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A DEMONSTRATION OF UNDERSEA WARFARE TECHNOLOGIES IN A HIGH FIDELITY SIMULATION ON THE DEFENSE SIMULATION INTERNET

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ABSTRACT

The Advanced Research Projects Agency is sponsoring a maritime simulation demonstration which will occur from the 13th to the 17th of September 1993 on the Defense Simulation Internet. The objective of the demonstration is to show how various ARPA developed technologies can be used to increase the fidelity of simulations.

Naval warfare relies on sensors and processing systems to detect, track, engage, and fire on hostile targets. These systems are unlike tank battles were visual contact with targets is needed to fire. The September demonstration will be the first distributed interactive demonstration to utilize sensor driven weapon systems.

The demonstration will link the components of a carrier battle group with low frequency active search, and mine countermeasures capabilities into a realistic command and control environment. The demonstration will play out components of a major regional contingency and engage hostile undersea forces. For this demonstration, platforms and or command centers will be located at CINCPAC, CTF-12, The Pentagon, SPAWAR, NAVSEA, ARPA, JHU/APL, SAIC, Alliant Tech, Draper Laboratories, NAVOCEANO, Sandia National Labs, etc.

1 INTRODUCTION

In this era of decreasing fiscal resources, the Department of Defense (DoD) is seeking innovative and effective ways to maintain its operational readiness and technological superiority. In support of this goal, the department's Director for Research and Engineering has identified seven technology areas on which to focus defense research. One of these areas is modeling and simulation. Progress in modeling and simulation has made it possible to apply simulation technology, at a very high level of fidelity, to a variety of defense readiness and systems development problems. Physical simulators (e.g., tank simulators, aircraft cockpit, and weapons system simulators) at diverse sites can be linked together with digital simulations of weapons systems and terrain databases to simulate tactical engagements in a "synthetic environment." Digital simulations of future weapons systems can be constructed to evaluate their effectiveness when assigned certain performance standards. Of particular interest to DoD is the use of models and simulations to enhance the effectiveness of joint force operations.

The Advanced Research Projects Agency (ARPA) has been tasked to develop simulation technology and provide components to support advances in this area. Toward this end, ARPA has developed and operates the Defense Simulation Internet (DSI). This wide area network links DoD decision makers, operational commands, DoD laboratories, academe, and industry on a single "backbone" using standardized data movement protocols. DSI is capable of supporting classified simulations, linking independently developed models operating at diverse sites. It can link, through network "gateways", individual simulators or large subnets of simulators or models already interconnected by local or wide area networks.

Within this research area the Maritime Systems Technology Office (MSTO) of ARPA is concentrating on the development of several simulation technologies to maintain the Navy's undersea warfare superiority. Specifically, these developments are expected to enhance the detection performance of undersea surveillance sensors, to provide a capability to localize antiship mines, and to improve decision making through integration of several command-level decision aids.

To illustrate the progress in the development of these technologies, MSTO will conduct a simulation demonstration linking those technologies with the DSI to simulate numerous surface, subsurface, and air platforms operating in a selected contingency scenario. The simulation will also include multiple levels of command and control to demonstrate advances in command, control, and communications (C3) technology and to integrate command authorities into the conduct of the simulation.

The Maritime Simulation Demonstration (MSD) will take place from 13 to 17 September 1993. It will be the first high-fidelity simulation of undersea warfare in a major regional contingency scenario. Tactical platforms and command nodes will be simulated by a widely distributed and varied set of computer simulations and physical simulators located at the following sites:

(1) The Pentagon
(2) Advanced Research Projects Agency ARPA, Arlington, VA
(3) Commander-in-Chief, U.S. Pacific Fleet, (CINCPACFLT) Pearl Harbor, HI
(4) Space and Naval Warfare Systems Command (SPAWARSYSCOM), Crystal City, VA
(5) Naval Sea Systems Command (NAVSEASYSCOM), Crystal City, VA
(6) Alliant Tech Systems, Rosslyn, VA
(7) Science and Applications International Corporation (SAIC), McLean, VA
(8) Draper Laboratories, Rosslyn, VA and Cambridge, MA
(9) The Johns Hopkins University/Applied Physics Laboratory (JHU/APL), Laurel, MD

