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Distributed Interactive Simulation Standards Development: Operational Concept 2.3

University of Central Florida Institute for Simulation and Training

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OPERATIONAL CONCEPT 2.3

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Distributed Interactive Simulation Standards Development

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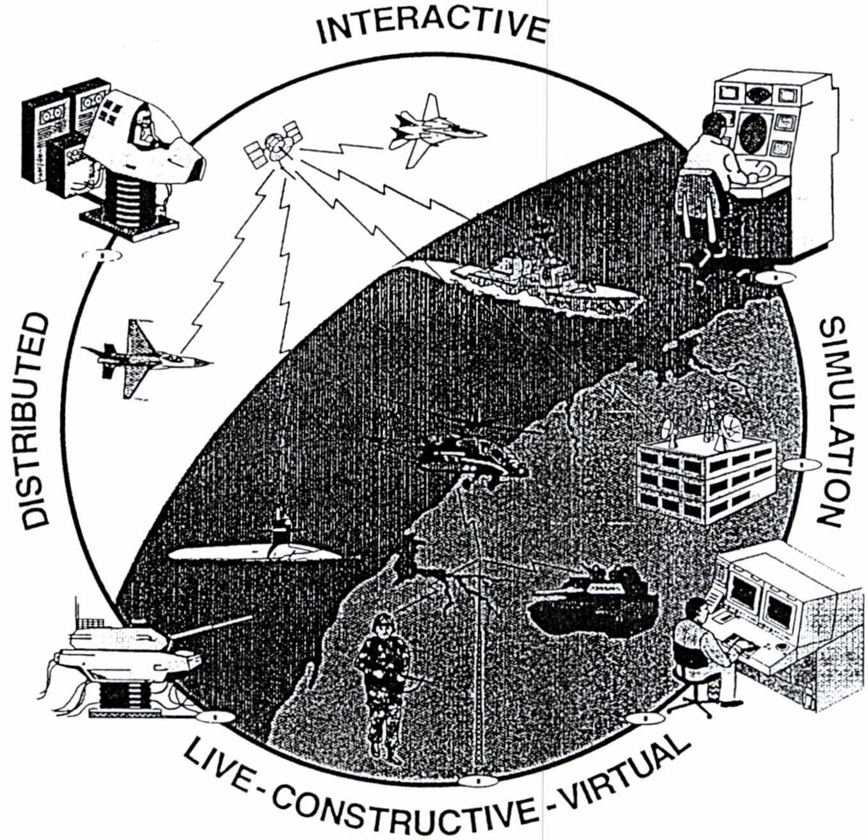

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FOREWORD

The purpose of this document is to present the Operational Concept for Distributed Interactive Simulation (DIS). This concept will evolve over time as more participants in the Training and Testing communities articulate their requirements. Comments on this Operational Concept are welcome and should be addressed to:

Margaret Loper
Chairman, DIS Steering Committee
UCF/Institute for Simulation and Training
3280 Research Parkway
Orlando, FL 32826
Voice - (407)658-5517
Fax - (407)658-5059

CONTENTS

Distributed Interactive Simulation
Operational Concept

MISSION

The mission of Distributed Interactive Simulation (DIS) is discussed under the headings User Needs, Primary Mission and Secondary Mission.

User Needs

Over the last two decades, the United States military has developed an impressive array of simulation and training systems. These devices are extremely adept at training soldiers to do their jobs as individuals or as members of a small team. In addition, the test community has developed simulations that test the ability of equipment to perform its mission as an individual unit. However, the United States found in Grenada, Libya and Panama that the ability to perform a mission as an individual does not guarantee the ability to function as a member of a coordinated task force.

Commenting on Operation Desert Storm, General Schwarzkopf stated, "Analysts write about war as if it is a ballet, like it's choreographed ahead of time and when the orchestra strikes up and starts playing, everyone goes out there and plays a set piece. What I always say to those folks is, 'Yes, it's choreographed, and what happens is the orchestra starts playing and some son-of-a-bitch climbs out of the orchestra pit with a bayonet starts chasing you around the stage and the choreography goes right out the window.'"

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>
> *General Schwarzkopf*
> *Desert Storm*

We need to provide a means for participants from the commander to the individual warfighter to experience these "bayonet" disruptions in a simulated environment and learn how to plan for them in real-world engagements.

Admiral F.B. Kelso II, Chief of Naval Operations, said, "Battle group commanders may be called upon to form and command a Joint Task Force in response to an emergency. This requires that they understand joint doctrine, tactics, planning and C^3I; strike planning cells need to know other service capabilities; and unit commanding officers must be equally capable when operating as part of a joint task force as they are in any other area. Training for this must begin with the education of the individual, continue through the unit and battle group, and conclude in full-scale joint exercises and operations. To effect this goal, the Navy training and education doctrine (from the basics to the most sophisticated exercises) must incorporate and address joint warfighting ideas. Additionally, this requires the mutual integration of Navy doctrine and tactics with joint doctrine and tactics. Our systems, from computer wargaming simulations to communications and weapons, must incorporate the ability to interoperate with the other services. In summary, we must and will

Defense Science Board Recommendations

A Defense Science Board Task Force on Improving Test and Evaluation Effectiveness states:

- Modeling and simulation offer great potential in improving the defense acquisition process and should be incorporated to an even greater degree.
- Every program should build mock-ups of man/machine interfaces as early as possible in the development cycle.

Figure 1 Defense Science Board Recommendations

Army Science Board Recommendations

The electronic battlefield embodied in Distributed Interactive Simulation (DIS) offers potential across the board and can revolutionize our way of doing business in:

- combat development
- system acquisition
- tests and evaluation
- training

High resolution mock-ups, or perhaps even actual hardware in-the-loop, can be evaluated under "realistic" battlefield conditions within the electronic battlefield.

