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MILITARY OPERATIONS RESEARCH SOCIETY

Workshop Report

Advanced Distribution Simulation (ADS) for Analysis

Ed Brady, FS, Chair

30 January - 1 February 1996
Williamsburg, Virginia

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MORS Advanced Distributed Simulations for Analysis '96 Workshop Executive Summary

1. Introduction. Advanced Distributed Simulations (ADS) and their appropriate use by the defense analytical community were the focus of a MORS Workshop, ADSA '96, sponsored by ODUSA(OR), OCNO(N81), HQ USAF/XOM, Joint Staff (J8) and OSD (PA&E). ADSA '96 was another in a long series of MORS Workshops whereby MORS leadership provides a forum for experienced military analysts from all Services and the supporting civilian communities to weigh in on a tough question or issue facing the defense community. Generally, these workshops take the form of working sessions where participants strive to clarify the question or issue and propose approaches to assist the DoD in issue resolution. These forums have served the defense community well by providing insight as to where DoD analytical efforts should be focused or leveraged, or, in some cases, to help the analytical community better understand major changes in policy affecting their work.

For this particular Workshop, over 100 senior military and civilian analysts gathered in Williamsburg, VA, from 30 January to 1 February 1996 to have a frank discussion on the applicability/utility of ADS and Distributed Interactive Simulation (DIS) technologies to the analytical community and to document findings and recommendations resulting from the discussion. Much of the discourse that preceded the Workshop and continued through the initial Workshop sessions focused on the need for a definition for ADS. Ed Brady, FS, the General Chair, believed that any definition would restrict the potential applicability of ADS but finally proffered the following:

Advanced Distributed Simulation — The evolving DoD distributed modeling and simulation (M&S) infrastructure, including synthetic environments, run-time infrastructures and connected human-in-the loop (HITL) simulations such as DIS.

For the purposes of this discourse, both ADS and DIS are distributed but ADS is considered a much broader set of modern M&S capabilities than DIS. For example, ADS has the potential to include the interaction of constructive-to-constructive simulations and constructive-to-live simulations as well as the virtual simulations connected by DIS. Note also that this definition does not require an HITL as part of any particular instance of an ADS. The variability of humans-in-the loop is a major concern to analysts dependent upon replicability of experiments

Leveraging off lessons learned from previous MORS Workshops, advance preparation for the ADSA '96 included a facilitators training session for chairs and co-chairs in Arlington, VA — scheduled in between the multiple snow storms that blanketed Washington most of that winter. This training session was to acquaint the chairs (listed in Table 1) and co-chairs with known ADS issues and to prepare them for getting the most out of their respective working groups. In addition, all Workshop participants were provided a healthy reading package (see Table 2) in advance of the actual Workshop.

2. Chair's Charge. During his comments at the opening of ADSA '96, Ed Brady, FS emphasized to the Workshop participants that they should focus on identifying potential solutions that would be of value to both the analytical community and the M&S community. In particular, the participants were asked to identify:

(1) Appropriate uses of ADS/DIS capabilities by the analytical community

(2) Inherent limitations and advantages of ADS/DIS capabilities

(3) Current shortcomings of ADS/DIS capabilities, that if remedied could significantly improve the utility of ADS/DIS capabilities to the analytical community

(4) Ways to analyze and test the relevance and quality of ADS/DIS-based tools for the analytical community

Table 1: ADSA '96 Workshop Chairs and Working Group Chairs

General Chair - ADSA '96	Ed Brady, FS	Strategic Perspectives Inc.
Working Group I- Battlefield Effectiveness Chair	Mike Bauman	Army HQ TRAC
Working Group 2 - Material, Systems and Acquisition Chair	LtCol Bob Sheldon	Air Force AFSAA/SAZ
Working Group 3 - Test and Evaluation Chair	Dr. Hank Dubin	Army OPTEC
Working Group 4 - Training, Mission Rehearsal and Alternate Courses of Action Chair	Fred Hartman	Foxhall Group
Working Group 5 - Analysis and Requirements Chair	Dr. Cy Staniec	OSD(PA&E)
Working Group 6 - Understanding Behavior/Performance Chair	Dr. John Friel	RAND
Working Group 7 - Synthesis Chair	Dr. Stu Starr	MITRE
Technical Co-Chairs	Ted Bean and Tana Reagan	MITRE

Table 2: ADSA '96 Read Ahead Package for Participants

Sikora, Jim, and Phil Coose	*"What in the World is ADS? PHALANX* June 1995
Under Secretary of Defense for Acquisition and Technology	*Modeling and Simulation (M&S) Master Plan*
DMSO	*HLA Management Plan High Level Architecture of Modeling and Simulation,* Version 1. 6
Davis, Paul K	*Distributed Interactive Simulation in the Evolution of DoD Warfare*
Davis, P. K., and D. Blumenthal	*The Base of Sand Problem: A White Paper on the State of Military Comhat Modeling*
Hammer, Peter L.	*Annals of Operations Research*
Lese, Jr., William G. and Jim Metzger	*Future Joint Warfare Analysis Model Designs*
Oswalt, Ivar	*Technology Trends in Military Simulation*
Smith, Mark E.	*Determining the Utility of Advanced Distributed Simulation to Test and Evaluation*
Kloeber, Jr., Jack M. and Jack A. Jackson	*Issues in Using a DIS Facility in Analysis*
Bolling, Robert H.	*The Joint Theater Level Simulation in Military Operations Other than War*
MORS Mini-Symposium	*Distributed Interactive Simulation (DIS) Proceedings*

Products resulting from the Workshop were to be focused on the clarification of issues and problems and the identification of potential solution "spaces." In particular, the expectations of MORS Sponsors included understanding ways to use ADS-based analysis that differed from those of other analyses as well as identification of classes of analyses most amenable to support by ADS-based tools. Those classes of analyses for which ADS tools are not useful would also be very useful to MORS Sponsors. This required the participants to think back on the question: "Why do we analyze what we analyze?" Is it because of available analysis tools? Our own limited knowledge? How can ADS-based tools be used to give us more insight? More importantly, given the changing nature of the questions military analysts are being required to answer, what class of questions looks amenable to analysis by ADS based tools independent of whether or not they are currently available or technologically feasible? Clearly, an answer to this last question would help focus ongoing research. Another area of particular interest is the identification of experiments designed to assist in the development of Measures of Merit (MoMs) for analysis of Command and Control (C2) and other heavily human-related functions. Given the evolving nature of ADS and the changing questions being put to analysts, there was room in the participants' discussions for many differing views of ADS and areas ripe for its potential use.

The remaining ADSA '96 Workshop format consisted of (1) an overview of ADS Technology by Dr. Randy Garrett of DARPA, (2) a keynote address by Dr. Anita K. Jones, Director of Defense Research and Engineering, OSD, (3) a senior practitioner's panel and (4) the kickoff of working group sessions. The Working Group (WG) sessions continued through the last day with WG Chairs reporting out the results of their sessions the last afternoon

3. Keynote Address. A summary of Dr. Jones' keynote address is available in the June 1996 *PHALANX*. For our purposes, Dr. Jones observed that it was propitious to conduct an ADS workshop since there are several things that are new in the world of the analyst.

First, the analyst is being asked to address questions, some of which are new, in a more sophisticated way. With the dissolution of the Warsaw Pact and the Soviet Union, the world is proving to be much more complex from a national security perspective. For example, the U.S. faces a much more ambiguous threat from multiple countries with diverse capabilities; defense planning revolves around "multiple scenario" problems; and the U.S. military and its allies are being asked to undertake new types of military operations, such as complex humanitarian operations in Africa and peacekeeping in the former Yugoslavia. Since most of these issues involve complex joint/ coalition activities, the analyst must consider the effect of joint/coalition involvement at the very outset of the analysis. In addition, it was not unusual, several years ago, for analysts to assume "perfect" C2 and to perform assessments within that context. In view of the importance of C2 in the Chairman of the Joint Chiefs of Staff (CJCS) Vision 2010, such an assumption is clearly no longer acceptable. Finally, there is increasing recognition of the importance that a broad set of environmental effects can have on analysis (for example, more granular terrain to capture the effects of terrain masking; the properties of obscurants and their effects on the performance of intelligence, surveillance and reconnaissance (ISR) systems; and the challenges posed by detecting,

characterizing and reacting to chemical and biological agents).

Second, the analyst is being asked to communicate information more effectively to decision makers. Most decision makers are no longer satisfied with columns of numbers. They want visualization and animation tools to capture the salient aspects of an analysis and the opportunity to participate in a dynamic, "what if..." dialogue with the analyst.

Finally, it was observed that several communities (e.g., trainers, acquirers of systems) are acquiring new simulations and data, both of which have the potential to support analysts substantively. This suggests the desirability of working more closely with these communities, both to leverage their investments and to share the simulations and data developed by the analytical community. The DoD "high level architecture" initiative was also introduced as providing an evolvable and accessible framework with a common support structure, common rules for how components interact, and shared support services to support the front-end analysis that must be done as part of any simulation design process. The structure and commonality encourage interoperability of simulations.

4. Senior Practitioner Panel. As Ed Brady, FS introduced the senior practitioner panel, he noted that it was placed on the Workshop agenda to motivate the participants with the diversity of opinion on ADS. Although working groups were formed around a major area, they were not independent and needed to be aware of other organizational and individual opinions as they went through their own deliberations. The comments of each of these panel members are summarized below.

Dr. Randy Garrett (DARPA) — Dr. Garrett highlighted the issue of technology transfer in relationship to acquisition, stressing that we must find quicker ways to take innovative solutions out of the labs and into systems where they can gain wider acceptance and usage. He asked the working groups to consider the obstacles that keep the two communities from sharing. On the high level architecture, he observed that the city planning analogy as a technology framework for achieving interactions among simulations and live C2 systems, only goes so far. Building codes used by city planners are based upon a lot of experience; civil engineers have a long history of knowing what works and what doesn't. But we are still learning in the software development community. We have become pretty good in dealing with syntax but are only beginning to understand meaning. We must learn how to deal with the semantics of communications to gain full meaning. And until we reach that level of understanding we will continue to have several false starts. There are limitations in what we can achieve with current software technology. But even if there were not, you can't correct a problem until you know what it is.

CAPT James Hollenbach USN (DMSO) — CAPT Hollenbach explained that DMSO's role in the M&S community is not to build simulations but to serve the broader community as a catalyst in accordance with the city planning analogy to the high level architecture. The High Level Architecture (HLA) was adopted to provide a more complete technical framework for interoperability and reuse which overcomes the limitations of DIS and Aggregate Level Simulation Protocol (ALSP). DIS and ALSP are point solutions and are inappropriate for many applications, especially when you need live systems interacting with virtual and constructive

simulations for analytical or training purposes. The HLA offers a fuller set of capabilities which will be incorporated in DIS 3.0 with a new vision document. No single simulation will be able to satisfy all requirements of the training, acquisition or analytical communities. Instead, the DoD will use the fundamental approach of composing a federation of simulations and systems, from each of these communities, to answer the new and broader questions posed by Dr. Jones and others from the joint world. DMSO definitely wanted the analytical community involved and requested aggressive feedback from the Workshop on what capabilities are required in the HLA to support this objective from the analyst's perspective. He then summarized a list of initiatives that DMSO has started and challenged the analysts represented to get engaged in these activities. These initiatives include seeking common data standards and data exchange formats, developing data quality tools to include security, understanding behavioral representations in decision making and understanding the state-of-practice in computer generated forces.

Dr. Ben Wise (SAIC) — Dr. Wise offered a series of observations from a hands-on-technologist looking up at ADS. He sees many technical problems; some with easy solutions, others with very hard solutions. He suggested that cross fertilization for analysts with the Testing and Evaluation (T&E) community would be a good bet for both communities. And as for federations composed of validated models interacting with other validated models, he observed that there is little assurance that the results obtained from the federation of models will be valid. Before reasonable conclusions can be reached, more rigorous thinking is needed by the analytical community to capture meta data on overarching validation within a federation of models. Particular attention must be paid to how models can be "called" by other models, taking note of time sequencing issues. A reliable time management scheme is needed and analysts must carefully design scenarios to reduce data latency across networks. Dr. Wise also observed that repeatability will be a real technical challenge. Real people don't repeat each other's behavior. But this issue also has its upside. Look at any federation with people in the loop as an opportunity to study how people change behavior or outcomes under differing scenarios. Soft factors, such as these, are little observed in this class of simulations and will be very useful data for representing human factors in other simulations for analytical purposes. Data produced in this way may be very similar to data obtained from WW II and Vietnam, and people were able to do good analysis. He concluded with a challenge to the working groups to understand why we put people in the loop and how would we do analysis with cogent software in the loop rather than attribute-based models.

Dr. Paul Davis (RAND) — Dr. Davis' comments were motivated by Dr. Jones' metaphor of city planning. He speculated what SimCity would be like if it had been developed with current DoD attitudes. He imagined buying it, installing it on his Macintosh, opening the application and discovering to his horror that he couldn't build a city without first spending six months to build a high resolution data base of bricks and mortar. Why? Because in his nightmare, the developer had a vision that focused exclusively on building from the bottom up (starting with the molecular?). He found this very troubling because in the real world, almost all really important decisions need to be formed by aggregate models, which can actually be understood. His point: "Where in the DoD program does one see

any appreciation of aggregate models and the need for them?" He also observed that there must be a new law of large numbers. It is obvious from the way people talk that there must be a law that says as the number of bad models and databases connected increases, the quality of the overall simulation improves, converging to truth." His point: "Why would a good analyst want to put his seal of approval on conclusions based on running some ungodly kluge of models that he neither comprehends nor trusts?" After making these pointed comments, Dr. Davis indicated that he was actually very bullish on ADS. He commented that ADS technology is creating wonderful opportunities for analysts to work closely with real world operators and problems; to conduct experiments yielding insights about very complex phenomena; to help calibrate models using the latest data; and to test various contingency plans. Key to exploiting these opportunities is to design ADS experiments to serve the mechanics of analysis such as the exploration of new tactics or model calibration, and, to use constructive models for the real analyses such as when extensive uncertainty analysis is required and to reach robust conclusions. In his view, ADS should not be used directly to do analysis. Indeed, he believes that the analyst community should strongly fight pressure to impose that mode upon them; remembering that using ADS directly means having to say: "Well. I don't understand what went on in the simulation or whether it is correct, but what the "model" said is that "x" is better than "y." This violates one of the most important commandments of analysis.

Mr. Mike Bauman (TRAC) — Mr. Bauman's comments were on the role of the analyst within ADS. He indicated that relevant and credible analysis is required to support decisions within DoD. And while dozens of simulations are putting out data, the most important aspect of any simulation is the analyst. Running a simulation and looking at the output does not equal analysis. The analyst must understand the algorithms within the simulation to include causality, etc. He sees the biggest challenge to the analytical community as an ethical one -- not a technical one. While many people are viewing ADS as shrink wrapped software, it cannot be used in credible analysis without understanding what the model does. And that will be a very difficult task with federations composed of simulations from multiple Services and of varying granularity. A greater burden is placed on the analyst to understand how we collect, interpret and share data. Analysts must make sure that they have a good match between problems and available simulations and to be responsible to stand up ethically if this isn't the case. This means that they must have the courage to tell leaders that the simulation doesn't support answering the questions they have posed. The community has a real challenge in maintaining confidence of leadership in the new way we are using simulations. Analysts are called in on an issue when there are unknown risks. They are asked to help understand the uncertainty. So they must be able to reach into models or simulations and manage change. This is a major problem with ADS. The community must be particularly vigilant in how we present "visualization" to the users of simulations. A realistic picture must be presented to operators and actors.

Dr. Hank Dubin (OPTEC) — Dr. Dubin commented on ADS issues relevant to the T&E domain. He has heard a lot of discussion about immediate significant cost savings in the training community, but very little has yet been proven with ADS. On-the-other-hand, the T&E community has used interactive simulations for over 30

years in live-to-live simulations, live-to-constructive and live-to-virtual. And the T&E community is moving forward with many new concepts to enhance realism and affordability of T&E. He cautioned that the ADS approach may be the most expensive way to do simulations; with return on investment often dependent upon reuse. He asked that ADS capabilities not be bought just because they are fun to play with. He charged the working groups to ask the following three questions:

(1) Is ADS the best way to solve the customer's problem?

(2) What are the trade-offs among cost, schedule and performance in building the needed pieces and integration for the ADS federation?

(3) How much confidence do we have in the selected ADS federation? He offered Dubin's ADS self fulfilling prophecy theory.

"The more complex the federation, the more interactive in aggregate, the more credible the results." Since we don't know or understand what is going on, we have no basis for discrediting the outcomes. He went on to comment that testing has long been a form of interactive simulation —test items interacting with test conditions (some of which are simulated). And since testing is already a development tool, better and more integration with other simulations has the potential to become a much better development tool, and, as such, will offer the potential for earlier checkout of the human-machine interface, system design, and procedural considerations. While other simulations cannot totally replace testing, if properly integrated, they can make testing more realistic while still affordable. Most agree that we can't use simulation alone to prove out capabilities of a system as fabricated in hands of typical users and in a complex environment, such as combat. One can use simulations to conclude that IF the system meets all design parameters and IF operated in accordance with prescribed procedures, then it SHOULD perform as indicated by the simulation. So if simulation cannot totally replace testing, what is its potential value to T&E? ADS can create effects on systems under test which otherwise would not be practical. ADS can help check out designs, procedures and components before the system is fabricated to do much better at reducing risk. But this potential value in reducing risk affordably is not yet proven.

CAPT Drew Beasley USN (JSIMS) — CAPT Beasley commented on the joint training simulation community. JSIMS is a joint training simulation under development that is expected to provide a training vehicle for a wide, diverse group of users. The customers for JSIMS are the CINCs, the JWFC and the Services with training requirements set by the JWFC. As development advances, there are several areas that need to be better understood and help is requested from the analytical community. One of these is analysis support for exercise planning. Currently, analysis support is done manually based upon the lessons remembered from the last exercise or last war. Surely there are better ways to accomplish this. Another is analysis support for After Action Reviews (AARs). Are there better ways to indicate what data needs to be collected and once it is collected how do you cull useful "stuff" from the reams of data? We need to examine ways to adjust analysis to support training objectives. What are the relevant measures of merit (MoMs)? These questions imply that we need to link the experimental design with the data collection effort and the analysis effort — something

in which the analysis community should be well versed. The JSIMS AAR capability needs to be able to identify cause and effect via analytical tools to predict relevant issues that need to be considered for mission planning and mission rehearsal. For example, is doctrine sound or would a change help? Or do we have the right weapon mix? These are important questions the JSIMS project office is addressing and it is important that this Workshop identify common objectives for the training and analytical communities that make sense to share and work towards.

5. Working Group Synthesis. ADSA '96 Proceedings were developed that contain detailed reports from each WG. But for the purposes of this section, we will draw upon the Synthesis Panel report developed by Dr. Stu Starr and his panel members. These panel members participated as active members of one of the other six working groups of the Workshop as well as the Synthesis Panel.

The nature of the problem. One of the first questions that emerged during the deliberations was the issue of the definition of the term ADS. The importance of developing a definition that was widely accepted by the community was suggested by one of the papers in the read-ahead package, "What in the World is ADS?" by Sikora and Coose. By invoking the image of the Tower of Babel in their paper, the authors suggested the confusion that can ensue if the participants in the dialogue lack a common frame of reference and vocabulary.

In recognition of this issue, the Synthesis Panel spent a moderate amount of time exploring the question, as did many of the other panels. It concluded that the strawman definition in DoD 5000.59-M is inadequate. A taxonomic approach to the question shows some promise and is discussed in the findings and recommendations below.

Several of the working groups spent considerable time identifying and discussing why the analysis community has been slow to embrace ADS. These issues can be loosely aggregated into two categories: quality and use.

In the area of Quality, the working groups cited the following issues:

- *Ambiguity.* Since many of the members of the analysis community are not sure what ADS is, they are not sure how useful it is to them.

- *Replicability.* Since many examples of ADS feature humans-in-the-loop, there is concern among some analysts about the ability to replicate results. In particular, there is concern about coping with the effects of subject learning and the impact of differences in subject background, experience, proficiency, and morale.

- *Credibility.* It was acknowledged by several working groups that Verification, Validation and Accreditation (VV&A) of ADS pose particular challenges.

- *Suitability for Some Issues.* Several working groups noted that there are classes of analysis problems for which ADS may not be suitable. This can stem from the limited knowledge base that may exist for a class of problems (e.g., studies of new classes of ships that are still in the preliminary, conceptual stage)

or the limited precision that one can hope to achieve using some classes of ADS (due to the likelihood of relatively small sample sizes).

In the area of Use the working groups cited the following issues:

- *Cost/Resource Implications.* Several working groups observed that it is likely to be relatively expensive to acquire, update and employ ADS in comparison to more traditional analysis tools. In addition, from a resource perspective, it is often difficult to obtain and train suitable test subjects.

- *Time/Schedule Implications.* Numerous Working Groups expressed concern about the extensive time implications of ADS. This includes the time to create an ADS capability, setup conditions for a specific analysis, perform test runs and reduce the data that is generated by exercising an ADS. These time considerations can preclude use of ADS when the analyst is given little lead or execution time (e.g., Program Objective Memorandum issue analyses).

- *Data Implications.* Several participants identified a broad spectrum of data issues associated with ADS. These include problems associated with acquiring data needed to setup and execute ADS; deciding what data to collect and collecting it (note: it may be difficult to introduce ad hoc "hooks" into an ADS to collect desired data); and storing and processing the resulting data (e.g., some of the data of interest may be spoken by the test subjects).

- *Exercising the ADS, Technically.* Several ADS practitioners identified the problems that they encountered in technically exercising an ADS. To illustrate the problem of control, a representative from the Theater Air C2 Simulation Facility (TACCSF) recalled an incident where a frustrated AWACS subject unrealistically walked from his simulated node to a simulated ground node to resolve a concept of operations issue. Second, the distribution of nodes can pose time synchronization issues (e.g., the use of satellite communications can give rise to latencies that are unacceptable in selected classes of analyses such as real time and extended air defense problems). Third, several practitioners pointed out that interconnection of heterogeneous nodes is still in its infancy. The Distributed Interactive Simulation (DIS) standards/protocols are still incomplete and evolving. In addition, the ambiguity in existing standards/protocols is such that two nodes can claim to be DIS compatible and still not be able to interoperate. Finally, the absence of multi-level security solutions makes it difficult to conduct experiments with ADS featuring nodes at different classification levels.

- *Administrative Burdens.* ADS can pose administrative burdens that

are far greater than those normally encountered by an analyst. For example, if the analyst is truly to leverage the resources of others (either those of other analysts or of other communities such as training or acquisition), it will entail extensive cross-community/ organization coordination. As an ancillary problem, it is generally onerous to schedule the facilities of others, particularly when the facilities are widely distributed. In addition, for those ADS that feature HITL, it can be quite difficult arranging for test subjects (i.e., getting people with the right experience, knowledge and skills for the times needed). Lastly, configuration management poses problems since it must be maintained as facilities are modified to meet analysis needs and to track real world evolution of systems.

- *Efficient, Effective Exercising of ADS.* In order to employ ADS efficiently and effectively, it is necessary to devise and implement experimental designs that provide confidence levels consistent with the issues under study and to contend with potential confounding factors that may be unique to ADS (e.g., compensate for potential learning by test subjects).

In view of the many issues associated with ADS, the most natural question is: "Why should analysts bother with ADS?" The Workshop identified several significant opportunities implicit within ADS that suggest that it is well worth the time of the analysis community to explore the application of ADS to a broad range of analyses.

First, several working groups reported that ADS has the potential to substantially enhance analytic support to a number of application areas. For example, in the area of operations, ADS has the potential to enhance dramatically the quality of "what if" analyses. As an illustration, an extension of ARPA's Project Odin technology might enable operational commanders to visualize the latest intelligence data and experiment with alternative tactics and procedures. In the area of acquisition, it was noted that the state-of-the-practice has enabled several commercial firms to improve the quality of their products (e.g., Boeing's use of (CATIA) to develop the "snap together" 777). ARPA is at the state-of-the-art level in this application and they are optimistic that it can be used to reduce the cost and schedule of an acquisition while enhancing the quality of the product (e.g., the simulation based design activities for acquiring future naval platforms).

Second, ADS may enable analysts to address issues in a richer context than they otherwise could. As illustrations, note that the use of HITL makes ADS an attractive candidate to treat human interactions explicitly and to consider information aspects of warfare. In addition, the ability to network the tools from several Services suggests that it should help to address joint issues more credibly.

Third, technology trends are providing new opportunities. The Information Technology (IT) that underlies ADS is being enhanced dramatically by the commercial sector (e.g., substantial improvements in processing speeds, storage size, and visualization tools at significantly reduced costs). In addition, efforts are underway in the defense

community, such as the HLA, to promote interoperability and reuse. The net effect of these trends is to suggest that ADS will become increasingly more capable, cheaper to create and easier to use and reuse.

Fourth, as observed by Dr. Jones, the analytic community has the opportunity to take advantage of the extensive ADS investments of other communities (most notably the training community). If done properly, this could provide the analysis community with ready access to expertise (e.g., knowledge on how to use ADS effectively and efficiently), resources (e.g., the opportunity to use existing ADS) and needed data and parameters.

Fifth, Mike Bauman, TRAC-Ft. Leavenworth, and Gene Visco, FS, ODUSA (OR), observed that in recent years we have seen the rise of "computer driven analysis." They postulated that ADS poses the opportunity for analysts to move to "computer assisted analysis" and thereby "return to our roots."

Sixth, it was observed by several participants, that decision makers are being exposed to ADS through its application by other communities. Thus, it would not be surprising if these decision makers were to mandate the selective use of ADS by analysts to capture many of its attractive characteristics (e.g., explicit treatment of human behavior; interactive features; high quality visual features).

Finally, Jack Thorpe, SAIC, made two observations about ADS. He predicted that "In ten years, everything can be connected to everything else and, given the spirit of experimentation that exists within the analytic community, it will!" Thus, he opined, ADS is coming and it will be pervasive in the defense community. In addition, he speculated that ADS may be the precursor to full "instrumentation" of every combatant on the battlefield. If that comes to pass, it will lead to unprecedented access to timely data for understanding warfare. By analyzing these data, analysts will have an unprecedented opportunity to formulate and validate models of conflict.

Findings and recommendations. Based on the insights that the Synthesis Panel gained from participation on working groups and Synthesis Panel discussions, a total of four areas were identified that the panel members felt were of overarching importance. For each of these areas, the Synthesis Panel developed findings and a set of recommendations. In each case, the Synthesis Panel identified the organizations that they believe should take the lead in implementing the recommendations. All these areas are subject to modification and addition as the Proceedings are completed with final WG reports.

ADS Definition. The Synthesis Panel observed that there is no existent definition of ADS that is deemed adequate by the Workshop participants. The Panel found that this lack of an adequate definition limits the analytic community's ability to understand the nature of the capability (i.e., to appreciate its current or future attributes or limitations). This, in turn, limits the analytic community's ability to plan for the effective application of both ADS and non-ADS M&S capabilities.

Consequently, the Synthesis Panel recommends that a taxonomy should be developed that defines and clarifies the nature of ADS and illuminates its relationship to related concepts such as DIS. Ed Brady's, FS, proffered definition can serve as the starting point. The MORS ADS Senior Advisory Group (SAG) would be an

appropriate organization to draft this taxonomy and then pass it on to the Defense Modeling and Simulation Office (DMSO) for approval and dissemination throughout the community.

Community Leadership. The Synthesis Panel found that the challenges associated with ADS transcend the abilities and resources of the individual analyst. If analysts are to use ADS effectively, a paradigm shift must occur to enhance collaborative analysis. This concept, which was put forth by the Analysis and Requirements WG, rests on pillars of cross-community shared data, tools (e.g., scenario generation tools, visualization tools), security, MoMs and an integrated family of analysis techniques. The last of these pillars should be emphasized. Most of the working groups observed that ADS should not be viewed as a "stand-alone" capability that can be applied to all analytic problems. In general, it must be harmonized and orchestrated with other analysis techniques to compensate for selected ADS features (e.g., extensive time to create and execute) and employed where appropriate.

In order to bring about this paradigm shift, key analytic organizations and the analytic community must provide needed stimulation and leadership. A partial listing of recommended actions to be undertaken by the Services, the Joint Staff and the OSD include the following:

- *Providing Incentives to Use ADS.* This would include providing appropriate resources to analysts and promoting those analysts who employ ADS appropriately and effectively.

- *Making Necessary Investments in Community Infrastructure and Accreditation Efforts.* It was observed that the analysis community is normally limited to "chump change." To provide the resources needed to develop and VV&A ADS, several members of the Synthesis Panel recommended that a "PM Analytic ADS" organization be established and supported with adequate budget line items. This recommendation should be assessed further to establish its feasibility and desirability.

- *Facilitating Needed Education, Training.* The cornerstone to effective creation and use of ADS is the education and training of the analyst and the decision maker. In view of the criticality of this step, it is amplified as a separate issue below.

- *Forming Teams With the Necessary Mix of Skills.* The effective creation and use of ADS demands a team effort. Representative skills include operations research (to help frame and scope the problem), experimental design (to formulate the experimental design matrices and support the analysis process), program management (to perform the myriad management and administrative tasks) and data mining (to acquire, process and store data associated with ADS).

ADS Plan for the Analysis Community. Once the analysis community becomes committed to the enhanced collaborative analysis paradigm, it will need a plan to guide its actions. Historically, the analysis community has been reticent to take this

step. For example, several years ago, DMSO sponsored a series of workshops to stimulate the various communities to identify their needs for advanced M&S. While several communities embraced this opportunity (e.g., training, T&E), the analysis community demurred. The Synthesis Panel further observed that there is no long range vision to guide the allocation of limited M&S development resources to support the analyst. Consequently, the analysis community tends to be excessively reactive to near-term needs at the expense of needed longer-term investments.

