



IEEE 1278

Distributed Interactive Simulation (DIS)

Mark McCall

DIS PDG Chair

james.mccall@mesa.afmc.af.mil

Bob Murray

DIS PDG Vice Chair

bob.murray@boeing.com

26 May 2010



Contents

- General DIS Overview
 - DIS History
 - DIS Documents
 - Key Definitions and Concepts
 - PDU Families
 - Details of coordinate systems, dead reckoning, entity type IDs
- The Updated DIS Version 7 Standard
 - IEEE 1278 Update History
 - General standard improvements
 - PDU-specific improvements and new PDUs
 - Annexes
- What's Next for DIS
- Get Involved



Distributed Interactive Simulation (DIS) Intro

- Open network protocol standard for linking real-time platform-level wargaming simulations
- DIS Protocol Data Units (PDUs) define:
 - Syntax (data format) and
 - Semantics (rules)for network data exchange and simulation interoperability
- Provides time and space coherent synthetic representation of real-world environments



More DIS Intro

- Designed for linking the interactive, free-play activities of people in operational exercises
- Synthetic environment is created through real-time exchange of data units between distributed, computationally autonomous simulations
- Simulators may be distributed geographically, connected through Wide Area Networks (WANs)



DIS History

- August 1989 – First DIS Workshop
 - Decided to develop DIS using SIMNET as core protocol
- March 1993 – IEEE 1278.1 approved
- Sept 1995 – IEEE 1278.1 revision approved
- 1997 – DIS Workshops replaced by SISO & Simulation Interoperability Workshops (SIW)
- March 1998 – IEEE 1278.1a addendum approved
- 2002 – IEEE 1278.1/1a Reaffirmed



DIS Documentation Relationships

Distributed Interactive Simulation standards, recommended practices, and related documents

IEEE 1278.1-1995
IEEE 1278.1a-1998
Standard for DIS
—
Application Protocols

IEEE 1278.2-1995
Standard for DIS
—
Communications Services and Protocols

IEEE 1278.3-1996
Rec. Prac. for DIS
—
Exercise Mgt. and Feedback

IEEE 1278.4-1997
Rec. Prac. for DIS
—
Verification, Validation, and Accreditation

SISO-REF-010 Enumeration and Bit-Encoded Values for use with Protocols for Distributed Interactive Simulation Applications



DIS Versions

- 1 - DIS PDU version 1.0 (May 92)
- 2 - IEEE 1278-1993
- 3 - DIS PDU version 2.0 - draft (May 93)
- 4 - DIS PDU version 2.0 - draft (Mar 94)
- 5 - IEEE 1278.1-1995
- 6 - IEEE 1278.1A-1998
- 7 - IEEE 1278.1-201x



Key DIS Concepts

- No central computer is required to control the entire simulation exercise
- Autonomous simulation applications are responsible for maintaining the state of simulated entities and objects
- A standard protocol is used for communicating the truth state of entities and objects
- Changes in the state of an entity/object are communicated by its controlling simulation application
- Perception of events or other entities and objects is determined by the receiving application
- Dead reckoning algorithms are used to reduce communications processing



Key DIS Definitions (1 of 5)

Simulation application:

- Executing software on a host computer that models all or part of the world phenomena for the purpose of training or experimentation
- Receives and processes information concerning entities/objects created by peer simulation applications through the exchange of DIS PDUs
- More than one simulation application may simultaneously execute on a host computer
- The application layer protocol entity that implements the protocol defined in this standard
- Equivalent to an HLA or TENA federate



Key DIS Definitions (2 of 5)

Host Computer:

- Computer that supports one or more simulation applications
- Host computers participating in a simulation exercise are connected by network(s) including local area networks, wide area networks, radio frequency links, etc.



