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Military Operations Research Society

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Mini-Symposium:
DISTRIBUTED INTERACTIVE SIMULATION (DIS)

(September 28 - October 1, 1992)
Chair: Dr Henry C. Dubin

Proceedings

Editor: Dr Julian Palmore

Proponents: Deputy Under Secretary of the Army (Operations Research)

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These proceedings record the results of a mini-symposium held on 28 September - 1 October 1992. The mini-symposium allowed participants in Military Operations Research (MOR) and Distributed Interactive Simulation (DIS) technology to meet and exchange views on ways in which developing DIS technology can influence future MOR.

Mini-symposium participants were enthusiastic about the potential of DIS while remaining both cautious about its limitations.

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PREFACE

This report on the Military Operations Research Society's Mini-Symposium on Distributed Interactive Simulation (DIS) provides an excellent view of the impact of DIS on Military Operations Research (MOR) in September 1992. It is a valuable aid to determining the influence of MOR on the development of DIS in the three years since the Symposium was held.

Since that time Distributed Interactive Simulation technology has matured rapidly. Many of the conclusions of this report on Military Operations Research and DIS remain valid. Many of the report's statements on the technology of DIS and the uses of DIS need to be revised in light of current technology. This has not been done within the report's context. The primary reason is to maintain accuracy about the state of knowledge of DIS which was reported at the Symposium.

The document is abbreviated to an Executive Summary, Introduction, and the Final Reports of Working Groups 1 - 10. It contains neither papers presented at the Symposium nor Working Group's preliminary slides presented to the Symposium. A reason for brevity is to bring the publication process to a conclusion.

An excellent recent reference to Advanced Distributed Simulation (ADS) and Distributed Interactive Simulation is the June 1995 special issue of *PHALANX*, The Bulletin of Military Operations Research, on ADS/DIS. Discussed there are ADS/DIS issues of architecture, conceptual modeling, current technology, experimental approaches, future technology, and verification, validation and accreditation. Statements about the technology of DIS in this report should be compared to those in *PHALANX*.

Julian Palmore
Editor
July 1995

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Henry C. Dubin
Chair

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EXECUTIVE SUMMARY

The Mini-Symposium allowed participants in Military Operations Research (MOR) and in Distributed Interactive Simulation (DIS) technology to meet and exchange views on ways in which this developing DIS technology can influence future MOR.

Mini-Symposium participants were enthusiastic about the potential of DIS while remaining both cautious about its limitations and desirous of further research.

Comments on DIS limitations or needs for further research in this document do not imply that work in an area has not already begun. The implication is that appropriate efforts must continue with concerned communities actively sharing responsibility. A goal of DIS is to integrate seamlessly on a network virtual simulations (human-in-the-loop, virtual reality), constructive simulations (engineering, force-on-force, or other closed-form), and live simulations (field tests or exercises) and their interactions.

APPLICATIONS AND LIMITATIONS

Development. Many DIS applications were identified as appropriate for system development. Perhaps the most important were determining how to use a new system effectively on the battlefield and how to integrate it into the existing force. Other early development applications included requirements generation; trade-off analysis; organizational, operational concept, and other force structuring experimentation; development of tactics, techniques, and procedures; work on systems integrations; assessment in the human factors area; and planning for later operational tests.

When a system offers a radically new capability for DIS there are many useful research applications. Examples of research topics are command and control, combat support and service support, behavioral phenomena, alternate technologies, development of consistent measures of effectiveness or performance for all communities, and calibration of different aggregate level simulations.

DIS applications are limited when the physics of the system under test are not well understood. DIS has no direct applications for engineering testing of the basic physics underlying system performance. The necessary high resolution engineering models need not necessarily be distributed or interactive. It was thought that DIS might give us insights on how to exploit performance changes in battle.

Planning or rehearsal. Battle planning or rehearsal may be applications of DIS. Terrain "reconnaissance" and analysis were considered promising provided that graphics capabilities improve. Semi-automated forces (SAFOR) may be worthwhile for course-of-action analysis or rehearsal options.

These DIS applications will be limited until further improvements are implemented. Over the next five years, the necessary improvement in simulation network (SIMNET) graphics technology is expected to become a reality. Then, the more important issue will be how much the tactical implication of systems might be altered by operators based upon erroneous data in the system representation. Running simulators with unclassified data is a particular concern. An interesting warning was voiced against the danger of overly specific scenarios that might influence units to be less flexible for unanticipated situations.

Test and evaluation (T&E). DIS could provide alternative means of evaluation to testing when particular conditions (e.g., in the case of nuclear, biological, chemical, and space systems) are limiting or testing is otherwise constrained (e.g., environmental, safety, political, electromagnetic emanations, cost). When DIS is accredited as a test tool, its proper focus would be on comparative human factors analysis. A consistent DIS application might produce developmental or user test results to support the credibility of Cost and Operational Effectiveness Analysis (COEA) and for front end screening of a next-generation system or set of mission requirements. DIS may also support multi-service and joint evaluations (usually for high-priced systems) requiring combined arms procedures before the actual systems are produced.

DIS T&E applications are limited when the system under test does not need to interact with other systems, the system is easy and inexpensive to test normally, or the system is one of the Major Automated Information Systems (MAIS) or any other information management systems.

Training. Training has the widest set of recognized DIS applications. DIS shows considerable promise for carefully controlled training applications, from small units to joint task force operations by allowing reactive activities with visualization to enhance credibility and playback for after-exercise reviews. Additional benefits will likely accrue from the linking of diverse simulators and simulations as less costly alternatives to live exercises. Constructive simulations are already important tools for higher echelon training exercises.

There will remain training events that are best served by live instead of virtual or constructive simulations. For example, individual weapon/vehicle skills or crew task proficiency training are best accomplished by field exercise or part task trainers, rather than DIS. Guidelines for using simulation for different training events should be developed and provided to the training community. One must consider that there is a significant risk of negative training when simulators are used for tasks in which their fidelity is inadequate.

It should be noted that there is no training objective for a DIS application covering all echelons from "god to squad" due to differences in planning horizons, tempo of operations, information needs, and training focus. In fact, it is best that various echelons pause, reexamine, or accelerate their exercises as necessary for specific training objectives, rather than be lock-stepped inappropriately by DIS with other echelons.

NEEDED ENHANCEMENTS, RESEARCH AREAS, RECOMMENDATIONS

Capacity. Although the capacity of a DIS network depends upon other requirements, more research is needed on how to size the network requirements. The potential of techniques such as data compression, combining like protocol data units (PDU), multicast, smart gateways, fibre chord, token rings, and more advanced update algorithms must be assessed. Latency (the delay experienced between an entity state change and the time other entities on the network become aware of that change) must be considered in terms of transmission time, PDU processing time, encryption constraints, and other factors. How more capable pre- and post-processors can be added should be explored.

DIS capacity reflects upon DIS availability. Participants felt DIS should be available to anyone with a valid need and a means to pay. The general consensus was DIS will be enriched by a diversity of users. Charges should offset the cost of DIS operations and maintenance, and discourage frivolous demands for access. Another concern impacting availability is DIS reliability which must be increased before critical exercises and expensive testing of procedures can be safely attempted. All components of DIS, including individual simulators, communications, computers, and software must be made more reliable for DIS to be used at its full functional capacity.

Cost-benefit analysis. How to measure costs and benefits must be practically addressed to make correct decisions regarding DIS. For example, cost-benefit comparisons should be done between DIS supported training events and other training options. Generally, the range of potential applications and, thus, benefits is much larger than the very limited applications which currently exist. Moreover, most evidence of benefits is anecdotal. Broadly speaking, there are no major impediments to estimating costs of desired DIS applications, but the effort has not yet been made. Defining the problem is even more important in a discussion of DIS where there is clearly the danger of becoming infatuated with the technology and end up applying it inappropriately.

Defining DIS. The traditional view of DIS is characterized as human-in-the-loop simulations interacting with each other to perform common tasks. A broader definition is needed. The new definition of DIS can and should refer to "any combination of virtual, constructive and live simulations that are distributed over a network and interact through standardized protocols." While this definition encompasses SIMNET as originally implemented, it would also include situations such as Corp Battle Simulation linked to TACSIM (an intelligence sensor simulation), SIMNET linked to EAGLE (a corps level command and control combat simulation), SIMNET linked to units exercising at the National Training Center, and similar examples from the Navy and the Air Force.

Environment. DIS needs improvements in the fidelity and resolution of environmental representations for nature (weather, illumination, terrain, clutter), man-made factors (obscurants, dynamic terrain, electromagnetic, artillery and effects), and the technical environment of the simulation (higher fidelity displays, algorithms, protocols, signatures, semi-automated forces/computer generated forces). "Good" fidelity and resolution are determined by particular users who have differing requirements, so either the strictest requirements must be satisfied, or simulations should be designed so that their environmental realism can vary.

Logistics simulation. Logistics elements should be included in DIS training at brigade and battalion level with visible and active support elements. SAFOR should preclude excessive manpower or simulator requirements. Also, to alleviate the disparity in simulation time between logistics problems and tactical exercises, logistics simulations must be able to run in a faster-than-real-time mode. For example, a battalion of tank crews would gain little value if they were to end up in division reserve for a week long exercise, doing nothing but moving from assembly area to assembly area. Additionally, DIS should be considered for use in operational training at logistics elements such as training equipment operators at a port facility. Further research is needed to determine the levels of fidelity and resolution appropriate for logistics portions of battlefield simulations, and the logistics community must begin to develop an appropriate "end-to-end" module for the current set of virtual simulations. This module should span service responsibilities including both airlift and sealift. Except for analyses for demands on recovery and combat damage repair assets, little of the actions at brigade or battalion as represented in SIMNET-like simulations directly affects the logistics training audience, which is better trained by constructive models in DIS having more aggregation. Actually, when significant numbers of SAFOR are in use, the DIS is operating more at an aggregate level. Furthermore, logistics may require many iterations to develop levels of confidence, which would be easier to accomplish with constructive simulation.

Management. A significant management concern is how to budget and schedule as more players become involved with DIS. Master planning and scheduling of utilization of DIS-related resources (network, nodal simulations, players) over a planning horizon of several years will be critical. One working group proposed a dedicated scheduling mechanism similar to the CINCs' exercise schedule or the Army's Five-Year Test Program (FYTP). DIS needs a network manager for network scheduling, assuring asset readiness, coordination of user needs, planning enhancements, integration, and budgeting. In the near term, this network manager should also advertise DIS capabilities to potential users. In the future, the network manager would serve as the single point of contact. Each installation with a node should also have a site manager. This person would schedule use of the node and possibly use of local DIS assets for user applications. There must be a disciplined process for accessing DIS resources, de-conflicting competing demands for their use, and reimbursing scheduled users when their plans are disrupted by out-of-cycle users (queue jumpers). Other management concerns include the distribution and maintenance of common data bases and module (components) under sound configuration management, more comprehensive documentation for components which cannot be examined first hand by a user, establishing libraries for remote access of such documentation, and monitoring capabilities such that when a critical node drops off of the net due to a system failure, the DIS network controller can take an appropriate corrective action immediately.

Semi-Automated Forces (SAFOR)/ Computer Generated Forces (CGF). SAFOR validity was discussed in great detail. SAFOR should be indistinguishable from manned systems in DIS to best support training. A data collection capability is needed to capture simulated communications among SAFOR as well as between SAFOR and live units. The decision processes affecting SAFOR actions must be captured and be available for debriefing. Human factors such as morale, fatigue, and indecision must be exhibited by SAFOR. Tactics, perceived objectives, rules of engagement, and decision processes must be adaptable to the specific enemy consistent with the training scenario. The span of control of SAFOR operators must be increased significantly so that units can train in large scale operations without excessive controller costs. Identification issues of friend, foe or neutral systems must not be automatically resolved either among or between SAFOR. Terrain avoidance and dynamic terrain representation are improvements necessary to realize the full training potential of DIS. The need to validate the performance of the SAFOR should be an integral part of the basic design to ensure that the necessary data is explicitly represented and captured for review. If SAFOR is to become a high resolution model of analytic choice, there is a need for a single analyst to run or interrupt the model repeatedly without a staff guiding the individual vehicles as they move through the battle. This is not meant to imply that the SAFOR would be used purely in an "unattended" mode. Most certainly, a reasonable analyst would carefully review the new battles for validity against a sound tactical plan at the division/brigade/battalion level. SAFOR should be enhanced to contain "pre-blessed" scenarios, rules of engagement, tactics, doctrine, etc.