The Synthesis Panel found that the absence of an "ADS Plan for the Analysis Community" has resulted in fragmented action within the analysis community and limited the leveraging of the resources and expertise that are resident in other communities (e.g., training, acquisition). To ameliorate those shortfalls, the Analysis Council that has been formed under the Executive Committee for M&S (EXCIMS) must take decisive action. It should develop the vision for the next generation of M&S tools for the analyst and draft an associated "ADS Plan for the Analysis Community." In the view of the need for timely action, these products should be drafted and circulated for community coordination no later than 1 February 1997. To ensure that the community takes full advantage of the opportunities implicit in commercial developments, the plan should explicitly identify steps to ensure maximum use and compatibility between Commercial-Off-The-Shelf (COTS) products and ADS.

Community Education Training and Experience. The Synthesis Panel found that a broad set of skills, knowledge and expertise will be needed by the community if it is to be able to appreciate the capabilities and limitations of ADS and to employ ADS effectively and efficiently. It must be emphasized that the community in question subsumes both analysts and decision makers. In the absence of appropriate education, training and experience, the results that analysts derive from the application of ADS are likely to be suspect and the decision makers' understanding of the meaning and validity of those results is likely to be limited.

To deal with these issues, the Synthesis Panel put forth several recommendations. First, key Service schools should develop curricula and offer a sub-specialty of "ADS Analyst." Candidate schools include the Naval Postgraduate School (NPS), the Air Force Institute of Technology (AFIT) and the Army Logistics Management College (ALMC). Second, assignments to "ADS Analyst" positions should be of suitable duration and consistency to ensure that necessary experience is acquired and sustained. Thus, for example, once an analyst has qualified as an "ADS Analyst" at one of the above institutions, his/her next assignment should be to an ADS activity or to an organization which may perform collaborative analysis employing ADS. Note that some Services currently assign recent graduates to field assignments. Subsequently, a sequence of assignments should be envisioned that help the ADS Analyst to continue to hone and apply his/her skills.

In support of decision maker education and training, appropriate programs on ADS should be developed and offered at institutions such as the Defense Systems Management College (DSMC), the Defense Acquisition University (DAU), the National Defense University (NDU) and the Senior Service Defense Schools. Thought should be given to updating DSMC's Handbook on M&S for the acquisition community to

highlight the challenges and opportunities associated with ADS.

Qualitative assessment of the Workshop. The TOR identified four objectives for the Workshop. To establish a qualitative measure of the effectiveness of the Workshop, the Synthesis Panel informally assessed the working groups against these four objectives, based on its observations of their operations and products. These assessments were in the form of a color (i.e., "green" implied fairly complete achievement of the objective, "amber" implied moderate achievement of the objective and "red" implied a failure to achieve the objective).

The first objective was to assess the utility of current and future (3-5 years out) ADS-based capabilities for analytic applications, especially possible areas of new analytic capabilities. The Synthesis Panel rated this as "amber." There was extensive consideration of the current time frame but less about the future because of the limited understanding about the likely nature of ADS by the turn of the century.

The second objective was to define areas of needed enhancements of ADS-based capabilities to increase their utility to the military analytic community. The Synthesis Panel rated this as "amber." It was felt that the absence of an agreed definition for ADS limited this discussion, although a number of panels put forth excellent suggestions for increasing the utility of ADS to the military analytic community.

The third objective was to increase the military analytic community's understanding of current ADS-based capabilities and near term improvement programs. The Synthesis Panel rated this as "green." This was due to the inclusion of descriptive material in the read-ahead package, the material covered in selected plenary presentations, the scheduling of ADS presentations within selected panels, and the ad hoc scheduling of a presentation on the HLA to the Workshop.

The fourth objective was to increase interactions between the military analytic community and developers of ADS-based capabilities. The Synthesis Panel rated this as "green." This was due to the mix of participants that were invited to the Workshop and the opportunities that were provided to enable them to have a fruitful dialogue.

MORS Workshop
Advanced Distributed Simulation (ADS) for Analysis

Working Group 1

Battlefield Effectiveness

(Did not submit a report)

MORS Workshop
Advanced Distributed Simulation (ADS) for Analysis

Working Group 2

Material, Systems and Acquisition

Working Group Chair:	Lt Col Bob Sheldon, AFSAA
Co-Chairs:	Dennis Shea, CNA
	Maj Willie McFadden, TRADOC

MORS ADS Workshop - WG 2 Challenges

- ADS is not a new methodology for analysis — all the components, including human-in-the-loop (HITL), have been available to analysts for years.
- Rather, it is the glue that allows analysts to tie together formerly stand-alone analytic tools into a more powerful mechanism for modeling complex problems.

Although the components of the technology are not new, the challenge is to integrate these technologies in new ways and to ensure that the resulting applications are appropriate and produce results that are meaningful and understandable.

The problem is made more difficult because the models and simulations that are being linked together were developed by different vendors, over many years, using different technologies and were not designed originally to interoperate together in useful and meaningful ways.

To ensure that ADS becomes useful for analysis in acquisition requires:

- Greater attention to experimental design and a disciplined approach to data collection and analysis
- Affordable V&V techniques for linked heterogeneous simulations
- Pre-planned control response "playbook"
  - To handle loss of link or simulations

(continued)

The following three slides summarize the essential requirements for ADS to be useful for analysis supporting acquisition decisions.

To ensure that ADS is useful for analysis, requires that we get the most information from the few ADS experiments that we can conduct practically on any particular issue. Traditional design of experiment techniques can help us structure these experiments to ensure that they are conducted in the most efficient manner.

Establishing the credibility of ADS through V&V will be critical to its utility and ultimate acceptance by DoD. It is relatively easy to be overcome by the apparent realism of some of the synthetic environment presentations and forget that the models underlying these presentations are based on assumptions and calculations that may or may not be appropriate for the application at hand. As the model outputs become more and more complex, analyzing the credibility of the model outputs becomes more challenging. Even if the models and simulations have undergone the V&V process as stand-alone models, linking them together in an ADS experiment may lead to conflicts and errors that can invalidate the model output.

When using ADS in practice, the exercise control team needs to have a plan in place to handle the inevitable system failures, such as loss of the network, other datalinks, or if a simulation drops off-line. The challenge is to keep system failures away from the participants. Ideally, exercise control can keep the scenario going and manage to smooth over minor software and hardware problems so they are transparent to the participants. One approach that is often successful, particularly in exercises run from distributed locations, is the development of a controller "playbook" that is a list of pre-planned responses that are designed to minimize the effect of technical problems.

To ensure that ADS becomes useful for analysis in acquisition requires:

- Experiments that don't confound acquisition objectives with training objectives
- Improved data collection/reduction/analysis tools
- Greater attention to data collection
- Training of both analysts and military decision makers on how to use ADS tools and results from ADS analyses

The high cost of conducting an ADS experiment/exercise suggests that it will be difficult to justify these costs for analysis purposes alone. Yet using an ADS experiment/exercise to both accomplish training and to analyze the effectiveness of a new system can pose conflicting requirements. The objectives of these two uses are likely to be different, as are the credibility requirements (including resolution and fidelity) of the ADS to support them.

Training applications are designed to promote the development of skills. Analysis applications, on the other hand, are intended to lead to more informed decisions about equipment, tactics, doctrine, etc. A lot of training objectives can be accomplished with fairly low fidelity models, even models that are not completely accurate. The military services have been using the CBS, AWSIM, RESA and ENWGS models for years even though they have not been through any formal VV&A. The minimum credibility criteria to support training is that the simulations provide the right stimulus for the training audience to learn better skills and that the models do not induce negative training. The credibility criteria to support analysis (e.g., to support an acquisition decision) are generally more stringent. Here the simulations must provide realistic information on the effectiveness of systems in a potential real world situation.

To make effective use of ADS for analysis will require significant improvements in automated tools to support data collection, reduction and analysis. Data collection cannot be viewed as an afterthought. Without careful planning to set the filters on which data and the frequency of data that will be collected, the ADS exercise will quickly overwhelm the data recording capabilities of most existing systems. Also, these current systems are somewhat awkward and painfully slow.

Finally, the use of ADS to support analysis is a new paradigm, which analysts and senior decision makers are just beginning to understand. Significant learning by both parties is required to understand appropriate applications, to structure the ADS experiments and to properly interpret the results.

To ensure that ADS becomes useful for analysis in acquisition requires:

- Better documentation of the analysis process
- Incentives to try ADS in specific acquisition programs
  - Services conduct AWE experiments
  - To further develop ADS technology
- Use ADS as part of a larger research strategy for analysis in acquisition
- Rethinking DoD acquisition strategy

Advanced Warfighting Experiments (AWE) is an Army initiative to explore innovative technologies and concepts.

If results from ADS experiments are to be useful to decision makers, they must be understandable and be able to withstand scrutiny by outside organizations. This mandates better documentation of the entire analysis process than we have today. This should include the following:

- Clear articulation of the analysis objectives
- The rationale for using ADS including selection of the models and an assessment of
- Their credibility and appropriateness for the particular application
- Explanation of the experimental design used
- Explanation of how the results of the ADS experiment were used in the analysis

To assess the credibility of the models and simulations requires documentation on the assumptions embedded in the model, the variables included and excluded and enough information about the algorithms and overall approach to convince the reader that the fidelity and modeled processes are appropriate for the application.

To ensure that ADS becomes useful for analysis in acquisition requires: notes (Continued)

Presently, there are few incentives for any program manager to try ADS. First, ADS is a new analytic paradigm and few understand how to use it for analysis. It isn't yet clear that it will be helpful for analysis or whether ADS results will be accepted within the formal DoD decision process. Therefore no program manager wants to spend his/her funds on such a risky venture. Second, because DoD lacks an M&S infrastructure (models, databases, standards, support tools, etc.) to support users and developers of this technology, there will be significant upfront costs to try ADS. These costs are too large to be borne by any individual program. The funds to develop the infrastructure to support ADS must come off the top of the budget or result from a tax levied on each program. To learn where and how ADS can support analysis, each of the services should nominate a few pilot programs to experiment with ADS. This selection process should include the necessary funding to support the ADS experiments.

Finally, to realize the benefits of ADS may require rethinking the present DoD acquisition strategy to assess whether ADS will enable some of the traditional steps in the acquisition process to be skipped or conducted in parallel. We need some analysis to understand where to seek the benefits from ADS when it is applied to acquisition programs. The analysis should examine whether ADS can reduce costs, help field systems faster or lead to more informed decisions as its proponents would have us believe. The results from a few pilot programs could help answer these questions.

1. When should ADS be used?

- Potential to be applied at all stages of the acquisition cycle
- To keep the warfighter in the loop
- Visualization to improve communications
  - Between warfighter, designer, analysts, etc
- Better define requirements
  - More realistic/credible in terms of human factors

- ADS should be used when it fits the problem and is cost effective.
- ADS is one way of getting the war fighter in the loop early and continuously.
- ADS should be used when visualization is crucial to better comprehension.
- ADS can be used to accomplish better requirements definition.
- There are several types of applications for which ADS may be appropriate:

1. When human factors are a critical element of the problem and representations of the human interactions through a constructive model are insufficient. For example, when the analysts are trying to assess how warfighters will use C4ISR systems in their tactical decision making, it may be appropriate to design an ADS experiment consisting of a mix of live, virtual and constructive forces. Getting the warfighter in the loop through the live or virtual components of the technology can be a better vehicle for examining human factors rather than a constructive model.

2. When the problem requires an M&S architecture comprised of multiple models interoperating together and the models must be run from geographically dispersed sites.

3. When multiple processors are needed because the problem is too large to run on a single computer.

When should ADS be used? notes (Continued)

4. When the application requires HITL, such as testing a Radar Warning Receiver (RWR) where the aircraft and RWR are placed in an anechoic chamber and signals from simulated threats are injected into the actual RWR.

5. When the application requires an operationally realistic scenario that cannot be constructed from live forces alone. Typical applications include T&E of systems operating against a high density threat such as found in an Integrated Air Defense System (IADS) and training exercises with large numbers of forces including training at the JTF-level.

6. For wargaming, when it is difficult for all of the participants to be physically present at the common gaming facility.

2. Is ADS better or worse for specific types of analysis already being done?

- ADS may be appropriate when issues involve:
  - HITL interactions
  - Information operations (IW, C4ISR)
- Inherent limitations such as repeatability and cost may place ADS in a complementary role supporting traditional analysis.

- ADS is better for investigating decision making and HITL issues.
- ADS is better for the investigation of information operations (information warfare and C4ISR).
- As the number of human interactions in the ADS event increases, the repeatability of the event becomes less likely and the analysis becomes more anecdotal.

ADS is better than traditional approaches to analysis when the problem involves human factors and we are looking for "plausible" rather than "expected" or "likely" outcomes. Constructive models don't handle human factors very well because these models typically do not allow human errors to occur. Constructive models usually assume that operators will make optimal decisions. However, exercises and field tests suggest that the real world includes a "fog of war" which leads to ambiguous, false and time-late information. In the real world humans make mistakes, but we have a hard time accounting for this in our models.

Is ADS better or worse for specific types of analysis already being done: notes (Continued)

ADS is most appropriate when we are performing exploratory analysis. Because of small sample sizes and problems of repeatability, ADS is not appropriate when the simulations are highly interactive and we need to obtain statistical validity. Examples of inappropriate applications include COEAs where we need to make hundreds of excursion runs to examine different scenarios, different sets of initial conditions and conduct sensitivity analysis to identify the key drivers in the problem and explore the effects of uncertainties in the values of these key variables.

Although many of its proponents envision using an ADS approach early (prior to milestone I) in the life-cycle of an acquisition program, this may not be a productive use. At this point in its life-cycle very little is known about the key characteristics of a new system. Thus it may be difficult to justify a high fidelity ADS approach to the problem prior to milestone I. At this stage, broad scoping tools and low fidelity models are most appropriate.

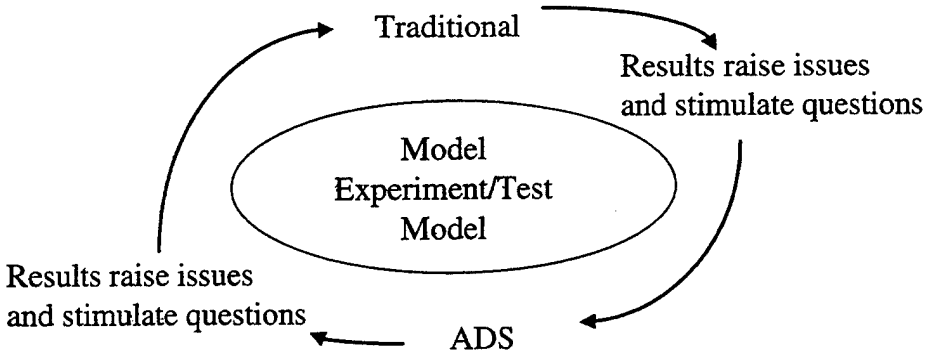
3. Does ADS allow analysis to address any new, necessary analytic questions?

- Information Operations
  - IW
  - C4ISR
- Horizontal technology integration

- ADS has potential for more credible analysis of information operations (information warfare and C4ISR).
- ADS has potential for better understanding horizontal technology integration.

ADS would allow analysts to examine human factors problems such as crew manning in naval ships or questions regarding how military operators react to certain stimuli and how they use information in the tactical decision process. Thus, in system acquisition, ADS could be helpful in designing the Navy's new ship (surface combatant of the 21st century) to try to reduce its crew size and to analyze the requirements for new C4ISR systems that are information intensive.

4. How does ADS fit with other types of analytic capabilities and approaches?



- ADS can be used to complement other analyses, with supportive results, mutual calibration, sharing of data and common scenarios, which allows for more informed decisions.
- ADS provides an environment where hypotheses developed through other analytic means could be tested and evaluated.

The live and virtual components of ADS could complement the traditional approach of using constructive models for analysis. We might use these components early in the analysis process to pre-play the scenario to establish its credibility and ensure that we have accounted for all of the critical variables in the problem. We could look for unanticipated interactions that may have been left out of the constructive models and to help identify key issues to focus the analysis.

By providing the human element, ADS runs using live or virtual components that could provide estimates of input parameters, such as average response times, for the constructive models.

5. What are the limitations of current and future ADS?

- Common architecture
- Data collection/reduction/analysis tools
- Non-repeatability
  - Human variance
  - Network capacity
- Bandwidth

(continued)

- Several limitations are inherent in the distributed nature of ADS.
- Many of these can be overcome by scientific control of experiments, others through technological or software advances.

We don't have a common set of verified and validated models, data bases and tools to support analysis. The DIS protocols are not fully developed and will only support a limited number of applications. JWARS will not be ready for several years.

As mentioned earlier, the data collection, reduction and analysis tools available today to support ADS are inadequate. Moreover, insufficient command attention (including funding) have been given to developing these tools.

Because of problems with repeatability and small sample sizes it will be difficult to use ADS to obtain statistical validity or to perform comprehensive sensitivity analysis.

Many ADS applications are bandwidth intensive. We need a set of smart communications protocols that minimize unnecessary data transfers.

5. What are the limitations of current and future ADS? (Continued)

- Control of experimental variables
- Latency
- Lead time
- Cost
- Training of the analysts/decision makers

Many ADS applications, especially T&E applications require real time operations. The latency associated with the current DIS protocols may not support these applications.

Due to the lack of an M&S infrastructure, there is a significant lead time and cost associated with conducting an ADS experiment. This includes the time and cost to build the databases and to configure the models for the experiment.

The ADS paradigm envisions a free flow of information across the network connecting requirements folks, designers, developers and users. Issues include sharing of proprietary information over the network, multi-level security, industry's access to sensitive information and how many and which particular concept design teams to invite from industry. The ADS paradigm is designed to enable industry to participate earlier in the acquisition process by testing new concepts in common synthetic environments accessible by government and industry. But the industry may not be willing to participate if this means that competitors could access proprietary information through the network. By allowing one firm's models to interact with models from another firm, they may be able to reverse-engineer the models to learn a lot about how the other firm plans to design their system. Similarly, the government will want to limit access to "black" programs. How will it decide which firms to invite to participate in the synthetic environment and which to exclude?

6. Are there pitfalls in analysis using ADS?

- If piggy-back on training exercises
  - Training objectives vs. analytic objectives
  - Data collection objectives
- Reliability of network and simulations
- Failure to plan for data collection
- Misinterpretation of results

(Continued)

- Training or exercise objectives usually take precedence over analysis objectives.
- Lack of control may invalidate analytic results.

ADS experiments that include both training and analysis objectives may not serve either purpose well. The training and analysis objectives can sometimes be at odds. Training exercises are designed to prepare forces to conduct operations against the threat most likely to be faced during the next deployment (six months). Acquisition experiments on the other hand, want to test the capability of a proposed system against the threat that is likely to exist once the system is fielded. This could be a threat 20-30 years in the future. The training objectives of the exercise will tend to dominate and it is unlikely that the objectives to support the acquisition experiment will have much influence over the scenario and threat in place to support training.

Other problems occur when mixing training with analysis objectives. For example, training expects learning to occur between trials but analysis expects the replications to be independent trials.

In an ADS experiment that involves a human element, it is very difficult to control what factors are held constant between replications. If multiple replications involve the same group of participants, the analysis must account for the learning that takes place from run to run.

Extreme care is required to develop hypotheses for ADS experiments that will support acquisition decisions and that are testable. In some recent experiences the hypotheses were too broad and untestable.

6. Are there pitfalls in analysis using ADS? (Continued)

- Failure to understand assumptions/limitations
- Lack of planning to accommodate disruptions
- Failure to correctly design experiments
- Lack of coordination among analysts
- Lack of pre-exercise training
- Lack of configuration/version control

7. Does the use of ADS affect the utility of analytic results?

- Cause and effect relationships difficult to establish
- Easier to communicate results
- May offer more credibility when analyses involves human factors
- Improve communication through visualization

- Results from ADS are easier to communicate and sell due to operator participation and visualization capabilities
- Results which indicate cross-domain analysis have more credibility.
- Credibility of cause and effect relationships can be more questionable in ADS.

Because of small sample sizes and problems with repeatability it may be very difficult to establish cause and effect relationships through ADS. It is important to remember that ADS experiments that are highly interactive will produce results that may be "plausible" but that are not necessarily "likely" or "expected" results.

The high-resolution graphical systems that allow visualization of three dimensional objects and their interactions may make it easier to communicate the results of ADS experiments to senior decision makers.

8. Are there useful ways to utilize the results from ADS-based analysis, exercise and training that differ from conventional methods?

- Accelerate acquisition process
- Earlier/easier insights into design trade-offs
- Improved communication through visualization
- Potential to bypass milestones

- ADS lends itself to the implementation of "smart product" concepts which could revolutionize the acquisition process allowing for better and more complete designs in less time and fewer milestone reviews.

9. Do ADS-based analysis capabilities make VV&A any harder, easier or different?

- Harder/Impossible
  - VV&A federation
  - Configuration control
  - Certification of databases
- HITL may facilitate perception of validation

- VV&A will be more difficult.
- The combination of a number of validated elements does not result in a validated whole.
- Data certification will be more difficult.
- HITL will facilitate the perception of validation.

VV&A of ADS systems will be much more difficult than stand-alone systems because the models and simulations that are being linked together were developed by different vendors, using different technologies and were not originally designed to work together. First the individual models must be V&V'd as stand-alone tools. (V&V of the stand-alone models is not done well today. The performance of many modeled weapon systems against third-world threats, in the scenarios and operational environments postulated today, is significantly affected by phenomena that are poorly understood, much less modeled. This includes the effects of multi-path and background noise.)

After the V&V of the stand-alone models is completed, the distributed architecture must be examined to ensure that the individual pieces fit together as a credible whole. Thus, the models must share common assumptions and define variables to mean the same thing. The outputs of one model must be in the form expected of the second model, if they are to be used as inputs to this model.

The current litmus tests to establish the credibility of ADS for training applications is whether Subject Matter Experts (SMEs) can discriminate the simulation from the real system. This criteria is not appropriate for acquisition analyses that use ADS because here the systems have not yet been built and the SME have no operational experience. Thus, the models cannot be tested directly against the real world systems.

MORS Advanced Distributed Simulation for Analysis '96 Workshop
Test and Evaluation Working Group Report (WG 3)

Introduction

Test and Evaluation (T&E) presents many opportunities for analytical support, but it is not always in the traditional sense, analysis. In fact, a T&E can be carried out without any analysis being done. The simplest situation would be to try something out and see if it does what you want it to. Unfortunately, that is rarely the case, or more importantly, rarely practical for T&E in the Department of Defense, DoD. The considerations which drive us to require analytic rigor in T&E are:

- Cost containment in T&E
- Complexity of military systems
- Justifying the strengths and weaknesses of development systems
- Complexity of operational environments
- Achieving confidence our fighting forces will have good capabilities
- Justifying the dollars to be spent on procurement and fielding

In this context, the T&E Working Group* (WG) addressed the nine issues posed by the Workshop Chairperson in the terms of reference for this Workshop.

Types of T&E Applications for ADS

Given the considerations above, the T&E (WG) addressed which types of analyses are applicable to each of the three traditional phases of the T&E mission: T&E planning, test conduct and evaluation. These phases and their associated analyses are not done independently of each other, and therefore, the analyses are often not mutually exclusive. The T&E WG did find that there were some general differences among the analyses done in support of the three phases.

For test planning, simulations are typically used for developing test conditions or scenarios. The main purpose is to ensure that the test will create sufficient events or opportunities for the test objectives to be satisfied. Other uses of simulation in the planning phase include determining the minimum resources needed to create the test conditions, developing procedures for the use of the system under test and training the operators for using a new capability. The pre-test uses of simulation are generally aimed at achieving efficient use of test resources. These applications usually require less fidelity and less rigor for accreditation than do the use of simulations to support test conduct and evaluation.

In support of test conduct, simulations are used to enhance the realism of the environment or to generate stimuli to the system under test. Here the key is getting adequate realism, commensurate with the maturity of the t est item, at less cost than

*Members listed at the end of this report

would be required for deploying live assets. Additionally, simulations are used to overcome test limitations such as simulating kills in combat (safety) or electronic countermeasures (open air operations security restrictions or lack of threat systems).

In the evaluation or post-test phase, simulations are generally used to explore conditions other than those which occurred during the test. The two most common uses are (1) relating tested system performance to performance in other scenarios or environments, and (2) estimating the potential contribution of the system being evaluated to larger scale (than could be tested) mission accomplishment, e.g., force effectiveness or campaign outcomes.

T&E Perspective on Simulation

In reviewing the uses of simulation in support of T&E, three principles surfaced often in the WG discussions. The first is that the item under test, whether it be a component, the integrated system or an operational unit employing the system, must be present in a live sense. One does not have a test of the system if the system, as fabricated and operated, is not actually present and operating. In contrast, simulations which also simulate the system of interest can be used to test or evaluate concepts, system design and procedures as well as provide an educated estimate of what test conditions would be most useful for meeting the overall T&E objectives.

The second recurring principle is that in a literal sense, all testing is simulation. That is, testing and simulations to explore other conditions are not real combat and are not the real operators. As a minimum, the use of a system by its operations in a test environment is influenced by the fact that the operators are being observed and instrumentation is interacting with a system under test. Looking at the T&E of military systems in both retrospect and the present, the WG concluded that systems under test always interact with some combination of live virtual and constructive environments. In this context, T&E has been a precursor to and is a leader in Advanced Distributed Simulation (ADS).

The third principle repeatedly discussed by the Group is that "caveat emptor" applies to the uses of ADS. The T&E community's experience to date is that the wide variety of "demonstrations" of ADS technologies have not been calibrated or substantiated as representing reality. There are few direct comparisons of simulations with the interactions among the systems and environments that would have occurred in the actual mission conditions assumed to be simulated. When such comparisons have been made, we have learned that there is much work to be done to achieve a test quality reality match. In other words, there is considerable risk of measures of performance (MOPs) obtained from ADS representations differing, with unknown biases, from the MOPs that would have been obtained from real operations. The T&E community is very sensitive to this risk because we are usually held accountable for the accuracy of our findings, and there is often evidence that is brought to our attention in the event that we could have been wrong in our characterization of system performance. Consequently, the T&E experience led the T&E practitioners to views ranging from "cautious optimism" to "skepticism" on the apparent unbridled proposals for the uses of ADS to create

complex combat situations by linking many disparate simulators and simulations.

By raising these recurring principles, the T&E WG members were on the verge of being gored by the horns of a dilemma they created. That dilemma is "How to be proponents for the uses of ADS in T&E while cautioning everyone that there are many unknown or unquantifiable risks in doing so." Our approach to reconciling this apparent contradiction is to encourage the developers and users of ADS to collaborate with the testers and evaluators whenever possible to do rigorous comparisons of the results of interactions in simulations with results of interactions that occurred live. The live sources, in order of priority, are well documented combat events, operational and other system tests, and documented training events. These comparisons are best done legitimately in the context of the scientific method: use the simulation to "predict" the interaction outcomes for the conditions of the live interactions; observe and document well the live interaction outcomes; and analyze the similarities and differences between the outcomes. It is important to apply common sense and military judgment in the comparative analysis of simulations and live events. In the case of combat, it is difficult to get complete and accurate simulations to differ from the combat situations they are trying to represent. Generally, this approach to improves simulations and builds confidence in their records. In testing and training, there are often constraints which cause those that are live to use over time is called "Model-Test-Model" (M-T-M). M-T-M is a partnership between those who build simulations and those who collect data from and create live events. This partnership is symbiotic in the sense that the two efforts complement each other in mitigating their respective limitations. The mode of operation should be that T&E and simulation are inseparable; they need each other in order for each to gain credibility.

Assessment of Current ADS Applications to T&E

There are generally two capabilities, under the umbrella of ADS, which have been used to date in T&E. The first is DIS compliant systems such as SIMNET and its recent upgrades. The second is an ad hoc integration of simulations to drive test conditions or scenario inputs. Examples are Aggregate Level Simulation Protocol integration of simulations to drive C4ISR (Command, Control, Communication, Computer, Intelligence, Surveillance and Reconnaissance) test and training exercises and scenario or event scripts driving test devices such as anechoic chambers. The following table lists some strengths and weaknesses of the current users of ADS in T&E.

Table 1: Current ADS Considerations for T&E

	PROS	CONS
GENERAL:	o Fast set-up o Process visibility (lessons learned)	o Investment $ o Semantic compatibility o Low fidelity o Requires VV&A
PLANNING:	o Develop T&E issues and measures o Refine concept of operations and procedures o Train operators, rehearse	o Competes for access to simulations, networks and warfighters
CONDUCT:	o C4ISR scenario drivers o Emulate, simulate and stimulate to reduce live assets o Interoperability/Joint Operations	o Simulation incompatibilities (e.g., terrain, detection) o Operations "noise/friction" o Updates of various simulations based on test item changes or changes in interacting simulations
EVALUATION:	o End to end assessments o Sensitivity analysis o Evaluate untestable conditions	o Replacing too much test with other simulations o Performance measures biased by unknown simulation flaws

The WG noted that, in terms of personnel, dollars and coordination costs, DIS is generally more costly than using constructive simulations, as was done in the past. The greatest benefits to date from DIS have been better preparations of the test unit for operational tests.