Key DIS Definitions (3 of 5)

Simulation object:

- Element of the synthetic environment that is created and controlled by a simulation application and affected by the exchange of DIS PDUs
- It is possible that a simulation application may be controlling more than one simulation object
- Entities representing physical objects such as aircraft, ships, vehicles, weapons and human in the environment are the most common type of objects exchanged
- Equivalent to an HLA or TENA object



Key DIS Definitions (4 of 5)

Simulation exercise:

- An exercise that consists of one or more interacting simulation applications
- Simulations participating in the same simulation exercise share a common identifying number called the exercise identifier
- Simulations utilize correlated representations of the synthetic environment collection and distribution of certain types of data which they operate
- Equivalent to an HLA or TENA federation



Key DIS Definitions (5 of 5)

Simulation environment:

- The operational environment surrounding the simulation entities
- Includes terrain, atmospheric, and oceanographic information
- Participants in the same DIS exercise will be using environment information that is adequately correlated for the type of exercise to be performed



PDU Families

- Entity information/interaction
 - Warfare
 - Logistics
 - Simulation Management
 - Distributed Emission Regeneration
 - Radio Communications
 - Entity Management
 - Minefield
 - Synthetic Environment
 - Simulation Management with Reliability
 - Live Entity
 - Non-Real Time protocol
 - Information Operations
- Color Key
 - 1995
 - 1998
 - 201X



PDU Families (Cont)

- Entity information/interaction
 - Appearance, type, and 3-D location of an entity
 - Markings, capabilities, state
 - Entity collisions
 - Attribute PDU (Version 7)
- Warfare
 - Weapons
 - Expendables
 - Munition and Non-munition Explosions (Version 7)
 - Fire/Detonation
 - Directed Energy (Version 7)
 - Entity Damage Status (Version 7)



PDU Families (Cont)

- Logistics
 - Representation of logistics support
 - Request and Response
 - Resupply
 - Repair
- Simulation Management
 - Centralized control of a simulation exercise
 - Start, restart, maintenance, shutdown, data collection, data distribution
 - Optional – used as required and supported



PDU Families (Cont)

- Distributed Emission Regeneration
 - Simulation of emissions
 - Electromagnetic – Radar, IFF
 - Underwater Acoustics
 - Laser Designators
 - Emitting entity describes the emission
 - Sensing entity responsible for regeneration of emission at required fidelity
- Radio Communications
 - Audio and Digital communications
 - Sending entity describes communications device
 - Sending entity provides the message
 - Receiving entities determine if they can receive the signal and determine what to do about the message
 - Tactical Data Links simulated using these PDUs



PDU Families (Cont)

- Entity Management
 - Four alternative methods for managing entities
 - Entity aggregation for large scale exercises
 - Communication of state of aggregated entities
 - Transferring ownership of an entity
 - Hierarchical linkage of separately hosted entities
- Minefield
 - Location of mines/minefields
 - Appearance of mines/minefields
 - Other pertinent details
- Synthetic Environment
 - Process approach used to exchange information about smoke, contrails, dust, obscurants, toxic chemicals
 - Object approach used to exchange information about point, line, or areal objects in environment



PDU Families (Cont)

- Simulation Management with Reliability
 - Uses simulation management PDUs
 - Specifies use of reliable communications
 - Optional – use as required and supported
- Information Operations (Version 7)
 - Simulate the use of electronic warfare, computer network attack, military deception, etc
 - Influence or disrupt decision making
 - Predicted effects are transmitted
 - Perceived effects are reported



