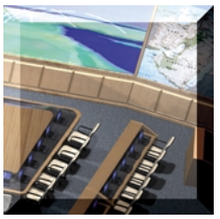

Warfare Analysis Laboratory 2000

Randy J. Dean

The design of the new Warfare Analysis Laboratory (WAL) reflects lessons learned from APL's earlier analysis laboratories and the evolution of our analysis processes. Its analytical tools and physical arrangement have been combined to create a unique collaborative environment. Technological advances have extended the reach of this environment and improved the interactivity and fidelity of its analytical tools. This article describes the key elements of the WAL's design, their capabilities, and the rationale for their inclusion. These features include an expansion of the facility's physical capacity to handle larger numbers of participants, the extension and development of its telecommunications and data networks to provide a geographically distributed dimension to the WAL, and the modernization and improvement of its analysis tools. (Keywords: Analysis, Simulation, Wargaming.)

INTRODUCTION

The APL Warfare Analysis Laboratory (WAL) serves as an important tool in support of our sponsors' studies and analytical efforts. Its combination of electronic analysis tools applied in a structured manner for audiences of scientists, engineers, analysts, program managers, and operators provides an integrated approach to understanding future requirements, exploring new concepts, and evaluating potential solutions. The WAL's collaborative environment, which has evolved over 20 years of experience, facilitates the analysis of new and emerging problems.

KEY WAL DESIGN ELEMENTS

The first APL WAL was built in 1981 in a 400-ft^2 room using standard office tables and furnishings. It hosted small groups of participants and relied on paper maps, mechanical "analyzers," and manual note taking. Each successive generation expanded and improved the WAL's capabilities by adding the latest technologies to facilitate and optimize the conduct of WAL exercises (WALEXs).

Since it is difficult and expensive to assemble WALEX participants for more than 2 or 3 days, time must be used productively. The physical configuration of the main seminar area, electronic support of collaborative discussions, easy availability of technical and analytic data, integrated audio and visual infrastructure, and advanced modeling and simulation capabilities of the WAL are all central elements to this efficiency and are discussed in the following sections.

Main Seminar Area Configuration

A key factor in facilitating the analysis of complex problems is properly balancing participant interaction

with each other as well as with the scenario displays. The geometry and physical layout of the WAL's main conference tables encourage informal discussion. This environment attempts to dismiss formal "briefings" and instead helps build the WALEX around group discussions and interchanges. The WAL's large projection screens serve to orient the participants as a group to the problems and issues at hand. They are also, when used with the facility's interactive three-dimensional computer-generated graphics capabilities, effective tools to help WALEX participants develop a common understanding of a given problem in a quick and intuitive format. This is useful when dealing with complex problems and exploring concepts for which systems or technologies are only postulated (i.e., do not exist).

Electronic Support of Collaborative Discussions

Collaborative discussions involve dynamics that require skillful guidance to promote active and candid participation, but excursions from the objectives of the WALEX must also be minimized. It is easy with a large group of participants in this type of setting for the debate to range across issues unevenly, leaving some incompletely examined. Some participants dominate discussions by virtue of their authority or personality. Often sidebar conversations take place between certain participants, distracting from the main issue. The WAL hosts a network of laptop computers with software designed to address these pitfalls as well as to help capture information that reflects the depth and breadth of opinions on a specific topic. The network equalizes participant contributions to the discussion; promotes candid audience inputs regardless of the participant's position, personality, or verbal communication and language skills; permits electronic surveying and voting of the audience; and provides sophisticated decision analysis tools designed to quantify subjective assessments from the participants.

Availability of Technical and Analytical Data

Appropriate technical and analytical data provide the basis for assessments during WALEXs and bring credibility to the discussions. Models, simulations, and databases from more detailed engineering analyses and tests offer valuable technical and operational insights.

Integrated Audio and Visual Infrastructure

The WAL provides a sophisticated audio/visual system complete with high-fidelity projectors capable of displaying high-resolution computer graphics and video, an automated sound reinforcement system, and a multipoint video teleconferencing (VTC) capability. These tools are linked to an electronic switching system that controls displays and audio in both the main conferencing room and the planning room. The system is easy to operate and is designed to allow a WALEX team to control displays in real time. Similar controls are provided for the sound system.