Security. Multi-level security issues must be resolved for various classified DIS applications. Smart gateways and security encryption may overcome problems, but users should be aware. Viruses transmitted via PDUs is a new danger for which scanners and protective techniques must be used. Multi-level security capabilities must be developed to more precisely manage access and use of classified material on the network would be a considerable assist in dealing with the use of unclassified ("inaccurate") data. Prudent management of network access, and encryption may be sufficient to protect a firm's proprietary information placed at risk while using DIS.

Standards. The need for additional work on standards is widely recognized. One new area for standardization is linking actual systems through data buses to the DIS network. Such linking would facilitate the verification, validation, and accreditation process. This is a task which requires much research, but one that may pay great dividends in terms of credibility. A standard that needs implementation is for a common time reference such as the Global Positioning System. Work at Armstrong Labs identified the need for additional data elements to be incorporated in each packet describing a fast moving airborne vehicle due to increased speed and three dimensional travel. Considerations for DIS training and how SAFOR replicates performance make this a prime research area under DIS standards to address joint operations. Also, it will sometimes be necessary to transmit and gather data not envisioned in current PDUs. Research is needed for flexible, variable resolution PDU standards to reserve such capabilities even for non-existent functionalities such as a death ray or transporter beam.

CONCERNS

Resourcing. Many participants felt that OSD should fund the continued evolution and operations and maintenance (O&M) of DIS which are "in common" to OSD, JCS, CINCs, and the Services. Customers with unique needs or applications should pay their own way. The funding issue was particularly worrisome because needs exceed the expertise of most organizations and will require contracted augmentation. Also, a key potential of DIS is in early development, before a funded program exists. "Where will the funds come from?" was the primary question. It had no satisfactory answer. The use of DIS can place significant demands for personnel resources; i.e., participants, as well as support staff such as controllers and data base experts. Full-time support staff should be identified for all DIS centers. The extent of the training program required for personnel who will operate DIS has not been adequately addressed yet. There are already indicators that the Army's growing capability in virtual simulations is not keeping pace with the demand for access to it. Furthermore, if DIS is to become a viable test adjunct, a new OSD directive is needed which will require all battlefield system requests for proposals (RFPs) to state that simulators must be DIS-compatible. The responsibilities must be clearly delineated in the Test and Evaluation Master Plan (TEMP). The potentials of DIS are dependent upon the degree that the acquisition strategy invokes DIS consistently throughout all milestones.

Requirements. So far, DIS has resulted from "technology push." For its full potential to be reached, it needs more "requirements pull." Work on identifying requirements is underway and should reduce the danger from warfighters being active DIS participants and becoming infatuated with the DIS capabilities before they receive an appropriate level of more rigorous scrutiny. It also reduces the potential danger of a mismatch between expectations and the near- or long-term results of DIS programs. It is equally important that existing tools and methods not be prematurely or inappropriately rejected because of misperceptions regarding the benefits and costs of DIS applications. "Turf" obstacles must still be overcome to clarify DIS requirements. One example is how to direct joint DIS applications such as combat developments. A less obvious example stems from the concurrent development of DIS and the system being simulated. It is likely DIS will continuously represent the latest version of a system, but who will have the responsibility for configuration management, fielding new versions, and deciding what system performance will be represented in a particular version for a specific application? It is not presently clear how to satisfy requirements. Should future versions of DIS be backwards compatible to allow users to make use of new capabilities in future versions with minimum adjustment?

Risks. Expectations that DIS is immediately available are based upon demonstrations and prototypes in limited numbers with limited capabilities. If past experience holds, hardware and software which are affordable and fieldable in larger quantities may not be available for a while. Also, the full costs of DIS have not yet been determined and many costs, particularly operating costs such as configuration management, data management, support staffing, verification, and validation, have not yet been addressed in detail. These "hidden" costs may be large and may not naturally fall into any one organization's budget. Additionally, the development of models and simulations for DIS applications will pose a series of challenges since it will be necessary to break new ground. Validation of these new developments will be very challenging. SAFOR is a good example of this. The costs of specific SAFOR applications and their associated benefits depend upon the validity and scope of SAFOR capabilities, but SAFOR technology is not yet mature. Similarly, the question of matching fidelity and resolution to applications remains open and must be resolved. Finally, among developers of DIS and among potential users, there are perceptions that DIS replaces tools currently used in all applications. This perception is not correct. DIS will augment other tools and approaches. Care must be taken if we are to avoid premature acceptance or rejection of DIS in various applications.

VERIFICATION, VALIDATION AND ACCREDITATION

Much of the discussion during the mini-symposium dealt with the thorny issue of verification, validation, and accreditation (VV&A) of DIS applications. VV&A appears to be the single issue that appropriately spans nearly all communities' interests. The challenges of VV&A embody the challenges of DIS overall. To understand this, consider what must be learned to credibly apply DIS as envisioned and examine how VV&A will be associated with future DIS management structure.

As DIS technology expands, research will be needed to develop new procedures and theory to meet the demand for VV&A of DIS. In particular, aspects of DIS requiring research include methods for verifying "boundary crossing" interfaces between characteristically different DIS components, requirements for certifying personnel playing a human-in-the-loop role, procedures for calibration of the system components with different levels of aggregation, experimental design methods to support interoperation of statistically dissimilar simulations, procedures to evaluate the physical (electronic) limitation or restriction of a particular network architecture. It will be necessary to identify and design experiments and test cases for DIS applications which can furnish information to support VV&A. Such research efforts should be documented through journal articles, issue papers or position papers with the ultimate goal of the development of primers or handbooks to instruct the analyst DIS user how to accredit a system for particular analytic application. This research will be necessary for the wider military community to accept DIS as credible.

While research continues, there will also be management challenges. For single service applications in the future, pre-accredited modules ("off the shelf") should be developed or archived for classes of DIS applications. Pre-accreditation implies an agency serving as the repository of VV&A and other documentation for "approved" modules. For multi-service DIS applications, the "user" (lead agency) should review VV&A of all net components, prepare the VV&A documentation, describe the limitations of the DIS application, and prepare inter-service MOAs as needed. The management to accomplish these VV&A efforts must be established in parallel with continued DIS activities on many fronts.

Concentrating on how VV&A will be conducted for the user communities is a good method to plan for how and to what extent DIS can be exploited. It will be key to ensuring that DIS will be used appropriately for its various applications. Although the DIS technology is believed by many to have the potential to be a key operations research tool of the future, it is clear that many improvements are needed to meet the needs of most practitioners. Most compelling, however, was a strong consensus from the mini-symposium participants that the technical challenges for DIS will be rivaled by the management challenges in developing and using Distributed Interactive Simulations.

CHAPTER 1
INTRODUCTION

DISTRIBUTED INTERACTIVE SIMULATION (DIS)

Distributed Interactive Simulation (DIS) represents a new and evolving area spawned from the Defense Advanced Research Projects Agency (DARPA) demonstrated simulation networking (SIMNET) technology. DIS encompasses the concept of multiple simulation components provided by a variety of simulators located at multiple locations which all work together through central architectures and standards to provide a common synthetic battlefield environment.

THE DIS CONCEPT

Combined arms teams must exercise their tactics and doctrine, sophisticated communications, and targeting and hand-off systems, but there are few locations available for such exercises. Furthermore, high costs, environmental policies, and safety concerns restrict how much of the desired combined arms training can feasibly be undertaken. To compensate, in the 1980s, DARPA and the U.S. Army initiated a joint program of research for real time, large scale, human-in-the-loop SIMulation NETworking or "SIMNET."

Intended for training combined arms teams potentially consisting of army, naval, and air forces, this program has evolved into the DIS concept. "Distributed" alludes to the geographic dispersion via networking of both the participants interacting with simulations portraying a single "virtual" battlefield environment, and the computational and communication resources supporting the simulation. "Interactive" refers to simulator operators performing actions within a common simulation environment and subjected to results that would likely occur in a real battle. "Simulation" is considered to include interfaces with computer combat models and human-in-the-loop simulators.

The Department of Defense (DoD) has recognized that DIS has potential in additional arenas besides training and has established synthetic environments as a science technology thrust. Combat developers could use DIS to develop requirements and assess new doctrine and tactics for current and future systems. Materiel developers could save money and reduce development risks by employing DIS to prototype and exercise system modifications or designs. Testers can use DIS to plan tests, or as a source of supplemental data for their evaluations. Military analysts have already exploited DIS to study actual combat by recreating battles.

A primary recommendation of the 1991 Army Science Board on Army simulation strategy was that the common representation of the battlefield could and should be developed to support the full community of users including developers, testers and trainers and includes "seamless" interconnection across different methods of simulation. An important attribute of the DIS environment relates to the suitability for human interaction and representation within the times of human perception and at the appropriate level of resolution above detailed engineering design and physical phenomena models and simulation.

OBJECTIVES

The overall objective of this mini-symposium was to explore military operations research applications of DIS technology and its environments. The mini-symposium provided a forum to examine DIS technology applications in analysis, test and evaluation, and training.

GOALS

- Provide a learning experience for the participants.
- Examine the utility and limitations of DIS environments.
- Develop issues in the use of synthetic environments for benchmarking and data collection.
- Explore the ramifications of humans interacting in DIS environments.

SCOPE

MORS conducted a three-day mini-symposium beginning on 29 September 1992. The mini-symposium was limited to an UNCLASSIFIED discussion of the concepts, capabilities, and application of DIS and synthetic combat environments. The mini-symposium was conducted at the Radisson Mark Plaza Hotel and at the Institute for Defense Analyses in Alexandria, VA.

All who registered to attend the mini-symposium were sent read-ahead information to familiarize them with the DIS concept. The read-ahead papers were not intended to be restrictive or exhaustive.

The mini-symposium was preceded by a tutorial on the evening of 28 September 1992. The tutorial covered an overview of DIS technologies and emerging interoperability standards and protocols. Dr. Duncan C. Miller, BBN Systems and Technology, Inc., discussed "SIMNET Architecture: An Historical Overview" and Dr. Bruce McDonald, University of Central Florida presented "Standards for the Interoperability of Defense Simulations." Symposium participants were encouraged to attend the tutorial in order to obtain useful background information for subjects to be discussed during the mini-symposium.

On the first day, the mini-symposium had a general session with opening remarks by Mr. E. B. Vandiver, MORS President, an orientation by Dr. Henry C. Dubin, Mini-symposium Chairperson, and a panel discussion by speakers (Dr. Duncan Miller, BBN Labs; Dr. Phil Dickinson, E-Systems; Dr. Monti D. Callero, RAND; and Mr. Edward C. Brady, Strategic Perspectives was the session chair).

The morning general session was followed by a lunch with a keynote speech by Mr. John Hamre, professional staffer for the U.S. Senate Armed Services Committee.

The afternoon general session on the first day focused on the use of DIS technology to date. Four "seasoned veterans" discussed their experiences using DIS to: evaluate new technologies; develop system requirements; develop tactics, techniques, and procedures; and testing. Each of these experienced users presented problems encountered and lessons learned, his/her view of the capabilities and limitations of DIS technology, and recommendations/plans for its future use. Mr. Richard E. Garvey was the session chair, and papers were presented by the following four "seasoned veterans" (Dr. Barbara A. Black, ARI Field Unit, Fort Knox; LTC Keith M. Moore, Office of the Assistant Secretary of the Army (Research, Development and Acquisition) (OASA(RDA)); CAPT H. C. Kaler, Naval Sea

Systems Command; and Mr. John V. Meier, Los Alamos National Laboratory).

On the second day, working groups focused on examining particular areas of interest in greater detail. The working groups were chaired by senior individuals with particular interest in the field. The working group sessions focused on discussions designed to inform, generate interest in, and improve the understanding of DIS and synthetic combat environments in the community. Each working group identified uses, limitations and needed enhancements of DIS to support their specific needs. Each group was encouraged to address human performance and behavioral concerns, environmental requirements such as terrain resolution, and data collection and reduction issues in support of performance and effectiveness measures. The working group chairs were charged to produce a short report on the objectives and issues addressed by their working group for DIS uses, limitations, and enhancements to support their specific needs.

