IEEE Recommended Practice for Distributed Interactive Simulation— Exercise Management and Feedback

Sponsor
**Distributed Interactive Simulation Committee
of the
IEEE Computer Society**

Approved 10 December 1996
Reaffirmed 17 June 2010
Reaffirmed 10 December 2002

IEEE-SA Standards Board

Approved 30 September 1997
Reaffirmed 31 March 2003

American National Standards Institute

Abstract: Guidelines are established for exercise management and feedback in Distributed Interactive Simulation (DIS) exercises. Guidance is provided to sponsors, providers, and supporters of DIS compliant systems and exercises as well as to developers of DIS exercise management and feedback stations. The activities of the organizations involved in a DIS exercise and the top-level processes used to accomplish those activities are addressed. The functional requirements of the exercise management and feedback process are also addressed. This standard is one of a series of standards developed for DIS to assure interoperability between dissimilar simulations for currently installed and future simulations developed by different organizations.
Keywords: automated simulation, computer-generated force (CGF), dead-reckoning algorithms, simulation, simulation management, simulator networking, validation, verification, warfare simulation, wargames

The Institute of Electrical and Electronics Engineers, Inc.

345 East 47th Street, New York, NY 10017-2394, USA

ISBN 1-55937-865-4

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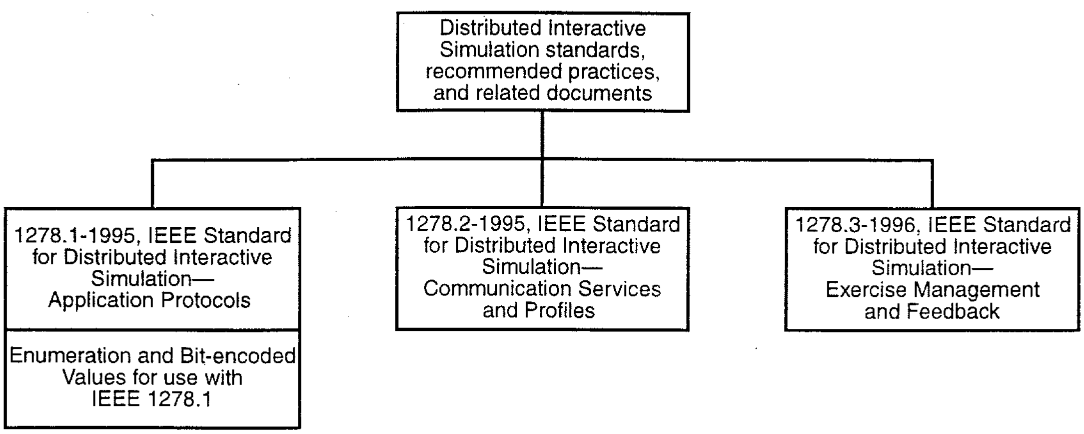
Introduction

(This introduction is not part of IEEE Std 1278.3-1996, IEEE Recommended Practice for Distributed Interactive Simulation—Exercise Management and Feedback.)

Distributed Interactive Simulation (DIS) is a government/industry initiative to define an infrastructure for linking simulations of various types at multiple locations to create realistic, complex, virtual "worlds" for the simulation of highly interactive activities. This infrastructure brings together systems built for separate purposes, technologies from different eras, products from various vendors, and platforms from various services and permits them to interoperate. DIS exercises are intended to support a mixture of virtual entities with computer-controlled behavior (computer-generated forces), virtual entities with live operators (human in-the-loop simulators), live entities (operational platforms and test and evaluation systems), and constructive entities (wargames and other automated simulations). DIS draws heavily on experience derived from the Simulator Networking (SIMNET) program developed by the Advanced Research Projects Agency (ARPA), adopting many of SIMNET's basic concepts and heeding lessons learned.

In order for DIS to take advantage of currently installed and future simulations developed by different organizations, a means had to be found for assuring interoperability between dissimilar simulations. These means were developed in the form of industry consensus standards. The open forum (including government, industry, and academia) chosen for developing these standards was a series of semi-annual workshops on standards for the interoperability of distributed simulations, which began in 1989. The results of the workshops have been several IEEE Standards along with supporting documentation. These standards provide application protocol and communication services and profile standards to support DIS interoperability. In addition, an IEEE recommended practice for exercise management and feedback provides user guidelines for setting up and conducting a DIS exercise.

The relationship between the component documents comprising the set of IEEE DIS documents is shown in the figure below. Used together, these standards and recommended practices will help to ensure an interoperable simulated environment.



Documentation relationships

The interoperability components addressed by these standards and recommended practices are as follows:

a) Application protocols
b) Communication services and profiles
c) Exercise management and feedback

IEEE Std 1278.1-1995, IEEE Standard for Distributed Interactive Simulation—Applications Protocols, defines the format and semantics of data messages, also known as Protocol Data Units (PDUs), that are exchanged between simulation applications and simulation management. The PDUs provide information concerning simulated entity states, the type of entity interactions that take place in a DIS exercise, and data for management and control of a DIS exercise. This standard also specifies the communication services to be used with each of the PDUs. These services are defined in IEEE Std 1278.2-1995, IEEE Standard for Distributed Interactive Simulation—Communication Services and Profiles.

An additional, non IEEE document is required for use with IEEE Std 1278.1-199.5 This document is entitled *Enumeration and Bit-encoded Values for use with IEEE 1278.1* and is available from the Tactical Warfare Simulation and Technology Information Analysis Center at the Institute for Simulation and Training of the University of Central Florida.[1]

IEEE Std 1278.2-1995 defines the communication services required to support the message exchange described in IEEE Std 1278.1-1995. In addition, IEEE Std 1278.2-1995 provides several communication profiles that meet the specified communications requirements.

Taken together, IEEE Std 1278.1-1995 and IEEE Std 1278.2-1995 provide the necessary information exchange for the communications element of DIS.

This recommended practice provides guidelines for establishing a DIS exercise, managing the exercise, and providing proper feedback. This recommended practice is to be used in conjunction with IEEE Std 1278.1-1995 and IEEE Std 1278.2-1995 .

Revisions are anticipated to each of these standards and recommended practice within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Future versions of these documents will contain information concerning additional interoperability components that are currently in the process of being defined.