The VTC capability was added to the WAL in 1998. It offers an inexpensive alternative to on-site meetings for pre-WALEX planning activities as well as a convenient means to extend WALEX participation to people at other geographical locations. The VTC capability also allows porting WAL three-dimensional displays into the VTC system so that other sites may observe them, permits online sharing of documents with other sites, and can host multipoint conferences with three additional sites simultaneously.

Advanced Modeling and Simulation Support

Historically, modeling and simulation runs were executed prior to a WALEX, with results summarized via visualization tools or briefing slides. Improvements in computing workstation performance and revisions of the tools themselves have led to a significant reduction in turnaround times. Gradually, models are being run in near–real time during WALEXs for limited mission excursions. Reducing simulation run time for an entire campaign to near–real-time response is much more difficult, but mechanisms for doing such assessments credibly are being investigated by the WAL staff.

Another important feature of the WAL is its working analysis setup, comprising associated rooms linked with the main room by a diverse, high-speed computing and network environment. Many software development tools (e.g., database technology, compilers, editors, software environments) are available to support the myriad project-specific tools. The environment also supports the more widely used campaign- and theater-level analysis and simulation tools. The products of all these tools can be displayed in the main room during a WALEX. Advanced distributed simulation tools are also available. Using this technology, the WAL has been connected interactively with other APL laboratories as well as with external DoD simulation exercises.

WAL 2000: NEW CAPABILITIES AND FEATURES

We have built a new WAL with improved capabilities that enhance the quality of our analytical processes and overcome limitations experienced with earlier facilities. These capabilities allow us to expand the WAL's collaborative environment and improve the technical fidelity of its WALEXs while maintaining the integrity and proven track record of previous WALs. The following list highlights the facility's enhanced capabilities.

- Expanded the WAL's video conferencing and data networks to extend the reach of its collaborative environment beyond APL
- Increased the capacity of our electronic seminar and decision support tools to accommodate 50 participants
- Modernized its computing capabilities to run the latest models and simulations, and to more rapidly integrate their results into WALEX discussions
- Increased the physical capacity to host larger audiences
- Improved scenario visualization tools to display platform and entity-level interactions across a large geographic area, and to "zoom" to a more detailed building and "street-level" view
- Added an integrated scenario database system with a Web-based user interface that includes an improved search-and-sort capability, an online archive capability, and a "drilldown" tool to access data at higher levels of fidelity
- Added a new WALEX preparation tool that allows a WALEX team leader to organize the inputs of other team members according to the design of the exercise (this includes linking the WAL's classified network to its "war rooms")
- Provided a modernized software development environment for tool development that includes the latest advanced distributed simulation tools

Figure 1. WAL 2000, APL's center for collaboration.

The following discussion presents the WAL's extended environment and our approach to the design of WAL 2000.

Extended Environment

By carefully integrating these new capabilities with our seminar-based WALEX approach, WAL 2000 is designed to be an important center for collaboration (Fig. 1), capable of selectively linking organizations with the needed skills and interactively engaging them in the issues surrounding a problem.

The WAL 2000 environment also allows us to better inject technical resources (e.g., simulation centers, system engineering laboratories, virtual prototypes) into our deliberative analysis process and add a greater technical dimension to WALEX discussions. This enables us to improve concept exploration by integrating high-fidelity data from other engineering laboratories or data obtained through virtual prototypes with our own and to use the WAL to present concepts of operation and capture the associated technical, tactical, and doctrinal issues. As one example, the WAL 2000 design includes interoperability with APL's Air Defense Systems Department, specifically their Systems Concept Engineering Center. By combining their center's high-fidelity engineering prototypes and simulations with our force-on-force modeling and collaborative analysis techniques, we can evaluate new concepts for combat system elements and support force-level system trade-off analyses.

