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MODELING AND SIMULATION

The Applied Physics Laboratory has identified modeling and simulation (M&S), including advanced distributed simulation (ADS), as a potential new business area and as an area of increasing importance to both current and potential Laboratory sponsors. The Laboratory has an extensive history of successful M&S development efforts for a diverse set of sponsors. These efforts range from very detailed physics-based phenomenology models, to engineering-level kinematics models, to complex combat systems/mission planning test and evaluation (T&E) simulation environments, to highly aggregated force-on-force campaign assessment models. Recent advances in computer hardware/software technologies, and the widespread advances in (and commercial uses of) distributed computing environments and distributed simulation applications, suggest that APL must continue to develop its capabilities to make use of advanced computer technologies in ADS environments.

Of particular significance to APL and its sponsors is the fundamental change under way in the defense acquisition process. The new acquisition environment and philosophy can no longer tolerate multiple major weapon system developments; the current focus is to ensure that only those weapon systems that significantly influence the outcome of a future battle or campaign will be produced. For a new system concept or proposed system development to be approved, its value-added warfighting capability, in the broadest arena, must be demonstrated. This implies that any new concepts (including weapons systems, command and control systems, and doctrine/tactics) will be measured in terms of their perceived ability to contribute directly and substantively to "winning the war"; therefore, participants in these developmental processes must devise means of demonstrating the value of proposed new concepts in a robust operational environment.

The Electronic Battlefield. The emerging technology that supports this need is the synthetic warfighting environment, an electronic battlefield. This synthetic battleground is a seamless assemblage of constructive, virtual, and live simulations, and is the testing ground/evaluation process for virtual prototypes of the system concept being examined. The key elements of this simulation are the synthetic environment and the virtual prototype. The synthetic environment is an internetted simulation that represents activities with a high degree of realism ranging from simulations of theaters of war to factories and manufacturing processes. It is created by a confederation of computers, connected by local- and wide-area networks and augmented by super-realistic special effects and accurate behavioral models. The synthetic environment allows complete visualization of and total immersion into the environment being simulated; it represents the real-world precisely. The virtual prototype is a computer-based simulation of a system or subsystem with a degree of functional realism that is comparable to that of a physical prototype. The new acquisition environment envisioned by DoD leaders (and already becoming visible in the commercial sector) relies heavily on M&S and an M&S architecture. Within this architecture, there is a smooth interface between requirements generation and development activities; systems are designed, analyzed, tested, and produced virtually, prior to building systems; and an integrated set of tools, utilities, and standards support integrated functional analysis of cost, schedule, and performance trade offs.

A Simulation-Based Design Program. Several examples of this new concept for developing systems have been successfully prototyped as part of the Advanced Research Projects Agency's (ARPA's) Simulation-Based Design Program—an attempt to integrate the technologies of distributed simulation, physics-based modeling, and virtual environments. Separate ARPA initiatives have been directed at developing extensive synthetic environments, including the development of both a Maritime Synthetic Theater of War (MSTOW) and a ground combat-oriented Synthetic Theater of War-Europe (STOW-E); demonstrating the capability to integrate high-fidelity systems performance models/environmental models within a widely distributed synthetic environment; demonstrating the capability to link and exercise many disparate simulated and virtual entities in a complex operational environment (Warbreaker); and developing and demonstrating the capability to perform distributed collaborative planning in support of national-level military exercises and contingencies. In addition, the Army and the Air Force have each demonstrated significant capabilities to link constructive, virtual, and live simulations in support of very large training exercises involving activities distributed throughout the country.

The Laboratory has participated in a number of these ARPA activities (including MSTOW and Warbreaker) and has had a key role in recent Theater Air Defense distributed simulation activities. In these activities, APL has begun to develop capabilities to provide sponsors a systems integration/systems engineering capability to support future distributed simulation endeavors. We have also demonstrated the capability to reconfigure existing high-fidelity systems simulations to make them compliant with the protocols and interactive processes inherent in real-time distributed simulation applications. The Laboratory has the proven capability to immerse naval officers in an interactive environment and thus facilitate their participation in distributed simulation applications. We have successfully developed connections both to the DoD Defense Simulation Internet (DSI) and to the ARPA Warbreaker network, and to naval warfare centers and contractor organizations. In addition, APL undertook an

