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Reference for
Guide: DIS Plain and Simple

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Revision History

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1 Introduction

This document is intended to be a primer on DIS. Our intent is to introduce a complex system in easy to understand steps. Our goal is to provide you with enough knowledge to enable you to begin to understand and implement a simulation exercise using DIS.

1.1 Purpose

The DIS Plain and Simple Guide provides guidance on how to use DIS to achieve interoperability in support of training, test and evaluation and experimentation events.

1.2 Scope

The DIS Plain and Simple" Guide provides information on Distributed Interactive Simulation.

1.3 Objectives

The objective of this document is to provide additional information to assist in implementing and using DIS either as part of a DIS exercise or when DIS simulations are integrated into a hybrid exercise, such as a DIS/HLA Exercise, or DIS/HLA/TENA exercise where DIS is not the primary protocol being used.

1.4 Intended Audience

This document is intended for users and developers who need to be familiar with DIS.

2 References

References for the body of the document are listed in Sec. 6.

2.1 SISO References:

The following SISO reference documents shall be used, when applicable, when conducting Distributed Interactive Simulations.

	Document Number	Title
1	SISO-REF-010-2006	Enumeration and Bit Encoded Values for use with Protocols for Distributed Interactive Simulation Applications

2.2 Other References:

	Document Number	Title
1	IEEE 1278.1	IEEE Standard for Distributed Interactive Simulation - Application Protocols
2	IEEE 1278.2	IEEE Standard for Distributed Interactive Simulation - Communication Services and Profiles
3	IEEE 1278.3	IEEE Standard for Distributed Interactive Simulation Exercise Management & Feedback (EMF) - Recommended Practice
4	IEEE 1278.4	IEEE Standard for Distributed Interactive Simulation - Verification Validation & Accreditation
5	DIS Find-It-Fast Guide	Download the latest copy from here.

3 Definitions

Definitions of vocabulary used for Distributed Interactive Simulation are as follows:

A

abstraction. 1. The process of selecting the essential properties of a simulation to be represented in a simulation. 2. The set of elements produced by this process. [3] 3. The act or process of separating the inherent qualities or properties of something from the actual physical object or concept to which they belong. 4. A product of this process, as a general idea or word representing a physical concept. [4]

accuracy. The degree to which a parameter or variable or set of parameters or variables within a model or simulation conform exactly to reality or to some chosen standard or referent. See resolution, fidelity, precision.

activity. A task that consumes time and resources and whose performance is necessary for a system to move from one event to the next. [2]

affected attributes. The specific attributes of an object class instance whose value in a federation execution may be affected by that instance's participation in a dynamic interaction with another instance of the same class or an instance of another object class. [7]

aggregation. 1. The ability to group items, whether entities or processes, while preserving the effects of item behavior and interaction while grouped. [8] 2. A relationship between objects in the data model where one object contains other objects. [9] See disaggregation.

aggregator. An object that is comprised of other objects; a 'has-a' relationship exists between the aggregator object and its component objects (e.g., a polygon is an aggregator for its vertex objects). [9]

algorithm. A prescribed set of well-defined, unambiguous rules or processes for solving a problem in a finite number of steps. [10]

analytical model. A model consisting of a set of solvable equations (e.g., a system of solvable equations that represent the laws of supply and demand in the world market). [1, 2]

architecture. The structure of components in a program or system, their interrelationships, and the principles and guidelines governing their design and evolution over time. [8]

associative entity. An entity that inherits its primary key from two or more other entities (i.e., those that are associated). An associative entity may represent many-to-many relationships. [12]

asynchronous transfer mode (ATM).

asynchronous transmission. A transmission in which each information character is individually synchronized, usually by the use of start elements and stop elements. [13]

atmosphere. 1. The mass of air surrounding the earth and the features embedded within it, including clouds, smoke, and fog. 2. A kind of mission space entity representing the atmosphere. [14]

attribute. 1. A property or characteristic of one or more entities or objects (e.g., COLOR, WEIGHT, SEX). 2. A property inherent to an entity or associated with that entity for database purposes. [6, 15, 16] 3. A quantifiable property of an object (e.g., the color of a building or the width of a road). [9]

authoritative data source. A data source whose products have undergone producer data verification, validation and certification activities. [3]

authoritative representation. Models, algorithms, and data that have been developed or approved by a source which has accurate technical knowledge of the entity or phenomenon to be modeled and its effects. [3]

automated force (AFOR). The most automated computer-generated force that requires little or no human interaction to accomplish its mission. [8]

B

battlespace. The physical environment in which the simulated warfare will take place and the forces that will conduct the simulated warfare. All elements that support the front line forces (e.g., logistics, intelligence) are included in this definition of battlespace. [8]

battlespace entity. A simulated entity that corresponds to actual equipment, supplies, and personnel that can be seen or sensed on a real battlefield. [13]

behavior. For a given object, how attribute value changes affect or are affected by the attribute value changes of the same or other objects. [14]

benchmark. The activity of comparing the results of a model or simulation with an accepted representation of the process being modeled. [1]

benchmarking. The comparison of a model's output with the outputs of other models or simulations, all of which represent the same input and environmental conditions. [18]

body coordinate system. A three-dimensional Cartesian coordinate system where the origin is the centroid of the specified body (or entity).

broadcast. A transmission model in which a single message is sent to all network destinations (i.e., one-to-all); a special case of multicast. See multicast, unicast. [1, 2]

built-in-simulation. A special-purpose simulation provided as a component of a simulation language (e.g., a simulation of a bank that can be made specific by stating the number of tellers, number of customers, and other parameters). [1, 2]

built-in-simulator. A simulator that is built into the system being modeled (e.g., an operator training simulator built into the control panel of a power plant such that the system can operate in simulator mode or in normal operating mode). [1, 2]

C

class. A description of a group of objects with similar properties, common behavior, common relationships, or common semantics. [7]

class hierarchy. A specification of a class-subclass, or "is-a" relationship between object classes in a given domain. [7]

compression. Any of several techniques that reduce the number of bits required to represent information in data transmission or storage, therefore conserving bandwidth and/or memory, so the original form of the information can be reconstructed; Compaction. [13]

computational model. A model consisting of well-defined procedures that can be executed on a computer (e.g., a model of the stock market, in the form of a set of equations and logic rules). [2]

computer generated force (CGF). A computer representation of forces in simulations that attempt to model human behavior sufficiently so that those forces will take some actions automatically (without requiring human-in-the-loop interaction); semi-automated force. [8]

computer hardware. Devices capable of accepting and storing computer data, executing a systematic sequence of operations on computer data, or producing control outputs; such devices can perform substantial interpretation, computation, communication, control, or other logical functions. [20]

computer resources. The totality of computer hardware, firmware, software, personnel, documentation, supplies, services, and support services applied to a given effort. [14]

computer simulation. A dynamic representation of a model, often involving some combination of executing code, control/display interface hardware, and interfaces to real-world equipment. [14]

computer software. A set of computer programs, procedures, and associated documentation concerned with the operation of a data processing system (e.g., compilers, library routines, manuals, and circuit diagrams); software. [14]

conceptual model. A description of the content and internal representations that are the user's and developer's combined concept of the model including logic and algorithms and explicitly recognizing assumptions and limitations. [1]

Conceptual Model of the Mission Space (CMMS). First abstraction of the real world that serves as a frame of reference for simulation development by capturing the basic information about important entities involved in any mission and their key actions and interactions; simulation-neutral view of those entities, actions, and interactions occurring in the real world. [14]

condition. The values assumed at a given instant by the variables in a system, model, or simulation. See boundary condition; final condition; initial condition; state. [1, 2]

configuration. A collection of an item's descriptive and governing characteristics, which can be expressed: in functional terms (i.e., what performance the item is expected to achieve); and in physical terms (i.e., what the item should look like and consist of when it is built). [14]

conservative synchronization. A mechanism that prevents a federate from processing messages out of time stamp order (e.g., Chandry/Misra/Bryant null message protocol). See optimistic synchronization. [7]

consistency. Data maintained so that it is free from variation or contradiction. [5, 6]

constant. A quantity or data item whose value cannot change. [2]

constrained simulation. A simulation where time advances are paced to have a specific relationship to wall clock time; real-time or scaled-real-time simulations (e.g., human-in-the-loop (e.g., training exercises), hardware-in-the-loop (e.g., test and evaluation simulations)). [7]

constructive model or simulation. Models or simulations that involve simulated people operating simulated systems. Real people may make inputs to such simulations, but are not involved in determining their outcomes. [8]

coordinate. 1. Linear or angular quantities which designate the position that a point occupies in a given reference frame or system. 2. A general term to designate the particular kind of reference frame or system, such as Cartesian coordinates or spherical coordinates. [13] 3. One of a set of numbers that determines the location of a point in a space of a given dimension. 4. Any of a set of two or more magnitudes used to determine the position of a point, line, curve or plane. [4]

coordinate system. An organized system for describing 2- or 3-dimensional locations. [9]

correlated levels of detail. The equal representation of synthetic environment objects at comparable levels of presentation (i.e., the same object seen or detected at a distance of 15 meters.). [9]

correlation. 1. A convergent relationship between parallel representations of the same data. [9] 2. A causal, complementary, parallel, or reciprocal relationship, especially a structural, functional, or qualitative correspondence between comparable entities. [4]

cultural features. Features of the environment that have been constructed by man including such items as roads, buildings, canals, marker buoys; boundary lines, and, in a broad sense, all names and legends on a map. [14]