New Application for ADS in T&E

The WG identified two areas in which ADS would enable new or significantly improved capabilities in support of T&E. The first is the general use of a common, synthetic battlespace to tie requirements generation to analysis of alternatives and in turn to simulations of test scenarios. With such a

common synthetic battlespace, one can relate test findings to the system attributes justifying program approval. The second type of new capability is to introduce high fidelity interactions with other systems earlier in the development process. This can enable a complete record of all interactions with the system under test by means of recording all protocol data units exchanged in a complex simulated combat. In the case where the system failed to perform a required function, this record can be used to replay the conditions which led to the failure as a means of checking the efficacy of a fix to the system. The new, necessary T&E questions that the WG identified which ADS could help address are listed in the table below.

Table 2: New, Necessary T&E Applications for ADS

GENERAL:	o ADS allows common synthetic battlespace, enabling several benefits
PLANNING:	o Effectiveness analysis in more realistic environment, common with DT/OT o Requirements traceability through test cases o Adaptive learning addressed during test design
CONDUCT:	o Introduction of interactions with high fidelity assets sooner in development o Application of effects of systems without "outdoor testing" (e.g., ECM) o Overcome more test limitations (e.g., safety, availability of assets, environmental conditions, etc.)
EVALUATION:	o Recording capabilities for "re-creation of test conditions" (check out fixes to problems) o Enhancement of DT evaluation to operational consequences o Enhancement of total system performance evaluations o Potential of evaluating how well battle damage assessments are performed o Multi-media/visual aids as analysis tool — spinoff to training and operations - Replay battles to gain insights about outcomes

ADS Fit With Other Analytical Capabilities

As discussed above, the T&E WG felt that the live aspects of ADS simulations can complement other types of simulations and interactions among simulations by providing data to support validation and accrediting various ADS configurations. Also exploring larger or different scenarios or combat environments with ADS can help relate observed system performance to more abstract notions of military worth. The final topic the WG considered in this area was a clear distinction between compliance, compatibility and interoperability in the context of VV&A. Compliance is an element of verification in that it is a determination that the information exchanged adheres to the specified standards for the exchange. Compatibility is an element of logical verification in that it addresses the consistency factors such as resolution, environmental fidelity and the ability of the simulated entities to use the exchanged data as intended. Interoperability is the most difficult requirement for supporting validation and accreditation. It is an indicator of how well the simulation matches how the actual objects behave in the real world. The following table lists the ADS relationship with other analytical capabilities from the T&E perspectives.

Table 3: ADS Fit with Other T&E Elements

COMPLEMENTARY:	o Validate physical and behavioral models in constructive simulations o Prepare for live simulations o Compose simulations from existing models o Running consistent simulations independently to address elements of evaluation
SYNERGISTIC:	o Expand scope of analysis such as scenario size and environmental factors

Fit and linking LIVE, VIRTUAL and CONSTRUCTIVE simulation depends upon:

- o Compliance - Can be solved
- o Compatibility - Uncertain (e.g., environmental fidelity, resolution...)
- o Interoperability - Tradeoffs, extensive validation tests, upgrades to live real time assessments.

Limitations of ADS for T&E

The table below lists the WG's assessment of ADS limitations for T&E organized by two notional timeframes on the top and the applicable phases of T&E on the left.

Table 4: ADS Limitations

	CURRENT	FUTURE
PLANNING:	o Plug & Play" capability for system and software o VV&A and M&S repository	
CONDUCT AND EVALUATION:	o Fidelity o Security o Proprietary M&S access o Technology (e.g. latency)	o Proprietary M&S access o Technology (e.g. latency)
ALL:	o Cost and resources o Robust environmental M&S o M&S interoperability o VV&A	o Robust environmental M&S o M&S interoperability and compatibility

Two areas warrant further explanation under this topic. The first is the WG's concern about the notion of "Plug and Play." Specifically, the Group's concern is that complex configurations of simulations can be constructed and operated with only compliance being satisfied. Especially for large ADS federations, compatibility and true interoperability will be difficult or nearly impossible to confirm, and therefore, may not be checked. The consequence would be unknown biases and errors in the performance or effectiveness measures produced by the running of such simulations.

The second concern in Table 4 is the cost and human resources required to develop, operate and accredit ADS elements and configurations. Although ADS as a tool may be easily reconfigurable, other costs and risks may make it impractical for some potential T&E applications. The points on cost which were raised and discussed in the WG are summarized in the following paragraph.

Good models or simulations usually come with substantial price tags. They are most useful for mitigating program risk in the areas of requirements generation, system design and development of employment procedures. T&E is the beneficiary when

models and simulation required for system development can be accredited for reuse in making efficient use of T&E resources, and in examining conditions which could not be tested. A concern is that further investment in modeling and simulation, solely for the purpose of evaluating test findings, does not always have a good or known return on investment. We need to develop a methodology for determining trade-offs between spending dollars on simulations versus on additional test capabilities. There may be cases where it costs less or we learn more from a test capability than we could achieve from spending on a yet to be proven, simulation.

Pitfalls in ADS Application to T&E

From a T&E perspective, some of the perceived pitfalls in using ADS are listed in the following table.

Table 5: ADS Pitfalls in T&E

PLANNING:	o Reluctance to give up trusted methods for unproven techniques
PLANNING/: CONDUCT	o Fidelity/scaleability including model approach, characteristics and analyst's knowledge; and overconfidence in "visual displays" o VV&A including time, responsiveness, cost, complexity and configuration management
CONDUCT:	o Latency issues & impact on areas such as ECM, ACM, C3I o Interoperability disconnects with LIVE, VIRTUAL and CONSTRUCTIVE entities including reliability, scheduling, seamless issues and reality "mismatches"
EVALUATION:	o Due to disparate sites, difficult to maintain positive control over input data and data collection and reduction

Most of these issues have been addressed already. Two are worthy of explanation here. One is infatuation with visualization. The T&E WG offers two cautions here. The first is that with the technology advances which enable realistic looking imagery, we may be generating imagery which is not required for analysis. Typically, imagery will be necessary for combat fought with manned simulators. This leads to the second caution for visualization; viz. when we see realistic looking imagery, we forget to question whether or not the underlying data and algorithms are faithfully representing the intended real phenomena. Nice looking, plausible responses are not sufficient to assure that the interactions are correct.

The second issue in Table 5 requires some additional explanation on the topic of latency. As ADS federations pass information over heavily loaded or wide area

networks, the arrival and processing times at different entities will likely not match the times that the represented influences would be realized in the real world interactions. For phenomena such as those relevant to electronic combat where complex waveforms are traveling and interacting at the speed of light, the latency problems inherent in ADS may be a fatal pitfall for those applications.

ADS Effects on the Utility of Analytical Results

The T&E WG's assessment of strength and weaknesses of ADS effects on the utility of analytic results are listed below.

Table 6: ADS Effects on T&E Analysis

IMPROVEMENTS:	o Quality of results - Tailorable scope - Prepare for live tests - Model reuse o Efficiency - Get system requirements, design, operational test measures consistently aligned. - Quickly reconfigure simulations - Analyze more issues
CHALLENGES:	o Transition period o Non-compliance o Integrating legacy models o Many configurations to accredit o Simulation runs often not repeatable

New Way to Utilize the Results from ADS-based Analysis, Exercise and Training

The T&E WG considered this issue in terms of a paradigm shift. The old paradigms that segregated users — analysts, testers, trainers and mission planners — and aligned event phases in chronological order — planning, conduct and evaluation — must be broken if the true benefits of ADS are to be derived. This "paradigm breaking" would be the direct result of achieving the ADS vision of a simulation toolkit that can be tailored for each event, which enables portrayal of a continuous war and which leverages the insights and experiences of an entire community of ADS users and developers. While ADS is not a panacea, it

does offer a vision and new way of thinking about how the DoD does its business. The ADS technologies which could lead to a common synthetic battlespace should bring improvements in the three major categories depicted in the following table.

Table 7: Key Concepts Supporting New Uses of ADS in T&E

o Visualization in three dimensions
  - During and after
  - Midcourse corrections
  - Improved test control
  - Pure and player's view
  - After Action Review (AAR) - multimedia, operational impact

o Expand the scale and scope
  - Broader issues
  - Larger common data set that leverages training products for T&E
  - Increase in number of data sets
  - Perform "what if" analyses

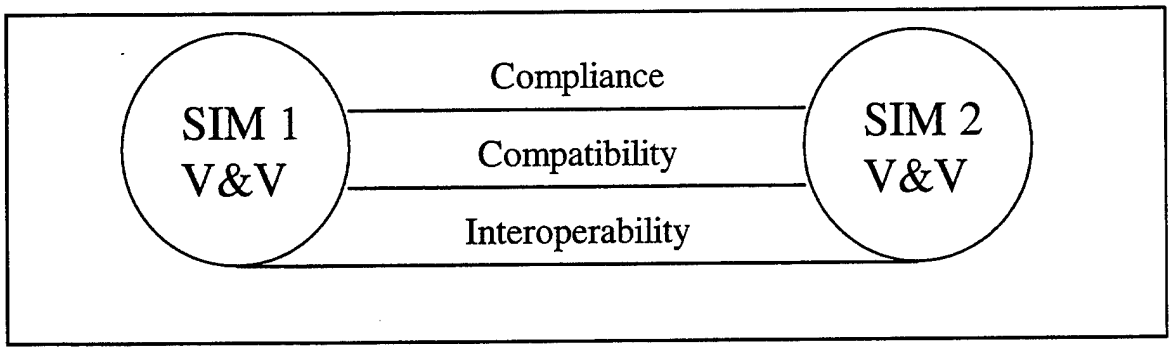
o Integrate across functions and categories
  - Non-linear merging of events (test, training and analysis), simulations (LIVE, VIRTUAL and CONSTRUCTIVE) and phases (planning, conduct and evaluation)
  - Balance use of tools based on feedback
  - Requirements and baseline tracking for continuous assessment, adaptive sequencing

The radical shift proposed by ADS for simulation methodology and technology makes it difficult to fully fathom the benefits that will be offered by its employment or to appreciate just how muddy the lines between traditionally distinguishable users and events will become. The Joint Advanced Distributed Simulation (JADS) Joint Test Force is forging an excellent first step in seeing how the vision can become a reality; however, exploration and feedback from the use of ADS must not stop there. Many users of simulations are already probing into the vision of ADS, even if not using specific DIS or High Level Architecture (HLA) standards and protocols. Their lessons learned must be examined for applicability to ADS. The DoD should also consider augmenting some events (test, training or analysis) financially and technically to establish them as test cases for proving out ADS. This seed money and intellectual support would enable users to explore new avenues while still insuring that the requirements which are driving their use of a simulation or suite of simulations is satisfied.

Verification, Validation and Accreditation (VV&A) Considerations

The WG identified aspects of VV&A for ADS that are envisioned to be easier, harder and different from our current VV&A experiences as shown in the Table 8.

Table 8: VV&A Considerations



"EASIER"	"HARDER"	"DIFFERENT"
o Use of commonly accepted, recommended practices o Use of VV&A histories from central repository o Previously validated pieces o Reuse of previous VV&A reduces cost	o Distribution of cost and schedule across programs o Validation across different levels of fidelity o Dependence on successful data collection (time, resources and cost complexity) o Configuration management issues	o VV&A not a "cure all" — analyst must interpret results in much more complex environments

For the items in the "easier" column to be realized, it is essential that an accessible, complete and user friendly repository of VV&A records and histories be kept current. By far, the most difficult aspect of VV&A for ADS identified by the WG is generating validation data for and accrediting the "interoperability" among the unbounded combination of simulation interactions for each ADS configuration and application.

The Group noted that generally less stringent accreditation standards would apply to test planning applications than would apply to test conduct applications. Depending on the use of simulation - generated measures, accreditation criteria could run the whole range of rigor when the application is for evaluation. The WG discussed the collective concern of practitioners' not doing accreditation

because the construction and running of an ADS is likely to take less effort that would be required to accredit that ADS configuration. This is of most concern for applications in test conduct and mission rehearsal where accuracy of simulated processes is especially important.

Common Themes from the T&E WG Deliberations

The points that tended to recur throughout the WG deliberations are summarized below. The "-," "o," and "+," signify negative, neutral and positive points respectively.

- "Reality matching" interoperability, much more difficult than "plug & play" compliance

- Biases in test item performance measures resulting from ADS unknowns

o Visualization
  +Causality for lessons learned
  - Promotes acceptance without knowing how ADS works

o "Testing" and "simulation" (pre ADS notions) need each other: through M-T-M testing and other simulations complement each other in overcoming limitations

o VV&A
  + Reuse
  - Configuration control/complexity
  + Potential for common synthetic environment to link requirements, development, techniques of use, T&E, training and operations
  + Broader scope/ "untestables"
  + More versatility

T&E WG Recommendations

The T&E WG recommendations for ADS '96 to:

o The HLA include data collection and recording standards

o Develop standards for "interoperability": semantic or reality matching

o Establish resource repository requirements and standards (to include lessons learned)

o Promote awareness to dispel
- "Plug & play" myth
- Visualization = "must be true"

o Initiate research on metrics for alerting ADS potential problem or flaws

o Require ADS ports or hooks in operational systems

Test and Evaluation Working Group Members

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MORS ADSA 1996

Training, Mission Rehearsal and Alternative Courses of Action Working Group (WG 4)

- Report to the Plenary Session -

1 February 1996

Frederick E. Hartman, Chair
CAPT Drew Beasley, Co-Chair

Group Membership

- **CAPT Drew Beasley, Co-Chair, JSIMS JPO**
- **Tony Brinkley. Teledyne Brown**
- **Howard Carpenter, Synthesis Group, MITRE**
- **Dr. Judith Dahmann, DMSO**
- **CAPT Lee Dick, SPAWAR**
- **Robert Eberth, Palmer-Eberth**
- **Dr. Randy Garrett, ARPA**
- **Fred Hartman, Chair, Foxhall Group**
- **LTC Kemp Littlefield, ACOM**
- **Leslie Lampella, TRADOC**
- **LTC Doug Martin, JWFC**
- **Brian McEnany, SAIC**
- **CDR Scot Miller, CINCPACFLT**
- **Miranda Moore, LIA**
- **COL Tom Verbeck, JWFC**
- **Bill Waite, Aegis Research**

INTRODUCTION/GROUP MEMBERSHIP - Slide 2

In preparation for the Training, Mission Rehearsal and Alternative Courses of Action Working Group (WG4), an attempt was made to assemble representatives from both the training and analysis communities. A deliberate effort was made to include the "user community" as described by the new emphasis on joint and interoperability training. The resulting attendance at the WG precipitated lively discussion from both the trainers/operators and the analysts. We appreciated the participation of the WG membership, which provided the opportunity to form a bridge between two very separate communities. One member of the group used the analogy that the training and analysis practitioners are residents of two different planets with the trainers from Mars and the analysts from Venus. The thought provoking dialogue that occurred in this session has resulted in recommendations that will assist in bridging the gap between the two worlds.

CAPT Drew Beasley, Program Manager of the Joint Simulation System (JSIMS) Program was co-chair of WG4 and provided an excellent overview that helped to tie-in with the current efforts that are underway to build a simulation tool for training and training analysis at a full range of training activities. COL Tom Verbeck heads the Technology Division of the Joint Warfighting Center (JWFC) which is responsible for working with the CINCs to translate their training requirements into the framework for JSIMS. The technical community and specifically Defense Modeling and Simulation Office (DMSO) was represented by Dr. Judith Dahmann. Other members of the WG were from either Joint and Service Staffs, FFRDCs or supporting industry contractors involved in the two communities.

In order to set the stage for meaningful discussion between the training and analysis communities a portion of the first day was set aside to receive relevant presentations on the JSIMS program, technology issues, the role of the JWFC and an example of distributed models from the functional area for logistics support.

Group Process/Agenda

- **BACKGROUND**
  - ADS For Training
  - Venn Diagram
  - Current Initiatives
  - Methodology
- **PRESENTATIONS**
  - Joint Simulation Initiatives, CAPT Beasley
  - Technology Issues, Dr Dahmann
  - Joint Warfighting Center, COL Verbeck
  - Distributed Intelligent Architecture For Log, Ms Moore
- **DISCUSSION**
  - DoD Definition
  - Context Of Problems
  - Treatment Of Issues
  - Framework For Analysis
- **RECOMMENDATIONS**

GROUP PROCESS/AGENDA - Slide 3

By way of background, an opening discussion session was held to introduce individuals to each other and to the perceptions of ADS, as it has been applied in the training area. The discussion produced the diagram and information found on Slide 4.

Relevant current initiatives and methodologies were covered by the briefings/presentations and discussions during the first day's session.

A JSIMS overview briefing presented by CAPT Beasley covered the background, objectives and development concept and a graphic of how JSIMS fits into the range of modeling and simulation and addressed our theme regarding the "Requirements for Analysis within the Training Domain". The questions raised and discussed, included:

- What analytic tools, techniques, and procedures can/should the analysis community offer to the trainers?
- What are the critical elements for analysis/support for exercise planning? For after action review? For supporting training objectives?
- How can analysis and ADS be used in support of: training events, trainees performance, tactics /doctrine, weapons systems and support systems development, force structures and operational planning?

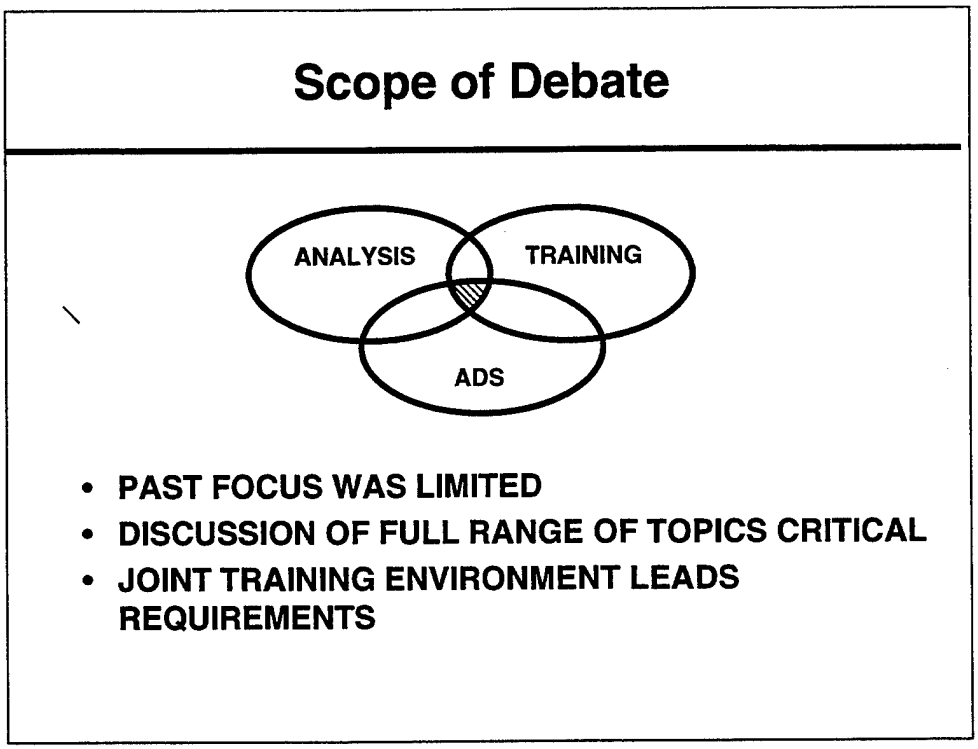
Dr. Judith Dahmann, DMSO, gave an excellent summary of technology issues concentrating on the HLA and run time infrastructure with further discussion of important issues such as aggregation /disaggregation, VV&A and logical consistency.

The overview of JWFC was presented by COL Tom Verbeck. He discussed their role in working with the CINCs and their staffs to move from their Joint Mission Essential Task Lists (JMETL) to requirements that will feed JSIMS. The JWFC is the "keeper of the keys" for the Executive Agents in JSIMS. The discussion led to a wide range of ideas regarding support for the joint training environment.

NOTES Slide 3 (Continued)

Ms. Miranda Moore of the Logistics Integration Agency discussed an example of a distributed approach for improving the joint analytic logistics decision process. The technical approach referred to as the "Distributed Intelligent Architecture for Logistics (DIAL)", will allow for existing functional area models to interface and communicate to cover logistics planning and integrate mobilization with deployment.

Early discussion by the group indicated an unwillingness to take the time to debate the basic definition of ADS, or what it is or isn't in great detail, but rather to move directly into the analysis and application of ADS in the training environment. A common treatment for issue discussion was the general session and introductory presentations. This set the foundation and framework for the following analysis of the WG.



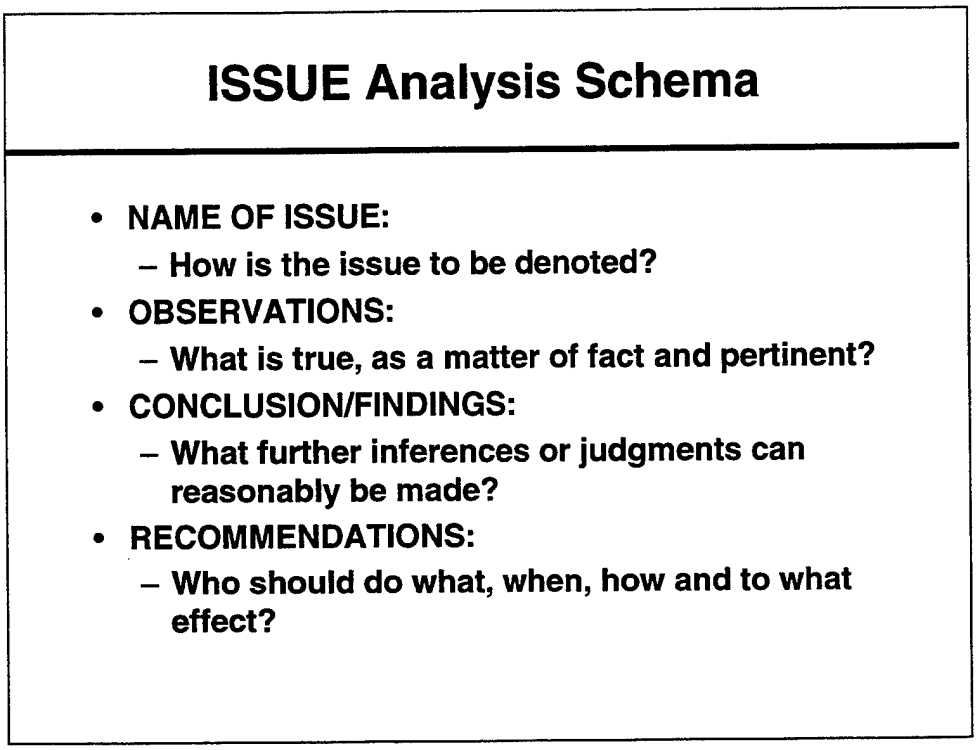
SCOPE OF DEBATE - Slide 4

In the past, there was a relatively common interface between the training and ADS portions of this diagram. The U.S. military has developed an impressive array of simulators and training systems over many years. These systems, largely stand alone single system simulators, became very effective and widely used for training individuals or small teams (crews) to accomplish their specific duties. These simulators range from simple devices (such as rifle marksmanship trainers) to more complex devices (such as tank gunnery simulators or sophisticated flight simulators). The current inventory of simulation systems does not offer the opportunity for training in combined operations or the wide range of scenarios that will be needed in joint and interoperability training required by today's world situation. The concept of networked simulations was first developed in the SIMNET program, which was sponsored by the Defense Advanced Research Projects Agency (DARPA). The linking of platform-level simulators provides the capability to train as teams and to set up battlefield scenarios. This system of networked, interactive simulations forms the intersection between training and ADS as depicted in the Venn diagram. With the improvements in ADS we have the opportunity to incorporate real time interaction during the course of analysis. Changes can be made in the course of an exercise or event that will affect the outcome, providing a strong analysis tool.

It is important to consider analysis in the support of training and, in particular, in support of distributed simulations used for training. Constructive simulation combines simulated combat forces and simulated systems. Constructive simulations are widely used for analysis, but they currently have a relatively narrow niche in training applications. The primary training value of constructive simulations has been in preparing command staffs for joint and service operations. Each of the Services has developed constructive simulations to meet its command staff training needs, but there are limited models available to support joint training. The use of constructive simulation has allowed the partial substitution for actual troop deployments or weapons systems saving valuable resources while enhancing training.

NOTES Slide 4 (Continued)

The joint training environment will be driving the need for the marriage of analysis, training and advanced distributed simulations. While joint training leads the requirements, the Services have specific activities which will benefit from support from analysis. The SIMNETs are in use at Forts Knox, Rucker and Benning, Gowan Field, Camp McCain and USAREUR. The Navy uses Battle Force Tactical Trainor (BFTT) for training exercises and the Army sponsors ALSP (Aggregate Level Simulation Protocol) exercises like "Prairie Warrior." The analysis community must learn more about training in order to help the trainers with their problems.



ISSUE ANALYSIS SCHEMA - Slide 5

As the group discussion progressed from the opening session and briefings, it was necessary to develop a methodology for the structured analysis of the issues which were surfaced. The slide above depicts the standard manner in which the remainder of the briefing has been formatted. As issues were brought up for discussion, they were described in the training/ADS/analysis context. The WG then made observations and developed conclusions or findings relative to the specific issue, before moving to make recommendations.

Issue: MOEs for Training

- **OBSERVATIONS:**
  - **Cost/benefit of approaches (traditional and ADS) should be determined**
  - **Tools available drive training**
- **CONCLUSION/FINDINGS:**
  - **Training audience and objectives should determine which tools are used**
  - **Less costly training may support requirements**
- **RECOMMENDATIONS:**
  - **Develop MOEs for evaluating training**
  - **Establish quantitative measures**

ISSUE: MOEs for TRAINING - Slide 6

It was observed that additional Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) are needed for evaluating training effectiveness. In many instances the available tools drive the training events. It was also felt that the cost/ benefit of traditional training approaches should be determined to serve as a benchmark for trading off the legacy systems for more advanced training systems. The Army's TRADOC Analysis Command (TRAC) has been conducting training effectiveness analysis to evaluate the value of training. This type of evaluation offers potential in the ADS environment. Additionally, TRAC has developed a training mix model to assist in determining the best combination of live, virtual and constructive based training.

The training audience and the purpose or objective of the training should drive the selection of the appropriate training tools. Just because it is possible to link platform level simulators to participate in joint training events, is it logical and desirable to do so? It is possible that simple, less costly training may actually support the training requirements of a given category of training adequately, or even better than some proposed complex systems?

It was felt that the training community should develop additional MOEs for evaluating training effectiveness and to establish quantitative measures that would be useful in determining the cost/benefit of traditional versus more advanced automated systems. The training community needs embedded training feedback and evaluation tools to evaluate joint/command staff decisions. Resident tools are normally preferred to shared tools and there is a recognized strong need for the CINCs models to be interconnected among the other users/players.

Issue: Lack of Functional Modules to Support Training

- **OBSERVATIONS:**
  - **Post Cold War emphasis on logistics... heightened awareness... seldom played in ADS**
  - **Exercises too short to encompass major resupply and IB**
  - **Needs include intelligence interaction, IW, IB, C4I interfaces, mine/counter mine, ...**
- **CONCLUSION/FINDINGS:**
  - **Incorporate log requirements for training and analysis**
  - **IB links provide realism for sustainment**
- **RECOMMENDATION:**
  - **Include log and C4I effects in federations**

ISSUE: Lack of Functional Modules to Support Training - Slide 7

Just as the post cold war period and Goldwater/Nichols has changed the way we fight our wars, it has also changed the way we provide support for our forces. There has been a significant heightening of the emphasis on logistics. The functional support areas are seldom played in an ADS environment, even with the increased awareness of their need in today's military forces. The cycle time for most exercises is too short to encompass the full spectrum of logistics support, let alone the Industrial Base (IB). The combat cycle at tactical combat level is usually 24 hours or less. As the level of combat activity increases, the time becomes even more compressed at lower, tactical units. The cycle time for aircraft or tanks engaged in combat for instance can be minutes or even seconds. In order to get full training benefit, it may be desirable to train at greater than real time for intense tactical combat activity. Conversely, at the Joint Task Force or CINCs staff, the strategic level of combat extends over greater periods of time. If an exercise is conducted over a period of days or even weeks, the full play combat support does not occur due to the increased cycle time.

In addition to logistics, other functional areas for incorporation include intelligence and information warfare, C4I interfaces, IB, mine/countermine and Military Operations Other than War (MOOTW). The need is evident for the incorporation of logistical support requirements into models and simulations for both training and analysis. It may also be necessary to modify the manner in which the above functional areas are incorporated in command staff training exercises. The IB links to logistics support will provide training realism for sustainment of forces in an operation.

The development of common functional modules should be the vehicle for including logistical support, C4I interfaces in ADS federations for training and analysis applications.

Issue: M&S Representation Scope and its Impact on ADS

- **OBSERVATIONS:**
  - **ADS typically addresses only part of the scope of the domain-of-interest of analysts and training communities**
  - **Much of data gathering, information awareness, and knowledge domains, are assumed away into 'the real C4I systems'; operations support is under-represented**
  - **Implications exist for ADS design and system specification**
- **CONCLUSION/FINDINGS:**
  - **Deserves attention by ADS development and user communities**
- **RECOMMENDATION:**
  - **Include full-domain-of-interest into ADS development**

ISSUE: M&S Representation Scope and its Impact on ADS - Slide 8

The use of ADS usually addresses only a part of the full scope of the domain of interest for both the analysis and training communities. In the JSIMS concept, the domain of interest of an individual training event may be played at a greater level of resolution or fidelity with distributed (or resident) modules supporting the other functional areas in a more gross level of detail or resolution. It was felt that much of the information related data gathering, information awareness and warfare/knowledge domains are assumed away as being covered by the C4I systems. The C4I systems must have seamless interface with other simulations and their capabilities enhanced to actually accommodate all the information issues discussed here. The area of operations support is felt to be under-represented in the community. The support of high level command and staff training functions is a natural bridge between analysis and training. Many of the current tools for these staffs are in fact analysis-type models. In this context there are significant implications for ADS design and detailed specification for the emerging systems.