The result of such evaluations should be substantial cost savings in the concept development, system development, test and evaluation, and product improvement process.

Source: Army Science Board 1991 Summer Study on Army Simulation Strategy (Draft) 1 August 1991

Figure 2 Army Science Board Recommendations

adjust in all areas of our thinking, education, and training. We must fully integrate and incorporate joint and combined operations."

The United States military has developed means for conducting large combined arms, multi-service exercises. However, these exercises are extremely expensive, subject to major environmental constraints, and can sometimes be interpreted as militarily provocative.

The Defense Science Board Task Force for Improving Test and Evaluation Effectiveness reports that models and simulation have great potential for improving the acquisition process and should be incorporated to a greater degree (see Figure 1). The task force also stated that designers should build mock-ups of the man/machine interfaces as early as possible in the development cycle.

The Army Science Board states that DIS offers enormous potential across the board in Combat Development, System Acquisition, Test and Evaluation, and Training (see Figure 2). The user needs a virtual representation of the warfare environment that is inexpensive enough to be used frequently, distributed for use at the duty station or development site and secure enough to be used without revealing tactics or operational capabilities to unauthorized personnel.

"To effect this goal [of training for Joint Task Force Operations], the Navy training and education doctrine (from the basics to the most sophisticated exercises) must incorporate and address joint warfighting ideas. Additionally, this requires the mutual integration of Navy doctrine and tactics with joint doctrine and tactics. Our systems, from computer wargaming simulations to communications and weapons, must incorporate the ability to interoperate with the other services. In summary, we must and will adjust in all areas of our thinking, education, and training. We must fully integrate and incorporate joint and combined operations."

Admiral F.B. Kelso II
Chief of Naval Operations

Primary Mission

The primary mission of DIS is to create synthetic, virtual representations of warfare environments by systematically connecting separate subcomponents of simulation which reside at distributed, multiple locations. DIS can be used as a substitute for some field training and testing; it also allows practice of warfighting skills when cost, safety, environmental and political constraints will not permit the field training and testing required to maintain readiness.

The property of connecting separate sub-components or elements affords the capability to configure a wide range of simulated warfare representations patterned after the task force organization of actual units, both friendly and opposing, including joint and combined force operations to represent a wide range of warfighting missions facing U.S. and Allied forces today and in the future. Equally important is the property of interoperability which allows different simulation environments to efficiently and consistently interchange data elements essential to representing warfighting interactions and outcomes.

In effect, interoperable simulations will exchange data in a manner such that the differences in the representation of the simulated battlefield will be transparent or "seamless" as experienced by participants interacting with their particular representation of the warfighting environment. This property affords the opportunity for linking heterogeneous representations, each providing a locally consistent simulated environment, through use of buffers or translators to create a seamless interconnection.

With these properties, it is possible to have simulation components which meet special purpose local needs and when required can link together to form larger scale warfighting environment representations.

Secondary Mission

In addition to DIS's primary mission of supporting training and testing needs, DIS can serve as a tool for mission planning and mission rehearsal.

OPERATIONAL ENVIRONMENT

The operational environment of DIS is discussed under the headings of Basic Concepts, Key Design Principles, Inter-operability Standards, and Opportunities to Impact Standards.

DIS Basic Concepts

The basic concepts of Distributed Interactive Simulation (DIS) are an extension of the Simulation Networking (SIMNET) program developed by the Defense Advanced Research Projects Agency (DARPA). The purpose of DIS is to allow dissimilar simulators distributed over a large geographical area to interact in a team environment. These simulators communicate over local area networks and wide area networks. The basic DIS concepts are:

- No central computer for event scheduling or conflict resolution.
- Autonomous simulation nodes responsible for maintaining the state of one or more simulation entities.
- There is a standard protocol for communicating "ground truth" data.
- Receiving nodes are responsible for determining what is perceived.
- Simulation nodes communicate only changes in their state.
- Dead reckoning is used to reduce communications processing.

The implications of each of these concepts as they apply to DIS are discussed separately below.

No Central Computer

Some war games have a central computer that maintains the world state and calculates the effects of each entity's (platform, person, missile, etc.) actions on other entities and the environment. These computer systems must be sized with resources to handle the worst case load for a maximum number of simulated entities. DIS uses a distributed simulation approach in which the responsibility for simulating the state of each entity rests with separate simulation nodes (host computers). As new nodes are added to the network, each new node brings its own resources.

Autonomous Simulation Nodes

The DIS nodes are autonomous and generally responsible for maintaining the state of one entity. In some cases, a host computer node will be responsible for maintaining the state of several semi-automated forces entities. As the user operates controls in the simulated or actual equipment, the host computer in that node is responsible for simulating the resulting actions of the entity using a high fidelity simulation model. That node is responsible for sending messages to others, as necessary to inform them of any observable actions. All nodes are responsible for interpreting and responding to messages from other nodes and maintaining a simple model of the status of each entity on the network. All nodes also maintain a model of the status of the world including bridges and buildings that may be intact or destroyed.