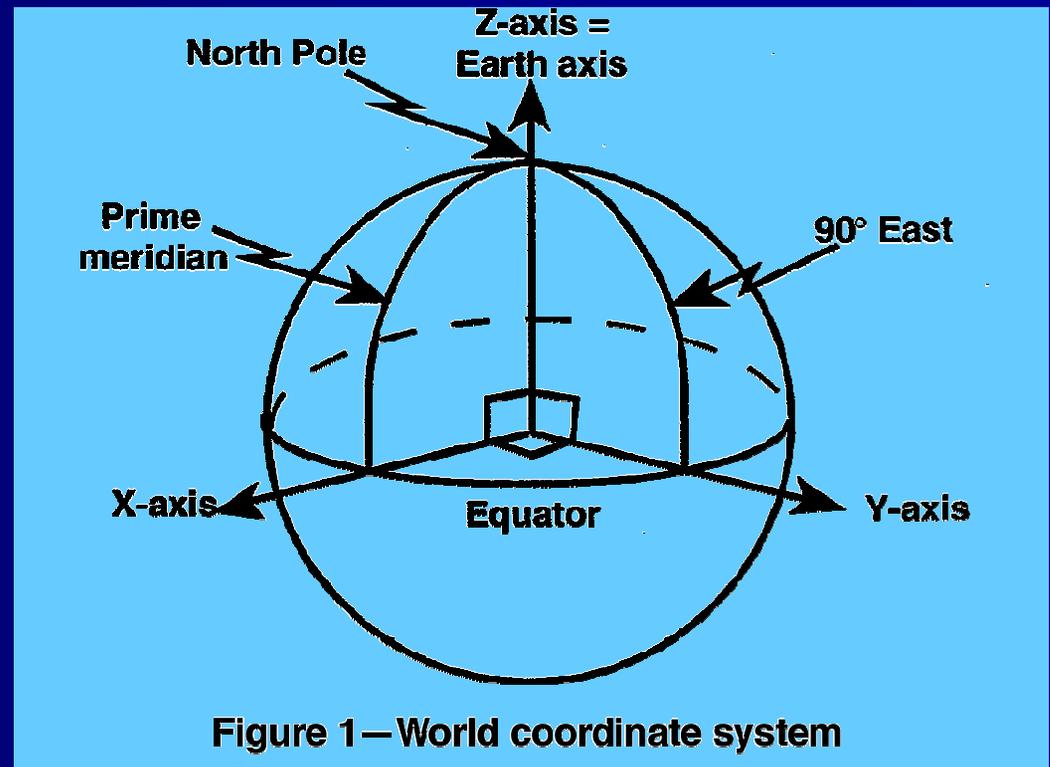
PDU Families (Cont)

- Non-Real Time (NRT) protocol
 - Although most DIS exercises are human-in-the-loop and operate in real time, DIS supports an NRT mode as well
 - Defines how DIS PDUs can be used in a non-real time exercise or event – does not define new PDUs
- Live Entity Information/Interaction protocol
 - Designed for bandwidth-limited range interactions
 - Architectural changes to PDUs to conserve bandwidth.
 - Not typically used in a combined Live-Virtual-Constructive (LVC) events as live training and test ranges prefer converting range protocols into DIS PDUs for better compatibility with virtual and constructive simulations.
 - DIS Version 7 supports identifying live objects when transmitted using other DIS family PDUs.



