Development of an Immersive Learning Environment for U.S. Northern Command (USNORTHCOM)

On Demand Validation of Training Requirements

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ABSTRACT

The rapid establishment of the U.S. Northern Command (USNORTHCOM) after 9-11 created significant training and education challenges. The North American Aerospace Defense Command (NORAD) – USNORTHCOM) (N-NC) needed to swiftly develop requirements for an education, training, and mission rehearsal capability to support both Department of Defense and interagency partners in meeting new homeland defense operational knowledge requirements. Meeting these needs involved developing open architecture tools, processes, and procedures to meet the time demands of a quickly evolving net-centric operational capability. In response, the Office of the Secretary of Defense organization responsible for Training Transformation sponsored the development of a next-generation capability called Immersive Learning Environments (ILES).

ILES is an exercise framework for handling activities associated with the complete training life cycle from initial establishment of training objectives to final After Action Reviews, while capturing Lessons Learned throughout the process. This framework traverses individual, small-team, and enterprise levels of education, training, and mission rehearsal activity.

The proposed standards-based exercise framework consists of five subsystems: Event Sequence that provides time-based exercise activity management; a Common Tools Interface that provides access to tools; Reusable Training Objects for representing training content; a Learning Management System that tracks training-related data such as participant profiles, performance levels, and participant progress, and a Data Repository for exercise database management services. The Event Sequence and the Reusable Training Objects are original concepts that innovatively address unique requirements.

The Event Sequence uses Nodes to represent time-based activity chunks either at the individual or at the group level. Decision, Injector, Observer, and Mentor Nodes are also used for providing a highly dynamic "what-if" experimentation platform. The Reusable Training Objects will be based on specifications in the Sharable Content Object Reference Model (SCORM®) model, with extensions to handle group-based learning activities and High-Level Architecture for linkages to modeling and simulation.

ABOUT THE AUTHORS

Dr. Stanley Supinski, (Deputy, Education and Training, N-NC J7) has 15-plus years of experience delivering and managing training and education programs for the Department of Defense. He was previously an Associate Professor and Director of Foreign Language Instructional Technology at the U.S. Air Force Academy. He is currently the Deputy for Education and Training for the North American Aerospace Defense Command and USNORTHCOM. He is also the founder and current director of the Homeland Security/Defense Education Consortium. Dr. Supinski has done extensive research in the area of

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Dr. Robert Wisher, (Office of the Deputy Under Secretary of Defense for Readiness) Ph.D., is the Director of the ADL Initiative for the Office of the Secretary of Defense and Program Manager for the ILES Program. Dr. Wisher is responsible for directing and implementing the ADL Initiative within the Department of Defense as well as other government organizations, academia and industry on an international basis. He also provides direction for the development and refinement of the Sharable Content Object Reference Model and for the continued expansion of the ADL Initiative.

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INTRODUCTION AND BACKGROUND

The rapid establishment of the U.S. Northern Command (USNORTHCOM) after 9-11 created significant training and education challenges. The North American Aerospace Defense Command (NORAD) –USNORTHCOM) (N-NC) needed to swiftly develop requirements for an education, training, and mission rehearsal capability to support both Department of Defense (DoD) and interagency partners in meeting new homeland defense training needs. Meeting these needs also involved developing open architecture tools, processes, and procedures to meet the time demands of a quickly evolving net-centric operational capability.

At the same time, many other important aspects of Defense organization and joint doctrine were undergoing fundamental transformation. In 2003, the Joint Forces Command helped establish a Standing Joint Force Headquarters (SJFHQ) at each Combatant Command as a catalyst for transforming operational-level command and control. The focus of the SJFHQ is to enhance war-fighting readiness through proactive engagement in the analysis, planning and operations processes with an in depth understanding of potential crisis areas; collaborative information environments, and application of effects-based planning and Operational Net Assessments as defined below.

The collaborative information environment is described as the integration of individuals, organizations, systems, and processes for the common purpose of creating and sharing the data, information, and knowledge necessary to rapidly plan, execute, and assess joint operations [1]. This capability is intended to exist across all levels of joint, interagency, and multinational organizations, providing a medium that transforms a collection of networks into a common cyber environment.