Ground Truth Versus Perception

Each entity communicates to all other entities its current status (location, orientation, velocity,

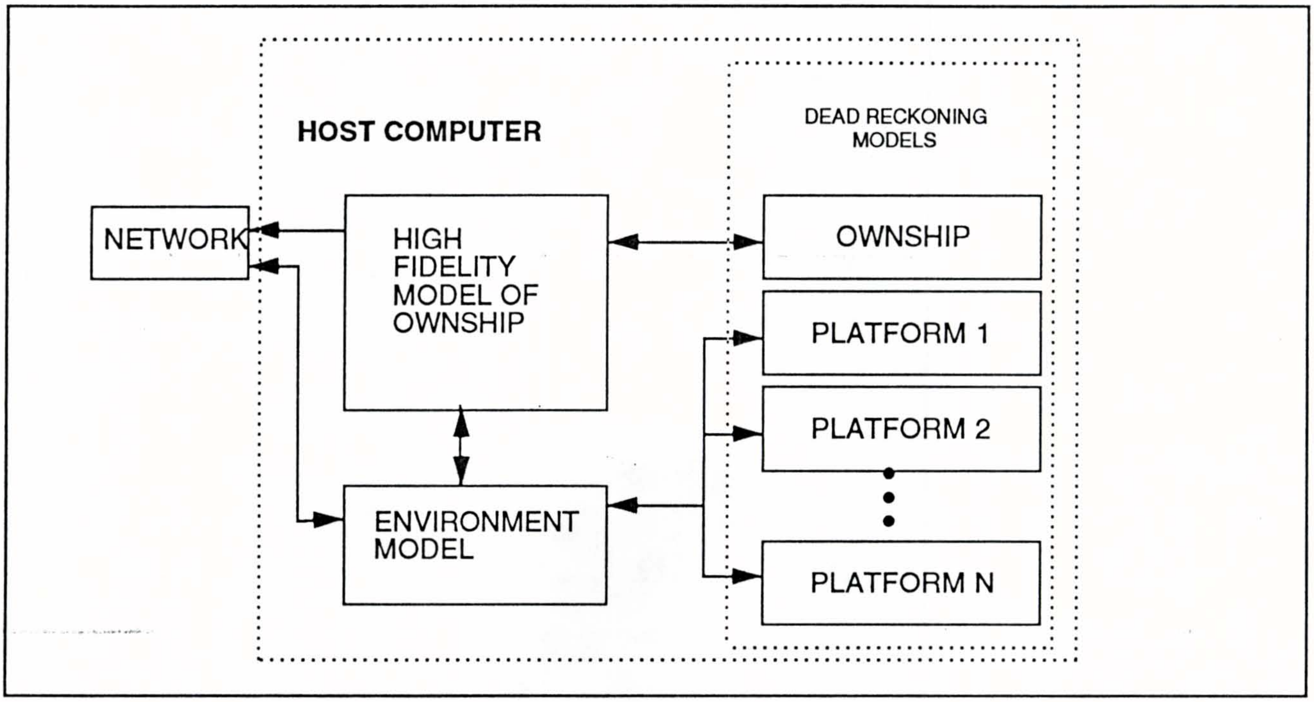

Figure 3 Dead Reckoning in DIS

active emitters, articulated parts position, etc.). The receiving entity's host computer must take this ground truth and calculating whether that entity is visible by visual or electronic means. This perceived status of the other entity is then displayed to the user on the simulated displays.

Dead Reckoning

In order to limit communications, each host computer maintains a simple model of the status of all other entities (within a given range) on the network (see Figure 3).

Between updates, the host computer extrapolates the position and orientation of the other entity based on its last reported location, velocity and acceleration. Each entity also keeps a simple model of its own state. When the state of the high fidelity model of ownship differs by a given amount from the simple model, the host computer sends out an update message to update the status of all simple models of the sending entity.

This dead reckoning approach allows a host computer to update its display of the status of other entities at its normal update rate (e.g.. 5, 15, 30, 60 Hz) while receiving updates in status from the other entities at a rate (about 1 Hz) that will not overload the communications network.

DIS Key Design Principles

The key DIS design principles are Object Oriented Entity Design, Entity Sphere of Interaction, Gaming Area, Model Designs, Synchronous and Asynchronous Interconnections, Aggregation and Level of Resolution, System Management, and Communication Services. Each of these topics is discussed below.

Object Oriented Entity Design

Each simulation element will be designed as an autonomous entity. Individual entities will include a "public" and "private" component. Multiple entities will be connected through their public components to form simulation systems which represent virtual warfighting environments. The public component, designed as a separate module, handles the exchange of data between

entities as well as any processing required to compensate for transmission delays and asynchronous arrival of data. For the purpose of discussion, the public component will include an entity state vector and a system state vector. The entity state vector maintains current values of the variables which describe the state of the entity. The system state vector maintains current values of variables which describe the state of conditions existing across the simulation system. While the public component must be "standard" across the system, the private component creates only the interactions and representations of the warfighting environment which are required for the simulation element created by the entity.

Entity Sphere of Interaction - Cause and Effect

The private component of each entity will compute an active simulation region within a "sphere of interaction" i.e. for each entity the sphere of interaction defines the spatial region in which state vector data from other entities must be monitored and processed in order to maintain the interactive simulation within the private component of the entity. Effects on the simulated warfighting environment are caused by results of actions initiated by the individual entities. Results such as collisions may be computed by the entity which occur within the entity sphere of interaction and indicated as an event change in the state vector.

In other cases actions initiated by the entity such as active emissions may be continuously present over intervals of time and indicated as a state change in the state vector. In either case, the public component of the entity will transmit the change in its own state vector variables to all other entities affected by the change. Likewise, entities affected by these actions will compute the effects of the action and/or results received from the initiating entity and update its own state variable to show the change in state caused by the action. In this manner entities initiating actions will be responsible for notifying other entities in the system of the actions taken. Entities affected by the actions will be responsible for determining the effects of the action and notifying other entities in the system of resulting changes in entity state caused by the action.

Gaming Area - Environment Model Data Base

In order to maintain ground truth within the simulation system, each host computer must access a common representation of the environment (land, ocean, atmosphere and space). Hence, digital terrain data bases used by individual entities must, as a minimum, use the same "survey markers" as a common reference for generating terrain surfaces and overlay of cultural features and objects. Likewise, all host computers must have common representations of ocean, atmosphere and space environment models.