D

data. 1. A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means. [6, 15, 16] 2. Assumed, given, measured, or otherwise determined facts or propositions used to draw a conclusion or make a decision. [4]

data attribute. A characteristic of a unit of data such as length, value, or method of representation. [15, 21]

data collection. The process of obtaining information that supports a functional activity, or information requirement. [6]

data dictionary. A specialized type of database containing metadata that is managed by a data dictionary system; a repository of information describing the characteristics of data used to design, monitor, document, protect, and control data in information systems and databases. [15, 22]

data element. A basic unit of information having a meaning and subcategories (data items) of distinct units and values (e.g., address). [22]

data exchange standard. Formally defined protocols for the format and content of data messages used for interchanging data between networked simulation and/or simulator nodes used to create and operate a distributed, time and space coherent synthetic environment. [23]

data integrity. The condition in which data is accurate, current, consistent, and complete. [6]

data logger. A device that accepts Protocol Data Units (PDUs) from the network and stores them for later replay on the network in the same time sequence as the PDUs were originally received. See protocol data unit. [1, 2]

data loss. The loss of original information through multiple conversions or transformations of data. [9]

data model. 1. The user's logical view of the data in contrast to the physically stored data, or storage structure. 2. A description of the organization of data in a manner that reflects the information structure of an enterprise. [6, 15, 16] 3. A description of the logical relationships between data elements where each major data element with important or explicit relationships is captured to show its logical relationship to other data elements. [9]

data quality. The correctness, timeliness, accuracy, completeness, relevance, and accessibility that make data appropriate for use. Quality statements are required for source, accuracy (positional and attribute), up-to-dateness/currency, logical consistency, completeness (feature and attribute), clipping indicator, security classification, and releasability. [6, 8]

data repository. A specialized database containing information about data, such as meaning, relationships to other data, origin, usage, and format, including the information resources needed by an organization. [6]

data representation. A variety of forms used to describe a terrain surface, the features placed on the terrain, the dynamic objects with special 3-D model attributes and characteristics, the atmospheric and oceanographic features, and many other forms of data. [9]

data source. An organization or subject matter expert who, because of either mission or expertise, serves as a data producer. [14]

data structure. The logical relationships that exist among units of data and the descriptive features defined for those relationships and data units; an instance or occurrence of a data model. [15, 21]

data validation. The documented assessment of data by subject area experts and its comparison to known values. [8]

data value. A value associated with a data element; one of the allowable values of a data element. [6, 22]

data verification. 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 that data are transformed and formatted properly. [8]

database. A collection of interrelated data, often with controlled redundancy, organized according to a schema to serve one or more applications; the data are stored so that they can be used by different programs without concern for the data structure or organization. A common approach is used to add new data and to modify and retrieve existing data. [6, 15, 16]

database management system (DBMS). A system that provides the functionality to support the creation, access, maintenance, and control of databases, and that facilitates the execution of application programs using data from these databases. [14]

dead reckoning. The process of extrapolating emulation entity position/orientation based on the last known position/orientation, velocity, and (sometimes) higher-order derivatives of position vs. time and/or other vehicle dynamic characteristics; remote entity approximation. [1, 13]

deaggregate. See disaggregate. [14]

descriptive model. A model used to depict the behavior or properties of an existing system or type of system (e.g., a scale model or written specification used to convey to potential buyers the physical and performance characteristics of a computer). See prescriptive model. [1, 2]

deterministic. Pertaining to a process, model, simulation or variable whose outcome, result, or value does not depend upon chance. See stochastic. [2, 13]

deterministic model. A model in which the results are determined through known relationships among the states and events, and in which a given input will always produce the same output (e.g., a model depicting a known chemical reaction). See stochastic model. [1, 2]

digital simulation. 1. A simulation that is designed to be executed on a digital system. 2. A simulation that is designed to be executed on an analog system but that represents a digital system. 3. A simulation of a digital circuit. See analog simulation, hybrid simulation. [1, 2]

disaggregate. Activity that decomposes an aggregated entity into multiple entities representing its components. [1]

disaggregation. The ability to represent the behavior of an aggregated unit in terms of its component entities. If the aggregate representation did not maintain state representations of the individual entities, then the decomposition into the entities can only be notional. [8]

discrete model. A mathematical or computational model whose output variables take on only discrete values; that is, in changing from one value to another, they do not take on the intermediate values (e.g., a model that predicts an organization's inventory levels based on varying shipments and receipts). See continuous model. [1, 2]

discrete simulation. A simulation that uses a discrete model. [1, 2]

discrete system. A system for which the state variables change instantaneously at separated points in time. [10, 24]

Distributed Interactive Simulation (DIS).

domain. The physical or abstract space in which the entities and processes operate. The domain can be land, sea, air, space, undersea, a combination of any of the above, or an abstract domain, such as an n-dimensional mathematics space, or economic or psychological domains. [18]

dynamic model. A model of a system in which there is change, such as the occurrence of events over time or the movement of objects through space (e.g., a model of a bridge that is subjected to a moving load to determine characteristics of the bridge under changing stress). [1, 2]

dynamic natural environment. The natural environment which is constantly changing as a result of man-made efforts (battlefield smoke) and natural phenomenon (weather). [23]

E

edge. A one dimensional primitive used to represent the location of a linear feature and/or the border of faces. [9]

elevation. The vertical component in a 3-dimensional measurement system measured in reference to a fixed datum. [9]

emitter. A device that is able to discharge detectable electromagnetic or acoustic energy. [1, 13]

emulate. To represent a system by a model that accepts the same inputs and produces the same outputs as the system represented (e.g., to emulate an 8-bit computer with a 32-bit computer). [1, 2]

emulation. A model that accepts the same inputs and produces the same outputs as a given system. See simulation. [1, 2]

emulator. A device, computer program, or system that performs emulation. [1, 2]

entity. 1. A distinguishable person, place, unit, thing, event, or concept about which information is kept. [12] 2. Something that exists as a particular and discrete unit. [4]

entity coordinates. Location with respect to a simulation entity. [1]

entity perspective. The perception of the synthetic environment held by a simulation entity based on its knowledge of itself and its interactions with the other simulation entities including not only its own view of the simulated physical environment (terrain, air, and sea), but also its own view of itself, the other entities in the synthetic environment, and of the effects of the other entities on itself and the synthetic environment; world view. [1]

environment. The texture or detail of the natural domain, that is terrain relief, weather, day, night, terrain cultural features (such as cities or farmland), sea states, etc.; and the external objects, conditions, and processes that influence the behavior of a system (such as terrain relief, weather, day/night, terrain cultural features, etc.). [1]

environmental database. See synthetic environment database. [9]

environmental domain. The physical or abstract space in which the entities and processes operate. The domain can be land, sea, air, space, undersea, a combination of any of the above, or an abstract domain, such as an n-dimensional mathematics space, or economic or psychological domains. [9]

environmental effect. The impact that the natural environment or environmental feature has on some component or process in the simulation exercise such as the propagation of energy and image formation, the performance of a weapon system, platform or sensor, or other non-visualized combat process. [14]

environmental effect model. A numerical model, parametric model, or database for simulating a natural environmental effect on an entity of a simulation exercise, such as a sensor or platform. [14]

environmental entity. A simulation entity that corresponds to dynamic elements of the natural state of the geographic, atmospheric, and bathyspheric environment, of the synthetic environment, that can be seen or sensed on a real battlefield (e.g., craters, smoke, building collapse, weather conditions, and sea state). [1]

environmental features. An individual element of the natural environment (e.g., a rain system, fog, cloud). [14]

environmental model. A numerical model, parametric model, or database designed to produce an accurate and consistent data set for one or more parameters that characterize the state of the natural environment. [14]

environmental phenomenon. An individual element of the physical environment (e.g., a rain system, fog, cloud). [9]

environmental representation. An authoritative representation of all or a part of the natural or man-made environment, including permanent or semi-permanent man-made features. [8]

environmental simulation. A simulation that depicts all or part of the natural or manmade environment of a system (e.g., a simulation of the radar equipment and other tracking devices that provide input to an aircraft tracking system). [2]

equilibrium. See steady state. [1] A condition in which all acting influences are canceled by others, resulting in a stable, balanced or unchanging system. [4]

error. The difference between an observed, measured or calculated value and a correct value. [3]

error model. 1. A model used to estimate or predict the extent of deviation of the behavior of an actual system from the desired behavior of the system (e.g., a model of a communications channel, used to estimate the number of transmission errors that can be expected in the channel). 2. In software evaluation, a model used to estimate or predict the number of remaining faults, required test time, and similar characteristics of a system. [1, 2]

Euler angles. A set of three angles used to describe the orientation of an entity as a set of three successive rotations about three different orthogonal axes (x, y, and z). The order of rotation is first about z by angle (psi), then about the new y by angle (theta), then about the newest x by angle (phi). Angles psi and phi range between +/- pi, while angle theta ranges only between +/- pi/2 radians. These angles

specify the successive rotations needed to transform from the world coordinate system to the entity coordinate system. The positive direction of rotation about an axis is defined by the right-hand rule. [1]

event. A change of object attribute value, an interaction between objects, an instantiation of a new object, or a deletion of an existing object that is associated with a particular point on the federation time axis. Each event contains a time stamp indicating when it is said to occur. [7]

event-oriented simulation. A simulation in which attention is focused on the occurrence of events and the times at which those events occur; for example, a simulation of a digital circuit that focuses on the time of state transition. [1, 2]

F

face. A region enclosed by an edge or set of edges. Faces are topologically linked to their surrounding edges as well as to the other faces that surround them. Faces are always non-overlapping, exhausting the area of a plane. [9]

face validation. The process of determining whether a model or simulation seems reasonable to people who are knowledgeable about the system under study, based on performance. This process does not review the software code or logic, but rather reviews the inputs and outputs to ensure they appear realistic or representative. [1, 13]

fair fight. A condition when the differences between the performance characteristics of two or more interoperating simulations have significantly less effect on the outcome of a simulated situation than the actions taken by or resources available to the simulation participants. See level playing field.

fast time. 1. Simulated time with the property that a given period of actual time represents more than that period of time in the system being modeled (e.g., in a simulation of plant growth, running the simulation for one second may result in the model advancing time by one full day, i.e., simulated time advances faster than actual time). 2. The duration of activities within a simulation in which simulated time advances faster than actual time. See real-time, slow time. [1, 2]

feature. A static element of the synthetic environment that exists but does not actively participate in synthetic environment interactions. Features are represented in the implementation environment by cartographic databases that are used by simulation assets. Entities can interact with features (building them, destroying them, colliding with them, etc.), but features are passive in that they do not initiate action. When features are dynamic (e.g., dynamic terrain) they are called environment entities. See environmental entity, synthetic environment. [1]

fidelity. 1. The degree to which a model or simulation reproduces the state and behavior of a real world or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it. See accuracy, precision, resolution, repeatability, model/simulation validation. 2. The methods, metrics, and descriptions of models or simulations used to compare those models of simulations to their real world referents or to other simulations in such terms as accuracy, scope, resolution, level-of-detail, level-of-abstraction and repeatability.