The Exercise Management and Feedback Working Group that developed this recommended practice had the following membership during the development cycle:

William Tucker, *Chair*

Peggy Anderson
Philip Baker
Richard Beahm
David Bessemer
Doug Classe
Mark Cosby
Neale Cosby
Jerry Forbes
George Gernert
Bill Gregory
Chris Hack
Lee Lacy
W. R. MacDiarmid
Joyce Madden
Ron Matusof
Bruce McDonald
Thom McLean
Larry Meliza
Tom Neuberger
Glenn O'Bannon
Jeff O'Byrne
Carol Paris
Marland Parsons
Edward Powell
David Roberts
Mike Robkin
Rick Severinghaus
Marshall Sherman
Ruth Willis

[1]For information on projects underway at the Institute for Simulation and Training at the University of Central Florida, check their web site at http://www.ist.ucf.edu.

The following persons were on the balloting committee:

Christina L. Bouwens	Barbara Jonew	Greg Schow
J. Joseph Brann	Margaret Loper	Frank Serna
Harris Brunch	David L. Macintire	Steven Sheasby
Brett Butler	Stephen Matsuura	Jack H. Sheehan
Ernest R. Carbone	Ron Matusof	Robert Sottilare
Richard L. Chandler	Mark McAuliffe	Lynn Stuckey
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Brian F. Goldiez	Wesley Potterton	Amy Vanzant-Hodge
David Gross	Mark Riecken	Douglas Wahrenberger
Peggy Halevi	John Robbins	Michael Wesdell
Ronald C. Hofer	Michael Robkin	Karen Williams
Mark Hoptiak	Randy Saunders	Philomena Zimmerman
	Richard Schaffer	

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CLAUSE PAGE

IEEE Recommended Practice for Distributed Interactive Simulation— Exercise Management and Feedback

1. Overview

1.1 Scope

This recommended practice establishes guidelines for exercise management and feedback in Distributed Interactive Simulation (DIS) exercises. It provides recommended procedures to plan, set up, execute, manage, and assess a DIS exercise. It is one in a series of standards that addresses the interoperability among interconnected simulation applications.

1.2 Application

This recommended practice provides guidance to sponsors, providers, and supporters of DIS compliant systems and exercises. It also provides guidance to developers of DIS exercise management and feedback stations. This document does not specify who may or may not participate in a DIS exercise. Depending upon the exercise objectives and the allocated time and assets, the degree that any of these practices can and will be followed can vary significantly.

1.3 Functions

This recommended practice addresses the activities of the organizations involved in a DIS exercise and the top-level processes used to accomplish those activities. It also addresses in some detail the functional requirements of the exercise management and feedback process. Broadly, these functional requirements characterize three points of view related to the formulation and conduct of a DIS exercise.

1.3.1 User/Sponsor view

The Users/Sponsor view focuses on describing the simulation exercise context, objectives, organization, and constraints from the perspective of the results expected from the exercise. This view does not require an in-depth understanding of the technical means needed to provide the simulation environment used for conducting the simulation exercise.

1.3.2 Exercise Manager View

The Exercise Manager view focuses on the planning, coordination, integration, and execution of the DIS exercise defined by the User. This role is detailed in the requirements clause. The Exercise Manager coordinates and integrates the detailed functions described in 4.1.3 through 4.1.10. These functions may require support from outside of the Exercise Manager's organization.

1.3.3 Exercise Architect view

The Exercise Architect point of view concentrates on the development of a verified, validated, and accredited "simulation exercise" environment that can support a common group of class of "scenarios" or "vignettes." Execution of individual scenarios or vignettes are conducted as "sessions" of the DIS exercise.

2. References

This recommended practice should be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

IEEE Std 1278.1-1995, IEEE Standard for Distributed Interactive Simulation—Application Protocols (ANSI).[1]

IEEE Std 1278.2-1995, IEEE Standard for Distributed Interactive Simulation—Communication Services and Profiles (ANSI).

3. Definitions and list of abbreviations and acronyms

3.1 Definitions

3.1.1 accreditation: (1) Distributed simulation accreditation is the official certification that a distributed simulation is acceptable for use for a specific purpose. (2) Model/simulation accreditation is the official certification that a model or simulation is acceptable for use for a specific purpose.

3.1.2 computer generated force (CGF): simulation of entities on the virtual battlefield. CGF entities may be fully autonomous (needing no human direction) or semi-autonomous (requiring some direction by a human controller who is not a participant in the virtual events). CGF entities represent friendly, opposing forces (OPFOR), and neutral battlefield participants not portrayed by manned simulators.

3.1.3 control station: Facility that provides the individual responsible for controlling the simulation and that provides the capability to implement simulation control as PDUs on the DIS network.

3.1.4 data certification: (1) The determination that data have been verified and validated. (2) Data producer certification is the determination by the data producer that data have been verified and validated against documented standards of criteria. (3) Data user certification is the determination by the application sponsor or designated agent that data have been verified and validated as appropriate for the specific Modeling and Simulation (M&S) usage.

3.1.5 data logger: Device that accepts PDUs from the network and stores them for later replay according to either the time sequence in which they were originally received or the time sequence as indicated by their time stamps.

3.1.6 DIS compliant: A simulation that can send or receive PDUs in accordance with IEEE Std 1278.1-1995 [2] and IEEE Std 1278.2-1995. A specific statement must be made regarding the qualifications of each PDU.

[1]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.
[2]Information on references can be found in Clause 2.

3.1.7 entity: Any component in a system that requires explicit representation in a model. Entities possess attributes denoting specific properties. *See also:* simulation entity.

3.1.8 exercise: (1) One or more sessions with a common objective and accreditation. (2) The total process of designing, assembling, testing, conducting, evaluating, and reporting on an activity. *See also:* simulation exercise.

3.1.9 local area network (LAN): A communications network designed for a moderate size geographic area and characterized by moderate to high data transmission rates, low delay, and low bit error rates.

3.1.10 long haul network (LHN): Also called wide area network (WAN). A communications network designed for large geographic areas.

3.1.11 measure of effectiveness (MOE): Measure of how the system/individual performs its functions in a given environment. Used to evaluate whether alternative approaches meet functional objectives and mission needs. Examples of such measures include loss exchange results, face effectiveness contributions, and tons delivered per day.