The M&S level of representation and domain of interest deserves attention by both the developers of our new systems and by the analysis and training community users.

The recommendation is that the development agents resolve the full domain of interest issue through ADS if appropriate, but also through the process of logical threads pulling the information needed at the appropriate level of resolution to fuel the main user interface/training event. The user should have a low sense of awareness that he or she is pulling from another model or system.

Issue: Potential Misuse of Training M&S Results

- **OBSERVATIONS:**
  - **Training exercises offer a potential source of data for analytical efforts**
  - **Results will be employed in collateral analysis**
- **CONCLUSION/FINDINGS:**
  - **Need standards and practices for use of training data for meaningful collateral analysis and to minimize misappropriation of training data**
- **RECOMMENDATION:**
  - **Address the general issue of application of findings from ADS in domains other than for their originally intended use**

ISSUE: Potential Misuse of Training Results - Slide 9

Training exercises offer a rich potential source of data for analysis efforts. Given the availability of data (even if only anecdotal) from training events/exercises, there will be use of that data for collateral analysis. The problem that is recognized here revolves around the potential misuse of data from training for analysis of resources, weapons system procurement decisions and so forth. This condition will potentially become more prevalent with the proliferation of M&S applications for training.

It was concluded that there exists a need for standards and practices for the use of training data for meaningful collateral analysis. There should be a recognition in both the training and analysis communities that the data from training must be taken in the proper context and used wisely to feed other analysis models and studies for exogenous purposes. We need to find ways to minimize the risk of misappropriation of training data for collateral analysis.

The recommendation addresses the larger issue of ADS and the use of data from large, distributed simulation federations. In general, the application of data and findings from ADS should be controlled and used wisely for collateral analysis in domains other than that for their original intended use.

Issue: Data Management

- **OBSERVATIONS:**
  - **ADS implies multiple, distributed databases**
  - **Configuration Management (CM) and VV&C are more critical**
  - **Historically, data management is an analytic after-thought**
- **CONCLUSION/FINDINGS:**
  - **More resources are needed for data management**
  - **Cost of multiple, heterogeneous exercise-initialization databases can be an inhibitor to ADS use**
- **RECOMMENDATION:**
  - **Develop tools and common data interface standards**

ISSUE: Data Management – Slide 10

It was recognized that a subject of the analysis and M&S community is very concerned with the data, data management/applications and certification issues. However, we feel strongly that the topic needed discussion in the context of our group, while recognizing that there is a need for the development of tools and standards in accordance with current guidelines and regulations. It was observed that ADS implies mutiple distributed databases. There is work being done by DMSO and their contractors in a program to develop "Conceptual Models of the Mission Space (CMMS)." This program responds to the DMSO Master Plan which advocates a common technical framework through the use of HLA/CMMS/Data Standards. The CMMS provides the common logical framework for knowledge acquisition and a standard format for expression. It will provide validated, relevant actions and interactions orgranized by specific task and entity/organization. The CMMS will be a high level, hierarchical representation of the interactions and actions of combat entitites in each mission space. This will potentially become a standard format for expression that will provide a simulation-independent source of information capturing in the data, tasks, entities and their interactions. Historically, the area of data management and sometimes even life cycle configuration management are analytic after thoughts.

Our conclusion for data is that we need to be investing more resources in the data management, configuration management and Verification, Validation and Certification (VV&C) areas of ADS development for training applications. After the above discussion, it was also recognized that on the downside the cost of multiple, heterogeneous exercise-initialization databases/systems/models can be an inhibitor for ADS use.

The recommendation is that the community give high priority to work on tools and common data interface standards. We feel that the CMMS program is a big step in the right direction.

Issue: Analysis/Training Community Interactions

- **OBSERVATIONS:**
  - **Roles and missions of the analysis community in support of training are not defined**
  - **There is no vision of analysis/training coordination to guide analysts**
  - **Requirements of analysis to support training are inexplicit**
- **CONCLUSION/FINDINGS:**
  - **Information exchange has been too limited**
  - **Analysis community can and will help but terms needed**
- **RECOMMENDATION:**
  - **Improve communications between training and analysis community**
  - **Develop future vision, goals and objectives**

ISSUE: Analysis/Training Community Interactions – Slide 11

Consistent with our earlier discussion as to the two communities being "planets apart," it was recognized early on that the traditional roles and missions of the analysis community in support of training are not/have not been well defined. There is not currently an existing model or vision of analysis in support of training to serve as guide for analysts and trainers. We are missions explicit requirements from the training community, for analysis to support training. Part of this problem was discussed earlier in the MOE and the functional representation slides.

It is believed that in the past information exchange between the two communities has been too limited. Another observation is that the analysis community can and will be able to help with the thorny problems facing the training community, but the requirements and an invitation to play are needed.

The recommendation developed here to improve communications between the two communities resulted in a capstone recommendation discussed later which will formalize involvement by establishing a MORS WG at the annual Symposium to address the topic of "Analysis Support for Training." As vision, goals and objectives are developed, the communities must work together to identify areas of expertise and responsibility to share development and operation of simulations, functional modules, common object and data models and the supporting infrastructure.

Issue: Multi-Level Security

- **OBSERVATIONS:**
  - **Still problematic**
  - **Multi-service coordination, intelligence data management cause difficulties**
  - **ADS network distribution exacerbates problem**
  - **Most operations default to "system-high"**
- **CONCLUSION/FINDINGS:**
  - **Much broader problem than ADS**
- **RECOMMENDATION:**
  - **Push for resolution within DoD community standards and practices**

ISSUE: Multi - Level Security - Slide 12

This issue has been with us for many years, but we are only now beginning to achieve the technological breakthroughs that will permit wide spread, logical solutions. The area is believed to be STILL problematic and likely to cause more problems in the areas of multi-service coordination/cooperation, intelligence data and information warfare as we move to more distributed environments. The ADS network serves to exacerbate the problem. In order to manage the risk of unauthorized entry or disclosure, most operations will default to a "system-high" mode, which may hamper both training and analysis applications (not to mention the distribution-over-networks problems).

It was concluded by the group that this is a far wider and deeper problem than just the ADS portion. And although we may not be able to resolve the problem in this forum, we should recognize it as a potential show stopper in the future and work toward mutual steps for resolution.

The training and analysis communities should push for resolution with the broader DoD community and establish standards, practices and incorporate leading edge technologies to solve this long standing and important problem.

Issue: Logical Consistency

- **OBSERVATIONS:**
  - **HLA supports technical means to implement *logical interactions* among entities in ADS**
  - **Logical unity of ADS ensembles must be designed-in**
  - **Critical to establishing a credible federation ensemble**
  - **Critical for enabling valid analyses**
- **CONCLUSION/FINDINGS:**
  - **Critical to ADS for both training and analysis use**
- **RECOMMENDATIONS:**
  - **Establish suitable recommended practices for logical consistency of federation ensembles**
  - **Explore aggregation/disaggregation issues**

ISSUE: Logical Consistency - Slide 13

A great deal of discussion centered on the issue of the representation of logical interaction between model, modules or functional data within and between federations. It was observed from Dr. Dahmann's briefing that DMSO developed HLA supports for the technical aspects of this problem and therefore ought to provide a technical means to implement logical interactions among entities in an ADS environment. This issue also crosses over into the aggregation/disaggregation issues and the desire for seamless, transparent interface between various entities. As discussed here, logical consistency is a technical requirement placed across an ADS federation ensemble for it to be valid and useful for analysis and possible for training. It is an extension of the concept of a "fair fight" that has become a major concern within the DIS community. In the DIS context, and largely due to the heavy emphasis on visual representations in that environment, the fair fight problem is generally characterized as the need to ensure that any interacting protagonists have the *same perception of reality.* There are a number of considerations in the interface that can cause problems. One is the level of resolution and fidelity of the representational entities and how they interact within their separate simulation environments. Others are time, terrain, sensors, weapons characteristics, C3, etc.

Logistical consistency is a more robust, macro level requirement. It means that when "looking across" at the ADS model ensemble, the participants in any potential interaction are — or can be made to be — behaviorally and representationally consistent. Representational consistency is more that just the fair fight concept described above. It extends to the aggregation/disaggregation type problem as well. Another concern is behavioral consistency, which may be even more difficult, largely because it is a far less visible, more subtle problem. The cure for the behavioral consistency problem across an ensemble can be achieved either by requiring potentially interacting models to be behaviorally homogeneous or by making them behaviorally commensurate. The first of those is too limiting, and the second is presently too hard. First, we need to develop the standards that will define the required conditions, and then we can begin the research to meet those standards. But if we are to succeed in building distributed simulations for either/or both training and analysis, we must address this issue. It is absolutely essential to establishing a credible federation ensemble and

NOTES Slide 13 (Continued)

First, we need to develop the standards that will define the required conditions, and then we can begin the research to meet those standards. But if we are to succeed in building distributed simulations for either/or both training and analysis, we must address this issue. It is absolutely essential to establishing a credible federation ensemble and enabling valid applications and analyses.The WG recommends the establishment of suitable practices to insure logical consistency of federation ensembles and further explore the complexities of aggregation/ disaggregation.

Issue: Training Exercise Planning Methodology

- **OBSERVATIONS:**
  - **Lack of common exercise-definition data and standards**
  - **Need rigorous methodology and effective tools to support exercise planning**
  - **Exercise planning must 'build-in' instrumentation sufficient for evaluation of objectives**
- **CONCLUSION/FINDINGS:**
  - **Planning support is key to exercise economy**
  - **A (meta-)model of the exercise may be worthwhile**
  - **ADS technologies (DBMS, visualization, etc..) may apply**
- **RECOMMENDATION:**
  - **Develop tools to assist in exercise planning and methodology**

ISSUE: Training Exercise Planning Methodology - Slide 14

The concept of model-exercise-model may help in addressing issues for a specific event and provide knowledge in designing a new event. It was observed by the group that the communities are absent a common exercise definition for data and standards. Simulations should be able to use real world data and have some easy input for analysis of the planning phase of exercises. It is also necessary to establish rigorous methodologies and effective tools to support exercise planning. For instance, the user needs automated development of data bases and scenarios. An automated, logical framework based on the mission essential task list would be useful for planners, operators and analysts alike. The CMMS discussed earlier has some of these attributes, but is intended for use by the model/simulation developer — not the end user. The planning for exercises must accommodate the necessary instrumentation sufficient for evaluation of training objectives.

Planning support is also key to economy/efficiency. Given the earlier discussion as to the difference in cycle time for tactical versus strategic levels of command staff interactions, a meta-model of tactical training could be created by collecting the relevant data produced by the many lower/tactical level training events. This meta-model could be used to feed the time compression necessary to conduct a JTF training event/exercise over a period of days instead of months which would be required for the CINC or JTF Commander's staff in a real time environment. It was recognized that ADS technologies for data and graphical representation may apply, but platform level of resolution seemed out of place in strategic level command/staff exercises.

We recommend that the communities work together to develop analysis and planning tools (and methodologies) to assist in the planning of exercises. Concentration should be first on the logical, automated framework described above that will be used by planners and operators to help do their jobs in the relatively short term.

Issue: Analysis Support for AAR

- **OBSERVATIONS:**
  - **Requirement exists to identify and analyze causal relationships and unusual events in exercises**
  - **Need automated data reduction tools, consistent with planning methodology**
- **CONCLUSION/FINDINGS:**
  - **AAR data should be formulated for use by both training and analysis communities**
- **RECOMMENDATIONS:**
  - **Develop AAR system to capture pre-planned automated data products**
  - **Analyst and development community coordinate post-processing tool prototypes**

ISSUE: Analysis Support for After Action Review (AAR) - Slide 15

AAR is an area in which analysis can interact readily with the training community. The requirement exists to identify and analyze causal relationships and unusual events that occur in training exercises. The community needs automated data reduction tools, consistent with the planning methodology. The AAR can be a logical extension of the planning cycle, where the same logical framework that plans and controls an exercise may be used to do a rapid turn around, post-mortem analysis of the training event.

The exercise data should be formulated for use by both the training and analysis communities. Up front planning should include the details of data collection for required information to conduct analysis and the AAR.

The group recommends that the training community work with the analysis community to develop a comprehensive planning/operating /AAR system to capture pre-planned automated data products. The analysis and development communities should coordinate post processing tool prototypes. The ADS technologies can be useful in pulling together the supporting data and information for all phases of the system.

Issue: Rapid Scenario Generation (Play-Revision-Play)

- **OBSERVATIONS:**
  - **Rapid scenario generation and efficient play-revision-play cycles apply to COA and operational mission-planning roles**
  - **Data are critical components. Download of real time intelligence data should be available**
- **CONCLUSION/FINDINGS:**
  - **Nothing in ADS (HLA) contributes to solving this problem — C4I technologies and practices will**
- **RECOMMENDATIONS:**
  - **Provide general support for rapid scenario generation outside ADS**

ISSUE: Rapid Scenario Generation (Generate-Play-Revise-Play) - Slide 16

The Rapid Scenario Generation as discussed by our WG relates to the play-revision-play cycles as they apply to Courses of Action (COA) and operational mission planning roles. The issue here is whether ADS, in the generic sense, enhances, degrades or has no impact on the ability to rapidly generate, play, revise and replay scenarios. This issue arose while considering the capabilities and limitations of ADS in "Analysis associated with determining the effectiveness of ...alternate courses of action during operational planning." In operational planning, unlike deliberate planning activities, analysts need the ability to rapidly set up and test and evaluate a multitude of COAs in a very short period of time. The turnaround times of the operational planning cycle are measured in minutes or hours (a very few hours) and not in days or weeks. As one aspect of the problem, operational planning MUST have access to the most current intelligence data. Today, that means real time data. A simulation supporting this type of planning process must be able to keep up with the compressed data flow — which will drive analytic turnaround to near real time responses.

The definition of ADS becomes important in the above context. As indicated earlier, WG4 did not try to redefine ADS, but was aware of the definition provided to all ADSA '96 participants by Sikora and Coose in the June '95 edition of *PHALANX*. This definition includes the geographically distributed environment for interactive simulations which may diminish the capability of ADS to respond in the rapid scenario generation situation. Some of the advantages/disadvantages of ADS over a stand alone simulation are:

NOTES Slide 16 (Continued)

- Time consumption impact of the data management problem that is inherent to multiple distributed databases (a particularly severe problem when the data is perishable intelligence data with a high potential for multi-level security problems,
- Time consumption impact of identifying and resolving new latency and logical consistency problems injected whenever simulations are added or deleted from an ADS ensemble,
- Inherently greater functional failure potential of an ADS ensemble over a stand alone simulation

After discussion of considerations such as these, the recommendation was that the general support for rapid scenario generation should be provided by means other than ADS-based systems.

Issue: Commonality of ADS for Analysis and Training

- **OBSERVATIONS:**
  - **ADS M&S framework suitable for training and analysis**
- **CONCLUSION/FINDINGS:**
  - **Logical consistency is attainable but may be expensive**
  - **Applications drive the details**
- **RECOMMENDATIONS:**
  - **Training and analysis must cooperate on ADS design and federation development (opportunity)**
  - **Must design and employ federations for 'intended use' (responsibility)**

ISSUE: Commonality of ADS for Analysis and Training - Slide 17

It was observed that the ADS M&S framework can be suitable for both training and analysis applications. The question is how one achieves the logical consistency as described earlier and at what cost. A well defined M&S infrastructure needs to be developed that will ensure easy access to M&S information, data and models. The applicability and use of M&S should in itself become a matter of military professional education to ingrain the somewhat standard, structured analysis process in the military trainers and developers.

Logical consistency is concluded to be attainable in an ADS environment, but it may be very expensive. The cost/benefit determination discussed earlier should be applied. The driving reason to move to a common ADS environment should be based on the specific application and the requirements for training, not the technical feasibility of hooking the pieces together.

The first recommendation in this area is that the training and analysis communities cooperate and collaborate on ADS design and federation development. That is our ***opportunity.*** The second recommendation is related. The two communities must design and employ federations for their "intended use" and with only their intended use forefront to avoid costly mistakes leading to unsatisfactory results. That is our ***responsibility.***

Issue: Commonality of VV&A in ADS for Analysis and Training

- **OBSERVATIONS:**
  - **The same VV&A practice is suitable for both training and analysis**
  - **Application/use is the discriminator**
  - **There are aspects of ADS which require VV&A tailoring**
- **CONCLUSION/FINDINGS:**
  - **No essential difference in the type of applicable techniques**
  - **Security and data management are important and related considerations**
- **RECOMMENDATION:**
  - **Analysis and training community together participate in determination of ADS VV&A practices**

ISSUE: Commonality of VV&A in ADS for Analysis and Training - Slide 18

One of the most important considerations with the use of M&S for either analysis or training is the confidence of the user and the "rightness" of the tool for the specific application. VV&A is a complex area that has troubled both the developers and users of M&S for years. There is a lively (and long running) debate in the analysis community as to how much VV&A is enough, and whether M&S users are being either insufficiently demanding and supportive of the outcome on one extreme, or requiring a degree of validation that is impossible on the other. All serious players agree on the need for VV&A, but may differ considerably on the degree or level of VV&A activity that is appropriate for a given model and application. It was observed by the group that common (established) VV&A practices are suitable for both training and analysis applications. The end application or use of the model/simulation system should be the discriminator as to what level of activity is enough, and the aspects of ADS will definitely require VV&A tailoring and activity.

It was concluded that there is no essential difference in the "kind" of applicable VV&A techniques when used for analysis or training applications. The issues of security and data management which were discussed on earlier slides, are felt to be very important related issues/considerations for the life cycle for the VV&A of models. A new DODI 5000.XX has been written and coordinated to lay out a common framework, process, methodologies, responsibilities and definitions as they are applied across the DoD.

It is recommended that the analysis and training communities should jointly participate in the determination of the appropriate and standard VV&A practices for ADS systems and their applications.

Issue: Relationships of Analysis and Training vis-a-vis ADS

- **OBSERVATIONS:**
  - **Clarifying the interesting and useful relationships between analysis and training is unexpectedly difficult**
  - **This taxonomic meta-analysis was worked in parallel with other issue analysis**
- **CONCLUSION/FINDINGS:**
  - **Producing such a correlation or field map ought to be useful in providing structure for follow-on deliberation or action**
- **RECOMMENDATION:**
  - **Develop and use an analyst-training relationship representation**

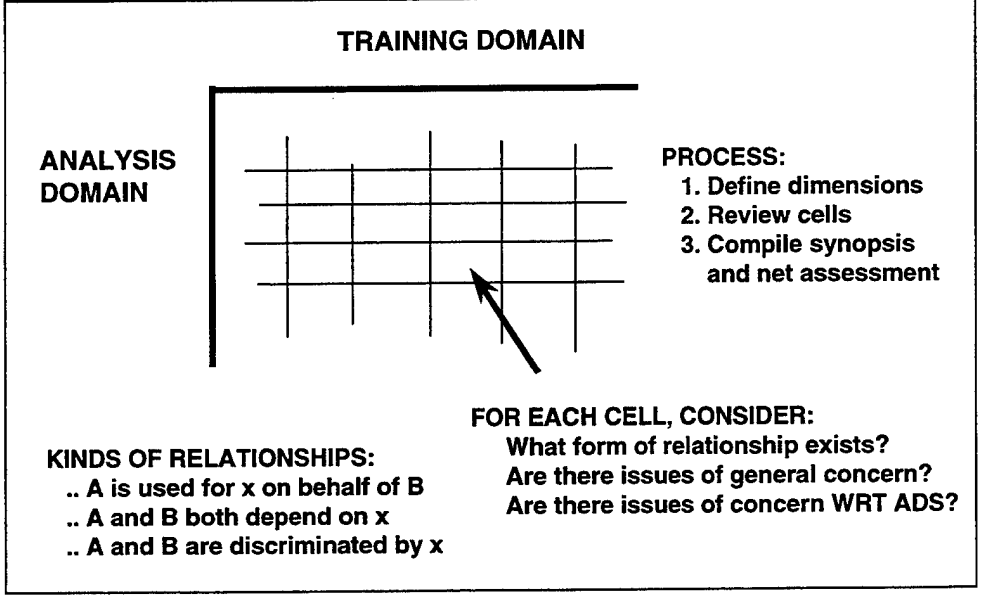
ISSUE: Relationships of Analysis and Training vis-à-vis ADS - Slide 19

As indicated in the introduction, the analysis and training communities are planets apart when it comes to working together to provide timely operational analysis to training exercises. This observation is independent of the thematic content of ADS for Analysis, but is applicable across the full spectrum of analysis in support of training. First, the group observes that it will be necessary to clarify the interesting and useful relationships between training and analysis. This first step, we find is unexpectedly difficult. There are undoubtedly reasons for this that go back to the early history of Operations Research (OR) and the more recent phenomenon of the linking of the stand alone simulation systems for training applications. The insights into this problem were manifest from the Group which consisted of both analysts and operational/training experts. Several of the issues chosen for development by the group lead to recommendations that the two communities cooperate in ways that are apparently not happening. The single most meaningful contribution of this group may be the first steps in forming a bridge between the two worlds.

In true OR fashion, the analyst must incorporate subject matter experts and get to know the users of the resultant products of analysis. That means in this case, analysts spending more time getting to know the systems, processes, policies and procedures of the training community. The resultant correlation was felt to provide a useful basis and structure for follow-on deliberation and action between the communities.

The recommendation resulting from this discussion was to develop and use an analyst-training relationship representation that will form the foundation for analysis support for training. An example of this representation in matrix format is found on the next slide.

ANALYSIS-TRAINING Relationships, (Continued)



Analysis - Training Relationships, Continued - Slide 20

The matrix shown here is a conceptual representation of how an analyst could, with some rigor, produce a mapping of the analysis-training relationships. It is stressed that this is only one quick attempt at producing a logical framework for this issue.

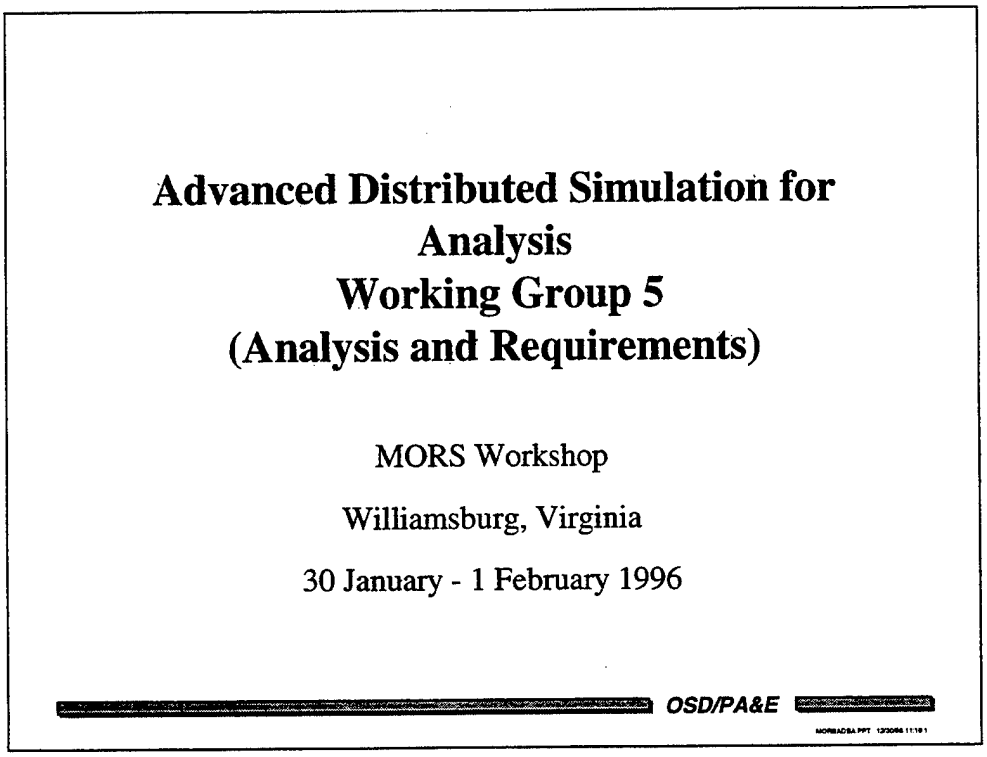
Recommendation

- **RECOMMENDATION:**
  - **Establish MORS WG *Analysis Support for Training* commencing at the 65th MORSS**
- **MISSION:**
  - **To facilitate coordination between the analysis and training communities**
- **INITIAL TASKING: (ORGANIZE AT 64TH MORSS)**
  - **Address methods, techniques and tools for the analysis community to support training:**
    - **» Exercise support planning**
    - **» AAR**
    - **» Effectiveness of training**

RECOMMENDATION - Slide 21

This chart is titled simply "Recommendation," because it is the result of many of the issues and recommendations which have gone before. The current structure of our annual MORS Symposium (MORSS) does not devote a single working group strictly to training. Training is discussed at the MORSS, but only peripherally in several of the existing groups. Currently, no one working group focuses on analysis for training support as part of its charter. Discussions which took place in ADSA '96 between the operators, JSIMS JPO, JWFC Technology Division and analysts presented a number of issues found in our earlier charts that indicate a real need for analytic support. These issues addressed AAR, exercise planning and support and training evaluations — all areas that have been studied over the years. With today's focus on joint training and command/staff interaction during JTF operations, the topic bears increased attention by both communities.

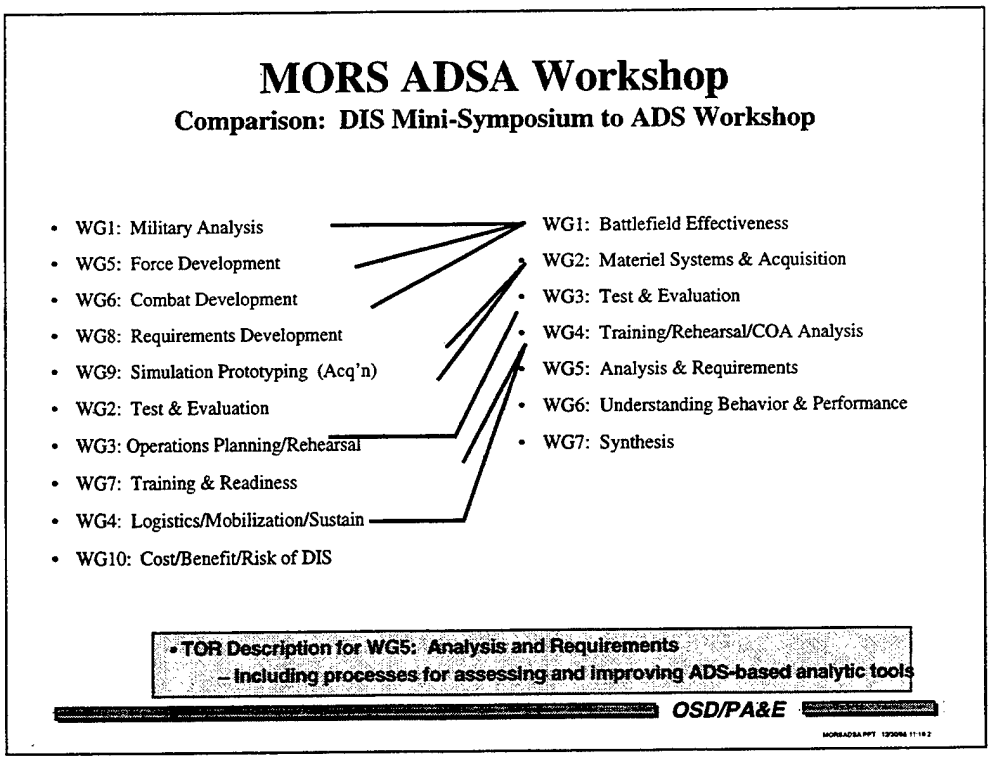
The MORS leadership will bring before the Board of Directors (BoD) at the June 1996 meeting a proposal to establish a WG for our MORSS devoted to "Analysis Support for Training" to commence during the 65th MORSS in Quantico, VA during June of 1997. The mission of this group will be to facilitate coordination between the analysis and training communities. Given approval by the MORS Board, an organizing meeting will be held during the 64th MORSS this coming June at Fort Leavenworth, KS. More details will be provided (as feedback and invitations to participate) to interested training organizations/individuals after our June organizational meeting.



