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August 22-23, 1989

Summary Report

The First Conference on Standards for the Interoperability of Defense Simulations

Editors:

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Brian Goldiez
Jack Thompson

This report is informational and does not express the opinions of PM TRADE or DARPA.

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This report presents a summary of the activities of the First Conference on Standards for Interoperability of Defense Simulations sponsored by DARPA and PM TRADE and hosted by IST/UCF on 22 & 23 August, 1989. The primary goal of the workshop was to take the first steps required to begin in the process of developing standards to be used for the interoperability of Defense Simulations.

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The First Conference on Standards for the Interoperability of Defense Simulations

August 22-23, 1989 Orlando, FL

Introduction

This reports presents a summary of the activities of the **First Conference on Standards for the Interoperability of Defense Simulations** sponsored by the Defense Advanced Research Projects Agency (DARPA) and the Program Manager for Training Devices (PM TRADE), and hosted by the Institute for Simulation and Training / University of Central Florida (IST/UCF) on 22 & 23 August 1989, in Orlando, FL. The primary goal of the workshop was to take the first steps required to begin the process of developing standards to be used for the interoperability of Defense Simulations.

The two day workshop focused on two major topic areas: **Network Communications** and **Terrain Data Bases.** The **Network Communications Working Group** was headed up by Col. Tom Herrick, USA, Deputy Director ~~of DCS Data~~ Systems, Defense Communications Agency. This group had two main objectives. The first objective was to determine whether the existing SIMNET Network and Protocols (July 31, 1989) would be suitable as a networking standard, and if not, recommend modifications and/or extensions to the SIMNET Protocol in order to implement networked simulations. The second main objective was to identify those willing to work the issues to achieve an interoperability standard for simulation systems, and to then proceed with a formal Standardization Procedure (i.e., IEEE or MIL SPEC) for the Protocol.

The **Terrain Data Bases Working Group** was headed up by George E. Lukes, Team Leader, Center for Autonomous Technologies, U.S. Army Engineer Topographic Laboratories. This group's main objectives were to establish an understanding of terrain database issues necessary to support development of interoperational network simulation standards and to set up a mechanism for working issues to support these efforts.

Contained within this report are summaries of all presenters' speeches, a listing of items/issues requiring further investigation, a section detailing planned standardization activities, an attendees list, and a copy of view graphs used during presentations.

The First Conference on Standards for the Interoperability of Defense Simulations

COMBINED SESSION - OPENING PRESENTATIONS
Tuesday, August 22, 1989

Speaker Summary:

Dr. A. L. Medin (Director of IST/UCF) - Welcome

Dr. Medin welcomed all conference presenters and attendees and thanked them, on behalf of IST/UCF, for their involvement in the workshop. He stressed the importance of standards in both the military and industrial arenas and alerted all participants to the importance of the work at hand. Dr. Medin then presented a short informational brief of both the Institute for Simulation and Training and the University of Central Florida. In concluding, Dr. Medin once again thanked all the workshop participants and wished them luck in accomplishing their goals.

Dr. Jack Shwartz (Director of Information Science and Technology Office, DARPA) - Opening Address

Dr. Shwartz opened the conference with several comments to help get all attendees acquainted with the goals of the workshop. He made an analogy to the "fog of battle", where too much information to digest can be present and, at the same time, not enough information is known about other necessary factors. This he related to other preparatory activities of design, development, and planning in the Defense Department. He stressed the objectiveness that is provided by SIMNET and its physical design, as well as the positive effects that it will achieve. Aggregated simulations and war games were briefly mentioned. Dr. Shwartz discussed the over and under-estimation of foreign defense systems and stressed the importance of the SIMNET "tool" in preparation. Simulation on the whole was discussed as a major tool involving tens of thousands of users at many different levels.

Discussion of standards was a main topic. Standards must be achieved to improve the simulation and access to the most current tactical information must be available all the way up the ladder. Accessibility of the simulation network, on a world-wide basis, to the Armed Forces was discussed, as well as the necessity of availability of simulation technology to defense industry.

Finally, the capability of simulation technology to save human lives, as well as maintenance of a constantly veteran force was discussed.

Mr. David J. Berteau (Assistant Secretary of Defense) - Keynote Address

Mr. Berteau opened his discussion with a brief overview on the networking of defense simulators and the challenges it presents. Standards, from his point of view, must be determined and maintained by industry, and must be followed strictly by government. He stressed the importance of the conference for progress and collaboration in these standardization efforts.

Applications of the technology of SIMNET were discussed. Training potential, combat development (including force-on-force simulation), MANPRINT, and contracting potential were discussed with both capabilities and vulnerabilities being mentioned. Mr. Berteau ended his presentation by stressing the need to take the existing technology, develop it, and apply it in an effective way to the training community.

A short discussion on the problems with shrinking federal allocation of funds for defense and the importance of optimization of available funds for simulation development followed.

Mr. Brian Goldiez (Program Manager, IST) - Workshop Overview

Mr. Goldiez opened by discussing the goals of the workshop. Recognized standards for training devices and interoperability of weapons systems with simulators is a major goal of this conference and for the immediate future. The intent of the conference was to provide a starting point. The distribution of the SIMNET Protocol was discussed and the time and money spent in the development of the SIMNET Protocol was emphasized. Mr. Goldiez communicated his desire for a free exchange of ideas amongst participants during this workshop. IST's goals in the facilitation of the conference was then discussed.

Mr. Goldiez next presented ideas concerning the organization of a steering committee for Simulation Networking Standards. Committee membership will consist of government, industry, and academic personnel. The purpose of the committee will be to create working groups in specific areas where further refinement/definition is required, to raise issues that need to be dealt with, to review and act on recommendations and the results of dealing with these issues, and to distribute information to all active participants.

To date, working groups dealing with Network Communications Protocols and Terrain Data Bases Standards have been formed. Discussion of a future workshop, in Jan. 1990 followed.

Mr. Goldiez closed with a short review of the agenda for the working groups and with a short announcement of general conference information.

Col. Jack Thorpe (DARPA, SIMNET) - Defense Simulation Internet Overview

Col. Thorpe opened with a brief insight of DOD interests. Draft directives suggesting defense simulations will be required to be network capable, as well as the development of a science of Military Technology were presented.

Long term implications of developmental protocols and shared technology were discussed. Col. Thorpe proceeded to discuss the theme of the **virtual world** that has been created and the constant change in the standards and protocols that is taking place. Emphasis was placed on the overall improvement of the simulation, rather than the enhancement of the various individual technologies (i.e. training technology, engineering simulation technology, etc.).

Topic selection changed as Col. Thorpe moved into some of the technical descriptions of the SIMNET structure. Future support for simulation networking, as well as current experimentation efforts in the area of Semi-Automated Forces was briefly mentioned.

Col. Thorpe then gave a brief examination of problems to be solved which included: agreeing upon a standard network structure (protocols) capable of accommodating the broad spectrum of defense simulations and figuring out how, on such networks, functionally equivalent representations of militarily relevant queues can be presented.

A brief synopsis of visual systems simulation was given. In closing, Col. Thorpe again emphasized the importance of the new simulation in all aspects of defense.

NETWORK AND COMMUNICATIONS WORKING GROUP BREAK-OUT SESSION

Tuesday, August 22, 1989

Speaker Summary:

Col. Tom Herrick (USA, Deputy Director of DCS Data Systems, Defense Communications Agency) - Working Group Objectives and Overview

Col. Herrick opened by giving the purpose behind his working group: to address the standards of interoperability of defense simulations, and to identify areas of agreement, outline the issues that need to be worked, and to put in place the mechanism to work the issues requiring resolution. Input from all participants was requested through a previously distributed questionnaire. In closing, Col. Herrick proceeded to introduce the various members of the working group panel: Mr. Stine (Standards), Col. Mengel (Interoperability), Dr. Miller (SIMNET System Overview), Mr. Art Pope (SIMNET Communications Protocol), Mr. Seidensticker (Extensions/Issues).

Col. Tom Herrick -- Afternoon Opening Remarks

The Network Communications afternoon working group session was opened by Col. Herrick. A brief review of working objectives was given. The DOD's Long Haul Data Communications Provider, supporting E-mail, data file transfer, and remote terminal access was reviewed. Benefits of future standards, including interoperability, technology independence, COTS and NDI products, market expansion and innovation, and force multiplier effects were discussed. Col. Herrick warned that these standards must be chosen very carefully. Some challenges, including the integration of international standards for interoperability and not just compatibility, as well as, a transition process which would acknowledge prevailing mission needs and required military extensions were discussed. Defense Communications Agency (DCA) interests involving the Joint Tactical Command & Control Agency, the Defense Communications System Office, and the Office of the Chief Scientist of the DCA were presented.

Mr. Larry L. Stine (MITRE Corp.) - The Standards Process

Mr. Stine presented his outline, which included benefits of standards such as streamlined operation, economies of scale, simplified human factors, and technical approaches. Definition of standards earlier in system design phases, as well as growth in applications and areas of increased interaction are seen as recent trends. A brief overview of Military Standards Processes was given. Areas of interest include: Communications Networks featuring long haul, tactical, and data communications protocols (PSSG); and Information Processing Directives including processing DCA Y220 and data elements (OSD production and logistics). Important aspects of a standards committee were mentioned. Some aspects included: 1) Defining applications and place in systems, 2) Identification of other relevant current and pending standards, and 3) Establishment of democratic meeting agenda with individual contributions. Discussion of typical subgroup sessions within the standards committee was offered. Typical subgroups would include: 1) systems architecture, evolution, and performance groups; 2) Services and features groups; and 3) Protocols groups.

In summary, Mr. Stine endorsed definition of relevant standards in the early stages of evolution of simulators, Military Standard approaches, and consideration for growth and evolution as a preliminary effort for the working group.

Mr. David J. Berteau - Comments and Observations

Before departing the workshop, Mr. Berteau addressed the Network and Communications Working Group from the floor and urged them to take a look at other options to MIL-STD's, since they seemed to be a one way street. In addition, he stressed the importance of capability relative to specificity and the importance of keeping a delicate balance between the two.

Col. Dick Lunsford (US Army, Program Manager Training Devices) - A Users Point of View

Col. Lunsford began with a brief overview of the SIMNET networking structure and its meaning for future activity. Advice for procurement of a standard set of equipment with high performance specifications was asked of the working group.

Dr. Duncan Miller (BBN Systems and Technologies Corp.) - SIMNET System Overview

Dr. Miller's opening topic centered around the architecture of the SIMNET network. Expansion and computer resources of additional nodes with different technologies was briefly discussed. Dr. Miller observed that communications and processing requirements can be kept low by letting each node have a copy of terrain that doesn't change, and having a system to exchange information about those parts that do.

Representation of remote simulators on a local simulator seems to be where the fidelity issues come in. Information flowing on the network must be the same information for every simulator, no matter what level of fidelity is involved. Discussion of the SIMNET Local Area Network (LAN) provided a brief description of current simulator technical operation. Local Area Networking levels should all be transparent, in that every vehicle will be represented in exactly the same way. Discussion pertaining to reliability of the vehicle state update message (representing 95% of all traffic on network) being received by all nodes on the network was observed. Several questions were then taken from the floor.

Question: Is it possible to hit something beyond one's visual range?

Response: No, not with the direct fire approach that was taken. Indirect fire protocols are a possible exception to this. Direct fire profiles will need all polygons that are possible to strike.

Question: Is it an inherent part that the image generator must be responsible for making the determination (of a hit) and that it needs to know the location of every vehicle in the simulation?

Response: No, each simulator must be prepared to determine what was hit and announce the result to the world. The key element and focus of the protocol is at the Local Area Network level. What happens within the simulator is a question of preferred design.

Question: Is each simulator keeping track of only the local line sight of its environment or of the entire world?

Response: The entire world lives on a disk within each simulator. The simulator discards the parts of the world that it moves away from and takes in information on parts it currently is dealing with.

Question: Is the state of the world updated by the destruction of other vehicles? Non-vehicles?

Response: All vehicles in the world maintain their own state on the terrain. Local network interface process will receive messages from wrecked vehicles. Other elements (bridges, trees, etc.) are more complicated and will be discussed later.

In closing, Dr. Miller made brief note of some underlying philosophical issues. Short descriptions of Ethernet interfacing, long haul links, manned simulators, automated and semi-automated simulations, data collection and analysis, imaging systems, and digital communications were also given.

Col. Larry Mengel (USA TRADOC Systems Manager for SIMNET) - Interoperable Simulation

Col. Mengel began by emphasizing the inclusion of the other Armed Forces in the SIMNET program. Funding and time scheduling are a vital issue to the Army. Defense budgets are shrinking annually. A device supported training strategy is the standard of the future. A brief description of current operating costs for field training devices and weapons systems was given.

Col. Mengel discussed his goal for design and simulation of new weapons systems which could be functionally tested before "ever bending metal". Distribution of DARPA SIMNET/AIRNET simulators both at home and abroad was presented. Networking simulators over the domestic long haul is a primary task. This network would eventually be linked abroad. The year 2000 is a tentative deadline for distribution of fully operational servicing simulators (mostly domestic) with estimated overall expenditures of one billion dollars.

Semi-automated opposing forces, as well as semi-automated friendly forces were noted and related to enhancement of networked systems. Simulation architecture and projected progress through the year 2004 were mentioned in closing.

Mr. Art Pope (BBN Systems and Technologies Corp.) - SIMNET Communications Protocol: Proposed Standards

Introductory comments involved discussion of the current SIMNET protocol. Mr. Pope gave a description the composition of the present SIMNET simulated world. Real-time effects of the distributed simulation internet architecture were discussed. Layering of protocols included discussion of the simulation, data collection, and association protocols. Topics related to data representation, object type numbering schemes, and elements of communication compatibility were briefly overviewed. Mr. Pope closed by examining some future objectives including enhancement of dead reckoning algorithms, coordinate systems, missiles, and extensions for additional types of vehicles and simulators.

Mr. Stephen Seidensticker (LOGICON Corp.) - Simulation Network Protocol Refinements/Extensions

Mr. Seidensticker opened with a brief introduction of himself and his employer, Logicon Corp. Classes and purposes of various simulators in industry were discussed in the context of mission rehearsals, mission training, etc. Usable SIMNET protocol components, as well as required SIMNET protocol extensions and development, including gaming/mission area definition, allowance for differences in individual simulator fidelities, and inter-vehicle communication links were key topics of discussion. The Ada software language was discussed as a possible basis for message definition, as well as a good distribution/control medium. Necessity for a standard internal data format, commonality on networks involving floating point formats, big Endian vs. little Endian, and ASCII character ordering in strings was emphasized. The who, what, and how of voice communications, equations of motion, simulator fidelity, and tactical link standards for the future were discussed. Industry's role in future creation and maintenance of standards were emphasized in closing.

NETWORK AND COMMUNICATIONS WORKING GROUP BREAK-OUT SESSION

Wednesday, August 23, 1989

Speaker Summary:

Col. Tom Herrick -- Working Group Recap

Col. Herrick began by addressing the working group on one of the original objectives: the suitability of the current SIMNET Network Protocol as a standard communications protocol. The morning was to be broken up with time spent on the standards process (30 minutes), protocol refinements (45 minutes), and protocol extensions (45 minutes).

Lt. Col. Bob Mills (USAF J-7, Joint Staff) - Joint Model & War Game Executive Council

Lt. Col. Mills opened with a brief background of the JMWEC. Recent history includes various documentation such as the Defense Science Board "Computer Applications to Training & Wargaming" Study (5/88), DOD IG Audit Report on "Wargaming Activities in the Department of Defense" (3/89), the SACEUR-DARPA European Distributed Wargaming System (2/89-5/89), and the Joint Warfare Center Issues (2/87-present). JMWEC objectives relative to the workshop's objectives were discussed briefly.

Open Discussion

Col. Herrick once again addressed the suitability of the existing SIMNET protocols as the starting point of a standard for simulation communications as was discussed by the panel. Satisfaction of this approach among various attendees was confirmed via the questionnaire addressed and returned on Tuesday.

Dr. Miller addressed the objectives of refinements, and the inter-linking to extensions. The first topic for discussion was the supporting of simulators of different fidelities. One consideration was that important information flowing on the network is essentially the same for simulators of different fidelity levels.

Data assumptions, default data parameters, etc. are areas that need additional consideration since all simulations and visual systems are not identical. Inquiry into passive network architectures as compared to "smart" network architectures, feasibility and efficiency were raised as items for further consideration. Other items requiring further consideration included the interfacing and machine dependency issues of the standard, as well as Interfacing with real-world Command and Control simulation systems.

Standardization of long haul communication protocols needs to be designed with the ground rules for the simulator being that the individual simulator does not have to deal with what is local and remote. This should be dealt with at the gateway level. Further work in this area must to be done since no long haul standard has been established.

Various other topics concerning possible enhancements / extensions were discussed and will also require further investigation. These topics include controlling data collection procedures for long haul networks and the related restrictions and the lack of guarantee for message delivery on the interfacing of different fidelity hardware.

Data buses on the theater level simulation, (i.e., JWC), dealing with large scale but low fidelity simulations and the different types of information protocol environments being supported must also be considered in the standard. Additional research into this interfacing is required.

Open Discussion (con't)

The morning session continued with discussion of classification of entities involved on the battlefield (i.e., reinforcements, support vehicles, etc.) and their simulated representation.

Enlargement of the network with implicant limitations to the individual simulator and establishment of position in space to some universal reference system, in particular, the latitude and longitude system in 32-bit floating point band format, was offered as an alternative to dead-reckoning representation. Upward scaling and implications to the developing protocols was cited as an issue for consideration.

Discussion of the establishment of the standards committee and necessary subcommittees ensued with the panel urging working group members to continue to provide their input and keep the process moving forward.

Final issues of the morning centered around simulator update rates and transport delays. Updating a simulator should occur as often as need be so that transport delays are within acceptable bounds for whatever the crew member needs to be doing. This is a separable issue from the level in which one is representing what the others are doing in the simulated world. The dead-reckoning algorithm is a mechanism that has proven satisfactory and stable for the current SIMNET implementation. A suggestion was made to add a "you-are-being targeted" message to the protocol. This message could allow update rates for certain vehicles in a very rapid fashion when necessary and drop back to slower updating when it was no longer an important event. This suggestion, along with others made during the workshop, will be evaluated as the standardization process progresses.

The issue of prioritization of network traffic to optimize network utilization was raised. The concensus indicated that the simulators need to prioritize the traffic themselves and that the standardization of the locational reference system would help relieve some of the traffic on the net. This issue will need to be addressed in detail.

The issue of environmental effects and their importance in the next generation simulated systems and sensor models was raised. Degradation of visual information such as dispersion through fog, smoke, and haze, low-light conditions, etc., and how they appear to the simulator was one example cited. Another example was how to represent a simulator's visuals when the simulator is in a smokey environment, for example, as compared to those outside the smoke

Final observations revealed the urgency for a common understanding of the layered architecture of the existing SIMNET protocol between the working group members and that it be the immediate direction to pursue. Distinction of these layers was deemed necessary due, in part, to the many varied interests of the working group members.

Col. Tom Herrick -
Overview of Working Group Findings

Col. Herrick briefly reviewed the working group objectives and the means by which the working group had achieved, or put in place the methods by which the objectives will be achieved The establishment a committee to carry on the standards activities and action items for future work were presented (see view graphs attached)..

Mr. Larry Stine -
Summary of Recommendations for Standards Process

Mr. Stine stressed the need for a total commitment of those participating in the standards process. Formation of the Standards Committee was emphasized as a major accomplishment, as well as the appointment of an executive agent (PM TRADE) to be responsible for the resolution of issues and distribution of information to all participants.