A thirty-minute demonstration of DIS capabilities was also offered on the second day at the Institute of Defense Analyses Simulation Center. Mr. Bob Clover conducted a tour of the facility and the DIS demonstration.

The mini-symposium concluded on the morning of the third day with reports from the working groups. The working group chairs reported the findings of their groups and identified any possible follow-on efforts appropriate for MORS support.

PARTICIPATION

Attendance was not restricted. The goal was to get a mix of people with various levels of DIS experience, but more importantly each individual should be currently involved with at least one of the working group topics. This goal was achieved with a wealth of backgrounds covering disciplines including engineering, systems design, testing, force structuring, tactics/doctrine development, support analysis for all components of the U.S. Armed Forces, national laboratories, federally funded research and development centers, and private contractual firms. Additionally, participants were to come prepared to play an active role as recorder, moderator, or discussion leader.

WORKING GROUPS

TABLE 1-1. ATTENDANCE BY AFFILIATION

Affiliation	Military	Civilian	Total
US Army	34	76	110
US Navy	9	13	22
US Air Force	7	13	20
US Marine Corps	3	1	4
Joint Civilian		2	2
Other DOD		6	6
Other Government		2	2
FFRDC		31	31
Professional Services		89	89
Manufacturing		17	17
Academic		3	3
Consultant		6	6
Other		8	8
TOTAL	53	267	320

WORKING GROUPS

There were 10 working groups. The working group titles, the primary questions that they examined, their chairs and co-chairs, and their approximate number of participants follow.

Working Group 1. Military Analysis. How can DIS supplement or extend existing military analysis techniques? How does DIS relate to existing military analysis techniques? Chair: Mr. Kent Pickett, Director, Model Directorate, U.S. Army Training and Doctrine Command (TRADOC) Analysis Command - Operations Analysis Center. Co-Chair: Mr. Wallace Chandler, Acting-Assistant Director, Research and Analysis Support Directorate, U.S. Army Concepts Analysis Agency. Approximate number of participants: 29.

Working Group 2. Test and Evaluation (T&E). How can DIS be appropriately applied to support or supplement T&E? Chair: COL Bernard Ferguson, Executive Assistant for the Director for Test and Evaluation, Office of the Under Secretary of Defense, Acquisition. Co-Chair: Dr. Adelia Ritchie, Manager, Information Systems Division, Science Applications International Corporation. Approximate number of participants: 31.

Working Group 3. Operations Planning and Rehearsal. How can DIS be applied to planning and rehearsing for military operations? Chair: Commander Dennis McBride, Program Manager, Defense Advanced Research Projects Agency. Co-Chair: CAPT Bruce McClure, Chief, Modeling and Analysis Section, Office of Naval Operations. Approximate number of participants: 34

Working Group 4. Logistics, Mobilization and Sustainment. How will DIS incorporate means to properly address logistics, mobilization, and sustainment? How can DIS be used to address logistical, mobilization, and sustainment issues? Chair: Dr. Lisa Sokol, MRJ, Inc. Co-Chair: Mr. Al Irwin, Science Applications International Corporation. Approximate number of participants: 27.

Working Group 5. Force Developments. What types of DIS can contribute to force development analysis and how? Chair: Dr. Darrell Collier, Director, TRADOC Analysis Command, White Sands Missile Range. Approximate number of participants: 30.

Working Group 6. Combat Developments. How can DIS be used to develop the most cost-effective solutions to mission needs? Chair: Mr. Mike Bauman, Acting Director, U.S. Army TRADOC Analysis Command. Co-Chair: MAJ Jeffrey Wilkinson, Chief, Close Combat Test Bed, USAAC Directorate of Combat Development (DCD). Approximate number of participants: 23.

Working Group 7. Training and Readiness. How can DIS be used for cost effective training and readiness? Chair: Mr. Kenneth Lavoie, Technical Director, Air Force Wargaming Center. Co-Chair: Colonel Steven S. Overstreet, Acting Project Manager of Close Combat Tactical Trainer, Simulation, Training and Instrumentation Command. Dr. Stanley Halpin, Chief, Field Unit, Army Research Institute. Approximate number of participants: 26.

Working Group 8. Requirements Development and Definition. How can DIS be used to identify, develop, and validate requirements? Chair: Dr. James Metzger, Operations Research Analyst, Office of Assistant Secretary of Defense (Program Analysis & Evaluation). Co-Chair: Colonel Gilbert M.F. Brauch, Jr., Chief, U.S. Army Model and Simulation Management Office, U.S. Army Model Improvement and Study Management Agency, Office of the Deputy Under Secretary of the Army-Operations Research (DUSA-OR), Headquarters, Department of the Army (HQDA). Approximate number of participants: 34.

Working Group 9. Simulation Prototyping to Support Acquisition. How can prototyping using DIS environments support the materiel acquisition process? What do we mean by rapid prototyping of simulations? Chair: Mr. Dick Garvey, Director, Leavenworth Operations, BDM International. Co-Chair: Dr. Ron Hofer, Technical Director, Simulation Training and Instrumentation Command. Approximate number of participants: 33.

Working Group 10. Cost/Benefit/Risk of DIS. What are the costs, benefits, and risks associated with DIS applications to training, military analysis, force development, combat development, and test and evaluation? Chair: Mr. Ed Brady, Consultant, Strategic Perspectives. Co-Chair: Dr. Peter Cherry, Vice President, Vector Research Inc. Approximate number of participants: 28.

CHAPTER 2
WORKING GROUP 1
MILITARY ANALYSIS

Kent Pickett

BACKGROUND/OBJECTIVES

The objective of Working Group 1 was to explore the uses of Distributed Interactive Simulations (DIS) in support of military analysis. The group consisted of 29 members with varying backgrounds in military analysis. These backgrounds included working in weapon engineering design, weapon testing, force structuring, development of tactics/doctrine and theater support analysis, to cite only a few. Members of the group also represented organizations of all components of the U.S. Armed Forces. Several nongovernmental organizations present included a national laboratory, a federally funded research and development center, and private military contractual firms.

Early in the session, two subgroups were established. The subgroups addressed the following topics:

- Subgroup 1 reviewed those areas of current DIS technology which could be applied to analytic tasks. The group chose to limit these discussions to technology that could be reasonably expected to mature in the next five years. Included in these discussions was the identification of those areas where DIS was clearly not applicable. Subgroup 1 closed its discussions with several recommendations for changes and additions to the DIS system to make the architecture more usable for military analysis.

- Subgroup 2 focused on the procedures to verify and validate DIS based models and architectures for potential use in military analysis. The subgroup found that verification and validation in a distributed, multi-resolution environment provides a different set of challenges than those experienced in validating conventional models and simulations. Recommendation for research topics to establish a basis for V&V activities in DIS resulted from the discussions of this subgroup.

CURRENT ANALYTIC USES FOR DIS AND RECOMMENDATIONS FOR IMPROVEMENTS.

The general consensus of Subgroup 1 was that the DIS environment provides a valuable laboratory in which the analytic community can learn more about human interaction with new and existing battlefield systems than has heretofore been possible. This knowledge can be used to support both early development of the new system concept in terms of how to use it effectively on the battlefield and how the system can be integrated into the existing force. Further, the subgroup believed that DIS can be effectively used in the areas of battle planning, tactics/doctrinal development and force structuring for currently existing systems.

The subgroup, however, did not believe that DIS can be used effectively for investigating the basic physics underlying the performance envelope of new weapon systems. In short, the DIS model can be no better than our understanding of the physical phenomena supporting the system and the virtual environment of DIS has only limited capabilities in expanding our understanding of the principles. High resolution engineering models are still needed when doing tradeoffs in weapon envelope performance. DIS can give us insights on how human beings can best exploit these performance changes in battle.

In the area of development for new systems, the group found the virtual environment technologies of SIMNET/SAFOR and DIS have a high potential for investigating the impact of human factors early in the development of a system. These types of analysis include:

- Front End Analysis describing the mission, requirements and the operational concept of the new system.
- Operation Mode Summary/ Mission Profile analysis describing how the new system will be used and how often the system will find itself in particular modes of operation.
- Organizational relationships between the new systems and current systems. This is a further refinement of the Organizational concept and will help lay the basis for force structuring analysis with the new system.

The key advantage in the use of the SIMNET/ SAFOR virtual environment in the early development of a system is that it gives the military analyst an insight into how soldiers will use the proposed weapon system. Current analysis is primarily based on how soldiers use systems based on similar technologies to those of the new system. But in cases where the technology is radically new (e.g., the use of a laser system as the main armament as opposed to a conventional munitions or missiles) this environment gives us an early, objective look at how to employ the new system without actually going to the expense of building it.

The Subgroup believes that SIMNET/ SAFOR also has the potential to be an effective tool in the area of Mission Planning. The virtual environment gives the commander the ability to "walk the battlefield" before the actual battle. It requires improvement for this to become a common use of the system. Over the next five years, however, it was believed that improved graphics in SIMNET will become a reality. In this case the SIMNET stealth capability might well support the required terrain analysis defining likely positions for friendly and enemy troops and even support tactics development through virtual battle rehearsal.

If SIMNET/SAFOR is to realize its potential as a usable tool in the analytic community, certain improvements will be necessary. The Subgroup listed the following upgrades as basic improvements which should be accomplished to insure the usefulness of the system throughout the analytic community:

- A review of existing SIMNET/ SAFOR algorithms, databases and methodologies must be conducted. In short, the basic representation of system/battle processes must be verified and validated. This is not to imply that work in the area has not already begun. Several successful efforts have been sponsored by DARPA and STRICOM in an effort to make

SIMNET a more realistic, responsive training tool. The implication here is that these V&V efforts must continue and that the analytical community needs to actively share the responsibilities in these reviews.

- The environmental representations in SIMNET/SAFOR need upgrading. Much of the developmental work in new combat systems depends on new sensors. The environment strongly affects how well or poorly these sensors perform. SIMNET/SAFOR must be able to fairly represent the attenuating effects of both the natural and man-made environment. This includes both physical obscurants and electromagnetic jamming affecting sensors and seekers. The subgroup recognized this as a high priority in current DIS/SIMNET development and simply wishes to reinforce DARPA/STRICOM's efforts.
- The SAFOR/Computer Generated Forces (CGF) should have the facility to run in a repeatable/systemic mode with intelligent responses of vehicles to dynamic battle conditions. The analytical community commonly uses a sensitivity based methodology to establish cause and effect between new weapon systems and battle results. In this type of analysis, a "base case" is established using the combat model of choice. The base case is carefully set up with valid battle positions for units performing particular missions. The base case is reviewed until it appears reasonable under the threat, battlefield, and friendly force conditions. The battle is run and the results are reviewed. A modification representing the new weapon's impact on the force is then made to the base case. This "modification" may be as simple as changing the performance envelope of an improved system or it may be as complex as restructuring the force with an associated change in mission and weapon positions. In either case, the appropriate changes are made and the battle rerun under the new conditions. Battle outcomes are then compared to the base case. The point is simply that if SAFOR is to become the high resolution model of analytic choice, there is a need for a single analyst to run the model without simulators or a staff of gamers guiding the individual vehicles as they move through the battle. This is not meant to imply that the SAFOR would be used purely in an "unattended" mode. Most certainly, a reasonable analyst would carefully review the new battles for validity. There must be a capability for the SAFOR to run in repeatable, interrupt capable, stand-alone mode when given a sound tactical plan at the division/-brigade/ battalion level.

VERIFICATION AND VALIDATION FOR MILITARY ANALYSIS IN A DISTRIBUTED SIMULATION ENVIRONMENT

Subgroup 2 of the Military Analysis Working Group developed their discussions from consideration of two base points:

- DIS is in fact a new simulation environment which places different demands on the VV&A process than those associated with and documented for independent "constructive" simulation models.

