Distributed Interactive Simulation Standards Development: Guidance Document (draft 2.0)

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SEPTEMBER 1992

STANDARDS DEVELOPMENT

GUIDANCE DOCUMENT (DRAFT 2.0)

DISTRIBUTED INTERACTIVE SIMULATION

IST-TR-92-33
DISTRIBUTED INTERACTIVE SIMULATION

Standards Development

Guidance Document (Draft 2.0)

September 1992

prepared for:
STRICOM

prepared by:
UCF Institute for Simulation & Training

IST-TR-92-33
Distributed Interactive Simulation Standards Development

Guidance Document
September 1992
INTRODUCTION

Purpose

The purpose of this document is to provide information about the development of interoperability standards for defense simulations. These standards are often referred to as the standards for Distributed Interactive Simulation (DIS). This document also serves as guidance for working groups acting to resolve interoperability issues.

Scope

This document applies to the Workshops on Standards for the Interoperability of Defense Simulations or standards development for Distributed Interactive Simulation. It also describes any activities directly related to the workshop such as interim meetings, teleconferences or development of standards and documents created as a result of the workshop.
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1 THE INTEROPERABILITY PROBLEM AND APPROACH

For nearly three years, attendees of the Workshops on Standards for the Interoperability of Defense Simulations have been grappling with the problem of networking simulators, operational, and test equipment to create a simulated battle environment suitable for training and developmental testing. Part of the interoperability problem is the fact that DIS uses simulation and networking technologies. Each of these has certain constraints which require tradeoffs to be made in a system which utilizes both. For example, since the simulation must be able to support real-time operations, the network has to deliver information in a timely manner. On the other hand, since the network could easily become overwhelmed with information in a large-scale exercise, the simulator is required to perform extra functions such as dead reckoning and conversion of the simulator’s state information into a form suitable for distribution on a network. Other interoperability problems are encountered when databases used by the various participating DIS systems do not correlate.

The approach to solving the interoperability problem has been to sponsor workshops which allowed developers and users to work out solutions together and thus develop an interoperability strategy that would be agreeable to the builders and useful to the users. The results of the workshops were and will continue to be a set of documents containing operational guidelines and standards designed to ensure interoperability. Operational guidelines specify guidelines for achieving interoperability in a DIS environment. DIS standards documents are written for aspects of interoperability where no standards currently exist and the specified actions are required to achieve interoperability. These standards are developed by the workshop attendees and submitted to official standards organizations for approval. These documents are intended to allow the developer the freedom to design a system as they choose while providing the necessary information for allowing their system to interact in a DIS environment. This approach also supports the integration of existing systems into a DIS environment.

Much progress has been made towards development of operational guidelines and standards for interoperability in defense simulations (the DIS standards). A draft standard for Protocol Data Units (PDU) has been produced and is in the final approval stage for IEEE standard. Draft standards for Communication Architecture and Security (CAS), Fidelity, Exercise Control, and Feedback Requirements (FECFR), and Field Instrumentation Working Group have been completed and are under review by the appropriate working groups.

2 WORKSHOPS ON STANDARDS FOR THE INTEROPERABILITY OF DEFENSE SIMULATIONS

2.1 Working Groups

The workshop attendees are divided into logical working groups to handle issues related to the environment, communication, and fidelity. These groups are responsible to address issues related to their particular area of interoperability and to report back to the whole workshop with recommendations. Each group keeps minutes for their meeting. Minutes for the individual working groups and for the workshop as a whole are published about one month following the workshop meeting.
2.1.1 Working Group and Subgroup Structure

The original working groups were formed in the summer of 1989 as recommended during the first workshop. Since then, many changes have occurred in the working group structure. The current groups and subgroups are as follows:

**Simulated Environment Working Group**
- Atmosphere Subgroup
- Land Subgroup
- Sea Subgroup

**Communication Protocols Working Group**
- Interface & Time/Mission Critical (ITMC) Subgroup
  - Emissions Subgroup
  - Radio Subgroup
  - Simulation Management Subgroup
- Communication Architecture and Security Subgroup (CASS)

**Fidelity, Exercise Control, and Feedback Requirements (FECFR) Working Group**
- Fidelity Subgroup
- Exercise Control and Feedback Subgroup

**Field Instrumentation Working Group**

The subgroups and the issues they face are described in the paragraphs that follow.

2.1.2 Working Group and Subgroup Descriptions

**Simulated Environment**

The Simulated Environment Working Group handles issues related to the representation of the environment in which the simulated entities operate. Models of the various environments are examined along with how different models may or may not correlate. Environmental elements, both natural and man made, which may have an effect on the simulation are identified. Databases are examined and methods of correlation considered.