Given standard file structures for relating cultural features and object models to the survey markers, the extent to which terrain representation is identical within each host computer will depend upon the degree that the terrain generation formatting and rendering processing is the same within each host computer and image generator. Certainly, consistent representations of terrain and warfighting interactions can be accomplished within any given host computer. However, the cause and effect design requirements described above will require further consideration of how to describe and define correlation between entities which are using different formatting and rendering processes for terrain generation commonly referred to as different fidelity levels. These considerations for terrain representation apply equally as well to the ocean, atmosphere and space environment models in separate host computers.

Model Designs

Model designs and algorithms used within the individual host computers to create dynamic

simulations of weapon system performance, soldier-machine interactions, soldier-battlefield interactions and general representation of the warfighting environment must consider that data elements used in computing the models will, in part, be received from other entities in the system. Moreover, the model designs should assure that variables or parameters which affect the model performance can be easily reset. In this manner, for example, a basic ballistics model for conventional guns could be used to represent a variety of specific weapons by changing the model parameters. Likewise, basic models for other classes of weapons and warfighting interactions can be defined. Also, model designs should include provisions for system state variable parameters which affect the model's performance, e.g. atmospheric attenuation coefficient which changes as a function of climate and weather conditions. Again, concern over model fidelity used in the individual host computers will have to be addressed. In order to keep the system designs tractable it may be necessary to allow some limited number of discrete values for model and system state variables initially which may be extended as experience grows and need dictates.

Synchronous and Asynchronous Interconnections

Conventional centrally controlled simulations use time steps to synchronize the advancement of the simulation. In these cases, computations required to determine interactions between entities and changes in entity status are completed during a prescribed time interval; the simulation is updated to reflect these changes at the end of the time interval.

In the case of asynchronous interconnections such as those demonstrated by SIMNET, each entity updates state variable parameters and transmits the new values whenever the change in these parameters exceeds preset thresholds. Thus, the update of parameters occurs asynchronously within the simulation system. To re-establish a synchronous simulation environment within individual entities, dead reckoning algorithms are used to extrapolate the state variable parameters of all external entities to the same current time of the individual entity. For reliable simulations, the extrapolating algorithms must be powerful enough to compensate for latency caused by transmission delays between entities and the lag in updating state variable changes.

Aggregation and Level of Resolution

Several entities may be aggregated to form a group. Typically, entities simulating weapon platform (item level) resolution would be grouped to form unit level representations. On the other hand, analytic force level simulations would also typically use entities representing unit level resolution. In these cases the entity state vectors would carry distinctly different kinds of data. For the item level resolution, the state vector would include data describing the state and activity of the weapon system. For the unit level resolution, the state vector would include data describing the state and activity of the unit at the aggregate level. Aggregation of item level to unit level and deaggregation of unit level to item level representations will require both clearly defined relationships between the two state vector variables and some additional processing resources to accomplish the translations. This most likely will be accomplished through some form of semi-automated force representation. The design goal would be to have elements of simulation operating at item (weapon system) level resolution smoothly interoperating with larger scale simulations operating at the unit (platoon, flight, action group) level resolution.

System Management

Operation of a simulation system comprised of several individual entities interacting to form a virtual warfighting environment representation will require some design principles for system management. System management (SM) will require

the capability to initialize or "set" the values of the system state vector variables and all entity state vectors that will be connected in the system at the beginning of the exercise. Also SM will load model parameters and data bases in individual entities when required for customizing entity simulation performance to specific weapon characteristics and defining the exercise gaming area. Likewise, SM will initialize communication services and interface parameters necessary for connecting the individual entities. During a simulation exercise, SM will be responsible for changes in the system state vector, updates or modifications of data bases which apply between entities, addition and deletion of host computers connected to the system, supervising data collection taskings and any other activity which applies to multiple entities in host computers connected to the system.

Communication Services

Network communication services will provide for the timely and efficient transfer of data between the public components of the individual host computers required to create virtual, interactive warfighting environment representations. Both local area and wide area services will be provided through routers and gateways which service multi-peer/multi-cast distribution of data.

In addition to providing time critical transfer of data required for creating the real time simulation environment, the communication services will have the provision to transfer tactical data and voice using either actual military communications or a segment of the simulation system communication service as appropriate. Likewise, the communication services will provide for the transfer of non time critical data supporting system management and administration. DIS will also include video conferencing capabilities to be used between warfighting exercises to provide briefing, exercise planning and debriefing capabilities.

DIS is intended to operate using the Government Open Systems Interconnection Protocol (GOSIP) which is the U.S. implementation of the Open Systems Interconnection (OSI) Reference Model developed by the International Organization for Standardization (ISO). Since GOSIP is still under development, DIS will use standard, commercially available communications protocols in the interim.

Standards for the Interoperability of Defense Simulations

DIS will take advantage of currently installed and future simulations manufactured by different organizations. Consequently, a means must be found for assuring interoperability between dissimilar simulations. The first step in achieving this interoperability is to develop a communications protocol. There must be an agreed-upon set of messages that communicate between host computers, the states of simulated and real entities, and their interactions. This information is communicated in the form of a protocol data unit (PDU).

The current work on standards began in August 1989 with the first workshop on Standards for the Interoperability of Defense Simulations. A second workshop took place in January 1990. These workshops were attended by an average of 500 participants representing over 90 organizations from U.S. and Allied governments and industry. As a result of these workshops and subsequent subgroup meetings, over 170 position papers containing recommendations for the standard were submitted to the Institute for Simulation and Training (IST). Using the work of SIMNET as a baseline and considering recommendations made in meetings and position papers, IST developed the first draft for a military standard which describes the form and types of messages to be exchanged between simulated entities in a Distributed Interactive Simulation (DIS). This draft was submitted to government and indusgtry representatives for review in 1990.