3.1.12 measure of performance (MOP): Measure of how the system/individual performs its functions in a given environment (e.g., number of targets detected, reaction time, number of targets nominated, susceptibility of deception, task completion time). It is closely related to inherent parameters (physical and structural), but measures attributes of system/individual behavior.

3.1.13 registration: Alignment of coordinate systems and phenomenological agreement between environment models.

3.1.14 scenario: (1) Description of an exercise (initial conditions). It is part of the session database that configures the units and platforms and places them in specific locations with specific missions. (2) An initial set of conditions and timeline of significant events imposed on trainees or systems to achieve exercise objectives.

3.1.15 segment: A portion of a session that is contiguous in simulation time and in wall clock (sidereal) time.

3.1.16 session: A portion of an exercise that is contiguous in wall clock (sidereal) time and is initialized by a session database.

3.1.17 session database: A database that includes network, entity, and environment initialization and control data. It contains the data necessary to start a session.

3.1.18 simulation application: (1) The executing software on a host computer that models all or part of the representation of one or more simulation entities. The simulation application represents or "simulates" real-world phenomena for the purpose of training or experimentation. Examples include manned vehicle (virtual) simulators, CGFs (constructive), environment simulators, and computer interfaces between a DIS network and real (live) equipment. The simulation application receives and processes information concerning entities created by peer simulation applications through the exchange of DIS PDUs. More than one simulation application may simultaneously execute on a host computer. (2) The application layer protocol entity that implements standard DIS protocol. The term *simulation* may also be used in place of simulation application.

3.1.19 simulation entity: An element of the synthetic environment that is created and controlled by a simulation application and is affected by the exchange of DIS PDUs. Examples of types of simulated entities include tank, submarine, carrier, fighter aircraft, missiles, bridges, or other elements of the synthetic environment. It is possible that a simulation application may be controlling more than one simulation entity. *See also:* entity.

3.1.20 simulation exercise: An exercise that consists of one or more interacting simulation applications. Simulations participating in the same simulation exercise share a common identifying number called the Exercise Identifier. These simulations also utilize correlated representations of the synthetic environment in which they operate. *See also:* exercise.

3.1.21 simulation fidelity: (1) The similarity, both physical and functional, between the simulation and that which it simulates. (2) A measure of the realism of a simulation. (3) The degree to which the representation within a simulation is similar to a real world object, feature, or condition in a measurable or perceivable manner.

3.1.22 subject matter expert (SME): Individual knowledgeable in the subject area being trained or tested.

3.1.23 unit: (1) An aggregation of entities: (2) A basis of measurement.

3.1.24 validation: (1) *Data validation* is the documented assessment of data by subject area experts and its comparison to known or best-estimate values. *Data producer validation* is that documented assessment within stated criteria and assumptions. *Data user validation* is that documented assessment of data as appropriate for use in an intended M&S. (2) *Distributed simulation validation* is the process of determining the degree to which a distributed simulation is an accurate representation of the real world from the perspective of its intended use(s) as defined by the requirements. (3) *Face validation* is the process of determining whether a model or simulation based on performance seems reasonable to people knowledgeable about the system under study. The process does not review software code or logic, but rather reviews the inputs and outputs to assure that they appear realistic or representative. (4) *Model/simulation validation* is the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended use(s) of the model.

3.1.25 verification: (1) *Data verification* is the use of techniques and procedures to ensure that data meets specified constraints defined by data standards and business rules. *Data producer verification* is the use of techniques and procedures to ensure that data meets constraints defined by data standards and business rules derived from process and data modeling. *Data user verification* is the use of techniques and procedures to ensure that data meets user specified constraints defined by data standards and business rules derived from process and data modeling and to ensure that data are transformed and formatted properly. (2) *Distributed simulation verification* is the process of determining that an implementation of a distributed simulation accurately represents the developer's conceptual description and specifications. (3) *Model/simulation verification* is the process of determining that a model implementation accurately represents the developer's conceptual description and specifications.

3.1.26 vignette: A self-contained portion of a scenario.

3.1.27 what-if analysis: An exercise that determines what capabilities an overall system would have if a changed capability were added (e.g., larger fuel tanks).

3.2 List of acronyms and abbreviations

ARPA	Advanced Research Projects Agency
C3	command, control, and communication
CGF	computer-generated force
DIS	Distributed Interactive Simulation
DoD	Department of Defense
LAN	local area network
LHN	long haul network
M&S	modeling and simulation
MOE	measure of effectiveness
MOP	measure of performance
OPFOR	opposing forces
PDU	protocol data unit
RF	radio frequency
SIMNET	Simulator Networking
SME	subject matter expert
V&V	verification and validation
VV&A	verification, validation, and accreditation
WAN	wide area network

4. Recommended practices

This clause describes the requirements, organization, management, and feedback systems needed for a DIS exercise. It provides detailed processes for exercise planning, development, and conduct, as well as for verification, validation, and accreditation (VV&A) (4.3).

4.1 DIS exercise management functions

This subclause describes the necessary functions of the personnel, agencies, organizations, or systems involved in management of any DIS exercise. Complexity of a particular exercise may dictate combination or further decomposition of these roles.

4.1.1 User/Sponsor

The DIS User or Sponsor is the person, agency, or organization who determines the need for and scope of a DIS exercise and/or establishes the funding and other resources for the exercise. The User/Sponsor also determines the exercise participants, objectives, requirements, and specifications. The User/Sponsor appoints the Exercise Manager and VV&A Agent.

4.1.2 Exercise Manager

The Exercise Manager is responsible for creating the exercise, executing the exercise, and conducting the post-exercise activities. The Exercise Manager coordinates with the VV&A Agent during these tasks and then reports the results of the exercise to the User/Sponsor.

4.1.3 Exercise Architect

The Exercise Architect designs, integrates, and tests the exercise as directed by the Exercise Manager.

4.1.4 Model/Tool Providers

The Model/Tool Providers develop, stock, store, maintain, and issue simulation assets. They maintain historical records of utilization and VV&A.

4.1.5 Site Managers

The Site Managers maintain and operate the physical simulation assets located at their geographic locations. They coordinate with the Mdel/Tool Providers to install and operate specific simulation and interaction capabilities specified by the Exercise Manager. Sites may include operational live equipment. Incorporation of live equipment requires special coordination.