field. A series of contiguous bits treated as an instance of a particular data type that may be part of a higher level data structure. [1, 13]

field instrumentation. An internal or external recording, monitoring, and relaying device employed by live instrumented entities, usually platform, facility, or exercise-unique, and not typically part of the operational system or equipment. These devices provide an independent source of data to assess the performance of operational systems involved in the exercise. [1]

G

game. A physical or mental competition in which the participants, called players, seek to achieve some objective within a given set of rules. See game theory. [1, 2]

gateway. A device that connects two systems, especially if the systems use different protocols (e.g., a gateway is needed to connect two independent local networks, or to connect a local network to a long-haul network). [13]

geocentric coordinate system. See 'World Coordinate System'.

geodetic coordinate system. A measurement system that relates Earth-centered angular latitude and longitude (and optionally height) to an actual point near or on the earth's surface. [9]

geometry. 1. A very abstract class, encapsulating both the concepts of traditional geometry as well as other classes containing measured data and organizational methods used to organize these traditional geometry and other 'real' data classes within a synthetic environment. 2. A geometry primitive such as a point, line, or polygon, or an assembly of such primitives or assemblies.[9] 3. The mathematics of the properties, measurement, and relationships of points, lines, angels, surfaces, and solids. [4]

glass box model. A model whose internal implementation is known and fully visible (e.g., a model of a computerized change-return mechanism in a vending machine, in the form of a diagram of the circuits and gears that make the change); white box model. See black box model. [1, 2]

granularity. See resolution. [3]

graphical model. A symbolic model whose properties are expressed in diagrams (e.g., a decision tree used to express a complex procedure). See mathematical model, narrative model, software model, tabular model. [1, 2]

Greenwich Mean Time (GMT). A measure of time that conforms, within a close approximation, to the mean diurnal rotation of the Earth and serves as the basis of civil time-keeping. Universal time (UT1) is determined from observations of the stars, radio sources, and also from ranging observations of the Moon and artificial Earth satellites. The scale determined directly from such observations is designated Universal Time Observed (UTO); it is slightly dependent on the place of observation. When UTO is corrected for the shift in longitude of the observing station caused by polar motion, the time scale UT1 is obtained. When accuracy better than one second is not required, Universal Time can be used to mean Coordinated Universal Time (UTC), also called "Universal Time [Coordinated]" or "Zulu Time." [24]

ground truth. The actual facts of a situation, without errors introduced by sensors or human perception and judgment. See perceived truth, truth. [1, 3]

guise. A function that provides the capability for an entity to be viewed with one appearance by one group of participants, and with another appearance by another group. [1, 13]

H

heterogeneous. Consisting of or involving dissimilar elements or parts. [14]

heterogeneous network. A collection of simulations with partially consistent behaviors and/or partially correlated data bases (e.g., simulators of different fidelity, mixed virtual and live simulations, and mixes of virtual and constructive simulations). [1]

heuristic. Relating to or using a problem-solving technique in which the most appropriate solution of several found by alternative methods is selected at successive stages of a program for use in the next step of the program. [14]

hierarchical model. A model of information in which data are represented as trees of records connected by pointers. [12]

hierarchy. A ranking or ordering of abstractions. [25]

High Level Architecture (HLA). Major functional elements, interfaces, and design rules, pertaining as feasible to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined. [13]

higher order model (HOM). A computer model representing combat elements, their functions and/or the terrain they operate on in an aggregated manner. A HOM may represent a battalion as a specific entity which is a conglomeration or averaging of the characteristics of its real-world components. "Higher Order" generally refers to echelons battalion and above with greater than 100m resolution (e.g. 3km, and with faster than real-time performance (e.g., days compressed into minutes, hours into seconds)). See war game. [1, 13]

homogeneous network. A network of DIS objects with fully consistent behaviors and fully correlated data bases. [1, 13]

host. A computer that supports one or more simulation applications; host computer. All host computers participating in a simulation exercise are connected by network(s) including wide area networks, local area networks, and RF links. [1, 2]

human-in-the-loop (HITL). A model that requires human interaction. See interactive model. [1]

human-machine simulation. A simulation carried out by both human participants and computers, typically with the human participants asked to make decisions and a computer performing processing based on those decisions. [1]

hybrid simulation. A simulation that combines constructive, live, and/or virtual simulations, typically in a distributed environment. Such simulations typically combine simulators with actual operational equipment, prototypes of future systems, and realistic representations of operational environments. [13]

I

implementation. The means by which a synthetic environment, or portions of a synthetic environment, is realized. [1]

independent time advancement. A means of advancing federate time where advances occur without explicit coordination among federates. Distributed Interactive Simulation uses independent time advancement. [7]

infrastructure. An underlying base or foundation; the basic facilities, equipment, and installations (e.g., systems and applications, communications, networks, architectures, standards and protocols, and information resource repositories) needed for the functioning of a system. [8, 10, 14]

initial condition. The values assumed by the variables in a system, model, or simulation at the beginning of some specified duration of time. See boundary condition, final condition. [1]

initial state. The values assumed by the state variables of a system, component, or simulation at the beginning of some specified duration of time. See final state. [1]

input. 1. An event external to a system that modifies the system in any manner. 2. A variable at the boundary of an organism or machine through which information enters; the set of conditions, properties or states that effects a change in a system's behavior. [36] 3. Something introduced into a system or expended in its operation to attain a result or output. See output, data. [4] 4. The externally-supplied data

to which a simulation responds and from which it calculates its output, e. g., operator controls, weapon detonation, wind speed and direction. [ST] 5. Observables in a natural system that are independent of other observables. See observables, natural system. [GC]

instantiation. To represent an abstraction by a concrete instance. [14]

interaction. An explicit action taken by an object, that can optionally (within the bounds of the Federation Object Model) be directed toward other objects, including geographical areas etc. [7]

interaction parameters. The information associated with an interaction which objects potentially affected by the interaction must receive in order to calculate the effects of that interaction on its current state. [7]

interactive model. A model that requires human participation; human-in-the-loop model. [1]

internal schema. An internal schema describes data as it is physically stored and includes all aspects of the environment in which a database is to reside. [6, 16]

interoperability. The ability of a set of models or simulations to provide services to and accept services from another models or simulations and to use the services so exchanged to enables them to operate effectively together. [3, 8]

J

K

L

latency. 1. The observable delay between stimulus and response. 2. The time interval required by a simulation to respond to a stimulus in excess of the time interval required for the corresponding real world or standard event. 3. The time interval required for a device to begin output of data after presented with a stimulus or stimuli (e.g., input of data, occurrence of an event).

linear network. A geographic entity that defines a linear (one-dimensional) structure (e.g., a river, a road or a state boundary). [9]

littoral region. 1. From seaward, the area from the open oceans to the shore that must be controlled to support operations ashore. From landward, the area inland from the shore that can be supported and defended directly from the sea. [9]

live entity. A perceptible object that can appear in the virtual battlespace but is unaware and non-responsive (either by intent, lack of capability or circumstance) to the actions of virtual entities. See field instrumentation. [1]

live simulation. A simulation involving real people operating real systems. See virtual simulation, constructive simulation. [8]

local area network (LAN). A class of data network that provides high data rate interconnection between network nodes in close physical proximity. [28]

logical verification. The identification of a set of assumptions and interactions for which the model or simulation correctly produces intended results. It determines the appropriateness of the model or simulation for a particular application and ensures that all assumptions and algorithms are consistent with the conceptual model. [29]

long-haul network (LHN). A communications network of devices which are separated by substantial geographical distance. A LHN could be any of numerous networks available commercially or through the

government that can accommodate the requirements of the DIS virtual battlefield for long distance network services; wide area network. [1, 13]

lookahead. A value used to determine the smallest time stamped message using the time stamp ordered service that a federate may generate in the future. If a federate's current time (i.e., federate time) is T, and its lookahead is L, any message generated by the federate must have a time stamp of at least T+L. In general, lookahead may be associated with an entire federate (as in the example just described), or at a finer level of detail e.g., from one federate to another, or for a specific attribute. Any federate using the time stamp ordered message delivery service must specify a lookahead value. [7]

lower bound on the time stamp (LBTS). Lower Bound on the Time Stamp of the next time stamp ordered message to be received by a Runtime Infrastructure from another federate. Messages with time stamp less than LBTS are eligible for delivery by the runtime infrastructure to the federate without compromising time stamp order delivery guarantees. Time stamped ordered messages with time stamp greater than LBTS are not yet eligible for delivery. LBTS is maintained within the runtime infrastructure using a conservative synchronization protocol. [7]

M

machine simulation. A simulation that is executed on a machine. See computer simulation. [1, 2]

Markov chain. A discrete Markov process. [2]

Markov chain model. A discrete, stochastic model in which the probability that the model is in a given state at a certain time depends only on the value of the immediately preceding state; Markov model. See semi-Markov model. [1, 2]

Markov process. A stochastic process that assumes that in a series of random events, the probability for occurrence of each event depends only on the immediately preceding outcome. See semi-Markov process. [1, 2]

message. A data unit transmitted between federates containing at most one event. Here, a message typically contains information concerning an event, and is used to notify another federate that the event has occurred. When containing such event information, the message's time stamp is defined as the time stamp of the event to which it corresponds. Here, a "message" corresponds to a single event, however the physical transport media may include several such messages in a single "physical message" that is transmitted through the network. [7]

mission space. The environment of entities, actions, and interactions comprising the set of interrelated processes used by individuals and/organizations to accomplish assigned tasks. [8]

model. 1. A physical, mathematical, or otherwise logical abstract representation of a system, entity, phenomenon, or process. See simulation, conceptual model, software model, mathematical model. [1, 8, 13] 2. A geometry or feature assembly built in a relative coordinate system with the intent to multiply instances of the assembly at one or more world coordinate positions. [9] 3. A system that stands for or represents another typically more comprehensive system. [36]

modeling. Application of a standard, rigorous, structured methodology to create and validate a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process. [10]

modeling and simulation (M&S). The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably. [13]

model-test-model. An integrated approach to using models and simulations in support of pre-test analysis and planning; conducting the actual test and collecting data; and post-test analysis of test results along with further validation of the models using the test data. [10]