Dr. Duncan Miller -
Summary of Simulation Network Protocol Extensions/Issues

Network Protocol Extensions/Issues requiring further investigation including increasing the size of the game world, details of machine dependencies, interfacing with live exercises, network security, and levels of coordinates were presented (see view graph attached). Dr. Miller expressed his encouragement for the future of the standardization process.

TERRAIN DATA BASES
WORKING GROUP BREAK-OUT SESSION

Tuesday, August 22, 1989

Speaker Summary:

Mr. George Lukes (Engineer Topographic Laboratories) - Working Group Objectives and Overview

Mr. Lukes mentioned that a common data source was definitely necessary for manned and non-manned simulators. He mentioned a "common geodetic format." He also described how simulators were useful for robotic planning, mission planning, and dress rehearsal.

Col. Larry Mengel (TRADOC Systems Manager for SIMNET, US Army Armor Center, Ft. Knox, KY) - Interoperable Simulation

Col. Mengel began the session with his perspective on SIMNET. He stated that the SIMNET program was very complex and spanned the entire Army. He looks at SIMNET for two purposes 1) to teach soldiers how to coordinate their efforts, 2) to test and evaluate new weapon systems before "bending metal."

Col. Mengel explained that the US Army was changing from field-based to simulation-based training strategy due to:

- physical ground size shrinking
- growing operational costs
- environmental risks increasing
- safety concerns
- less tolerant civilian communities

He proposed that a major problem for simulator research was how to create enough terrain for all the users to be able to train simultaneously.

Dr. Dexter Fletcher (Institute for Defense Analysis) - Automated/Semi-Automated Vehicles (Forces)

Dr. Fletcher described three classes of SIMNET vehicles:

- **Fully automated:** Logistics vehicles appear at the appropriate time without crossing intervening terrain.
- **Semi-automated:** (i.e., go from point A to point B via the terrain, but are unmanned) Seamless integration was identified as the central technical goal. All of the simulators must know the terrain, however they should not be the same as robotic vehicles, and should not take advantage of terrain

features that would be unknown to crews of manned vehicles, such as cliffs over the horizon.

- **Manned** (current SIMNET simulators)

Emphasis was placed on route planning. How to get from point A to B in formation? Without specifying way stations along the route, there is a need for Opportunistic Behavior (Terrain Intelligence) in the semi-automated vehicles to prevent manned vehicles from having an inappropriate advantage.

There is also a need for the semi-automated vehicles to become more sophisticated as the trainees do. He also stated that students should not be able to distinguish between manned and semi-automated forces. He stated that polygons were no longer sufficient and that there is a need for a new geodetic frame of reference.

Col. Jack Thorpe (DARPA, SIMNET) - Defense Simulation Internet Overview

Col. Thorpe was concerned with correlation (i.e. How do you make sure everybody sees the same thing?). Col. Thorpe was also concerned with issues such as: what are military valid cues, and will people be able to fight together and see the same scene (i.e. given a tree, the tree must be able to obscure objects in the same way). He also extended an open invitation to the audience to visit the facility at Ft. Knox.

LTC William Szymanski (PM TRADE, CCTT Project Director) - CCTT Program Overview

LTC Szymanski identified action items concerning the Close Combat Tactical Trainer (CCTT. We want to simulate a battlefield that creates the illusion of moving and fighting over real terrain.

Col. Szymanski identified some needs and characteristics of CCTT:

- 50x75 km terrain data base
- Needs to be able to cover and conceal movements of tanks
- Active terrain radius of 3500 meters
- Central Europe and Middle East representation on database

Some of the identified Pre-Planned Product Improvements for CCTT are:

- 75x125 km terrain data base
- Mixed agricultural and jungle terrain
- Active terrain radius of 6000 meters
- DMA digital terrain data compatibility

- Capability of maneuvering to 1 meter accuracy

- Dynamic terrain.

Mr. Pete Robison (DMA, Washington, DC) - DMA Standardization Activities for Digital Mapping Charting & Geodesy (MC&G) Data

The Defense Mapping Agency (DMA) provides timely and tailored maps. DMA now has a variety of formats: DTED, DFAD, CD ROM, TTD, ITD, P2851, RRDB, DIGITS. There exists a JROC standardization program. DMA wants to establish its standards as military standards. Mr. Robison mentioned DIGITS as another "standard". DIGITS and P2851 may mesh and coalesce. DIGITS is currently not funded and not staffed. Currently it is still only a concept. DIGITS will represent DMA and non-DMA data and convert them to military standard data sets which would then be transformed to media types for simulators.

The Mark 85 is a present day program. The Mark 90 (due to operate in 1992) is a program which will digitally produce all data (expected to reduce waiting time by 75%).

For a list of DMA products and information write to:

Mr. Pete Robison
Defense Mapping Agency Systems Center
Advanced Weapons and Systems Division
8613 Lee Highway
Fairfax, VA 22031-2138
Phone: (703) 285-9325

Frank Capece (Engineer Topographic Laboratories) - Army Approach to Digital Terrain Data Requirements

Digital Terrain Data was defined in three formats:
- Grid Point (DTED)
- Raster Array
- Vector

Mr. Capece identified major concerns of DMA in the past as:
- users overstating digital terrain data (DTD) requirements
- redundant data collection & software support was costly
- Army's growing desire for detailed DTD is uncontrolled

ETL was placed in charge of managing these problems which led to the formation of the Digital Concepts and Analysis Center (DCAC). DCAC's mission is to be the army's center of technical expertise of DTD. Their goal was to accomplish three objectives: 1) requirements analysis, 2) prototype evaluation, and 3) MC & G standards.

Mr. Capece identified the Army's DTD strategy:

- Use existing digital products (DTED, DFAD)
- Convert existing DMA paper products into digital format for near term use
- Support TTD as land combat data base of the future

Mr. Capece discussed Interim Terrain Data (ITD) which is a subset of Tactical Terrain Data (TTD). ITD is produced from existing products (DTED 1, TTADB's, PTADB's). Its proposed use is for ground mobility, perspective, contouring, surface, vegetation, obstacles. DMA's scheduled production of ITD is: 20 sheets in FY89, 150 sheets in FY90, and 1200 by FY94 (of Germany and Korea). Plans are to support operations field Army systems in Europe over the next decade.

There have been discussions of high resolution data (1m) over small areas, however, nobody has been required to produce that data. ETL has looked at the equipment necessary for this kind of work, but is not planning on doing any volume of work at that resolution (or any finer than 30m).

Dr. Pete Wever (BBN Systems and Technologies Corp.) - SIMNET Database Interchange Specification

BBN has developed a framework for interchanging datasets among SIMNET database producers and consumers. BBN's method defines representation of objects using Abstract Syntax Notation One (ISO ASN.1). Linear and aerial features, 3d models, and terrain models all have common source data. A "standard" must be flexible and able to support growth and revision. Correlation and interoperability are also important. Correlation - how well do different databases agree. Interoperability - how well do different simulators play together. Standards should be independent of any specific application.

ASN.1 is simple, clear, machine-readable, and a recognized standard. It utilizes CASE (implies that one can build tools to check syntax) and ISO standards 8824 & 8825. The flow of models is: real world entity -> conceptual model -> object/attribute representation -> ASN.1 Representation -> ASN.1 Physical Encoding.

Dr. Wever will have a sample database of Bald Hill by 10 September and can be reached at 206/746-6800 or **pwever@bbn.com** by e-mail. There will be a subset of a SIMNET database available in November.

Mr. Tony DelSasso (P2851 Wright Patterson AFB, OH) - Standard DOD Simulator Digital Data Base (Project 2851)

Mr. DelSasso began by giving a brief description of Project 2851. Project 2851 gives us a standard data base that consists of four basic components:

1. Terrain (terrain elevation data)
2. Feature data
3. Models (3-D representations of real objects)
4. Texture (not currently implemented)

Mr. DelSasso listed the database networking issues as:

Where does the database reside?

- Centralized - a single copy shared by all simulators. This is not a realistic solution after the number of simulators increases beyond a certain number.

- Distributed - one database distributed over several different nodes. This method is efficient for storage but not for update considerations.

- Replicated - every simulator has a copy of the data base. This is the least efficient for storage considerations, however it is best for retrieving information. This is the most feasible method at this time.

Real-time terrain database update

- Static - cannot modify environment.

- Dynamic - database is modifiable; tough problem: how to modify photo-texture.

Correlation

- This is the most challenging issue. If everyone uses their own terrain triangularization algorithm then the peaks and valleys of the same terrain on different databases might be in different locations.

Security

Some of the activities of Project 2851 are:

- they can produce single computer GTDB

- real-time update, can provide multiple representations of various data base features

- correlation -> SSDB acts as common data source.

TERRAIN DATA BASES
WORKING GROUP BREAK-OUT SESSION

Wednesday, August 23, 1989

Speaker Summary:

Tom Garvey (SRI International) -
Planning and Decision Making Issues/Concerns

Mr. Garvey's major concern was planning, route planning, mission planning, resource allocation, robotics, perception/image understanding, uncertainty management, terrain analysis, and decision making. He is also interested in helicopter planning: real-time, enroute re-planning, situation data and initial planning with plan execution => real-time re-planning.

SRI has developed two types of route selection:

1) pixel method - using cost function on pixel array
2) region method - characteristic areas of topographic similarity

Mr. Garvey showed a video of non-real-time flyby. With a Connection Machine they can generate 4 frames/sec and use a joystick as control.

Linda Mathews (BBN Systems and Technologies Corp.) -
Data Base Creation

Ms. Mathews spoke of the issues of creating a data base. She explained BBN's format. The terrain data base in the SIMNET system is replicated; each simulator has its own copy of the database but will need to share information.

The question was asked about how to process data. If different simulators have different levels of detail, one may see the other but the other may not see the one. How about a low level format to permit different databases? These remain as open issues for further investigation.

Major Mike Sieverding (USAF, Project 2851) -
Comments on P2851

Major Sieverding made the distinction between mission training and mission planning. He then combined them to form combat mission rehearsal (CMR). CMR was defined by the "we must train as we will fight" concept, validate mission plans with men-in-the-loop, and networking implications. P2851 exists to support training system programs and is being enhanced for CMR.

Ron Taupal (Merit Technology) -
Simulation Interoperability

Mr. Taupal's presentation dealt mainly with interoperability and level-of-detail (LOD). He supports a distributed simulation database with LOD. There exists a wide range of representations, from complex to simple. LOD is designed to reduce processing time. LOD anomalies - how much detail is enough? The answer depends on the task. For example, for in-air refueling the detail need is high, while for a tank driving along a mountain the detail need is low.

Problems: texture vs lots of polygons, stamps vs textures, anti-aliased vs non-anti-aliased polygons, maybe military symbols are sufficient for visual cues.

Mr. Taupai pointed out that BBN's format is independent and allows for growth.

David Tseng (Hughes Research Laboratory) - Unmanned Systems

Mr. Tseng focused on unmanned systems. Problems: gullies above ground, holes in polygonal data, polygon overlap, broken roads, elevation mismatch. He needs seamless boundaries between adjacent maps, winged polygons, and true connectivity of roads and intersections. He believes visibility to object and object parts, dynamic update of database, interpolation of elevation data, and separation between map and real world are all necessary items.

Dr. Mike Zyda (Naval Postgraduate School) - Low Cost Visualization

Dr. Zyda began his talk with an overview of the work being done at the Naval Postgraduate School. Dr. Zyda's interests were in low cost visualization. What is needed in order to build a low cost visual systems in the future? You can begin with a graphics workstation with basic 3-D representation. Some of the difficult problems with these representations are:

1. the 3-D representations vary from workstation to workstation
2. field of view
3. terrain display

Other problems exist such as: determining minimum number of polygons, volume computations, cpu/graphics balance issues (off-load graphics to cpu and pre-process database), 3d icon production usage, dynamic terrain, and autonomous vehicles for driving and fighting.

ITEMS/ISSUES REQUIRING ADDITIONAL INVESTIGATION

The following items, identified during the course of the workshop, will be taken as Action Items by the Steering Committee. These items, along with others will surely arise, will be assigned to various working groups who will investigate the item in detail and provide a recommendation to the Steering Committee.

Network and Communications Working Group

Required Protocol Refinements/Extensions

- Support for Simulators of Different Fidelity
- Interfacing with Existing Simulators
- Ability to *Scale-Up* or *Scale-Down*
- Ability to Support Time Critical Applications
- Incorporation of Additional Entities
- Support for Voice and Data Communications
- Incorporation of Environmental Effects
- Security
- Publish Info on Connecting Dissimilar Simulators
- Increase Size of the *Game Board*
- Machine Dependency Issues - External *vs* Internal Representation
- Use of ADA PDL
- Interfacing with the *Live Exercise* Environment
- Standard Protocols for Wide Area Communications (Long Haul)
- Determine Events Requiring Guaranteed Delivery
- Non-Visual Issues
- Liaison NSA Secure Data Network System (SDNS)
- Some Time Critical Events May Make Tighter Update Periods Necessary (Adaptive Thresholds)
- Absolute Clock Time
- Define Scope / Applicability of the Standard

- Annotation of Location (Lat / Long)
- Prioritize What Needs to be Standardized & When
- Look at *Protocol Stack* Architecture for Protocols
- Look at Protocol Stds for Net & Transport for Multi-cast
- Possible liaison with GOSSIP

Standards Process

- MIL-STD is Preferred Approach
  - No Objections
  - DoD Control of Pace and Scope
- Need Total Commitment by Participants in Standards Project
- Need to Develop **Common** Systems Level View and Evolutionary Path
  - Facilitates Discussion of Technical Details
  - Context for Extension and Future Standards
- Solicited Written Responses So Standards Project Can Start
  - SIMNET as Basis for First Standards
  - Technical Issues to be Resolved
  - Some Idea of Other Standards and Liaisons with Other Standards
- PM TRADE Appointed as Executive Agent (Lead MILDEP)

ITEMS/ISSUES REQUIRING ADDITIONAL INVESTIGATION

Terrain Data Bases Working Group

- Need to coordinate effort with DMA.
- Interim Terrain Data Assessment.
- Project 2851 Engineering Change Proposal
- Geodetic frame-of-reference.
- Working group to investigate correlation parameters and metrics.
- Working group to investigate dynamic terrain.

PLANNED STANDARDIZATION ACTIVITIES

Steering Committee
A steering committee composed of Government, Industry and Academia representatives will be formed to facilitate the standardization activities of both the Network and Communications Working Group, Terrain Data Bases Working Group, and other groups which may form or be disbanded over time.

Formation of Working Groups

Simulation Network and Communications Standards
Judging from the comments made during the working sessions of the workshop, the SIMNET Protocol presented by Art Pope (BBN) appears to be sufficient for SIMNET type simulations and will serve as a good starting point for the standardization process. It will not, however, support the long range goals of Standards for the Interoperability of Defense Simulations without refinements and/or extensions.

- **Protocol Refinements / Extensions**

The Simulation Network and Communications Protocol Refinements / Extensions Working Group will be co-chaired by Duncan Miller & Stephen Seidensticker and will focus on addressing the items/issues requiring further investigation mentioned above, along with additional items/issues which will arise as the standardization process proceeds.

- **Standardization Process**

The Simulation Network Protocol Standardization Process Working Group will be chaired by Larry Stine and will focus on pressing forward with the process of formal standardization (i.e., MIL-STD) for the Simulation Network and Communications Protocol.

Terrain Database Standards
Narrowing in on a standard for terrain databases for use in the Interoperability of Defense Simulations is not a straightforward task. During the workshop many issues arose from the various presentations which were given. From the feedback given by the workshop participants, it appears that the BBN SIMNET Database Interchange Specification does not satisfy enough requirements to make it the basis for standardization.

Further work must be done before the next workshop to be held in January 1990 to directly address the wide range of database issues and come to some common agreements whereby the standardization process can begin. Mr. George Lukes will continue to head this working group.

Long Haul Networking (LHN)
Issues related to LHN will be addressed in the future. AT&T will head up this group.

Distribution of Information

IST will be responsible for the distribution of information to all participants involved in the standardization processes. Information on the attendees list provided as an attachment should be reviewed and any corrections should be sent in writing to Jorge Cadiz, IST, 12424 Research Pkwy., Ste. 300, Orlando, FL, 32826.

Follow-Up Standards Conference

The Second Conference on Standards for the Interoperability of Defense Simulations hosted by IST/UCF with the assistance of DARPA and PM TRADE, will be held on January 16-17, 1990 at the Orlando Hyatt Hotel, Orlando, FL. The National Security Industrial Association (NSIA) is coordinating all registration and administrative activities. For further information contact NSIA National Headquarters, 1025 Connecticut Ave. N.W., Wash., D.C. 20036.

APPENDIX A

Speeches by

Mr. David Berteau & Dr. Jack Schwartz

REMARKS BY

MR. DAVID J. BERTEAU

DEPUTY ASSISTANT SECRETARY OF DEFENSE

(RESOURCE MANAGEMENT AND SUPPORT)

INTEROPERABLE SIMULATION: THE POWER STRIP OF SIMULATION

INSTITUTE FOR SIMULATION AND TRAINING

UNIVERSITY OF CENTRAL FLORIDA

22 AUGUST 1989

ORLANDO, FLORIDA

FROM MY EXPERIENCE IN THE PENTAGON, I APPRECIATE THE IMPORTANCE AND THE VALUE OF INDUSTRY AND GOVERNMENT WRESTLING WITH CHALLENGES SUCH AS THIS. I THINK A CONFERENCE LIKE THIS, WITH BOTH INDUSTRY AND GOVERNMENT FOCUSING ON SPECIFIC ISSUES, IS AN EXCELLENT WAY TO DO BUSINESS. WE HAVE NOT DONE THIS OFTEN, BUT WHEN WE HAVE, IT HAS LED TO GREATER ACHIEVEMENTS THAN POSSIBLE BY EITHER OF US WORKING ALONE.

WE FACE A TOUGH DECADE AHEAD, WITH THE POTENTIAL FOR FLAT DECLINING BUDGETS, AND WITH RISING COSTS. WE CAN'T AFFORD TO MODERNIZE THE FORCE STRUCTURE WE HAVE UNLESS WE DRAMATICALLY CHANGE THE WAYS WE DO

GOOD MORNING LADIES AND GENTLEMEN. IT'S GREAT TO BE WITH YOU TODAY TO TALK ABOUT THE LATEST AND MAYBE THE MOST REVOLUTIONARY IDEA TO HIT THE SIMULATIONS INDUSTRY THIS DECADE. THAT IDEA IS THE CONCEPT OF HAVING SIMULATIONS NETWORKED TOGETHER AROUND THE WORLD.

LET ME START, BEFORE I GET CARRIED AWAY THIS MORNING, BY EXTENDING MY THANKS TO THE INSTITUTE FOR SIMULATION AND TRAINING OF THE UNIVERSITY OF CENTRAL FLORIDA FOR HOSTING THIS MEETING. I UNDERSTAND THEY WILL ALSO BE OUR HOST FOR THE FOLLOW-ON CONFERENCE NEXT JANUARY, AND WE ALL APPRECIATE THAT.

BUSINESS -- SIMULATOR NETWORKING WILL BE A KEY PART OF THOSE CHANGES

WE IN GOVERNMENT WANT SIMULATOR NETWORKING TO FOLLOW INDUSTRY STANDARDS -- STANDARDS THAT ARE ESTABLISHED BY AND MAINTAINED BY INDUSTRY. CLEARLY, WE IN GOVERNMENT WANT TO AND MUST BE INVOLVED, BUT IT MUST BE AN INDUSTRY STANDARD. THE TASK BEFORE US AT THIS CONFERENCE IS TO FIGURE OUT HOW TO MAKE THAT HAPPEN.