Additional computer, networking, and database support will be provided by the following organizations:

(1) Sandia National Laboratories, Albuquerque, NM
(2) Naval Oceanographic Office (NAVOCEANO), Bay St. Louis, and
(3) Institute for Defense Analysis (IDA), Arlington, VA.

2 DEMONSTRATION OVERVIEW

This demonstration, to be conducted by ARPA MSTO, will simulate undersea warfare, mine countermeasure, and command and control assets involved in a major regional contingency scenario. The objective of this effort is to demonstrate the capabilities of advanced high fidelity simulation technology operating in a distributed interactive environment to support the training and readiness of operating forces, development of strategies and tactics, mission rehearsal, and development and acquisition of new weapons and combat support systems. The simulation will be conducted using the Major Regional Contingency - West scenario developed by SPAWARSYSCOM and consistent with the Defense Planning Guidance.

Using the connectivity of the DSI, several ARPA-developed high fidelity synthetic environment technologies will be integrated for the maritime demonstration. Specifically, these technologies are as follows:

(1) Acoustic Time Series Simulator (ATSS)
(2) Acoustic Warfare Integration Laboratory (AWIL)
(3) Submarine Combat Information Laboratory (SCIL)
(4) Unmanned Underwater Vehicle (UUV) Simulator

In addition, several new planning and decision support tools, also under development by ARPA, will be integrated into a single command center. Figure 1 depicts the simulated platforms and command nodes to be networked for the demonstration. AWIL, using a wide area network separate from DSI, will simulate various antisubmarine warfare (ASW) air, surface, and submarine platforms. The DSI will be used to integrate the several AWIL nodes with other computer simulations, physical simulators, and databases operating in several different locations.

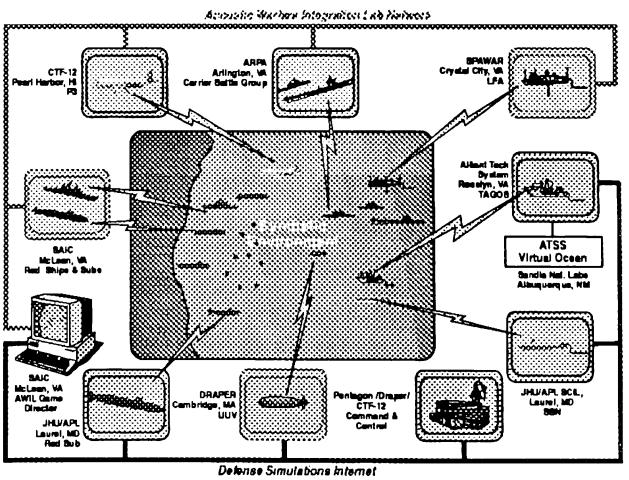

Figure 1: Simulated Platforms and Command Nodes

Of these simulations, ATSS is at the core of high-fidelity, virtual environment developments. Currently, ATSS can synthesize the acoustic components of a virtual ocean when it is given inputs of shipping distributions, wind wave activity, ship and target acoustic signature information, active acoustic transmission waveforms, and target motion data. It then calculates an acoustic pressure field across an array of individual hydrophones; calculates hydrophone time series output using selected environmental databases and acoustic propagation models; and provides sensor level inputs for operational or prototype beamformers and signal processors. For this demonstration, ATSS will be used to generate a synthetic ocean environment for a simulated Surveillance Towed Array Sensor System (SURTASS) vessel. The ATSS will be run in real time on the Touchstone Paragon supercomputer located at the Sandia National Laboratories in Albuquerque, NM. Its output will be sent via dedicated phone line to a SURTASS signal processor located at Alliant Tech Systems Advanced Technology Center (ATC) in Rosslyn, VA. The SURTASS will simulate operations in both passive monostatic and active bistatic modes.