Workshop Reviews of Standard

A third workshop was conducted in August 1990 in which industry and government provided feedback on the proposed standard. These comments were incorporated into the standard and the final draft standard was submitted in January 1991 for approval by the workshop working groups. The working groups approved the final draft standard with minor changes, which have been incorporated by IST.

IEEE Standards Approval Process

This document has been approved by the Institute of Electrical and Electronic Engineers (IEEE) as an IEEE standard (IEEE 1278). Since the standard will be used by industry to develop systems for the U.S. military, the balloting group for standards approval consisted of members from industry and DoD. The Joint Interoperability and Engineering Organization (JIEO) of the Defense Information Systems Agency (DISA) served as the focal point for balloting by the three military services. After approval by the IEEE, the standard was submitted for approval as an international standard because DIS is envisioned to include U.S. allies. During this IEEE standards approval process, the workshops has continued to develop versions two and three with expanded capabilities. These revisions to the standard will also be submitted for approval as an IEEE standard. We also intend to develop three additional standards for (1) the required correlation between simulated environments in different host computers (2) communications architecture and (3) performance measures for evaluating the actions of the participants.

As work on the DIS standards continue, the following ideas must be kept in mind.

1. Nomination and definition of new Protocol Data Units must consider the underlying approach to modeling the warfighting environment interaction being represented. This should be described as a general purpose approach which can be tailored to represent specific characteristics. The issue becomes to what extent such "design rules" become an explicit or implicit part of the standard.

2. The key to distributed interactive simulation systems lies in the determination and definition of the data elements contained in the entity "state vectors" and the corresponding definition of the responsibilities of the public component of the entity for transacting the exchange of changes in these data elements with other entities. This becomes a system design question and raises the issue of to what extent the standards process will identify specific interfaces and performance characteristics of the public component versus providing design guidelines.

3. The evolving front of computer network communication services and standards is much broader than that used by DIS. However, DIS has some unique requirements which must be provided by these services. The issue here is to what extent and in what way should the DIS standards group be directly or indirectly participating in the forums leading the standards for computer network communication standards.

Opportunities To Impact Standards

Although considerable progress has been made in the development of DIS, there is still ample opportunity to impact future revisions of the standards. Other participants in the Training and Testing communities are strongly encouraged to articulate their requirements at future DIS workshops, which occur in March and September of each year. To participate in future workshops, please contact Margaret Loper at the address shown in the Foreword of this document.

The workshop is broken into five working groups (Interface & Time/Mission Critical; Communication Architecture; Field Instrumentation; Fidelity, Exercise Control and Feedback Requirements; and Simulated Environment). These working groups take their direction from the DIS Steering Committee which has representatives from the U.S. Army, Navy and Air Force, as well as DoD and Industry.

SYSTEM ARCHITECTURE

The DIS objective is to achieve the capability to create virtual warfighting environment representations suitable for use in training military personnel, testing, and all phases of force development which share a common architecture. This architecture will provide the basis for interoperability, interconnectivity and a common investment strategy between different warfighting environment simulation representations. Common to all simulations is the need to consistently represent the warfighting functions and dynamic interactions which affect the conduct and results of warfighting. Differences between the simulations include the size of the warfighting environment, the level of resolution and fidelity of representation.

Technologies demonstrated through the Army/DARPA SIMulator NETworking program provide the basis for developing an architecture which supports the interoperability and interconnectivity between the different warfare environment simulations operationally distributed at multiple sites and locations. The main elements of this architecture are shown in Figure 4.