Monte Carlo algorithm. A statistical procedure that determines the occurrence of probabilistic events or values of probabilistic variables for deterministic models (e.g., making a random draw). [10]

Monte Carlo method. In modeling and simulation, any method that employs Monte Carlo simulation to determine estimates for unknown values in a deterministic problem. [1, 2]

Monte Carlo simulation. A simulation in which random statistical sampling techniques are employed such that the result determines estimates for unknown values. [1]

multicast. A transmission mode in which a single message is sent to selected multiple (but not necessarily all) network destinations (i.e., one-to-many). See broadcast, unicast. [1, 2]

N

narrative model. A symbolic model the properties of which are expressed in words (e.g., a

natural environment. The Earth-based environment modeled by a synthetic environment. [9]

network byte order. The Internet-standard ordering of the bytes corresponding to numeric values. [13]

network communication services. The capability provided to electronically transmit modeling and simulation data between networked computational nodes in a manner that meets requirements for transmission latency, multi-cast addressing and security needed to support the creation and operation of distributed time and space coherent synthetic environments. [23]

network filter. A system to selectively accept or reject data received from the network. [1]

network node. A specific network address; node. See processing node. [1]

node. 1. A general term denoting either a switching element in a network or a host computer attached to a network. See processing node, network node. [1, 2] 2. A zero-dimensional primitive used to store a significant location. [9]

non-absorbing state. In a Markov chain model, a state that can be left once it is entered. [1, 2]

non-standard cell. A cell that is not compliant with the Distributed Interactive Simulation message and data base standards. Non-standard cells require a Cell Adapter Unit in order to join a Distributed Interactive Simulation exercise. [1, 13]

non-standard data element. Any data element that exists in a system or application program and does not conform to the conventions, procedures, or guidelines established by the organization. [15]

notional data. Speculative or theoretical data rather than actual data. [3]

O

object. A fundamental element of a conceptual representation for a federate that reflects the "real world" at levels of abstraction and resolution appropriate for federate interoperability. For any given value of time, the state of an object is defined as the enumeration of all its attribute values. [7]

observable. 1. Capable of being observed systematically or scientifically; discernible. 2. A physical property, such as temperature or weight, that can be observed or measured directly. [4] 3. A state

variable, computable by a function or functions, or mathematical relation(s). [FH] 4. A function that maps a subset of the real world states into the set of real numbers. See natural system. [GC]

occlusion. 1. The effect of closer objects overlapping or obscuring more distant ones thus preventing the observation of parts or all of the distant objects and so providing clues to judge how close objects are from the viewer. [31] 2. The process of preventing the passage of something; obstruction. [4]

octet. A sequence of eight bits, usually manipulated as a unit. [13]

operational environment. A composite of the conditions, circumstances, and influences that affect the employment of military forces and the decisions of the unit commander. Frequently characterized as permissive, semi-permissive, or non-permissive. [1]

optimistic synchronization. A mechanism that uses a recovery mechanism to erase the effects of out-of-order event processing (e.g., the Time Warp protocol). Messages sent by an optimistic federate that could later be canceled. See conservative synchronization. [1]

original data. The source data used by a resource producer to construct their initial synthetic environment representation. [9]

output. 1. Any change produced in the surroundings by a system. 2. A variable at the boundary of an organism or machine through which information exits; the products, results or the observable parts of system behavior. [36] 3. The data produced by a computer from a specific input. See input, data. [4] 4. The aspects of the simulated system being modeled; calculated during each pass in response to inputs and time passing, normally output for external use; values providing a snap-shot of the current state of the simulated system, e.g., position, velocity, alive-or-dead. [ST] 5. An observables in a natural system that depends on some other observables. See observables, natural system. [GC]

output validation. The process of determining the extent to which the output (outcome distributions for the models, simulations and/or sub-models) represent the significant and salient features of distributions or real world systems, events, and scenarios. [29]

P

parallax. 1. The vision effect of having two eyes viewing the same scene from slightly different positions that creates a sense of depth. Computer-generated environments, one for each eye, can artificially create the parallax effect. [31] 2. An apparent change in the direction of an object, caused by a change in the observational position that provides a new line of sight. [4]

parameter. 1. A constant or variable that distinguishes special cases of a general mathematical expression, e.g., the general form of the equation for a line, $y = mx + b$ contains the parameters m and b, representing the gradient and y-intercept of any specific line. [35] 2. A constant in a mathematical program , not subject to choice in the decision problem, but one that could vary outside the control of the decisions. [37] 3. That which determines the structure of a system. Parameters themselves can be changed by inputs, but usually the parameters determine how input will be transformed into outputs. [36] 4. Observables in a natural system that remain constant for every state. [GC]

parametric model. A model using parametric equations that may be based on numerical model outputs or fits to semi-empirical data to succinctly describe a particular process, feature, or effect. [13]

perceived truth. That subset of ground truth acquired or distorted by sensors, human perception or judgement; the situation as perceived by an observer. See ground truth, perception, truth.

perception. 1. An observer's awareness or appreciation of objects, processes or situations in his environment mediated through their sensory organs. 2. An observer's descriptions, hypotheses or constructs of the world of which they become thereby a part. [36] 3. To take notice of; observe. [4]

period. The time interval between successive events in a discrete simulation. [1, 2]

pixel. A "picture element," referring to the smallest visual unit in an image on a computer display. [31]

platform. A generic term describing a level of representation equating to vehicles, aircraft, missiles, ships, fixed sites, etc., in the hierarchy of representation possibilities. Other representation levels include units (made up of platforms) and components or modules (which make up platforms). [1, 13]

point feature. A geographic entity defining a zero-dimensional location (e.g., a well or a building). [9]

polygon. 1. A flat plane figure with multiple sides, the basic building block of virtual worlds. The more polygons a computer can display and manipulate per second, the more realistic the virtual world will appear. Humans perceive the equivalent of 80 million polygons at more than 30 frames per second in normal vision. [31] 2. Thematically homogenous areas composed of one or more faces. [9]

positional accuracy. The root mean square error (RMSE) of the coordinates relative to the position of a real world entity being modeled. Positional accuracy shall be specified without relation to scale and shall contain all errors introduced by source documents, data capture and data processing. [9]

precision. 1. The quality or state of being clearly depicted, definite, measured or calculated. 2. A quality associated with the spread of data obtained in repetitions of an experiment as measured by variance; the lower the variance, the higher the precision. [35] 3. A measure of how meticulously or rigorously computational processes are described or performed by a model or simulation.

probabilistic model. See stochastic model. [1]

process. 1. Something that affects entities (e.g., attrition, communications, and movement). Processes have a level of detail by which they are described. [18] 2. A system of operations in producing something. 3. A series of actions, changes, or functions that achieve an end or result. [4]

projected coordinate system. An instantiation of a coordinate transformation; a planar, right-handed Cartesian coordinate set which, for a specific map projection, has a single and unambiguous transformation to a geodetic coordinate system. [9]

protocol. A set of rules and formats (semantic and syntactic) that define the communication behavior of simulation applications. [1, 2]

Protocol Data Unit (PDU). Distributed Interactive Simulation terminology for a unit of data that is passed on a network between simulation applications. [8]

protocol entity. An object that exchanges information with other protocol entities in a network via Protocol Data Units in accordance with an established protocol. A key attribute of a protocol entity is its state. State transitions occur in a given protocol entity in accordance with the established protocol as the result of: a. Protocol Data Units received from other protocol entities, and b. occurrence of an external event (e.g., expiration of a time-out counter.) See Protocol Data Unit. [1]

protocol suite. A defined set of complementary protocols within the communication architecture profile. [13]

Q

qualitative data. A non-numeric description of a person, place, thing, event, activity, or concept. [15]

quantitative data. Numerical expressions that use Arabic numbers, upon which mathematical operations can be performed. [15]

R

random. Pertaining to a process or variable whose outcome or value depends on chance or on a process that simulates chance, often with the implication that all possible outcomes or values have an equal probability of occurrence (e.g., the outcome of flipping a coin or executing a computer-programmed random number generator). [1, 2]

real battlefield. See real-world. [1]

real-time. In modeling and simulation, simulated time advances at the same rate as actual time (e.g., running the simulation for one second results in the model advancing time by one second). See fast time, slow time. [1]

real-time service. A service that satisfies timing constraints imposed by the service user. The timing constraints are user specific and should be such that the user will not be adversely affected by delays within the constraints. [13]

real-time simulation. See constrained simulation. [7]

real-time system. A system that computes its results as quickly as they are needed by a real-world system. Such a system responds quickly enough that there is no perceptible delay to the human observer. In general use, the term is often perverted to mean within the patience and tolerance of a human user. [14]

real-world. The set of real or hypothetical causes and effects that simulation technology attempts to replicate. See real battlefield. [1] The real world defines one standard against which fidelity is measured that includes both imagined reality and material reality in order to accommodate assessment of simulation fidelity when future concepts and systems are involved. See fidelity, imagined reality, material reality.

real-world time. The actual time in Greenwich, Great Britain; sidereal time. [1, 2]

reality. The quality or state of being actual or true. [4]

remote entity approximation (REA). The process of extrapolating and interpolating any state of an entity based on its last known state including dead reckoning and smoothing. See dead reckoning. [1]

representation. 1. Something that stands in place of or is chosen to substitute for something else, e.g., representation of constituencies in government, linguistic representation of an event. [36] 2. Something that describes as an embodiment of a specified quality. [4] 3. The homomorphism of a group of abstract symbols into a group of more familiar objects. [35] 4. A model or simulation. [GC]

resolution. 1. The degree of detail used to represent aspects of the real world or a specified standard or referent by a model or simulation. 2. Separation or reduction of something into its constituent parts; granularity. [4]

retraction. An action performed by a federate to unschedule a previously scheduled event. Event retraction is visible to the federate. Unlike "cancellation" that is only relevant to optimistic federates such as Time Warp, "retraction" is a facility provided to the federate. Retraction is widely used in classical event oriented discrete event simulations to model behaviors such as preemption and interrupts. [7]