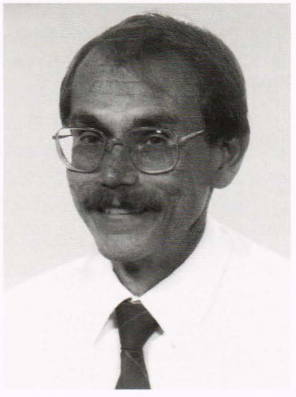
IR&D effort in FY 94 which was the first step toward development of a Precision Integrated Strike Concept Evaluation Suite (PISCES). PISCES will ultimately support the development, evaluation, and demonstration of emerging strike-related systems concepts and employment concepts; when linked to external facilities via the DSI, it will support examination of naval systems and contributions in a joint environment.

The infusion of many of the ADS concepts described previously is pervasive. Almost every major simulation effort being pursued today will become a part of this ADS infrastructure. Every major system development contemplated will probably make some use of the virtual prototyping capabilities currently being developed. The USACOM and other commanders in chief will surely turn to ADS for the bulk of their future joint training requirements. ARPA will likely continue to fund the development of those tools and technologies necessary to bring the vision of simulation-based design to fruition. System developers and T&E commands will look for ways to augment their T&E with modeling and simulation as a means of reducing test costs and as a means of examining system performance in operational environments perhaps too complex to physically construct merely for test purposes. Whereas the future direction of this simulation concept seems manifestly clear (and is convincingly argued in the Director of Defense Research and Engineering Acquisition Task Force on Modeling and Simulation Report and in the recently completed Naval Research Advisory Committee Report on Modeling and Simulation), significant technical and organizational challenges remain. The Laboratory, with its traditional M&S expertise and with its developing expertise in ADS applications, has the opportunity to contribute significantly to the resolution of these challenges.

Modeling and Simulation Thrust Area Objectives. The Modeling and Simulation Thrust Area has been established to carry out the research and development necessary to establish APL as a solid contributor in M&S (including ADS applications), to develop M&S capabilities of value to our current sponsors, and to initiate pilot projects capable of attracting new sponsors. Particular emphasis will be placed on projects that address the near-term needs of multiple sponsors (e.g., the Services and ARPA and the T&E community and systems developers), leverage existing APL strengths, build on previously developed capabilities, are extensions of departmental IR&D thrust area projects, and reflect interdepartmental collaboration. One of the principal initial objectives of the Modeling and Simulation Thrust Area is to define and implement a Laboratory-wide distributed simulation experiment (FY 95) leading to the articulation and development of a Laboratory-wide distributed simulation infrastructure and capability (FY 96). This infrastructure will consist of both Laboratory and community capabilities, provide representation of the joint warfighting physical and operational environment at selectable and variable levels of fidelity, and support examination and articulation of the ways in which this environment can be made useful to systems developers throughout the entire life cycle of a program.

In addition, this environment will serve as a testbed for examining selected virtual prototypes contemplated for development in FY 96/FY 97; these prototypes will include both engineering-level representations of selected physical systems and fully detailed representations of command information systems. Our vision for FY 97/FY 98 includes the development of a prototype Integrated Acquisition Environment that marries a physical/operational synthetic environment consisting of Laboratory and community capabilities; detailed virtual prototypes constructed at the Laboratory or within the community; and the standards, technologies, and infrastructure necessary to provide an initial integrated functional capability. This prototype will allow the Laboratory to continue to help our sponsors as they adapt to and adopt the advanced distributed computing environment that will characterize the enterprise of the future.

THE AUTHOR



HEIDE E. HEIDEPRIEM is a member of the Principal Staff and a group supervisor at APL. He is currently the supervisor of the Mission Analysis Group in the Analysis Department, the head of the Laboratory's Advanced Distributed Simulation Development Team, and the coordinator for the IR&D Modeling and Simulation Thrust Area. Mr. Heidepriem received a B.S. degree in electrical engineering from Valparaiso University in 1968, an M.S. degree in technology of management from The American University in 1976, and an M.S. degree in technical management from The Johns Hopkins University in 1984. His current interests include the application of advanced distributed simulation technologies and processes to decision making in support of the system design and development process, including the development and implementation of both a distributed collaborative planning capability and a prototype integrated acquisition environment.