**Atmosphere Subgroup**

The Atmosphere Subgroup addresses environmental effects such as weather and smoke. Models for representing certain atmospheric conditions are considered here.

**Land Subgroup**

The Land Subgroup addresses representation of the terrain along with cultural features. Methods for representing terrain database information is discussed. Correlation is a very important issue in this group.

**Sea Subgroup**

The Sea Subgroup addresses representation of the sea environment. Various sea state models are examined as well as methods for representing various ocean characteristics such as salinity, temperature, and ocean bottom effects.

**Communication Protocols**

The Communication Protocols Working Group is concerned with the information that is conveyed between DIS systems and how that information is communicated.

**Interface & Time/Mission Critical (ITMC) Subgroup**

The ITMC Subgroup examines the DIS system and determines the types of information that are public and need to be communicated to other DIS participants. The group then determines the form in which the information should be communicated and the conditions under which the information is issued. This information takes the form of Protocol Data Units (PDU). The first draft standard addresses PDUs primarily for visual interactions. Other types of public information being considered by several sub-subgroups are: electromagnetic and acoustic emissions, radio and voice, and simulation management.

**Communication Architecture and Security Subgroup (CASS)**

The CASS handles the problem of taking the information identified by the ITMC subgroup and getting the messages to the intended receivers. This group has taken a layered approach, identifying communication architecture services required for DIS type messages.
Fidelity, Exercise Control, and Feedback Requirements (FECFR)

The FECFR Working Group concerns are found in the group name. This group tackles issues which include simulation fidelity, exercise control functions, and exercise feedback information. This group addresses the needs of the exercise controller or training instructor. Functions which support the CINCS are also determined here. This group forwards its recommendations to other subgroups which then develops appropriate correlation, PDUs or communication services as required by FECFR recommended functions.

The FECFR working group has two subgroups: one addresses fidelity issues, and the other addresses exercise control and feedback issues.

Field Instrumentation Working Group

The purpose of the Field Instrumentation Working Group is to define PDUs and address issues required to enable instrumented soldiers, marines, and operational equipments (e.g., tanks, ships, aircrafts) to efficiently use DIS.

2.2 The Steering Committee

2.2.1 Purpose of the Steering Committee

The purpose of the steering committee is to facilitate and expedite the process of developing DIS standards. The committee operates under the direction of PM TRADE and IST. The committee is responsible for the following activities:

1. Workshop Planning: This includes establishing the agenda and extending invitations to plenary session speakers.

2. Facilitation of the DIS standards process. This includes:
   - Approving workshop/subgroup recommendations
   - Arbitrating opposing workshop/subgroup recommendations
   - Providing an interface across the various working groups
   - Conducting regular teleconference meetings to monitor the standards process

3. DIS Standards Integration: This includes providing an interface between the various working groups to coordinate standards progress and reduce duplication of effort.

2.2.2 Steering Committee Structure

The steering committee consists of representatives from the funding organization, IST, the military, industry, and the working group chairmen. Current steering committee members are as follows:

Ray Beaver Loral
Joseph Brann IBM
Neale Cosby Institute for Defense Analysis
Karen Danisas STRICOM
Ron Hofer STRICOM
Tom Hoog Air Force
Sam Knight Air Systems Command
Lee Kollmorgan CAE-Link
George Lukes Engineering Topographic Labs
Bruce McDonald UCF/IST
Michael McGaugh McDonnell Douglas
Duncan Miller Bolt, Beranek, and Newman
John Mills NTSC
Bob Moore Evans and Sutherland
Bill Parrish NTSC
Steve Seidensticker Logicon
James Shifflett DMSO
Bob Sotilare NTSC
James Wargo DARPA
Gene Wiehagen STRICOM

2.2.3 Steering Committee Meetings

Steering committee meetings are held via teleconference on a monthly basis. The committee also meets before, after, and if needed, during semi-annual workshops.

2.3 Goals and Objectives of the Workshops

The primary goal of the workshops is to debate issues associated with interoperability of networked
simulations, and then recommend a strategy for ensuring interoperability. Based on these recommendations, operational guidance documents and standards documents will be written. These documents will be reviewed at subsequent workshops and related meetings and amended as recommended by the subgroups. Documents approved for release will be considered the recommended methodology for making a system compatible with other DIS systems. Recommended standards will be submitted for consideration as IEEE, Military, or ISO standards.

3 ISSUES TO BE ADDRESSED

The issues to be addressed in DIS workshops will evolve over time. Consequently, these issues have been placed in the appendices to facilitate their future revision (see Appendix A).

4 BIBLIOGRAPHY

WORKSHOP SUMMARY REPORTS


DRAFT STANDARDS


APPENDIX A: INTEROPERABILITY ISSUES

EXPLANATION OF ISSUES

Because working group issues change from meeting to meeting, this subject is addressed in an appendix of this guidance document rather than as part of the main body. As issues change, so will this appendix.