I AM ENCOURAGED BY THE FACT THAT THE PROCURERS OF TRAINING SYSTEMS FROM THE ARMY, NAVY AND AIR FORCE ARE JOINTLY CO-SPONSORING THIS EFFORT WITH DARPA. THAT GIVES AN INDICATION THAT WE IN THE MILITARY ARE ALSO

COMMITTED TO WORKING TOGETHER, AND THAT MAY BE THE TOUGHEST PART OF THIS WHOLE EFFORT.

ALL THAT COOPERATION IS A GOOD SIGN, BECAUSE IN MARCH OF THIS YEAR, THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, DR. ROBERT COSTELLO, ASKED DR. CRAIG FIELDS, THE DIRECTOR OF DARPA, TO DRAFT A DIRECTIVE FOR HIM TO SEND TO THE THREE SERVICES, INSTRUCTING THEM TO HENCEFORTH ACQUIRE ONLY NETWORKABLE SIMULATION. THAT DIRECTIVE EXISTS IN DRAFT FORM, BUT ITS FINALIZATION AWAITS THE OUTCOME OF THIS CONFERENCE AND ANY FOLLOW-ON WORK THAT IS NEEDED TO DEVELOP THOSE MILITARY STANDARDS -- STANDARDS BY WHICH THE MILITARY SERVICES WILL SPECIFY, IN

PROCUREMENT ACTIONS, WHAT INDUSTRY NEEDS IN ORDER TO DELIVER THE SIMULATION TO THE USERS.

WE HAVE THE BEST TRAINED TROOPS IN OUR PEACETIME HISTORY, AND I BELIEVE WE HAVE THE BEST IN THE WORLD, BUT WE FACE REAL CHALLENGES IN TRAINING TODAY. ONE OF THE BIGGEST CHALLENGES IS HOW TO TRAIN TOGETHER, IN A REALISTIC ENVIRONMENT, GIVEN THE CONSTRAINTS WE FACE. ONE OF THE BEST IDEAS ON HOW TO DO THIS IS THROUGH BUILDING AND USING LARGE-SCALE NETWORKS OF INTERACTIVE COMBAT SIMULATORS.

NOW, THERE IS OFTEN CONFUSION OVER WHAT IS MEANT BY PHASES LIKE "INTEROPERABLE

SIMULATION" AND "DEFENSE SIMULATION INTERNET" AND OTHER SUCH PHRASES. LET ME SAY THAT, FROM MY PERSPECTIVE, IT DOES NOT MATTER WHAT WE CALL IT. WHAT IS IMPORTANT IS THAT WE ALL UNDERSTAND THAT WE WANT AND NEED THE ABILITY TO HAVE ALL COMBATANTS CONDUCT INDOOR MANEUVERS INTERACTIVELY IN THE SAME ENVIRONMENT. WE WANT A NETWORK -- NOT UNLIKE AN ELECTRICAL POWER STRIP -- INTO WHICH ALL KINDS AND ALL BRANDS OF SIMULATORS CAN BE PLUGGED AND FUNCTION INTERACTIVELY.

THE POWER STRIP ANALOGY LETS US UNDERSTAND THAT WE ARE IN A NEW ERA OF SIMULATION. IT IS INDEED AN OPEN ARCHITECTURE APPROACH THAT WILL REQUIRE AN OPEN MIND AND A NEW WAY OF

THINKING, BOTH FOR US AND FOR YOU. BUT THE POWER IT CAN BRING US IS WELL WORTH THE CHANGE.

FORTUNATELY, THERE IS A WORKING MODEL WITH WHICH TO BEGIN. IT IS EMBODIED IN THE CRITERIA FOR THE LARGE SCALE SIMULATION NETWORKS -- SIMNET. EACH OF YOU HAVE ALREADY RECEIVED COPIES OF THE DRAFT COMMUNICATIONS PROTOCOLS AND THE SPECIFICATIONS FOR DATA BASE EXCHANGES. I'M NOT HERE TO TALK ABOUT THE "HOW" OF SIMNET, BUT RATHER THE "WAY." I KNOW THAT EACH OF YOU HAS DONE YOUR HOMEWORK AND ARE PREPARED TO LABOR OVER THESE DRAFT DOCUMENTS. EQUALLY IMPORTANT IS THE TIME AND ATTENTION THAT YOU AND YOUR ORGANIZATIONS COMMIT TO THIS EFFORT BETWEEN

THIS CONFERENCE AND THE NEXT CONFERENCE IN JANUARY.

BEFORE WE BEGIN TO WORK THIS EFFORT, IT IS IMPORTANT THAT ALL OF US UNDERSTAND HOW IMPORTANT THIS NETWORKING CONCEPT IS. LET ME REVIEW SOME OF THE APPLICATIONS THAT EXCITE US IN THE PENTAGON.

WITH REGARD TO TRAINING, THIS TECHNOLOGY HAS TREMENDOUS POTENTIAL TO IMPROVE BOTH INDIVIDUAL AND COLLECTIVE TRAINING. THINK OF THE ABILITY TO HAVE A HIGH FIDELITY, INDIVIDUAL SKILLS FLIGHT TRAINER TO THROW A SWITCH, AND EXPAND HIS WORLD. HE OR SHE WILL GO FROM THAT STERILE ENVIRONMENT WHERE WE BRUSH UP ON INDIVIDUAL SKILLS, AND BE IN

A REALISTIC COMBAT ENVIRONMENT WHERE ALL OF THE "FOG OF WAR" COMES INTO PLAY, WITH NOT ONE TARGET, BUT 50, OR 100. ALTHOUGH WE DO NOT PRETEND THAT SIMULATION PROVIDES A 100% REPLACEMENT FOR FIELD TRAINING, THERE ARE SO MANY THINGS THAT CAN BE DONE IN SIMULATION THAT CANNOT BE DONE IN THE REAL WORLD DUE TO SAFETY AND ENVIRONMENTAL CONSTRAINTS, OR WITH HIGH-COST, HIGH-TECH INDIVIDUAL SIMULATORS.

FOR COLLECTIVE TRAINING, THERE IS NO WAY THAT A COMMANDER CAN PRACTICE ALL OF THE WARFIGHTING SKILLS REQUIRED FOR THAT COMMAND IN TODAY'S ENVIRONMENT. THERE ARE TOO MANY CONSTRAINTS OF TIME, SPACE, MONEY AND LOGISTICS. AND A COMBAT ENVIRONMENT WHERE

THERE ARE LIVES AT STAKE IS CLEARLY THE WRONG PLACE TO PRACTICE SOMETHING FOR THE FIRST TIME IF WE CAN POSSIBLY AVOID IT.

IN UNIT TRAINING, WE HAVE TO CONSIDER THE RELATIVE ADVANTAGES OF TRAINING IN A SURGE VS STEADY, HIGHER LEVELS. THIS HAS PARTICULAR RELEVANCE FOR QUESTIONS OF ACTIVE VS RESERVE TRAINNG. OUR PRELIMINARY DATA SHOW THAT STEADY, HIGHER TRAINING PRODUCES GREATER RESULTS THAN LOWER LEVELS FOLLOWED BY A SURGE, BUT IT MAY BE POSSIBLE TO OVERCOME THAT WITH NETWORKABLE SIMULATION. THIS WILL PROVIDE US WITH MORE WAYS TO ENSURE THAT OUR TOTAL FORCE POLICY CAN BE EVALUATED.

WITH REGARD TO WHAT THE ARMY CALLS MANPRINT, AND WHAT WE REFER TO AS MPTS, MANPOWER, PERSONNEL, TRAINING, AND SAFETY IN WEAPONS DESIGN, WE CAN DETERMINE THRU SIMULATION, (PRIOR TO BENDING THE FIRST METAL IN A PROTOTYPE) WHETHER THE SOLDIER CAN HANDLE THE SYSTEM IN A FULLY TASK LOADED COMBAT ENVIRONMENT (OR DOES HE TURN OFF OR IGNORE SOME OF THE CAPABILITIES BECAUSE HE IS TOO BUSY TRYING TO FIGHT AND STAY ALIVE). IN THE LONG RUN, NETWORKABLE SIMULATION WILL HAVE HUGE PAYOFFS HERE.

WITH REGARD TO COMBAT DEVELOPMENT, THE REQUIREMENTS CAN BE ARTICULATED, VALIDATED, AND THE CAPABILITIES AND VULNERABILITIES

FINE TUNED PRIOR TO AND DURING PROTOTYPE DEVELOPMENT. FOR EXAMPLE, WE CAN DETERMINE WHETHER OR NOT THE ADATS NEEDS A GUN FOR SELF PROTECTION.

WITH REGARD TO OPERATIONAL TEST AND EVALUATION, WE CAN DETERMINE PRIOR TO THE CONDUCT OF THE EXERCISE, THE IMPORTANCE OF THE DATA ELEMENTS WE NEED TO COLLECT. WE CAN RUN THE TEST ON SIMULATION, COMPARE THOSE RESULTS TO THE FIELD TEST, AND IF THERE IS A CORRELATION, WE SHOULD BE ABLE TO CONDUCT EXCURSIONS IN SIMULATION AND MAKE INFERENCES TO THE REAL WORLD. THIS WILL DRAMATICALLY EXPAND WHAT WE CAN TEST, AND

HOW, NOT JUST FOR OPERATIONAL TESTS BUT FOR DEVELOPMENTAL TESTS AS WELL.

FOR THE CONTRACTORS, IT GIVES THEM THE ABILITY TO "DIAL-UP" A WAR, AND TO INSERT THEIR NEW CONCEPTS (WEAPON SYSTEMS, C3I, ETC) INTO THE WAR. AS THEY REFINE THEIR CONCEPTS, THE RESULTS OF THE REFINEMENTS CAN BE SEEN AND MEASURED. I WOULD HOPE THAT NOT TOO MANY YEARS DOWN THE ROAD, WE ARE ABLE TO TOTALLY REVAMP THE MATERIAL ACQUISITION PROCESS. TO DEVELOP ONE IN WHICH THE CONTRACTORS ARE CONSTANTLY "AT WAR" ALONG SIDE OF THE SOLDIERS, SAILORS, AND AIRMEN WHO ARE THEIR FINAL CUSTOMERS.

I AM INCREDIBLY ENTHUSIASTIC ABOUT ALL THESE POTENTIAL APPLICATIONS, WHICH I THINK WILL REVOLUTIONIZE THE WAY WE TRAIN, THE WAY WE DEVELOP, TEST, AND PROCURE SYSTEMS, AND THE WAY WE ADJUST STRATEGY, TACTICS, AND DOCTRINE.

THE BOTTOM LINE IS THAT OUR MEN AND WOMEN IN UNIFORM DEPEND UPON US TO PROVIDE THE CAPABILITY TO PRACTICE THE BUSINESS OF WARFIGHTING AND EFFECTIVE WEAPON SYSTEMS SHOULD THEY EVER BE CALLED UPON TO EXECUTE NATIONAL POLICY. SIMULATION NETWORKS CAN GIVE US MORE OF THAT CAPABILITY.

IN CLOSING, I WANT YOU TO KNOW THAT THE DEPARTMENT OF DEFENSE IS SERIOUS ABOUT THIS

EFFORT, AND WE SOLICITE YOUR TALENTS IN MAKING IT HAPPEN.

THANK YOU.

Keynote Talk for Simulation Networking Conference

August 22, 1989, Orlando, Florida JTS

Let me welcome you all to this conference. As you know, its specific purpose, though urgent and important, is limited and very directly practical: to work toward agreement on software standards for networked simulations of the SIMNET type. Behind the specific questions which will occupy you there is, however, a very much larger issue on which I would like to comment in this opening talk. I believe that simulations of the type pioneered by SIMNET have truly revolutionary potential for Defense effectiveness. To the extent that this is true we can expect such simulation systems to proliferate steadily and rapidly in the military (and also in defense industry), and ultimately to become standard, daily-use instruments for Defense training, planning, procurement, and development of doctrine. Let me explain why I believe that this will be the case.

The enormous influence on military events of the *fog of battle*, i.e., of that inescapable confusion which engulfs the participants in battle and renders many of their actions ineffective, is a truism of military history. I submit that other, equally dense and debilitating 'fogs' have surrounded, and still surround, all the activities by which the military *prepares* for battle, vitiating the effectiveness of all these preparatory activities to an equal or greater degree. In this sense, there is and has always been a *fog of procurement* – a *fog of development* – a *fog of planning*. The real importance of the kind of detailed, large scale military simulation exemplified by the SIMNET system is that, for almost the first time, it gives effective means for cutting through these debilitating fogs.

Let me touch on these points one by one, beginning with weapons system specification design, and procurement: By inserting hypothetical new weapons systems into the simulated world of military detail provided by SIMNET, one can assess the value of these systems in a combined arms setting. Countervailing systems can be assessed systematically and objectively, and effectiveness–enhancing system modifications can be explored far more rapidly and inexpensively than is now possible. This will allow much sharper focusing of the acquisition process than has previously been possible, making it feasible to assign some proposed weapons systems urgent priority, and to set others aside as ineffective. It allows threat systems to be evaluated in the same objective accurate, manner as friendly systems. It will allow weapons system developers to become aware of the difficulties of using their system in a combat environment, with great potential benefit to system design and battlefield usability. All this is now more than speculation; I take these points from experience DARPA has already had, for example in simulations of a still hypothetical battlefield air defense systems (FAAD–LOS) run some months ago at Ft. Knox.

Next, as to training and doctrine. The Services have become increasingly aware of the potential importance of large-scale computer Battle Simulation as a tool for training both at the tactical level and for Senior Commanders. Simulations of two kinds are in active use. *Detailed* or *engagement* simulations, exemplified by the SIMNET system, simulate all the essential tactical characteristics of individual weapons platforms and systems, allowing them to be fought, in real-time battles over visually recreated terrain, just as they would be fought in real battle. *Operational* or *aggregated* simulations, exemplified by Joint Warfare Center's JESS system, are intended for use in higher level command training exercises, up to multi-corps and theater levels. Aggregated systems are used not only for commander training but as tools of military analysis. However, in this crucial role they suffer from a crucial shortcoming; they cannot be decisively calibrated. For this reason conclusions, especially unpalatable conclusions, emerging from a simulation whose inner details are visible only to software (but not to military) experts always remain debatable, and are bound to be disputed. The following trenchant remark[5], taken from a recent Rand Corporation analytic study of Strategic balance in the European Central Region, underlines this problem and also reinforces my earlier remarks about the potential impact of simulation on procurement: "One problem with analytic efforts to understand war and evaluate options is that our data and intuition depend largely on experiences from many years ago (e.g. the 1973 Arab-Israeli wars, and even WW II.) It is likely that we are greatly underestimating the value of some weapons systems or tactics, while overestimating others. Certainly we can see that analogous mistakes were made by planners before previous wars. ... The Israelis greatly underestimated the impact of improved Arab air defenses as they entered the 1973 war. In Vietnam, precision-guided munitions (PGMs) took out bridges that had been subjected to countless attacks with conventional munitions. Those PGMs could have been available much sooner had their value been fully appreciated as defense programs were defined."

The visibility attained by engagement simulations of the SIMNET type, their rootedness in physical reality, insulates them in very large part from otherwise endless debate between the always zealous proponents and equally convinced opponents of particular defense investments and systems. Once detailed and aggregated simulations have been appropriately interfaced, detailed simulation can be used to calibrate the methods of aggregation used in large-scale operational simulations, improving the realism of the information that these simulations supply to the senior commanders and staffs who use them for analytic and training purposes. This point is of fundamental importance. As the Rand remarks emphasize, development and refinement of military doctrine now relies on analysis of past battles, supplemented by analytical tools far less precise than the new integrated simulation technology is capable of providing. This leaves open the danger of catastrophic strategic and doctrinal misapprehensions, like that which led to the French WW II collapse, through failure to understand the ability of mechanized forces massed on a narrow front to achieve and exploit breakthroughs.

In this connection let me repeat the observation that, counting tank for tank, the French Army was not decisively inferior to the Wehrmacht at the start of WWII: the decisive failure lay instead in French doctrine, specifically in France's failure to understand the potential impact of breakthroughs by massed tanks. DeGaulle understood this at the time, but was never able to convince his superiors of this crucial point. Had a SIMNET-like tool been available, the inconclusive debate in which he was forced to engage might well have become a much less disputable demonstration, leading the Battle of France along quite different lines. Similar remarks apply to many other aspects of military planning and readiness. Had the U.S. Pacific commanders been using military simulations on a daily basis to work out the options available to then likely adversaries, the danger of air attack in Pearl Harbor might have stood out much more clearly, and the readiness of the Pacific fleet for such an event might have been much higher.

What I mean to suggest by such speculations is that simulation technology is not *peripheral* to defense: it *strikes deeply into all aspects of defense*, and needs to be thought of as *the* key instrument of peacetime defense preparedness.

To capture the full benefit, for acquisition and force readiness, of the new simulation technology will require a much larger program than has yet been mounted. Such a program would need to incorporate the following main elements:

(a) A comprehensive distributed simulation system covering all Service branches needs to be developed. This should integrate both detailed engagement simulations of the sort exemplified by DARPA's present SIMNET and aggregated approaches allowing units of at least battalion, but preferably brigade or division, size to be simulated economically in joint exercises up to theatre level. The *Underlying simulation technology should be developed to the point at which exercises involving tens of thousands of participants at engagement and command levels become feasible.* Use of simulation training for maintenance of readiness should become a routine daily matter across all services. One does well, one remains ready to do, what one does every day. Unused skills rust, unused security measures decay.

Simulation-based training in the use of new and existing systems can ensure that fully qualified crews are available as soon as new systems are deployed. Modern computer/communications technology can be used to link multiple sites into a single virtual battle, allowing effective and inexpensive combination of diverse military skills into task forces, and participation of reserve units in active-force training. In crisis situations, forces can be trained on simulated versions of the very terrain on which they may be required to operate (terrain which would typically be inaccessible for such purpose.)

(b) Over the course of such a program, detailed simulations should be constructed for all essential friendly and threat platforms and weapons.

(c) Sufficiently accurate simulation of military communications, EW activities, and intelligence gathering activities must be supportable in the simulation system. This is a key requirement. Communication systems are complex and vulnerable; there are many ways in which they can be attacked. Their collapse would have devastating consequences for force effectiveness. To get a good intuitive sense of exposure in this regard, to get ahead of an adversary's carefully worked out but hidden plans, simulation of attacks on the military communication system is an essential tool.

(d) The analytic and system-assessment capabilities of the comprehensive simulation complex to be developed needs to be made available to senior DoD planners, including the JCS; to the CINCs; and to other Senior Commanders. 'Requests for experimental assessment' originating with these clients should ~~ideally~~ be supported and prioritized by a JCS-level simulation authority, scheduled for experimental trial at appropriate scale, and serve to drive both major specific ~~designs~~ [illegible] (continuing upgrade of the simulation complex itself. Arrangements should also be made for use of these capabilities by congressional staff. I believe that in the future all key national officials, up to and including the President, will come to use results provided by the comprehensive simulation system of which I speak.

(e) Development of simulations for all proposed new weapons systems should become a required step in the present DoD design/acquisition process. The development process should be systematically taxed, say 1%, to pay for this.

(f) The simulation system should be designed to be accessible over secure channels from any geographic location and to have an open architecture which facilitates plug-in of an indefinite variety of new systems.

The potential benefits, to military system designers, of the ~~kind of~~ direct view of the battlefield afforded by SIMNET and its much more sophisticated follow-on systems are very great. An hour spent on the electronic battlefield will, I believe, be of greater value than days or weeks spent trying to determine a system's potential battle value, vulnerability, desirable features, and usability under battle conditions by other means. For this reason, DARPA has encouraged acquisition of the existing simulators by defense contractors, and is working out a program to ease such acquisition.