- A particular DIS environment (network, nodes, communication protocols, hardware and software component, etc.) does not acquire or inherit a degree of quality assurance from the fact that some or all of its component parts have been subjected independently to VV&A. In short, verification and accreditation of the parts does not imply verification and accreditation of the whole system. The discussion in the group focused more on verification and accreditation and less on validation issues.
- The important aspects of the DIS environment affecting the VV&A problem are its distributed nature and its heterogeneity of resolution. Its interactive quality, also an important aspect with respect to VV&A, was not considered as prominently since there is not a consensus on whether man-in-the-loop is a necessary condition to a DIS environment.
- Several problems impact an effective VV&A effort of a DIS based system being used for analysis. The system may be so geographically distributed that not all components are available for review. It may be distributed across multiple hardware platforms with various modes of communication among them. Simulators and closed simulation operating at different levels of resolution, aggregation, or fidelity may all be "interoperating" on the network. Models supporting a particular DIS application may produce outputs which are deterministic, or represent single or multiple instances of a stochastic process. A transition from one hardware platform, type of model or level of aggregation to another introduces the possibility of misinterpretation or loss of information. Each of these "boundary crossing" situation must be examined and verified as part of the accreditation process.

The group felt the situation called for the development of new procedures and new theory to meet these demanding VV&A conditions of the DIS environment. Several aspects of this required development were identified as follows:

- Methods for verifying the "boundary crossing" interfaces between components of the DIS structure being used for analysis.
- Requirements for certifying personnel playing a man-in-the-loop role.
- Procedures for calibration of the system components with different levels of aggregation.
- Experimental design methods to support interoperation of statistically dissimilar simulations.
- Procedures to evaluate the physical (electronic) limitation or restriction of a particular network architecture.
- More comprehensive documentation for components which cannot be examined first hand by a DIS user.
- Better data collection and data management techniques which allow increased visibility and monitoring of system interfaces.

In summary, the subgroup's recommendations were consolidated under four principal points:

- Seek a way to encourage and sponsor the development of theory and methodology to address the issues cited above.

- Promote the documentation of such research efforts through journal articles, issue papers or position papers with the ultimate goal of the development of primers or handbooks to instruct the analyst DIS user in how to accredit a system for particular analytic applications
- Start collecting data on system interfaces and issues associated therewith using current, not necessarily analytic, application of DIS technology.
- Identify and design experiments and test cases for DIS applications which can furnish information to support the exploration of the issues cited above.

CHAPTER 3
WORKING GROUP 2
TEST AND EVALUATION (T&E)
Colonel Bernard Ferguson

PURPOSE

To examine Distributed Interactive Simulation (DIS) as it might be used to support Test and Evaluation, identifying uses, limitations, and enhancements required.

BACKGROUND

DIS has had very limited use in Test and Evaluation (T&E) to date. The Working Group heard a briefing from one member who was involved with the testing of NLOS using DIS. Based upon that briefing, upon the demonstration at the IDA Simulation Facility, and on the group's expertise, the Working Group proceeded to examine the use of DIS to support T&E, focusing on the differences between DIS and stand-alone simulations of similar size or complexity.

The Working Group discussed when to use and when not to use DIS in T&E. They developed several key limitations to DIS applications, most of which, if resolved, would make DIS applications in T&E more feasible. Key research topics, where more consideration and deliberation will be required, were discussed and conclusions and recommendations were developed, as discussed in the following paragraphs.

TOPICAL DISCUSSION

The T&E Working Group was charged with proposing potential applications of DIS in test and evaluation. In addition to those instances where DIS should be considered applicable, the Working Group developed a set of circumstances where DIS should not be considered for T&E applications.

When to Consider DIS for T&E Applications. In theory, DIS could be applied throughout the life cycle of a weapon system's acquisition process, e.g., in requirements generation, concepts analysis, Operational Utility Evaluations (OUEs), Early Operational Assessments (EOAs), Initial and Follow-on Operational Test and Evaluation (IOT&E and FOT&E), etc. Of particular interest to the T&E community is that a consistent DIS application could provide a means for linking Cost and Operational Effectiveness Analyses (COEAs) to Test and Evaluation Master Plans (TEMPs). Also, applications in FOT&E could provide front end screening or a view of the next generation system or mission requirements.

DIS could be used to help identify test issues, to train participants, and to refine tactics and doctrine. The Working Group believes that DIS may allow practical tactics to be exercised. For a given system, test planners must identify the issues to be addressed by DIS. The advantage is that this process may force more advance thinking and planning for test resources, including requirements for DIS which is itself a test resource in this case. Test planning must be conducted early, as early as Milestone 0, in order for the projected capabilities to be available at test time. This process will be facilitated if the acquisition strategy invokes DIS consistently throughout all milestones.

Like "modeling and simulation," DIS could be invoked when constraints require alternatives to testing, e.g., in the case of nuclear, biological, chemical, and space systems. Constraints that force testers to use alternative tools are generally in the categories of environmental, safety, political, electromagnetic emanations, cost, and the like.

Other potential applications include Multi--Service procurement (combined arms, many players), Joint Tests (e.g., JSTARS, JLOTS), and highly concurrent systems, usually the high cost items, when sufficient numbers of the system are not ready in time to conduct tactical unit testing prior to a production decision.

A large proportion of major system testing is classified at the Secret level or even higher. The net must be secure, with all players and sites being cleared as well.

When Not to Use DIS in T&E. Technology limitations and common sense are the guidelines in this case. Latency problems preclude applications for highly mobile systems. DIS is not needed if the system under test does not need to interact with other systems or if the system is easy and inexpensive to test normally. Engineering testing, "shake and bake," does not require DIS, nor could the working group find any potential applications for this phase of testing. DIS is not for testing of Major Automated Information Systems (MAIS) nor any other information management systems. Above all, when the physics of the system under test is not well understood DIS must be used either with caution or not at all.

LIMITATIONS

An extensive list of limitations exists, several of which are technical, bureaucratic, and administrative, that could preclude DIS applications in T&E.

- Security - DIS should not be applied in T&E until multilevel security issues are resolved (networks must be classified for most applications).
- Accuracy of representation of sensors & countermeasures (IR, laser, etc.)
- Dynamic environments (terrain, clutter)
- Protocol limitations (latency, flexibility, volume)
- Network management - Who's in charge?
- Consistency between SAFOR and man-in-the-loop
- Logistics may be more difficult to play.
- Test control may be more difficult. DIS requires increased coordination, planning time, etc. More players are involved, more difficult to budget, schedule. But, more in-depth test planning may be possible.
- Data collection, reduction, and handling may be more difficult.
- VV&A issues are more complex.
- DIS requires distribution and maintenance of common data bases.

ISSUES

Protocols When considering protocols in DIS, one is considering protocol data units (PDUs) used to transmit information on the network. The Working Group used Version 1.0 in considering PDU capabilities, because this is the only version close to being accepted as a standard. The working group discussed the following problem areas and possible solutions:

LATENCY. This is the delay experienced between an entity state change and the time at which other entities on the network become aware of that change. This delay occurs because of transmission time, PDU processing time, and other factors. This problem can never be completely overcome, but it might be significantly reduced by use of fibre optics or token rings -- devices and procedures allowing two particular entities to transmit data direct for a very limited time at very high exchange rates. Particular entities might be assigned lower update thresholds -- the amount of state change requiring a state change PDU be transmitted. Update algorithms could be changed for critical systems to speed the update rather than focus on presentation graphics movement. One could use these techniques when critical entity state changes needed to be transmitted to another entity.

FLEXIBLE PDUs. To gather data not available from standard PDUs, testers need a special request PDU or one with blank slots. These would give the capability to gather such data.

NETWORK PDU VOLUME CAPABILITY. The volume capacity of current networks limits the number of PDUs that the system can handle at any one time. This in turn limits the number of entities that can be represented and the amount of data that can be transmitted. This problem is directly related to the bandwidth of the network. There are techniques, however, that can help: data compression techniques, combining like PDUs, multicast, and smart gateways. These methods of handling PDU transmissions have the potential of minimizing the associated problems.

TEST PLANNING. Testers should plan for the early use of DIS. They should plan for the capability projected to be available at the time they plan to execute their test. This will require much coordination with the "DIS and Defense Simulation Internet (DSI) managing agencies" very early in the acquisition cycle. From this respect, the tester's planning would be much easier if the system acquisition strategy included the use of DIS/DSI throughout -- requirements definition, concept trade off analysis, developmental testing, and operational testing.

VERSION COMPATIBILITY. Future versions of DIS should be backwards compatible. This will allow testers to make use of new capabilities in future versions with minimum adjustment from previous testing.

SYSTEM MONITOR. When a critical node drops off of the net due to a system failure, the tester needs to know so he/she can stop the test until that node is brought back on line. Other failures may be of equal importance. Identifying such failures could be accomplished through the use of smart gateways and special PDUs, generated by the failure.

Who Is in Charge? DIS/DSI needs a network manager to perform functions such as scheduling, assuring asset readiness, coordination of user system needs, and planning enhancements -- integration and budgeting. In the near term, this network manager should be advertising the system -- letting installations know the capability that will be available so users can plan and budget for nodes. In the future, the network manager would serve as the single point of contact for test planners.

Each installation with a node will need a site manager. This person would schedule use of the node and use of local simulations and simulators which the user needs to run a test or other application.

Timing. Timing on the network is an all important issue; especially for events such as the missile end game and aircraft evasive maneuvers. Just as important, all entities need to be running on the same reference time. The latter issue will be resolved through the use of the Global Positioning System to provide the reference time for all entities. The former issue partially revolves around latency which we discussed earlier. Compatible processing capability between nodes can affect timing. If one or more nodes have a lower processing capability, the other nodes can overload those with limited capability and eventually jam those nodes. Once that happens, the lower capability nodes will drop off the system and be lost. Therefore, the nodes should have compatible capabilities.

Linkage - Live Systems to Virtual Environments. Use of an actual weapon system on the network -- vs. use of simulators -- would enhance fidelity and make the verification, validation, and accreditation process more simple. Weapon systems might be linked through their data buses -- not a current capability. The desirability of doing this is certainly system and application dependent. PDUs would have to be developed or modified to transmit information used to simulate the system. This is a task which requires much research, but one that may pay great dividends in terms of credibility.

Viruses. Viruses transmitted on any network are potentially catastrophic -- and no less so on DIS. Scanners and protective techniques must be used. DIS also opens the door for false PDUs. Imagine running a test and all of a sudden a ship or airplane disappears! Smart gateways and security encryption may overcome these potential problems, but users should be aware of the potential risks.

Reliability. Several testers in the working group who have previously used DIS/DSI experienced reliability problems. Parts of the system failed during a test, thus stopping the test until repairs were complete. In a large scale test this might be very expensive in terms of resource availability, data lost, or time lost. Testers using DIS/DSI should be aware of this potential and consider using back-up capability such as automatic switching to redundant hardware and redundant transmission links for critical nodes. Developers of the DIS system should provide system monitoring so a person monitoring the test could be advised when a node or link fails, thus allowing the appropriate actions to be taken.

KEY RESEARCH TOPICS

Topics discussed below were determined to be essential issues for resolution to enhance the T&E community's confidence in DIS.

SAFOR was deemed inadequate to support the realism required by the T&E community, its critics, and its overseers. From the operational testing perspective, more manned simulators will be needed to improve realism, with the long range goal being improvement of the credibility and realism of SAFOR. The working group challenged the T&E community at large to develop and articulate its requirements in this area.

Credibility and VV&A of the entire DIS network (all nodes, all models, all network interactions): who does it and what inter-agency and intra- and interservice agreements will be required? Who is ultimately responsible for network management and credibility of results, particularly in multiservice test exercises? Even though each node may be running accredited simulations, the interactions and dynamics around the network raise unanswered questions about the VV&A process for an interactive system.

CONCLUSIONS AND RECOMMENDATIONS

- The T&E community should identify the issues that should be addressed well in advance by DIS for the testing of a given weapon system. These issues should be documented in the Test and Evaluation Master Plan (TEMP).
- SAFOR should be enhanced to contain "pre-blessed" scenarios, rules of engagement, tactics, doctrine, etc. The T&E community should develop and articulate its requirements for SAFOR as soon as possible.
- If DIS is to become a viable test adjunct, a new DoD Directive is needed which will require all system RFPs to state that hardware simulators must be DIS-compatible. With concurrent development of DIS and the system or item being modeled, simulations do not always represent the latest version of the system.
- For multiservice DIS applications, the lead agency "user" should review VV&A of all net components, prepare the VV&A section of the TEMP, describe the limitations of the DIS application, and prepare inter-Service MOAs as needed. The responsibilities must be clearly delineated in the TEMP. For single service applications in the future, pre-accredited "off the shelf" modules should be developed and archived for classes of DIS applications. Pre-accreditation implies the need for an agency who serves as the repository of VV&A and other documentation for "approved" modules.
- The T&E community should state their data requirements now (e.g., formats, resolution) as most differ from the training community's needs.
- DIS should be considered a test resource (or series of test assets) and be planned for and funded accordingly.
- DIS modules should be developed for use in COEAs with the intent of using them throughout the acquisition cycle (through all phases of T&E).
- DIS/DSI enhancements are required to overcome latency problems.