The Operational Net Assessment uses multiple information sources and collaborative analysis to build shared knowledge of the adversary, the environment, and ourselves. The goal is to develop the kind of actionable knowledge to help decision-makers focus capabilities when, where, and how they are needed to achieve desired outcome. The concept calls for a persistent and habitual collaborative process among subject matter experts from diverse organizations [2].

The Joint Forces Command has stated that the transformational benefits of SJFHQ depend upon our success in rapidly developing and maturing the synergistic application of these enabling capabilities, and that the true power of these collaborative information environments is not limited to the capabilities that exist in the SJFHQ, but the capabilities that reside throughout the joint and interagency communities.

In his testimony before Congress about lessons learned from Operation Iraqi Freedom, Major General Gordon Nash, stated, "The significance of what we saw was that our commanders realized that the key to harnessing the full power of *jointness* begins at the operational level of command and links to strategic planning and tactical execution. We saw that the ability to plan and adapt to changing circumstances and fleeting opportunities is the difference between success and failure in the modern battlespace" [3].

The Deputy Under Secretary of Defense for Homeland Defense reinforced the urgency of the need to harness the full power of *jointness* when he said: "We have tremendous ... national capabilities and military

capabilities within the United States that we can bring to bear upon the offensive actions of transnational terrorists. But we can't do it alone. We must work with friends and allies to maximize the strength of our defense." [4].

In response to this urgent need, the Office of the Deputy Under Secretary of Defense for Readiness sponsored the rapid spiral development of an Immersive Learning Environments (ILES) system. ILES is focused primarily on USNORTHCOM requirements in Phase I, but is intended to expand to incorporate and leverage the capabilities of other interagency and multinational organizations.

In his guidance to those submitting papers for this forum, Admiral Fred Lewis states that "To defeat adaptive enemies, we must out think them as well as out-fight them. By realizing a heightened state of shared situational awareness and knowledge amongst all elements of our team, we are positioned to achieve situational dominance. And, by implementing command and control structures focused on interoperability and integration, we dramatically increase survivability, timeliness, and responsiveness."

Admiral Lewis goes on to state that the most pressing task before the training community is "to provide an integrated suite of tools to address the full scope of training from high-level staff to individual combatants across the Services." The authors of this paper believe that an immersive learning environment system is a major step toward realizing the goal of achieving *one team, one fight, and one training future*.

STRATEGIC APPROACH

Given the urgent nature of the task, the ILES team devised a unique approach to developing a prototype designed to meet the needs of a rapidly changing environment. This strategic approach consists of the following concepts:

- Implement a Rapid Spiral Development approach designed to minimize the workload on the USNORTHCOM staff and to show quick and evolving capabilities.

- Adopt a Network Centric Approach that leverages the existing tools, organizations and processes inherent in the joint operational environment; accelerate the development of low-cost online tools and techniques for collaboration, training, and exercises; leverage innovation, expertise and productivity from across the Department of Defense and Interagency community; refine evolving joint concepts and procedures through low-cost online simulation; and integrate real-world and real-time geo-spatial information capabilities.

- Utilize open architecture standards to ensure large-scale interoperability distribution and reuse of course and exercise modules; enable plug-and-play use of commercial off-the-shelf systems, and provide access to Digital Libraries and Human Experts anywhere and anytime.

- Create an Exercise and Training Capability that is coherently integrated with the Joint Force Headquarters organization, tools, and processes with the capability to support a full range of education and training needs from self-paced individualized instruction; use of online simulation in support of reconfigurable distributed teams; the planning and execution of large-scale national exercises; and the ability to conduct mission planning, analysis and rehearsal in a real-time real-world environment across multiple organizations at the operational and tactical levels.

- Fuse instructional strategy, assessment, feedback, and the ability to learn and adapt on-the-fly into the overarching and dynamically evolving systems architecture in keeping with the agile systems design and processes employed by Joint Warfighting Center (JWFC) in their conduct of Mission Rehearsal Exercises [5].