Right-Hand Rule. Positive rotation is clockwise when viewed toward the positive direction along the axis of rotation. [1]

S

scalability. The ability of a distributed simulation to maintain time and spatial consistency as the number of entities and accompanying interactions increase. [8]

scenario. 1. Description of an exercise. 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 time line of significant events imposed on trainees or systems to achieve exercise objectives. [1, 2] 3. An identification of the major entities that must be represented by the federation, a conceptual description of the capabilities, behavior, and relationships (interactions) between these major entities over time, and a specification of relevant environmental conditions (e.g., terrain, atmospherics). Initial and termination conditions are also provided. The style of format of the scenario documentation (e.g., graphics, tables, text) is entirely at the discretion of the federation developer. However, communities of use may wish to establish scenario documentation standards among themselves to facilitate reuse of scenario components. [7] 4. A part of the modeling and simulation database that contains the force structure, its mission and plans, and the terrain area in which the simulated engagement occurs. [32]

scenario development. A phase of the development of a federation during which the federation developer(s) formulate a scenario whose execution and subsequent evaluation will lead toward achieving the study objectives set forth by the federation sponsor. The output of this phase is a functional-level scenario description, which is provided as input to the Conceptual Analysis phase. Certain key activities during Conceptual Analysis may also drive reiterations of the Scenario Development phase. [7]

seamless. 1. Perfectly consistent. 2. Transparent. [3]

Semi-Automated Forces (SAFOR). Simulation of friendly, enemy and neutral platforms on the virtual battlefield in which the individual platform simulation are operated by computer simulation of the platform crew and command hierarchy. The term "semi-automated" implies that the automation is controlled and monitored by a human who injects command-level decision making into the automated command process. See also: computer-generated forces. [10]

session. A portion of an exercise that is contiguous in wall-clock (sidereal) time and that is initialized per an exercise database. [1, 2]

sidereal time. 1. Time based upon the rotation of the Earth relative to the vernal equinox. 2. Time that is independent of simulation clocks, time zones, or measurement errors; the ground truth of time measurement. See real world time. [33]

simulated time. Time as represented within a simulation; virtual time. See fast time, real-time, slow time. [2]

simulation. 1. A method for implementing a model to determine how key properties of the original may change over time. [8] 2. An unobtrusive scientific method of inquiry involving experiments with a model rather than with the portion of reality this model represents. See representation. [36]

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, analysis, or experimentation. Examples include manned vehicle (virtual) simulators, computer generated forces (constructive), environment simulators, and computer interfaces between a Distributed Interactive Simulation network and real (live) equipment. The simulation application receives and processes information concerning entities created by peer simulation applications through the exchange of Distributed Interactive Simulation Protocol Data Units. More than one simulation application may simultaneously execute on a host computer. 2. The application layer protocol entity that implements standard Distributed Interactive Simulation protocol. [1, 2]

simulation clock. A counter used to accumulate simulated time. [1, 2]

simulation entity. An element of the synthetic environment that is created and controlled by a simulation application through the exchange of Distributed Interactive Simulation Protocol Data Units (e.g., tanks, submarines, carriers, fighter aircraft, missiles, bridges). A simulation application may control more than one simulation entity. [1, 2]

simulation environment. 1. The operational environment surrounding the simulation entities including terrain, atmospheric, bathyspheric and cultural information. 2. All conditions, circumstances, and influences surrounding and affecting simulation entities including those stated in 1. [1]

simulation game. A simulation in which the participants seek to achieve some agreed-upon objective within an established set of rules (e.g., a management game, a war game); gaming simulation . The objective may not be to compete, but to evaluate the participants, increase their knowledge concerning the simulated scenario, or achieve other goals. [1, 2]

simulation management. A mechanism that provides centralized control of the simulation exercise including start, restart, maintenance, shutdown of the exercise, and collection and distribution of certain types of data. [1, 2]

simulation process. The imitative representation of the actions of platform(s), munitions(s), and life form(s) by computer program(s) in accordance with a mathematical model and the generation of associated battlefield entities that may be fully automated or partially automated. [1]

simulation support entity. Processing modules used to support, control, or monitor the simulation environment, but which do not actually exist on the battlefield including battlefield viewing devices for controllers or exercise observers such as the stealth vehicle, the plan view display, after action review systems, and simulation control systems. [1, 13]

simulation time. 1. A simulation's internal representation of time which may accumulate faster, slower, or at the same pace as sidereal time. 2. The reference time (e.g., Universal Coordinated Time) within a simulation exercise, this time is established by the simulation management function before the start of the simulation and is common to all participants in a particular exercise. [1, 2]

simulator. 1. A device, computer program, or system that performs simulation. 2. For training, a device which duplicates the essential features of a task situation and provides for direct human operation. [1]

SISO. Simulation Interoperability Standards Organisation. http://www.sisostds.org/

six degrees of freedom (6 DOF). The number of simultaneous directions or inputs a sensor can measure typically used to describe the combination of spatial positions (X, Y, Z) and orientation (roll, pitch, yaw). [31]

slow time. The duration of activities within a simulation in which simulated time advances slower than actual time. [1]

smoothing. Interpolation of the previous state of an entity (location, velocity, etc.) to the current state, creating a smoothed transition between two successive entity state updates. [1]

space representation. Representation of the regions beyond the upper boundary of the troposphere (including ionosphere) including data on neutral and charged atomic and molecular particles (including their optical properties). [9]

stability. 1. Constancy of purpose; steadfastness. 2. Reliability; dependability. [5] 3. Resistance to sudden change, dislodgment or overthrow. [4]

standard. 1. An accepted measure of comparison for quantitative or qualitative value; a criterion. [4] 2. Proposition of a norm or general pattern to be followed when constructing, operating or testing a

(technical) device. A standard contains a set of reference criteria for functional, structural, performance or quality aspects of a device or for any combination of these. [36]

state. 1. The internal status of a simulation entity (e.g. fuel level, number of rounds remaining, location of craters). 2. A condition or mode of existence that a system, component, or simulation may be in (e.g., the pre-flight state of an aircraft navigation program or the input state of given channel). 3. The values assumed at a given instant by the variables that define the characteristics of a system, component, or simulation; system state. See final state, initial state, steady state. [1]

stimulate. To provide input to a system in order to observe or evaluate the system's response. [1, 2]

stimulation. The use of simulations to provide an external stimulus to a system or subsystem (e.g., using a simulation representing the radar return from a target to drive (stimulate) the radar of a missile system within a hardware/software-in-the-loop simulation). [10]

stimulator. 1. A hardware device that injects or radiates signals into the sensor system(s) of operational equipment to imitate the effects of platforms, munitions, and environment that are not physically present. 2. A battlefield entity consisting of hardware and/or software modules that injects signals directly into the sensor systems of an actual battlefield entity to simulate other battlefield entities in the virtual battlefield. [1]

stochastic. Pertaining to a process, model, or variable whose outcome, result, or value depends on chance. See deterministic. [1, 2]

stochastic model. A model in which the results are determined by using one or more random variables to represent uncertainty about a process or in which a given input will produce an output according to some statistical distribution (e.g., a model that estimates the total dollars spent at each of the checkout stations in a supermarket, based on probable number of customers and probable purchase amount of each customer); probabilistic model. See Markov-chain model, deterministic model. [1]

symbology. A graphic representation of concepts or physical objects. [22]

synthetic battlefield. One type of synthetic environment. [8]

synthetic environments (SE). Inter-networked simulations that represent activities at a high level of realism from simulations of theaters of war to factories and manufacturing processes. These environments may be created within a single computer or a vast distributed network connected by local and wide area networks and augmented by super-realistic special effects and accurate behavioral models. They allow visualization of and immersion into the environment being simulated. [8, 23]

synthetic environment database. An integrated set of data elements, each describing some aspect of the same geographical region and the elements or events expected there. [9]

T

T-1. Data communications service that supports 1.544 megabits per second bandwidth. [28]

T-2. Data communications service that supports 45 megabits per second bandwidth. [28]

terrain representation. The configuration, composition, and representation of the surface of the earth, including its relief, natural features, permanent or semi-permanent man-made features, related processes, terrain coverage including seasonal and diurnal variation such as grasses and snow, foliage coverage, tree type, and shadow. The terrain surface includes inland waters, and the sea floor bottom to the 20 meter depth curve. [9]

terrain skin. The physical conformation of the Earth's surface. [9]

textures. Application of surface detail to a polygon by mapping an image to the polygon (i.e., to show foliage on a polygon to represent a tree) [9]

three-dimensional (3-D). A visual display that exhibits breadth, height and thickness or depth. [31]

tile. A spatial partition of a coverage that shares the same set of feature classes with the same definitions as the coverage. [9]

time. The measurable aspect of duration. Time makes use of scales based upon the occurrence of periodic events. These are: the day, depending on the rotation of the Earth; the month, depending on the revolution of the Moon around the Earth; and the year, depending upon the revolution of the Earth around the Sun. Time is expressed as a length on a duration scale measured from an index on that scale (e.g., 4 p.m.). Local mean solar time means that 4 mean solar hours have elapsed since the mean Sun was on the meridian of the observer. [7]

time stamp (of an event). A value representing a point on the federation time axis that is assigned to an event to indicate when that event is said to occur. Certain message ordering services are based on this time stamp value. In constrained simulations, the time stamp may be viewed as a deadline indicating the latest time at which the message notifying the federate of the event may be processed. [7]