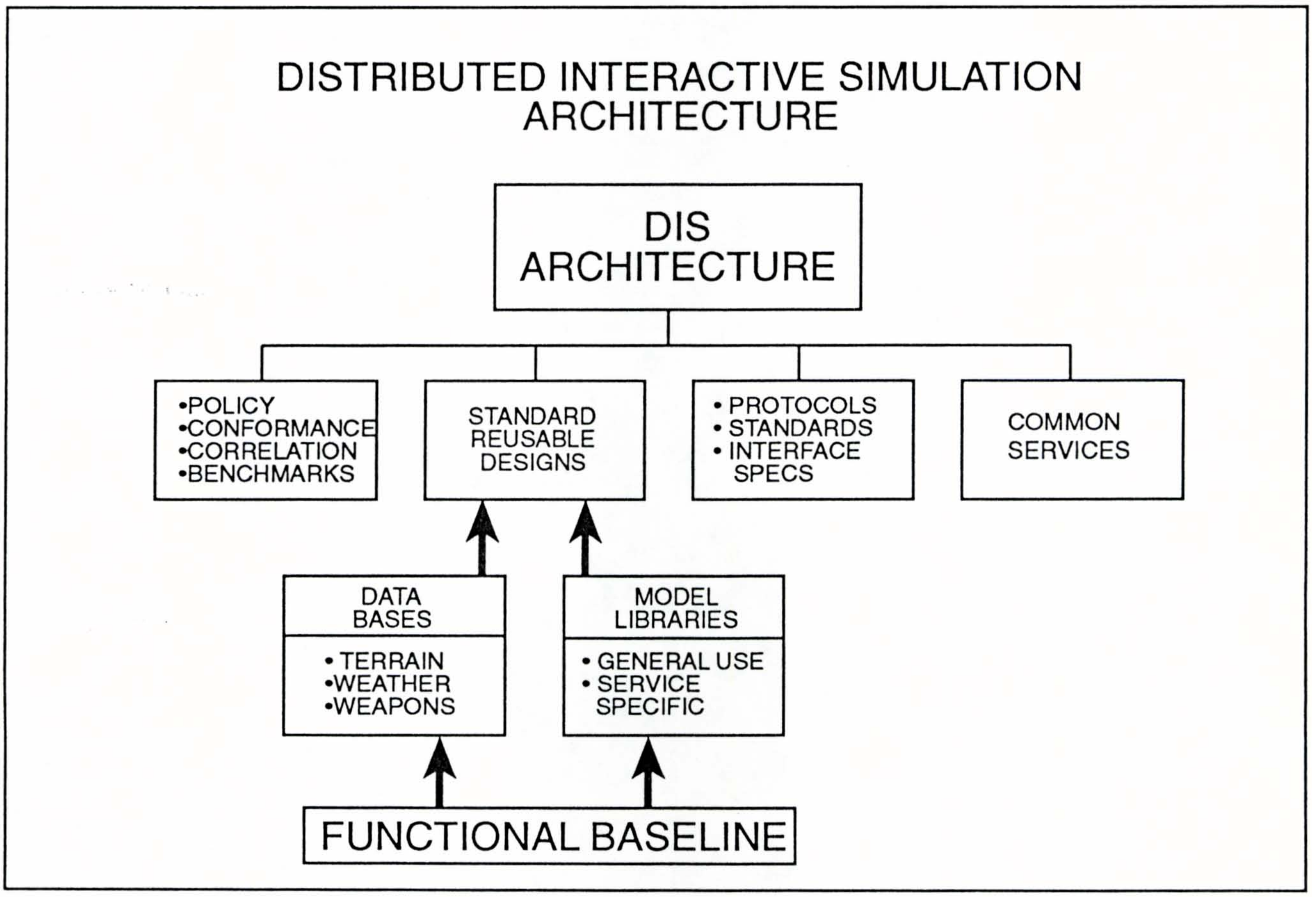

Figure 4 DIS Architecture

Starting with a functional baseline of warfare environment characteristics and interactions, model libraries are established which include requirement specifications and model definitions for the individual warfighting functions. Supporting these model definitions will be a number of data bases with standardized data elements (e.g. digital terrain data bases and weapon characteristics data bases) which provide the parameters needed to tailor the model performance over a wide range of uses. These individual models will in turn be incorporated into general purpose or "standard" designs for simulators and simulations. These designs will be modular, object oriented, and reusable, incorporating open, non-proprietary elements which can be supported by a wide base of industrial suppliers.

Protocols and interface control specifications will define the interchange of essential data elements within and between warfare simulations through use of standard computer communication services. Likewise, general purpose designs for data collection and feedback would further provide common linkage between the simulations. Also included as part of the architecture would be DoD Model and Simulation policy and benchmark conformance and correlation measures to assure reliable and consistent warfighting environment simulations.

Development and implementation of the architecture will be accomplished through a single system engineering and integration contractor. In addition to providing the technical services needed to support model libraries and data bases, the contractor will serve as the primary agent supporting configuration management and assuring technical integration across and within the warfare environment simulations.

Configuration management of the architecture and associated components of the warfare environment simulations will be closely tied with Verification and Validation (V&V) processes. Proponents will be responsible for accomplishing V&V for components to be included in the warfare simulations. Verification will focus on the requirement specification and model definition for inclusion in the model library. Validation will concentrate on assuring that the performance of the simulated warfare environment appropriately reflects the functional baseline. Once a component has completed the V&V process, it will be included as part of the formally controlled configuration baseline available for future reuse. In this manner, through continued and consistent evolution and application of the architecture to each separate simulation component investment, overall efficiencies and expanded DoD wide capabilities will be achieved through integrated and leveraged investment strategies. This approach will also provide the mechanism for incorporating emerging advances in simulation technology as part of the integrated investment strategy.

OPERATIONAL SCENARIOS

As stated above, DIS is intended to serve as a tool for the Combat Development, System Acquisition, Test and Evaluation and Training communities. In the first three communities, DIS will be used as a decision support aid in the evaluation of design concepts, developmental hardware and software, and prototypes. This section contains two scenarios: one describes the use of DIS for training, and the other describes the use of DIS for testing.

DIS Training Exercise Scenarios

The primary customers for Distributed Interactive Simulation (DIS) training exercises are commanders, from unit commanders to Commanders In Chief (CINCs). Unit commanders who wish to conduct a training exercise involving only their unit will coordinate with other unit commanders at that base, schedule time for their personnel on the simulators and conduct the exercise using the simulation resources attached to the Local Area Network (LAN) at the base. If the unit commander requires outside support in the form of

an OPFOR or additional friendly forces, the commander will follow the procedure discussed below for CINCs.

CINCs will use the wide area network (WAN) services of DIS. The CINC will specify the mission objective (liberate country Green) and the CINC's staff will plan the exercise in the same manner as an actual mission. Once the staff has determined which forces will be required to conduct the exercise, they will contact the commanders of these forces through normal channels. In addition, they will contact the DIS Administrative Unit to determine the availability of (1) simulators at those forces' bases and (2) bandwidth on DIS. DIS is being designed such that a number of separate exercises can be conducted simultaneously on the WAN in a way that is transparent to the participants. The DIS administrative unit will assign a unique exercise number to differentiate it from other simultaneous exercises. It will also calculate the required bandwidth for the required simulators as well as that required for the exercises already scheduled during the desired time period. If the available bandwidth is exceeded, the administrative unit will resolve the conflicts with rescheduling acceptable to all participants. Once this scheduling is complete, all participants will complete their planning for the exercises.

As the planning continues, the CINC will hold video conferences (on the DIS WAN) with the unit commanders to simulate planning meetings. As the mission start day approaches, the Operations Officer will issue orders to the unit commanders for initial deployment of forces. These unit commanders will determine the deployment of their forces and give the initial locations to the local DIS exercise controllers to feed into the simulators.

