon Load was added to all Air Mission orders. Finally, the ability was added to change a number of air mission attributes while the mission was flying.

The move from the DEC VAX/VMS environment was a much harder change than originally anticipated. Hardware purchases had to be made and basically every JTLS component had to be re-designed. The CEP was relatively easy to move to the open system architecture. Other than the file naming protocol and a new game time synchronization methodology, no other changes were required. Functionally, the IMT was the only other program not being re-designed, but over 80% of the program needed to be re-written to move away from the VAX/VMS capabilities. The MIP and GraphOver graphics system were thrown out completely. They were replaced with the Message Processor Program (MPP) and the GIAC. The GIAC took over the order entry function of the original MIP and the MPP took on the message receipt and viewing function of the MIP. During this time period, the R&A development team needed to maintain two complete versions of the code. Not only were functional changes being made to JTLS 1.85, but JTLS 2.0 was in full development.

The August 1995 CCB included attendees from the same commands and organizations that met the previous year. JTLS 2.0, although not ready for release, was demonstrated at the CCB. One of the outcomes of this CCB was a prioritized list of outstanding ECPs for planning purposes over the next few years of JTLS development. The ECP providing for enhancements to the

Intelligence functionality of the model was at the top of the list. The Integrated Air Defense ECP was also ranked very high by the user community.

JTLS was beginning to get wide recognition from the military analysis community. For example:

1. In September of 1995, R&A began support of research conducted at the Naval Postgraduate School by Professor Parry that involved using JTLS in its initially envisioned analytical mode. The purpose of the research was to evaluate Joint Staff training and readiness in exercises. The research was conducted under the sponsorship/direction of the Deputy Undersecretary of Defense for Readiness and of the Deputy Undersecretary of the Army for Operations Research. It involved developing post-exercise analysis techniques designed to help identify Joint Mission Essential Task Lists (JMETLs).

2. At the 1995 Winter Simulation Conference, LTC Bob Bolling, USAF, JTLS Program Manager, delivered a paper on JTLS. The paper was titled "The Joint Theater Level Simulation in Military Operations Other Than War (MOOTW)", and can be found in the conference proceedings. It outlined current JTLS capabilities in area of MOOTW, such as airspace control, protection of land, air, and sea Lines of Communications (LOC), Noncombatant Evacuation Operations (NEO), blockades, and nation building.

In March of 1996, JTLS Version 2.0 was released. Besides Open Architecture it also incorporated other ECPs such as Civil Affairs and Psychological Operations (PSYOPS) and the modeling of casualties and remains on the battlefield. JTLS 2.0 also included the first release of the Air Tasking Order Translator (ATO-T). The ATO-T read in a real world ATOCONF message and generated JTLS orders directly from the information contained in this US Message Text Format (USMTF) message. This program greatly reduced the amount of time required to enter the air orders required for large JTLS exercises.

During 1996, JTLS 2.0 was the exercise driver for a total of six exercises around the world: Keen Edge (Japan), Internal Look (Central Command), Ultimate Resolve (Kuwait), Cobra Gold (Thailand), Tempo Brave (PACOM), and Northern Trilogy (Australia). Two maintenance releases, Version 2.0A and 2.0B were delivered in 1996. Among the functional upgrades that were part of these maintenance releases were a number of ATO-T improvements, and the ability of a Controller to create a brand new unit while a JTLS game is in progress. These were the result of requirements defined in Internal Look 96. Other upgrades included the ability to host JTLS on a Hewlett Packard system, which proved the success of the open system architecture design.

In1996 the JTLS project entered its next important phase, the use of the system by countries other than the United States. It started when the Greek government asked JCS/J8 for and received JTLS for an initial cost of $60,000. JWFC did not receive any of the money paid by the Greek government for the model, but they were responsible for the costs incurred to install the system and conduct the initial training. This put JWFC in a no-win situation. They didn't want to continue training foreign users, nor did they want JTLS to be used by inexperienced personnel. Both R&A and JWFC realized this situation could not continue.

Around this time, the Government started a new technology transfer program called the Cooperative Research And Development Agreement (CRADA). The CRADA provided a vehicle in which the Government and private industry could work together to move projects, which had been developed primarily for the Government's use, into the open market. The Government and private industry became partners in the effort, and both the Government and private industry would reap the benefits from the effort.

R&A proposed that they enter into a CRADA with the U.S. Government for the distribution and training of JTLS to organizations other than the U.S. Government. The negotiated CRADA was beneficial to both JWFC and R&A. For example, R&A received:

Permission to use of the U.S. Government equipment, already installed at R&A's JTLS development laboratory, to support foreign users.

Sole right to distribute and train users who applied and received permission to obtain JTLS.