AWIL is an integrated wargaming system comprising SUN workstation computers linked by a telephone network. Functionally, AWIL consists of a Game Director computer and any number of other computers used to simulate ships, submarines, aircraft, and command centers. The AWIL Game Director may configure any of the workstations on the network to simulate any platform or command node. For the maritime demonstration, the AWIL network will be used to simulate the following units:

(1) An aircraft carrier battle group (CVBG), with individual ships in the battle group being uniquely controlled. The CVBG will be simulated by an AWIL node located at ARPA in Arlington, VA
(2) P-3 maritime patrol aircraft (MPA) capable of deploying sonobuoy fields. This node will also be located at Commander, Task Force (CTF) 12 in Pearl Harbor, HI.
(3) A SURTASS low frequency active (LFA) ship simulated by an AWIL node located at SPAWARSYSCOM, Crystal City, VA.
(4) Enemy submarines. These simulation nodes will be located at SAIC in McLean, VA

AWIL nodes will also be used to support the command and control structure and integrate command nodes into the synthetic environment. Colocated at these command nodes will be various decision support and intelligence processing systems. Commander, SEVENTH Fleet (COMSEVENTHFLT) will be represented by an AWIL node located at Draper Laboratories in Rosslyn, VA. This command node will be supported by ARPA's ASW Anchor Desk. The Anchor Desk operates in a Joint Operational Tactical System/Government off-the-shelf (JOTS/GOTS) environment with its capabilities clustered around the Decision Support System (DSS). Additional features include the ASW Tactical Decision Aid (ASWTDA), Glimpse Tracking and Fusion (GT&F), the Naval Intelligence Database (NID), the Aquarius and MAKO intelligence processors, and the Joint Electronics Analysis processor (JEAP). The ASW Anchor Desk is configured to operate as part of the Operations Support System (OSS). A senior member of the CINCLANTFLT staff if expected to play CJTF.

Commander, Joint Task Force (CJTF), as well as CTF 70 and CTF 74 will be represented by an AWIL node located at CTF 12, Pearl Harbor, HI. This command node will also be supported by OSS. A senior member of the CINCPACFLT staff is expected to play COMSEVENTHFLT.

The ASW Task Group (ASWTG) Commander will operate from an AWIL command node located at the Pentagon. Two AWIL workstations and the DSS will be installed at this location for the demonstration. Commander, Surface Warfare Development Group is expected to play this role.

The SCIL is a mock-up of a submarine control center. It was developed by JHU/APL (where it resides) to test new sensor performance and combat decision technology in a realistic combat environment. The monitors and displays in the SCIL are driven by several computers located in adjoining spaces. Targets injected into the SCIL's sensors can be manipulated interactively or driven by a set of computer-resident rules. Weapons performance is governed by a predetermined rule set. For the maritime demonstration, the SCIL will be configured to simulate a Los Angeles-class (SSN 688) submarine conducting independent ASW operations or participating as part of the ASWTG.

Draper Laboratory's UUV simulator will be operated from Cambridge, MA as part of the simulated mine countermeasures (MCM) operations. The UUV simulator (which includes the underwater vehicle and MCM-1 host platform) will be used for mine hunting and to report the locations of the detected minefield and individual mines. The mines themselves will be simulated by computer models developed by Draper Laboratories or the Coastal Systems Station, Panama City, FL.

The oceanographic environment in which the simulation is to be executed will be representative of actual conditions in the scenario region at the chosen time of year. The required ocean environmental parameters will be supplied to each participating system in order to provide a common realistic environment. During the early stages of the simulation demonstration, the ocean environment will undergo limited evolution in time (representative of typical changes over a few days), but will then remain unchanged throughout the actual operations portion of the simulation.