time stamp order (TSO). A total ordering of messages based on the "temporally happens before" ($-->_t$) relationship. A message delivery service is said to be time stamp ordered if for any two messages M_1 and M_2 (containing notifications of events E_1 and E_2, respectively) that are delivered to a single federate where $E_1 -->_t E_2$, then M_1 is delivered to the federate before M_2. The Runtime Infrastructure ensures that any two time stamp ordered messages will be delivered to all federates receiving both messages in the same relative order. To ensure this, the Runtime Infrastructure uses a consistent tie-breaking mechanism to ensure that all federates perceive the same ordering of events containing the same time stamp. Further, the tie-breaking mechanism is deterministic, meaning repeated executions of the federation will yield the same relative ordering of these events if the same initial conditions and inputs are used, and all messages are transmitted using time stamp ordering. [7]

topology. 1. time-tested technique for storing a variety of relationship information amongst features that allows you to quickly answer certain types of questions. 2. Any relationship between connected geometric primitives that is invariant under transformation by continuous mappings. [9]

transmit management. The control of the transmission rate to match the transmission media. The transmission rate is selected to reduce total network traffic. [1]

transportation service. A Runtime Infrastructure provided service for transmitting messages between federates. Different categories of service are defined with different characteristics regarding reliability of delivery and message ordering. [7]

truth. 1. Conformity to fact or actuality. 2. Fidelity to an original or standard. 3. Reality; actuality. 4. A statement proven to be or accepted as true. [4] 5. A property implicitly ascribed to a proposition by belief in or assertion of it; the denial is "falsity". 6. In the verification theory of truth, a correspondence between the proposition and the events, properties or objects to which it refers linguistically or operationally. 7. In the logical theory of truth, the coherence between that proposition and other propositions. 8. In the constructivist theory of truth, constructability implying the absence of paradox and contradiction. [36]

two-dimensional (2-D). A visual display that exhibits only height and breadth (e.g., computer images and television). [31]

U

unbundling. The process of unpacking a bundled Protocol Data Unit into multiple separate Protocol Data Units. See bundling. [1]

unicast. A transmission mode in which a single message is sent to a single network destination (i.e., one-to-one). [1, 13]

unit. 1. An aggregation of entities. 2. A basis of measurement. [1, 2]

unit conversion. A system of converting measurement from one basis to another (e.g., English/metric, knots/feet per second). [1]

Universal Transverse Mercator projection. An ellipsoidal Transverse Mercator Projection to which specific parameters, such as central meridians, have been applied. The Earth, between latitudes 84.0 degrees North and 80.0 degrees South, is divided into 60 zones each generally 6 degrees wide in longitude. [9]

Universal Time [Coordinated] (UTC). Greenwich Mean Time. A nonuniform time based on the rotation of the Earth, which is not constant; Coordinated Universal Time. [7]

Universal Space Rectangular (USR) Coordinate System. A right-handed orthogonal coordinate system with its origin at the center of the Earth, positive x-axis in the equatorial plane and passing through the zero degree meridian, positive y-axis in the equatorial plane and passing through the ninety degree east meridian, and positive z-axis passing through the North Pole. [33]

user. Persons or organizations that are or will be the recipients of simulation products or services, and who, as a result of this position, may be involved in the evolution of such products or services.

V

validation. The process of determining the degree to which a model or simulation is an accurate representation of the real-world from the perspective of the intended uses of the model or simulation. [27]

validity. 1. The quality of maintained data that is found on an adequate system of classification (e.g., data model) and is rigorous enough to compel acceptance for a specific use. 2. The quality of being inferred, deduced or calculated correctly enough for a specific application.

verification. The process of determining that a model or simulation implementation accurately represents the developer's conceptual description and specification. Verification also evaluates the extent to which the model or simulation has been developed using sound and established software engineering techniques. [8]

vignette. A self-contained portion of a scenario. [1]

virtual. 1. The essence or effect of something, not the fact. [31] 2. Existing or resulting in effect or essence though not in actual fact, form, or name. [4]

virtual battlespace. The illusion resulting from simulating the actual battlespace. [1]

virtual prototype. A model or simulation of a system placed in a synthetic environment, and used to investigate and evaluate requirements, concepts, system design, testing, production, and sustainment of the system throughout its life cycle. [8]

virtual simulation. A simulation involving real people operating simulated systems. Virtual simulations inject human-in-the-loop in a central role by exercising motor control skills (e.g., flying an airplane), decision skills (e.g., committing fire control resources to action), or communication skills (e.g., as members of a C4I team). See live simulation, virtual simulation, constructive simulation. [8]

virtual time. See simulated time. [1]

virtual world. See synthetic environment. [1]

visualization. The formation of an artificial image that cannot be seen otherwise, typically, abstract data that would normally appear as text and numbers is graphically displayed as an image. The image can be animated to display time varying data. [31]

W

wall clock time. A federate's measurement of true global time, where the measurement is typically output from a hardware clock. The error in this measurement can be expressed as an algebraic residual between wall clock time and true global time or as an amount of estimation uncertainty associated with the wall clock time measurement software and the hardware clock errors. [7]

wide area network (WAN). A communications network designed for large geographic areas. [1, 2]

World Coordinate System. The right-handed geocentric Cartesian system. The shape of the world is described by the World Geodetic System 1984 standard. The origin of the world coordinate system is the centroid of the Earth. The axes of this system are labeled X, Y, and Z, with: the positive X-axis passing through the Prime Meridian at the Equator; the positive Y-axis passing through 90 degrees East longitude at the Equator; and the positive Z-axis passing through the North Pole. [1, 2]

World Geodetic System 1984 (WGS 84). A geocentric coordinate system which describes a basic frame of reference and geometric figure for the Earth, and which models the Earth from a geometric, geodetic, and gravitational standpoint. The WGS 84 coordinate system origin and axes also serve as the x, y, and z axes of the WGS 84 ellipsoid, the z axis being the rotational axis. [34]

X, Y & Z

yoked variable. One of two or more variables that are dependent on each other in such a manner that a change in one automatically causes a change in the others. [1, 2]

4 Acronyms and Abbreviations

CC Conference Committee. The element of SISO responsible for developing and presenting Simulation Interoperability Workshops throughout the year.

DIS Distributed Interactive Simulation

EXCOM Executive Committee

IEEE Institute of Electrical and Electronics Engineers. The IEEE is a professional society that also has an affiliated standards organization that develops international standards in a manner similar to SISO's. IEEE's relationship to SISO includes that the SAC is also a Sponsor of IEEE standards under the Institute of Electrical and Electronics Engineers Computer Society Standards Activity board (IEEE-CS SAB).

PDG Product Development Group

PDU Protocol Data Unit. The message formats that carry information between simulations.

SAC Standards Activity Committee. The element of SISO responsible for developing the processes, procedures, and guidelines for standards development.

SISO Simulation Interoperability Standards Organization. SISO is a public, charitable organization (IRS 503©) that encourages the development of interoperable simulation through discussion of technology standards. SISO has three elements: the EXCOM, the CC, and the SAC.

5 DIS Plain and Simple

First, let's define DIS. DIS stands for Distributed Interactive Simulation and consists of the connecting of simulations using a series of messages called Protocol Data Units (PDUs) which have specific formats and contain specific information about individual players in an exercise.

DIS is defined in a set of international standards known as IEEE Standard 1278.

The way they do that is by sending a group of agreed upon messages back and forth to each other over some kind of physical media. (The media could be anything from a telephone line, to a wireless LAN, to an Asynchronous Transfer Mode (ATM) WAN.) (More about networks later.) The messages tell the other simulations where the various things in your simulation are located, what they are, and what they are doing. If they are moving, then the things will have a speed and their location will change. The things that you define in your simulation that interact with each other are called Entities. Information about the current state of each entity is passed in a message called (cleverly named) an Entity State message. The various messages that can be sent are called Protocol Data Units, or PDUs, and, in addition to telling location and movement, there are PDUs that define and declare the interaction between entities such as Fire, Detonation, IFF, emissions, and other things.

If you forget the meaning of some of the specialist words that we use throughout DIS Plain and Simple, don't worry. There is a glossary of many of the DIS application specific terms in Sec. 3 of this document.

5.1 History

Distributed Interactive Simulation (**DIS**) is a standard for conducting real-time platform-level wargaming across multiple host computers. The standard was developed over a series of "DIS Workshops" at the Interactive Networked Simulation for Training symposium, held by the University of Central Florida's Institute for Simulation and Training (IST). The standard itself is very closely patterned after the original SIMNET distributed interactive simulation protocol, developed by Bolt Beranek and Newman for Defense Advanced Research Project Agency in the early through late 1980's. BBN introduced the critical concept of dead reckoning to efficiently transmit the state of battle field entities, as well implementing DARPA's vision of simulations involving inexpensive general purpose computers (vs. 6DOF motion platforms and/or supercomputers), hundreds of online players (not just the 'onesies and twosies' which had been done before), wherein the realism and training value came not from high-fidelity simulation of vehicle dynamics but by the real time play with lots of intelligent allies and lots of intelligent opponents.

In the early 1990's, IST was contracted by the United States Defense Advanced Research Project Agency to undertake research in support of the US Army Simulator Network (SimNet) program. Funding and research interest for DIS standards development decreased following the proposal and promulgation of its successor, the High Level Architecture (HLA, initially entitled DIS++), in 1996. HLA was produced by the merger of the DIS protocol with the Aggregate Level Simulation Protocol (ALSP) designed by Mitre.
There was a NATO standardisation agreement (STANAG 4482, *Standardised Information Technology Protocols for Distributed Interactive Simulation (DIS)*, adopted in 1995) on DIS for modelling and simulation interoperability, but this was also abandoned in favour of HLA as early as 1998. The first draft HLA STANAG ran afoul of administrative procedures when it changed sponsors within NATO, which forced the process to start all over again at square one —which is why the HLA STANAG (4603) is still at the draft stage.

DIS is defined under IEEE Standard 1278:

IEEE 1278-1993 - Standard for Distributed Interactive Simulation - Application protocols
IEEE 1278.1-1995 - Standard for Distributed Interactive Simulation - Application protocols
IEEE 1278.1-1995 - Standard for Distributed Interactive Simulation - Application protocols - Errata (May 1998)
IEEE 1278.1A-1998 - Standard for Distributed Interactive Simulation - Application protocols

IEEE-1278.2-1995 - Standard for Distributed Interactive Simulation - Communication Services and Profiles
IEEE 1278.3-1996 - Recommended Practice for Distributed Interactive Simulation - Exercise Management and Feedback
IEEE 1278.4-1997 - Recommended Practice for Distributed Interactive - Verification Validation & Accreditation
IEEE 1278.5-XXXX - Fidelity Description Requirements (never published)

In addition to the IEEE standards, the Simulation Interoperability Standards Organization (SISO) maintains and publishes an enumerations and bit encoded fields document yearly. This document is referenced by the IEEE standards.