Design Approach

We did not completely overhaul the previous WAL design to meet these new requirements; both internal and external feedback from our users clearly validated much of its earlier design. Instead, we have applied lessons learned to guide our application of the new technologies for WAL 2000. For instance, we have noticed that interaction through VTC among geographically separated participants can be awkward and not optimal. Their "virtual peripheral environment" is less fluid and more constrained to the size of their video

monitor. They lose some of the social aspects of a collaborative session that are difficult to capture with electronic transmission of discussions and data. We have therefore designed our telecommunications infrastructure to work with collaborative tools to support "WAL-quality" interactions with multiple sites—interactions that restore some of the smoothness to the mechanics of the collective discussions.

The new WAL provides three new functional capabilities to meet our most pressing needs: (1) facility physical capabilities, (2) distributed collaborative capabilities, and (3) virtual collaborative analysis environment. These are detailed below.

Physical Expansion

Sponsor requirements to expand participation for their WALEXs have continually pushed the physical limitations of the current WAL. Desires to augment and add specific viewpoints or skills (cost and affordability analysis is a good example), or to more comprehensively represent a sponsor's operational community have increased the need for more workstations and space. The previous WAL facility (Fig. 2) in its entirety encompassed approximately 2700 ft^2, with about 950 ft^2 devoted to seating in its main seminar area. For a "standard" WALEX, the facility accommodated 25 participants with electronic seminar support (ESS) workstations, 25 participants in gallery seating, and a 5-person WALEX team. This capacity was once sufficient. However, as the benefits of collaborative analysis became more generally known and appreciated, participation expanded. Many WALEX designers and analysts were frustrated by having to balance their sponsors' desire for greater participation with the physical limitations of the previous WAL.

WAL 2000 is larger so as to accommodate the expanding application of collaborative analysis processes and sciences. It occupies 5800 ft^2, with over 2300 ft^2 devoted to the main seminar area (Fig. 3). This setup allows significant expansion to 50 participants with ESS workstations, 50 participants in gallery seating, and a 5-member WALEX team.

To address potential visibility problems with the larger main conference area, WAL 2000 has a three-tier seating arrangement, with the gallery section in the