TECHNICAL APPROACH

The JWFC and N-NC concurrently refined and adapted their command and staff exercise process to quickly respond to "pop-up" requirements associated with the Global War on Terrorism. These JWFC exercises typically consist of four phases: academic training, planning and deployment, exercise execution, and analysis. This JWFC exercise process is exceptionally quick and flexible when compared to other complex large-scale joint training exercise processes.

Underlying the highly dynamic and agile JWFC exercise process is a unique architecture that enables near real-time joint training support to the mission planning and rehearsal, course of action analyses, dynamic scripting, injects from opposing forces, access to global simulation and information technologies, and real-time feedback from senior mentors and observer controllers. These capabilities are provided in support of Combatant Commanders and Joint Planning Groups

that include coalition and interagency forces at the Operational and Strategic level. As such, the JWFC exercise architecture is a critical systems design template that ILES plans to incorporate for adapting to the highly dynamic homeland defense and security environment.

In addition to the technical architecture guidelines discussed above, at the start of the ILES effort, N-NC worked with the program partners to understand the current operational environment at N-NC for developing an Operational Requirements Description [6] in the context of education and training needs. Summary of this effort is a list of observations of the operational environment at N-NC:

- USNORTHCOM is a newly established organization that is experiencing growth and transition issues typical to an organization in its infancy.
- N-NC has a unique mission related to Defense Support to Civil Authorities and Homeland Defense that makes them inherently different than other Combatant Commands.
- Facilitated communication and collaboration is a critical training and exercise support need.
- Rapid training on the infrastructure and tools used in the N-NC environment is critical due to the short time frame (2-3 years) in which individuals may be stationed at N-NC.
- Individuals should have 24-7 access to performance support training and to reference material as they perform their job responsibilities.
- The learning environment must accommodate a decentralized approach to performance assessment to better facilitate experiential learning.

In addition to the observations noted above, the following challenges for the current exercise environment were identified:

- Course development and exercises are costly and resource-intensive.
- Joint Mission Essential Tasks (JMETs) are not fully exercised with the current exercise schedule.
- JMETs, Training Objectives, Education and Training resources, and exercises are poorly integrated.
- Exercise participants are not fully prepared prior to exercises and there exists a large variation in baseline knowledge and skills among participants.
- Methods for capturing learning progress from the individual to the group and enterprise levels are not well-established.
- Education and Training requirements are not linked to the exercise schedule.
- Knowledge and information management tools are not directly integrated with exercise tools.
- Collaboration tools are not consistently used even during exercises.
- A Collaborative Knowledge Environment that provides individual to collective learning is not present.
- Operational tools and training content are developed by various commercial and government organizations without following standards or guidelines thus they cannot work together in the exercise environment.
- Large numbers and types of personnel requiring training at the command level, as well as the state, local, and federal levels.
- Large variations in knowledge and skills required due to the changing nature of the threat.
- Overlap exists among jurisdictions, procedures, and conditions.
- Need exists for information and knowledge integration in real time.
- There is lack of common standards for knowledge and skills.
- There is limited ability to experiment, develop new doctrine, tactics, and procedures.
- Lesson Learned and After Action Reviews are well-captured, but not readily accessible for reinforcement.
- The Learning Management System is not integrated with exercise activities.

The underlying technical approach to address these observations and challenges was to develop an environment that allows more individuals and groups to rehearse their roles in support to potential events. In keeping with the need for decision support, the exercise environment should be agile and scalable enough to support rapid and frequent exercises through large-scale and small-scale environments and integrated with the tools used in the N-NC operational environments.

Bridging the Gap

Currently, N-NC conducts a few large-scale exercises per year that involve thousands of participants from various federal/interagency, state, and local organizations that are distributed throughout the continental United States.

As shown in Figure 1, N-NC has an exercise planning process where the exercise planners identify JMETs, training resources, and training objectives for the exercise planning process. Then, they work with other organizations along with N-NC's organizational and functional cells to plan their exercises.