Entity Coordinates

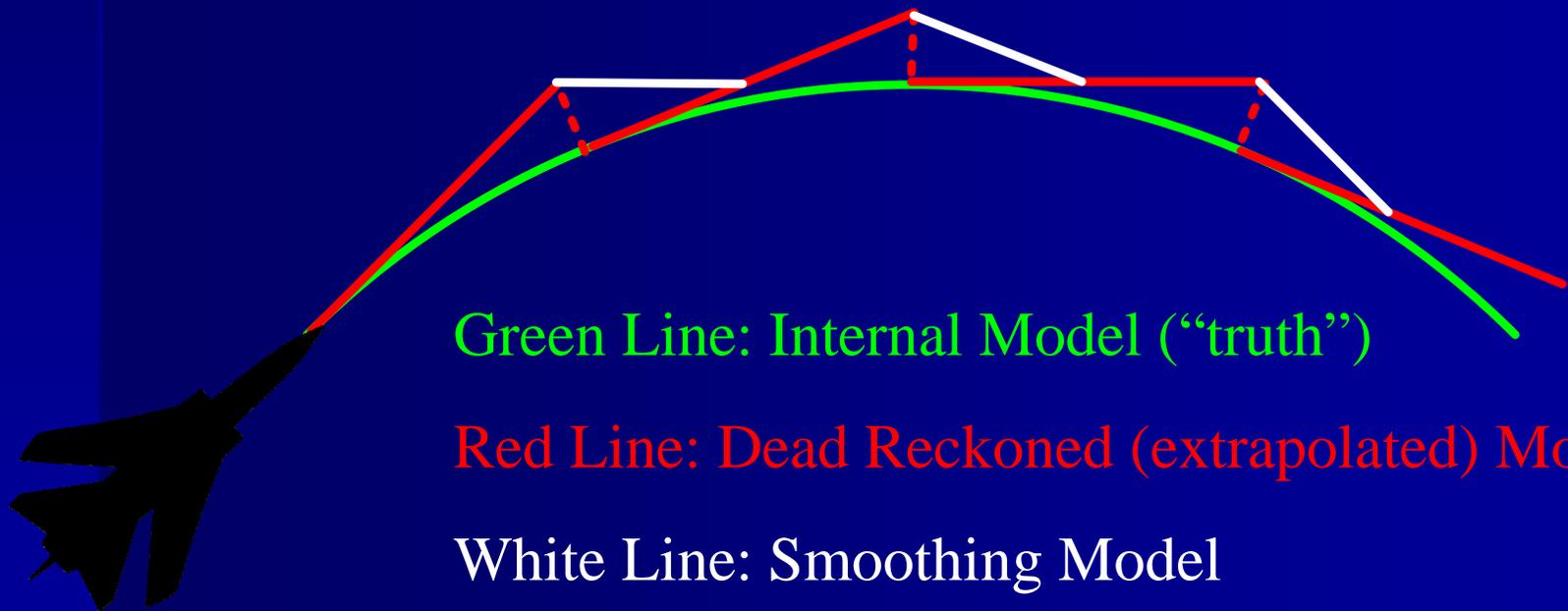
- Geocentric Coordinates
 - Position and Orientation
- WGS-84 elliptical Earth model
- Units in meters and radians





Dead Reckoning and Smoothing

- Entity sends update when error $>$ threshold
- Receiver extrapolates between updates
- Spatial jump at update is smoothed over



Green Line: Internal Model (“truth”)

Red Line: Dead Reckoned (extrapolated) Model

White Line: Smoothing Model



Entity Type Identification

- Hierarchical designation of Entity Type
- Enumerations are listed in SISO-REF-010
 - Over 13,000 entity types

ENTITY TYPE RECORD	
Entity Kind	8 bit enumeration
Domain	8 bit enumeration
Country	16 bit enumeration
Category	8 bit enumeration
Sub Category	8 bit enumeration
Specific	8 bit enumeration
Extra	8 bit enumeration



Examples of Type Enumerations

	Kind	Domain	Country	Category	Sub Category	Specific	Extra
F-15C	1	2	225	1	5	3	-
F-15E	1	2	225	1	5	5	-
MiG-27K	1	2	222	2	1	2	-
M1A2 Abrams	1	1	225	1	1	3	-
T-72B	1	1	222	1	2	6	-
D 98 York	1	3	224	4	1	12	-
Mk 44 torpedo	2	7	225	1	9	-	-



Entity Instance Identification

- Combination of 3 numbers identify individual entities and objects
- Exercises can assign site numbers, sites can assign apps at the site, apps can assign entity numbers
- An application that can generate more than 65,533 objects uses contiguous application numbers and is referred to as a Serial Simulation (Version 7)

Site	16-bit unsigned
Application	16 bit unsigned
Entity/Object	16 bit unsigned



New DIS Version 7 Update History

- 2003 – DIS Study Group formed under the SISO SAC
 - Identified approximately 100 Problem/Change Requests
 - Recommended revision of IEEE 1278 standards
- 2004 – DIS Product Development Group formed
 - Initial focus to combine and revise 1278.1 & 1278.1a
 - Problem/Change Requests and revision areas identified based on interest and willingness of PDG members to work on revision.
- 2005 – IEEE Project Authorization Request approved
 - 4-year effort to revise and update standard
- Sep 2009 – Draft 14 voted to go to IEEE balloting



IEEE 1278.2, .3, .4 Update History

- 2007 – DIS PDG submitted Product Nomination for the revision of IEEE 1278.2
- 2007 – SISO SAC decides to reaffirm IEEE 1278.3/4 pending their replacement by IEEE 1730 series
- 2008 – IEEE Project Authorization Request approved revision of IEEE 1278.2
 - 4-year effort to revise and update 1278.2