4.1.6 Network Manager

The Network Manager is responsible for maintenance and operation of a network capable of providing the DIS link between two or more sites. For a given exercise, the Exercise Manager selects a Network Manager.

4.1.7 VV&A Agent

The VV&A Agent is the person, agency, or organization appointed by the User/Sponsor to measure, verify, and report on the validity of the exercise, and to provide data allowing the User/Sponsor to accredit the results.

4.1.8 Exercise Analyst

The Exercise Analyst is the person, agency, or organization tasked to reduce the exercise data and provide analytical support.

4.1.9 Exercise Security Officer

The Exercise Security Officer ensures that the exercise planning, conduct, and feedback are compliant with all applicable laws, regulations, and constraints associated with security of the network and the participating systems (e.g., communications, sites, processing, etc.).

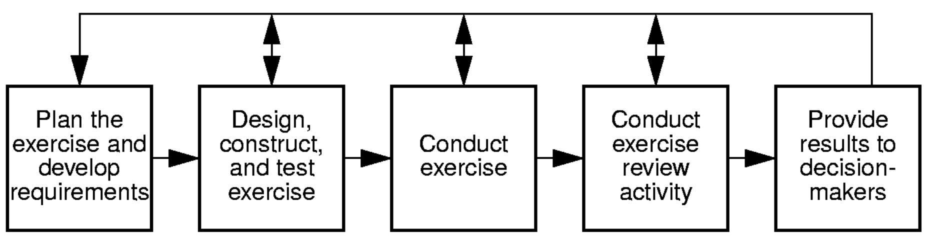
4.1.10 Logistics Representative

The Logistics Representative participates in all exercise phases, interfaces with other systems on logistics issues, and evaluates logistics realism, regardless of whether logistics is specifically portrayed in the exercise.

4.2 DIS exercise development and construction process model

The DIS exercise development and construction process consists of five phases, as shown in Figure 1. The DIS Exercise Management Team performs the functions listed in 4.1 to implement the process described in the following subclauses.

Extensive planning is required to assure that the exercise is capable of achieving the user's objectives. Once the planning is completed, the Exercise Architect leads the design, construction, and test of the exercise. Once satisfied that the planned exercise can achieve the intended objectives, the Exercise Manager will conduct the exercise. During the exercise and after its completion, the Exercise Manager and Exercise Analysts conduct post-exercise activities, such as after-action review, data analysis, and compilation of aids for decision-makers. As part of each phase, unanticipated results or changes to exercise requirements will be fed back to the appropriate point in the process model for corrective action.



Phase	1	2	3	4	5
Subclause	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5
Lead	Exercise Manager	Exercise Architect	Exercise Manager	Exercise Analyst	Exercise Manager

Figure 1—DIS exercise development and construction process

4.2.1 Plan the exercise and develop requirements

The Exercise Manager leads this activity, but should coordinate with the exercise User/Sponsor and obtain technical support while performing these planning activities. All members of the Exercise Management Team participate in the planning for the DIS exercise. Critical planning tasks to be performed for a DIS exercise are listed here in approximate sequential order. As a minimum, the Exercise Manager should consider the following:

a) Exercise purpose, objectives, exercise completion date, and security requirements
b) Measures of effectiveness (MOEs) and measures of performance (MOPs) applicable to the exercise
c) The required feedback products, audience, and timeliness
d) Specific data collection requirements, e.g., protocol data unit (PDU) set, field radio frequency (RF) data set, and other mechanisms to support b) and c)
e) Plans for VV&A, test, configuration management, etc.
f) Exercise schedule
g) Rules of engagement and political environment
h) Location to be simulated
i) Exercise scenario time frame
j) Exercise environment (weather, climate, electromagnetic, oceanographic)
k) Exercise forces—friendly, opposing, and neutral
l) Mix of simulation forces among live, virtual and constructive categories
m) Simulation resources available
n) Simulation resources to be developed
o) Technical and exercise support personnel required
p) Applicable range safety requirements
q) Initial conditions, planned events, scenarios, and vignettes
r) Functional/performance requirements and interface specifications for models and instrumented ranges
s) Required utilities to translate data from instrumented ranges and sensors to DIS format
t) Battlespace databases
u) Plan for including logistics realism
v) Contingency plan for reallocation of resources to recover from unavailability of planned simulation assets

4.2.2 Design, construct, and test exercise

In this phase, the Exercise Architect develops the DIS exercise to meet the requirements specified during the planning phase, making maximum reuse of existing DIS components. The Exercise Manager, along with the Model/Tool Providers, plays a major role in the design and construction of the exercise. The exercise development includes selection or development of components such as simulation applications, databases, architecture, and environment. The VV&A Agent ensures that the simulations/simulators are sufficient to conduct the exercise, as outlined in 4.3 of this document. This phase consists of a sequence of five steps: conceptual design, preliminary design, detailed design, construction and assembly, and integration and testing.

a) *Conceptual design*—In this step, the Exercise Architect develops the conceptual model and high level architecture for the exercise that show the participating components, their interfaces, behavior, and control structure.
b) *Preliminary design*—In this step, the Exercise Architect translates the requirements developed during the planning phase into a preliminary DIS exercise. This includes development of scenario(s), mission plans for various participants, database and map development and distribution, communications network design and tests, and planning for training and rehearsals.
c) *Detailed design*—In this step, the Exercise Architect works with the Exercise Manager to elaborate on the design model and architecture generated in the previous step to the extent necessary to support and complete the definition of all required functions, data flow, and behavior. The exercise Architect and Exercise Manager specifically include communication data rate requirements and data latency limitation requirements.

d) *Construction and assembly*—The Exercise Manager, with the assistance of the Model/Tool Providers and the Exercise Security Officer, assembles existing DIS components and develops new components that meet all security requirements.
e) *Integration and testing*—The Exercise Manager and Exercise Architect work this as an incremental process, starting with a minimum number of components and connectivity, then adding and building until they reach operational status. They then test to determine whether or not requirements and performance criteria are met. The exercise support personnel are also trained and rehearsed (dry run).

4.2.3 Conduct exercise

The Exercise Manager conducts the DIS exercise using the resources developed during the design, construct, and test phase. The goal of this third phase is to satisfy the established objectives. The management functions that the Exercise Manager needs to address are detailed in 4.4.