As the day of exercise start arrives, the local commanders and their staffs will assemble in the DIS LAN controller's room to participate in a video conference final briefing with the CINC. At the mission start time, the DIS WAN will issue a start command to each location and the LAN controllers will issue start commands to the simulators. The other threats and friendlies will then begin to appear on each simulator's displays. Radio communications will be digitized and sent in packets over the DIS network to the appropriate simulators and replayed if the receiving simulator is in range and on the same frequency. As the battle proceeds and each side takes losses, the LAN controllers may be allowed to reconstitute forces to simulate replacements and to allow participants to continue training. During the battle, the debrief station at each location will store all forces location and status messages (protocol data units) for later replay. The LAN and WAN control stations may also issue commands before or during the exercise for specific simulated entities to report status parameters.

When the CINC has achieved his goal, he will issue a Cease Fire command and the DIS LAN controllers will issue a freeze command to all simulators. After participants have gathered in each DIS LAN controller's room, the CINC will conduct a video conference debrief of the exercise. During this debrief, the WAN manager will issue commands to each LAN exercise feedback device to replay the exercise. The CINC will have the controller start, stop and reverse the playback as required to illustrate the lessons learned during the exercise. If desired, the debrief will be broken into segments such as maneuver, logistics, etc. and the LAN controller will enter a command for the debrief station to display only the desired forces.

Once the CINC's debrief is completed, the unit commanders will call in lower ranking personnel for a debriefing. During this debriefing, the LAN controllers will play back the exercise but will concentrate the debrief view on the area of responsibility for that unit. After completion of the exercise debriefs, the stored forces location and status messages will be permanently stored for use in future classroom demonstrations or analysis efforts.

DIS Decision Support Scenarios

The primary customers for Distributed Interactive Simulation (DIS) decision support exercises

are the Combat Development, System Acquisition, and Test and Evaluation communities. If the organization has sufficient simulations of threat and friendly forces at their facility, they will schedule time for their personnel on the simulators and conduct the exercise using the simulation resources attached to the Local Area Network (LAN) at their facility. If the organization requires outside support in the form of an OPFOR or additional friendly forces, the exercise manager will follow the procedure discussed below.

Exercises that require outside simulation resources will use the wide area network (WAN) services of DIS. The organization will specify the exercise objectives (determine system improvement's effect on outcome of realistic battle engagement) and the director's staff will plan the exercise. Once the staff has determined which forces will be required to conduct the exercise, they will contact the DIS administrative unit to determine (1) the availability of the simulated/actual equipment/personnel at other locations, and (2) bandwidth on DIS. DIS is being designed such that a number of separate exercises can be conducted simultaneously on the WAN in a way that is transparent to the participants. The administrative unit will assign a unique exercise number to differentiate it from other simultaneous exercises. It will also calculate the required bandwidth for the required simulators as well as that required for the exercises already scheduled during the desired time period. If the available bandwidth is exceeded, the administrative unit will resolve the conflicts with rescheduling acceptable to all participants.

Once this scheduling is complete, all participants will complete their planning for the exercises. As the planning continues, the exercise director may hold video conferences (over the DIS WAN) with the participants to iron out procedures.

As the day of exercise start arrives, the participants will assemble in the DIS LAN controller's room to participate in a video conference final briefing with the Exercise Director. At the exercise start time, the DIS WAN will issue a start command to each location and the LAN controllers will issue start commands to the simulators/actual equipment. The other threats and friendlies will then begin to appear on each simulator's/actual equipment's displays. Radio communications will be digitized and sent in packets over the DIS network to the appropriate simulators/actual equipment and replayed if the receiving entity is in range and on the same frequency. As the exercise proceeds and each side takes losses, the LAN controllers may be allowed to reconstitute forces to simulate replacements and to allow participants to continue to provide additional threats and friendlies. During the exercise, the debrief station at each location will store all forces location and status messages (protocol data units) for later replay. The LAN and WAN control stations may also issue commands before or during the exercise for specific simulated entities to report status parameters.

When the exercise is complete, the Exercise Director will issue a stop command and the DIS LAN controllers will issue a freeze command to all simulators/actual equipment. After participants have gathered in each DIS LAN controller's room, the Exercise Director will conduct a video conference debrief of the exercise. During this debrief, the WAN manager will issue commands to each LAN exercise feedback device to replay the exercise. The Exercise Director will have the controller start, stop and reverse the playback as required to illustrate the lessons learned during the test exercise. If desired, the debrief will be broken into segments such as maneuvers, electronic warfare, etc. and the LAN controller will enter a command for the debrief station to display only the desired forces. After completion of the exercise debriefs, the stored forces location and status messages will be permanently stored for use in future demonstrations or analysis efforts.

FUNCTIONAL REQUIREMENTS TO PARTICIPATE IN DIS

The extent to which a participant must comply with the DIS standards depends on the functions that participant intends to implement. For example, if the participant does not intend to simulate logistics functions (e.g. refueling), then there will be no need to process Resupply Offer/Received PDUs. Three tables have been included in the DIS Operational Concept document to give the reader a more detailed understanding of how a participant becomes a part of a DIS exercise.

Table 1 lists the general requirements for participating in a DIS exercise. In order to implement each of the functions listed in the table, the participant must fulfill the associated requirements. Note that DIS is a real time simulation system that uses a standard communication protocol and standard PDUs. Simulated systems with weapons will have to implement weapons flyout models. Implementation of each of the remaining functions will require implementation of the associated requirements in Table 1.

Table 2 lists which PDUs must be created/ transmitted or received/processed in order to implement the associated functions. DIS exercise participants that simulate electronic emissions will have to implement the Emission PDU. Participants that can provide resupply functions to other participants must implement the Resupply Offer PDU.