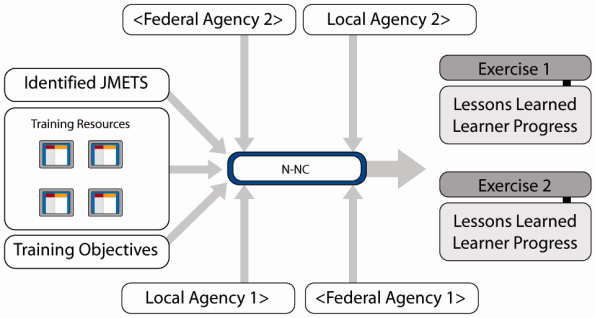

Figure 1. N-NC's current exercise planning process

These large-scale exercises are very time-intensive and costly, thus requiring a long lead time for preparation, coordination, and resources. In addition, there are small-scale exercises (1-2 day duration) and individual training activities. Although these small-scale exercises prepare individuals for their operational responsibilities, there is a gap in training and preparation for large-scale exercises. The ILES exercise framework intends to bridge the gap between individual training, small-scale, and large-scale exercises for preparing individuals, groups, and enterprises (see Figure 2). ILES intends to provide an on demand validation of training requirements.

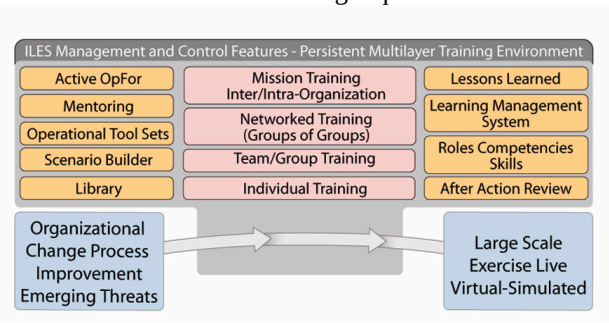

Figure 2. Building a bridge between individual training, small-scale, and large-scale exercises.

Based on the challenges and the observations noted above, this paper proposes an adaptive architecture for building an extendible exercise framework for N-NC.

ILES EXERCISE FRAMEWORK

The proposed exercise framework consists of the following five major subsystems:

1. **Event Sequence (ES)** – provides time-based training and exercise activity management
2. **Reusable Training Objects (RTOs)** – training activity module or actual content
3. **Common Tools** – provides access to tools required for completing training activities
4. **Learning Management System (LMS)** - tracks training related data such as training participant profile, performance level, learning progress, and feedback
5. **Data Repository** – provides exercise database management services

Shown in Figure 3 are the major ILES subsystems and details of each subsystem. Major innovations in this approach are the ES and the RTO concepts. Provided below are details for these two subsystems.

Event Sequence

The Event Sequence is built on the traditional visual representation metaphor (similar to IDEF0 [IDEF0 is a method designed to model the decisions, actions, and activities of an organization or system] charts, Unified Modeling Language sequences, or flow charts that provide branching and sequels). Event Sequence concept provides the following capabilities:

- Event synchronization
- Battle tempo control and dynamic scripting of exercises
- Nodes with hierarchy and relationships to represent group activities
- Execution Control (Pause, Stop, Increase tempo, etc.) of the exercise

For the N-NC environment, events can be identified as any activity that is conducted by an individual, group, or enterprise performing some training or operational activity as part of the exercise. The sequence relates to the fact that these activities progress over time, moving from one activity to another. Each activity has its own lifecycle within the sequence. In general, there are inputs and outputs from each activity contributing to the next activity in the sequence.

The Event Sequence uses Activity or Group Nodes to represent activity chunks either at the individual or at the group level. Group Activity Nodes are used to manage group training activities such as in an online multi-player game. The Activity Nodes are used to represent activity of an individual. Injector Nodes, Observer Nodes, and Mentors Nodes are used for providing a highly dynamic "what-if" experimentation platform. Decision Nodes are used to provide loops, branches, and sequels in the Event Sequence.