The DoD, and in particular the USAF's Distributed Mission Operations Center (*DMOC*), continues to advance the DIS protocol and SISO, a sponsor committee of the IEEE, promulgates improvements in DIS. Contrary to some people's opinions (and desires), DIS is not dead, but is alive and well and working just fine.

In 1992, following the success of SIMNET, DARPA began developing a method for transmitting information about various simulators to each other which would become known as Advanced Distributed Simulation (ADS). The method chosen was to define a series of specific messages that would carry the necessary information. The first major exercise ever conducted using the defined series of messages was called Zen Regard. The series of messages became known as Distributed Interactive Simulation Protocol Data Units (DIS PDUs).

The first series of messages was limited. The primary message is called an Entity State message and includes information about the force, type, location, velocity, orientation, appearance, and capabilities. To conduct operational activities, Fire and Detonation PDUs are also necessary. Fire PDUs carry information on: who fired, the target, munition type, location fired from, munition type, warhead, fuse, quantity and rate of fire, initial velocity of the munition, and fire control solution range. Detonation PDUs include target, detonation location, type of munition, warhead, fuse, quantity and rate of fire, velocity at detonation, and detonation result if known.

As more sophisticated exercises were attempted, additional PDUs were added to the list. The ability to start and stop exercises led to the development of Start/Resume and Stop/Freeze PDUs. Many simulation management PDUs have been developed to pass information about the state of the simulators playing in an exercise. Aspects such as IFF and jamming have required the addition of PDUs for those functions. A total of 67 PDUs are defined in the current IEEE DIS standard (IEEE 1278.1A-1998).

Each revision of the DIS standard is identified by a version number that is reported within each PDU. Table 1 provides a summary of the version numbers.

Table 1: Summary of protocol versions

Version	Document Description	Publication	No. of PDUs
1	Standard for Distributed Interactive Simulation - Application Protocols, Version 1.0 Draft	1992	10
2	IEEE 1278.1-1993	1993	10
3	Standard for Distributed Interactive Simulation - Application Protocols, Version 2.0 Third Draft	1993	27
4	Standard for Distributed Interactive Simulation - Application Protocols, Version 2.0 Fourth Draft	1994	27
5	IEEE 1278.1-1995	1995	27
6	IEEE 1278.1A-1998 (amendment to IEEE 1278.1-1995)	1998	67

5.2 DIS as a Language

Perhaps the most appropriate analogy for DIS and PDUs is to picture a group of people (simulations) who all speak different languages sitting around a table together (on a network). In order to communicate, they first need a common language (protocol). All people (simulations) communicate, but they may not all use the same language (protocol). Some people may speak the common language (protocol) natively, others will need someone to translate (a gateway). When a person (simulation) speaks in this common language (protocol), they pass messages or sentences (PDUs) to other people (simulations). Even if a person (simulation) claims to speak the common language (protocol), they may not speak the same dialect as all the others; hence these subtle differences in language must be worked out between the people (during integration testing). When these people (simulations) speak in this common language (protocol),

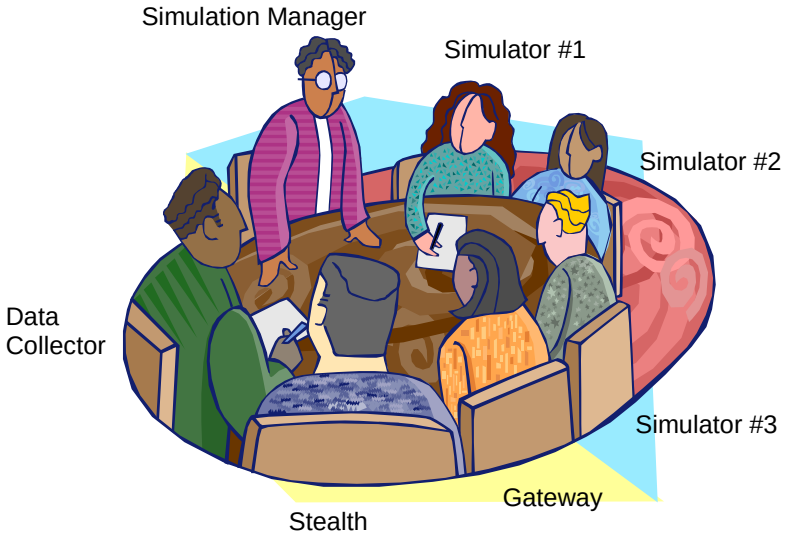

Figure 1 - A Typical DIS Group

they pass messages (PDUs) to everyone else in the room (broadcast). What the other people (simulations) choose to do with these messages (PDUs) is up to them - they may ignore all except what they are interested in. When a person (simulation) tells (sends a PDU) the other people (simulations) about something, that person may not fully describe the object. The people (simulations) receiving the message (PDU) must interpret what that object means to them (radar cross section, visual database, electronic cross section, etc.)

5.3 Assumptions

Before we continue, you need to understand that there is a set of assumptions that permit DIS to work. They were agreed to and incorporated as part of the standard. The assumptions, called the basic architecture, are an extension of the Simulator Networking (SIMNET) program of the late 1980s developed by the Advanced Research Project Agency (ARPA). The basic architecture concepts for DIS, and their implications as they apply to DIS, are:

5.3.1. No central computer controls the entire simulation exercise

Some simulation systems 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.

5.3.2. Autonomous simulation applications are responsible for maintaining the state of one or more simulation entities.

Simulation applications (or simulations) are autonomous and generally responsible for maintaining the state of at least one entity. In some cases, a simulation application will be responsible for maintaining the state of several entities.

5.3.3. Perception of events or other entities is determined by the receiving application.

In other words, you determine the effect of any interaction that you receive.

5.3.4. Dead reckoning algorithms are used to reduce communications processing.

A method of position and orientation extrapolation, called dead reckoning, is used to limit the rate at which simulations must issue state updates for an entity.

5.4 DIS Exercises

When a simulation receives the PDUs from another simulation application called a Host and, perhaps from another location called a Site, it converts the information in the PDUs into information that it can understand. Some sites receive the PDUs from a Wide Area Network on a special Gateway that they built and change them to more usefully formatted data. 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 via a network. As new host computers are added to the network, each new host computer brings its own resources.

As you operate controls in the simulated or actual equipment, your simulation is responsible for modeling the resulting actions of the entity using a simulation model. Your 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 of interest from other simulations and maintaining a model of the state of entities represented in the simulation exercise. Simulations may 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.

All simulators treat the data from other sites in exactly the same way that they treat data from the local host; they can "see" it with their sensor models and react appropriately. If the entity is friendly, you might want to communicate with it via the Communications PDUs. If you have identified the entity as an enemy and have a weapon, like a missile or a gun, you can shoot at the target. If you fire at it, a Fire PDU is then sent to the other site or host to inform it that you fired a weapon at their entity. . Conversely, a Denotation PDU is sent when the projectile (e.g. missile, bullet, shell) impacts with the target or terrain object, and ceases to exist within the simulation. The other site then decides whether our missile was close enough to damage their track. If so, then they send us an Entity State PDU that indicates their entity was damaged or killed or, perhaps nothing at all happened.

To reduce the amount of messages on the network, Entity State PDUs (which make up over 70% of the message traffic in some exercises) are only sent when the entities have moved a specified amount in any dimension, significantly changed their attitude or moved an attached part like a turret, arm or antenna. Even if none of these things has happened each entity must be updated every few seconds (usually, 5). The way you know when the entities have moved enough is that you dead-reckon their positions based on the information in the last entity state PDU. If the actual location or condition disagrees with the dead reckoned position by the specified amount, then we send another PDU. Everyone else does the same thing.

Each host computer maintains two models of each entity that it has control over, one high fidelity model and one dead-reckoned model. The host compares the difference between the two models to a threshold value and sends an Entity State PDU to remote simulations only when the difference exceeds the

threshold. Every simulation site maintains a dead reckoned model of every entity which will have an affect on the local simulation regardless of whether it was originated locally or was received from a remote site.

Before we can run an exercise with another facility, we have to have a meeting to agree on the numbers we will pass back and forth to tell each other what types of platforms we are using, how often we will update state, what information we will include in interaction PDUs, and other aspects. Some of this is defined in the Enumeration tables. Enumerations are values that we all agree represent specific information, for instance a one (1) in a field might represent a friendly vehicle while a two (2) represents an opposing vehicle.

A typical military exercise would consist of two or more simulators running at different sites communicating over a network. A Local Area Network (LAN) could be any media that can conduct UDP/IP traffic. A WAN can be any media that can carry the volume of traffic (Bandwidth). This has traditionally been a T-1 or DSI phone line; but could also be an ATM cloud or microwave link.

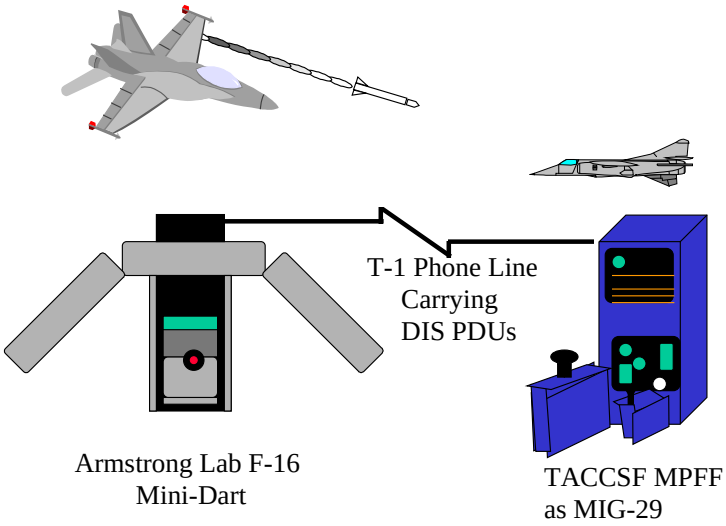

Figure 2 - A typical Exercise

The positions of the two simulators are passed in Entity State PDUs. When the two simulators approach close enough to be seen on one or the other's sensors (this could include visual, IR or radar), the radar cross section is compared by the environment generator and found sufficient. When the two simulators are within firing range, one simulator fires a missile at the other, causing a Fire PDU to be sent. Position updates on all three entities, the two simulators plus the missile are then passing over the DIS WAN. At some point, the process flying the missile decides that it is time to detonate and sends a Detonation PDU with the position of the missile at time of detonation. The owner of the simulator which was fired upon then determines whether the missile was close enough to the simulator to damage or destroy it and sends out an Entity State reporting that condition. The simulator may then be removed from the exercise if it was destroyed by the missile.