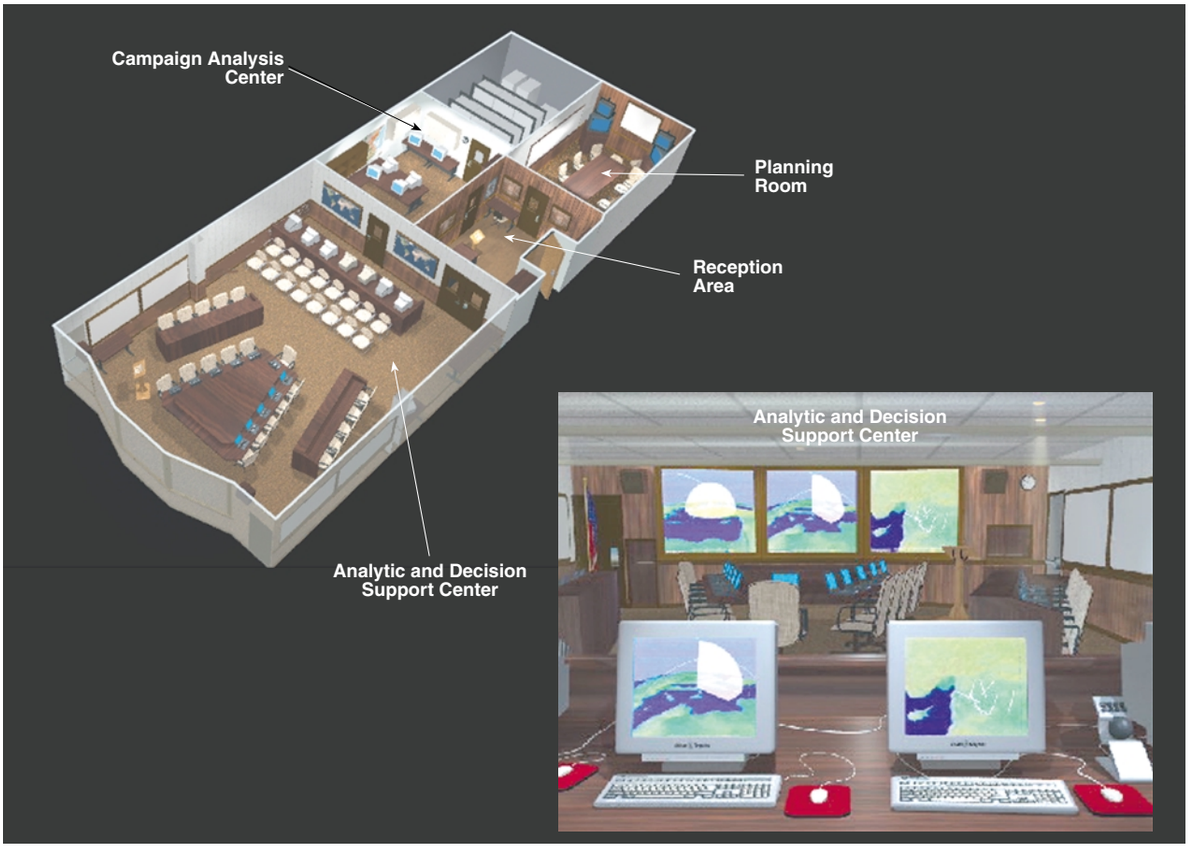

Figure 2. The previous WAL in Building 13 provided capabilities to conduct requirements analysis, system engineering and assessment, and collaborative analysis while offering responsive threat perspectives and a seminar analysis format. These capabilities were aided by decision analysis and support tools, models and simulations, databases, and secure network connectivity.

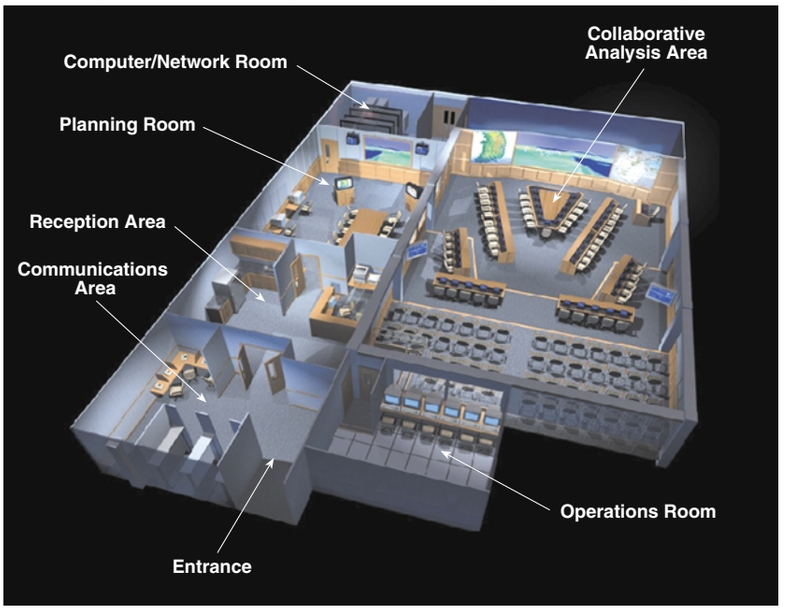

Figure 3. WAL 2000. The Planning Room can function as a separate collaborative meeting area with a stand-alone 12-workstation ESS System, or it can be used in conjunction with activities in the Collaborative Analysis Area. The main area has been enhanced to include a 50-station ESS System, 50-seat observer gallery, large-screen displays, video teleconferencing, information network access, models and simulations, and scenario and parametric databases.

final tier. The center projection screen is doubled in width to allow larger displays, and wall-mounted flat-screen monitors are located near the gallery area to enhance visibility.

The seating arrangement follows a similar design to the previous facility: a V-shaped pattern of tables configured to house and network up to 50 ESS workstations. We examined alternative seating arrangements but found that the close physical proximity of participants afforded by this design better facilitated informal discussions. The design makes it easy for participants to speak in normal conversational tones and engage in informal exchanges, which is so important to a successful collaborative session.