Let me note one last, particularly important, potential benefit. Training in simulation, used at sufficiently large scale, would, I believe, allow the U.S. to maintain something approaching a 'constantly veteran force.' It is well known that casualties are highest among troops going into battle for the first time; those who survive the first three weeks of combat have a much increased change of surviving a full tour. For this reason, the simulation technology you will be discussing has potential to save U.S. lives on a very large scale, were major battles again to be forced upon us.

APPENDIX B

View-Graphs for the
Network Communications Working Group
Break-out Sessions

DCS DATA SYSTEMS

Benefits Of Standards

- Interoperability
- Technology Independence
- COTS and NDI Products
- Market Expansion and Innovation
- Force Multiplier Effect
- WARNING: Choose Them Carefully

Challenges Of Transition

DCS
DATA
SYSTEMS

- MILSTDs Established 1978
- International Standards Now Coming On Line
- Protocols Are Compatible But Not Interoperable
- International Protocols Adopted By DoD For Cost Advantages
- Mission Needs Still Prevail Military Extensions Required

Agenda

▪ Opening Comments	Col Tom Herrick DCA (Chairman)
▪ Standards Process	Mr. Larry Stine MITRE Corp.
▪ User's Perspective	Col Larry Mengel US Army Armor Center
▪ SIMNET System Overview	Dr. Duncan Miller, BBN Corp. Mr. Art Pope, BBN Corp.
▪ Extensions/Issues	Mr. Stephen Seidensticker LOGICON Corp.
▪ Open Discussion	Working Group Members
▪ Closing Remarks	Col Tom Herrick

What Is The Defense Data Network

DCS DATA SYSTEMS

- DoD's Long Haul Data Comm Provider
- Interconnects Thousands of Computer Users
- Subscribers Use Multi-Vendor Equipment
- Supports E-Mail, Data Files, Remote Terminals
- Interoperability Through Standard Protocols

Defense Data Network
(DDN)

DCS
DATA
SYSTEMS

Standards For Interoperability Of Defense Simulators

NETWORK COMMUNICATIONS WORKING GROUP

CHAIRMAN: Col Tom Herrick, USA
Program Manager, The Defense Data Network

OBJECTIVES

DCS
DATA
SYSTEMS

- Determine Suitability of SIMNET as The Standard
- Identify Protocol Extensions and Issues
- Recommend Approaches to Resolve Issues
- Initiate Working Groups

DCA Interest

DCS
DATA
SYSTEMS

- Simulate Tactical Comm Systems (JTC3A)
- Provide Long Haul Service (DCSO/DDN)

NETWORK COMMUNICATIONS WORKING GROUP OBJECTIVES

- Determine the suitability of SIMNET communications protocols as the standard for the interoperability of Defense simulations.
- Identify needed protocol extensions
- Identify issues
- Recommend approaches for resolving issues
- Identify those willing to work the issues to achieve an interoperability standard for simulations systems.

Network Protocol Working Group

Required Protocol Refinements / Extensions

- Support for Simulators of Different Fidelity
- Interfacing with Existing Simulators
- Ability to Scale-Up
- Ability to Support Time Critical Applications
- Incorporation of Additional Entities
- Support for Voice & Data Communications
- Incorporation of Environmental Effects
- Security

Network Protocol Working Group

<u>Additional Issues - Refinements / Extensions</u>

- Non-visual Issues
- Liaison NSA Secure Data Network System (SDNS)
- Some Time Critical Events May Make Tighter Update Periods Necessary (Adaptive Thresholds)
- Absolute Clock Time
- Define Scope / Applicability of the Standard
- Annotation of Location (Lat / Long)
- Prioritize What Needs to be Standardized & When
- Look at *Protocol Stack* Architecture for Protocols
- Look at Protocol Stds for Net & Transport for Multi-cast
  - Liaison with GOSSIP

Network Protocol Working Group

Issues from the Floor

- Publish Info on Connecting Dissimilar Simulators
- Increase Size of the *Game Board*
- Machine Dependency Issues
  - External *vs* Internal Representation
  - Use of ADA PDL
- Interfacing with the *Live Exercise* Environment
- Protocols for Wide Area Comm Need Standardizing
- Determine Events Requiring Guaranteed Delivery

Network Protocol Working Group

Standards Process

- MIL-STD is Preferred Approach
  - No Objections
  - DoD Control of Pace and Scope
- Need Total Commitment by Participants in Standards Project
- Need to Develop **Common** Systems Level View and Evolutionary Path
  - Facilitates Discussion of Technical Details
  - Context for Extension and Future Standards
- Solicited Written Responses So Standards Project Can Start
  - SIMNET as Basis for First Standards
  - Technical Issues to be Resolved
  - Some Idea of Other Standards and Liaisons with Other Standards
- Appoint Executive Agent (Lead MILDEP)

The Standards Process - Benefits, DOD Environment, Formulation

Larry L. Stine
MITRE Corporation
McLean, Virginia 22102

22 August 1989

MITRE

Outline of Brief

- Benefits of standards
- MIL-STD's
- The standards formulation process

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Benefits of Standards

- Steamlined interoperation
- Economies of scale
- Simplified human factors
- Consideration of range of technical approaches

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Trends in Standards

- Defined earlier in design process
- Growth in applications and areas
- Increased interaction
  - Many more liaison relationships between standards organizations

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The Military Standards Process

- Covers a wide range of subjects
- Two areas of interest
  - Communications networks
  - Information processing

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Communications Standards (DCA, JTC^{3}A)

- Long haul
- Tactical

$\left.\begin{array}{l}\text{Long haul}\\ \text{Tactical}\end{array}\right\rangle$ Joint Steering Committee

- Data communications protocols - PSSG

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Information Processing (Office of the Comptroller) - 1964 Directive

- Processing DCA Y220
- Data elements - OSD Production and Logistics

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Organization Hierarchy for Data Element Standards

- OSD P&L
- Deputy Assistance Secretary of Defense for Total Quality Management (TQM)
- Standards and Data Management (STM)
- Defense Quality and Standards Office (DQSO)

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Getting Started

- Memo describing need and scope
- DQSO assigns project number, memo establishing MIL-STD project
- DD Form 1585 completed
- MIL-STD project started
  - Proceeds according to DOD 4120.3-M Defense Standards Manual-Policy, Procedures, and Instructions

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Important Aspects of a Standards Committee

- Define applications and place in system
- Identify other relevant current and pending standards
- Establish meeting agenda and structure of committee

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Other Relevant Current and Pending Standards

- Spatial data transfer
- Graphics transfer
- Graphics standards
- Performance of data networks
- High resolution TV

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Other Relevant Military Simulation Systems

- Distributed Wargaming System (DWS)
  - Warrior preparation center
- Joint Exercise Simulation System (JESS)
  - Joint warfare center

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Meeting Agenda

- Plenary
  - Minutes
  - Distribution of contributions
  - Liaison reports
  - Formation of subgroups
  - Agenda (special sessions)
- Subgroup sessions
  - Results of ballots, technical contributions, review of drafts
- Plenary
  - Results of subgroups
  - Liaison requests or directions
  - Letter ballots
  - Formation of new subgroups

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Typical Subgroups

- Systems architecture, evolution, performance (e.g., data base, status reporting, environment)
- Services and features (e.g., security, motion and location, detection)
- Protocols

<u>OR</u>

- Combined arms
- Interoperability between simulation systems
- Data base
- Message and protocol structure

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Summary

- Sound strategy to define relevant standards in early stages of evolution of simulators
  - Interoperability
  - Increased competition in procurement
  - Easier evolution
- MIL-STD is good approach
  - Data element MIL-STD
  - Define scope and need at first step
  - SIMNET may form good basis for first standard
- Growth and evolution
  - Other simulations may require interoperability at some level
  - More features to increase realistic conditions

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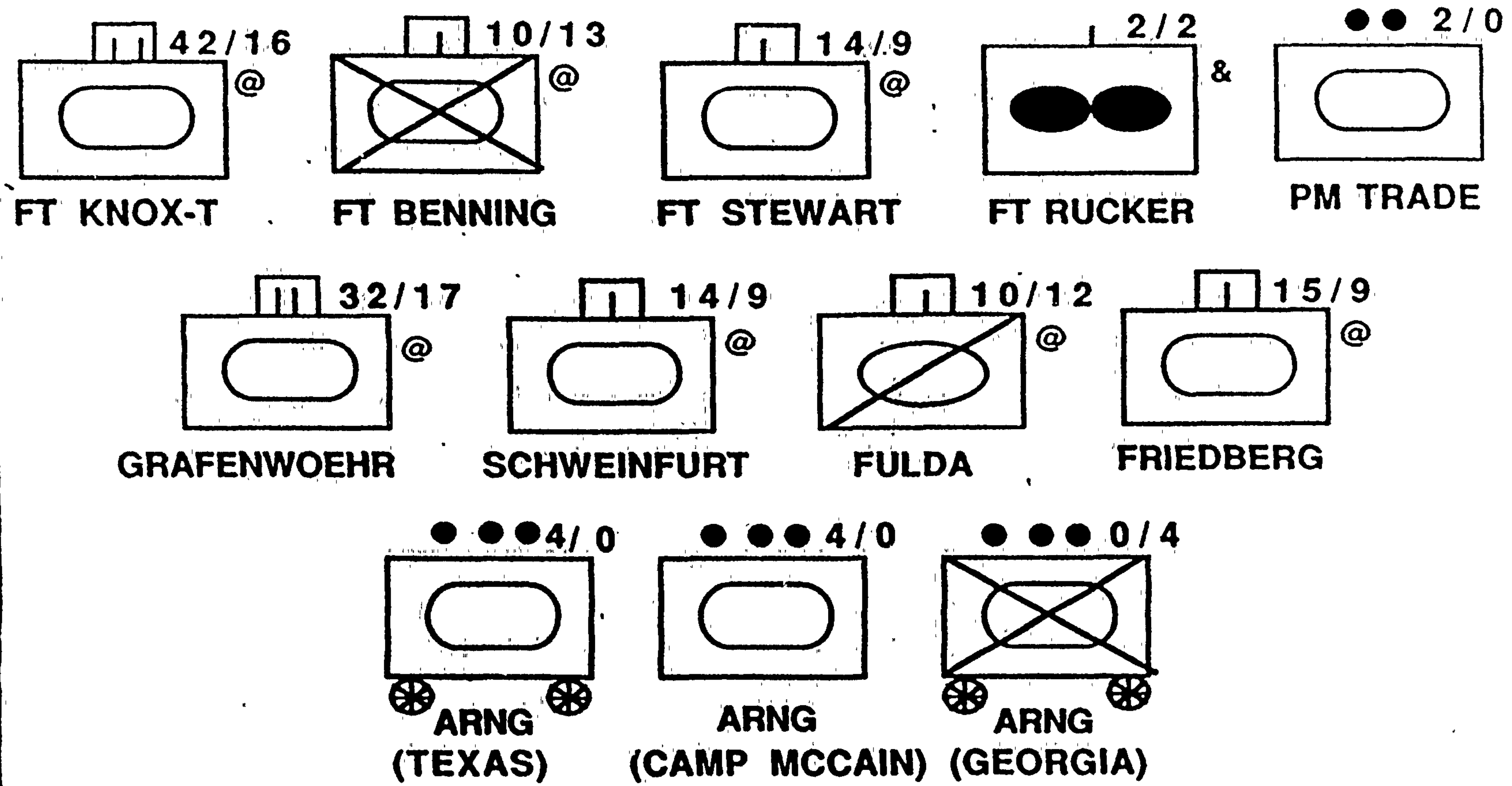
Standards for the Interoperability of Defense Simulations

Interoperable Simulation: A User's Perspective

COL Larry Mengel,
US Army Armor Center

MPF87-070589

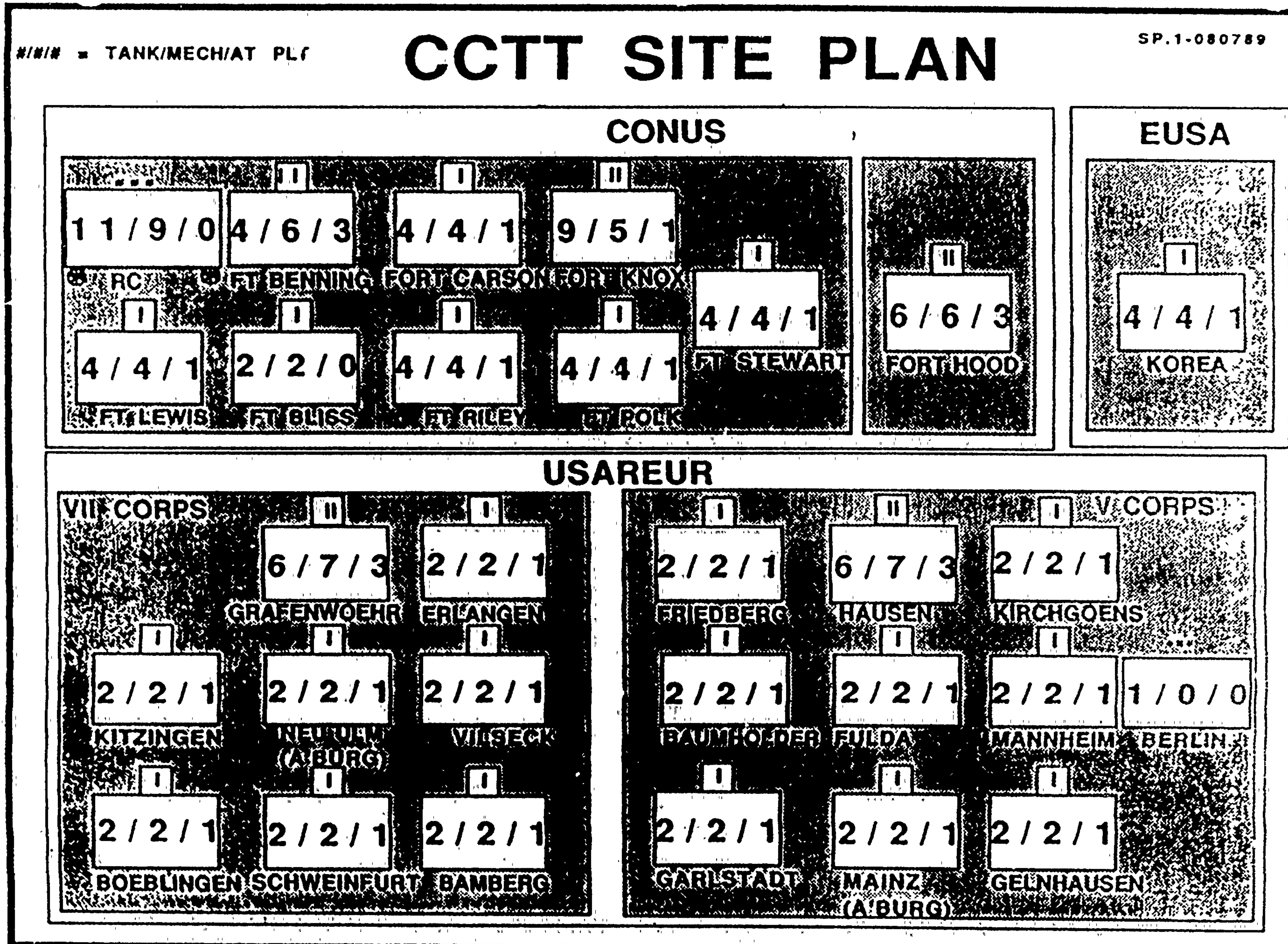
DISTRIBUTION OF SIMNET/AIRNET SIMULATORS