4.2.4 Conduct exercise review activity

Exercise review activity may initially center on rapidly providing after-action review material. The Exercise Manager can recall events or situations marked with observed event markers in the data log and incorporate the data into presentation material. Topics about which the Exercise Manager may wish to draw material for analysis and feedback include interactions, communications, Rules and Engagement, logistics, and command decisions. From this material, analysts and exercise participants can attempt to develop an understanding of the exercise and of the decision-making processes based on what each participant knew and perceived at a given time. The Exercise Analysts may want to obtain tools to select, integrate, and display exercise data for these purposes. These data can also be supplemented by information provided by exercise observers and analysts located with the exercise participants during the conduct of the exercise. The Exercise Manager must work with the Exercise Architect who will task the Model/Tool Providers to develop tools to select, integrate, and display exercise data. Additionally, the Exercise Manager ensures that exercise data is archived for future cross-exercise analysis.

The exercise feedback system should include various data presentation methods. These methods will present data in accordance with the data indices and filters as described in 4.4.5.1 and 4.4.5.2. The exercise feedback system should provide a selection of analytical functions for preliminary analysis and after-action review of each exercise as described in 4.4.5.3, as well as support the bulk of post-exercise data consolidation and analysis task.

4.2.5 Provide results to decision-makers

Exercise results will be reported to designated levels of User/Sponsor and other audiences according to the reporting requirements of the exercise. These results may include the following:

a) Exercise credibility
b) Cause and effect relationships
c) Detail and aggregation
d) Analysis
e) Exercise improvement

4.3 Verification, validation, and accreditation (VV&A) process

The VV&A process is shown in Figure 2 as a series of shadowed boxes (numbered 1 through 9) that are superimposed upon the DIS exercise development and construction process model discussed in detail in 4.2. The VV&A Agent, appointed by the User/Sponsor, should perform this process in parallel with, but independently from, the exercise planning and development activity, and report results to the User/Sponsor and Exercise Manager. Detailed further guidance for VV&A is being developed as a separate standard. The following subclauses introduce the VV&A process. The process steps listed here are recommended. The VV&A activities to be conducted in a specific exercise depend on the availability of resources, time, and the degree of risk statement desired.

4.3.1 Phase 1—Develop VV&A plans

This phase covers the activity that occurs as the DIS exercise is being planned. The VV&A Agent assesses that the requirements list to be used throughout the VV&A process correctly implements the User need statement. The agent generates the draft verification and validation (V&V) plan, correlates it with the DIS exercise requirements and concept, and from it, generates the final V&V plan and the accreditation plan in accordance with the applicable guidelines. It should be noted that the V&V plan and accreditation plan are normally separate documents and may be prepared by different organizations. The VV&A Agent can also assist during exercise planning by reviewing the capabilities and VV&A histories of previously developed exercise components.

4.3.2 Phase 2—Perform compliance standards verification

This phase serves as the gatekeeper to prevent nonconforming modeling & simulation (M&S) components from entering the DIS repository. Regardless of who is planning and administering the DIS exercise, tests are appropriate for ensuring DIS interface compliance. Products that pass these tests are then placed in the repository. Thus, this verification step can be conducted for M&S products at any time, independent of pending DIS exercises, or it can be conducted to screen products just prior to an exercise.

4.3.3 Phase 3—Performance conceptual validation

The VV&A Agent validates the conceptual model developed against the DIS exercise requirements. Achievability of the requirements and preliminary design is analyzed. Conceptual model validation is performed by testing a model of the DIS exercise. If the Exercise Architect has assembled such a model, the VV&A Agent should share, verify, and use it for this validation step. If not, the VV&A Agent should generate one. Otherwise, face validation of available model interface diagrams, behavior representations, and document is performed. The goal of conceptual validation is to confirm that all of the operational requirements are addressed. The VV&A Agent should determine that

a) The interface structure will support the planned data.
b) The conceptual model satisfies the proposed scenario and asset configuration.
c) The conceptual model supports the planned dynamic behavior.