CHAPTER 4
WORKING GROUP 3
OPERATIONS PLANNING AND REHEARSAL
Commander Dennis McBride

This working group issued no final report.

CHAPTER 5
WORKING GROUP 4
LOGISTICS, MOBILIZATION AND SUSTAINMENT

Dr Lisa Sokol

OBJECTIVES

Our intent during the working group session was to perform an objective assessment of the potential of Distributed Interactive Simulation (DIS) for logistics applications, and to assess the capability of DIS to support current conflicts, and, in particular, to assess the capability of DIS to help establish the rapid, flexible reaction on the part of the logistics support system required by modern scenarios.

DISCUSSION AND USES

This section presents a summary of the discussions of the working group arranged in a more logical sequence than that in which they occurred.

A significant issue within the working group was the definition of the boundaries of DIS. We determined that two sets of values are indicated by the term DIS. The narrow set relates to simulations such as SIMNET or Close Combat Tactical Trainer (CCTT). It has the characteristics of human-in-the-loop simulations interacting with each other to perform common tasks. Generally, the human participation is at the crew or operator level, and the human participants have a real-time task requiring the cooperation of all or most of the manned simulators. The second definition is much broader, and widens DIS to include any interactive simulations at any level. In this case the key characteristic is the presence of two or more independent simulators, sharing common data and exchanging results over a network. The group decided that both definitions needed to be considered.

The group considered both training and analysis applications of DIS. It also considered the applications to Brigade/ Battalion echelons, Division/Corps/Theater echelons and to the mobilization/sustainment base.

Training Applications

APPLICATIONS AT BRIGADE/ BATTALION ECHELONS. The operations of Brigade and Battalion S4s are properly the subject of the Combat Arms proponents. Our group decided, however, that these operations would likely become orphans if we did not consider them. It was our opinion that the logistics elements at brigade and battalion levels could benefit from training using DIS technology. In particular, we believe that the movement of such personnel into the training audience of exercises using SIMNET like simulations would be beneficial to both the logistics and combat players. Rather than using a "teleportation" approach, logistics vehicles should be visible as they move about the battlefield. The forward logistics support elements should also be visible and active. Appropriate use of Semi- Automated Forces (SAFOR) would preclude excessive manpower or simulator requirements. However, the absence of these elements hurts the present training conducted with DIS.

In a nonlinear battlefield, combat forces should expect to encounter non-combat elements on the battlefield. It would be considered a tactical success to avoid direct conflict with an opposing force and instead destroy his logistics support capability. Likewise, our commanders must learn to protect the forward logistics elements that are otherwise vulnerable to enemy action. The absence of these elements significantly reduces the realism of the training presented.

DIS (in the narrow sense) was also considered as a possible means to train operations at logistics elements. For example, the coordination of various equipment operators at a port facility might be improved by training in DIS simulators of their equipment.

APPLICATIONS AT DIVISION/ CORPS/ THEATER ECHELONS. The training audiences at these echelons consist of managers and decision makers who do not directly view the battlefield, but rather depend on reports and analyses to support their activities. As such, these training audiences have little to gain from the narrow definition of DIS, but can make use of the wider definition. In this manner, linking aggregate level simulations can provide significant advantages in training. As an example, the group discussed the Combat Service Support Training Simulation System (CSSTSS) and its potential interfaces. Interfacing CSSTSS to the Corps Battle Simulation (CBS) is already being explored. It was generally agreed that training at this echelon benefits from such linkages.

When considering the linking of aggregate level simulations to SIMNET-like versions of DIS, the group saw little real advantage and several major disadvantages. While the use of SIMNET participants in a logistics exercise might seem to improve the overall realism, in fact, little of the actions at brigade or battalion would directly affect the logistics training audience. It is clearly not practical to field a full corps of manned simulators. Once significant numbers of SAFOR are in use, the exercise is once again operating more at the aggregated level. Data from DIS exercises can be used to calibrate aggregate level simulations.

Another key limitation is that logistics problems are generally many days in duration, while a tank battle at battalion level occupies minutes to hours. For example, it may take thirty to sixty days of logistics work to prepare for a five hour tank battle. This disparity in time frame would make it difficult to train both tactical and logistics management training audience elements at the same time. The tactical units can better use their time by concentrating on significant engagements. A battalion of tank crews would gain little value if they were to end up in division reserve for a week long exercise, doing nothing but moving from assembly area to assembly area. In order to rationalize this disparity in simulation time, the logistics simulation must be able to run in a faster than wall clock mode. Furthermore, if the simulation was fast enough, the users would be able to compare alternative strategies within the allotted wall clock time.

Analytical Applications. The group recognized that caution must be used when using training simulations to support analysis. Training simulations are generally designed to produce an environment in which the student can learn battlefield skills. They are not intended, however, to predict the outcome of any given battle. Only when the limitations of training simulations are fully understood, can experiments be designed to take advantage of them in an analytical mode. While this caveat has been stated, it does not preclude a careful approach to using such simulators for analysis. The Louisiana Maneuvers intend to use training simulations for analytical purposes. One observation of the results of such analysis is that training simulations may well disclose problems in a particular approach. That is, they may be able to demonstrate that something cannot work. However, only in very carefully limited circumstances can they be taken to prove that a particular concept will work.

Examples of appropriate use of training simulations for analysis are the 73 Easting and the demonstrated WARBREAKER approaches. In each case, the approach is to first recreate the historical situation in the simulation, and then to make careful excursions from the known performance. A potential exploitation of this method of analysis for logistics purposes could be the interface of two versions of CSSTSS. One would represent the European Theater, while the other would represent the Desert Shield logistics elements. The simulators could then be used to recreate the events involved in the transfer of 7th Corps from Europe to the Saudi Arabian Peninsula. It is known that many problems occurred, and the use of this simulation might make possible the study of the problems to prevent their recurrence.

CONCLUSIONS

Many analytical models exist within the various logistics communities, and it was the opinion of the group that it would be to our advantage to try to establish links between the best of these models so that an "end-to-end" simulation of the logistics process could be accomplished. It was also the opinion of the group, that the owners of such models would have reservations about their use in such a linkage. The group identified a strong need for interfaces that spanned service responsibilities so that both airlift and sealift could be factored into the simulation of battlefield logistics.

The group was unanimous in its belief that the omission of logistic simulation components skews the outcome of the simulation model. We must incorporate logistics models within the context of the battlefield model. Further research is needed to determine the level of detail and fidelity which would be appropriate for the logistics portions of the battlefield models.

We also recognize that different portions of the logistics simulation model are relevant to different people. The portions of the model which run a high aggregation level, those portions of the model which address strategic and operational planning, will be most valuable to the logistician. The portions of the model which run a low level of aggregation, the levels which focus on details, will be most relevant to the tactical forces.

We believe that the visualization portions of the model are critical to the success of the model. Furthermore, the appropriate visualization tools will vary with the user.

Finally, we recognize the large disparity that exists between the time frame of the typical battlefield model and the time required to plan the logistics support and resupply for a battle. In order to manage this disparity of temporal interests, the logistics portion of the battlefield must be run in faster than real time. It would also be useful to be able to run several iterations or projections of alternatives within the appropriate time steps.

RECOMMENDATIONS

The following is a list of recommendations that were generated as a result of the workshop:

- The logistics community must begin to develop an appropriate module for the current set of virtual simulations.
- The time frame for battlefield simulations must be extended to introduce interactions with logistics capabilities.
- The time frame of logistics simulations relative to that of battlefield simulations makes it imperative to introduce faster than real time simulation.
- Logistics simulation fidelity and speed can be enhanced by research in aggregation and disaggregation techniques.
- The logistics community should begin to try to establish links between the best of the logistics models to create an "end-to-end" simulation of the logistics process.

CHAPTER 6
WORKING GROUP 5
FORCE DEVELOPMENT
Dr Darrell Collier

This working group issued no final report.

CHAPTER 7
WORKING GROUP 6
COMBAT DEVELOPMENT

Michael Bauman

Although Working Group 6 was assigned the topic "Combat Developments," the group members were not inhibited about encroaching into the topic areas assigned to other working groups. This was rightfully so since Combat Developments (CD) embraces the development of concepts and doctrine, design of forces, definition of system requirements, test and evaluation; while at the same time cutting across the domains of combat arms, logistics and military personnel.

Working Group 6 (WG6) was comprised largely of hard-core practitioners, which helped keep the group firmly anchored to the reality of military operations research and focused "where the rubber meets the road." The group also benefitted by having several members who have played instrumental supporting roles in the development of DIS. Although enthusiastic about the tremendous potential DIS offers to Combat Developments, the group was not blinded by its visual allure. To a disciplined OR practitioner, seeing is not necessarily believing, whether it is DIS or another venue. Guarded optimists best describes persons in WG6.

Following opening introductions, all of WG6 met together to explore the potential uses and limitations of applying DIS to CD. These ideas were then grouped into major headings and discussed in more detail within four smaller groups to stimulate greater discussion by everyone. At the close, all of WG6 met together again to share individual positions and findings, and to contribute to the final report.

DIS POTENTIAL

Three key potentials dominated our discussion of DIS applied to CD. The first and most often cited potential was the opportunity to embed actual warfighters and operators into the simulated environment as an integral part of the weapon system design, particularly during the system's early development, but also throughout the complete development process leading to fielding. This recognizes the advantages held by virtual simulations (simulators) over other simulation components of DIS, e.g., the introduction of human operators, hands-on, in-control, reacting to the environment, making real-time decisions and taking actions which influence the simulation outcomes. WG6 believed this potential will greatly aid combat developers in early system design such as man-machine interfacing and early evaluation of new operational and tactical concepts.

The second key potential also pertains to the human dimension of DIS. The ability to monitor and record events in virtual simulations (simulators), particularly human actions and reactions within the simulated environment, adds a new powerful dimension to the evaluation of human performance and after-action review of simulated exercises or trials, compared to either constructive simulations (without a human-in-control) or testing and live simulations (where instrumentation may be limited in its ability to monitor and record crew member or operator actions). The virtual simulations are more controllable than a field test or exercise, yet still permit the human crewmember or operator to interact with the environment, something that is missing in constructive simulations.

The third key potential is the facilitation of joint-ness in combat developments. Until recently, below the JCS level, the joint-ness depicted in each of our service simulations has been largely the result of the individual service (who owned the simulation), rather than the joining of each service's perspective. The promise of DIS to seamlessly integrate heretofore disparate, stand-alone simulations across service boundaries may create new opportunities for interservice CD. WG6 recognized that "turf" obstacles must still be overcome to achieve Joint CD in a practical way; that is, just because it can be done doesn't guarantee it will ever happen. Nevertheless, the DIS movement will promote greater dialogue and exchange among service and industry modelers as they prepare their particular simulations for linkage within DIS. In turn, this should make it easier to create a simulation environment comprised of the best available representations of military sea, land, air and space functions. This will facilitate joint-ness in CD, whether it is joint CD conducted by or on behalf of JCS, OSD or multiservices, or simply CD conducted by or for a single Service.

CONCERNS: CREDIBILITY AND MANAGEABILITY

WG6 addressed a multitude of real and potential problems related to using DIS for CD. For the most part, the problems were linked to two practical concerns: credibility and manageability. Under the first, WG6 repeatedly surfaced issues about Verification, Validation, and Accreditation (VV&A), and Configuration Management. VV&A was the #1 vote getter as a problem area. Under the second, WG6 identified a variety of issues pertaining to priority of usage, accessibility, and funding. In addition, the group expressed dismay at the technical challenges confronting the realization of DIS to its fullest, most often mentioning the linking of heterogenous simulations. The group also worried that high-visibility weaponeering simulations will dominate as they have in the past the evolution of DIS at the expense of achieving a balanced, integrated combined arms simulation capability.