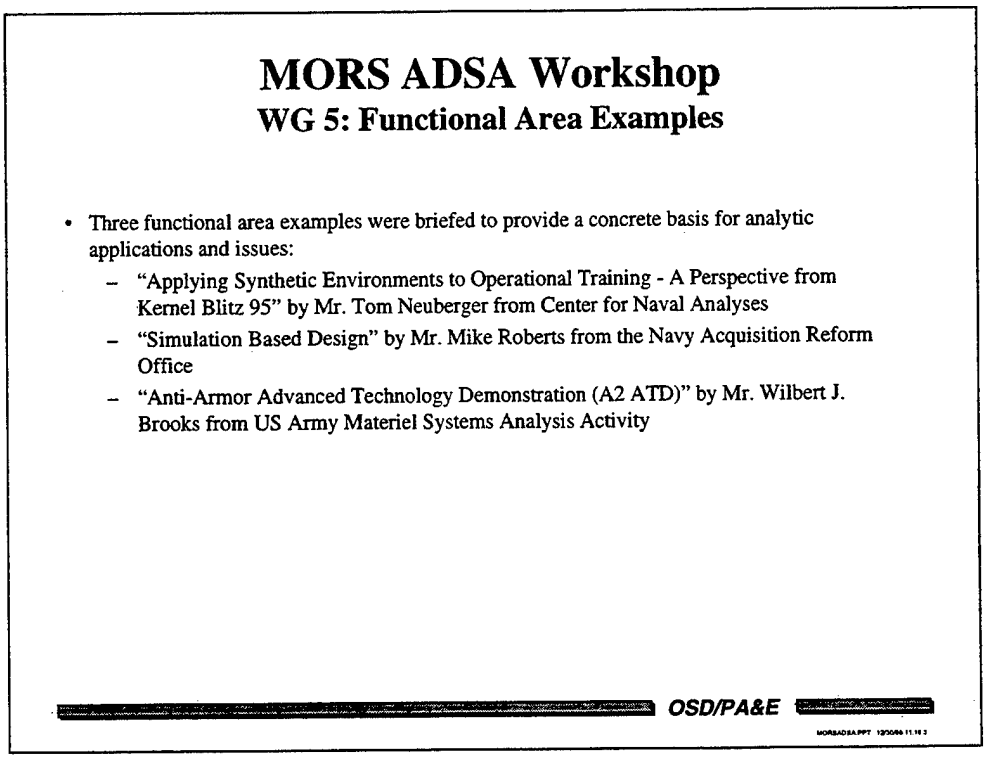
WG 5, responsible for Analysis and Requirements, was chaired by Dr. Cyrus Staniec of OSD(PA&E), and assisted by

Co-Chairs: Col. Paul Hanover, USMC
Ms. Marchelle Stahl, IDA
Mr. Steve Starner, SAIC (DMSO Technical Support)

The Group had about twenty participants, representing a wide experience base — primarily analysts, salted with engineers and M&S technologists. All of the Services, OSD and BMDO were represented. Major DoD analytic organizations, FFRDCs, academia and defense industry were present. Analytic experience was heavy in the areas of battlespace effectiveness, acquisition and training/rehearsal. This Group clearly had the depth and breadth to address the analytic issues at hand. (However, one interesting post-Workshop self-assessment question at the end of the conference was whether we had enough involvement of the customer — the consumers of our proposed analysis...)



The ADSA Workshop Terms of Reference (TOR) chartered WG 5 to examine analysis and requirements issues applied to ADS, "including processes for assessing and improving ADS-based analytic tools." The WG took this definition as a cross-cutting charter to look at all possible opportunities for analysis applications. This point of view is illustrated in this slide mapping working groups from the first MORS DIS Mini-Symposium into the ADSA working groups. Since the major functional categories from DIS mapped well into the the first four ADSA working groups, we felt free to look for an overarching view.

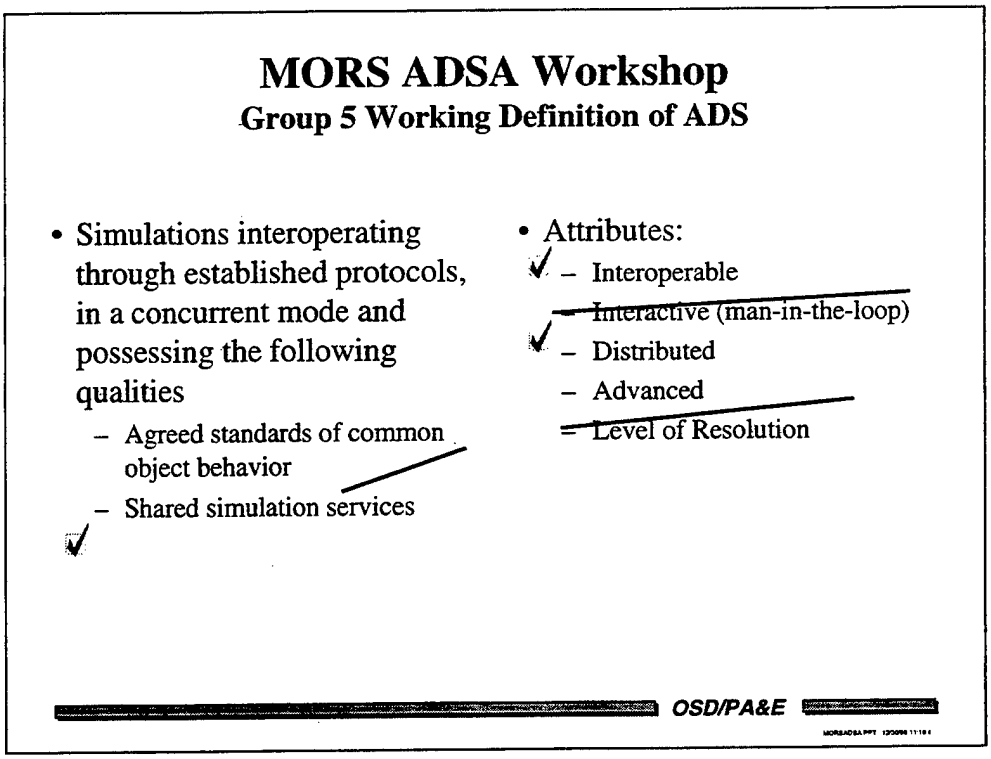


To ensure a broad, even understanding of the demands and opportunities for analysis across function areas, the WG received briefings on three current ADS-based programs spanning the four major functional areas:

1. "Applying Synthetic Environments to Operational Training - A Perspective from Kernel Blitz 95" by Mr. Tom Neuberger from Center for Naval Analyses. This briefing described a major ADS exercise conducted by the Navy in the Spring of 1995. Models and infrastructure used to support KernelBlitz 95 were described and several issues concerning analysis were highlighted. Mr. Neuberger indicated that ADS is more applicable to certain military operations than to others. Live, virtual and constructive linkage is not viable for all players and purposes (e.g....., Navy C2 structure, submarine operations and carrier flight deck personnel). There is a lack of analysis tools to support ADS analysis and no standard data recording formats. Lastly, one should be cautious about the outputs of an analysis conducted using ADS because sophisticated displays often cover simulation flaws and man-in-the-loop doesn't necessarily translate into credibility of output.

2. "Simulation Based Design" by Mr. Mike Roberts from the Navy Acquisition Reform Office described ARPA efforts to use ADS to support the design of new weapon systems. ADS was lauded as a technology with unlimited potential to provide insight into the collaborative efforts of designers, developers and program managers, alike.

3. "Anti-Armor Advanced Technology Demonstration (A2 ATD)" by Mr. Wilbert J Brooks from US Army Materiel Systems Analysis Activity provided an insightful overview of the process developed to ensure a credible ADS experiment was conducted, including a summary of the results and insight into lessons learned. The first integrated DIS capability was demonstrated by A2 ATD. DIS analytical tools were developed and demonstrated, VV&A approaches were designed and conducted on several systems, and, most importantly, a process for conducting a credible DIS evaluation was developed and demonstrated.

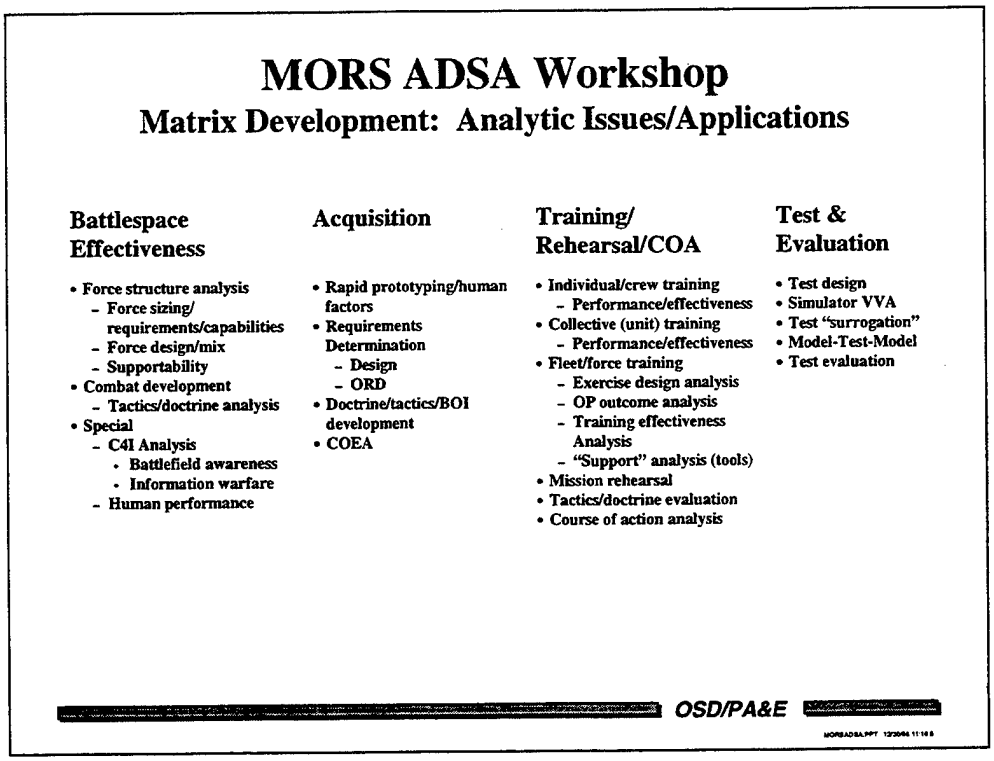


WG five developed a working definition of ADS starting from the outline above. This definition is purposely quite broad and brings one of the Group's requirements for analysis to the discussion.

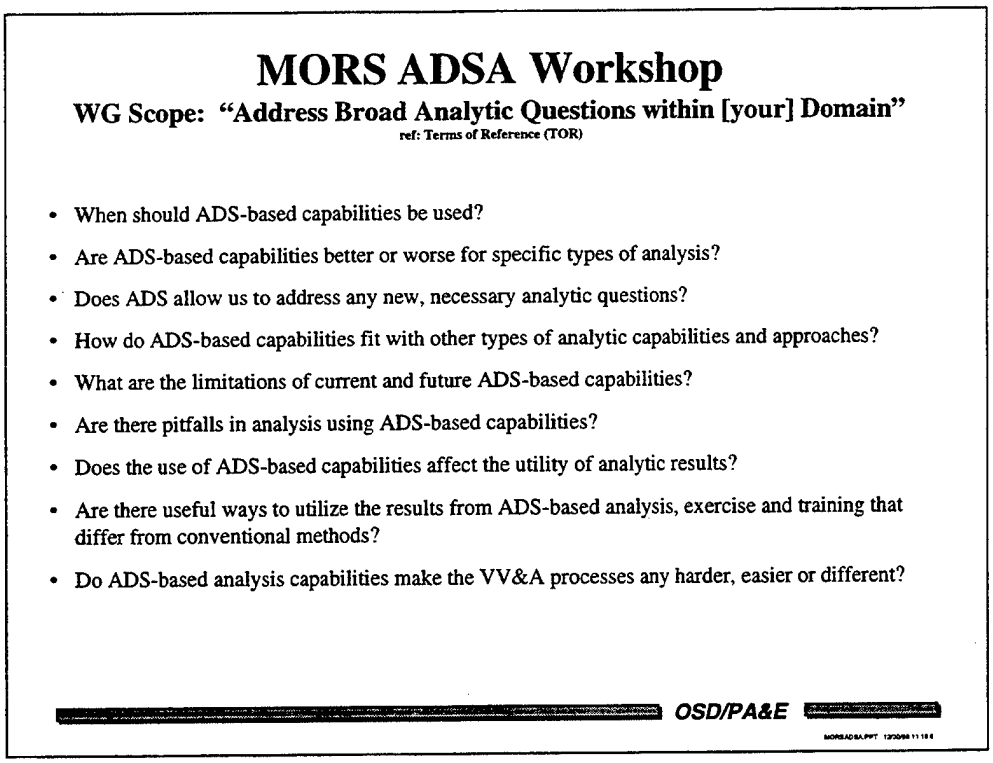
The Group accepted the fundamentals of distribution — HLA, RTI, etc. — quite straightforwardly, as well as the concept of interoperability. However, man-in-the-loop is not required by this definition (though permitted) and resolution need not be entity-level to qualify. The following examples would be characterized as ADS applications according to this definition. They illustrate the breadth of ADS and are not meant to be limiting.

- Man-in-the-loop, both live and virtual simulations.
- Interoperable constructive simulations, in which the level of entity aggregation may be high or entities may be integrated at the platform/system level.
- A distributed collaborative environment to support interaction among several communities that may be involved in planning and conducting an exercise. This environment might be supported by GroupWare and a VTC capability.

(Postscript: Dr. Paul Davis made the point during review of this report that analysts could relax this definition further by removing the "protocols" requirement. Certainly being able to distribute models through an intelligent interface not requiring a protocol would qualify as "advanced," and have significant attraction to analysts. He would use a modifier to define when a protocol is included, such as Protocol-Mediated ADS (PMADS), for example.)

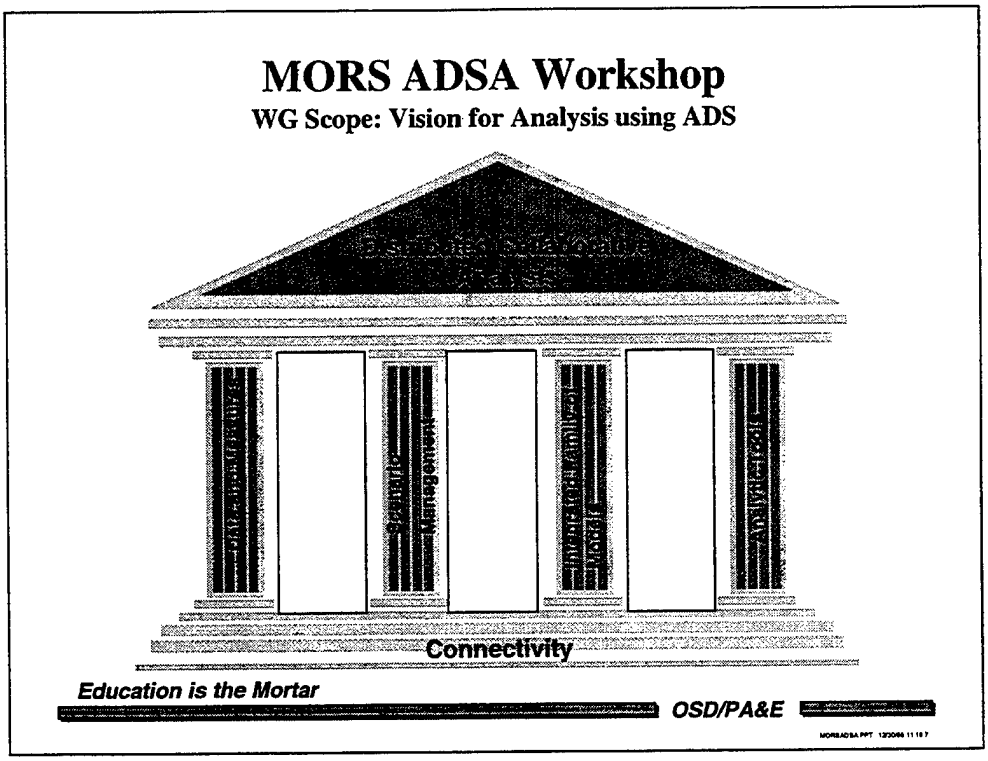


In preparation for a detailed review of the various functional areas of analysis, this table of analytic applications was developed. Not intended to be comprehensive, it provided a basis for evaluating ADS potential. Each application presents different demands for the level and scope of the associated simulation, and therefore presents differing levels of opportunity and demand on analysis. The Group split into two sub-groups to develop discussion of ADS applicability, opportunity and pitfalls for the battle space effectiveness, acquisition and training functional areas. T&E was not addressed explicitly due to lack of time.



The TOR provided the questions listed above to help focus responses. WG five reviewed these questions and incorporated their essence into its discussions, but deferred direct discussion of them until after it reviewed selected functional areas. The flavor of WG five's responses is captured in the following slides. Specific responses to the questions are provided at the conclusion of this briefing.

The task for each subgroup was to examine at least one specific analytic application in its assigned functional areas to assess potential value added by using ADS. Where potential was indicated, the assignment was to identify opportunity and pitfalls, then attempt to fathom requirements necessary to achieve the highest potential of the ADS - analysis interface. One subgroup considered battlespace effectiveness and COA analysis, while the other worked on acquisition and training/rehearsal. Upon review of the integrated product of the subgroups, certain trends emerged, leading to a few overarching principles.

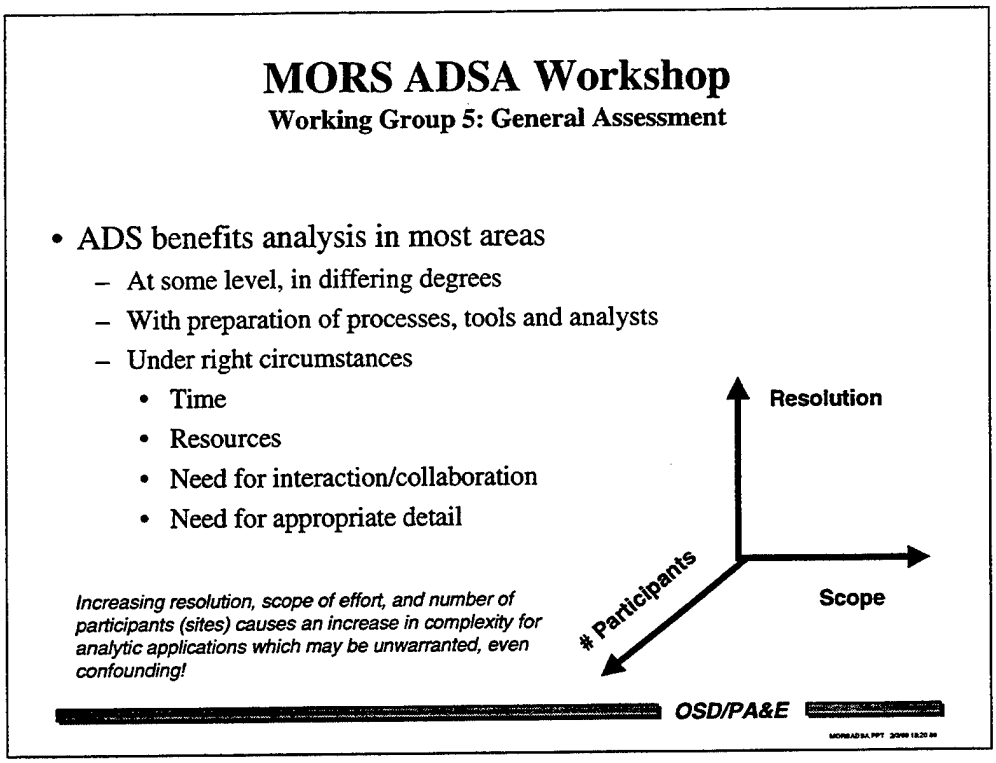


The detailed observations of the subgroup for each functional area are presented in the following slides. However, the detailed observations led to a set of generalized principles which we described as the "analytic vision" depicted above.

The thesis of the vision is that there is potential for a quantum increase in the value of analysis based in ADS — if we construct the right capabilities on the right foundation. The foundation is the connectivity provided by the physical communication network, the high level architecture, run time infrastructure and common object models. The pillars of progress are: development of broad data support and suitable MOEs, improved scenario management tools designed to assist in setting up and executing analysis, a family of models integrated to span the spectrum of conflict with appropriate levels of resolution and interfacing procedures and a set of tools to support analysis in this advanced, but more demanding, environment.

The overarching goal of the vision is an environment supporting distributed collaborative analysis — in which analysts are able to interact from their various distributed locations to conduct all aspects of analytic effort.

This includes the distributed execution of models, data development and distribution, planning, sharing of analytic work and telecommunications. The value of these contributions is described in the ensuing charts.

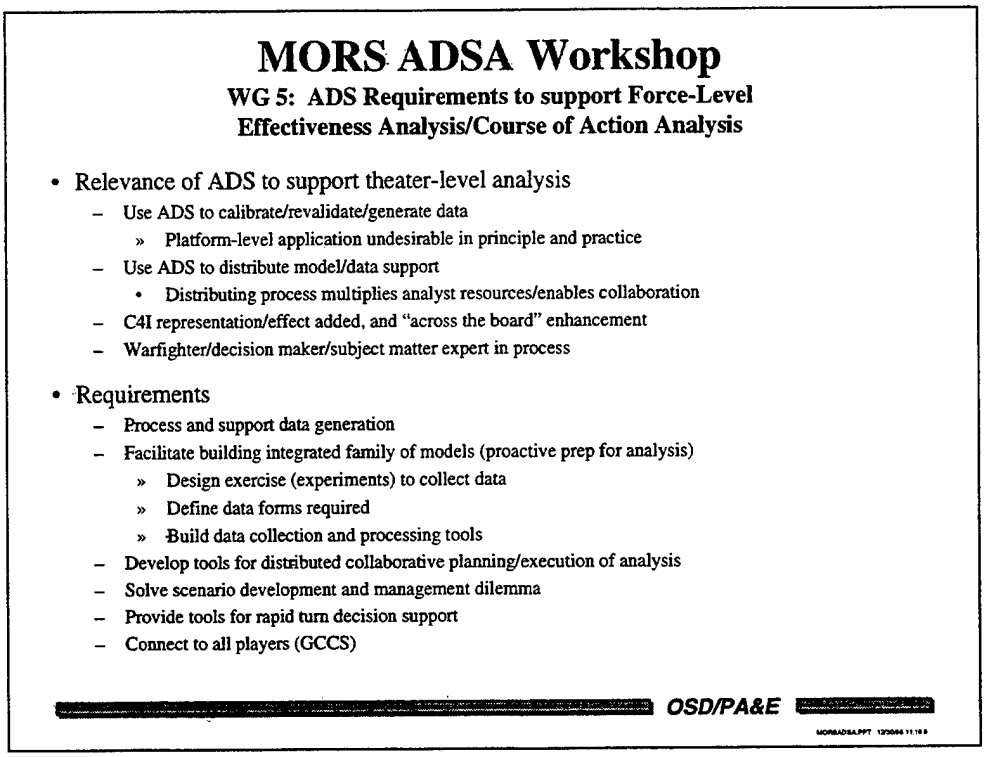


This graphic depicts the "complexity continuum" of ADS-based analysis. As the degree of resolution and the number of distributed participants increases, the simulation itself becomes more complex. As the scope of the simulation or analysis grows, complexity increases further. The utility of ADS for analysis depends on whether the complexity of a particular application is appropriate and affordable for the analytic need.

Some considerations in evaluating when ADS adds value to an analysis include the time available, the amount of interaction required and the type and amount of data available that is required for the analysis.

Resolution ranges from small unit tank exercises that are relatively easily instrumented and information captured, to the need for theater level analysis, where the possible constructive simulation of 100,000 entities is not desired. A force-level COA analysis requiring very quick turn around may not be compatible with high resolution ADS, both due to time constraint and undue complexity. On the other hand, a single carefully scripted exercise with larger scope and more detail may support several analyses of lesser scope. Human interaction provides for credible insertion of key subjective factors: NBC, C4I, political military factors, etc.

Here again, we make the point that distribution of the analysis may be more in terms of the overall process, as opposed to the simulation entities and engines themselves. In either event, developing the aspects of ADS that support collaboration among the participants is rated as an important improvement of the analytic process.



Considering the requirements typically found in theater force analysis, the following issues in applying ADS to analysis arise:

1. Successful simulation of large numbers of high-resolution entities, while required for realistic training simulations, are not required for theater level modeling. The interactions of multiple entities confound the analytical results. Aggregate models provide the best basis for theater level analysis.

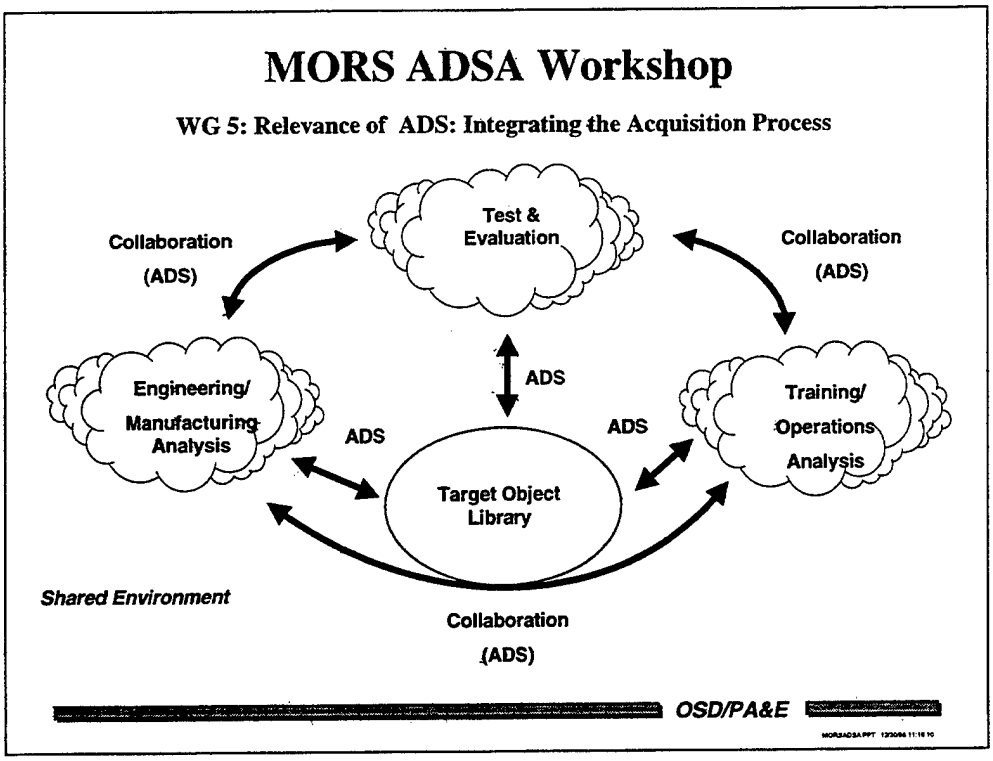
2. Collaboration (both vertical and horizontal) provides perhaps the most value added to analysis. It will provide a capability to more easily bring together analytical agencies and extend the range of variables. The use of ADS will provide an ability to harness many resources in a short period of time to support both crisis planning and COA analysis.

3. The ability to include a human decision maker in the analysis system will allow better representation of C4I and permit more detailed C4I analysis. There is potential for an across-the-board enhancement in forces and processes.

4. The warfighter and the decision maker can be involved in both the ADS exercise and be allowed to visualize the exercise and the results using advanced techniques, such as Virtual Reality (VR). This facilitates both user feedback and sponsor acceptance of the results.

5. ADS allows for HITL, insuring that difficult concepts, such as new doctrinal concepts and C4I, are creditably and accurately represented.

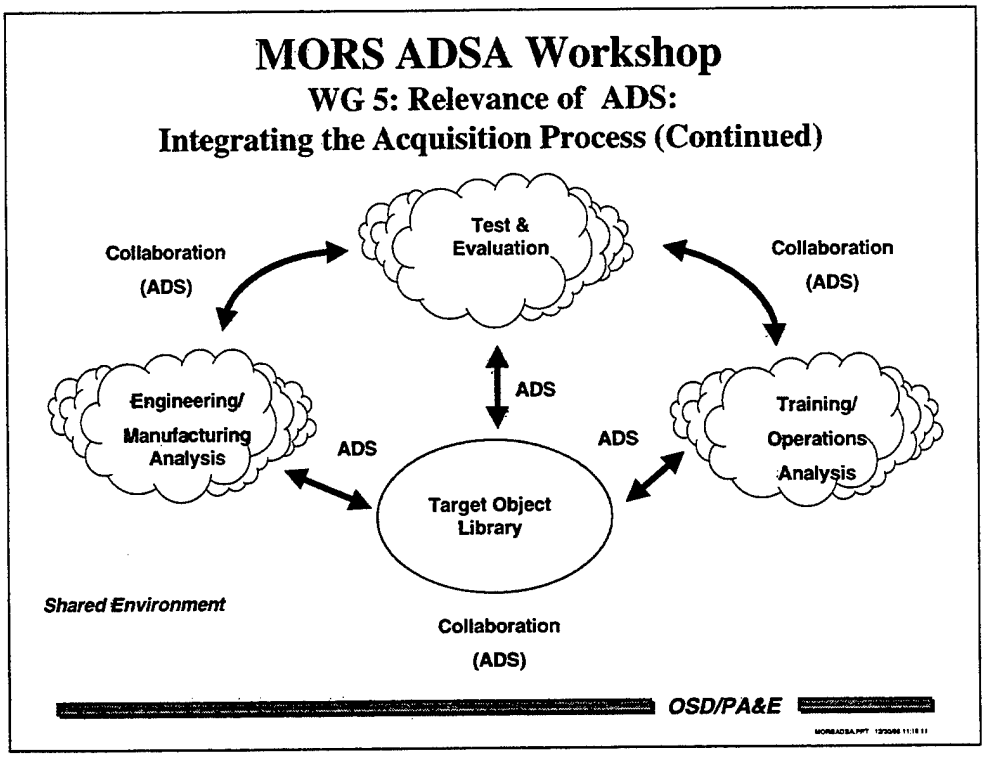
6. The development of supporting tools is essential for successful use of ADS in analysis.



Nowhere else in our deliberations of the relevance and merits of ADSA did an obvious need emerge so clearly as in ADSA support to the acquisition process. Mr. Mike Roberts, acquisition reform leader within the DoN RD&A office, briefed convincingly about a vision of distributed information technologies in support of acquisition, and we quickly accepted him as the customer of our discussion results.