#/# = M1/M2,3
@ = FIST V
& = 16 HELO

ARNG= ARMY NATIONAL GUARD

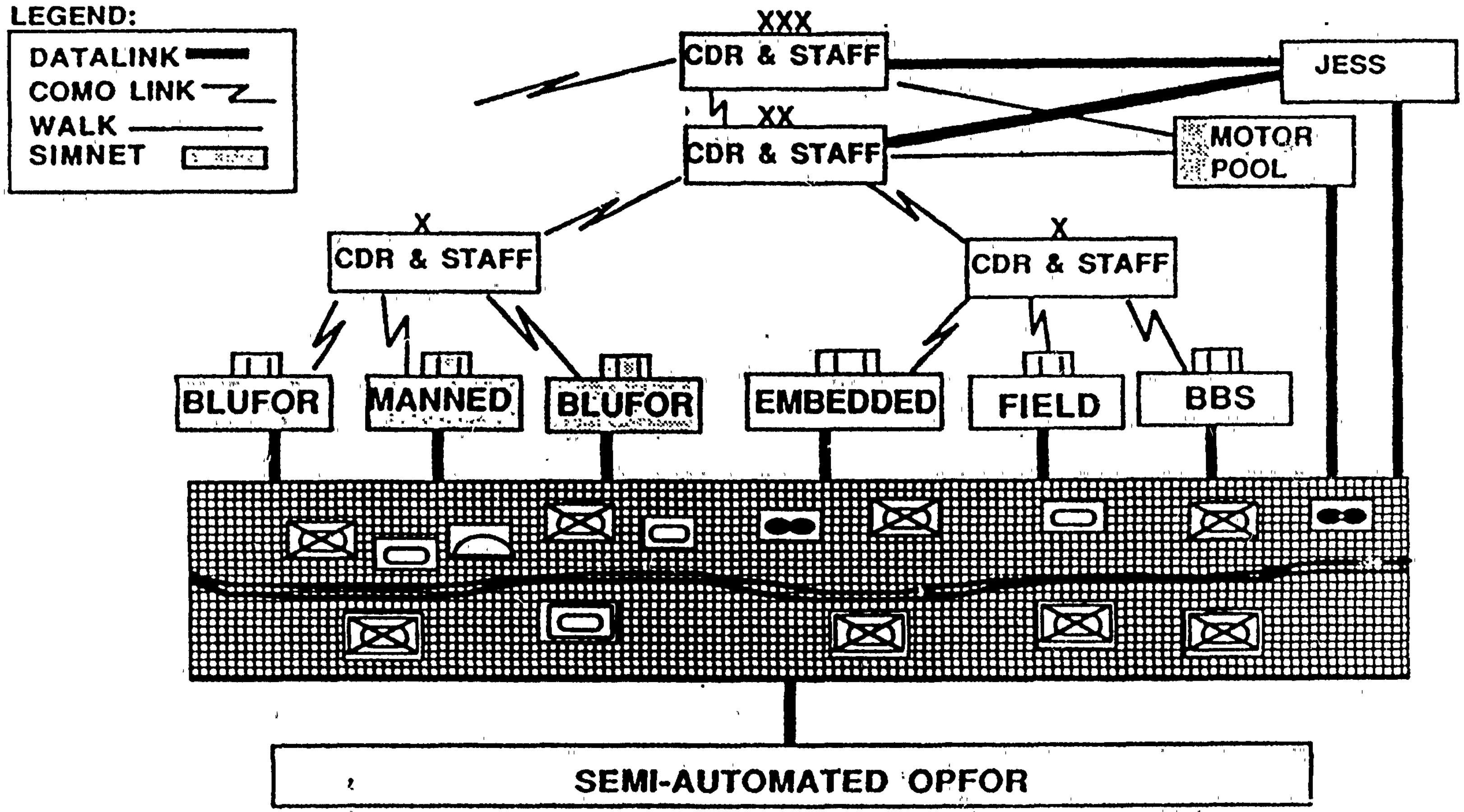
Col. Larry Mengel, USA



· CCTT = CLOSE COMBAT TACTICAL TRAINER

MPD20-082189

2004 SIMULATION ARCHITECTURE



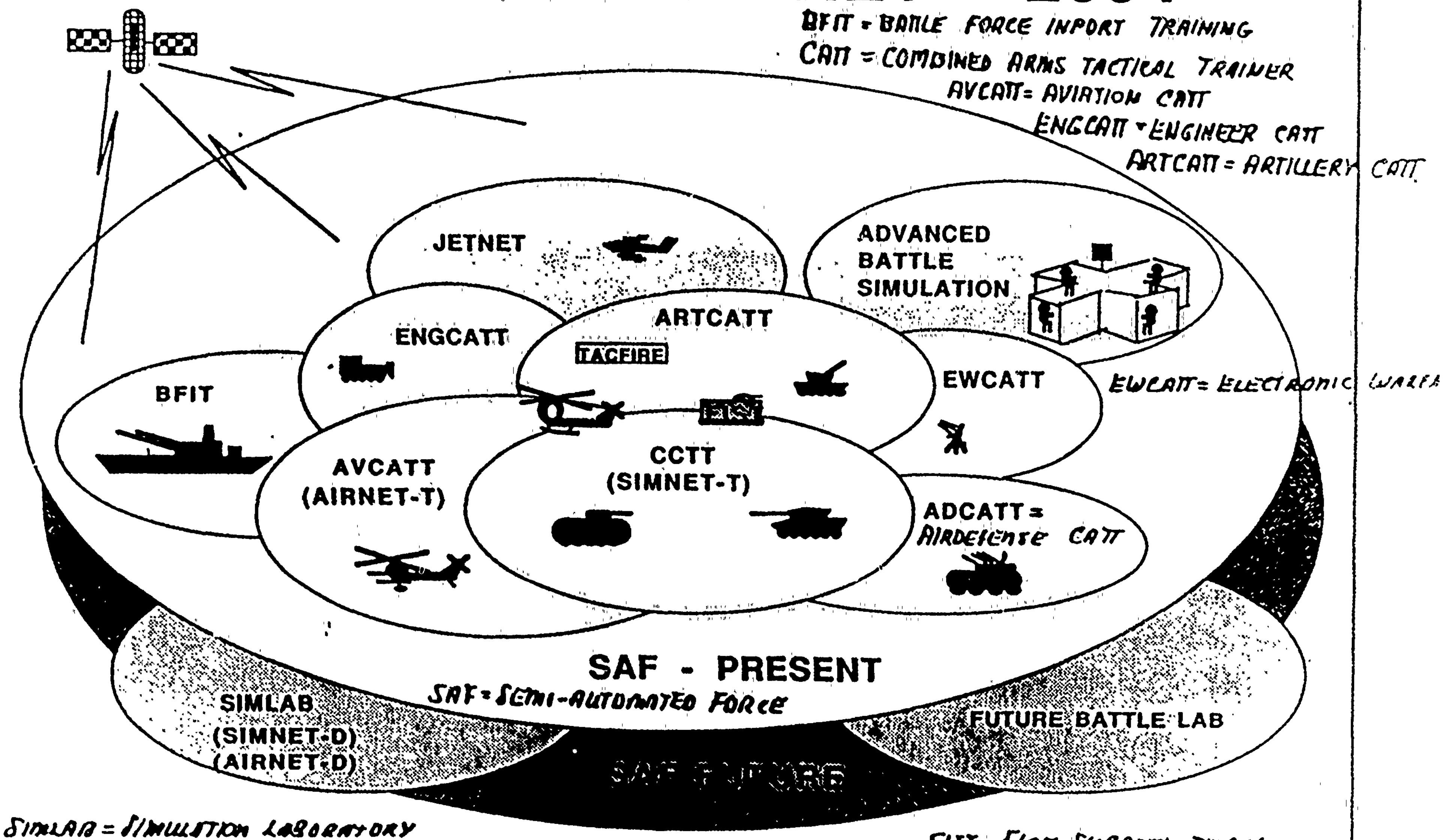
BBS = BRIGADE BATTLE SIMULATION

BLUFOR = BLUE FORCE (SEMI-AUTOMATED)

OPFOR = OPPOSING FORCE

MPARC-081889

THE PLANET SIMNET - 2004



Standards for the Interoperability of Defense Simulations

SIMNET System Overview

Dr. Duncan Miller
BBN Systems & Technologies Corporation
Cambridge, Mass.

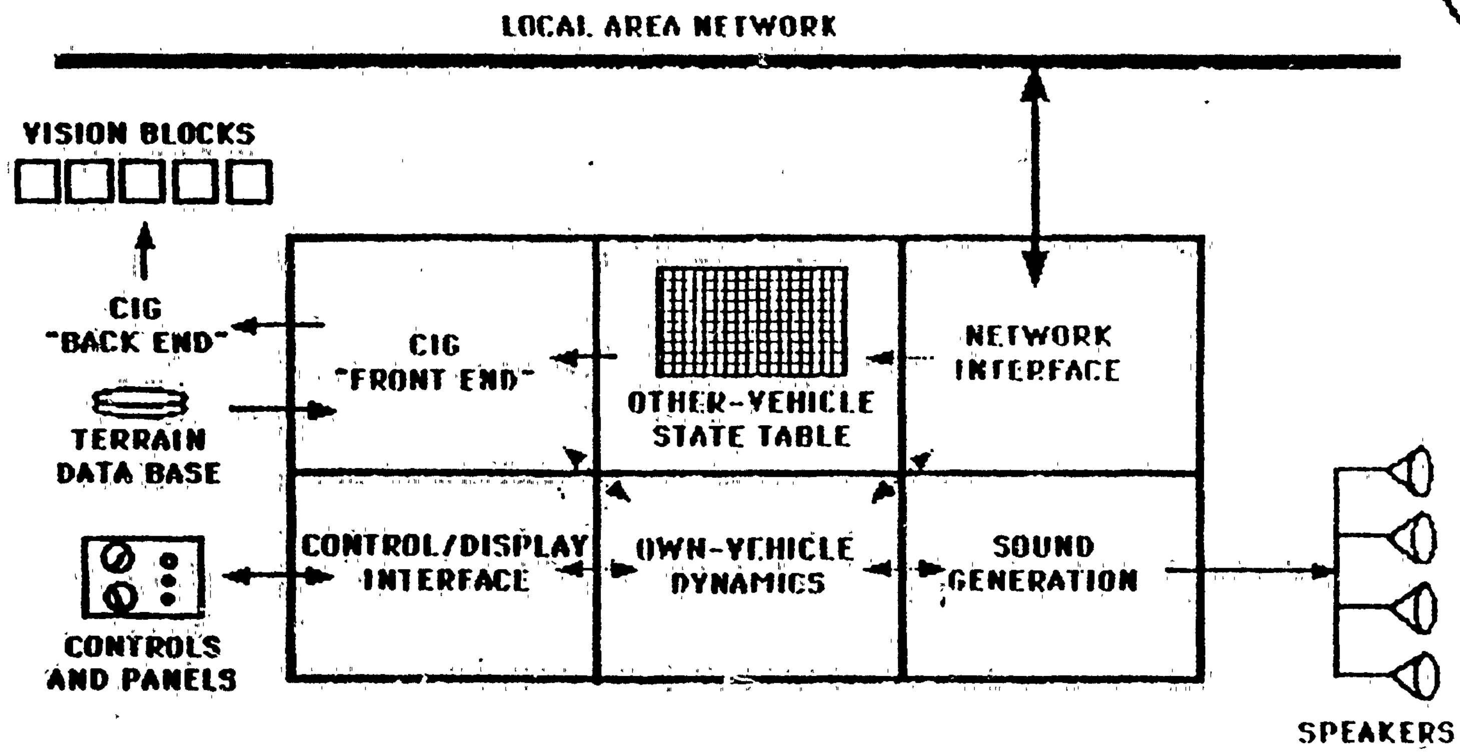
"Distributed simulation" approach

- An object-oriented simulation architecture
- No central computer is used for event scheduling, etc.
- Each simulation microcomputer is autonomous
  - responsible for maintaining state of one simulation element
  - responsible for sending messages to others, as necessary
  - responsible interpreting and responding to messages
- As network expands, each new simulator brings its own resources
- Each simulator has its own copy of the non-changing world
- Simulators communicate only <u>changes</u> in world state
- "Dead reckoning" used to reduce communications load

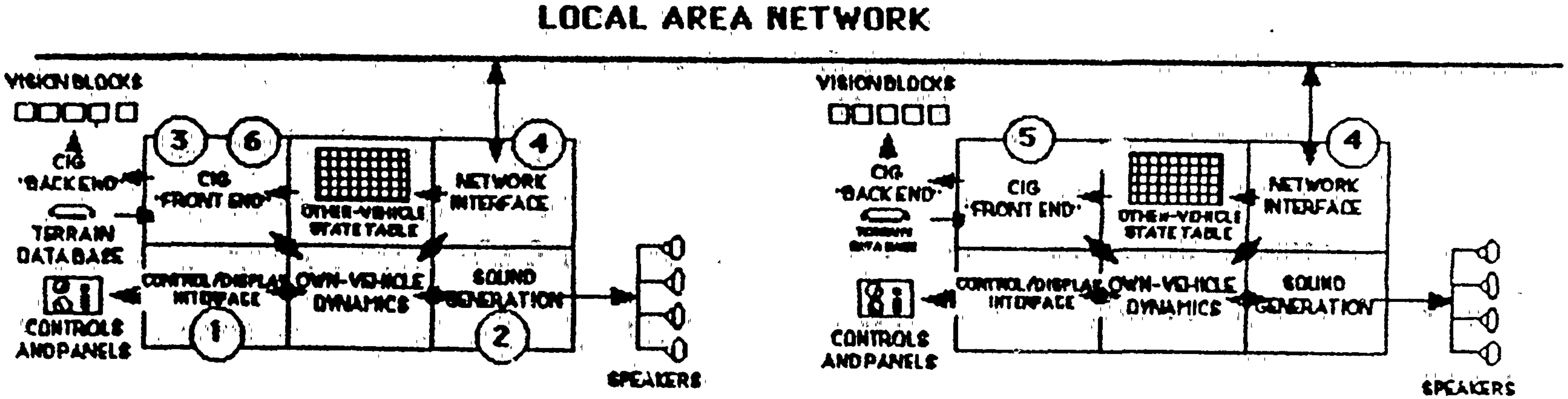
Dr. DUNCAN MILLER
BBN

Dead reckoning technique

- Each simulator maintains a model of the position of all others
- Last reported states are extrapolated until updates arrive
- Each simulator must maintain a dead reckoning model of itself
- Update broadcast whenever true state diverges from extrapolation
- Minimum update interval now used is 1/15 second, max is 5 seconds
- Updates are limited to externally visible information
  - position, velocity, attitude
  - turret azimuth, gun elevation, etc.
  - dust clouds, smoke column, muzzle flash, etc.
  - 128 bytes (1024 bits) total per update
- State update protocol is self-healing
  - if an update is missed, extrapolation of old state continues
  - next update corrects state and initiates new extrapolation



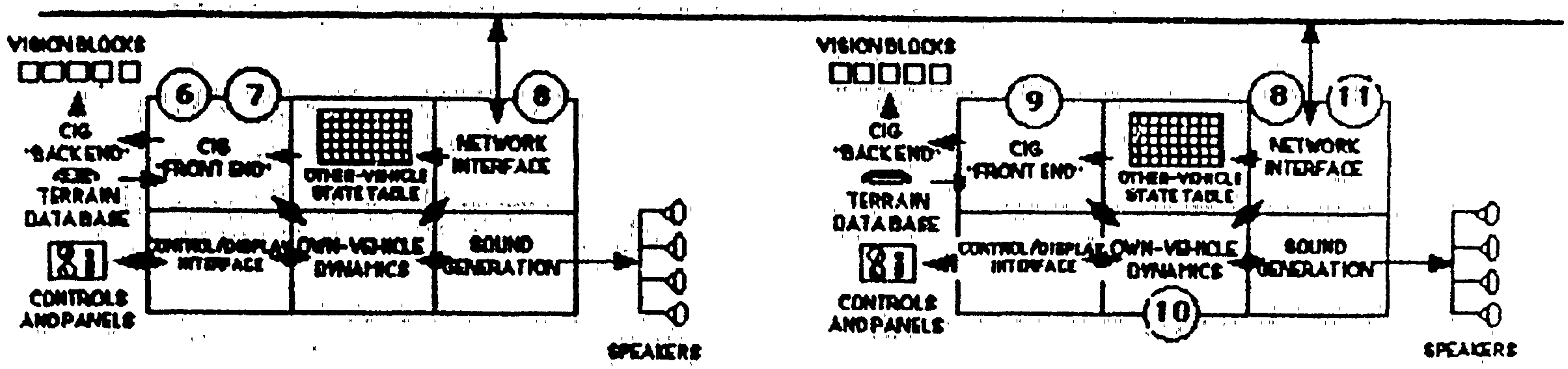
PRINCIPAL SOFTWARE INTERFACES



SEQUENCE OF EVENTS WHEN SIMULATOR A FIRES AT SIMULATOR B

1 TRIGGER PULL DETECTED
2 LOCAL SOUND EFFECT
3 LOCAL MUZZLE FLASH
4 MUZZLE FLASH MESSAGE SENT; RECEIVED
5 MUZZLE FLASH DISPLAYED BY OTHER VEHICLES
6 BALLISTIC FLYOUT CALCULATIONS; TRACER DISPLAYED

LOCAL AREA NETWORK



SEQUENCE OF EVENTS WHEN SIMULATOR A FIRES AT SIMULATOR B

6 BALLISTIC FLYOUT CALCULATIONS; TRACER DISPLAYED
7 IMPACT DISPLAYED LOCALLY
8 IMPACT MESSAGE SENT
9 IMPACT EFFECT DISPLAYED BY OTHER VEHICLES
10 DAMAGE CALCULATED BY STRUCK VEHICLE
11 VISIBLE EFFECTS (IF ANY) SENT IN STATE UPDATE MESSAGE

Balancing communication, computation, and precision

- Dead reckoning approach requires design tradeoffs
  - communications load is reduced (typically by factor of 10)
  - computational load is increased (and grows with size of net)
  - communications load increases as thresholds are reduced
- Higher-order dead reckoning algorithms change balance point
  - higher-order extrapolation can stay within threshold longer
  - communications load will be reduced
  - computational loads will be increased, however
- Currently using first-order extrapolation for all vehicles
  - average rate of 1 kilobit/sec per ground vehicle
  - average rate of 3 kilobits/sec per air vehicle
- With second-order extrapolation, air vehicle drops to 1 kilobit/sec

Local Area Network (LAN)

- Ethernet selected for low cost, multiple vendors
- Ethernet interfaces are available for almost every computer
- Ethernet efficiently handles 1024-bit SIMNET datagrams
- Up to 1024 devices can be connected to a local area net

Long-haul links

- Small Butterfly gateway interfaces local area net to long-haul link
- Currently using 56 kilobit/second dial-up lines
- Demonstrations have been conducted on Wideband Net
- 56 kilobit/second lines support 100 vehicles (each direction)
- Multiple lines can be used to increase capacity
- T1 lines, or other high-bandwidth links, can be used if needed

Manned simulators
• M1 Abrams Main Battle Tanks • M2/M3 Bradley Fighting Vehicles • Generic fixed- and rotary-wing aircraft • Generic air defense artillery

Automated simulations

- Represented by low-cost (Macintosh) workstations on sub-network
- Fire support (howitzers, mortars)
  - fire support officer enters firing missions
  - if battery is within range and available, mission is executed
  - missions are also limited by resupply rates, etc.
- Logistics (fuel, ammunition trucks)
  - S-4 controls and dispatches vehicles
  - vehicles "teleport" across battlefield with realistic delays
  - vehicles must return to supply points for reloading
- Maintenance and recovery
  - battalion maintenance officer controls and dispatches vehicles
  - vehicles "teleport" across battlefield with realistic delays
  - repair actions consume realistic time intervals
  - if correct actions are performed, simulated damage is repaired

Semi-automated simulations

- Unlike automated simulations, involve realistic motion over terrain
- Commander provides goals and objectives, may designate routes
- Vehicles move in formation, avoid obstacles, follow terrain
- Vehicles scan for enemy, make target engagement decisions
- Commander may override priorities, redirect vehicles at any point
- Semi-automated vehicles are indistinguishable from manned vehicles
- Current forces implemented (each with red and blue versions)
  - armor
  - mechanized infantry
  - helicopter
  - fixed-wing aircraft

Data collection and analysis system

- Data Loggers record all state update messages for later replay
- Replay provides "time travel" capabilities for observing action
- Plan View Display provides continuous view of battlefield state
  - controls include pan, zoom, intervisibility plots, etc.
  - replay controls include fast time, rewind, freeze frame, etc.
- DataProbe and RS/1 provide statistical analysis and plotting tools

Stealth vehicle

- Invisible to other participants (can be used during exercise)
- Used primarily for after-action reviews
- Very simple, "flying carpet" dynamics
- Can teleport to any desired location in the simulated world
- "Tractor beam" can be used to attach to, and follow, any vehicle

Electro-optical and thermal imaging systems
• Modified texture maps used to simulate appearance of terrain • Alternative models used to simulate appearance of vehicles • Bank-switching being added to CIG to permit switching models • Same line-of-sight algorithms used as for daylight displays

IVIS displays, digital communications among vehicles

- Own-vehicle position displayed, as well as other vehicles in unit
- Target locations can be transmitted among displays
- Situation reports, etc., can be composed and transmitted
- First implementation used mouse, now using touch screens

Mine laying and clearing

- Automated simulation, running on Macintosh workstation
- Minefields laid in designated areas (which takes realistic time)
- Server computes vehicle proximity to mines, announces detonations
- Each simulator computes possible damage, as for artillery round
- Minefields can be cleared in designated areas (which also takes time)

Radar simulation

- Local horizon computed, line-of-sight calculations made
- Radar warning receivers notified when radar is radiating
- Detection probability depends on target aspect, range, masking
- Radar emitters are vulnerable to radiation-seeking missiles

Missile models

- Optically-tracked missiles
  - hit depends primarily on tracking accuracy of controller
  - missile flyout model runs in controller's simulator
  - visual effect messages broadcast by controller's simulator
- Fire-and-forget missiles
  - hit depends primarily on evasive actions of target
  - missile flyout model runs in target vehicle's simulator
  - missile appearance messages broadcast so everyone sees trajectory
- Laser-designated missiles (planned)
  - success requires line-of-sight between designator and target
  - also requires line-of-sight between missile and target
  - target simulator informed when it is being designated
  - target vehicle adds designation codes to its appearance messages
  - missile flyout model calculates line-of-sight, broadcasts trajectory

Radio communication simulation

- Voice digitized at transmitter; transmitted via network
- Signals compressed to reduce bandwidth requirements
- Location, frequency, power of transmitter included in packets
- Receivers are responsible for computing which signals are heard
  - VHF signal strength computed from path length to source
  - path length includes diffraction across major obstacles
  - FM radios lock in on strongest source
- Only "winning" signal gets decoded, mixed with noise
  - this signal may be a jammer, of course
  - jamming may be intentional or unintentional
- Direction finders utilize emitter location information
  - can be used by own forces, for navigation
  - can be used by enemy anti-radiation weapons

Semi-Automated Force enhancements

- In early versions, SAF commanders "knew too much"
  - perfect knowledge of own forces
  - perfect knowledge of opposing forces in contact with own forces
- In a "fight-to-win" atmosphere, they had an unrealistic advantage
- More realistic model includes battlefield intelligence/communications
  - own forces provide periodic situation reports, including contacts
  - these reports are subject to realistic communications losses
- SAF participates in, and is subject to, electronic warfare
  - loss of communications assets will degrade commander's knowledge
  - SAF can be targeted to destroy enemy communications
- Semi-automated air defense artillery protect forces
- Semi-automated air-to-air combat will follow
- SAF workstations can now operate at battalion/regimental level
- Planned extensions may permit brigade-level operations

Standards for the Interoperability of Defense Simulations

SIMNET Communications Protocol: Proposed Standard

Mr. Art Pope
BBN Systems & Technologies Corporation
Cambridge, Mass.