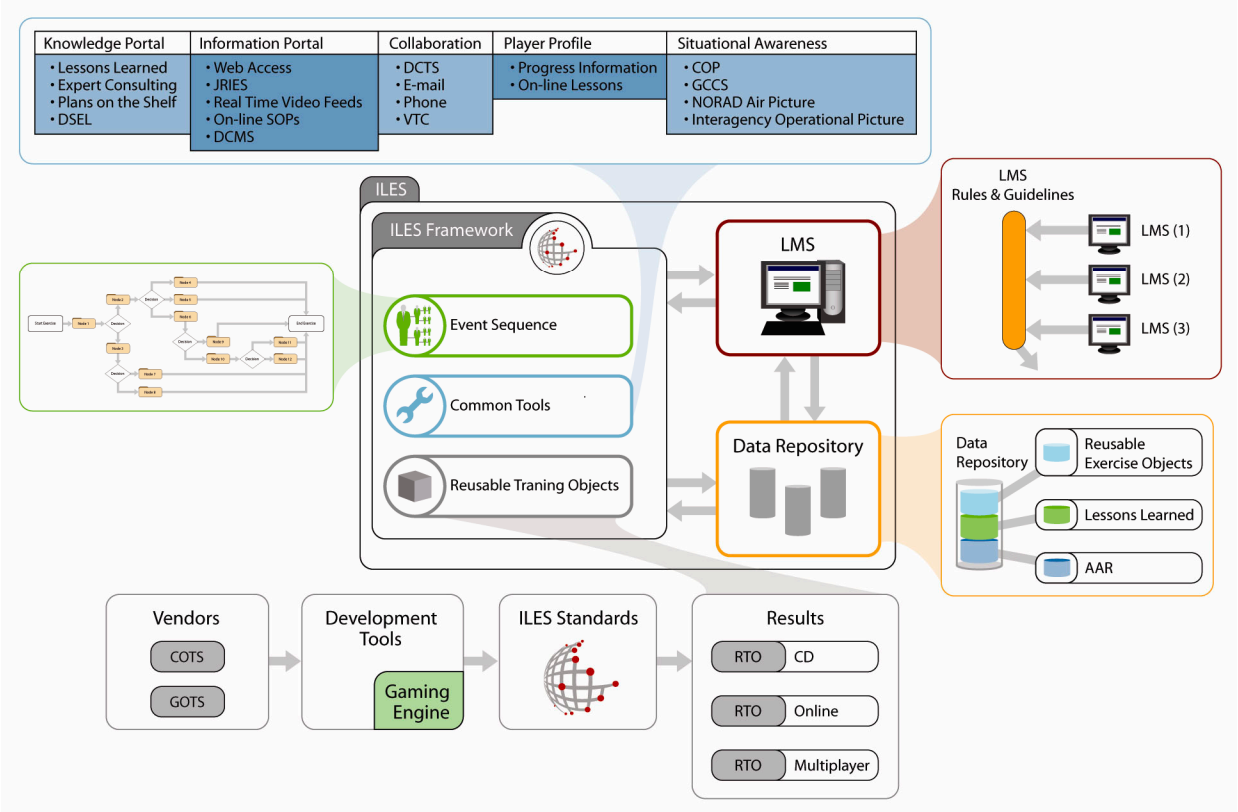

Figure 3. ILES exercise framework with subsystems expanded

Due to the hierarchical representation of nodes (Group Activity Nodes), the exercise framework is able to capture group performance by aggregating performance at any level of the organization. Shown in Figure 4 is an example of an Event Sequence for N-NC where three activities are conducted in a simple linear sequence.

Figure 4. An example of an event sequence with three activities.

Reusable Training Objects (RTOs)

RTOs provide capabilities for an individual player to complete a goal-driven training activity. It is envisioned that the ILES Framework will expand existing Web-based content development specifications such as SCORM for developing the RTO development guidelines. The new guidelines will provide data communication schemes that allow many types of learning objects, as well as planning and execution tools, to use a common language through which they can interact and communicate without the need for human-applied engineering of their interaction.