5.5. Coordination of Site, Application, and Entity IDs.

The use of all site, application, and entity IDs should be coordinated before the start of a DIS exercise. It is especially important for these to be configuration managed for exercises that will be logged and used for analysis. These IDs will be used for identifying simulation management originating and receiving entities. Lists of these values should be available to all participants for use before and during exercises. In the case of CGF systems, ranges of entity IDs should be specified. Use of IDs that have not been registered should be considered invalid and should fail pre-exercise interoperability testing.

5.5.1. Site IDs. In a multi-site DIS exercise, new site IDs should, where feasible, correspond to site IDs previously assigned for use with the Defense Simulation Internet (DSI) or at I/ITSEC DIS demonstrations.

5.5.2. Application IDs. Application IDs should be defined so that each simulation application that can respond to simulation management PDUs will have a unique application ID. Setting the assignment of IDs at this level of granularity allows the direct control of simulation applications by the SM. These application IDs should be maintained for at least the duration of a configuration managed set of DIS exercises, if not permanently.

5.5.3. Entity IDs. Simulation entities should maintain the same entity ID for the duration of an exercise or set of related exercises (or for as long as is needed to maintain traceability). Practically, this means that an entity ID should be unique at least from the time the simulation applications Receive the fist exercise start command to the time that they receive the last exercise stop command (This definition may be different if the create and Remove entity commands are used in an exercise.) Entity IDs should not be reused during an exercise.

5.6. Broadcasting and Stealth Viewers.

Messages that are sent on the DIS WAN are broadcast to all listeners. The only filtering criterion for a normal set of messages is a value called Exercise ID. This is a number between 0 and 255. As long as all participants agree on the number, they can receive all the DIS messages. Various types of DIS viewing systems such as Meta-VR, SimTools, SpaceVIS, and MAK Stealth have been developed which allow observers to see the action in a DIS exercise without actually participating. For this reason, these types of systems are often referred to a “Stealth Viewers”. Many of these viewers allow three-dimensional graphic representations of an exercise area and can view the participants from any angle or can attach to one of the participants and follow it around. Some of these systems can also act as an environment generator and allow new tracks to be entered into an exercise and create the appropriate DIS traffic to do so.

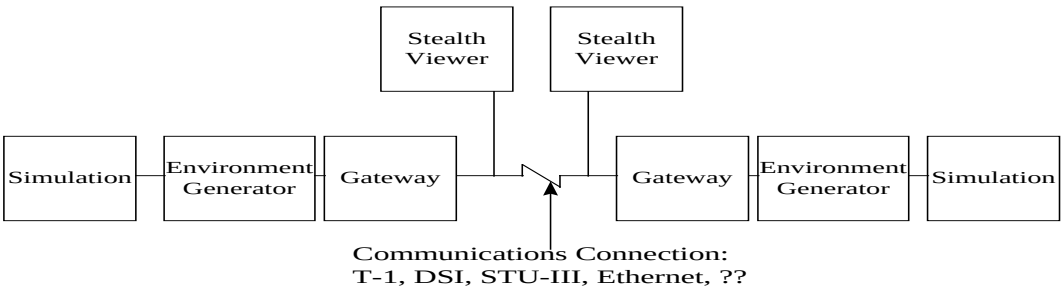

Figure 3 - A typical DIS network

5.7. DIS Enumerations.

So that all participants in an exercise know what entities can be expected to be seen during the exercise, a list of all platform types to be used during the exercise must be agreed upon before the exercise begins. This list is referred to as the DIS Enumeration List. The Simulation Interoperability Standards Organization (SISO) publishes an annual enumerations and bitfields document, often referred to as the “SISO enumerations document”. The entities listed are designated by a series of numbers which indicate their platform type. The numbers are divided into a set of seven numbers which indicate Kind, Domain, Country, Category, Subcategory, Specific, and Extra. The type of information available in the Kind field is Platform, Munition, Lifeform, Environmental, Cultural, Supply, Radio, Expendable, or Sensor/Emitter. The Domain information can be Ground, Air, Water, Underwater, or Space. The other fields are simply numbers that represent the appropriate field. The values for the F-15C are 1-2-225-1-5-3-2. For a Patriot,

they are 1-1-225-5-13-2-1. For a Fulcrum, the numbers are 1-2-222-1-2-0-0. For a SA-6, they are 1-1-222-4-19-0-0.

5.8. Simulation Management (SIMAN).

SIMAN requirements are drawn from the products and papers of the Simulation Interoperability Workshops (SIW) held semi-annually. The use of the SIMAN protocol in a DIS exercise can be divided into four categories: simulation management, exercise control, simulation initialization and control, and data collection. The SIMAN protocol is for use for communication between simulation managers, and between simulation applications and a simulation manager. It is not intended for communication between simulation applications.

5.8.1. Simulation Management. Simulation management is the active management of simulation hosts and applications. Simulation management includes: Performing diagnostic and other maintenance procedures on simulation hosts and applications, monitor the application and entities for signs of problems which the manager should and can address (e.g. overloading).

5.8.2. Exercise Control. Exercise control describes the process of controlling simulations and simulated entities for the purpose of conducting a DIS exercise. Exercise control includes the use of the start, stop, freeze, and resume commands to control the flow of exercises and simulation entities. The exercise control category also includes the direct control of simulation applications and the monitoring of application and network error events.

5.8.3. Simulation Initialization and Control. Simulation initialization and control describes the process of setting exercise scenario, and simulation parameters and data.

5.8.4. Data Collection and Analysis. Data collection describes the retrieval of simulation parameters, performance statistics, event data, and other data defined to be useful in an exercise. The data collection category includes the automated collection of data for exercise analysis, exercise feedback, and Validation, Verification, and Accreditation (VV&A).

5.8.5. Intended Use of SIMAN PDUs. The Event Report PDU is designed for asynchronous events such as error reporting. The Data PDU is for responding for data collection and for asynchronous data collection. The Comment PDU is for use by operators or simulation managers to record text information for later retrieval. It is not for use by entities for real-time interactions.

5.8.6. SIMAN Considerations. Typical simulation management functions do not need to occur in strict real-time. For example, configuration and initialization occur before entry into a real-time exercise and exercise coordination allows a lead-time to be specified in the relevant PDUs.

Simulation management functions will not typically generate a tremendous amount of traffic. Most functions are transaction-oriented, with a request from a manager eliciting a single response from each managed application or entity requested. The two exceptions are the Event PDU and the periodic Data response. However, if the Event PDU and Data Query response are constrained to convey information solely for the purposes of simulation management, they will still not constitute a major source of PDU traffic.

The characteristics of the simulation management traffic are relatively low-volume without strict real-time requirements. For these reasons, the PDUs do not to be defined in a manner which minimizes their space or processing requirements. Flexibility and extensibility are more important

5.8.7. Using Simulation Management for Data Collection. Data Collection PDUs must be produced during the exercise in real -time and logged at the rate they are produced. The analysis of the PDUs, however, can occur at a slower rate.

Data collection does not have to be implemented entirely over a network. Entities may be implemented such that they store requested data internally, off-line, or in a logger on a different multicast group than the simulation manager.

5.8.8. Simulation Management PDUs Used for Exercise Control. Only the core set of simulation management PDUs is needed for exercise control. These include the Start/Resume, Stop/Freeze, and

Acknowledge PDUs. These PDUs allow simulations to transition from the Stopped State to the Simulating State and vice-versa.

5.8.8.1. Start/Resume PDU. Prior to the start of the exercise, the start PDU can be sent again to remind applications of the intended start time. This is useful because some applications may not have been on the network to receive the earlier messages. The Start PDU can also be sent again to adjust the scheduled start time of the exercise. The Start PDU should be sent long enough before the scheduled start of an exercise to allow all simulation applications to be ready to start. The time needed will depend on the exercise and the applications involved.

5.8.8.2. Acknowledge PDU. The Acknowledge PDU should be used to acknowledge the receipt of Start/Resume and Stop/Freeze PDUs.

Start/Resume and Stop/Freeze PDUs sent directly to an entity should be acknowledged by the entity. Start/Resume and Stop/Freeze PDUs broadcast to all sites, all applications, or all entities should be handled in one of two ways. If the simulation application manages a large number of entities, (especially those generated using random processes) then that Simulation application may acknowledge only once to a broadcast command, indicating compliance for all its entities. If the simulation application manages a small number of entities, especially human-in-the-loop (HITL) simulators, then an Acknowledge PDU should be sent for each entity.

5.9. Problems with DIS

A number of problems have been identified associated with DIS. Because an entire PDU must be passed at a time, a lot of network bandwidth is used for information which is not needed to be passed. This is referred to as the “bandwidth problem”. DIS messages can sometimes be slow in being transmitted or received because of processing in various computer systems. This is referred to as the “latency problem”. Because there are a large number of messages on the network, it is feared that they may collide with each other and prevent a message from arriving at its desired destination. This is referred to as the “missing messages problem”.

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[ST] Steven Turrin, Motion Dynamics, ECC International

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Annex A - Definitions

(planned, not completed)

Annex B – IEEE 1278.1

(planned, not completed)

Annex C – Problem/Change Request Form

(planned, not completed)