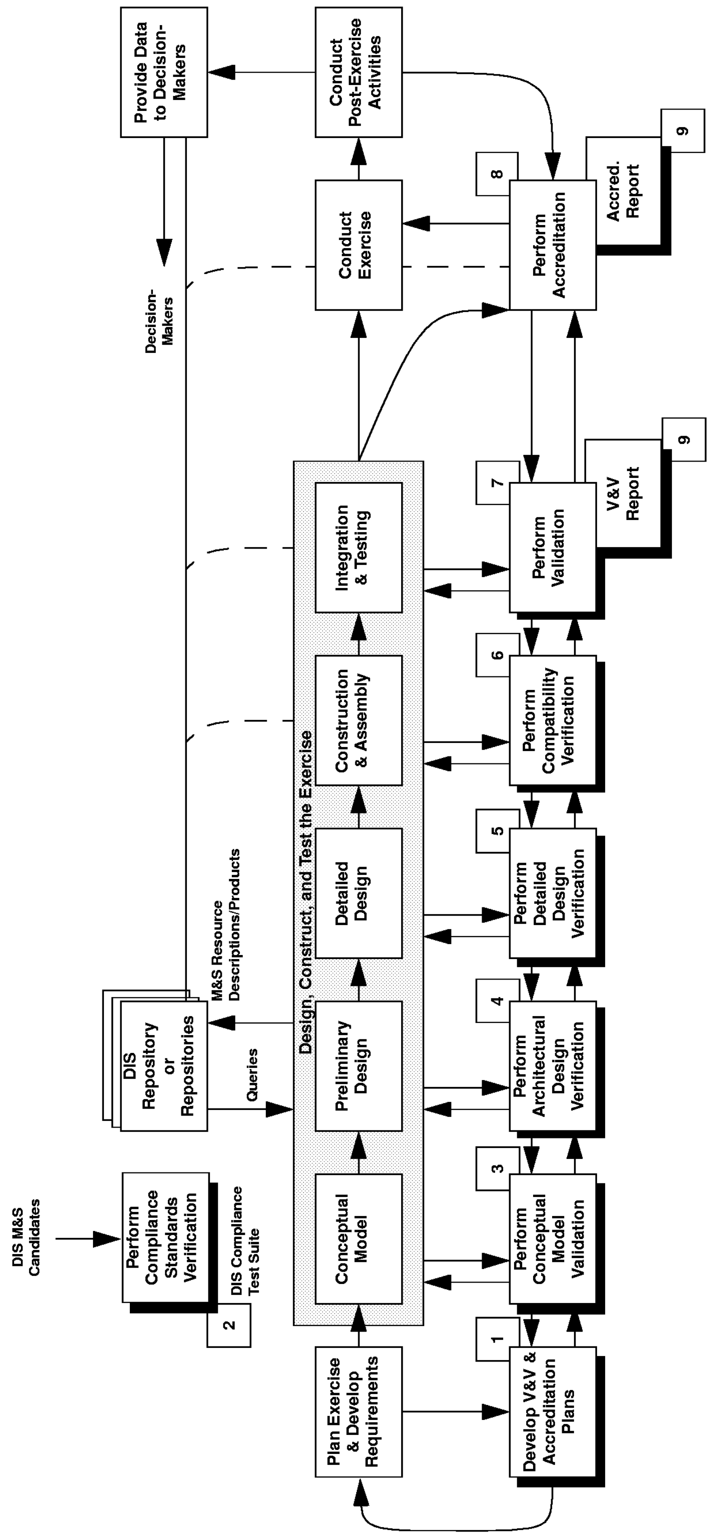


Figure 2—Applying the VV&A process to a DIS exercise

4.3.4 Phase 4—Perform architectural design verification

This phase is coupled to the architectural design of the DIS exercise. Most or all of the components should a) already exist, and b) already have had some amount of VV&A at the component level. The VV&A Agent evaluates the completeness and correctness of the DIS exercise conceptual model. The VV&A Agent should

a) Verify allocation of functions to exercise components.
b) Trace requirements to User/Sponsor needs statement.
c) Verify compatibility and interoperability of input data and interface requirements.
d) Understand theoretical assumptions, degree of fidelity, employment interaction, phenomena modeling, and precision and aggregation levels.
e) Verify consistency in use of common DIS resources (e.g., earth model, terrain, weather, phenomena, man-made and natural objects).
f) Recommended use of previously certified data sources whenever possible (and perform in-line certification).
g) Independently estimate behavior and overall performance of the exercise, evaluate and benchmark hardware platforms and network requirements, generate timing and sizing estimates, and compare results to those prepared by the Exercise Architect.
h) Analyze scenario timelines.
i) Review and assess test requirements.
j) Propose independent tests to more fully evaluate the performance of the exercise.

4.3.5 Phase 5—Perform detailed design verification

The VV&A Agent should

a) Ensure that the operational and functional requirements are in a usable form for tracing and verification.
b) Participate in the Exercise Architect's design walk-throughs and/or hold independent reviews for the purpose of fully understanding the detailed design.
c) Verify dead-reckoning algorithms' implementation and their initial thresholds.
d) Verify roles (e.g., of CGFs).
e) Predict the expected behavior of the live players.
f) Evaluate the test criteria for each component and the overall DIS exercise.
g) Reassess timing, sizing, and resource estimates (e.g., network loading).
h) Evaluate training requirements.

4.3.6 Phase 6—Perform compatibility verification

The compatibility of simulation assets during their coding, construction, and assembly into the DIS exercise are verified. Compatibility verification examines the internal attributes of the component that will make it interact correct with other interfacing DIS components, and also determines the compatibility of the component with the common "shared" DIS models and databases—earth, terrain, sea, weather, atmosphere, phenomena, etc. DIS components need not have the same fidelity or performance characteristics as long as the DIS Exercise Architect knows what is expected of each part, and there is compatibility among the parts that exchange data. Code verification uses the most appropriate tools and techniques available for the software language in use. Implementation of dead-reckoning algorithms and thresholds are verified, input and output data values are carefully analyzed, databases are verified, and the interface are tested to ensure that loading and latency do not adversely affect the behavior of the component(s). The instrumentation described in 4.4.4 may be useful for this function.

4.3.7 Phase 7—Perform exercise validation

Exercise validation addresses how well the components integrated into a total DIS exercise meet the behavior, appearance, performance, fidelity, and interoperability expectations for this application, stressing interoperability and performance measurement. The VV&A Agent should concentrate on testing and evaluating the capability of the exercise to meet requirements. During testing, the VV&A Agent determines performance boundaries and sensitivities that evolve into a performance baseline keyed to one or more scenarios. This testing should produce a comprehensive test suite that enables the evaluators and validators to profile and evaluate the effectiveness of the entire DIS exercise, more or less entity-by-entity. Comprehensive non-intrusive monitoring and data collection software should be used to observe the network continuously to measure traffic and each participant's activity, and to identify problems and possible stressing conditions. During this part of the testing process, computer-generated forces are often used as surrogates for live forces to reduce resource burdens. This validation step makes comparisons to the real world and to any other validated and/or accredited sources available and critically examines the input data sources to ensure that they are valid and certified where possible. This validation phase focuses on the completeness and structural soundness of the DIS exercise and the realism of the outputs in terms of the needs of the specific application. It also determines the acceptability of each component in the context of the complete DIS exercise.

4.3.8 Phase 8—Perform accreditation

Accreditation involves the formal acceptance of a DIS exercise by the User/Sponsor based on results of the preceding V&V phases. Accreditation team(s) should be formed as early as possible (early in the DIS exercise development) to participate in key technical interchange meetings and to monitor the DIS exercise development and V&V activities throughout the process. Comparisons to real-world behavior and to any other validated and/or accredited sources are provided. Input data sources are validated and certified where possible. In the military employment, joint (interservice) DIS exercises should be accredited according to the responsible Service/DOD component's accreditation policies or guidelines. Joint military DIS exercise accreditation decisions should be based upon mutually accepted guidance. Thus, accreditation is quite dependent upon the User/Sponsor organizations and their ultimate application and expectations for the DIS exercise in question.

4.3.9 Phase 9—Complete V&V report, accreditation report

V&V and accreditation activities are separately reported. The V&V report should be written incrementally so that information can be captured as the DIS exercise development effort proceeds. The recommended procedure is to produce an increment as each V&V phase is completed, documenting open items and unresolved issues. These report increments are fed back to the DIS exercise designer and user organizations as they are produced to help continuously improve the DIS exercise as it evolves. It is here that much of the VV&A cost benefit is realized.