As shown in Figure 5, in the RTO development process, commercial off-the-shelf vendors, and DoD organizations will use various development tools, including gaming engines, while following the newly developed RTO guidelines (non-proprietary) to develop RTOs that will provide different training activities. It is assumed that RTOs may be delivered via CD-ROMs, the World Wide Web, or other networks. The new guidelines will allow an RTO to provide different training activities based on the user's role. This capability allows the player to select different roles to complete distinct training activities to facilitate proficiency in different areas.

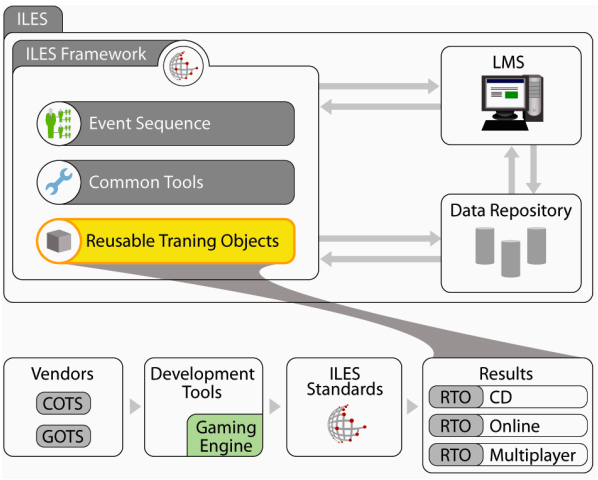

Figure 5. Proposed RTO development process by using commercial off-the-shelf and government off-the-shelf tools within the ILES Framework.

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RTOs are based on Sharable Content Objects (SCOs) developed by the DoD's Advanced Distributed Learning (ADL) Initiative, but extended to handle group-based learning activities. The final objectives of the RTO concept are to not only to support live, constructive, and virtual content, but also to combine online content development standards such as SCORM and the High-Level Architecture (HLA) that supports the DoD's modeling and simulation community.

Prominent Role of SCOs in RTO

The RTO guidelines will be based on extensions applied to the specifications for SCOs developed by the ADL Initiative, but with additional metadata required for executing within the ILES Framework. Currently, the DoD uses Distributed Interactive Simulation (DIS) and HLA for simulations that can interoperate in a distributed environment. It is assumed that the new standard will adapt additional requirements from DIS and HLA standards.

Once the RTO guidelines mature, government agencies and commercial vendors can develop RTOs that can be used and reused within the framework for individual, group, and enterprise-level exercise activities. In the future, some of the applications used in the N-NC operational environment will follow the standard for executing within the ILES Framework, thus allowing the framework to be used within the operational environment.

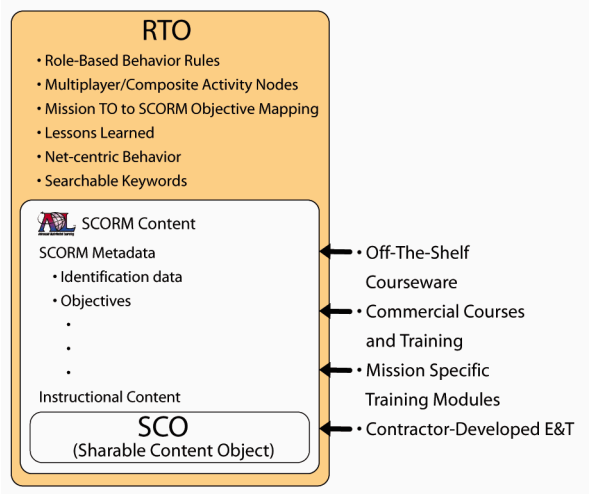

Figure 6. It is anticipated that the RTOs will extend SCO specification/SCORM content

Other Subsystems

In addition to the subsystems discussed above, the ILES concept integrates Common Tools, a Learning Management System, and a Data Repository for providing a reusable and persistent N-NC learning environment. The Common Tools subsystem provides access to commonly used tools at the N-NC operational environment for assisting learners during exercise activities. The Learning Management System captures and stores educational and training related information for exercise participants such that proficiency and readiness information from exercises are captured for future reference. The Data Repository provides a centralized data location for storage and retrieval of information for exercises.