Issues for the individual working groups are listed in bullet form in Appendix A. An explanation of the main issues follows.

COMMUNICATION PROTOCOLS: Communications Architecture & Security Subgroup (CASS)

The approach to communications architecture has been to define required communication services and to recommend an architecture that will provide the necessary services. The preferred strategy would be to utilize the Open Systems Interconnection (OSI) related protocols developed by the International Organization for Standardization (ISO). A long term goal toward this end has been chosen, since OSI protocols are not widely available. For the short term, an architecture utilizing commercially available protocols is recommended along with a migration strategy to an OSI compliant architecture.

A draft standard for communication architecture is currently being reviewed by CASS. This standard and rationale include information about the migration of protocols, performance requirements and general interoperability issues. In the coming year, CASS will fill in the details for the migration from the interim architecture to the OSI compliant architecture. In addition to this, CASS has started work to define a strategy for handling security in DIS.

COMMUNICATION PROTOCOLS: Interface & Time/Mission Critical (ITMC) Subgroup

The May/92 DIS PDU standard is progressing to its final stage of approval by IEEE. ITMC Subgroup has released the DIS PDU Draft Standard Version 2.0, which includes the new sets of PDU's to support Simulation Management, Radio Communication, and Emission Regeneration functions. There are still other issues remaining to be addressed by ITMC subgroup.

Video Conferencing

To aid in the planning of a simulated exercise as well as the after-action reviews, video conferencing should be supported by DIS. This issue has yet to be addressed in the coming workshops.

Aggregation of Simulated Entities

In order to interface with Wargaming systems, DIS must support aggregation and de-aggregation of entities. This mechanism will allow entities to sort other entities by type and distance with fewer computation. Several position papers have been presented to ITMC and they discuss how to incorporate these function without impacting the existing PDUs.

Assume Control (Handover) Protocol

There have been a number of proposals for the creation of a Assume Control protocol. One use of this protocol would be to solve the problem of a weapon that is launched at a target and that target deploys a countermeasure before the weapon detonation, but too late for the firing entity to take the countermeasure into account.

ENVIRONMENT

For simulated entities to participate in the same exercise, they must all have access to the same environment information. It is also necessary that renderings of this information correlate sufficiently in order to conduct a realistic and fair fight. Much work remains on developing a measurement for environment correlation as well as determining the degree of correlation required. In addition, changes to the
environment must be communicated or made accessible to DIS systems which require the information.

Atmosphere

Issues relative to the Atmosphere subgroup include definition of various atmospheric representations for a clear day for use with maneuver forces, high performance air, and Navy forces. Representation requirements for natural and man-made effects must then be developed. These effects include pressure, wind, temperature, humidity, solar angle, smoke, chaff, and flares. Phenomena effects of these elements on radar, ultraviolet, electro-optical and infrared are important and need to be examined. A methodology for setting up simple weather effects is needed in DIS. Identifying atmospheric models and developing a method to correlate them are also necessary.

Sea

The Sea group is concerned with representations of the ocean and its effect on acoustic signatures. Critical elements contained in ocean models need to be defined and a correlation index between models developed based on these elements. PDUs have already been proposed for handling environmental entities in the sea environment.

Land

Correlation of terrain databases and their renderings is an issue that has long been debated but still unresolved. This group is examining various classes of simulators based on their functionality and performance characteristics. An interim terrain database needs to be recommended as the correlation issue continues to be examined. An environmental server was proposed to help correlate dynamic changes in the terrain. This master database requires further definition in content, format, and hierarchical structure.

FIDELITY, EXERCISE CONTROL, AND FEEDBACK REQUIREMENTS (FECFR)

All simulations and simulators have, as an elemental property, a level of fidelity. Fidelity is a measure of how faithfully real world events are depicted in the context of the simulation. Critical fidelity measures that have been identified address the allowable delay between operator action and simulated response, as well as the required fidelity for representing the visual appearance or sensor imagery of an entity or the environment. Many fidelity measures issues have been resolved in previous research on individual operator training systems. Of the remaining DIS fidelity issues that require discussion, the three most critical are delay, entity appearance at long ranges, and depiction of environmental appearances.

Delay

The allowable delay between operator action and simulation response will depend on the criticality of the task being executed by the operator. One of the most time-critical tasks in distributed interactive simulation is tracking a target just prior to firing a weapon. Consequently, the smallest acceptable delay in a DIS will be that between the issuance of an Entity State PDU by a target entity and the display of that entity’s location on the engaging entity’s display. Determination of acceptable delay will require empirical studies of operator performance under varying delay conditions.