The spacious gallery seating area will support portable enclosures when necessary for WALEXs requiring isolated teams. These teams provide a specific perspective or intentionally limited view and are isolated so that they cannot be influenced by the discussions or data presented. Data and video can be fed to these enclosures, incrementally or in a filtered fashion, depending on needs.

The administrative support areas are substantially expanded to accommodate the increase in WAL audiences. There is an expanded reception area that supports two people for security and check-ins, an enlarged area for food and beverage service, and more phones, all equipped with modem connections. WAL 2000 includes a planning room with additional capability. It can function as a separate collaborative meeting area with a stand-alone 12-workstation ESS System, or it can be used in conjunction with activities in the main room. Three large viewing windows and audio/video connections will allow participants to interact.

An operations room located along the back of the main room provides scenario visualization and simulation support. Although physically isolated from the conference room, the operations room includes two large viewing windows and audio communications that link it to the main room.

Access to the WAL 2000 is also substantially eased. No longer will visitors have to trek through numerous hallways and buildings and climb up several floors to gain entrance. Instead, they will be able to park outside the new building, climb a single staircase, and arrive at the new facility. A nearby elevator and main entrance ramp provide wheelchair access.

Distributed Collaborative Capabilities

The physical expansion of the WAL is certainly the most visible change, but not the most significant. The true innovation of the new facility is that it will allow another facility, external to APL, to be completely connected to the WAL, thus enabling its audience to fully participate in a WALEX. This connectivity entails more than just establishing telecommunications and network links between facilities. That is relatively easy. Rather, the challenge is in establishing seemless connections of sufficient capacity that allow the use of the WAL's tools at both facilities and automating the mechanics of using these connections for the analysts.

Essential features of this capability are described in the following paragraphs. Often several approaches are available, each with varying levels of sophistication and fidelity. WALEX requirements and costs drive the approach selected for each application.

Near–full-motion video and audio links between both sites. Video and audio links that are "jumpy," delayed, or out of sync interfere with group dialogue and make interactions difficult. Current VTC at a 384-kbps rate, although providing a reasonable level of fidelity, presents its own problems. For example, if the system at the other end cannot frame its camera on the

speaker, either manually or automatically, the view on the WAL's VTC system will be a single broad picture of the entire remote site. If the remote site is a large facility, then the WAL audience will have difficulty identifying the speaker.

Full viewing of the WAL's three-dimensional computer-generated scenario visualizations by other "connected" facilities. Scenario visualizations are critical to WALEXs, especially when representing complex scenarios or scenarios with many components. VTC systems operating at a 384-kbps rate provide a convenient means of conveying visualizations to the other site and vice versa. At this data rate, the graphic is degraded but reasonable.

Collective use of ESS. It must be possible to connect the group decision support tools of both sites and use them compatibly. Document sharing between sites must allow simultaneous editing of the same presentations, memos, spreadsheets, and maps. Several commercially available software packages can provide this capability. Each is inexpensive, easily available, and compliant with international standards for use with VTC.

Modeling and simulation interoperability between each site. Much of the work of DoD's advanced distributed simulation community has paved the way for this essential interoperability, which has been adapted for WAL use.

WALEX analysis data availability to each site. Analysts prepare and research considerable amounts of data for their WALEXs. Some of the data are displayed in tables, bar charts, spreadsheets, or other visualization tools. Some are used as backup data only. Each site needs real-time access to these data via a high-capacity network.

Virtual Collaborative Analysis Environment

A defining element of the previous WAL was its analysis tools. Their use extended far beyond the WALEX itself to include WALEX preparation and the evaluation or processing of data collected during its execution. The tools were operated in the auxiliary rooms of the WAL but were accessible in the main conferencing and planning areas. WAL 2000 continues to provide and expand this capability. The new design takes advantage of advances in information technology to better integrate these tools and make them accessible and usable from the WAL and its supporting modeling and simulation laboratories, war rooms, and conference rooms. Each auxiliary room of the WAL provides access to tools that organize, generate, process, and prepare supporting material for a WALEX.