On the other hand, the Government received or maintained the following benefits as a result of the CRADA:

1. A fee from R&A for the right to distribute the JTLS system.

2. Control over which countries or organization had the right to obtain JTLS.

3. Free of charge, all improvements made to JTLS for users of the system other than the Government.

As a result of the CRADA, R&A engineers went to Abu Dabi, the United Arab Emirates (UAE) to demonstrate JTLS. The UAE Ministry of Defense was interested in using JTLS as an analysis tool and as the centerpiece wargame for their new staff college. The interest from the UAE was followed by interest from Turkey, Japan, and France.

During 1997, JTLS was the exercise driver for five more exercises. JTLS supported exercises during 1997 included: Blue Advance, Dynamic Action, Cobra Gold, Burning Bale (a NATO Headquarters North exercise in Norway), and Trail Blazer.

JTLS Version 2.1 was released in June of 1997. This version included extensive changes to the way a JTLS initialization database was structured. A JTLS Version 2.0B initialization database consisted of a total of 11 data files. In Version 2.1, an initialization database was made up of 170 smaller files. The data base structure changes accommodated the completely new Database Development System (DDS), which replaced the Scenario Development System (SDS) and the Scenario Preparation System (SPP). The DDS became the primary software tool for a JTLS Version 2.1 database developer. The new DDS used Oracle, instead of the Ingres used for the SDS.

The JTLS 2.1 release included over 40 Engineering Change Proposals (ECPs). One of the most significant of these involved substantial enhancements to the JTLS intelligence model. Intelligence model upgrades included: improvements to the representation of collection assets, implementation of the Directed Search Area (DSA) function, the addition of the Orbiting Recce mission, presentation of non-fused information (unidentified units and targets) to the Players, and the development of more realistic-looking reports that could be sent directly to the training audience. Other improvements in JTLS 2.1 included: the detection and reporting of wreckage on the battlefield, the implementation of polygonal patrol areas for both ships and air missions, the addition of the capability for ships to maintain relative station locations, and the capability for players to choose unique units of measure for the data displayed in MPP messages and on the IMT screens.

The CCB in 1997 developed an extremely ambitious development cycle for JTLS Version 2.2. The list of requested ECPs was significant and resulted in an 18 month delivery schedule. Due to the planned exercise load for JTLS, project management decided to divide the ECPs into four smaller releases, JTLS 2.1.1, 2.1.2, 2.1.3, and 2.1.4. The first complete sub-release, called JTLS Version 2.1.1 was delivered in November. This release included implementation of a total of 23 ECPs. Examples included: the addition of the DDS "hierarchy delete" function, the capability for a player to create a single ship formation, the capability to detach a unit of a defined Tactical Unit Prototype (TUP) different from that of the parent unit, and modeling of the impact of disease on humanitarian relief. The disease model was the first specific 00TW enhancement made to JTLS. It gave JTLS the ability to model the effects of defined diseases on personnel and other failure modes on non-personnel combat systems.

During 1998, JTLS was the exercise driver for a total of nine exercises, more than in any other year to date. JTLS supported exercises during 1998 included: Ultimate Endeavor, Keen Edge, Dynamic Action, USMC Block3CPX, Cobra Gold, Yildiz (Turkey), Matador, Burning Harmony. This year also saw the merging of the US Atlantic Command (ACOM) Joint Training and Exercise Support command (JTASC) and JWFC. The new combined organization became known as US ACOM-JWFC.

Because of the exercise schedule and the cancellation of the major Internal Look 98 exercise due to real-world events, the JTLS 2.1.2 release was canceled. It was rolled into the JTLS 2.1.3 release, which was delivered in September of 1998. The 2.1.3 release included a number of major enhancements to the model. The most significant of these was the introduction of the High Resolution Unit (HRU) entity. These small units can be detached from units of any type during the game or can exist at game start. The are created to perform a variety of specific missions (reconnaissance, engineering tasks, coalition support, ambush, etc.). When their tasking is complete, they rejoin the parent unit. The introduction of HRUs allowed the modeling of Downed Aircrews, and Search and Rescue operations that were represented by the new Insert/Extract Mission. Similarly, a number of Special Operations Forces (SOF) functions were incorporated into the HRU functionality along with the old JTLS HUMINT team concept.

Since JTLS 2.1.2 and 2.1.3 were combined into a single release, JTLS 2.1.3 represented a major change in the functional capability of JTLS. In fact it was felt that the single release had too many changes all at once. Players had a hard time assimilating to all of the changes, and the data base builders had significant work to do before the new version could be used for an exercise. Some of the other significant enhancements included in JTLS 2.1.3 were:

Improved weather model. There were changes concerning how weather conditions affect operations and the addition of weather fronts that move across the game board.

Representation of water depths. Hex water depths, analogous to altitudes for land hexes, and depth zones, analogous to altitude zones were added to the model. Water depth and depth zones affect naval operations, such as the maximum allowable speed of a naval unit in a given depth zone.