In its simplest form, the current acquisition process is stratified by DoD 5000 into three major stages: concept development, system development and T&E. Most Services precede this with a requirements definition phase (often referred to as "pre-milestone 0" work). Insofar as milestone decisions are sequential, and demand repeated (and sequential) cost-benefit analyses, the whole process involves time-phased, linear product development.

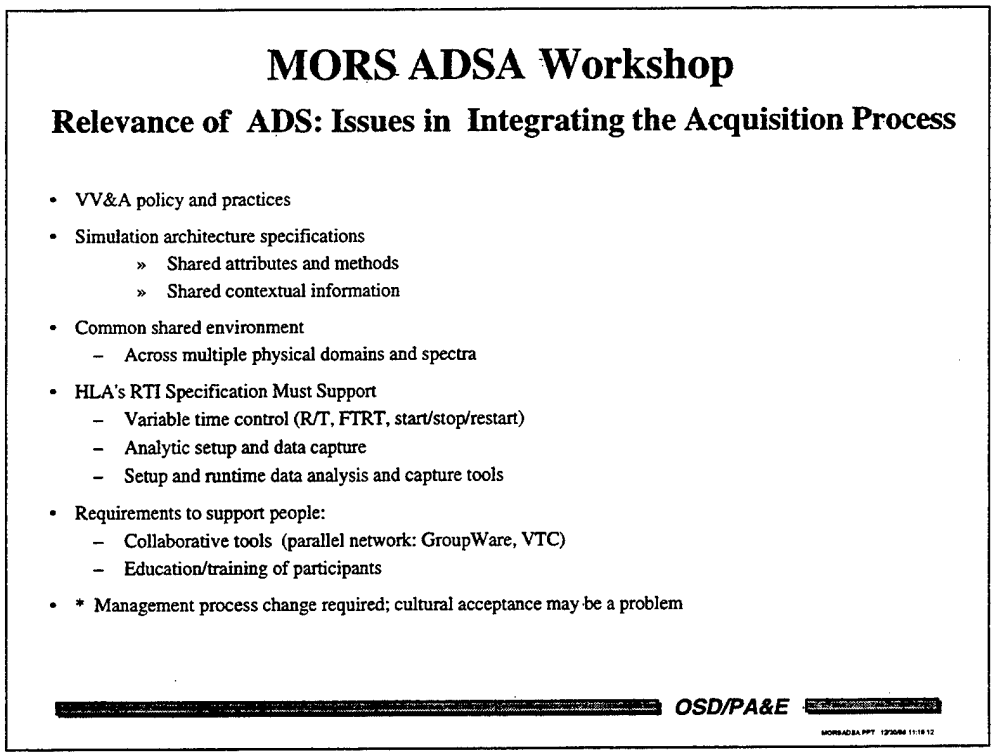
Mike Robert's brief called for a central repository of concurrently shared information pertaining to/describing a target widget, currently in the acquisition process. He envisions that training personnel, analysts, engineers and manufacturers could access appropriate parts of the widget's data files in order to complete their respective pieces of the acquisition effort. Furthermore, he says, changes driven by one user community would become immediately visible and available to the others. Rather like Microsoft's OLE, right?



Our WG developed Mike's vision from the ADSA standpoint. This slide shows the relationships and process dependencies we defined.

- The target widget is described in an object library which contains a suite of widget models, built to the varying degrees of fidelity appropriate to the users in the simulation confederation.
- The various widget data users are grouped arbitrarily and depicted in the clouds.
- The stubby two-headed arrows depicts the ADS network connectivity.
- The curved two-headed arrows represent the distributed, parallel collaboration effort we determined was essential to the success of this process (described more completely below).

The message of the slide is threefold. First, it connotes the concurrency of the interaction of data users. Otherwise stated, it intends to substantially revise, if not fundamentally redefine, the formerly sequential process. Secondly, it denotes and supports, the vital involvement of the training and operations community in every iteration of the product definition. And finally, it asserts that there is one, and only one, authoritative representation of the widget (although of various levels of detail) for use by planners, analysts, operators, engineers, supporters and naysayers, budgeteers, trainers, et al. This vision would exploit ADS in every sense. If accepted and implemented, it would help analysts in every functional area substantially reduce time in virtually every phase of product development, manufacture and introduction to the user. However, making this happen obviously entails some challenges.



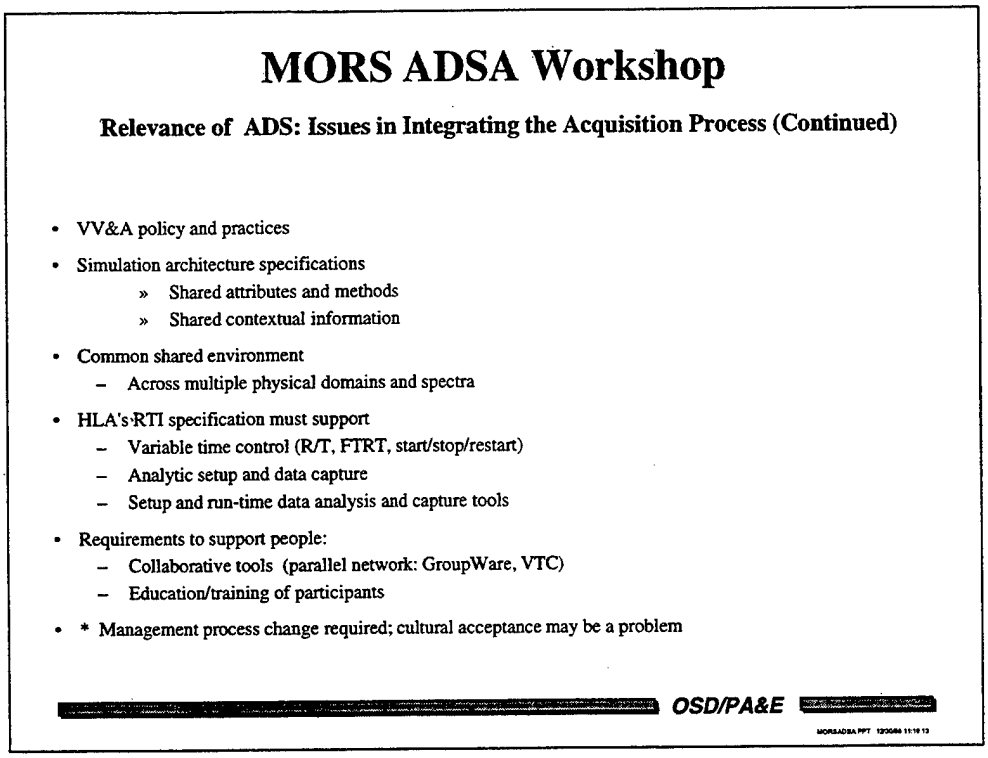
This slide presents issues which we considered most daunting in making this vision a reality. As might be expected, the really hot-button item of VV&A provoked an hour of discussion. Full appreciation of the complexity of the V&V process was enjoyed by all. In fact we concluded with the finding that our attitudes and expectations with regard to VV&A would need to change, because the feasibility of V&Ving n interacting simulations was actually an nn-1 problem, assuming static simulation relationships. If we consider that ADS supports dynamic simulation and joins and retires , the V&V problem becomes impractical to define, let alone to satisfy. We hastened to add that this does not automatically condemn the concept. It simply asserts that VV&A has to be rethought.

Although many of the technical support requirements named on the slide are already a part of the DMSO HLA build effort, we asserted them to ensure that they are stated matters of record, in case resource or technical constraints demand reduction in HLA scope. Specifically, we saw the need for the following:

The HLA must define specifications for the sharing of object attributes and methods (attributes and behavior) to facilitate consistent object behavior across heterogeneous simulations.

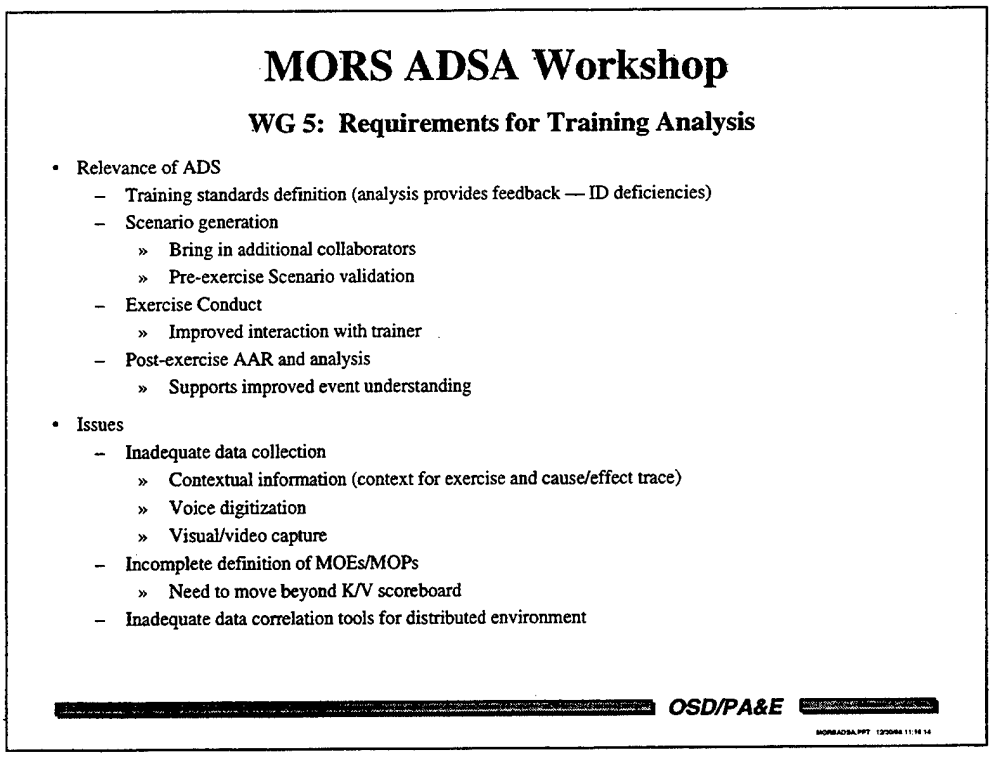
The HLA must define a method for the exchange of event context information. By this we mean that triggering events must be visible with each observable event. For example, a Stinger launch event PDU should include reference or mapping to the event which justified the launch event, like an aircraft detection. Although analysts need to define this clearly for the technicians to incorporate in the HLA development, this capability was considered essential to meaningful distributed analysis.

The RTI of the HLA must continue to include variable time control, and must develop switches which support the pre-runtime analytic setup and data capture filters, as well as run-time, real time, data analysis and capture adjustments.



A fundamental benefit of the integrated acquisition process shown on the previous slide, is that it enables collaboration among a variety of communities, most of whom do not communicate with each other today. Technology to support this human collaboration is just as important as technology to support the object library and simulations. This includes a parallel network which would support collaborative analysis using modern collaboration tools like GroupWare, and VTC. Without this, ADS-A in support of the acquisition effort and probably in every other functional area as well, would not attain the level of effectiveness needed to make it worth the expense of attempting it.

Finally, we dealt with what will probably be the hardest issue of all: cultural reluctance and people management. Integrating the acquisition process will entail adopting an integrated process management philosophy. This kind of dramatic change will not be readily adopted by all affected parties. In addition, the sheer simulation complexity implied in ADS mandates a fresh look at the process of educating and monitoring the assignments of the military analyst population. The prevailing approach of sideline tours in staff analyst positions is incompatible with the time required to attain familiarity and comfort with ADS technologies.



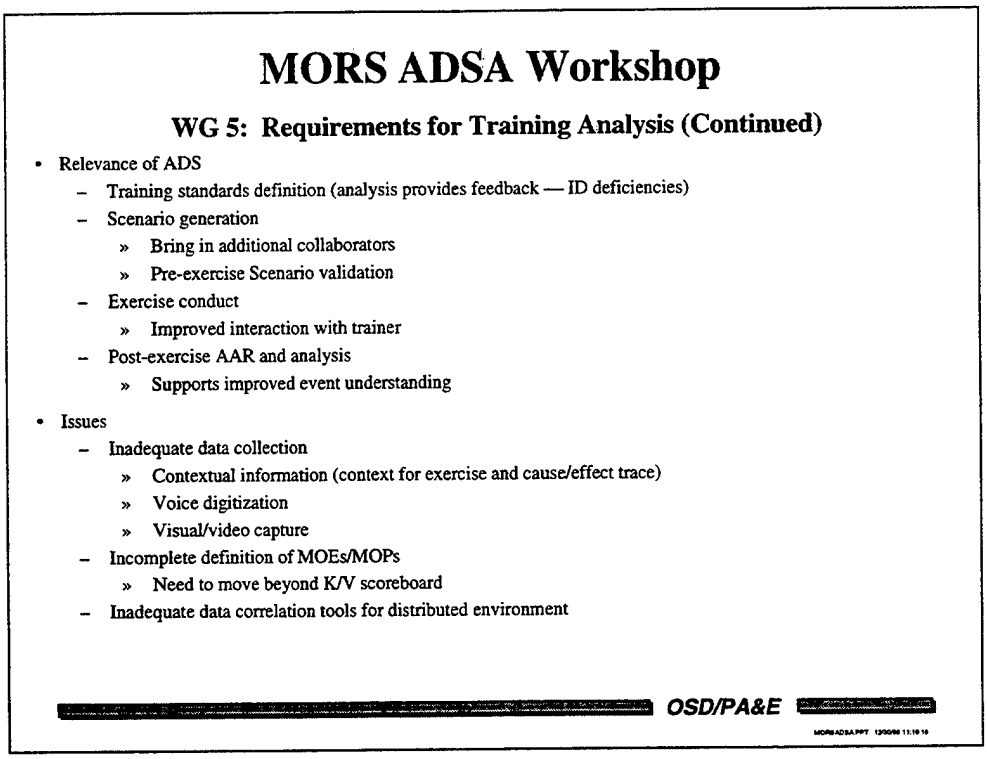
This slide discusses the potential relevance of ADSA to the four phases of training and identifies areas in which improvements are needed.

1. *Definition of Training Standards.* The Services define the tasks which are to be trained and the standards to which units (or individuals) must train each task. Analysis using ADS can provide feedback to the training community to help identify training deficiencies. For example, if unit training histories and training outcomes were saved (ignoring the anonymity issue for a moment), groups of outcomes associated with a particular training event could be analyzed to identify distributions that seem irregular; then the training support packages associated with the event which might be modified.

2. *Scenario Generation.* A distributed environment can enrich the development of scenarios for training by enabling disparate communities to collaborate. Currently, most training exercises begin with scripted orders and force laydowns being given to the units. In the future, intelligence analysts, as an example, could participate by providing realistic information through the distributed environment to be used in the intelligence preparation of the battlefield. Another use for ADS in this area is to review and test the scenario in a simulated environment prior to using it in a training environment.

3. *Exercise Conduct.* ADS supports an unprecedented degree of non-invasive analyst interaction with the trainer during the training evolution. In addition to providing contextual insight to the progress of the evolution, ADS here affords the analyst the chance to refine the collection efforts in real time.

4. *Post-Exercise AAR and Analysis.* ADS supports substantively improved situational awareness through distributed visualization. The capability of replaying selected pieces of an evolution from varying points on the battlefield or from varying perspectives in the chain of command which will provide insight and data not available before.



Though there is much fertile ground in analyzing training exercises, either as AARs for the unit or for other purposes, our analytic capabilities are hampered by the following issues:

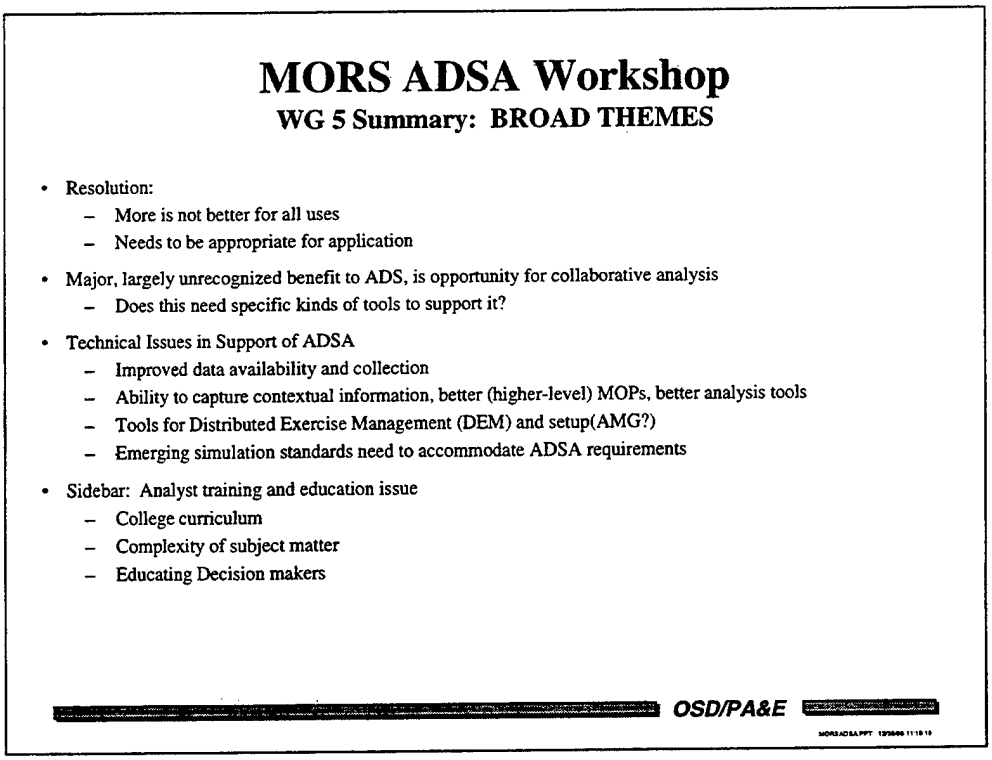
1. First, there is not enough data captured to support a complete analysis. Most importantly, contextual information is generally not available and if it is available, it is normally not in a digital format. Contextual information describes the purpose of the exercise and its meaning; this provides the context for understanding what the exercise was trying to achieve. (This is a more general problem with ADS that is not confined to training.)

Analysis of C2 decisions and their effects is an area of rich potential for analysts but is relatively uncharted. (See Army Research Institute-Ft. Knox work to assess the value of digitized C2 equipment (POSNAV, IVIS) as a significant exception.) Until training exercises incorporate digital C2, much (and sometimes all) of the C2 information will be in voice radio traffic. This information is very seldom recorded and even when it is, there do not seem to be any commercially available tools to support word spotting or speech processing . A complicating factor is the generally poor quality of these recordings. Voice transmissions should be digitized and parsed for evolution-significant events.

Video and visual information that may be available to the trainer is not currently captured in formats which facilitate analysis. Video capture digitization needs to be indexed to event time so that the analyst can collaborate visually those events for which other recorded data is confusing or contradictory.

2. Second, the kinds of MOPs that the analytic community currently relies on are at the killer-victim scoreboard level. These MOPs describe the facts of the battle, but do not shed light on the decisions made and the reasons for those decisions. We need to move to more abstract MOPs, and to MOPs that describe cause and effect relationships.

3. Third, given a variety of MOPs and the complexity of cross-simulation data correlation, the analyst would like to know which factors are correlated with each other. We need better tools for this.



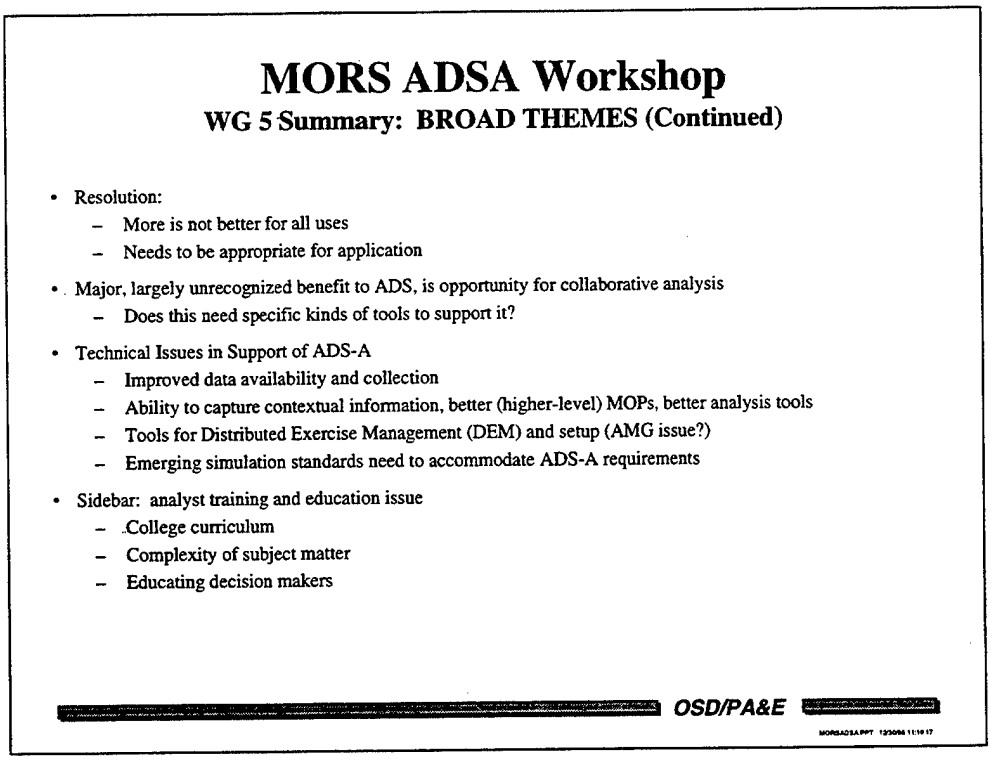
We summarize important observations from the preceding discussions here:

1. Analysis does not always benefit from higher resolution. In fact, high resolution adds unwanted complexity to some applications — complexity that makes execution difficult and may actually confound results. More appropriate is an integrated hierarchical family of models so that the detail of high resolution ADS, especially including human interaction effects, may be used to calibrate lower resolution models or to help generate aggregate data.

2. Analysts have always collaborated — over structure, data, models and the analysis itself. Collaboration has always been difficult if the participants were not co-located, but it is now more difficult in ADS because the overall process is distributed. That need not remain the case if we design and provide a parallel "network" to enable analyst collaboration. Regardless of whether the models or simulations are widely distributed, the process of analysis can be widely distributed, enabling collaboration and providing important leverage to Defense analysis.

3. To enhance or enable the use of ADS for analysis requires investment in appropriate tools and capabilities:

- First and foremost, valid data must be made widely available at all levels. At the aggregate levels, much work remains to be done to support future models such as JWARS. The problems with providing higher resolution data are well known.
- The nature of the data collected must also be enhanced to allow addressing details inherent in some issues. For example, data which captures the context of simulation events is necessary to allow causative analysis. This data is now gathered apart from the automated data and is hard to store and use. As important, are the tools necessary to enable data analysis. This includes the ability to handle large amounts of data distributed at several locations and the ability to do sophisticated data analysis and correlation.



- Finally, the overall process of exercise execution must be made simpler. The time necessary to assemble an analysis should be substantially reduced by providing tools to do the following:
  - Assist with scheduling and coordinating resources
  - Developing and documenting scenarios
  - Pre-exercise evaluation relating issues to experimental design, MOEs and data adequacy

4. The final observation is that providing these technical capabilities will not fully answer the issues of ADS-based analysis. We believe that the nature of analysis will be fundamentally more demanding. Technology can make using the environment feasible, but the complexity of the environment will demand better preparation of the analyst and the decision maker. The analyst will require better understanding of the distributed environment itself, implying better education in computer science. And analytic complexity issues imply that the analyst must be able to analyze the analysis beforehand for complexity, resource requirements and appropriate analytic approach. Likewise, decision makers must understand the issues required by ADS analysis, both in terms of cost to execute and the quality and substance of the analytic results.

MORS ADSA Workshop

WG Scope: "Address Broad Analytic Questions within [your] Domain"

ref: Terms of Reference

- When should ADS-based capabilities be used?
  - When analytic complexity from added detail is necessary, affordable and appropriate.
- Are ADS-based capabilities better or worse for specific types of analysis?
  - This is specific to the application, but it is also very useful for distributed collaborative analysis.
- Does ADS allow us to address any new, necessary analytic questions?
  - For operations, OOTW and C4ISR: For acquisition, integrated system mgmt/evaluation.
- How do ADS-based capabilities fit with other types of analytic capabilities and approaches?
  - By applying direct application to acquisition and indirect for force structure analysis. Provides a medium for peer review through distributed collaborative analysis.
- What are limitations of current and future ADS-based capabilities?
  - Current data content, storage and analysis must be overcome in general
  - Current and future, analysis is more complex, time consuming, needs more preparation.
    - Tools and education lighten impact, but increased complexity remains a limitation.

OSD/PA&E

MORSADSA.PPT

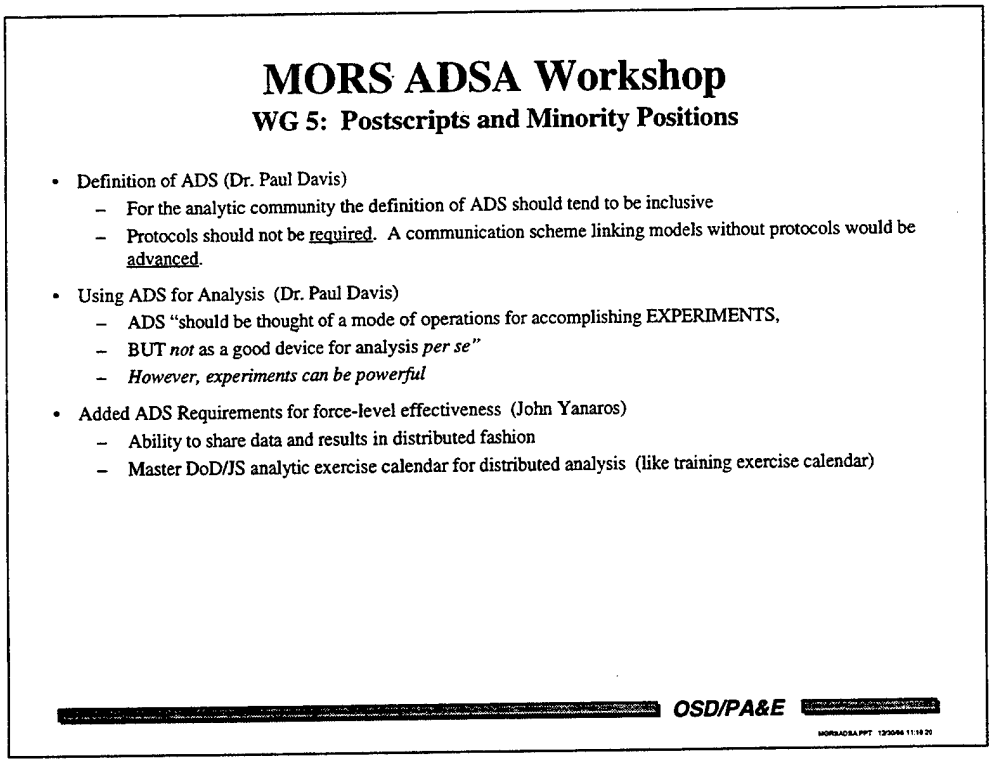
These final two slides provide short answer replies to the nine questions originally provided to the working groups in the TOR. They are provided here as a final summary of the WG five report.

MORS ADSA Workshop

WG Scope: "Address Broad Analytic Questions within [your] Domain"

ref: Terms of Reference **(Continued)**

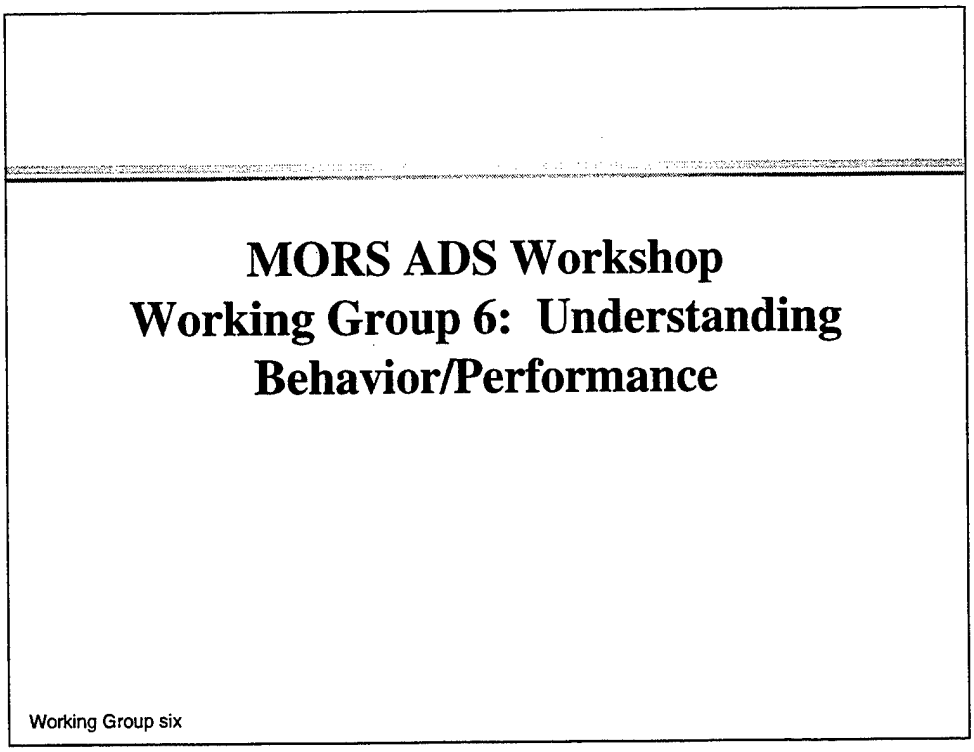
- Are there pitfalls in analysis using ADS-based capabilities?
  - Demand on resources, more time, need for tools, complexity and a need for collaboration.
- Does the use of ADS-based capabilities affect the utility of analytic results?
  - Complexity may cause "anecdotal" versus "analytic." But, "immerse" decision maker in process and/or results.
- Are there useful ways to utilize the results from ADS-based analysis, exercise and training that differ from conventional methods?
  - Concurrent or spiral development for acquisition. Calibration/validation for force effectiveness.
- Do ADS-based analysis capabilities make VV&A processes any *harder,* easier or *different*? *But more important!*



During post-Workshop reviews, comments were returned which expanded upon what was said during the Workshop or represented a valuable minority position on an issue. Hence shorter comments are annotated directly in the appropriate text. These comments are more substantial, and therefore are noted separately.