Protocol Tutorial

- Introduction
- What the simulated world includes
- Goals of the SIMNET protocols
- Architecture of the distributed simulation
- Layering of protocols
- Distributed simulation concepts
- Communicating vehicle appearance
- Effect of dead reckoning on network traffic
- Data communication requirements
- Network performance
- Association protocol
- Simulation protocol
- Data collection protocol
- Data representation
- Object type numbering scheme
- Elements of communication compatibility
- Future work

Introduction

- the SIMNET protocols were developed for linking combat vehicle simulators
- current version is described in the report "The SIMNET Network and Protocols", dated 31 July 1989

What the simulated world includes

- a region of terrain
  - typically tens or hundreds of kilometers on a side
  - populated with features: hills, rivers, roads, trees, buildings...
  - static — not changing in the course of a simulation
- a particular date and time
- vehicles that move dynamically and engage in combat
- supplies of munitions, such as fuel and ammunition
- the transfer of munitions from one vehicle to another
- weapons fire and its effects upon vehicles
- damage to vehicles and vehicle breakdowns
- repairs performed by one vehicle on another
- radar emissions and detection by radar

Goals of the SIMNET protocols

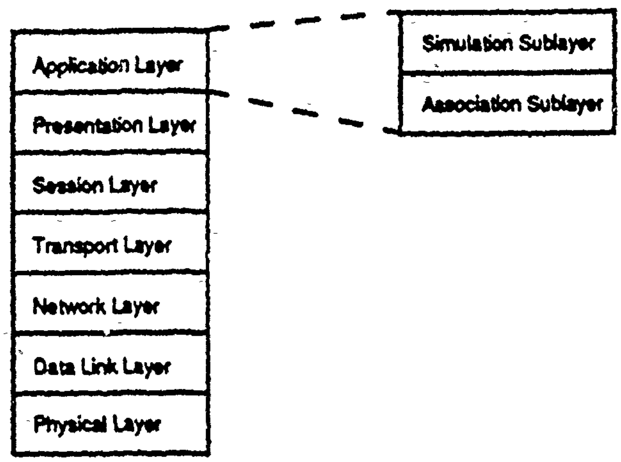
- a real–time network of hundreds of simulators
- ensure a consistent view of the simulated world
- be parsimonious and efficient
- allow efficient distribution of computation tasks
- be robust (not error-sensitive; self-correcting, if possible)
- easily accomodate new kinds of vehicles, weapons, phenomena...
- make available information useful for analysis

Architecture of the distributed simulation

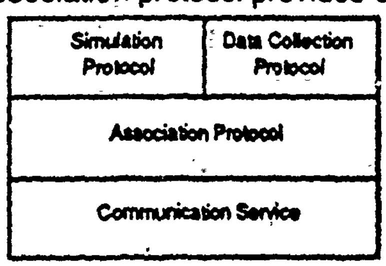
- the overall network is called a *distributed simulation internet*
- it consists of one or more *sites*
- at each site are one or more computers, called *simulators*
- a simulator might:
  - simulate a single vehicle (e.g., a flight simulator)
  - simulate a group of vehicles (e.g., Semi–Automated Forces)
  - play a role in initializing other simulators (e.g., MCC system)
  - give a window into the simulated world (e.g., Plan-View Display)
  - make an historical record (e.g., Data Logger)
- three simulator–to–simulator protocols are defined:
  - a *simulation protocol* for representing the simulated world
  - a *data collection protocol*, to support analysis
  - an *association protocol*, to convey the other two

Layering of protocols

- protocols are defined within the framework of the OSI reference model



- the association protocol provides common services



Distributed simulation concepts

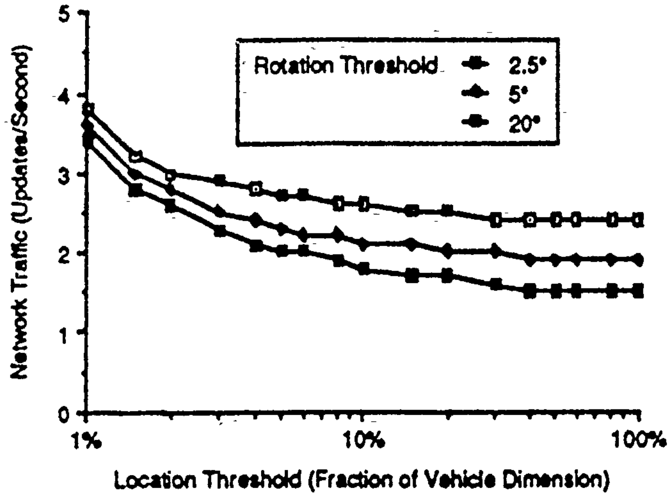
- an exercise is a joint activity of simulators
- it has a simulated world, some participating simulators, and an exercise identifier
- there can be many concurrent but independent exercises
- a simulated world is populated by vehicles
- each vehicle has these static attributes:
  - which side it is fighting on
  - what organizational unit it is allocated to
  - what type of vehicle it is
  - a unique vehicle identifier
- each vehicle has a dynamic appearance described by:
  - where it is, and how it is oriented
  - a marking or label (e.g., "Titanic" or "PltLdr/3/C")
  - variations on its basic appearance: flames, smoke, dust cloud...
- each vehicle has internal state represented by:
  - operational status of various subsystems
  - quantities of various munitions on board
- each vehicle's appearance is periodically reported with a state update message

Communicating vehicle appearance

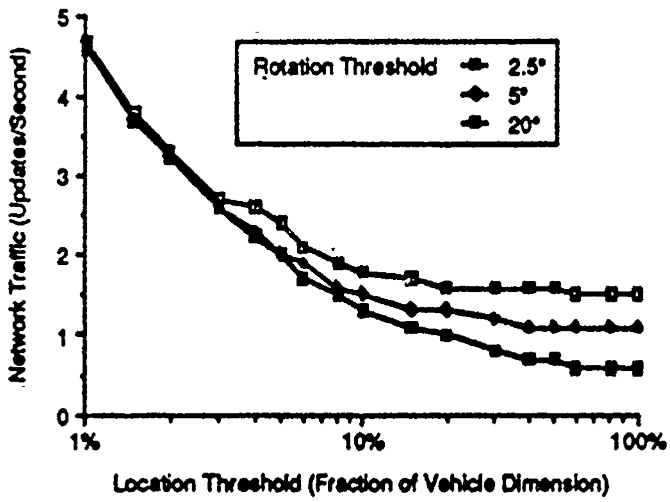
- dead reckoning reduces the need for communication bandwidth
- various dead reckoning approaches are possible:
  - no use of dead reckoning
  - location updated using velocity
  - velocity updated using linear acceleration
  - rotation updated using rate of rotation
  - velocity updated using rotation
- vehicles are classified, partially according to dead reckoning method
  - *static class* — those that remain stationary
  - *simple class* — location updated using velocity
  - *tank class* — like simple, but has a turret
- discrepancy thresholds determine when state updates are issued
  - any discrete change in appearance (e.g., catching fire)
  - translation by 10% of vehicle's dimension
  - rotation about any axis by 3 degrees
  - movement of turret or gun barrel by 3 degrees

Effect of dead reckoning on network traffic

- dead-reckoning a tank using velocity only:



- dead-reckoning an aircraft using velocity, linear acceleration, and rate of rotation:



Data communication requirements

- SIMNET protocols are application layer protocols
- SIMNET protocols are supported by network layer service
- network must support broadcasting or multicasting of datagrams
- datagrams range up to 256 bytes; most are 128 bytes
- guaranteed delivery not required; occasional failures tolerated
- a level of performance determined by the "size" of the simulation
- various network technologies may be used
- network may be a combination of local-area and long–haul networks
- Ethernet has been used successfully as a LAN

Network performance

- most network traffic is due to vehicle state updates
- network traffic depends on:
  - number of vehicles participating
  - types of vehicles (ground vs. air vehicles)
  - how vehicles are behaving (stationary, cruising, jinking...)
- ground vehicles (tanks) produce an average of one update per second
- close–support air vehicles produce an average of six per second
- each update is communicated as a 128–byte datagram
- each update must be communicated to all simulators in "real time"
- network delay, and delay variance, can be detrimental
- how much delay is acceptable depends on application:
  - relatively slow–moving ground vehicles can tolerate 300 ms
  - high–speed aircraft flying in formation cannot

Association protocol

- streamlined composite of certain transport, session, and application layer services
- eliminates need for separate transport and session layer protocols
- supports two modes of communication:
  - datagram service provides best-effort delivery
  - transaction service pairs request and response, provides retransmission
- clients are addressed by site number, simulation number
- clients belong to multicast groups

Simulation protocol

- activation of vehicles
  - Activate Request PDU
  - Activate Response PDU
- deactivation of vehicles
  - Deactivate Request PDU
  - Deactivate Response PDU
- vehicle state update
  - Vehicle Appearance PDU
  - Radiate PDU
- weapons fire
  - Fire PDU
  - Impact PDU
  - Indirect Fire PDU
- collision between vehicles
  - Collision PDU
- transfer of munitions between vehicles
  - Service Request PDU
  - Resupply Offer PDU
  - Resupply Received PDU
  - Resupply Cancel PDU
- repairs by one vehicle to another
  - Service Request PDU
  - Repair Request PDU
  - Repair Response PDU

Data collection protocol

- status reporting
  - Exercise Status PDU
  - Simulation Status PDU
  - Vehicle Status PDU
  - Status Query PDU
  - Status Response PDU
- event reporting
  - Status Change PDU
  - Laser Range PDU
  - Event Flag PDU

Data representation

- formal notation: *data representation notation*
  - provides a concise, unambiguous description of data element encoding
  - e.g.,

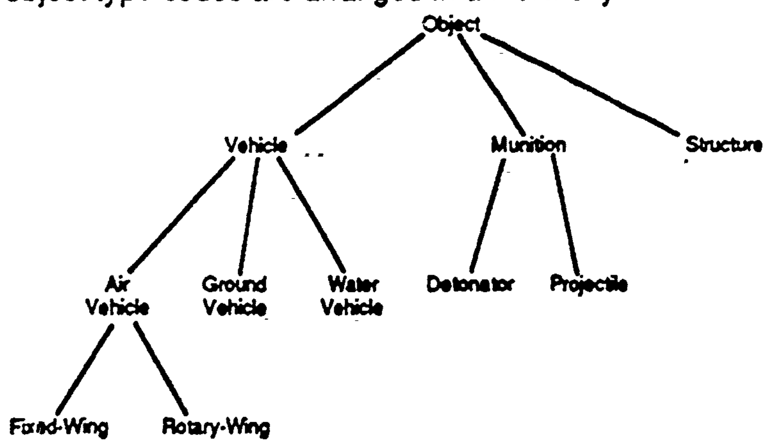
```
type ObjectType UnsignedInteger (32)

type MunitionQuantity sequence {
    munition  ObjectType,
    quantity  Float (32)
}
```

- aim is to minimize protocol's dependence on machine architecture and language
- restrictions on data element alignment and size are enforced
  - e.g., a floating point number occupies 32 or 64 bits
  - e.g., a 32-bit quantity is aligned on a multiple of 32-bits

Object type numbering scheme

- objects include vehicles, ammunition, quantities of fuel, repair parts...
- an object's type must be represented for communication (e.g., M1A1 tank, 155 mm HE shell)
- object type codes are arranged in a hierarchy



- this scheme, once defined, remains valid as new objects types are added
- software can understand something about an object based on where its type code places it in the hierarchy
- this allows new types of objects to be introduced without disrupting existing software

Elements of communication compatibility

- scope of simulation
  - what phenomena are part of the simulated world
- architecture
  - what things are computed where
  - the use of dead reckoning
- messages and their contents
  - what PDUs are used
  - what information each PDU contains
- message encoding
  - how information is represented as bits
  - e.g., the use of ANSI/IEEE standard floating point format
- underlying network services
  - choice of networks for various parts of the internet
  - e.g., use of Ethernet or FDDI
- ongoing internet administration
  - the assignment of site and simulator addresses
  - coordination of exercise identifiers
  - registration of simulator type codes
  - extensions — e.g., to object type numbering scheme

Future work

- extensions for additional types of vehicles and simulators
- missiles
  - transfer of missile simulation from firing simulator
  - homing on continuously designated targets
- dead reckoning algorithms
  - using higher–order derivatives of location and rotation
  - blending in new appearance information
- coordinate systems

Standards for the Interoperability of Defense Simulations

Extensions/Issues

Mr. Stephen Seidensticker
Logicon Corporation

Training/Simulation Industry Interests

- Steve Seidensticker, Tactical and Training Systems, Logicon, Inc
- Personal Opinion and Observation from Outside the SIMNET World
- Look at SIMNET Communication Protocol Extensions
- Look at Some Basic Issues Regarding Linked Simulators

LOGICON

Future is Variety of Simulators Linked for Variety of Purposes

- Selective Fidelity Simulators Linked for Mission Rehearsal
- High Fidelity Simulators Linked for Initial and Mission Training
- Large Number of Relatively Inexpensive Simulators Linked for "War Fighting Training"

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Avoid Issues of Simulator Roles, Fidelity, Cost, Etc.

- Of Interest, but Time Consuming and Not the Issue
- Conference not a Platform for General Promotion of SIMNET

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Usable SIMNET Protocol Components

- Basic Techniques
    - Message/Network Based
    - Dead Reckoning
- Basic Methodology
    - Message Definition
    - Documentation

LOGICON

Required SIMNET Protocol Extension and Development

- Gaming/Mission Area Definition
- Tighten All Definitions
- Allow for Differences in Individual Simulator Fidelity
- Include Actual Inter-Vehicle Communication Links

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Gaming/Mission Area Definition

- Make Larger (Limited by Individual Simulator)
- Make Geospecific
- Account for Differences in Image Database Representations of Same Area

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No Longer One Project, One Company

- More Organizations Involved
- Greater the Opportunity for Misinterpretation

LOGICON

Ada Language

- Should be Considered as Basis of Message Definition
- Must Have Full Data Representation Definition
  (MIL-STD 1815A Chap 13)
- Ada Packages Good Distribution/Control Media

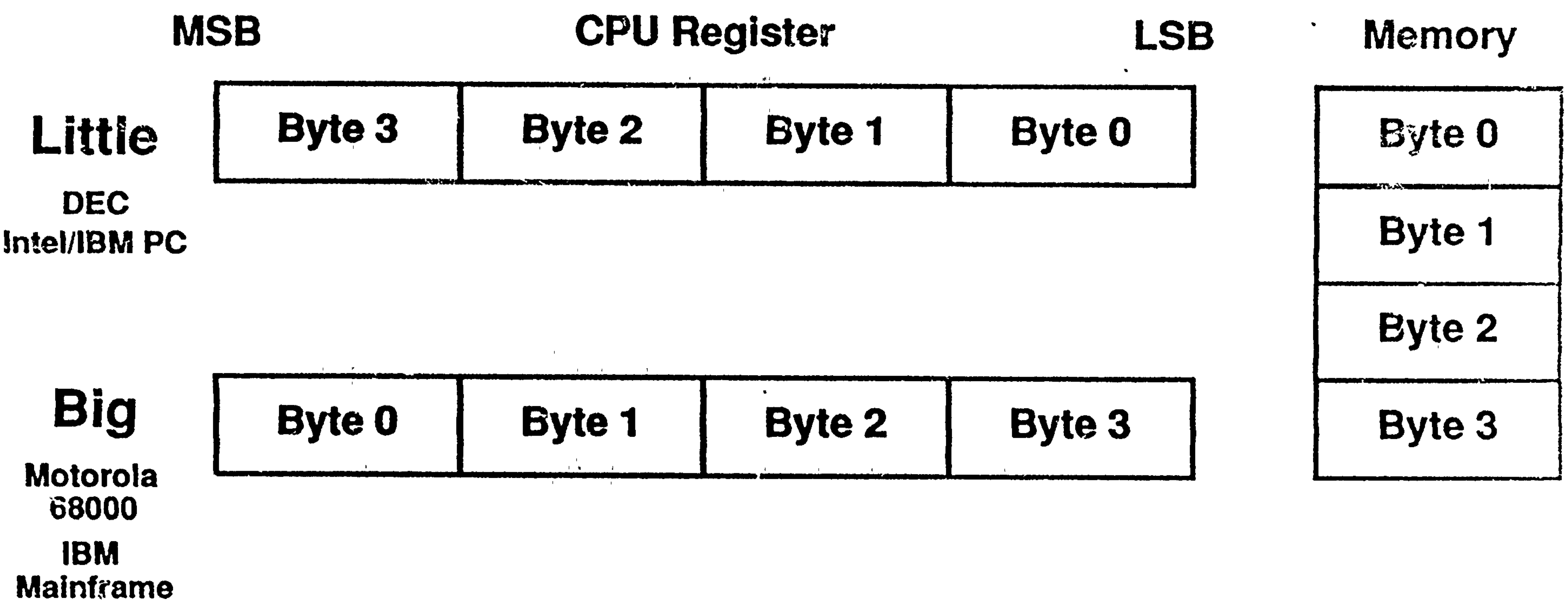
LOGICON

Internal Data Format Commonality on Network is Essential

- Floating Point Format
- Big Endian vs. Little Endian
- ASCII Character Ordering in Strings

LOGICON

Big Endian vs. Little Endian



Equations of Motion

- Must Use Identical Algorithm
- Must Use Identical Precision
- Ada Packages Good Potential Distribution/Control Media

LOGICON

Allow for Differences in Individual Simulator Fidelity

- Well Designed System Can Do So, Cannot be Afterthought
- Lower Fidelity Simulators Gracefully Ignore Data they cannot Use
- Higher Fidelity Simulators Make Intelligent Assumptions about Data not Available

LOGICON

Tactical Data Links

- JTIDS for Aircraft
- M1 Tank Inter-Vehicle Digital Communication
- Real-Time Threat Update
- Moderate Bandwidth Requirements

LOGICON

Voice Communication Between Simulated Vehicles

- Wide Bandwidth Requirements
- Formidable but Manageable Technical Challenge

LOGICON

General Industry Issues

- Who Will Create Basic Standard?
- How Will Standard be Maintained?
- What's the Next Step?