3 THE DEMONSTRATION SCENARIO

In order to effectively exercise the capabilities of the models and simulations, of the DSI, and of the other supporting wide area networks, a regional conflict scenario has been selected for execution during the demonstration week. The selection of the Major Regional Contingency - West scenario provides a realistic conflict situation in which U.S. naval capability is required, and one in which the ARPA MSTO simulation technologies play key roles. This scenario is consistent with other Navy and DoD planning scenarios including the current Defense Planning Guidance, the Joint Planning Scenarios, and other Navy-approved planning scenarios. It was developed by the SPAWARSYSCOM Multi-warfare Assessment Division (SPAWAR-311) to provide Naval activities with the guidance needed to perform assessments in support of Naval Warfare Appraisals and cost and operational effectiveness analyses (COEAs). The details of the Major Regional Contingency - West scenario are classified, and will not be discussed in this paper.

The scenario development process consists of the selection of the scenario, generation of the script, and lastly, the detailed development of several demonstration vignettes. The process itself is guided by the technical objectives of the demonstration, the desire to impart a high level of tactical realism and verisimilitude, the feasibility of implementation, the allotted schedule and manpower resources, and the extent to which the demonstration itself may be of interest to viewers.

The operational background and context of the demonstration (i.e., the synthetic environment) are determined by the selected scenario. The scenario script provides a "story line" and an embarkation point for the demonstration vignettes. The script will detail the tactical situation, focusing on the involvement of the platforms and commands being actively played. It provides the participants with background information leading up to the vignette, a chronology of previous actions, and a description of the friendly and enemy forces involved. In addition, the script specifies the overall objectives of the armed forces as they are known or, in case of the enemy, assessed, establishes a command and control structure, and imposes rules of engagement on friendly forces.

From the scenario script several vignettes have been identified for execution during the demonstration time period. The initial conditions of each vignette are provided to the demonstration players prior to its start. These conditions include the environmental conditions and sensor systems performance predictions, specific mission objectives, communications and reporting requirements, and specific rules of engagement. Initial conditions for each vignette should be consistent with the overall scenario script. Entities not actively played in the vignette will have their actions or responses predetermined. Execution of the vignette will be "freeplay" as long as it remains within the guidelines of the scenario and the time allotted for the demonstration itself. If the vignette begins to digress or "stall", the demonstration controller may intervene to redirect the players, restart the vignette, or inject some stimulus. The demonstration controller's primary focus is to observe the freeplay and ensure that the vignette guidelines are followed and demonstration objectives met.

4 THE SIMULATION NETWORK

For the Maritime Simulation Demonstration, the ARPA-maintained DSI will be the primary network to connect the remote simulators. Several subnets (wide area networks themselves) will also be constructed to augment the DSI where access to the DSI is not feasible or sufficient bandwidth is not available to meet simulation requirements. Figure 2 shows the overall network configuration for the demonstration, including special telecommunications links and communications security (CommSec) device requirements. The figure also indicates the platforms and commands to be represented at each of the simulation nodes. Six gateways, located at the Pentagon, JHU/APL, USCINCPAC, IDA, NAVOCEANO, and Navy Command, Control and Ocean Systems Center (NCCOSC) Research and Development Division (NRAD) will provide access to the DSI for all participants. Access will be either directly or through "intelligent" gateways. (An intelligent gateway filters out unnecessary protocol data units (PDUs), which consist of data passed on the network between application processes. Since the filtering is done before the PDUs would be passed on to the ultimate addressee, the communications bandwidth requirements are reduced.)