Dr. Paul Davis stood out from the crowd somewhat by asserting that ADS would never be suited to analysis as we think of it using closed, constructive models. Rather, he more distinctly suggests ADS as suited to experiments, from which insights are gained or data developed to help calibrate the constructive analytic models. This is rather a stronger opinion than the Group discussion, but does follow the complexity and aggregation issues discussed previously.

John Yanaros added a few more requirements for ADS-based analysis. The paradigm of collaborative and distributed analysis will pose problems in developing data and distributing results to the distributed analysts, and the limitations on the shared distributed assets will result in a need to manage the distributed analysis calendar for major events. Both of these things can be addressed during the development of a collaborative analysis environment if we pay attention up front.



One of the more important contributions of ADS is the ability to use either virtual or live simulations to understand and capture human behavior. This is an aspect of constructive simulations that has not been well represented in the past. Therefore, WG six is addressing an important issue for the analysis process.

The Mission of Working Group 6 with Amended Objective

Address the nine questions from the ADS Workshop TOR list in the context of the WG six objective *as amended.*

Analysis of DIS simulations with the objective of deepening understanding of warrior behavior/ performance and then incorporating that understanding in improved *analysis,* constructive models and data.

Working Group six

We were asked to address the nine questions from the TOR list in the context of the WG six objective. We felt the need to amend the objective as shown in italics. In addition to incorporating an improved understanding of warrior behavior in constructive models and data, we wished to emphasize that that improved understanding should be incorporated at the top level of the intellectual process, the analysis itself, not just the tools that help execute the analysis. Next, we defined ADS.

Definition: Advanced Distributed Simulation

- *Advanced:* **Applies to all training, readiness and the requirements prototyping process with the same core technology base**
- *Distributed:* **Shared battlefield data are entered from geographically separated sites via communications networks**
- *Simulation:* **Allows mix and match of live, constructive and virtual simulation methods**

Working Group six

These definitions were developed to provide us with a framework for further study of the question.

Approach: We Split Into Two Subgroups

- **One subgroup used "Seven Steps of Design for Success," a systems design approach to the problem**
- **The second subgroup used a matrix approach to compare steps in the analysis process with questions from ADS Workshop TOR**
- **Remarkable convergence of results from two different approaches**

Working Group six

We split into two subgroups. The first used a system called "Seven Steps of Design for Success," a commercially supported systems design approach. This could be characterized as a synthesis process.

The second subgroup compared the steps in the analysis process with the questions from the workshop TOR. This is fundamentally an analysis process.

As we will see later in the report, the synthesis process and the analysis process converged rather well.

General Chair's Guidance to ADSA WG Chairs: Consider the Following Questions

1. **What are the most central requirements of needed analysis? (current and future)**
2. **Which models and simulations are most frequently used now?**
3. **What are key limitations of these models and simulations in meeting analytical needs? (current and future)**
4. **Are there planned developments to resolve these limitations?**
5. **Do ADS-based tools offer the potential to meet central requirements of needed analysis?**
6. **Are they different from or redundant with other approaches existing or planned? (How?)**

Working Group six

The general chair of the Workshop asked the working groups to consider these questions. We felt the need to organize the questions as we will show on subsequent slides.

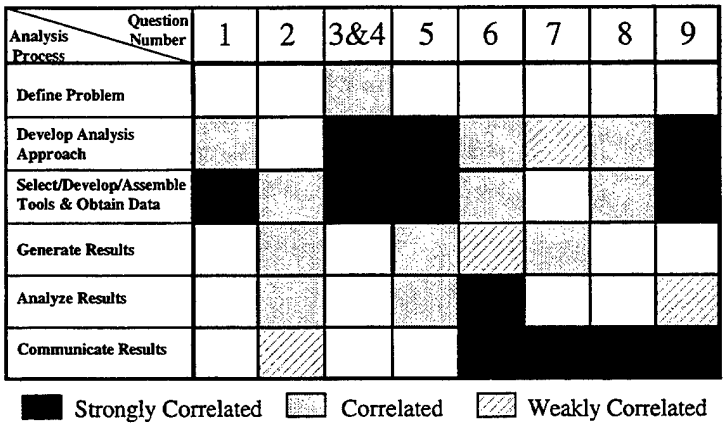
General Chair's Guidance to ADSA WG Chairs: Consider the Following Questions (Continued)

7. **Do the desired ADS-based capabilities exist? Have they been "Verified and Validated"? Is there a funded program in place, or is there one that could be modified?**
8. **Are there challenges to conducting credible analysis using ADS? (Are they unique or harder than with other methods?)**
9. **What are the impediments to using ADS-based analytical tools, and how can they be resolved? (What have demonstration programs shown us we need more — for what? Does the current and planned set of DIS PDU's address relevant areas of analytic interest with sufficient fidelity? Is there sufficient linkage between instrumentation and simulations, etc.?)**

Working Group six

These questions are quite involved and are in fact the subject of numerous published papers. For the convenience of the reader, we cite the following: MR-744-AF, *Understanding the Air Force's Capability to Effectively Apply Advanced Distributed Simulation for Analysis: An Interim Report*, 1996, T. Lucas, B. Kerchner and John A. Friel. This report is cited not because it is particularly profound, but because it is easily available from RAND and includes an extensive bibliography. This would provide a convenient starting point for someone interested in becoming familiar with the subject.

Correlation of TOR Questions with Steps in Analysis Process



Working Group six

In an attempt to provide a framework for our discussion, we created this matrix with the rows defined by a representation of the steps in the analysis process and the columns defined by the question numbers from the previous slides. The dark cells indicate that we believe that the question was strongly correlated with the given step in the analysis process. For example, we believe that Question 1, "What are the most central requirements of needed analysis? (current and future)" is strongly correlated with the step in the analysis process, "Select/develop/assemble tools and obtain data."

TOR Questions Focused on Particular Steps in Analysis Process

- **Analysis approach development, tool selection and communication of results most affected by TOR issues**
- **Issues raised by questions three, four, five and nine most important to analysis process**
- **Introduction of ADS does not significantly impact problem definition**
  - **Problems are not significantly different or new**
  - **ADS affects HOW questions are approached**

Working Group six

This slide captures in words the information contained in the matrix. The first bullet refers to the fact the second, third and sixth rows have the most black cells.

The second bullet refers to the fact that columns three, four, five and nine have the most black cells.

The third bullet reflects that fact that ADS doesn't interact very strongly with the problem definition step of the analysis process. This first row is the one with the least overall correlation.

Two Subgroups Mapped Nine TOR Questions into Four Aggregate Questions

- **Question A: Aggregate of Questions 1–4**
- **Question B: Aggregate of Questions 5–6**
- **Question C: Aggregate of Questions 7–8**
- **Question D: Question 9**

Working Group six

To organize the results of our discussions, we aggregated the nine questions from the TOR into four aggregated questions, as shown.

Question A: ADS-Based Capabilities

When should ADS-based capabilities be used; are they better or worse for specific types of current analysis; do they fit with other analytic capabilities; and do they allow the analyst to address any new, necessary analytic questions?

WHEN

- **Less cost, risk and environmental impact than live exercises and tests**
- **New CONOPs, technologies, systems and organizational structures are being evaluated**

Working Group six

Question A, aggregated from questions 1 through 4, is shown at the top of the slide. The answers are shown under the general heading "When."

The first bullet is an obvious cost-effectiveness consideration. The second bullet involves developing new ways for HITL to interact with systems and with each other.

Question A: ADS-Based Capabilities (Continued)

WHEN (Continued)

- **HIL more viable, acceptable and valid**
- **Lack of constructive alternatives**
- **Assess impact of information on force effectiveness**
- **Involvement of decision maker desired**
- **Demonstration of results desired**
- **Assembly of simulation components at one location impractical**

Working Group six

The first four bullets under the heading "When" involve the importance of the role of HITL in the analysis. All of these considerations suggest a need to include virtual or live simulations in the ADS approach to an analysis.

Demonstration of results is currently one of the strong points of ADS. It is possible to do very illuminating demonstrations of system behavior and results in general. Some traditional analysts argue that the compelling nature of demonstrations available through ADS often masks fundamentally weak analysis.

Obviously ADS, with emphasis on the *Distributed*, would be attractive when all the simulation components are not available at one location.

Question A: ADS-Based Capabilities (Continued)

SOLUTION SPACE

ADS is *not* always the appropriate tool to be used for analysis. DMSO and the appropriate Service agencies need to provide guidelines for when and how to use ADS

Working Group six

ADS is not always the answer. DMSO and the appropriate Service agencies should provide guidance on this subject. We refer back to the two previously cited documents as a source of the views that exist in the analysis community on the subject of ADS.

Question B: Current Limitations and Future Pitfalls

What are the limitations of current and future ADS-based capabilities, and what are the pitfalls in analysis using these capabilities?

LIMITATIONS

- **Reliability of federated simulations**
- **Lack of reproducibility**
- **Limited number of replications**

Working Group six

Question B is an aggregation of questions five and six from the TOR. The "limitations" are rather obvious implications of using ADS.

Question B: Current Limitations and Future Pitfalls (Continued)

LIMITATIONS (Continued)

- **Cost, coordination and competing resources required**
- **Data security (multiple classification sources, multiple levels and proprietary)**

PITFALLS

- **"Gaming the game!"**
- **ADS as "only approach to analysis" syndrome**
- **Failure to control human factors**
- **High visibility — institutional bias for "RIGHT answer"**

Working Group six

The two "Limitations" cited are not uniquely related to ADS, but rather are problems that exist whenever large scale analysis is done.

The first and third "Pitfalls" are a consequence of any experimentation that involves humans. The second and fourth "Pitfalls" are a consequence of the current popularity of the ADS technique.

Question B: Current Limitations and Future Pitfalls (Continued)

SOLUTION SPACE

- **Central repository needs to be developed for analysts for use to coordinate schedules of ADS facilities and to provide information about resources available at those facilities, including simulators, software, expertise, data bases, etc.**
- **Investment in ADS needs to be rationalized and coordinated**

Working Group six

Certainly, an easily accessible database containing information on ADS facilities, schedules and the like would be a very valuable asset to the community.

The additional costs associated with using ADS have to be understood up front, and the investments in facilities and software need to be coordinated.

Question C: Utility of Analytic Results and New Ways to Utilize These

Do ADS-based capabilities affect the utility of analytic results, and are there useful ways to utilize these results that differ from conventional methods?

- ***Use ADS-based results to calibrate and validate conventional methods***
- ***Ability to develop HITL data repository***
- **Operators in the loop**
- **Decision makers in the loop**

Working Group six

ADS can provide valuable insight into how HITL should be represented in constructive models. An HITL data repository could be developed to calibrate the kinds of tasks that are representative of military applications and the time it takes to execute those tasks. ADS-based capabilities would dramatically improve our ability to represent operators and decision makers in the loop.

Question C: Utility of Analytic Results and New Ways to Utilize These (Continued)

- **Use stakeholders in the loop to enhance utility of results**
- **Easier to communicate results to non-participants**

SOLUTION SPACE

- **Resources should be provided to assist with training analysts in the use of ADS — for example, courses and training materials**
- **Promote the collection and collation of the human behavior/performance data from planned ADS exercises for use in the calibration of constructive models**

Working Group six

Stakeholders in the loop of an ADS exercise could enhance the acceptability of the analytic results in the operational community. But ADS also has an inherent capability to communicate the richness of the results to non-participants.

Serious attempts must be made to train analysts in the use of ADS in academic institutions, such as the Air Force Institute of Technology (AFIT)and the Naval Post Graduate School (NPS). In addition, senior service schools should attempt to make decision makers aware of when ADS is an appropriate technique to employ and how to interpret the results of ADS exercises.

ADS exercises should be planned so as to provide inputs to a database of human behavior and performance for use in calibrating constructive models.

Question D: Verification, Validation, and Accreditation (VV&A)

Do ADS-based analysis capabilities make the VV&A process any harder, easier or different?

- **Face validity is easier**
- **Other forms of validity are harder**
- **Configuration control is harder**
- **Operator or decision maker in the loop makes accreditation easier**

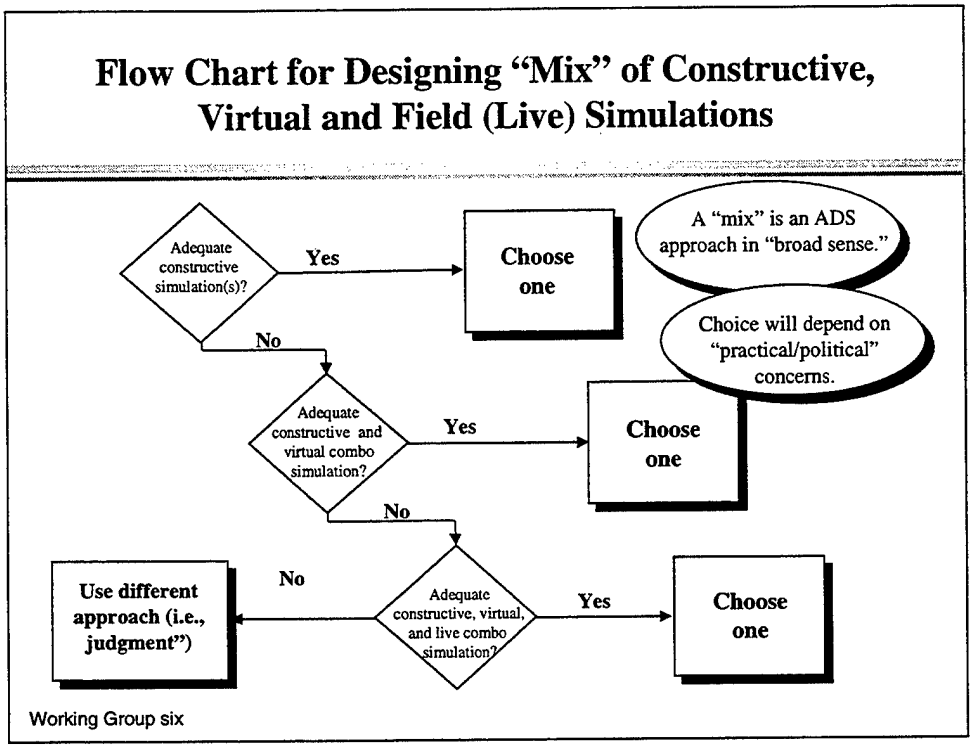
SOLUTION SPACE

- **Continue emphasis on V&V methodology in each Service**

Working Group six

VV&A are difficult enough when only one constructive model is present. Because of the enhanced graphics normally associated with ADS, face validity is easier. But other forms of validity are harder because of the multiplicity of simulations and locations. Similarly, configuration control is harder. However, operators and decision makers in the loop may not help with V&V, but accreditation may be an easier status to achieve.

A solution to this question will only come through continued hard work on the part of the analytic communities of the Services.



This flow chart provides a logic flow for deciding upon the "mix" of simulations to address an issue. Note that the process selects a constructive simulation as a first choice. If one is adequate, virtual and live simulations are not considered. Similarly, if an adequate combination of constructive and virtual simulations can be found, live simulations are not considered. This probably represents the current attitude of the DoD analytic community.

Summary of Recommendations

- **ADS is *not* always the appropriate tool to be used for analysis. DMSO and the appropriate Service agencies need to provide guidelines for when and how to use ADS. (Question A)**
- **A central repository needs to be developed for analysts for use to coordinate schedules of ADS facilities and to provide information about resources available at those facilities, including simulators, software, expertise, data bases, etc. (Question B)**

Working Group six

ADS is not always the preferred approach to an analysis. Better OSD and service guidelines should be published on this issue

A central, easily accessed database describing ADS facilities, simulators, software, databases and experts should be developed.

Summary of Recommendations (Continued)

- **Investment in ADS needs to be rationalized and coordinated within DoD. (Question B)**
- **Resources should be provided to assist with training analysts and decision makers in the use of ADS. For example, courses and training materials are needed. (Question C)**
- **Promote the collection and collation of the human behavior and performance data from planned ADS exercises for use in calibration of constructive models. (Question C)**

Working Group six

These summary recommendations come from the deliberations of each of the two subgroups. First, the investment in ADS should be rationalized and coordinated throughout DoD. Resources should be provided to train analysts to perform ADS and decision makers to understand when ADS is an appropriate approach to a problem.

The human behavior and performance data that are collected in ADS experiments must be collated in an easily accessible database for use in calibration of constructive models.

Summary of Recommendations (Continued)

- **Continue emphasis on V&V methodology within each Service. (Question D)**

Working Group six

Finally, VV&A of ADS must receive renewed emphasis within DoD and the services.

Advanced Distributed Simulations for Analysis (ADSA '96)

Synthesis Panel Report

21 February 1996

Agenda: Synthesis Panel

- Introduction
- Nature of the Problem
- Findings/Recommendations
- Assessment of Workshop

Agenda

The Synthesis Panel report is divided into four sections. The first section, Introduction, describes the composition of the Synthesis Panel and its concept of operations. The next section characterizes the nature of the problem as derived from the deliberations of the Workshop panels. It discusses the definition of ADS, what is new (from an analyst's perspective), why analysts have not embraced ADS and why analysts should bother with ADS. The third section identifies and discusses the findings and recommendations in four overarching areas that the Synthesis Panel felt were of particular significance. These areas include the definition of ADS, community leadership, an ADS plan for the analysis community and ADS education, training and experience. This report concludes with a qualitative assessment of the Workshop. It heuristically evaluates the degree to which the participants were able to satisfy the four objectives set forth in the Workshop TOR.

Synthesis Panel Members

- **Chair: Stuart Starr, MITRE**
- **Co-Chair: Dr. Dale Pace, JHU/APL (Analysis and Requirements)**
- **Panel Members:**
  - **Robert Worley, IDA (Battlefield Effectiveness)**
  - **Dr. Jerry Kotchka, McDonnell Douglas (Materiel, Systems and Acquisition)**
  - **Priscilla Glasow, SAIC (T&E)**
  - **Howard Carpenter, MITRE (Training, Mission Rehearsal and Alternative Courses of Action)**
  - **Gene Visco, FS, ODUSA(OR) (Understanding Behavior/Performance)**
  - **Dick Hayes, EBR (Understanding Behavior/Performance)**
  - **Jack Thorpe, SAIC (floater)**
  - **Vern Bettencourt, FS, ODUSA(OR) (floater)**

Synthesis Panel Members

This slide identifies the individuals that participated on the Synthesis Panel. In most cases the individuals had dual assignments. They participated as active members of one of the other six panels of the Workshop as well as the Synthesis Panel. In selected cases, Synthesis Panelists "floated" (i.e., they sampled the deliberations of several other panels during the Workshop).

To focus the data collection efforts of the Synthesis Panel, a "war room" was created. Butcher block paper was mounted on the walls of the room and the panelists posted summaries characterizing the deliberations of the Workshop attendees as they addressed the issues identified in the TOR. In addition, butcher block paper was used to capture comments on definitions, observations by plenary speakers, insightful observations, findings and recommendations (e.g., "blinding flashes of the obvious").

In addition to these data collection activities, the Synthesis Panel convened periodically after other panels had adjourned to identify and discuss the status of the Workshop and to identify and discuss key, cross-cutting issues. This report represents a synthesis of all of the above activities.

What in the World is ADS?

"Come, let us go down and there confuse their language that they may not understand one another's speech"

The Tower of Babel
Genesis 11:7
(cited by Sikora & Coose;
***PHALANX*, June 1995)**

What in the World is ADS?

One of the first questions that emerged during the deliberations was the issue of the definition of the term ADS. The importance of developing a definition that was widely accepted by the community was suggested by one of the papers in the read-ahead package, "What in the World is ADS?" by Sikora and Coose. By invoking the image of the Tower of Babel in their paper, the authors suggested the confusion that can ensue if the participants in the dialogue lack a common frame of reference and vocabulary.

In recognition of this issue, the Synthesis Panel spent a moderate amount of time exploring the question, as did many of the other panels. It concluded that the strawman definition in DoD 5000.59-M is inadequate and noted that a taxonomic approach to the question shows some promise. That approach is discussed at greater length in the next section of this report.

What's New (from the Analyst's Perspective)?

- **Analysts are being asked to**
  - **Address questions (some of which are new) in a more sophisticated way; e.g.,**
    - » **Deal with a much more complex world (e.g., ambiguous threats, "multiple scenario" problems, new types of military operations)**
    - » **Address issues from a joint/coalition perspective**
    - » **Treat C2 issues more credibly**
    - » **Consider environmental effects more specifically (e.g., terrain, obscurants and chemical/biological agents)**
  - **Communicate information more effectively to the decision maker; e.g.,**
    - » **Help the decision maker visualize the results**
    - » **Facilitate "What If..." dialogue**
- **Other communities (e.g., training, operations) are acquiring new tools (featuring HITL), data that may prove to be of increasing value to analysts**

What's New (from the Analyst's Perspective)?

Several of the speakers in the plenary session (most notably the keynote speaker, Dr. Anita Jones, DDR&E) observed that it was propitious to conduct an ADSA workshop since there are several things that are new in the world of the analyst.

First, the analyst is being asked to address questions, some of which are new, in a more sophisticated way. For example, with the dissolution of the Warsaw Pact and the Soviet Union, the world is proving to be much more complex from a national security perspective (e.g., the U.S. faces a much more ambiguous threat; defense planning revolves around "multiple scenario" problems; the US military and its allies are being asked to undertake new types of military operations, such as complex humanitarian operations in Africa and peacekeeping in the Former Yugoslavia). Since most of these issues involve complex joint/coalition activities, the analyst must consider the effect of joint/coalition involvement at the very outset of the analysis. In addition, it was not unusual, several years ago, for analysts to assume "perfect" C2 and to perform assessments within that context. In view of the importance of C2 in the Chairman of the Joint Chiefs of Staff (CJCS) Vision 2010, such an assumption is clearly no longer acceptable.

What's New (from the Analyst's Perspective?) (Continued)

Finally, there is increasing recognition of the importance that a broad set of environmental effects can have on analysis (e.g., more granular terrain to capture the effects of terrain masking; the properties of obscurants and their effects on the performance of Intelligence, Surveillance and Reconnaissance (ISR) systems; the challenges posed by detecting, characterizing and reacting to chemical and biological agents).

Second, the analyst is being asked to communicate information more effectively to decision makers. Most decision makers are no longer satisfied with columns of numbers. They want visualization/animation tools to capture the salient aspects of an analysis and the opportunity to participate in a dynamic, "what if..." dialogue with the analyst.

Finally, it was observed that several communities (e.g., trainers, acquirers of systems) are acquiring new tools and data, both of which have the potential to support analysts substantively. This suggests the desirability of working more closely with these communities, both to leverage their investments and to share the tools and data developed by the analytical community.

Why Have Analysts Not Embraced ADS?

- Quality Issues
  - Ambiguity about what ADS is (and is not)
  - Replicability of results (e.g., dealing with human subjects)
  - Credibility of results (e.g., VV&A issues)
  - Suitability for issues confronting analysts
- Use Issues
  - Cost/resource implications
    - » Expensive to acquire, update and employ
    - » Difficult to get trained subjects
  - Time/schedule implications; time required to:
    - » Create ADS capability
    - » Set-up conditions for a specific analysis
    - » Perform test runs
    - » Reduce data

Why Have Analysts Not Embraced ADS?

Several of the panels spent considerable time identifying and discussing why the analysis community has been slow to embrace ADS. These issues can be loosely aggregated into two categories: quality and use.
In the area of quality, the panels cited the following issues:

- *Ambiguity.* Since many of the members of the analysis community are not sure what ADS is, they are not sure how useful it is to them.

- *Replicability.* Since many examples of ADS feature HITL, there is concern among some analysts about the ability to replicate results. In particular, there is concern about coping with the effects of subject learning and the impact of differences in subject background, experience, proficiency and morale.

- *Credibility.* It was acknowledged by several panels that VV&A of ADS pose particular challenges.

Why Have Analysts Not Embraced ADS? (Continued)

• *Suitability for Some Issues.* Several panels noted that there are classes of analysis problems for which ADS may not be suitable. This can stem from the limited knowledge base that may exist for a class of problems (e.g., studies of new classes of ships that are still in the preliminary, conceptual stage) or the limited precision that one can hope to achieve using some classes of ADS (due to the likelihood of relatively small sample sizes).

In the area of use, the panels cited the following issues:

• *Cost/Resources Implications.* Several panels observed that it is likely to be relatively expensive to acquire, update and employ ADS in comparison to more traditional analysis tools. In addition, from a resource perspective, it is often difficult to obtain and train suitable test subjects.

• *Time/Schedule Implications.* Numerous panels expressed concern about the extensive time implications of ADS. This includes the time to create an ADS capability, set-up conditions for a specific analysis, perform test runs and reduce the data that is generated by exercising an ADS. These time considerations can preclude use of ADS when the analyst is given little lead or execution time (e.g., program objective memorandum issue analyses).

Why Have Analysts Not Embraced ADS?(Conclusion)

- **Use Issues (Conclusion)**
  - **Data implications; problems associated with**
    - » Acquiring data to set up, execute ADS
    - » Deciding what data to collect and collecting it
    - » Storing, processing resulting data
  - **Exercising the ADS (technically)**
    - » Control issues
    - » Time synchronization
    - » Interconnection issues (e.g., immaturity of protocols)
    - » Security issues
  - **Administrative burden; e.g.,**
    - » Cross-community/organization coordination
    - » Scheduling facilities
    - » Arranging for test subjects
    - » Configuration management
  - **Efficient, effective exercising of ADS; experimental designs that:**
    - » Provide acceptable confidence levels
    - » Cope with potential confounding factors (e.g., learning by test subjects)

Why Have Analysts Not Embraced ADS? (Continued)

• *Data Implications.* Several participants identified a broad spectrum of data issues associated with ADS. These include problems associated with acquiring data needed to set-up and execute ADS; deciding what data to collect and collecting it (note: it may be difficult to introduce ad hoc "hooks" into an ADS to collect desired data); and storing and processing the resulting data (e.g., some of the data of interest may be spoken by the test subjects).

• *Exercising the ADS, Technically.* Several ADS practitioners identified the problems that they encountered in technically exercising an ADS. To illustrate the problem of control, a representative from the Theater Air C2 Simulation Facility (TACCSF) recalled an incident where a frustrated AWACS subject unrealistically walked from his simulated node to a simulated ground node to resolve a concept of operations issue. Second, the distribution of nodes can pose time synchronization issues (e.g., the use of satellite communications can give rise to latencies that are unacceptable in selected classes of analyses such as real time, extended air defense problems). Third, several practitioners pointed out that interconnection of heterogeneous nodes is still in its infancy. The DIS standards/protocols are still incomplete and evolving.

Why Have Analyst's Not Embraced ADS? (Continued)

In addition, the ambiguity in existing standards/protocols is such that two nodes can claim to be DIS compatible and still not be able to interoperate. Finally, the absence of multilevel security solutions makes it difficult to conduct experiments with ADS featuring nodes at different classification levels.

• *Administrative Burdens.* ADS can pose administrative burdens that are far greater than those normally encountered by an analyst. For example, if the analyst is truly to leverage the resources of others (either those of other analysts or of other communities such as training or acquisition), it will entail extensive cross-community/organization coordination. As an ancillary problem, it is generally onerous to schedule the facilities of others, particularly when the facilities are widely distributed. In addition, for those ADS that feature HITL, it can be quite difficult arranging for test subjects (i.e., getting people with the right experience, knowledge and skills for the times needed). Lastly, configuration management poses problems since it must be maintained as facilities are modified to meet analysis needs and to track real world evolution of systems.

Why Have Analyst's Not Embraced ADS? (Continued)

• *Efficient, Effective Exercising of ADS.* In order to employ ADS efficiently and effectively, it is necessary to devise and implement experimental designs that provide confidence levels consistent with the issues under study and cope with potential confounding factors that may be unique to ADS (e.g., compensate for potential learning by test subjects).

Why Should Analysts Bother With ADS?

- **ADS has the potential to enhance substantially analytic support to**
  - **Operations (e.g., dramatically enhance quality of "what if..." analyses)**
  - **Acquisition (e.g., revolutionize the process via simulation based design)**
- **ADS may enable analysts to address issues in a richer context than they otherwise could; e.g.:**
  - **Consider information aspects of warfare**
  - **Treat human interactions explicitly**
  - **Address joint issues more credibly**
- **Technology trends will make ADS**
  - **More capable**
  - **Cheaper to create**
  - **Easier to use and reuse**

Why Should Analysts Bother With ADS?

In view of the many issues associated with ADS, it poses the question "Why should analysts bother with ADS?" The Workshop panels identified several significant opportunities implicit within ADS that suggest that it is well worth the time of the analysis community to explore the application of ADS to a broad range of analyses.