The V&V and accreditation reports should be organized and written directly from their respective plans. This provides a comprehensive template and the VV&A Agent need only report what actually occurred based upon what was required in each detailed part of the plan. This reduces preparation time, simplifies the reports, and facilitates review.

4.4 Session management

An exercise consists of one or more session, each consisting of a set of live, virtual, and/or constructive entities interacting within the virtual environment to accomplish the goals of the exercise. Session management involves setup, initialization, control, monitoring, and feedback (post-analysis and reporting) necessary to administer each session within an exercise. Each session should contain a simulation management station and be capable of performing these simulation management functions. Table 1 provides a matrix of simulation management functions, along with the simulation management PDUs that support them. These PDUs are defined in IEEE Std 1278.1-1995. These simulation management functions should be performed at one or more control stations.

Table 1—Simulation management functions and PDUs

Simulation management functions	Implementing PDUs
Create Entities (new entity I.D.) Initialize CGFs	Create Entity PDU Set Data PDU Start/Resume PDU
Set Initial Conditions	Set Data PDU
Initiate Session	Start/Resume PDU
Freeze	Stop/Freeze PDU
Resume	Start/Resume PDU
Terminate Session	Stop/Freeze PDU
Remove Entities	Stop/Freeze PDU Remove Entity PDU
Regenerate Entities (retain entity I.D.)	Stop/Freeze PDU Set Data PDU Start/Resume PDU
Save State	Action Request PDU
Return To Save State	Stop/Freeze PDU Action Request PDU
Start Segment	Start/Resume PDU
Stop Segment	Stop/Freeze PDU
Observed Event Input	Comment PDU
Query Application Parameters —Simple Query (datum id) —Complex Query	Action Request PDU, Data Query Data Query Action Request/Data Query
Query Entity Parameters —Simple Query (datum id) —Complex Query	Action Request PDU, Data Query Data Query Action Request/Data Query
Modify Entity Parameters	Set Data PDU

4.4.1 Set up the session

As part of a session, each simulation application is given a role to play. Each role consists of initial conditions and other pertinent data necessary to initialize a simulation application. Like network initialization data, these roles can be generated and stored in advance. A session database, therefore, is generated for each session consisting of the network initialization data along with the data necessary to give a role or roles to each simulation application included in each session. Participants must be briefed.

4.4.2 Initialize a session

The items listed in 4.4.2.1 through 4.4.2.4 enable proper initialization of each simulation in the session.

4.4.2.1 Start data collection

Start collecting data as described in 4.4.5.1.

4.4.2.2 Establish common time reference

Establish a common time reference in accordance with the exercise plan. For instruction, see IEEE Std 1278.2-1995.

4.4.2.3 Initialize simulation application

Initialize the simulation application for the exercise. Below are types of initialization that should be performed:

a) *Initialize CGFs*—Initialize computer-generated forces to include rules of engagement, standard operating procedures, and proficiency or intelligence level.
b) *Create entities*—Bring entity on line.
c) Initialize non-entity applications (e.g., data logger, stealth, control station).
d) *Set initial conditions*—Set initial session conditions to include the following:
    1) Visual/terrain databases (databases representing the virtual environment that will be used for a given session, including terrain and features, ocean models, and atmosphere models, as appropriate)
    2) Environment (states and conditions), dynamic terrain, and relocatables
    3) Entities (e.g., states, conditions, types, amounts, location, and orientation)
    4) Expendable items, such as fuel and ammunition
e) Ready live equipment and crews and verify communications.

4.4.2.4 Establish query parameters

Establish query parameters to direct a simulation application to transmit or record entity data that is not routinely available on the network for one or more entities. These parameters include the data to be collected, the method to be used, and the frequency. These data might include switch hits, pilots' heart rates, or other non-PDU data.

4.4.3 Control a session[3]

For session control, the following functionality should be available:

a) *Initiate session*—Initiates a new or continues a previously saved session; see h).
b) *Freeze*—Temporarily freezes a given session, segment, or entity.
c) *Resume*—Resumes a frozen session, segment, or entity.
d) *Terminate session*—Terminates a session.
e) *Remove entities*—Selectively removes entities from a session.
f) *Create entity*—Establishes a new unique entity during a session.
g) *Regenerate entity*—Regenerates an entity in its old or reconstituted state after it has been killed or, for some other reason, removed from the simulation.
h) *Save state*—Directs a given simulation state to be saved or archived (e.g., entity locations and states, status, environmental conditions). Multiple save states in a single session should be accommodated.
i) *Return to save state*—Directs all entities to return to a selected save state.
j) *Start segment*—Identifies and initiates session segments from any save state.
    NOTE — Evaluation of operational plans requires a what-if capability. Therefore, the system should be able to stop a session, return to an earlier point, and restart a new sequence. This new sequence will consist of the save state point and the subsequent PDU stream. The new sequence will be collected without destroying the original sequence.
k) *Stop segment*—Defines and marks the end of a segment.
l) *Observed event input*—Inputs an observed event marker into the PDU stream for recording and later analysis.
m) *Query application parameters*—Directs a simulation application to transmit entity parameters that are not routinely available on the network.
n) *Modify entity parameters*—Modifies simulation application internal data.

[3]Controlling live entities, presents unique challenges and requires special coordination.

4.4.4 Monitor a session

A mechanism should be provided for monitoring session progress via graphical and tabular displays. These displays should include the following:

a) *A plan view or map display*—Graphical representation of the virtual environment and the entities involved in a session from on overhead perspective.
b) *A three-dimensional display with free-play eye point (stealth)*—Three-dimensional representation of the virtual environment and the entities involved in a session from a free-moving, user-controlled perspective, not constrained by any entity's maneuver capability.
c) *An entity and/or unit status display*—Status (e.g., damage, fuel, or other entity/unit parameters) of each entity and/or unit (group of entities).
d) *A network health display*—Technical status and health of the network.
e) *A system health display*—Technical status and health of the systems participating in the exercise.