Credibility issues. Credibility is absolutely vital to the use of DIS in CD. VV&A is the prerequisite. Ultimately, the business of CD is about making important choices (What doctrine and tactics? How to structure? Where to invest in modernization?). The decision makers who make the choices must have confidence in the evidence presented to them. The OR practitioners must instill that confidence. The underlying modeling must represent the full functionality necessary for the particular CD application. Combat cause-and-effect relationships must be properly accounted for. The model data must be accurate and up-to-date. These requirements continue across the spectrum of verification, validation, and accreditation (VV&A) issues.

WG6 asserted that V&V is still the responsibility of the individual Service modelers (those who are proponents of the simulation), even under DIS; and that Accreditation still belongs to the customer of the simulation-based work. However, being part of DIS carries extra VV&A burdens. For example, the unique interface software between a particular simulation and the DIS network (e.g., Cell Adaptor Unit or CAU) must also be subjected to VV&A. When two or more simulations linked on the network are modeling the same functions (and most likely they will), precedents must be established for dominance of events and outcomes. The VV&A of Semi-Automated Forces (SAFOR) or Computer-Generated Forces (CGF) was particularly worrisome to WG6 to include the representation itself and its consistency with virtual (manned) simulations. There was partial agreement that a single service agency (or a union of a few) should be made responsible for SAFOR/CGF.

The group saw great merit in establishing and publishing DIS-wide standards for particular sub-models and algorithms embedded within individual simulations, as a function of granularity or resolution (e.g., 6-degree of freedom (DOF) engineering, item-system, sortie, battalion). The standards could address how to model target acquisition from air to ground, how to adjudicate direct fire engagements, how to model mobility of ground vehicles, etc. This approach would support V&V in a building block fashion from the bottom-up, help to overcome the shortcoming of stovepiped V&V of individual simulations by separate agencies, and promote greater consistency among the simulation linked on the network.

WG6 believed industry could play a greater role in VV&A, and would do so enthusiastically when offered the opportunity. Industry has a vested interest in the modeling of the functional areas, e.g., air-to-air engagement, logistics resupply, where they are investing or competing. Why not let industry firms review and provide an assessment of the simulation within their particular areas of expertise to support the overall V&V effort?

Finally, in support of VV&A, WG6 concluded: Document ... Document ... Document! Always important, simulation documentation is even more important under DIS because the VV&A process is no longer confined to the simulation owner and a few select customers. With DIS, there are many potential "co-owners" and customers of a particular simulation. Each DIS player must have sufficient information via documentation in order to intelligently select those simulations with which to link, understand what they have linked into, and have confidence about the results they got from it.

Management Issues. WG6 surmised a number of ways that DIS could be mismanaged, mostly based on first-hand experience with today's simulations, and extrapolating into a DIS environment where "demand-exceeds-supply" and budgets are shrinking. There are already indicators that the Army's growing capability in virtual simulations is not keeping pace with the demand for access to it.

WG6 concluded that DoD should fund the continued evolution and operations and maintenance (O&M) of DIS which are "in common" to DoD, JCS, CINCs, and the services; and that customers with unique needs or applications should pay their own way. The funding issue was particularly worrisome to WG6 because they exceed the expertise of most organic resources and will require contracted augmentation. Also, a key potential of DIS is in early concept development, before a funded program exists. "Where will the funds come from?" was the million-dollar question with no satisfactory answer.

The deliberate master planning and scheduling of utilization of DIS-related resources (network, nodal simulations, players over a planning horizon of several years) were cited as critical. WG6 believed the network should be centrally managed while nodal assets should be de-centrally owned and controlled. There must be a disciplined planning process by which to access the resources, and to de-conflict competing demands for their use. In the event that schedules are disrupted and impact costs are incurred, the out-of-cycle users (queue jumpers) should reimburse the expenses of those affected. The DIS network needs a dedicated scheduling mechanism similar to the CINCs' exercise schedule or the Army's Five-Year Test Program (FYTP).

WG6 believed that DIS should be available to anyone with a need to use it and a means to pay for it, to include private industry, FFRDCs, and non-governmental agencies such as universities and research centers. The general consensus was DIS will be enriched by the diversity of users. It should not be free; a charge-back fee to non-government users would offset the cost of DIS O&M and also curtail frivolous demands for access. Prudent management of network access and encryption may be sufficient to protect a firm's proprietary information placed at risk while using DIS.

CONCLUSIONS

DIS offers tremendous potential for combat developments, but not without a price to pay and many challenges to overcome, both technical and managerial. Proof-of-principle demonstrations and video shows are inadequate to build the experience and confidence necessary to exploit DIS for CD. The key is relentless VV&A. To realize its full potential, DIS must be applied to real and tough problems where it will be subjected to critical OR practitioners, demanding military warfighters and users. It must be challenged by minimal-risk decision makers seeking to reduce risk for billion-dollar decisions. We all have to roll up our sleeves and make DIS work for us.

CHAPTER 8
WORKING GROUP 7
TRAINING AND READINESS

Kenneth Lavoie

FOCUS

Investigate the use of DIS for cost effective training and readiness.

SUGGESTED TOPICS

Training multiservice teams; adequate levels of operational realism; potentials for and safeguards against negative training; proper applications of semi-automated forces (SAFOR); additional features desired to optimize training impact; training density issues; command and control considerations; potential for interfacing with mission task trainers and other training devices; utility for reserve components; training and orientation of military personnel to DIS applications; electronic warfare and intelligence operation; exploiting prototype simulators as training devices. Requirements such as terrain resolution, and data collection and reduction issues in support of performance and effectiveness measures.

QUESTIONS EXAMINED

After initial discussions to determine general areas of interest among the participants, the suggested topic areas were restructured under four major issues: training effectiveness, simulator realism, joint and multiservice applications, and semi-automated forces (SAFOR). This grouping did not eliminate the remaining topic areas, but clearly focused the discussions on major areas of group interest. As a matter of working vocabulary, the group limited its deliberations on DIS to virtual simulations. The focus upon manned simulators engaged on wholly synthetic computer generated battle environments seemed the principal application of DIS. There are clearly other more inclusive interpretations of DIS which encompass both constructive or computer combat models, and live or field training exercises. It is important in reading this report to recognize the limits placed by the group on the range of application of the DIS terminology.

SPECIAL WORKING GROUP BRIEFING

After determining the four major topic areas that the group would focus on, two briefings were provided by group members. COL Overstreet provided a briefing on the Army's Close Combat Tactical Trainer project. The briefing covered the objectives, development schedule, and provided insights on the near term technology to be implemented. The second briefing by Dr. Herb Bell of the Air Force Armstrong Laboratory addressed ongoing efforts to apply DIS technology to Air Force training needs.

On the topic of SIMNET or DIS protocols, the work by Armstrong Labs identified the need for additional data elements to be incorporated in each packet describing a fast moving airborne vehicle. These additional elements were necessitated by the increased speed and three dimensional travel of the vehicles.

Work done at Armstrong Labs with front line pilots provided significant insights into the applicability of DIS to aircrew training.

It was found that for air-to-air engagements occurring beyond visual range, or at extended visual ranges, the simulators were capable of providing a positive contribution to aircrew training. However, once the combat range collapsed to close-in encounters, the importance of near instantaneous position updates, coupled with the need for near perfect visual representation to support visual cueing, exceeded the capabilities of the simulators.

Similarly, it was found that the requirements for graphical representation of terrain and target features precludes the use of current systems for air-to-surface weapons delivery training.

It was also confirmed during the experiments that there is a significant risk of negative training when simulators are used for tasks in which their fidelity is inadequate. Pilots attempt to use the information provided by the simulator and modify real world procedures to compensate for simulator short falls. This is a fundamental danger zone for negative training to be watched for with great diligence.

It would appear, therefore, those SAFOR that can credibly replicate the performance, impact, and C^2 relationships of tactical airpower would be prime research areas for the support of joint operations.

GENERAL APPROACH

The evolution of DIS capability from its genesis in SIMNET has been significantly influenced by technology. To the point that it is probably safe to say that DIS is the result of a "technology push" effort. For this reason the working group adopted the contrary view of "requirements pull" in discussions of the applications and purposes of DIS. In fact, some time was spent discussing the DIS vision that has appeared in the literature for a seamless exercise spanning the entire command and control structure from theater commander to the individual weapon system operator -- the "god to squad" view. The discussions within the working group did not support a training requirement served by this capability. Because of the significant differences in planning horizons, tempo of operations, information needs, and fundamental training focus at the various levels within the command and control structure, we saw no direct training benefit from such an exercise structure. In fact, it was more likely that there could be disadvantages to such an expansive training exercise. The inability of various echelons to pause, reexamine, or accelerate the exercise as necessary for the accomplishment of their specific training objectives because of the linkage to other echelons of the C^2 structure was seen as a disadvantage.

FINDINGS - TRAINING EFFECTIVENESS AND SIMULATOR REALISM

The discussions on Training Effectiveness and Simulator Realism followed fairly classical lines emphasizing the need to clearly articulate and understand the training objectives, as well as carefully defining the target training audience. The training equivalent of defining the problem seems even more important in a discussion of DIS where there is clearly the danger of becoming infatuated with the technology and ending up applying

Table 2-1. Training Objectives

CINC View	Unit/System View
- Exercise Decision Making	- Safety/Constraint Relief
- Develop Staff Procedural Proficiency	- Large Group Participation
- Evaluate OPLANs	- Employ EW Systems
- Examine Strategy Options	- Ease Maneuver Limits
	- Improve Tactics

it inappropriately. With training objectives clearly defined for a specific training audience, the final stage of problem definition is to evaluate the relative costs and benefits associated with DIS versus other training opportunities.

FINDINGS - JOINT AND MULTI-SERVICE APPLICATIONS

As stated previously, a requirements based viewpoint was adopted to determine the most effective applications of DIS technology in the training area. Broad training objectives were developed from both the theater CINC perspective and from a small unit or weapon system operator perspective. The objectives are provided in Table 2-1.

The most striking aspect of this categorization of objectives is the lack of common training objectives for the two groups. Thus,our discussions lead to the general consensus that large combined arms and multiservice training exercises were most efficiently and effectively accomplished using constructive simulation. Smaller training audiences composed of teams, new systems, or joint task forces were the training areas best suited to capitalize upon the capabilities of DIS. Individual weapon/vehicle skills or crew task proficiency training constituted the third group of training events. These were considered to be best accomplished by field exercise or part task trainers. This categorization is captured in Table 2-2.

FINDINGS

A considerable amount of time and effort was devoted to defining the requirements for semi-automated forces (SAFOR). The ability of the SAFOR to demonstrate the required degree of realism in their actions and reactions are critical to DIS being a viable tool for effective training. Figure 2-1 identifies the fundamental components of a SAFOR system. Specific functional charac-

Table 2-2. DIS Training and Readiness

Type/Level of training	Appropriate Technology	Comments
Combined Arms Multiservice	Constructive Simulation	"Joint" does not equal "large"
Teams Systems	DIS	Tasks requiring external simulation are good candidates for DIS
Individual Skills Crew Tasks	Weapons/vehicle trainer Embedded trainers Live field training	DIS not cost effective for operation skill

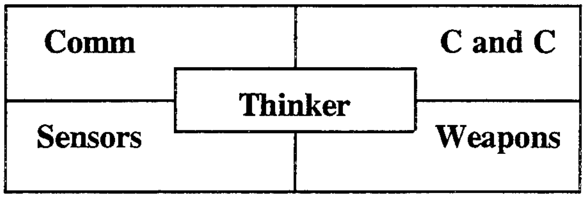

Figure 2-1. Data Collection

teristics of SAFOR systems are as follows:

- Being indistinguishable from manned systems is critical to the accomplishment of training objectives.
- A data collection capability is needed to capture simulated communications among SAFOR as well as between SAFOR and live units.
- The decision processes affecting SAFOR actions must be captured and be available for debriefing.
- Human factors such as morale, fatigue, and indecision must be exhibited by SAFOR.
- Tactics, perceived objectives, rules of engagement, and decision processes must be adaptable to the specific enemy consistent with the training scenario.
- The span of control of SAFOR operators must be increased significantly so that units can train in large scale operations without excessive controller costs.
- Identification issues of friend, foe or neutral systems must not be automatically resolved either among or between SAFOR.
- Terrain avoidance and dynamic terrain representation are improvements necessary to realize the full training potential of DIS.
- The need to validate the performance of the SAFOR should be an integral part of the basic design to ensure that the necessary data are explicitly represented and captured for review.