First, several panels reported that ADS has the potential to enhance substantially, analytic support to a number of application areas. For example, in the area of operations, ADS has the potential to enhance dramatically the quality of "what if..." analyses. As an illustration, an extension of ARPA's Project Odin technology might enable operational commanders to visualize the latest intelligence data and experiment with alternative tactics and procedures. In the area of acquisition, it was noted that the state-of-the-practice has enabled several commercial firms to improve the quality of their products (e.g., Boeing's use of CATIA to develop the "snap together" 777). ARPA is at the state-of-the-art level in this application and they are optimistic that it can be used to reduce the cost and schedule of an acquisition while enhancing the quality of the product (e.g., the simulation based design activities for acquiring future naval platforms).

Why Should Analyst's Bother With ADS? (Continued)

Second, ADS may enable analysts to address issues in a richer context than they otherwise could. As illustrations, note that the use of HITL makes ADS an attractive candidate to treat human interactions explicitly and to consider information aspects of warfare. In addition, the ability to network the tools from several Services suggests that it should help to address joint issues more credibly.

Third, technology trends are providing new opportunities. The Information Technology (IT) that underlies ADS is being enhanced dramatically by the commercial sector (e.g., substantial improvements in processing speeds, storage size and visualization tools at significantly reduced costs). In addition, efforts are underway in the defense community, such as the HLA, to promote interoperability and reuse. The net effect of these trends is to suggest that ADS will become increasingly more capable, cheaper to create and easier to use and reuse.

Why Should Analysts Bother With ADS? (Conclusion)

- **ADS will facilitate leveraging other communities' resources, expertise and data**
- **ADS may enable us to "return to our roots" (e.g., computer assisted analysis vice computer driven analysis)**
- **Decision makers may demand that analysts employ it**
- **It is coming and it will be pervasive in the defense community**

("In ten years, everything can be connected to everything else ... and it will!" Jack Thorpe)

- **ADS may be the precursor to full "instrumentation" of every combatant on the battlefield, leading to unprecedented data for understanding warfare**

Why Should Analysts Bother With ADS? (Continued)

Fourth, as observed by Dr. Jones, the analytic community has the opportunity to take advantage of the extensive ADS investments of other communities (most notably the training community). If done properly, this could provide the analysis community with ready access to expertise (e.g., knowledge on how to use ADS effectively and efficiently), resources (e.g., the opportunity to use existing ADS) and needed data and parameters.

Fifth, Mike Bauman, TRAC-Ft. Leavenworth, and Gene Visco, FS, ODUSA(OR), observed that in recent years we have seen the rise of "computer driven analysis." They postulated that ADS poses the opportunity for analysts to move to "computer assisted analysis" and thereby "return to our roots."

Sixth, it was observed by several participants that decision makers are being exposed to ADS through its application by other communities. Thus, it would not be surprising if these decision makers were to mandate the selective use of ADS by analysts to capture many of its attractive characteristics (e.g. explicit treatment of human behavior, interactive features and high quality visual features).

Why Should Analyst's Bother With ADS? (Continued)

Finally, Jack Thorpe, SAIC, made two observations about ADS. He predicted that "In ten years, everything can be connected to everything else and, given the spirit of experimentation that exists within the analytic community, it will!" Thus, he opined, ADS is coming and it will be pervasive in the defense community. In addition, he speculated that ADS may be the precursor to full "instrumentation" of every combatant on the battlefield. If that comes to pass, it will lead to unprecedented access to timely data for understanding warfare. By analyzing these data, analysts will have an unprecedented opportunity to formulate and validate models of conflict.

Selected Findings and Recommendations

- **ADS Definition**
- **Community Leadership**
- **ADS Plan for the Analysis Community**
- **Community Education, Training and Experience**

Selected Findings and Recommendations

Based on the insights that the Synthesis Panel gained from participation on other panels and Synthesis Panel discussions, a total of four areas were identified that the Panel members felt were of overarching importance. For each of these areas, the Synthesis Panel developed findings and a set of recommendations. In each case, the Synthesis Panel identified the organizations that they believe should take the lead in implementing the recommendations.

Issue: ADS Definition

- **Findings**
  - **There is no existent definition of ADS that was perceived as adequate by the Workshop participants**
  - **The lack of an adequate definition limits the analytic community's ability to**
    - » **Understand the nature of the capability (attributes/limitations, current or future)**
    - » **Plan for the effective application of both ADS and non-ADS capabilities**
- **Recommendations**
  - **A taxonomy should be developed that**
    - » **Defines and clarifies the nature of ADS**
    - » **Illuminates its relationship to related concepts (e.g., DIS)**

(Action: ADS SAG; DMSO)

Issue: ADS Definition

The Synthesis Panel observed that there is no existent definition of ADS that is deemed adequate by the Workshop participants. The Panel found that this lack of an adequate definition limits the analytic community's ability to understand the nature of the capability (i.e., to appreciate its current or future attributes or limitations). This, in turn, limits the analytic community's ability to plan for the effective application of both ADS and non-ADS M&S capabilities.

Consequently, the Synthesis Panel recommends that a taxonomy should be developed that defines and clarifies the nature of ADS and illuminates its relationship to related concepts such as DIS. The MORS ADS Senior Advisory Group (SAG) would be an appropriate organization to draft this taxonomy and then pass it on to the DMSO for approval and dissemination throughout the community.

Strawman Taxonomy for ADS

Factor*	Alternative Levels			
Interoperability	Not	"Swivel Chair"	...	Fully Interoperable
Distributed	Not	Distributed Data	...	Distributed Data and Processing
Interactive	Not	Sequential	...	Highly Interactive
Human Representation	Not	Constructive	...	HITL

Non-ADS | Variations of ADS

* Other factors of interest might include: level of technology (e.g., processing, interfaces), representation granularity, architecture (e.g., object-oriented), protocols/standards and infrastructure

Strawman Taxonomy for ADS

As a point of departure for that task, a strawman taxonomy for ADS is put forth. The chart above identifies a selected set of factors that may prove useful in discriminating between ADS and non-ADS M&S. The factors cited include some of the most commonly used descriptors of ADS: the ability to interoperate with selected M&S, the extent to which it is geographically distributed; the degree of interactivity with other M&S and the way in which humans are represented. In addition, the footnote to the figure identifies a number of additional factors that might prove useful in discriminating ADS and non-ADS capabilities (e.g., the level of technology employed the level of representation granularity or aggregation; the architecture employed; the protocols/standards that are used and the reliance on a community infrastructure such as the Run Time Infrastructure (RTI)).

It should be observed that the factors cited are generally not binary in nature (e.g., a system can take on a spectrum of values of interoperability). Thus, the proposed taxonomy should be viewed as an array in which selected contours will carve out communities that share interesting common properties. As a limiting example, it is suggested that M&S that share the common properties of being non-interoperable, non-distributed, non-interactive and not representing human behavior, should be excluded from the ADS category.

Strawman Taxonomy for ADS (Continued)

As a side comment, several participants at the Workshop identified DIS-compatibility with ADS. However, the acquisition community is more prone to employ tools that use Standards for the Exchange of Product Model Data (STEP) protocols and standards. This suggests that the factor "protocols/standards" should be employed in the taxonomy and that ADS should transcend the DIS limitation.

Issue: Community Leadership

- **Findings**
  - **The challenges associated with ADS transcend the abilities, resources of the individual analyst**
  - **If analysts are to use ADS effectively, a paradigm shift must occur to *enhanced collaborative analysis*, built on the "pillars" of cross-community shared data, security, Measures of Merit (MoMs) and an integrated family of advanced analysis techniques**
- **Recommendations**
  - **Analytic organizations/the analytic community must stimulate/lead the paradigm shift by:**
    - **» Providing incentives to use ADS**
    - **» Making necessary investments in community infrastructure efforts (e.g., consider establishing a "PM Analytic ADS" organization and budget line items)**
    - **» Facilitating needed education, training**
    - **» Forming teams with the necessary mix of skills (e.g., OR, experimental design, program management and data mining)**

(Action: Services, Joint Staff, OSD)

Issue: Community Leadership

The Synthesis Panel found that the challenges associated with ADS transcend the abilities and resources of the individual analyst. If analysts are to use ADS effectively, a paradigm shift must occur to enhanced collaborative analysis. This concept, which was put forth by the Analysis and Requirements Panel, rests on pillars of cross-community shared data, tools (e.g., scenario generation tools, visualization tools), security, Measures of Merit (MoMs) and an integrated family of analysis techniques. The last of these pillars should be emphasized. Most of the panels observed that ADS should not be viewed as a "stand-alone" capability that can be applied to all analytic problems. In general, it must be harmonized and orchestrated with other analysis techniques to compensate for selected ADS features (e.g., extensive time to create and execute) and employed where appropriate.

In order to bring about this paradigm shift, key analytic organizations and the analytic community must provide needed stimulation and leadership. A partial listing of recommended actions to be undertaken by the Services, the Joint Staff and OSD include the following:

- *Providing incentives to use ADS.* This would include providing appropriate resources to analysts and promoting those analysts who employ ADS appropriately and effectively.

Issue: Community Leadership (Continued)

• *Making necessary investments in community infrastructure and accreditation efforts.* It was observed that the analysis community is normally limited to "chump change." To provide the resources needed to develop and VV&A ADS, several members of the Synthesis Panel recommended that a "PM Analytic ADS" organization be established and supported with adequate budget line items. This recommendation should be assessed further to establish its feasibility and desirability.

• *Facilitating needed education, training.* The cornerstone to effective creation and use of ADS is the education and training of the analyst and the decision maker. In view of the criticality of this step, it is amplified upon as a separate issue below.

• *Forming teams with the necessary mix of skills.* The effective creation and use of ADS demands a team effort. Representative skills include OR (to help frame and scope the problem), experimental design (to formulate the experimental design matrices and support the analysis process), program management (to perform the myriad management and administrative tasks) and data mining (to acquire, process and store data associated with ADS).

Issue: ADS Plan for the Analysis Community

- **Observations**
  - **Historically, spokespersons for the analysis community had resisted**
    - » **Identifying its needs for advanced M&S (in contrast to other communities)**
    - » **Developing a proactive plan to redress M&S deficiencies**
  - **There is no long range vision to guide the allocation of limited M&S development resources to support the analyst —we tend to be reactive to near-term needs**
- **Findings**
  - **The absence of an "ADS Plan for the Analysis Community" has resulted in**
    - » **Fragmented action within the community**
    - » **Limited leveraging of cross-community resources, expertise**
- **Recommendations**
  - **The Analysis Council should take on the responsibility of**
    - » **Developing the vision for the next generation of M&S tools for the analyst**
    - » **Drafting an "ADS Plan for the Analysis Community," no later than 1 February 1997**
  - **The plan should explicitly identify steps to ensure maximum use/compatibility between COTS and ADS**

(Action: Analysis Council)

Issue: ADS Plan for the Analysis Community

Once the analysis community becomes committed to the enhanced collaborative analysis paradigm, it will need a plan to guide its actions. Historically, the analysis community has been reluctant to take this step. For example, several years ago, DMSO sponsored a series of workshops to stimulate the various communities to identify their needs for advanced M&S. While several communities embraced this opportunity (e.g., training, T&E), the analysis community demurred. The Synthesis Panel further observed that there is no long range vision to guide the allocation of limited M&S development resources to support the analyst. Consequently, the analysis community tends to be excessively reactive to near-term needs at the expense of needed longer-term investments.

The Synthesis Panel found that the absence of an "ADS Plan for the Analysis Community" has resulted in fragmented action within the analysis community and limited the leveraging of the resources and expertise that are resident in other communities (e.g., training, acquisition). To ameliorate those shortfalls, the Analysis Council that has been formed under the Executive Committee for M&S (EXCIMS), must take decisive action. It should develop the vision for the next generation of M&S tools for the analyst and draft an associated "ADS Plan for the Analysis Community."

Issue: ADS Plan for the Analysis Community (Continued)

In the view of the need for timely action, these products should be drafted and circulated for community coordination no later than 1 February 1997. To ensure that the community takes full advantage of the opportunities implicit in commercial developments, the plan should explicitly identify steps to ensure maximum use and compatibility between Commercial-Off-The-Shelf (COTS) products and ADS.

Issue: Community Education, Training and Experience

- **Findings**
  - **A broad set of skills, knowledge, and expertise will be needed by the community if it is to be able to employ ADS effectively and efficiently**
  - **In the absence of appropriate education, training, and experience,**
    - **The results that emerge from the application of ADS are likely to be suspect**
    - **Decision maker understanding of the meaning, validity of results is likely to be limited**
- **Recommendations**
  - **Key Service schools should develop curricula and offer a sub-specialty of "ADS Analyst" (Action: NPS, AFIT and ALMC)**
  - **Assignments to "ADS Analyst" positions should be of suitable duration to ensure that necessary experience is acquired and sustained (Action: Services, JS)**
  - **Training programs for decision makers should be augmented with material on ADS (Action: DSMC, DAU, NDU and Senior Service Schools)**

Issue: Community Education, Training and Experience

The Synthesis Panel found that a broad set of skills, knowledge and expertise will be needed by the community if it is to able to appreciate the capabilities and limitations of ADS and to employ ADS effectively and efficiently. It must be emphasized that the community in question subsumes both analysts and decision makers. In the absence of appropriate education, training and experience, the results that analysts derive from the application of ADS are likely to be suspect and the decision makers' understanding of the meaning and validity of those results is likely to be limited.

To deal with these issues, the Synthesis Panel put forth several recommendations. First, key Service schools should develop curricula and offer a sub-specialty of "ADS Analyst." Candidate schools include the Naval Postgraduate School (NPS), the Air Force Institute of Technology (AFIT) and the Army Logistics Management College (ALMC). Second, assignments to "ADS Analyst" positions should be of suitable duration and consistency to ensure that necessary experience is acquired and sustained. Thus, for example, once an analyst has qualified as an "ADS Analyst" at one of the above institutions, his/her next assignment should be to an ADS activity or to an organization which may perform collaborative analysis employing ADS.

Issue: Community Education, Training and Experience (Continued)

Note that some Services currently assign recent graduates to field assignments. Subsequently, a sequence of assignments should be envisioned that help the ADS Analyst to continue to hone and apply his/her skills.
In support of decision maker education and training, appropriate programs on ADS should be developed and offered at institutions such as the Defense Systems Management College (DSMC), the Defense Acquisition University (DAU), the National Defense University (NDU) and the Senior Service Defense Schools. Thought should be given to updating DSMC's Handbook on M&S for the acquisition community to highlight the challenges and opportunities associated with ADS.

Summary Assessment: Achievements Versus Objectives

- **Assess the utility of current and future (3-5 years out) ADS-based capabilities for analytic applications, especially possible areas of new analytic capabilities — AMBER**
- **Define areas of needed enhancements of ADS-based capabilities to increase their utility to the military analytic community — AMBER**
- **Increase the military analytic community's understanding of current ADS-based capabilities and near-term improvement programs — GREEN**
- **Increase interactions between the military analytic community and developers of ADS-based capabilities — GREEN**

Summary Assessment: Achievements Versus Objectives

The TOR identified four objectives for the Workshop. To establish a qualitative measure of the effectiveness of the Workshop, the Synthesis Panel informally assessed the other panels against these four objectives, based on its observations of their operations and products. These assessments were in the form of a color (i.e., "green" implied fairly complete achievement of the objective, "amber" implied moderate achievement of the objective and "red" implied a failure to achieve the objective).

The first objective was to assess the utility of current and future (3-5 years out) ADS-based capabilities for analytic applications, especially possible areas of new analytic capabilities. The Synthesis Panel rated this as "amber." There was extensive consideration of the current time frame but less about the future because of the limited understanding about the likely nature of ADS by the turn of the century.

The second objective was to define areas of needed enhancements of ADS-based capabilities to increase their utility to the military analytic community. The Synthesis Panel rated this as "amber." It was felt that the absence of an agreed definition for ADS limited this discussion, although a number of

Summary Assessment: Achievements Versus Objectives (Continued)

panels put forth excellent suggestions for increasing the utility of ADS to the military analytic community.

The third objective was to increase the military analytic community's understanding of current ADS-based capabilities and near-term improvement programs. The Synthesis Panel rated this as "green." This was due to the inclusion of descriptive material in the read-ahead package, the material covered in selected plenary presentations, the scheduling of ADS presentations within selected panels and the ad hoc scheduling of a presentation on the HLA to the workshop.

The fourth objective was to increase interactions between the military analytic community and developers of ADS-based capabilities. The Synthesis Panel rated this as "green." This was due to the mix of participants that were invited to the Workshop and the opportunities that were provided to enable them to have a fruitful dialogue.

TERMS OF REFERENCE
MORS WORKSHOP:
ADVANCED DISTRIBUTED SIMULATIONS for ANALYSIS (ADSA '96)
November 27, 1995

1. **Goal:** The primary goal of this workshop is to assess the applicability of current and near-term Advanced Distributed Simulation (ADS) capabilities as applied to military analysis. A secondary goal of this workshop is to stimulate communication regarding the continuing evolution of Advanced Distributed Simulation capabilities, and to foster interaction between the military analytic community and developers of ADS-based capabilities.

2. **Background:** In September of 1992 MORS sponsored an ADS mini-symposium with the objective of familiarizing the military operations research community with the concept and capabilities of ADS and synthetic combat environments. A second goal was to have participants explore the use of these capabilities to meet operations research and analysis needs. The objectives of that conference were accomplished and a Proceedings has been published.

Over the last three years a considerable amount of work has been initiated across the Department of Defense (DoD) with respect to the use and development of ADS capabilities. Major technology demonstrations have been conducted and many programs have been initiated within the department to continue development of ADS capabilities. In March 1994, MORS organized a Senior Advisory Group (SAG) to review and coordinate Society activities related to ADS. As a result of the continued emphasis and importance that the DoD has placed on the use of modeling and simulation, the ADS SAG recommended that MORS convene a workshop to pursue a more detailed examination of the use of ADS by the military operations research community.

Numerous reports identify the fact that our military forces now face an extensive variety of potential adversaries, presenting US military forces with a wide spectrum of missions and operations, including "other than war" roles. Many of these stress aspects of the use of military forces beyond that of conventional analysis of "attrition combat." The DoD continues to stress the need for, and potential of, application of advanced modeling and simulation capabilities to increase the readiness of our military to execute the roles and missions necessary to achieve the objectives of our National Military Strategy.

Many changes have occurred with regard to ADS over the past two years. For example, all of the military services now have plans for new constructive models utilizing many ADS-based technologies; all of the services' major current constructive models now interact with current

DIS-based virtual systems; ARPA has a new major program underway to expand the capabilities of synthetic theater of war environments (STOW-97). DMSO has recently promulgated a draft of a DoD-wide high level architecture for modeling and simulation; and a master plan for achieving ADS-based capabilities and improving modeling and simulation capabilities overall. Additionally, all of the Services have a considerable number of initiatives underway to improve and to integrate many live, constructive and virtual instrumentation, and modeling and emulation capabilities. Also, recently a Joint Simulation (JSIMs) Program Management Office has been created to oversee development of joint simulations. Recently the Theater Missile Defense (TMD) community has recognized the potential of ADS to facilitate testing, exercise, and demonstration of its systems in the environment of wartime operations that cannot be created in any practical way using real threat systems. DoD needs such as these represent an analytical challenge that must be addressed by the military operations research community as well as an operational challenge faced by the war fighters. This major evolution of modeling and simulation capabilities requires that the military analytic community understand both the uses and limitations of ADS-based capabilities, current and potential; and that they participate in defining the needs of the analytic community with regard to ADS-based capabilities.

3. **Objectives:**

a. The purpose of this workshop is to achieve the following objectives:

(1) Assess the utility of current and future (3-5 years out) ADS-based capabilities for analytic applications, especially possible areas of new analytic capabilities.

(2) Define areas of needed enhancements of ADS-based capabilities to increase their utility to the military analytic community.

(3) Increase the military analytic community's understanding of current ADS-based capabilities and near-term improvement programs.

(4) Increase interactions between the military analytic community and developers of ADS-based capabilities.

b. Within these broad objectives the workshop will focus on the following subject areas:

(1) Analysis associated with determining the battlefield effectiveness of operational concepts, tactics, doctrine and forces.

(2) Analysis associated with determining material requirements, system to system comparisons of battlefield effectiveness, system life cycle design tradeoffs, and decisions pertaining to the acquisition process.

(3) Analysis associated with Test and Evaluation.

(4) Analysis associated with determining the effectiveness of training, mission rehearsal, and alternate courses of action during operational planning.

(5) Analysis and requirements, including processes for assessing and improving ADS-based analytic tools.

(6) Analysis of DIS simulations with the objective of deepening understanding of warrior behavior/performance and then incorporating that understanding in improved constructive models and data.

c. A working group will be convened to address each of the above subject areas. Each working group will be specifically charged to address broad analytic questions within its analytic domain to include:

- When should ADS-based capabilities be used? (For what types of analysis and to answer what kinds of analytic questions?)
- Are ADS-based capabilities better or worse for specific types of analysis already being done? (Which, how, why, when in the analytic process?)
- Do ADS-based capabilities allow analysis to address any new, necessary analytic questions?
- How do ADS-based capabilities fit with other types of analytic capabilities and approaches?
- What are limitations of current and future ADS-based capabilities? (Which are generic limitations and which are limitations which could be mitigated or eliminated with enhancements to ADS-based capabilities?)
- Are there pitfalls in analysis using ADS-based capabilities? (What are they, are they generic?)
- Does the use of ADS-based capabilities affect the utility of analytic results? (How, why, when?)
- Are there useful ways to utilize the results from ADS-based analysis, exercise, and training that differ from conventional methods? (How, when, under what conditions and assumptions?)

- Do ADS-based analysis capabilities make verification, validation and accreditation processes any harder, easier, or different? If so, in what ways? What are suggested ways to take advantage of these differences or to mitigate them?

In addressing these questions, each working group will consider them in the context of scenario development, robustness of analytic results, consideration of a variety of adversaries and missions, comparisons between analytic results and field experience, other issues affecting the utility of analysis, and other specific issues raised by the workshop participants.

4. **Approach:**

a. The working groups will consist of a strictly limited number and mixture of analysts interested in ADS applications, persons with hands-on experience using existing ADS capabilities, and developers of advanced ADS capabilities. Working group size will be limited to 15 persons to ensure adequate opportunity for participation in the discussion. Six working groups will specifically address the areas delineated in Section 3b. In addition, working groups may also address applications of ADS capabilities to analysis of the BMD system.

b. A read ahead package will be sent to all participants to provide background information and an overview of key ADS capabilities and objectives. This will include a baseline description of service analytical needs, widely used models, simulations, tools, and techniques along with the recognized shortfalls of these capabilities identified to date by both the ADS user and development communities.

c. The first day of the workshop will be primarily devoted to information briefings to ensure that participants have a broad understanding of current ADS-based capabilities, on-going development programs, and key concepts and plans as they relate to analysis. The latter portion of the afternoon will be devoted to the initial meetings of working groups, their organization, and the introduction of participants to one another. The first day will include an evening social to facilitate the interaction of participants. The second day and morning of the third day will be devoted to individual working group sessions. The early afternoon of the third day will be devoted to short presentations by each working group and a summary of the workshop. The ADS SAG will meet in the late afternoon after the workshop participants have been released.

d. Synthesis Group: A small synthesis group will be formed to observe the activities and discussion of the working groups. This group will assist in identifying important and cross-cutting subjects among the groups.

5. **Membership:** Representation will include DoD, industry and academia. Working group chairs will be subject matter experts in their session area. Membership in the working groups will be determined by the working group chairs, and will be limited in number to facilitate the preparation of focused products.

6. **Products:** MORS workshops are designed to examine problems related to military operational analyses and to identify approaches to solutions of those problems. Products of MORS workshops are (1) clarification of problems and problem areas and (2) identification of solution "spaces." The clarification of problems are summarized in terms of observations and findings of the workshops. Identification of solution "spaces" result in recommendations for action by the MORS community (Department of Defense institutions, other government elements, private sector organizations, and academic institutions). Of special interest are recommendations particularly directed to the MORS sponsoring agencies. The products are conveyed by: (1) briefings to the workshop proponents and other sponsors as requested (within 30 days of the end of the workshop); (2) proceedings consisting of an executive summary (including key findings and recommendations, and common and most prevalent themes), a report from each working group at the workshop with findings and recommendations, and papers and briefings presented (proceedings are targeted for production within three months of the end of the workshop); and (3) an article for the earliest issue of *PHALANX* following the end of the workshop.

The products of this ADS workshop will include:

- Specification of classes of analyses most amenable to support by ADS and those for which ADS is not useful;
- Assessment of the "value-added" of ADS for analyses presently underway;
- Identification of experiments which can be designed to assist in the development of MOEs for analysis to include human-related functions; and
- Ways to use results from ADS-based analyses that differ from those of other analyses.

Recommendations relevant to findings and observations will be presented to specific sponsors, as necessary. Overall, the ADS workshop will form the basis of a status report on the present and possible contributions to analysis afforded by ADS, and recommendations for action that will increase the likelihood that ADS will make significant and valuable contributions to military analysis in the future.

7. **Proponents:** The ODUSA(OR), OCNO (N81), HQ USAF/XOM, Joint Staff, J8, OSD (PA&E) have agreed to be proponents for the workshop. MCCDC has expressed supportive interest.

8. **Administrative:**

Title: "Advanced Distributed Simulations for Analysis (ADSA '96)"
Dates: 30, 31 January, 1 February 1996
Fee: $150 (Federal Government)
$300 (Others)
Attendance: Limited to 115-140 attendees.
Classification: Unclassified

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GLOSSARY OF ACRONYMS

A2	Anti-Armor
AAR	After Action Review
ACM	Air Combat Maneuvering
ADS	Advanced Distributed Simulation
ADS-A	Advanced Distributed Simulation for Analysis
AFIT	Air Force Institute of Technology
ALMC	Army Logistics Management College
ALSP	Aggregate Level Simulation Protocol
AMG	Antenna Mast Group
APL	Applied Physics Laboratory of Johns Hopkins University
ARPA	Advanced Research Projects Agency
ATD	Advanced Technology Demonstration
AWACS	Airborne Warning and Control System
AWE	Advanced Warfighting Experiment
AWSIM	Air Warfare Simulation
BFTT	Battle Force Tactical Trainor
BMDO	Ballistic Missile Defense Office
BoD	Board of Directors
BOI	Basis of Issue
C2	Command and Control
C3I	Command, Control, Communications and Intelligence
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CATIA	Computer Assisted Three-dimensional Interactive Application
CBS	Coprs Battle Simulation
CINC	Commander-in-Chief
CJCS	Chairman of the Joint Chiefs of Staff
CJCS	Chairman Joint Chief of Staff
CM	Configuration Management
CMMS	Conceptual Models of the Mission Space
COA	Course of Action
COEA	Cost and Operational Effectiveness Analysis
CONOPS	Concept of Operations
COTS	Commercial-Off-The-Shelf
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University

GLOSSARY OF ACRONYMS

DBMS	Database Management System
DDR&E	Director, Defense Research & Engineering
DEM	Distributed Exercise Management
DIAL	Distributed Intelligent Architecture for Logistics
DIS	Distributed Interactive Simulation
DMSO	Defense Modeling & Simulation Office
DoN	Department of the Navy
DSMC	Defense Systems Management College
DT/OT	Development Test/Operational Test
EBR	Evidence Based Research, Inc.
ECM	Experiment, Control and Monitor
EXCIMS	Executive Committee for M&S
GCCS	Global Command and Control System
HITL	Human in the loop
HLA	High Level Architecture
IADS	Integrated Air Defense System
IB	Industrial Base
IDA	Institute for Defense Analyses
ISR	Intelligence, Surveillance and Reconnaissance
IT	Information Technology
IVIS	Inter-Vehicular Information System
JADS	Joint Air Defense System
JMETL	Joint Mission Essential Task List
JPO	Joint Program Office
JS	Joint Staff
JSIMS	Joint Simulation System
JTF	Joint Task Force
JWFC	Joint Warfighting Center
K/V	Killer/Victim
M&S	Modeling & Simulation
MOE	Measures of Effectiveness
MoMs	Measures of Merit
MOOTW	Military Operations Other Than War
MOP	Measures of Performance
MORS	Military Operations Research Society
MORSS	Military Operations Research Society Symposium
M-T-M	Model-Test-Model
NBC	Nuclear Biological Chemical
NDU	National Defense University
NPS	Naval Postgraduate School
NRT	Near Real Time
OLE	Object Linking and Embedding

GLOSSARY OF ACRONYMS

ODUSA(OR)	Office of the Deputy Undersecretary of the Army (Operations Research)
OPTEC	Operational Test & Evaluation Command
OR	Operations Research
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OSD(PA&E)	Office of the Secretary of Defense (Program Analysis & Evaluation)
PM	Program Manager
PMADS	Protocol-Mediated Advanced Distributed Simulation
R/T	Receive/Transmit
RD&A	Research Development and Acquisition
RESA	Research Evaluation and System Analysis
RTI	Run Time Infrastructure
RWR	Radar Warning Receiver
SAG	Senior Advisory Group
SAIC	Science Applications International Corporation
SIMNET	Simulation Network
SPI	Strategic Perspectives, Inc.
STEP	Standards for the Exchange of Product
TACCSF	Tactical Air Command and Control Simulation Facility
TOR	Terms of Reference
TRAC	TRADOC Analysis Command
TRADOC	Training & Doctrine Command
USAREUR	U.S. Army Forces: U.S. European Command
VR	Virtual Reality
VTC	Video Teleconference
VV&A	Verification, Validation and Accreditation
VV&C	Verification, Validation and Certification