IMPLEMENTATION

After the requirements were refined and the system architecture was developed, N-NC worked with program partners to apply a rapid spiral development approach for implementing this concept. This development approach allowed N-NC to work closely with the development team to provide feedback on system design and user interface approaches. Provided below are details of the spiral one release of the ILES environment.

The spiral one implementation consists of three major components; the ExLobby (Exercise Lobby) where participants join exercises; the ExPlayer (Exercise Player) interface for completing the training, and the ExMan (Exercise Manager) that uses a visual

programming environment for facilitating exercise management activities.

Typical Use Case

In a typical use case, the Exercise Controller will use the ExMan interface to build exercises using Nodes and RTOs. Once built, these exercises are published in the ExLobby. As required, the Exercise Controller will make published exercises "live" for individuals or groups to join. Based on a scheduled event or at their own pace, training participants will select a server and log onto the exercise lobby where multiple exercises are hosted.

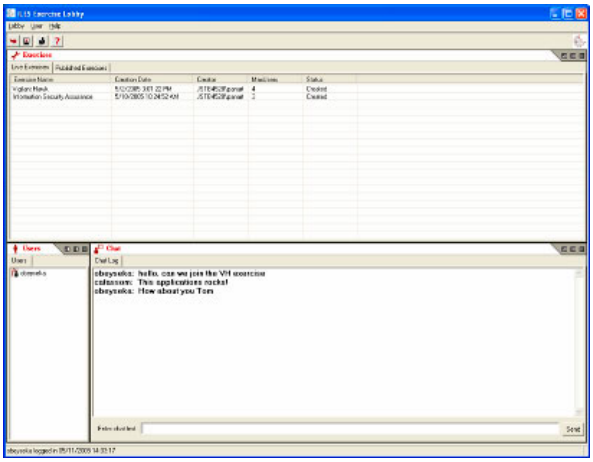

Figure 7. ExLobby interface

In the lobby, users can communicate via chat rooms to plan their next exercise. Once the users join an exercise, they are hosted to the exercise player interface where their activities are pushed from the server. As the participants complete their activities while using common tools, the data repository and the Learning Management System capture activity data.

The server sends out activities as they are completed until the exercise is completed. For group activities, participants have to wait until all arrive at the activity. In such a manner, participants can use ILES tools to participate in exercises individually or as a group. Shown in Figures 7 and 8 are screen captures of the Lobby and the ExPlayer interface. *Note: As of this writing, the ExMan interface was still under development.*

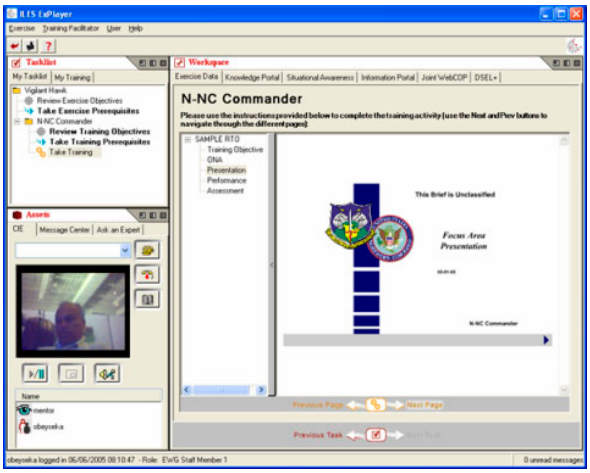

Figure 8. ExPlayer interface

Facilitated Pilot Test

At the end of the Spiral One, a facilitated Pilot Test with eight training participants from the SJFHQ at N-NC was completed. The two day exercise involved two groups from SJFHQ working in sequence to exercise a small segment of the Operational Net Assessment process. This early test provides an excellent opportunity for the ILES team to get additional feedback that will be incorporated into requirements for the next Spiral.