AREAS FOR FURTHER RESEARCH

During the discussions about the four major topics above, a number of issues were found to require further research to determine if they constitute real issues or to advance the current state of their representation within DIS.

Topics Requiring Basic Research. (1) Measurement of Training Value: While the participants were convinced that DIS offers great training potential, the practicality of quantifying the improvement in training was an issue. It was central to the overall approach to the training and readiness issue that cost benefit comparisons be done between DIS supported training events and other training options. It, therefore, seems prudent to commission a study to identify those training events for which DIS provides the most cost efficient training approach.

(2) Real vs. Generic Data and Positive Vs. Negative Training: In many instances the training community is either limited to using unclassified data, or actually prefers using unclassified data. Discussions centered on the training implications of using less accurate data (tacit assumption being that classified information is more accurate) for training purposes and whether this would have a practical, adverse effect. The fundamental concern was for those situations where the tactical implication of a weapon system would be altered by the operator based upon erroneous data in the system representation.

(3) Train the Trainer: The extent of the

training program that will be required to train the personnel who will operate the DIS was another area of discussion and concern.

Topics Requiring Further Research. (1) Bandwidth: Despite assurances to the contrary, it appears prudent to consider the impact upon bandwidth of increased data elements necessary to accommodate fixed wing aircraft, and significantly increased systems represented by either SAFOR or manned simulators.

(2) Multi-Level Security: The ability to more precisely manage access and use of accurate classified data on the network would be a considerable assist in dealing with the use of inaccurate unclassified data.

(3) EW Representation: The current representation of Electronic Warfare (EW) needs to be enhanced to ensure the most effective training. Training in a representative EW environment can be of considerable benefit in minimizing the disruptive impact of real world exposure to EW and can greatly enhance the awareness of system operators to existing work around procedures to minimize the impact of EW on operations.

(4) Dynamic Terrain: The ability of the terrain to reflect the impact of operations is important to the continued improvement of training fidelity.

(5) Debriefing System: A first class debriefing capability is key to maximizing the training potential of DIS. The requirements for such a system should be integrated into the design of the overall DIS, as was suggested in the design of the SAFOR.

CONCLUSIONS AND RECOMMENDATIONS

- DIS shows considerable promise in the training arena particularly for small unit to joint task force operations.
- Joint training objectives should be defined which have been specifically identified as being most efficiently accomplished using DIS.
- There will remain training events that are best suited to live, DIS, or constructive model supported exercises. The specific areas of application of the three exercise types should be studied and guidelines provided to the training community.

CHAPTER 9
WORKING GROUP 8
REQUIREMENTS DEVELOPMENT AND DEFINITION

Dr James Metzger

PURPOSE

As stated in the Terms of Reference, Working Group 8 was responsible for investigating the use of DIS as the basis for experiments to determine whether a conceptual materiel system can satisfy an identified need and what the performance characteristics of such a materiel system should be. The actual discussions of the Working Group focused on the topic of the use of DIS to support the overall Acquisition Management process; that topic is, therefore, the subject of this chapter.

BACKGROUND

Features of DIS that are useful for supporting the Acquisition Management process include:

- DIS allows warriors to be active participants, thereby enhancing the acceptability of results.
- Due to its interactive nature --
  - DIS allows for reactive activities, for both friendly and enemy forces, thereby again enhancing acceptability.
  - DIS provides for visualization and play back, thereby facilitating assessments of cause and effect.
  - DIS can be used as a calibration tool for the representation of command and control in constructive M&S.
- DIS permits the linking of diverse simulators and simulations.
- DIS provides a less costly alternative to live exercises.

ESSENTIAL TECHNICAL AREAS

It is essential that DIS be capable of providing assistance in the following technical areas:

- Determining a mission need. This includes assessment of the contributions of doctrine, organization, training, leader development, and user, as well as the contribution of a materiel system.
- Defining, refining, and assessing the operational requirements for a materiel system.
- Developing, refining, and assessing performance characteristics of a materiel system. Note that this requirement demands significantly more fidelity than does dealing with operational requirements.

POTENTIAL TECHNICAL AREAS

DIS may be helpful in the following areas:

- Determining training characteristics for a materiel system.
- Determining supportability requirements for a materiel system.
- Determining requirements for interoperability of a materiel system with other systems.

FUNDAMENTAL CAPABILITIES

In order to be able to provide assistance in the essential technical areas identified above, DIS must have:

- Validated representations of battlefield activities and materiel systems.
- Extensive pre- and post-processors.
- A realistic environment. It must be robust, portable, common to all participants, and capable of representing joint activities.
- Extensibility, both in terms of types and numbers of materiel systems represented and in terms of the level of detail for individual systems.
- Well-defined interfaces, standards, and protocols.
- "Good" fidelity at varying levels of resolution. Here "good" is determined by the particular application; e.g., the fidelity must be greater for dealing with performance characteristics than for dealing with operational requirements. In conjunction with extensibility in level of detail, this argues that simulators and protocols should be designed in such a way that resolution can be varied depending on the application.
- Modular, adaptive simulators. This means that individual simulators can be easily reconfigured to represent new or revised materiel system capabilities, and possibly could mean generic simulators that can be configured to represent a variety of systems and associated capabilities.
- A full-time support staff for DIS centers.
- High reliability for all components of DIS, including individual simulators, communications, computers, and software.

CAVEATS

The positive potentials of DIS must be tempered with realism:

- Development of DIS with the "good" fidelity necessary for support to Acquisition Management may require significant up-front investment.
- The use of DIS can place significant demands for personnel resources; i.e., participants, as well as support staff such as controllers and data base experts.
- DIS is but one tool for supporting Acquisition Management. It cannot answer all questions.
- DIS lacks repeatability, thereby complicating experimental design and potentially masking cause and effect relationships.

CONCLUSION

DIS has potential value in supporting the Acquisition Management process, but may require significant investment to be useful.

RECOMMENDATIONS

- Perform research to identify the level of detail needed to provide "good" fidelity for the use of DIS in support of Acquisition Management.
- Perform a cost-benefit analysis to address the costs and benefits of DIS in support of Acquisition Management.
- Invest in the following fundamental capabilities now:
  - Validated representations.

- Pre- and post-processors.
- A realistic environment.
- Extensibility.

- Support the proposed proof-of-principle project initiated by the Office of the Assistant Secretary of Defense (Program, Analysis and Evaluation) and the Defense Advance Research Projects Agency to demonstrate the utility of DIS for combat identification.

CHAPTER 10
WORKING GROUP 9
SIMULATION PROTOTYPING TO SUPPORT ACQUISITION

Richard E. Garvey, Jr FS

The focus of Working Group 9 was to examine prototyping using Distributed Interactive Simulation (DIS) environments to support the materiel acquisition process.

On 29 September 1992, we met and spent about an hour in a "get acquainted" mode. Each person explained his current work and reasons for coming to the DIS Mini-Symposium. We then discussed the purpose of our working group, the required format of our report, and the agenda for the following day. We ended by organizing into sub-groups on the following topics: Uses of DIS, Limitations of DIS, Required DIS Enhancements, and Technical Considerations.

On 30 September 1992, we began with the presentation of two papers:

- "Simulation Prototype: the LOSAT Weapon System" was presented by Mr. Gregory B. Tackett, U.S. Army Missile Command.
- "DIS Prototyping for Intelligent Subsystems" was presented by Dr. Alton L. Gilbert, Technical Solutions, Inc.

Following these presentations, we had a general discussion with the entire working group participating. We then divided into sub-group discussions. Each sub-group reported on its findings to the entire working group which provided the opportunity for exchanging comments and clarifying main points. At the conclusions of the presentations, the four sub-group chairs and the working group chair met to discuss and assemble the report that would be delivered to the Mini-Symposium the next morning.

Summary findings of each sub-group along with general conclusions and recommendations follow below.

FINDINGS

Sub-Group A, which was chaired by Mr. Richard E. Helmuth of Douglas Aircraft Company, reached the following conclusions regarding principal uses of DIS for simulation prototyping (Pre-Milestone 0 through Milestone II):

- Development of consistent MOE/MOP for ALL communities
- Requirements definition/refinement
- Research
  - C^2
  - Support (CS and CSS)
  - Behavioral phenomena
  - Alternate technologies

Sub-Group B, which was chaired by James P. Hogarty of General Research Corporation, came up with the following <u>Current Limitations</u> of DIS for simulation prototyping:

- Configuration control/documentation
- VV&A
- Testbed availability
- Limited warfare "arena" (NOT seamless)

- Resources
- Community acceptance

Sub-Group C, which was chaired by Mr. Gregory B. Tackett of the U.S. Army MICOM, concluded that the following are the major Required Enhancements of DIS for simulation prototyping:

- Environment
  - Natural
    - -- Weather, Day/night
    - -- Fidelity, Correlation
    - -- Standard data base library
    - -- Rapid terrain DB generation
  - Man-Made
    - -- Battlefield obscurants
    - -- Dynamic terrain
    - -- EW/Commo
- DIS System
  - Higher fidelity displays
  - Number of entities
- Systems
  - Sensor algorithms/signatures
  - Artillery and effects
  - Modular system component libraries
- Data
  - Approved weapons performance data
  - Approved scenarios

Sub-Group D, which was chaired by Dr. Ronald C. Hofer of the U.S. Army STRICOM developed the following list of Issues/ Questions for Further Research:

- Classified operations/shared data bases/ communication services
- Aggregation/Disaggregation
- Linkages to Higher Order Models
- VV&A
- Linkages between Combat Development, Materiel Development, Analytic, and Operational Test Communities

CONCLUSIONS

- DIS prototyping can be valuable to the materiel acquisition process
- Acceptance will depend on enhancements, disciplined use, and education
- A shared investment by DOD is required

RECOMMENDATIONS

- That DOD invest in the further development and enhancement of DIS technology
- That DOD change the materiel acquisition process to include DIS prototyping as appropriate

CHAPTER 11
WORKING GROUP 10
COST/BENEFIT/RISK OF DIS

Edward C. Brady, FS

Working Group 10 of the DIS Mini-Symposium was charged with the exploration of the costs, benefits, and risks of DIS. Over 20 attendees at the mini-symposium participated in the working group's discussions and deliberations, which covered a very wide range of potential applications and issues.

DEFINE DIS AND ITS APPLICATIONS

The working group found that it needed a definition of DIS. The group included representatives from multiple application areas, and their vision of DIS appeared to be much broader than that comprised of manned weapon system simulators, SAFOR, and associated protocols. The group defined DIS to be:

> "Any interactive combination of virtual, constructive and live simulations."

This definition encompasses SIMNET as originally implemented, but it would also include situations such as CBS linked to TACSIM and ENWGS, SIMNET linked to EAGLE, and SIMNET linked to units exercising at the NTC. Similar examples could be drawn from the Navy and the Air Force.

In addressing the issues of cost, benefit, and risks the group included applications that ranged from macro to micro levels. The macro levels began with the "road to war" and included such applications as crisis management, industrial readiness, mobilization conflict, demobilization, and reconstitution. Micro levels included system on system or item level applications, ranging from one-on-one duels to small unit engagements in a combined arms context.

The group developed the categorization scheme illustrated in Figure 11-2 -- a DIS architecture organized according to echelon, continuum of conflict, and application. It was the consensus of the group that all elements of this architecture are valid candidates for DIS. It was further noted that experience to date is narrow: primarily collective training at the small unit level in hostilities. The benefits of the technology clearly can and should be extended throughout the architecture.

Given the architecture described above the working group concluded that DIS offers significant benefits. The group believes, however, that it is a matter of major concern that the range of potential applications and, thus, benefits is much larger than the very limited applications which exist currently. Moreover, rigorous, quantitative evaluation of benefits for existing applications is not widespread; most evidence is anecdotal.