Improved representation of minefields. The number of minefield types that can be created was increased, and minefields were given an automatic deactivation option.

Representation of Integrated Air Defense (IADS). Target complexes and target networks were introduced into the model. Links can exist between sensor sites, communications sites and Air Defense Artillery (ADA) sites. The ability of a SAM or AAA site to fire is based on whether there is a communications link between an air detection radar and the firing site.

Representation of long bridges or tunnels. Long bridges or tunnels allow units to cross over several hexes.

Representation of multiple support units for different re-supply categories. In previous versions of JTLS, a unit, by default, ordered all its re-supply from its primary support unit. In JTLS 2.1.3 it was possible to explicitly designate a different re-supply support unit for each represented supply category.

Representation of truck companies. Trucks could be ordered to move supplies to and from several units, all within a single Directed Resupply Order. The same concept was applied to the airlift of supplies from one location to another.

Representation of multiple target Air Mission Packages (AMPs). The AMP capability was redesigned. Not only could the attack missions be sent to several widely dispersed targets, but the timing of the packages was changed to represent both the manner in which NATO plans its AMPs and the manner in which the US plans its AMPs.

Solaris x86 PC host approval. JTLS 2.1.3 release included all the executable code (and associated object code and data files) to allow a complete JTLS Player station to be hosted on a Solaris x86 PC. A Player station consists of a GIAC, MPP, IMT, and On-line Player Manuals (OPM).

Other highlights of 1998 included continued use of JTLS by foreign users through the CRADA. Japan (Mitsubishi Electric Company), Turkey (Turkish Armed Forces Staff College), UAE (through a contract with Coleman Research Corporation, Huntsville, AL), and France (Center of Information and Defense) all became JTLS users. The United Kingdom and Thailand also showed interest in obtaining the model.

Finally, during 1998, a portion of the JTLS development team was dedicated to making JTLS HLA (High Level Architecture) compliant. Under the direction of Defense Modeling

Simulation Office (DMSO) an HLA federation, known as the JTLS-GCCS-NC3A Federation, was formed. This federation included JTLS, the Global Command Control System (GCCS), the Over-the-Horizon Genis External Module (OTH-GEM), and the North Atlantic Treaty Organization (NATO) command and control system known as the Integrated Command Control System (ICCS). A JTLS HLA version of the code was developed separate from, but in parallel with, the functional JTLS development code. Although JTLS HLA compliance was achieved later in the year and the federation successfully fulfilled its design goals, the HLA version of JTLS was too slow to be successfully used within an exercise environment.

JTLS has come a long way since its beginnings in 1982. It is one of the more successful simulation and modeling projects ever undertaken by the Department of Defense. There are many reasons why it has been successful, but the entire R&A development team believes that there are three primary reasons why JTLS has maintained its usefulness beyond the normal life cycle of similar projects. These reasons are:

1. A single development agency. ROLANDS & ASSOCIATES Corporation has been responsible for the model from the very beginning. They have the historical perspective, an understanding of the basic modeling concepts, and in depth knowledge of the code organization required to successfully plan for improvements. They have worked with the model for such a long time that they feel a deep and personal responsibility for insuring the model continues to serve the Department of Defense to its fullest potential.

2. Slow but steady improvements. JTLS has never had the luxury of a large funding budget. At times this hasn't seemed like a benefit, but in the long run it has truly turned into an advantage. The limited funding has forced the development team to create deliverable working software on a regular basis. This meant the user community got to see and work with improvements, and provide immediate feedback to the development team. The slow, evolutionary approach to model development has time and time again proven to be a successful paradigm.

3. Ability to make major shifts or improvements in the model's capability. The JTLS development team has never been afraid to make major shifts in the model's design concepts. So many legacy systems "patch improvements" into the existing system. When needed, the JTLS development team hasn't been afraid to throw away major sections of logic, and re-do them so they can support new concepts needed by the user community.

The Joint Warfighting Center and the rest of the JTLS development team are looking forward to the continued improvement and use of JTLS by the Department of Defense and the allied partners of the United States into the next millennium[2].

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[2] This History was written in late 1998. During calendar year 1999, the JTLS user community conducted nine major exercises, along with the associated database tests and training events. These included exercises conducted by both government and commercial client users. The 1999 JTLS CCB occurred in June, after the annual May Cobra Gold exercise. The major improvements scheduled for release in October 1999 were:

(1) National Boundaries - the representation of boundaries and other lines used to restrict movement and formulate Rules Of Engagement (ROE) areas that are not necessarily circular and that are no longer centered on a specific game object.

(2) Improve Post-Processor - the delivery of an Oracle based Post-Processor system.

(3) Integrated HLA - the development of the JTLS HLA Interface Program which will allow other simulations to obtain data from JTLS and send orders to JTLS using the High Level Architecture (HLA) in a much more efficient manner than experienced with the 1998 HLA compliant version of JTLS.