LOGICON

JOINT MODEL & WAR GAME EXECUTIVE COUNCIL (JMWEC)

LT COL BOB MILLS, USAF
J-7, JOINT STAFF

OVERVIEW

- BACKGROUND
- PURPOSE
- ORGANIZATION

BACKGROUND

- DEFENSE SCIENCE BOARD "COMPUTER APPLICATIONS TO TRAINING & WARGAMING" STUDY (MAY 1988)
- DOD IG AUDIT REPORT ON "WARGAMING ACTIVITIES IN THE DEPARTMENT OF DEFENSE" (MARCH 1989)
- SACEUR-DARPA EUROPEAN DISTRIBUTED WARGAMING SYSTEM (FEBRUARY - MAY 1989)
- JOINT WARFARE CENTER ISSUES (FEBRUARY 1987 - TO DATE)

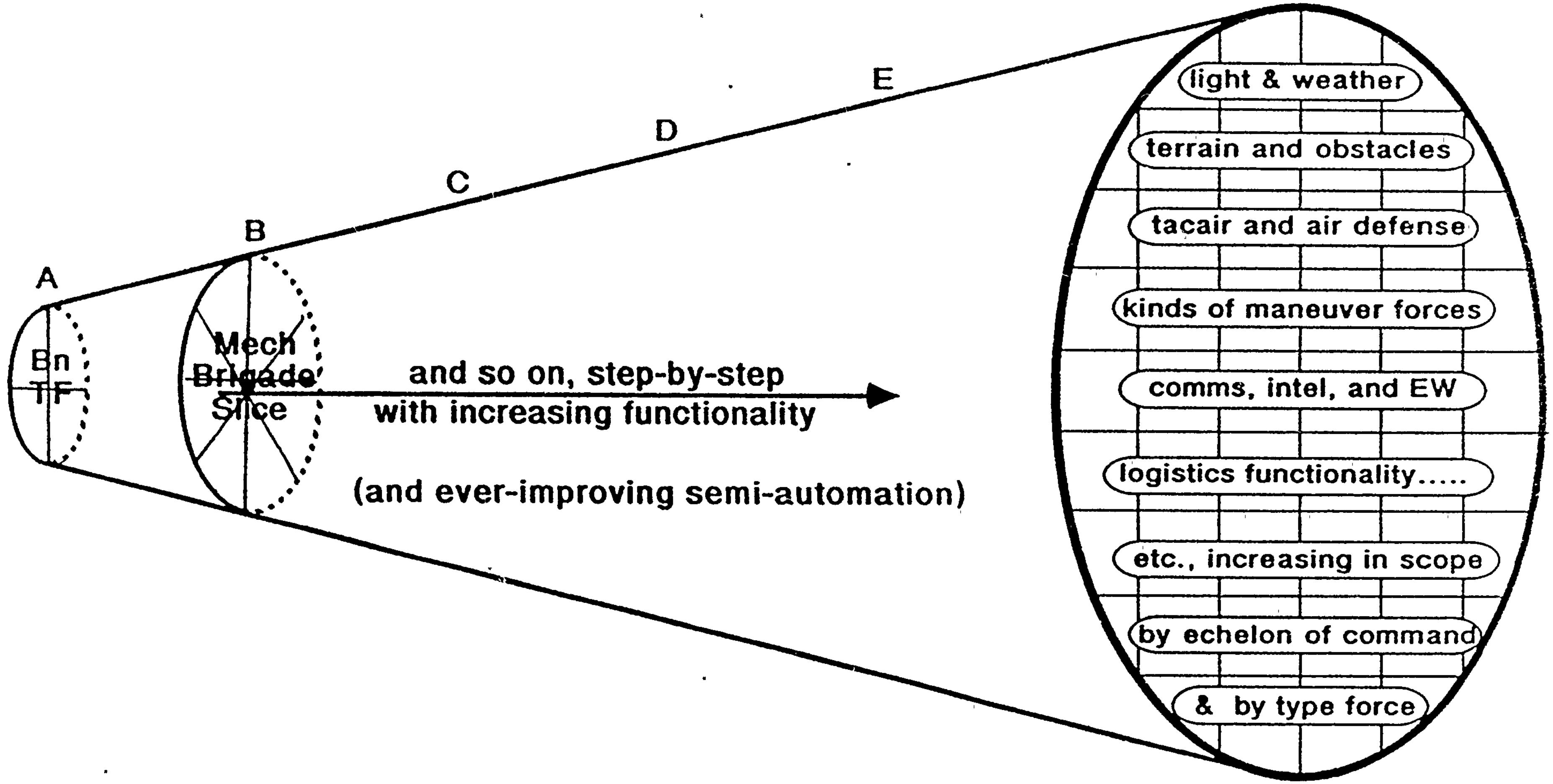
Two challenges of Advanced Battle Simulation...

1. Expansion outward within current functional areas, (e.g., field artillery) and to new functional areas (e.g., intelligence collection)

2. Extension upward to higher command echelons, with semi-automation...

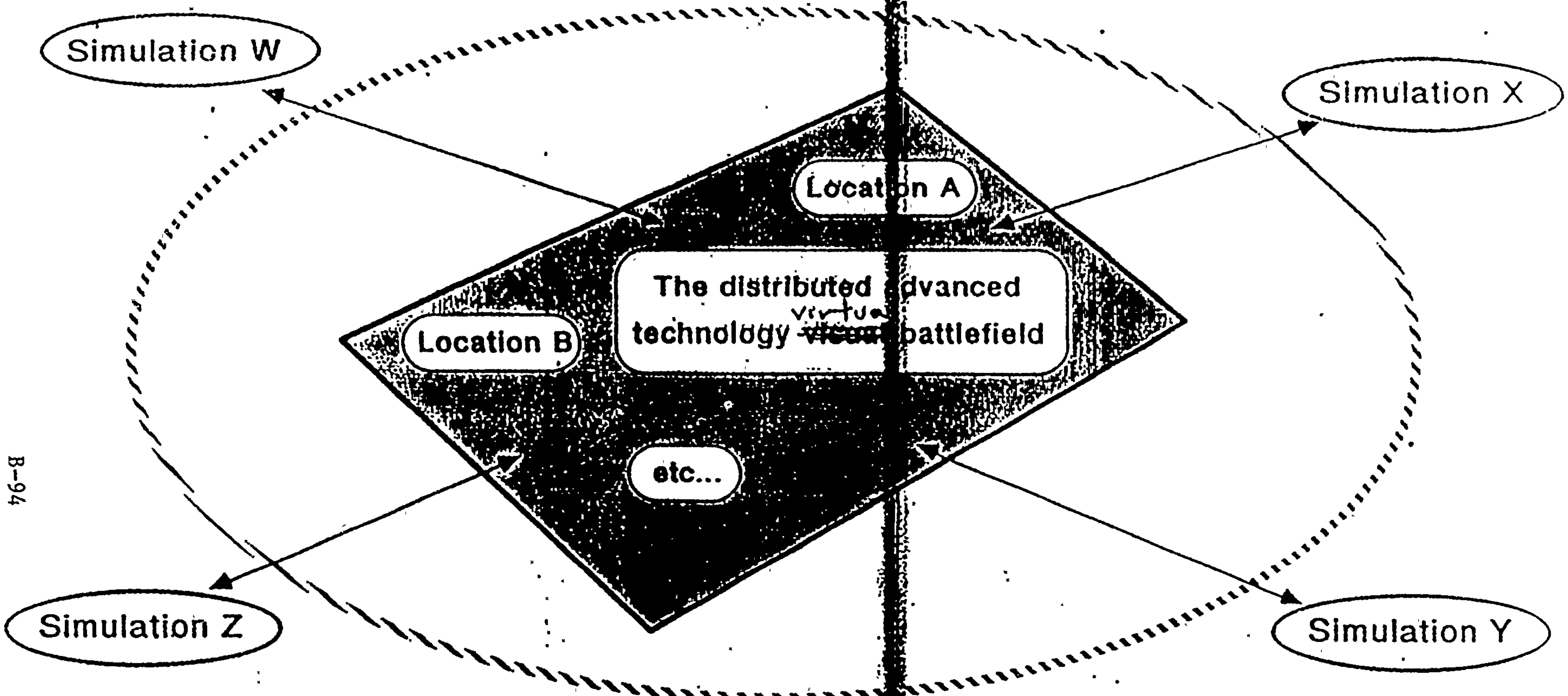
Chart 12

LTG, CUSHMAN (RET)



A Management Challenge, for Users and Developers/Providers

Chart 19



The Vision

A Common Battlefield That Anyone Can Join

Thru the Protocols of Defense Simulation Internet

Chart 2

APPENDIX C

View-Graphs for the Terrain Data Bases Working Group Break-out Sessions

George's WorkshopViewgraphs

- ***Terrain Database Working Group***

Workshop on Standards for the
Interoperability of Defense Simulations
22-23 August 1989
Omni Hotel, Orlando, Florida

George E. Lukes, Chairman
U. S. Army Engineer Topographic Laboratories

Objectives

- Identify issues which must be resolved to develop terrain database standards for interoperational simulation networking.
- Recommend approaches for resolving these issues.

- Identify individual & organizations able to work the issues.

- ***Terrain Database Interests***
  Convergence of Diverse Communities

  - Real-time Visualization
    - Traditional High-Performance Simulators
    - New Low-Cost/Reduced-Performance Simulators
  - Robotic Planning (Ground and Air Vehicles)
  - All-Source Terrain Database Construction
  - Mission Planning (Ground, Air and Sea)

- Operational Force Structure (U & S Commands)

- ***Terrain Database Issues***
  - Diverse terrain data requirements of manned and unmanned ground and air vehicle simulators, combat support systems, electronic map displays and hardcopy maps.
  - Need for common source database to support manned and unmanned simulation systems for ground forces, close air support and other Air-Land Battle theater assets.
  - Feasibility of establishing explict transformation criteria for each application which operate on a common spatial database.
  - Need for explicit level-of-detail (LOD) representations for object models, point/linear/areal features, terrain.

- Need for a common geodetic frame-of-reference.

- Trade-offs between emerging spatial data format standards.

- Implications of centralized vs. decentralized database production strategies.

- ***Terrain Database Working Group Agenda***

  Tuesday, 22 August 1989

1:30 PANEL: Terrain Data for Simulation Networks

- COL Larry Mengel, U. S. Army Armor Center, Ft. Knox, KY
- Dr. Dexter Fletcher, IDA, Alexandria, VA
- COL Jack Thorpe, DARPA SIMNET, Washington, DC
- LTC William Szymanski, PM TRADE, Orlando, FL

2:15 DMA Standardization Activities for Digital MC&G Data

Mr. Pete Robison, Defense Mapping Agency, Washington, DC

2:45 Army Approach to Digital Terrain Data Requirements

Mr. Frank Capece, Digital Concepts and Analysis Center, Army Engineer Topographic Laboratories, Ft. Belvoir, VA

- ***Terrain Database Working Group Agenda***

Tuesday, 22 August 1989 (con't)

3:30 SIMNET Database Interchange Specification

Dr. Pete Wever, BBN Systems and Technologies, Bellevue, WA

3:55 Standard DoD Simulator Digital Data Base (P2851)

Mr. Tony DalSasso, Project 2851, Wright-Patterson AFB, OH

4:25 Rapidly Reconfigurable Database (RRDB)
Mr. Ray Green, PM TRADE, Orlando, FL

4:30 Speaker's Panel
- Mr. Frank Capece (USAETL)
- Mr. Tony DalSasso (WPAFB)
- Mr. Ray Green (PM TRADE)
- Mr. Pete Robison (DMA)
- Dr. Pete Wever (BBN)

- ***Terrain Database Working Group Agenda***
  Wednesday, 23 August 1989

8:30 PANEL: Terrain Representation & Correlation

Issues

- Dr. Tom Garvey, SRI International, Menlo Park, CA
- Ms. Linda Matthews, BBN, Bellevue, WA
- MAJ Mike Sieverding, Project 2851, WPAFB, OH
- Mr. Ron Taupal, Merit Technology, Plano, TX
- Dr. David Tseng, Hughes Research Laboratory, Malibu, CA
- Prof. Michael Zyda, Naval Postgraduate School, Monterey, CA

10:45 SUMMARY PANEL

- COL Larry Mengel, U. S. Army Armor Center, Fort Knox, KY
- Dr. Dexter Fletcher, IDA, Alexandria, VA
- COL Jack Thorpe, DARPA SIMNET, Washington, DC

- LTC William Szymanski, PM TRADE, Orlando, FL

11:30 Wrap-Up / Results / Recommendations

2:00 Presentation of Working Group Results

- ***Terrain Database Working Group Goals***
  - Identify areas of consensus.
  - Identify areas of controversy.
  - Identify critical issues which must be resolved.
  - Recommend approaches for resolving these issues.
  - Identify organizations able to address these issues.

- Prepare a report summarizing the terrain database working group discussions.

TERRAIN DATABASE WORKING GROUP

- Range of Terrain Data Dependent Application for Simulation Networking:
    - Visual out-the-window displays
    - Radar
    - Plan View Displays
    - Hardcopy maps
    - Semi-automated ground and air vehicles
    - Calculations
        - Intervisibility, coverage diagrams
        - Route selection, spatial reasoning
    - other

- Under the Defense Standardization Program (DSP), Defense Mapping Agency has lead for MC&G data:
  - DMA Product Specification --> Mil Spec
  - Seven layer hierarchy incorporating various emerging national/international standards (MiniTopo, SDTS, ISO8211 . . .)
  - Orders taken for informational booklet on digital products and concepts

- ETL recommends DMA new Interim Terrain Data (ITD) as the only near-term source of standard digital terrain data to support ground forces
  - Derived from 1:50,000 Tactical Terrain Analysis Database (TTADB)
  - Derived from 1:250,000 Planning Terrain Analysis Database (PTADB)
  - 1,200 Sheets of Germany & Korea by 1994
  - To support operational systems (DTSS, ASAS)
  - Initial datasets available to Defense contractors
  - Numerous fact sheets distributed

- BBN has devised SIMNET Database Interchange Specification (SDIS) as an exchange format for SIMNET databases
    - Small database in early September
    - Example database (8 km x 8 km) in November
    - Several sites indicate interest in datasets

- Project 2851 represents emerging production system to produce Standard DoD Simulator Databases
    - IOC 1991 at St. Louis facility
    - Focused on visual and sensor simulators
    - Draft DB Spec for GTDB
    - Interim provided for XDFAD Output
    - Simulation networking requirement not originally envisioned
    - Unmanned systems not currently scoped
    - Ready to consider additional requirements
    - ECP for TTD (should be expanded to ITD/TTD)

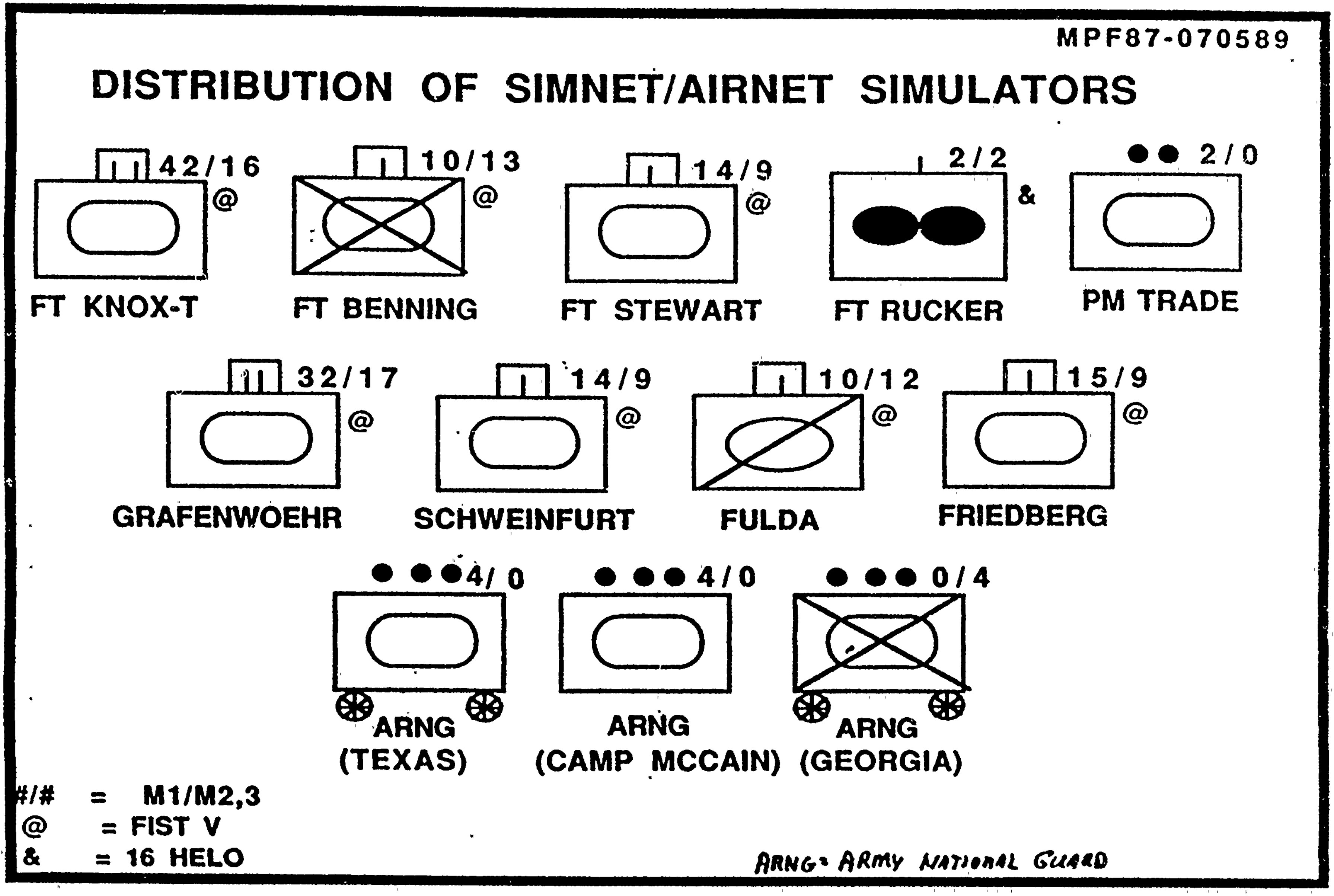
OPEN ISSUES:

- Coordination within DMA Standards Activities
- Interim Terrain Database (ITD) Assessment (currency, metric accuracy, etc)
- Project 2851 ECP
- Geodetic frame-of-reference
- Working group to investigate correlation parameters and metrics
- Dynamic terrain