Three subnets will be implemented to support other unique elements of the demonstration. ATSS data will be transmitted outside of the DSI on a special network between Alliant Tech Systems and Sandia Laboratories. ATSS output consists of sensor level signals for the Surveillance Towed Array Sensor (SURTASS) platform computed in real time. The encrypted bandwidth of the composite sensor level data is large enough to require a

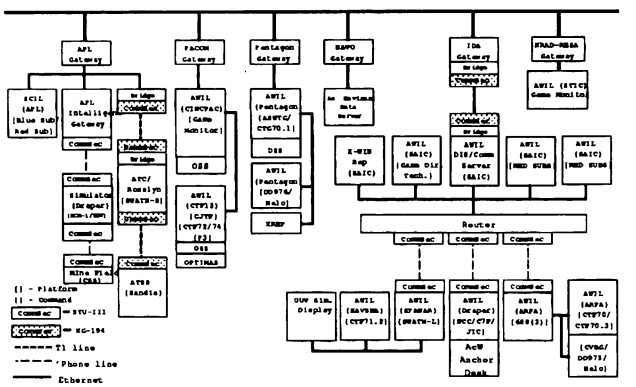

Figure 2: Maritime Simulation Demonstration Network

dedicated T1 line with a bandwidth of 1.5 megabits per second (Mbit/sec). A second subnet will be implemented by JHU/APL to connect the Mine Countermeasures-1 (MCM-1)/UUV simulator to the DSI. This subnet connects a remotely located simulator to the DSI where local access to a DSI gateway is not available.

The third subnet is being constructed to support AWIL connectivity among its own nodes and with other simulators via the DSI. AWIL, as a system of distributed computers, does not use Distributed Interactive Simulation (DIS) protocols - those normally used between dissimilar simulators connected on the DSI - or PDUs for internal communications. Therefore, the AWIL subnet is interfaced to the DSI through a Communications/DSI server. This server functions as a bridge between the DSI PDUs transmitted over the DSI and internally generated AWIL communication packets. The AWIL subnet is an ethernet local area network (LAN) with remote connections implemented through a router and encrypted telephone links. For the demonstration, AWIL will implement most of the simulation environment locally. However, two remote simulators (T-AGOS and MCM-1/UUV) will communicate with the AWIL environment over the DSI using a nonstandard DIS PDU especially developed for this demonstration. Where communications are required between remote AWIL nodes not part of the LAN, the DSI will be used as an extension of the AWIL LAN. Communications between these AWIL nodes will use standard internet protocols (IPs).

5 VIDEO TELECONFERENCING AND VOICE COMMUNICATIONS

For the simulation demonstration, video teleconferencing (VTC) will be implemented to permit on-line "looks" into the operations and activities at various remote simulation sites. Secure VTC, transmission is supported by the DSI, and each site (except NAVOCEANO and NRAD) served directly by the DSI will have VTC available for the demonstration. In addition, two non-DSI sites, Alliant Tech Systems and NAVSEASYSCOM, will be equipped with separate cameras, video converters, compression/decompression (CODEC) and encryption devices (e.g., KG-194s). These sites will then be connected to a central video control station at IDA by a dedicated high bandwidth T1 telephone line. At IDA these sites will be merged with the DSI VTC through a selector switch, allowing the DSI sites to view any other site having a camera or video display converter. Thus, sites such as the Pentagon can use the VTC capability directly; non-DSI VTC sites will not have a monitor capability.

Voice communications on a point-to-point basis among the various simulation facilities are necessary to control the demonstration and to ensure that all systems are functioning properly. In addition, voice communications capability will be used to augment the tactical communications functions resident in AWIL and the other simulators. This network will be implemented using standard dial up telephone lines and STU-III CommSec equipment. Each demonstration site will be equipped with at least one dedicated STU-III telephone line.

6 CONCLUSIONS

Many of the recent large simulations conducted in response to the Science and Technology thrust in Synthetic Environments have concentrated on the training and readiness objectives of that thrust area. In order to use this technology for acquisition decisions of high tech weapon and sensor systems a detailed knowledge of the physics of how those systems perform in the battlefield environment must be known. This demonstration is the first of a series which bring qualitative performance measures for high tech systems into the distributed interactive environment.

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