LONG-TERM BENFITS TO N-NC

A major benefit of the ILES Framework over existing systems at N-NC is its ability to develop scenario libraries that can be captured, stored, adapted, and reused (see Figure 9 below for details) across multiple levels of command and other federal, state, and local agencies. This network-centric capability enables training developers to access, review, and adapt existing scenarios quickly and distribute them across commands and agencies in support of dynamic education, training, and mission rehearsal needs of the changing national security environment.

FUTURE ACTIVITIES

The ILES program plans to continue with the spiral development approach to expand the current implementation with constant user involvement. The ILES development team will conduct pilot tests at the end of each spiral to evaluate the effectiveness of the approach. Specifically, during the next spiral, more emphasis will be applied to developing a more complex Event Sequence architecture for creating a truly flexible "what-if" experimentation platform.

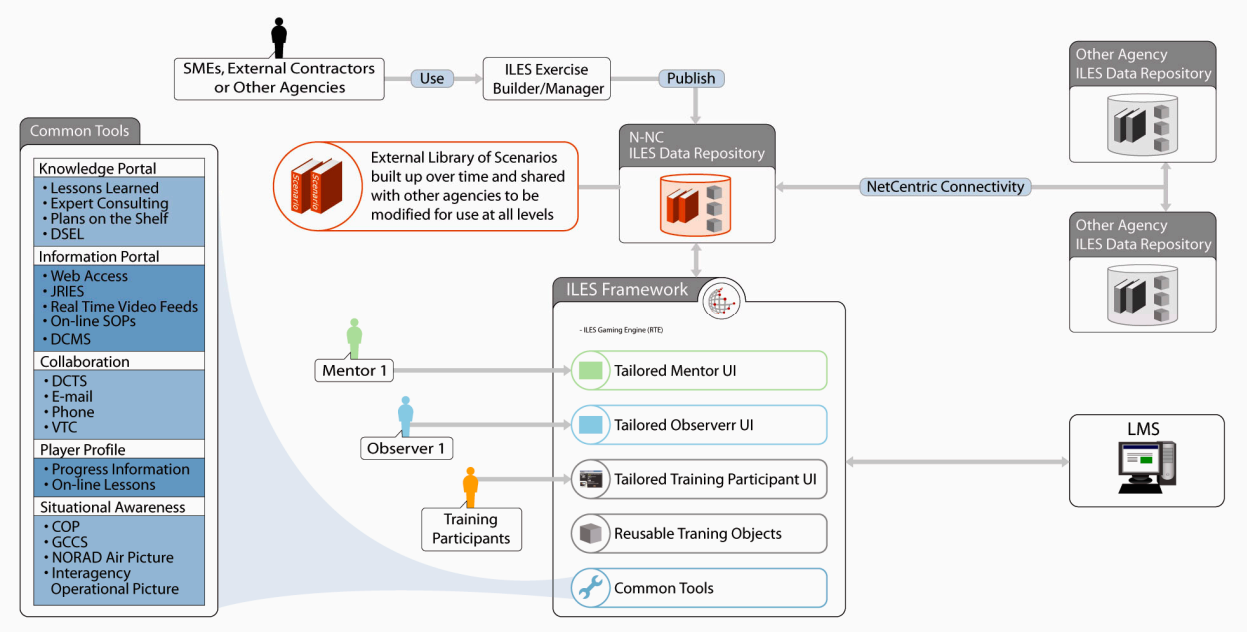

Figure 9. Tools are required for building libraries of scenarios that can be used in a networked environment.

Currently, the architecture has a simple client server architecture that will be expanded to implement more distributed/federated server architecture where exercises may be organized by nodes hosted on different servers. In addition, the ExMan will be more fully developed.

SUMMARY

In summary, the ILES open architecture exercise framework offers great promise to support immediate education and training requirements of N-NC. It is envisioned that in the future the persistent (24-7) environment provided by ILES can provide capabilities for not only "on-demand individual and group training validation" capabilities but also support for wargaming and mission rehearsal capabilities.

ACKNOWLEDGEMENTS

The N-NC acknowledges the OUSD for providing funds and guidance for implementing the concept. In addition, the N-NC acknowledges the ILES Development Team for working with N-NC personnel on understanding requirements and working with N-NC on applying a rapid spiral development approach.

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