DIS V7 - Extensive Rule Clarifications

- New and improved rules, capabilities, and flexibility
 - Lessons learned from 15 years of use
- Current DIS 7 draft is 683 pages
- The 1995 and 1998 standards combined were 330 pages

Even if you have no plans to upgrade to DIS 7, the new standard is still extremely useful, with clarified rules that apply to Version 5/6 as well as 7



Compatibility with Version 5/6

- Almost every change in the PDU formats and rules are backward compatible with Version 5/6 PDUs
- Most changes are also forward compatible (i.e. Version 5 simulations can still make sense of Version 7 PDUs)
- Use of former padding fields
 - New sims can add info, old sims ignore it



DIS Exercise Rules

- The DIS Exercise section 4.2 has been expanded significantly
- A comprehensive section covering simulations, objects, heartbeats, timeouts, thresholds, gateways and protocol version



Objects and Identifiers

- Clearer definition of “object” and “entity”
 - Entities are objects that have an ESPDU
 - Other objects are usually attached to entities or are things such as environmental objects
- Confusion on the 3rd number of the Site-App-Entity IDs is cleared up
- Non-object IDs clarified
 - e.g. Simulation IDs, Request IDs



Variable Heartbeat Periods

- Entity State default heartbeat periods now defined by entity kind, domain, and whether moving or stationary
- Other PDU types have individual default heartbeat periods
- Standard defines defaults
 - Exercises can set actual values
- Provides flexibility and reduces the number of heartbeat updates



Protocol Version Rules

- Lack of rules on use of Versions 5 or 6 led to confusion
- Rules for interoperability between Version 5/6 and Version 7 are defined
 - Mixed version exercises are allowed
 - A single sim may issue both 5/6 and 7
 - Must obey rules of the version in the PDU, both sending and receiving



Transfer Ownership

- The Transfer Control function has been renamed to Transfer Ownership
- The Transfer Control Request PDU has been renamed the Transfer Ownership PDU
- The entire Transfer Ownership function has been revised to improve its functionality
- Changes based on existing Transfer Ownership implementations that improved on the original 1998 standard



Time

- Time requirements have been extensively clarified and revised
 - Absolute, relative, simulation time
 - Timestamp usage
 - Time synchronization
 - Absolute Time does not have to be synched to a GPS Time source, just to some source agreed to by the exercise
 - New 8 page Annex of additional info



Dead Reckoning

- Dead Reckoning annex has been revised to clarify and correct technical details
- Existing algorithms 1 to 9 are unchanged. Alternate algorithms 10 and 11 have been deleted.
- Addition of a new quaternion method of rotational extrapolation



Protocol Extensibility

- DIS now more easily customized
- Corrects a weakness in the original standard
- Backward compatibility maintained mostly
- Variable Parameter Records (new name)
 - Entity State, Detonation PDUs
- Standard Variable Records
 - Transmitter, IFF, DE Fire, Entity Damage, IO
- Attribute PDU
 - Can extend any other PDU
 - Or, info that doesn't have a PDU



Variable Parameter Records

- The Articulated/Attached Parts record in the Entity State and Detonation PDUs was renamed to show its extensibility
- First 8 bits denotes record
- Other 120 bits is definable
- Still fixed at 128 bit length
- 3 new records so far
- Several ideas for other appearance records

Entity Separation VP Record

Parameter Type Designator	8-bit enumeration
Reason for Separation	8-bit enumeration
Pre-Entity Indicator	8-bit enum
Padding	8-bits unused
Parent Entity ID	48-bit enum
Padding	16-bits unused
Station Location	32-bit enum