Additional aids provide specific session information appropriate to the instructional or test objectives of the exercise. These aids should work with the session monitoring displays. These aids include the following:

— Interdetectability (i.e., can two entities see or sense each other?)
— Range safety
— Range between two entities
— Course and speed of a given entity
— Range and bearing of a given entity

4.4.5 Post-Session review activity

Exercise Managers should ensure that capability is provided to reduce, analyze, and evaluate the outcome of the session immediately after the session is conducted. They should also make sure that data collected during the session is archived for longer term analysis and evaluation by decision-makers.

4.4.5.1 Data

The feedback system should provide the following data handling capabilities:

a) It should collect and archive PDUs such that the PDU stream can be reproduced exactly as received.
b) It should provide tools to edit archived PDU stream (e.g., to correct out-of-order or corrupted PDUs).
c) It should accept and archive non-PDU data, such as operation and fragmentary orders and voice radio traffic. These data should be indexed to the PDU data.
d) It should archive the collected PDUs and non-PDU material such that data can be retrieved for analysis of single exercises or across exercise boundaries.
e) It should provide user-selectable checks to validate events determined by two or more PDUs (e.g., a collision PDU must be matched by another collision PDU).
f) It should provide user-selectable filters to reduce data flow by eliminating undesired PDUs.

4.4.5.2 Presentation functions

The feedback system should provide correlated data presentations of any combination of the elements listed below. Displays should be presented in accordance with the data indices and filters established in 4.4.5.1.

a) A bird's eye/plan/overhead view that depicts all of the entities, topographic and cultural features, and user-defined annotations. These depictions are user-selectable.
b) A three-dimensional view with free-play viewpoints that can be linked with an entity
c) Playback functions, such as fast forward/reverse, jump forward/reverse, pause/freeze, selectable play speed forward/reverse

d) The ability to zoom in or out on any view as well as pan the view across the display and adjust map display scale
e) The ability to select specific entities or classes of entities for replay
f) Environmental effects (e.g., smoke, illumination, or rain)
g) Movement of articulated parts as required by the user
h) Hard copy (snapshot) output of any display
i) Audio playback
j) Audio/video output compatible with video transmission and storage media

4.4.5.3 Analytical functions

The feedback system should provide the following preliminary analysis and after action review functions:

a) It should allow users to overlay displays with appropriate non-PDU data such as unit missions or other pertinent portions of orders.
b) It should replay exercises at a level appropriate to the exercise participants being debriefed against an appropriate environmental model. It should use changes in entity icons and other graphical aids to indicate all relevant variables and status changes. Examples include the following:
    1) Firing events
    2) Major changes in entity status where information is contained by PDUs (e.g., assessed as casualty, dismount)
    3) Real-time movement and track history with user-specified start, stop, and interval time
    4) Evasive actions other than movement described by PDUs (e.g., smoke, flares)
    5) Movement of gun tubes and other articulated parts
    6) Command, control & communication (C3) connectivity (active, passive, and broken)
    7) Significant events in the electromagnetic spectrum
    8) Reported contact movement and track, track start and stop time
c) It should display interdetectability of two or more entities at user command.
d) It should provide alphanumeric and graphical displays including graphs, tables, summaries, and time lines showing critical exercise events, as defined by the user, and tools to customize the output.
e) It should provide editing features for the preparation of structured debriefs.

Annex A Bibliography
(Informative)

These publications provide background information related to this document in addition to the references listed in Clause 2.

A.1 Standards

[B1] IST-CR-95-18, Standard for Distributed Interactive Simulation—Exercise Management and Feedback.[4]

[B2] IST-CR-96-04, Standard for Distributed Interactive Simulation—Fidelity Description Requirements.

A.2 Accompanying documents

[B3] IST-CR-92-21, Guidance Document: Communication Architecture for Distributed Interactive Simulation (CADIS).

[B4] IST-CR-93-03, Rationale Document: Standard for Information Technology—Protocols for Distributed Interactive Simulation Applications.

[B5] IST-CR-93-34, Rationale Document: Fidelity Correlation Requirements for Distributed Interactive Simulation.

[B6] IST-CR-93-42, Rationale Document: Communication Architecture for Distributed Interactive Simulation (CADIS).

[B7] IST-CR-95-29, Rationale Document: Distributed Interactive Simulation—Exercise Management and Feedback.

A.3 Interoperability meetings

[B8] IST-CF-89-01, Summary Report: The First Conference on Standards for the Interoperability of Defense Simulations.

[B9] IST-CF-90-01, Summary Report: The Second Conference on Standards for the Interoperability of Defense Simulations.

[B10] IST-CR-90-13, Summary Report: The Third Workshop on Standards for the Interoperability of Defense Simulations.

[B11] IST-CR-91-11, Summary Report: The Fourth Workshop on Standards for the Interoperability of Defense Simulations.

[B12] IST-CR-91-13, Summary Report: The Fifth Workshop on Standards for the Interoperability of Defense Simulations.

[B13] IST-CR-92-02, Summary Report: The Sixth Workshop on Standards for the Interoperability of Defense Simulations.

[B14] IST-CR-92-17, Summary Report: The Seventh Workshop on Standards for the Interoperability of Defense Simulations.

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[4]For information on projects underway at the Institute for Simulation and Training at the University of Central Florida, check their web site at http://www.ist.ucf.edu.

[B15] IST-CR-93-10, Summary Report: The Eighth Workshop on Standards for the Interoperability of Defense Simulations.

[B16] IST-CR-93-39, Summary Report: The 9th Workshop on Standards for the Interoperability of Defense Simulations.

[B17] IST-CF-94-01, Summary Report: The 10th Workshop on Standards for the Interoperability of Defense Simulations.

[B18] IST-CF-94-02, Summary Report: The 11th Workshop on Standards for the Interoperability of Defense Simulations.

[B19] IST-CF-95-01, Summary Report: The 12th Workshop on Standards for the Interoperability of Defense Simulations.

[B20] IST-CF-95-02, Summary Report: The 13th Workshop on Standards for the Interoperability of Defense Simulations.

A.4 General information

[B21] IST-SP-94-01, DIS Steering Committee, The DIS Vision, A Map to the Future of Distributed Simulation, Version 1, May 1994.

[B22] IST-SP-96-01, A Glossary of Modeling and Simulation Terms for Distributed Interactive Simulation.

[B23] IST-TR-94-08, Guidance Document: Distributed Interactive Simulation Standards Development Guidance Document Version 2.3.