Imagine a study team director planning a WALEX and being able to post a series of electronic folders outlining key discussion points and a storyboard of the desired discussion flow. The WALEX team would have access to these folders and fill them with the required presentation material, analytical data, simulation results, and reference material from one of the WAL's auxiliary rooms allocated for their use. They would also retrieve data needed from each other as input into their portion of the WALEX. For instance, system engineers could run a high-fidelity engineering model in one of the modeling and simulation areas of the WAL (or their own simulation laboratory). The output would be posted on a file or data server, downloaded by analysts running a campaign-level simulation in another modeling and simulation laboratory, and stored on the same file or data server that others would access from a study room to analyze and develop summary charts for potential display.

Other team members, including the study director (who may be in another study room constructing the storyboard for the WALEX) would access these charts in a similar manner. If another organization or facility is participating and appropriate security precautions can be taken, it could be given access and could add to the material directly from its own site. On the day of the WALEX, the final presentation materials would be accessed in the main room for display. Materials developed but not used would still be available if called upon.

This collaborative environment has many hardware and software components, all combined to provide easy online access to data and applications. Important features that enable this environment are as follows:

- WAL 2000 has a secure, high-speed local-area network that connects its UNIX and Windows NT-based workstations. A CISCO Catalyst 5500 switch provides connectivity between the workstations and network peripherals such as CD towers and printers. The switch also provides a connection into APL's secure network, allowing exchange of data with other APL laboratories. A SUN Enterprise 3000 server with associated RAID storage and tape library provides network system administrative services, i.e., file and data server, automated workstation backups, network monitoring and management tools, and the WAL classified intranet.
- WAL 2000 has a variety of platforms that can host sponsor-specific models and simulations and support APL-developed tools. Most of these platforms are one- or two-processor systems, but each has access to more powerful multiprocessor systems (SUN Enterprise 3500, Ultra2, and Ultra60; SGI Origin 2000 Dual Rack, Onyx2 Infinite Reality, and Octanes; HP 9000/750 Model J210XC; and INTEL-equipped PCs running WINDOWS NT) when additional computing power is required.
- Group decision support tools, which we call ESS, continue to be an important element to collective discussions and decision making. WAL 2000 provides

an assortment of tools that help collect viewpoints and perspectives, facilitate brainstorming and the organization of new ideas, allow group voting and surveys, help develop group consensus, and aid in analyzing alternatives.

- Secure, classified electronic connectivity with the DoD community is provided via the Secret Internet Protocol Routing Network (SIPRNET). Workstations with SIPRNET access are available for classified electronic communications and receipt of Global Command and Control System data.
- The cornerstone of WAL scenario visualization is three-dimensional computer-generated graphics. High-fidelity visualization is an excellent tool for representing operational situations, a sequence of events, interactions between platforms and sensors, and data flows. Several excellent tools will be available for use that cover most of the environmental domains, i.e., space, land, sea, undersea, air, and information.
- Compilers, editors, software debuggers, and other software development tools are available to support the development of automated analysis tools that process data from these models and simulations, experimental data, or electronic data from other sources. These tools have full access to all data repositories.
- To improve data collection and storage during WALEX preparations and to make data more accessible, a database tool that provides easier accessibility, search capabilities, and processing capabilities will be developed for the new facility. This tool will manage, organize, and store raw analysis data and provide a means to easily manipulate and process the data via conventional spreadsheets or Web browser–based applications. In addition, the WALEX team can access data archived from previous projects.

CONCLUSION

The current WAL, WAL 2000, became operational this year. It is the fourth generation of a collaborative analysis laboratory whose lineage traces back to a facility less than 10% of its present size. Each successive generation expanded and improved the WAL's capabilities by applying the latest electronic technologies to a warfare analysis methodology centered about collaborative group discussions and exchanges among operational commanders, scientists, analysts, program managers, government officials, and engineers. WAL 2000 will help APL continue to work with other organizations and industry to support our sponsors in addressing complex systems problems.

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