Table 3 lists which PDUs must be implemented in order for a Simulation Manager to control exercise participants distributed geographically. To bring an entity into being in the battlespace, the Simulation Manager's host computer must transmit a Create Entity PDU. The host computer for the entity will receive and process this PDU, instantiate the entity and send back an Acknowledge PDU. The Simulation Manager's host computer will process the Acknowledge PDU to determine that the command was executed.

Table 1
Simulation Functional Requirements to Participate in DIS Exercises
General Requirements

FUNCTION	REQUIREMENTS
Interface with Other DIS Simulations	Operate in Real Time Use Standard Comm. Protocol Use Standard Protocol Data Units (PDUs)
Determine Target Location Between Updates	Execute Dead Reckoning Algorithms
Determine Hit or Miss	Execute Weapons Flyout Models
Calculate Impact Damage	Execute Battle Damage Assessment Models
Detect Collisions	Execute Collision Detection Algorithms
Determine Terrain Effects on Weapons Flyout Emissions Propagation LOS Intervisibility	Process Terrain Model
Determine Atmosphere Effects on Emissions Propagation Visibility	Process Atmosphere Model
Determine Ocean Effects on Emissions Propagation Background Noise	Process Ocean Model
Display to Live Participants	
Visual Appearance of Entities	Process Entity Models Render Visual Image
Atmospheric Effects on Vis	Process Atmosphere Model Process Sensor Models Render Visual Image
Terrain and Features	Process Terrain Data Base Process Sensor Models Render Visual Image
Sea State Effects on Detection	Process Ocean Model Process Sensor Models Render Visual Image

Table 2
Simulation Functional Requirements to Participate in DIS Exercises
Protocol Data Units (PDUs)

FUNCTION	CREATE/TRANSMIT PDUs	RECEIVE/PROCESS PDUs
Entity Interactions		
Appear on Other Displays	Entity State	
Display Other Entities		Entity State
Fire at Other Entities	Fire	
Display Firing Flash		Fire
Damage Other Entities	Detonation	
Conduct BDA* on Self		Detonation
Notify Others of Emissions	Emission	
Sense Emissions of Others		Emission
Notify Others of Radio Trans	Transmitter	
Sense Radio Trans of Others		Transmitter
Send Radio Message Over DIS	Signal	
Receive Radio Mess Over DIS		Signal
Communicate Receiver State	Receiver	
Receive Receiver State		Receiver
Notify Others of Laser Emissions	Laser	
Sense Laser Emissions		Laser
Notify Others About Collision	Collision	
Determine Collision Damage		Collision
LOGISTICS FUNCTIONS		
Request Logistics Support	Service Request	
Sense Logistics Request		Service Request
Provide Resupply	Resupply Offer	
Receive Resupply		Resupply Offer
Indicate Supply Received	Resupply Received	
Understand Supply Received		Resupply Received
End Resupply Action	Resupply Cancel	Resupply Cancel
End Repair Action by Receiver	Stop Sending Service Req	
End Repair Action by Supplier	Repair Complete	
Understand Repair Complete		Repair Complete
Indicate Repair Result	Repair Response	
Understand Repair Result		Repair Response

* BDA - Battle Damage Assessment

Table 3
Simulation Functional Requirements to Control DIS Exercises
Protocol Data Units (PDUs)

FUNCTION	SIM MANAGER CREATE/TRANSMIT PDUs	SIM HOST COMPUTER RECEIVE/PROCESS PDUs
Exercise Control Functions		
Instantiate Entities	Create Entity	Acknowledge
Select Exercise Area	Set Data	Data
Set Initial Conditions	Set Data	Data
Set Expendables	Set Data	Data
Position Forces	Set Data	Data
Initialize SAFOR*	Set Data	Data
Entity Status Report	Data Query	Data
Exercise Initiation	Set Data	Data
Freeze	Stop/Freeze	Acknowledge
Resume	Start/Resume	Acknowledge
Remove Entities	Remove Entity	Acknowledge
Regenerate Entities	Set Data	Data
Save States	Action Request	Action Response
Record Observed Event	Event	None
Record Message	Message	None
Paramenter Query	Data Query	Data
Exercise Termination	Stop/Freeze	Acknowledge
Host Computer Exercise Control Functions		
Instantiate Entities	Acknowledge	Create Entity
Select Exercise Area	Data	Set Data
Set Initial Conditions	Data	Set Data
Set Expendables	Data	Set Data
Position Forces	Data	Set Data
Initialize SAFOR	Data	Set Data
Entity Status Report	Data	Data Query
Exercise Initiation	Data	Set Data
Freeze	Acknowledge	Stop/Freeze
Resume	Acknowledge	Start/Resume
Remove Entities	Acknowledge	Remove Entity
Regenerate Entities	Data	Set Data
Save States	Action Response	Action Request
Parameter Query	Data	Data Query
Exercise Termination	Acknowledge	Stop/Freeze
Data Logger Functions		
Record Observed Event	None	Event
Record Message	None	Message

* SAFOR - Semi-Automated Forces

Do you have any comments?

See reverse side for instructions.

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Comments on the Document *(You may add pages as needed and send comments in an envelope to the address listed on the reverse side.)*

Problem areas

Section name and wording

Recommended Wording

Reason/rationale for recommendation

Other suggestions

The purpose of this document is to present the Operational Concept for Distributed Interactive Simulation (DIS). This concept will evolve over time as members of the Training and Testing communities contribute their ideas.

If you have any suggestions for improving or adding to the document, fill out the form below. You can mail this page by removing it from the document, fold along the lines indicated on the other side, and tape along the open edges. Place a stamp where indicated.

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Institute for Simulation and Training
3280 Research Parkway
Orlando, FL 32826

ATTN: Danette Haworth