Standard Variable Specification Record

Number of Standard Variable Records (N)	16-bit unsigned integer
Standard Variable record #1	Record Type – 32-bit enumeration
	Record Length – 16-bit unsigned integer ($6+K_1+P_1$)
	Record-Specific Fields – K_1 octets
	Padding to 64 bits – P_1 octets
	<ul style="list-style-type: none"> ○ ○ ○
Standard Variable record #N	Record Type – 32-bit enumeration
	Record Length – 16-bit unsigned integer ($6+K_N+P_N$)
	Record-Specific Fields – K_N octets
	Padding to 64 bits – P_N octets



Uses of Standard Variable Spec Record

- Transmitter PDU – Variable Transmitter Parameters records
- IFF PDU Layers 3, 4, 5 – IFF Data records
- Directed Energy Fire PDU – DE records
- Entity Damage Status PDU – Damage Description records
- IO PDUs – IO records
- Attribute PDU – Attribute records
- All future PDUs to contain Std Var records



The Attribute PDU

- Allows existing PDUs to be extended without breaking forward or backward compatibility
- The PDU contains sets of Attribute records
 - Each set is tied to an entity or object
- Attribute records are open format Standard Variable records
- Not allowed to contain information that already exists in other PDUs
 - Otherwise, there would be confusion about which PDU to use



The Attribute PDU (cont)

- A transient PDU can be extended by attaching an Attribute PDU to it
 - This is called Coupled Extension
 - Requires PDU Bundling
- State PDUs can be extended by sending Attribute PDUS at any time
 - Or, the Attribute PDU can be coupled



PDU Bundling rules clarified

- Improves network efficiency by allowing one or more PDUs to be concatenated in a UDP datagram
- Bundling rules given in 1278.2
- Tradeoff between delaying PDUs to build bigger bundles
 - Latency vs. network efficiency
- Max size of bundle also explained



Maximum PDU Size

- Max PDU size clarified to be 8K bytes
 - Original 1278.2 mentions 8K but didn't have a clear rule
- 1400 bytes is still a good limit where possible
 - Network MTU is the guideline
 - Avoids fragmentation - more efficient transfer
- 8K size is available for large data sets or bundles



Expanded Weapons Support

- Fire and Detonate PDUs now have better support for:
 - Expendables (IR flares, chaff)
 - Non-munition explosions such as kinetic weapon or secondary explosions (e.g. fuel tank)
- Original Burst Descriptor record is now:
 - Munition Descriptor record (unchanged)
 - Expendable Descriptor record
 - Explosion Descriptor record for non-munition explosions



Entity Separation

- Clarified and includes support for:
 - Multi-stage missile separation
 - Portraying submunitions
- Variable Parameter records for Separation
 - Entity Type VP record
 - Separation VP record
- Towed Decoys
 - Association VP record



Electromagnetic Emissions

- Better description of radar beam parameters, scan volumes, phased array radar
- Jammer field redefined to better support a wider range of multi-resolution simulations



Partial Updates for Emissions

- Original standard was not clear if every system for an entity had to be included in every PDU update
- It is now clear that this is not necessary
 - Systems can be spread across multiple PDUs
 - Can send only changed systems and beams
 - This potentially breaks forward and backward compatibility
 - However, the 1995 standard was ambiguous on this matter so compatibility is difficult regardless



IFF Mode 5/S

- New layers in the IFF PDU
 - Layer 3 for Mode 5 IFF (new military mode)
 - Layer 4 for Mode S (new civilian mode)
 - Layer 5 for the exchange of actual, real-world IFF message formats and to add new fields to Layer 1 or Layer 2 information
- All IFF record formats presently contained in the SISO-REF-010 Enumeration document have been moved into the standard
- The requirements related to each IFF transponder and interrogator system type are clearly specified in a new 1278.1 Annex



Major Radio Simulation Changes

- Extensive Transmitter PDU clarifications
 - Transmitter PDU heartbeats sent even if Power is off
 - Must contain all radio parameter settings
- New annex for radio systems specifics
- New basic and High Fidelity HAVE QUICK Radio records
- SINCGARS and JTIDS/MIDS radio MP records moved from DIS Enumeration document
- New Variable Transmitter Parameter (VTP) Record format in Transmitter PDU
 - Minor forward compatible software change