The working group is convinced that DIS applications will be valuable and that the sooner the applications are available, the better. Moreover, the group urges caution. Resources are scarce. DIS overall will compete for funding and within DIS various applications will make claims on limited

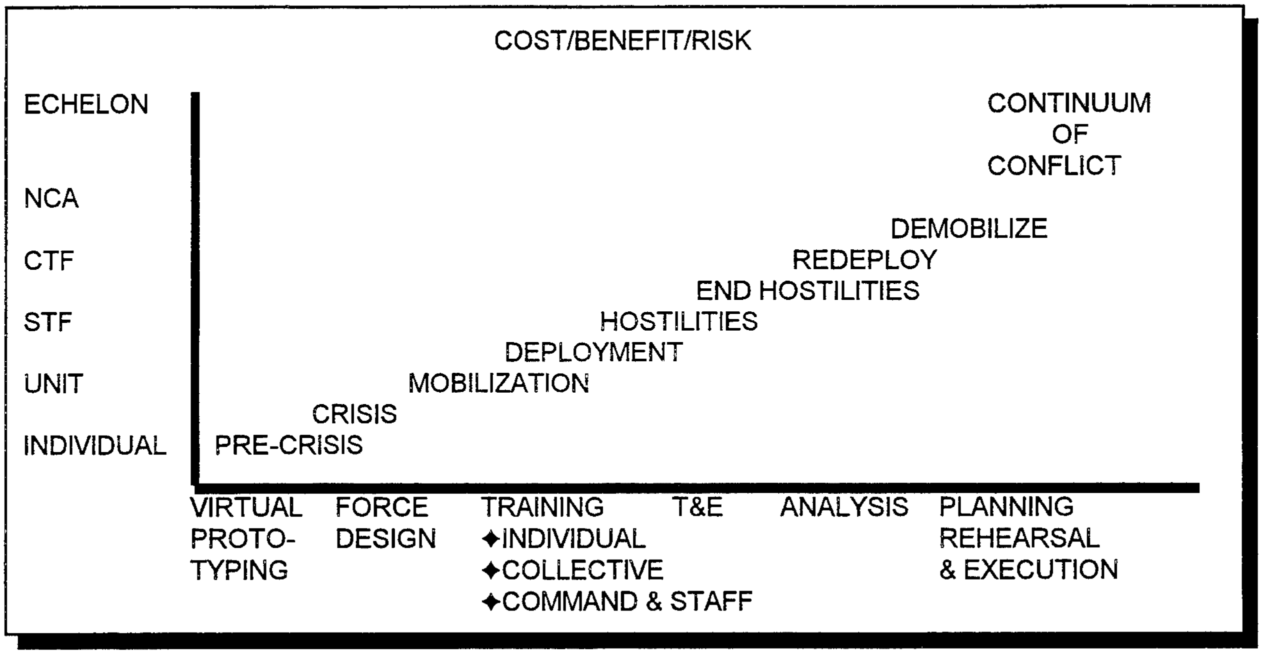

FIGURE 11-2. DIS Architecture

resources. Given this situation, it is important to have an overall strategy or plan -- what to do, why, and when. That plan does not, in the group's view, exist. We recommend that such a plan be developed.

COST/BENEFIT/RISK

In initiating its discussions, the working group examined a set of hypotheses concerning costs, benefits, and risks. Broadly speaking, the hypotheses were that:

- There were no major impediments to estimating the costs of DIS applications, but that the effort had not yet been made;
- There were significant benefits to DIS, but that benefits of specific applications had not yet been measured; and
- Risks associated with costs, schedule, and performance while not exhaustively identified appeared to be manageable.

In its discussions and deliberations the working group uncovered no reasons to reject these hypotheses. However, the following risks were identified as worthy of note:

- The expectations that DIS is immediately available are based upon demonstrations and prototypes in limited numbers with limited capabilities. If past experience holds, hardware and software which are affordable and fieldable in larger quantities may not be available for a while.
- The full costs of DIS have not yet been determined and many costs, particularly operating costs such as configuration management, data management, support staffing, verification, and validation, have not yet been addressed in detail. These hidden costs may be large and may not fall naturally into any one organization's budget.
- The development of models and simulations for DIS applications will pose a

series of challenges since it will be necessary to break new ground. Validation of these new developments will be very challenging. SAFOR is a good example of this -- the costs of specific applications and the benefits depend upon the validity and scope of associated SAFOR. SAFOR technology is not yet mature. Similarly, the question of matching fidelity to application remains open and must be resolved.

- Among developers of DIS and among potential users, there are perceptions that DIS replaces tools currently used in all applications. This perception is not correct. DIS will augment other tools and approaches. Care must be taken if we are to avoid premature acceptance -- or rejection -- of DIS in various applications.

CONCLUSION

In summary, the working group concluded that the benefits of DIS may be substantial. These benefits must be defined, data must be collected, and quantitative estimates developed. There is evidence that initial steps toward this goal are being taken (an interesting briefing on an ongoing project was presented). They should be emphasized and resourced. With respect to costs the working group believes that there is no methodological barrier to estimating costs, but that commitment of resources is required. Attention must be focused on hidden costs which to date have largely been ignored. Finally, the group concluded that risks are real but manageable. Further, the group noted the potential existence and danger of a mismatch between perceptions and expectations and the likely near term and longer term results of DIS programs. It is important to proceed with and to implement DIS. It is equally important that existing tools and methods not be rejected prematurely or inappropriately because of misperceptions regarding the benefits and costs of DIS applications.

Appendix A
GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ADS	Advanced Distributed Simulation
ALSP	Aggregate Level Simulation Protocol
ASA(RDA)	Assistant Secretary of the Army (Research, Development and Acquisition)
C^2	Command and Control
CAU	Cell adaptor unit
CCTT	Close Combat Tactical Trainer
CD	Combat Development
CSSTSS	Combat Service Support Training Simulation System
COTS	Commercial off the shelf
CGF	Computer Generated Forces
CBS	Corps Battle Simulation
COEA	Cost and Operational Effectiveness Analysis
DARPA	Defense Advanced Research Projects Agency
DSI	Defense Simulation Internet
DOF	Degree of freedom
DoD	Department of Defense
DIS	Distributed Interactive Simulation
EOA	Early Operational Assessment
EW	Electronic warfare
FFRDC	Federally funded research and development center
FOT&E	Follow-on OT&E
FYTP	Five year test plan
GOTS	Government off the shelf
IOT&E	Initial OT&E
LANL	Los Alamos National Laboratory
MAIS	Major Automated Information Systems
MOR	Military Operations Research
MORS	Military Operations Research Society
O&M	Operations and maintenance
OASD(PA&E)	Office of Assistant Secretary of Defense (Program Analysis & Evaluation)
OSD	Office of the Secretary of Defense
OT&E	Operational test and evaluation
OR	Operations Research
OUE	Operational Utility Evaluation
PDUs	Protocol data units
RFPs	Requests for proposals
SAFOR	Semi-automated forces
SIMNET	Simulation network
STRICOM	U.S. Army Simulation, Training and Instrumentation Command
T&E	Test and evaluation

TRAC	U.S. Army Training and Doctrine Command Analysis Command
TRAC OAC	U.S. Army TRAC Operations Analysis Center
TRADOC	U.S. Army Training and Doctrine Command
USAAC (DCD)	US Army Armor Center Directorate of Combat Development
VV&A	Verification, validation, and accreditation

APPENDIX B
TERMS OF REFERENCE

MORS Mini-Symposium:
Distributed Interactive Simulation (DIS)
8 July 1992

1. **Goal:** The first goal of this mini-symposium is to familiarize the military operations research community with the concept and capabilities of a Distributed Interactive Simulation (DIS) and synthetic combat environments. The second goal is to have the participants explore the use of these capabilities to meet their operations research and analysis needs.

2. **Background:**

a. Synthetic Combat is a computer simulation that allows groups of users immersion in a simulated battle. Synthetic combat environments allow a computer-human interface where analysts may navigate in information-based space to explore systems and combat operations without going to the field.

b. The DARPA/Army SIMulator NETwork (SIMNET) is the current proof-of-principle. SIMNET has proven itself as:

(1) a useful man-in-the-loop combat simulation;
(2) a tool for exploring operational concepts, unit tactics and procedures;
(3) and a means of introducing very early manned simulators of developmental weapon systems into simulated combat environment.

The core notion of SIMNET, a DIS system, has been designated as a key element of the DDR&E's Science and Technology area number six (Synthetic Environments). This thrust includes technology for acquisition, combat developments, and training and readiness.

c. Future DIS systems must interoperate with different SIMULATORS and SIMULATIONS at different levels of resolution and aggregation. Real-time dynamic objects must allow modification of terrain and cultural features distributed in the DIS network. Protocol data units may allow a wide variety of operational systems, manned simulators and closed-form simulations to be interoperable in real-time. DIS protocols require a style of interaction that is different from traditional modeling and simulation. The simulation and modeling architectures are radically different. The Military Operations Research Society (MORS) Mini-Symposium is an excellent organizational vehicle to stimulate thought and work in this area.

3. **Objectives:**

a. The purpose of this MORS mini-symposium is to explore military operations research applications of DIS technology and its environments. The symposium will provide a forum to examine DIS technology applications to analysis, testing, and training. The major objectives are to provide:

(1) a learning experience;
(2) examine the utility and limitations of the DIS simulation environments; and
(3) develop issue areas in the use of synthetic environments for bench marking and data collection.

b. Within these general objectives, the forum will specifically address the following subjects:

(1) explore the role of DIS in force planning and contingency analysis;
(2) examine the use of DIS to analyze adaptive tactics, techniques and procedures;
(3) examine the role of DIS in defense acquisition systems and early life cycle prototyping and testing of new concepts. Use of selective fidelity and rapid prototyping, and computer networking for concurrent engineering will also be examined;
(4) analyze the use of DIS for historical representation and analysis of battles; and
(5) identify useful extensions for DIS.

4. **Approach:** The mini-symposium will achieve the above objectives through a multi-layered approach which will include:

a. A read-ahead package will be sent to all participants to provide background information and an overview of DIS capabilities and objectives.

b. Plenary sessions featuring keynote speakers who will address visions for DIS synthetic combat as well as assessments of DIS limitations and current applications and lessons learned. Working group introductions and a social mixer will close out the first day of the mini-symposium.

c. *Working groups*: Working group tracks will meet on the second day of the mini-symposium. The working groups are:

(1) Military Analysis (investigating battle outcomes, tradeoff studies),
(2) Test and Evaluation,
(3) Operations Planning and Rehearsal,
(4) Logistics, Mobilization, and Sustainment,
(5) Force Developments (force structure, mission area analyses),
(6) Combat Developments (doctrine, tactics, procedures),
(7) Training and Readiness
(8) Requirements Development and Definition,
(9) Simulation Prototyping to Support Acquisition, and

(10) Cost/Benefit/Risk of DIS.

Each working group will identify uses, limitations and enhancements of DIS to support their specific needs. Each group is encouraged to address human performance and behavioral concerns, environmental requirements such as terrain resolution, and data collection and reduction issues in support of performance and effectiveness measures.

d. *Demonstrations*: During the second day of the mini-symposium, a War Breaker demonstration on the acquisition and attack of critical mobile targets will be given at the Simulation Center, Institute for Defense Analyses, 1801 N. Beauregard Street, Alexandria, VA.

e. On the morning of the third day, a wrap-up session will be held for the working groups to present their findings and to identify any possible follow-on efforts appropriate for MORS support.

f. An optional tutorial for DIS standards will be offered the evening prior to the start of the mini-symposium.

5. **Membership:**The representation is expected to be 50% DoD and 50% industry and academia. Congressional staffers and General Accounting Office (GAO) personnel will be invited. Working groups should be limited to 25 people. Working group chairpersons should be considered subject matter experts in their session area. Membership in the working groups will be controlled by the working group chairpersons.

6. **Product:** A briefing will be prepared for the sponsors of the meeting to report findings, conclusions, and recommendations. A proceedings will be prepared containing an executive summary, each working group's report, and copies of papers and briefings presented.

7. **Proponents:**The Army and Navy have agreed to be co-proponents for the mini-symposium. The Air Force, OSD, and the Joint Staff have expressed supportive interest.

8. **Planning and Organizational Committee:**

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9. **Administration:**

Title: Distributed Interactive Simulation (DIS) a Synthetic for Military Operations Research

Proponent: US Army and US Navy. The Executive Agent will be the US Army Operational Test and Evaluation Command. MORS will provide administrative and logistics support.

Dates: 29 Sept - 1 Oct 92

Fee: $150.00 (Federal Government)
$300.00 (Others)

Attendance: Limited to 250 attendees

Classification: Unclassified

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