Entity Appearance At Long Ranges

One shortcoming of current distributed interactive simulation is that the displays have insufficient resolution to accurately depict entities at long range, thereby preventing the engagement of these entities at a range specified in doctrine. This problem may be solved by using higher resolution displays or by color coding images too small to identify. Determining acceptable means of increasing target identification ranges will require empirical studies of operator performance with alternative modifications to the current approach.

Depiction of Environmental Appearance

The appearances of environmental entities such as smoke, fog, clouds, rain and snow need to be depicted in a manner realistic enough to achieve the training or equipment evaluation objectives. Each of these environmental entities effects visibility to a varying degree based on the density of the entity.

Target/Background Contrast

In order for all DIS exercise participants to engage in a “fair fight,” the target/background contrast must be
approximately the same on all displays. The FECFR group has developed a candidate technique and metric for measuring the target/background contrast correlation between displays as well as the allowable differences. Empirical investigations will involve validating and/or establishing human target/background contrast sensitivity thresholds for a representative set of military targets and backgrounds.

EXERCISE CONTROL AND FEEDBACK

The FECFR group has identified detailed pre-exercise setup steps, the functions required to control an exercise and obtain information from participants during an exercise. They have also identified the functions required to provide feedback to trainees or test directors. In addition, the FECFR group has recommended that the ITMC group develop PDUs that execute these functions.

OTHER ISSUES

Unmanned Forces

In order to populate the warfare environment in a cost effective manner, one type of entity that is represented in a simulated battle is the Unmanned Force or Semi-Automated Forces (SAFOR). As simulated entities in the exercise, unmanned forces have many of the same requirements as manned forces. The data messages (PDUs) communicated on the network are the same as those for manned simulators. Unmanned forces, however, have some unique informational and database requirements that other entities do not have. Further discussion is required before effective semi-automated forces can be added to DIS.
APPENDIX B: DIS BASIC CONCEPTS

DIS BASIC CONCEPTS

The basic architecture concepts of DIS are an extension of the Simulator Networking (SIMNET) program developed by DARPA. The basic architecture concepts for DIS are:

1) No central computer controlling the entire simulation exercise
2) Autonomous simulation applications responsible for maintaining the state of one or more simulation entities
3) A standard protocol for communicating "ground truth" data
4) Changes in state are communicated by simulation entities
5) Perception of events or other entities is determined by the receiving entity
6) Dead reckoning used to reduce communications processing

The implications of each of these concepts as they apply to DIS are discussed in the following paragraphs:

No Central Computer

Some war games have a central computer that maintains the world state and calculates the effects of each entity’s 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 applications residing in host computers connected a network. As new host computers are added to the network, each new host computer brings its own resources.

Autonomous Simulation Applications

Simulation applications (or simulations) are autonomous and generally responsible for maintaining the state of one entity. In some cases, a simulation will be responsible for maintaining the state of several entities. As the user operates controls in the simulated or actual equipment, the simulation is responsible for modeling the resulting actions of the entity using a high fidelity simulation model. That simulation is responsible for sending messages to others, as necessary, to inform them of any observable actions. All simulations are responsible for interpreting and responding to messages from other simulations and maintaining a simple model of the state of each entity represented in the simulation exercise. All simulations also maintain a model of the state of the environment and non-dynamic entities such as bridges and buildings that may be intact or destroyed.

Ground Truth Versus Perception

Each simulation application communicates the state of the entity it controls (location, orientation, velocity, articulated parts position, etc.) to other simulations on the network. The receiving simulation is responsible for taking this ground truth data and calculating whether the entity represented by the sending simulation is detectable by visual or electronic means. This perceived state of the entity is then displayed to the user as required by the individual simulation.

Dead Reckoning

A method of position/orientation estimation called dead reckoning is used to limit the rate at which simulations must issue state updates on an entity. Each simulation maintains a high fidelity model of the entity it represents. In addition, the simulation maintains a simple model of its entity. The simple model represents the view of that entity by other simulation applications on the network and is an extrapolation of position and orientation state based on previous state information.
On a regular basis, the simulation compares the high fidelity model of its entity to the simple model of the entity. If the difference between the two exceeds a pre-determined threshold, the simulation will update the simple model using information from the high fidelity model. At the same time, the simulation will send updated information to other simulations on the network so that they can update their models of the entity. By using dead reckoning, simulations are not required to report the status of their entities every frame.
### APPENDIX C: ACRONYMS

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<tr>
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<td>Battle Force Tactical Trainer</td>
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Problem areas

Section name and wording

Recommended Wording

Reason/rationale for recommendation

Other suggestions
The purpose of this document is to acquaint the reader with the development process for standards for Distributed Interactive Simulation (DIS).

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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