Five New PDUs

- Warfare
 - Directed Energy Fire PDU
 - Entity Damage Status PDU
- Information Operations
 - IO Action PDU
 - IO Report PDU
- Attribute PDU
 - Adds extensibility to the DIS standard





Directed Energy Fire PDU

- Supports high-fidelity directed energy engagements
- Conveys detailed characteristics of the energy deposition
 - Type of weapon (e.g. Laser, Microwave)
 - Duration
 - Beam shape



Entity Damage Status PDU

- Allows an entity to report high-fidelity damage details for any physical location on an entity or other object
- Uses Standard Variable records
- Can be sent at any time to reflect damage to an entity or other object
 - While firing at a target to show progressive damage
 - Or damage from any cause whether or not related to a weapons firing



Information Operations

- IO supports interoperability of simulated electronic warfare, computer network operations, military deception, and similar operations used to influence or disrupt enemy decision making
- IO Action PDU can contain the predicted effects of an attack by the attacker
- The actual effects of an attack are communicated in the IO Report PDU



Annexes

- Annex A Warfare - Additional requirements to support the warfare functional area
- Annex B Specific Transponder and Interrogator Systems for IFF
- Annex C Radio Systems - Details of specific radio systems
- Annex D Objects - Details of object types and primary and secondary identifiers
- Annex E Dead reckoning definitions and algorithms



Annexes (cont)

- Annex F Heartbeats, Timeouts, Thresholds - Guidance on interoperability when some simulations have implemented the new entity timeout requirements and some have not
- Annex G Time Calculations and Uses - Additional information on time and its uses in a distributed simulation environment
- Annex H Transfer Ownership - Detailed requirements for transfer ownership
- Annex I Articulated and Attached Parts



What's Next for V7

- SAC approved Draft 14 to go forward
- Draft 14 was submitted to IEEE in 2009
- IEEE editorial cleanup completed
- Ballot pool formed
- Next step is IEEE review, comment, vote
- Usually 2 rounds of balloting or more
- Plan to complete balloting in 2010 or early 2011



What's Next for DIS

- IEEE 1278.2 is undergoing an update to better support multicast, SIP and web-based protocols
- The DIS Enumeration Process has been placed under management of a new DIS Enumeration Group within the DIS PSG
 - An XLM-based data base has been developed
 - The backlog of DIS enumerations is being cleared
 - SISO-REF-010 will be updated regularly again
- IEEE 1278.1 - There are still many proposed enhancements that did not make it into DIS 7
- Work on DIS 8 will be started soon



DIS Enumeration Working Group (EWG)

- Supports and maintains a data base of enumerations used by DIS, HLA, TENA, and CTIA federations
- Enumeration Change Requests (CRs) now have a more automated update process
- An XML Enumeration database has been developed and will be made available for any simulation that uses DIS-based enumerations to incorporate into their software
- Special enumeration projects are underway to support:
 - Robust portrayal of lifeforms (humans, animals, plants, etc.)
 - New Portable Weapon schema
 - New civilian land vehicle schema
 - New civilian aircraft schema



Get Involved

- To join IEEE 1278.1 and 1278.2 IEEE DIS Product Development Group, send an email to the Mark McCall james.mccall@mesa.afmc.af.mil and requesting to become a member of the PDG
 - You must be a SISO member to join:
 - <http://www.sisostds.org/index.php?tg=articles&idx=More&article=70&topics=1>
 - Participate in the DIS PDG discussion group and gain access to the file library (latest 1278.1 and 1278.2 Draft Standard)



Get Involved

- Join the DIS Enumeration Working Group (EWG) and DIS Product Support Group (PSG)
 - You do not have to be a SISO member to join
 - DIS EWG - Just subscribe to the Enumeration reflector
 - <http://discussions.sisostds.org/default.asp?action=10&fid=31>
 - Weekly telecons are held. File library has XML data base and Change Requests (CRs).
 - Information on the SISO DIS PSG
 - <http://www.sisostds.org/index.php?tg=articles&idx=More&article=449&topics=110>
 - DIS discussions, PCR form and copies of submitted PCRs available