Standards for the Interoperability of Defense Simulations

Interoperable Simulation: A User's Perspective

COL Larry Mengel,
US Army Armor Center

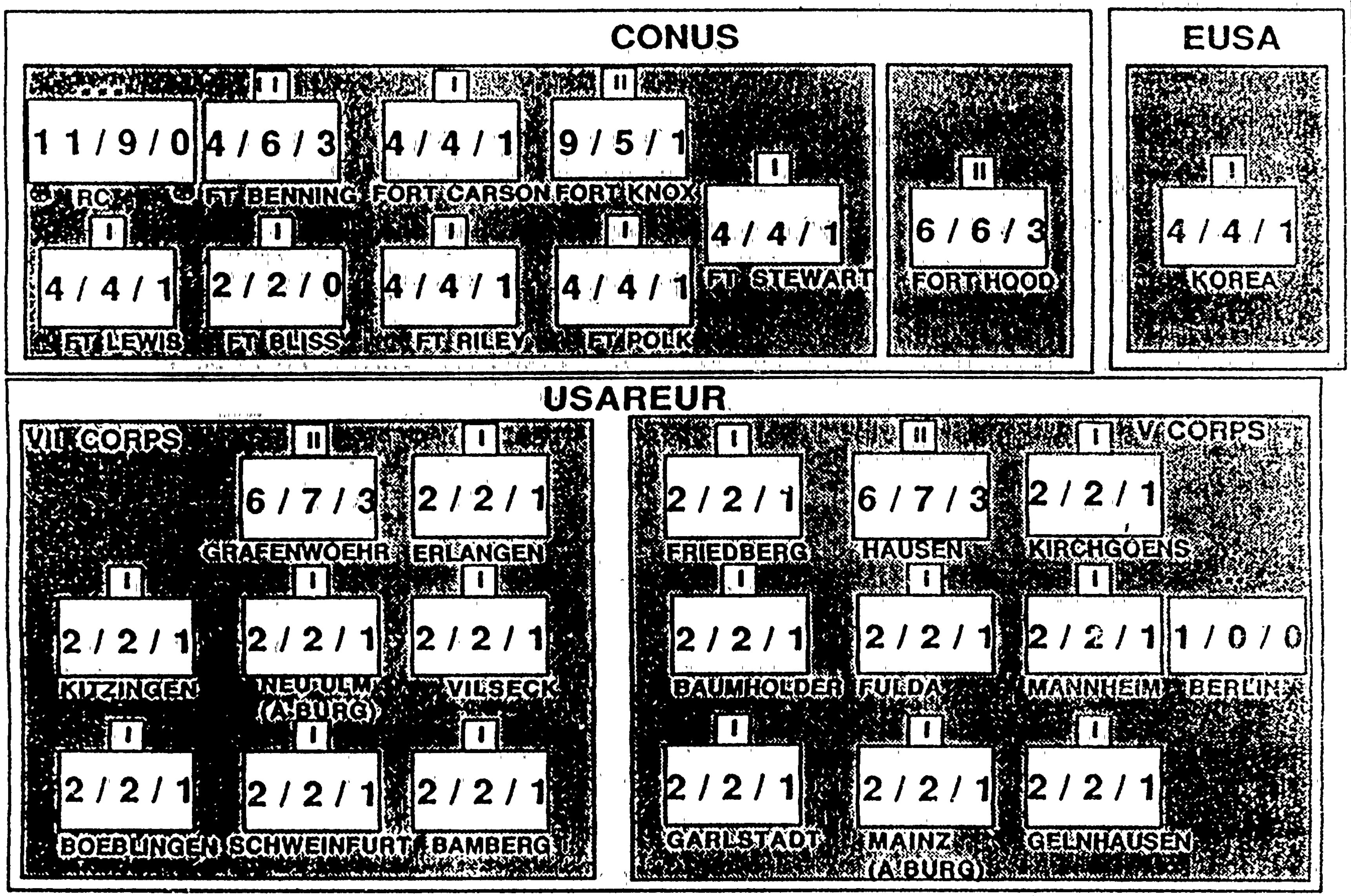


Col. Larry Mengel, USA

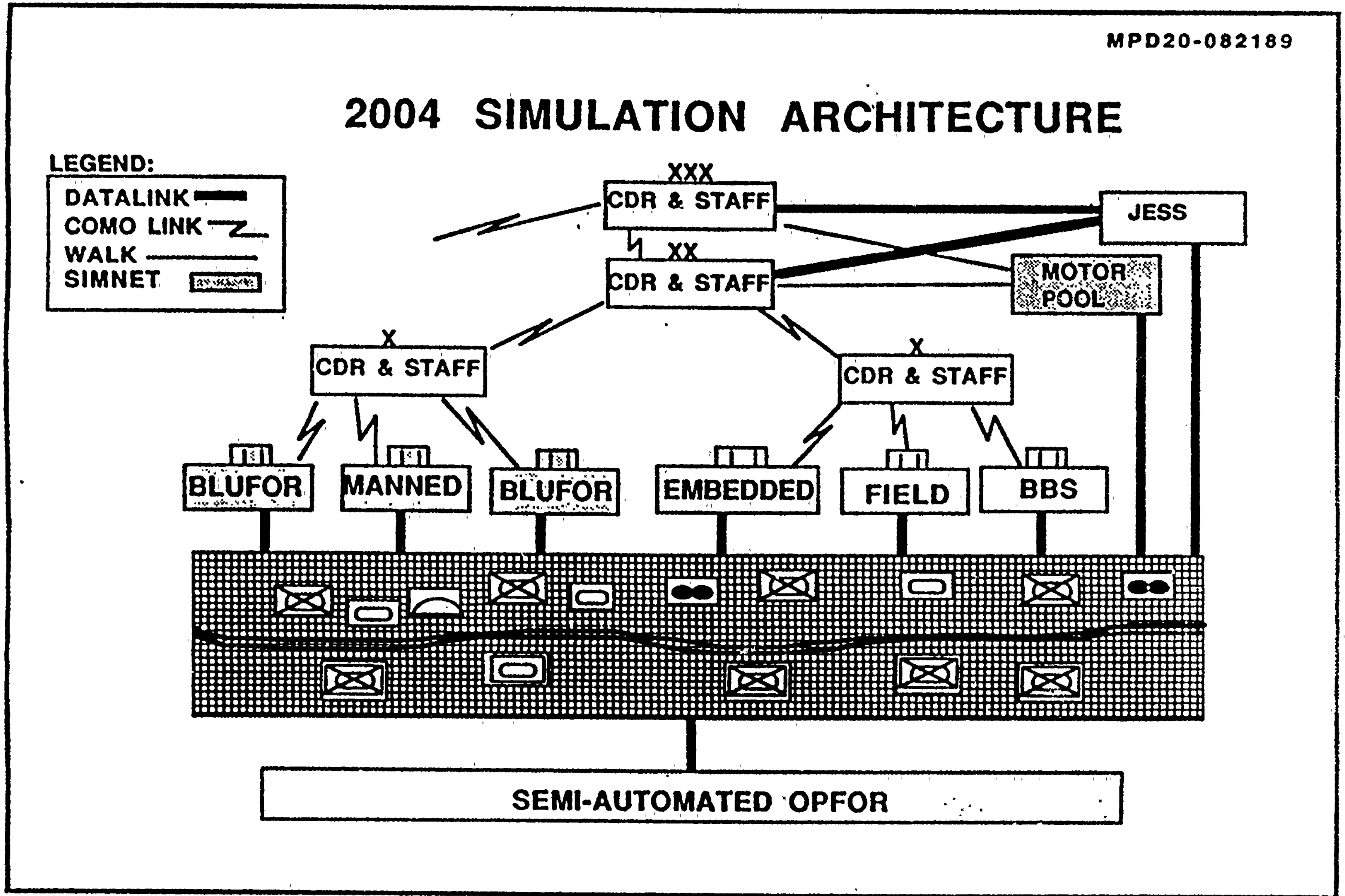
#/#/# = TANK/MECH/AT PL[

CCTT SITE PLAN

SP.1-080789



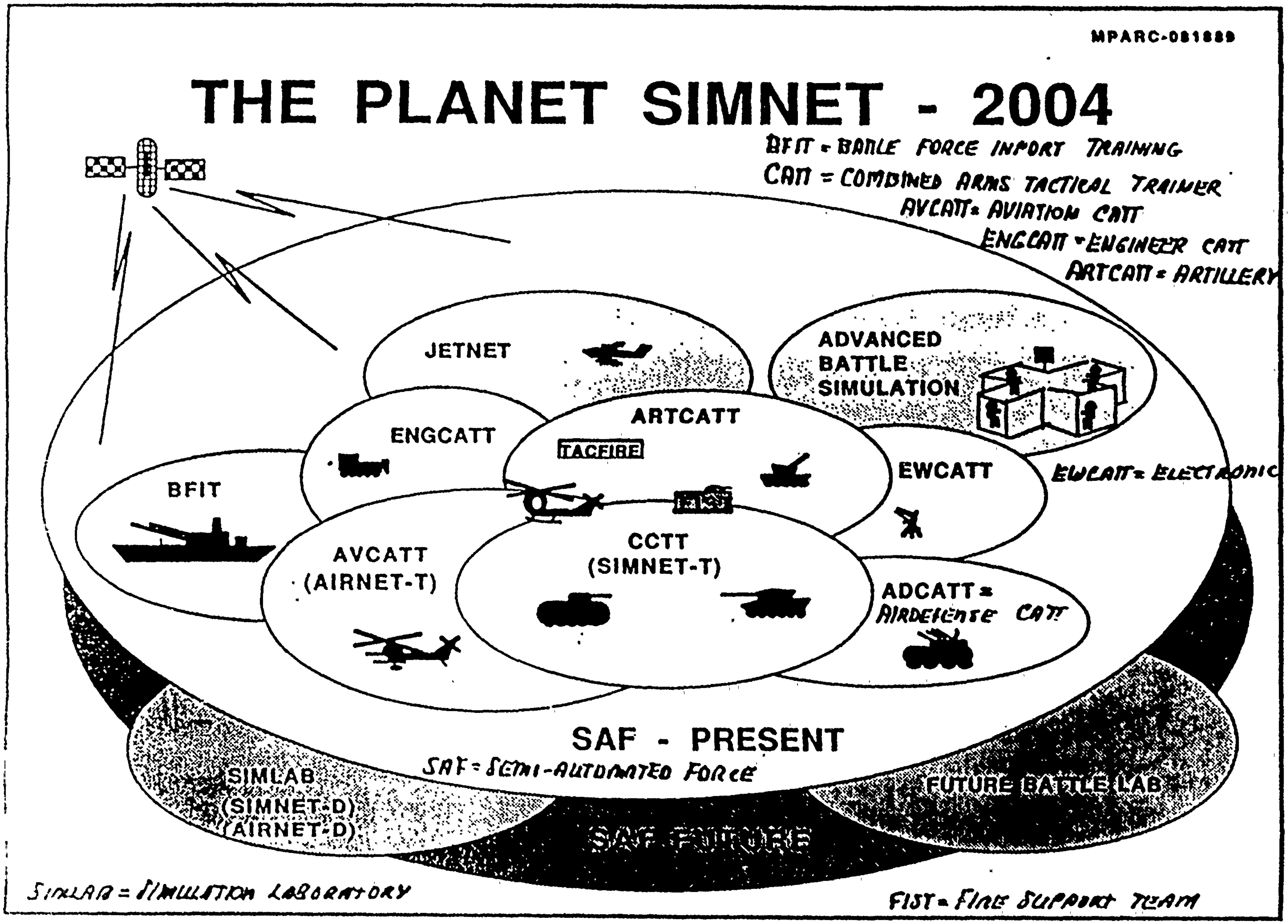
: CCTT = CLOSE COMBAT TACTICAL TRAINER



BBS = BRIGADE BATTLE SIMULATION

BLUFOR = BLUE FORCE (SEMI-AUTOMATED)

OPFOR = OPPOSING FORCE


MPARC-081889
THE PLANET SIMNET - 2004
BFIT = BATTLE FORCE INPORT TRAINING
CATT = COMBINED ARMS TACTICAL TRAINER
AVCATT = AVIATION CATT
ENGCATT = ENGINEER CATT
ARTCATT = ARTILLERY CATT
JETNET
ADVANCED BATTLE SIMULATION
ENGCATT
ARTCATT
TACFIRE
BFIT
EWCATT
EWCATT = ELECTRONIC WARFARE
AVCATT (AIRNET-T)
CCTT (SIMNET-T)
ADCATT = AIRDEFENSE CATT
SAF - PRESENT
SAF = SEMI-AUTOMATED FORCE
SIMLAB (SIMNET-D) (AIRNET-D)
FUTURE BATTLE LAB
SAF FUTURE
SIMLAB = SIMULATION LABORATORY
FIST = FIRE SUPPORT TEAM

Standards for the Interoperability of Defense Simulations

SIMNET Data Base Interchange Specification

Dr. Pete Wever
BBN Systems & Technologies Corporation
Bellevue, WA

Outline

Purpose & Scope of Interchange Specification

Interchange Design Method

Suggested Approach to Problem of Correlation

Interchange Implementation

Purpose & Scope
of
Interchange Specification

SIMNET Database Interchange Specification

Framework for Interchanging Datasets among SIMNET Database Producers and Consumers

- Describes Procedures for Interchanging Data

- Defines the Representation of Objects Using Abstract Syntax Notation One

Organization of Interchange Document

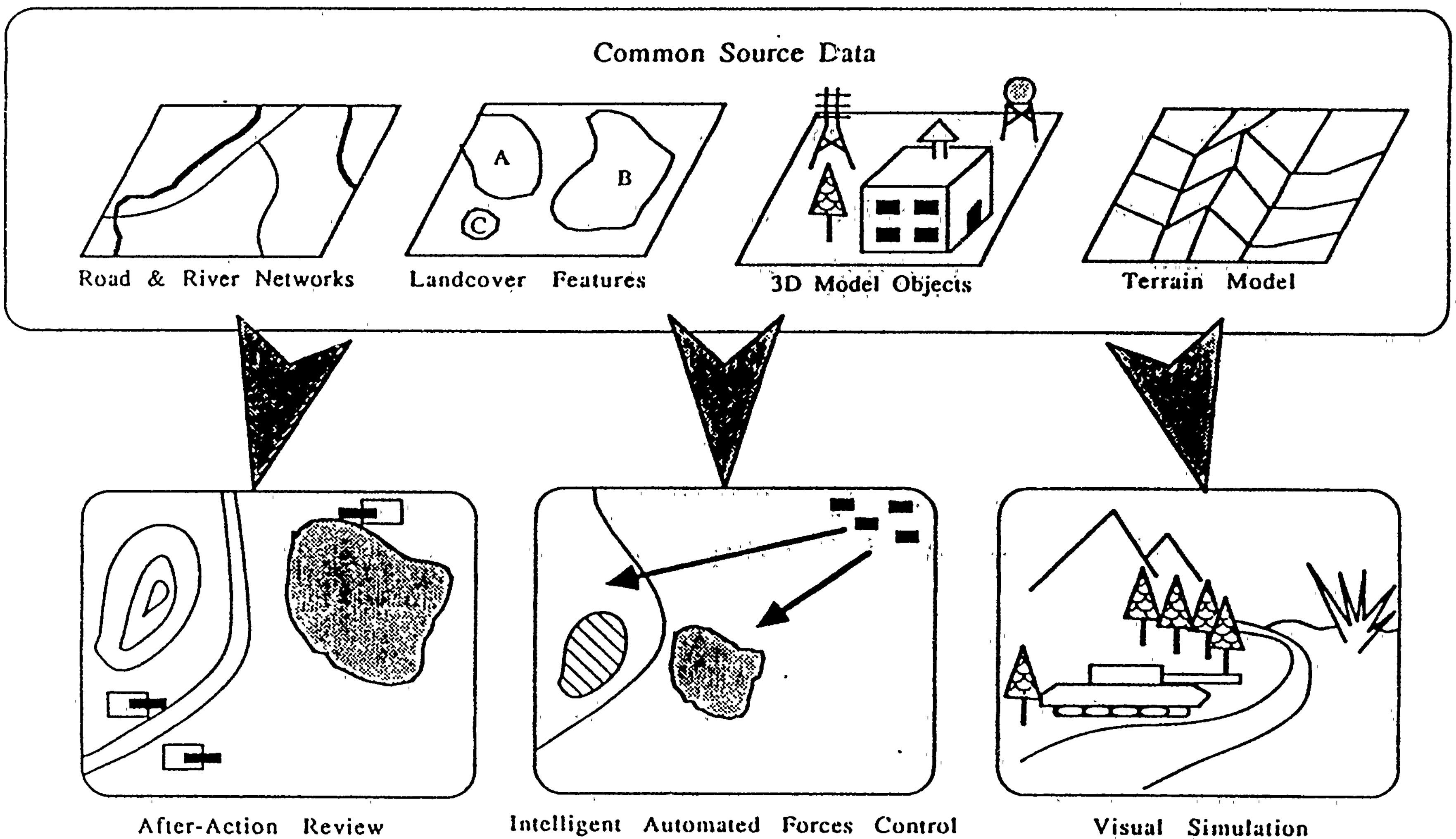
1. Introduction
2. Method
3. Correlation
4. Database Interchange

Appendix A: Physical Representation

Appendix B: Attribute and Object Class Definitions

Appendix C: Interchange Dataset Specification

Distributed Simulation Applications



Interoperability

How Well Different Simulation Modules Play Together in a Distributed Environment (Functional Interoperability).

- Depends on the Goals and Objectives of Simulation
- Depends on the Role of the Simulation Module
- Beyond the Scope of an Interchange Specification

Interchange Design Method

Assumptions

- Common Reference Model for Correlated Data
- Complete to Highest Detail Needed
- Independent of Specific Application Implementations
- Evolve as Simulation Requirements Change

Specification Language

"The key to the whole problem of representing, encoding, transmitting, and decoding data structures is to have a way of describing the data structures that is flexible enough to be useful in a wide variety of applications, yet standard enough that everyone can agree on what it means. As part of the OSI development work, ISO has devised such a notation. It is called abstract syntax notation 1 or ASN.1 for short."

-- Andrew Tanenbaum, <u>Computer Networks,</u> 2nd Ed.

Abstract Syntax Notation 1

- Simple
- Unambiguous
- Machine-readable
- Automated Tools (CASE)
- Recognized Standard
  - ISO Standards 8824 & 8825

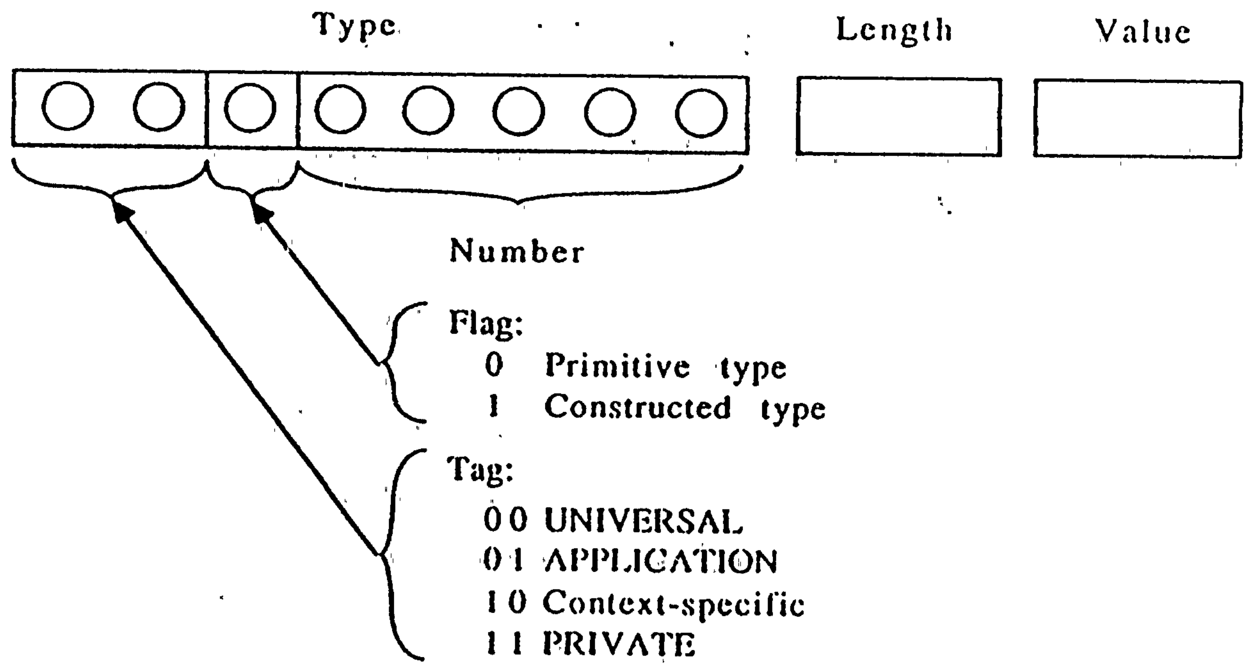
ASN.1 Primitive Types

INTEGER	Arbitrary length integer
BOOLEAN	TRUE or FALSE
BIT STRING	List of 0 or more bits
OCTET STRING	List of 0 or more bytes
ANY	Union of all types
NULL	No type at all
OBJECT IDENTIFIER	Object name

ASN.1 Constructors

SEQUENCE	Ordered list of various types
SEQUENCE OF	Ordered list of a single type
SET	Unordered collection of various types
SET OF	Unordered collection of a single type
CHOICE	Any one type taken from a given list

ASN.1 Transfer Syntax



Available Software

ISO Development Environment (ISODE 5.0)

- Non-proprietary OSI Application Tools
- Berkeley (4.2, 4.3) and AT&T (SVR2, SVR3)
- Modules include:
  - ASN.1 to C Structure Generator
  - Basic Encoding Rules

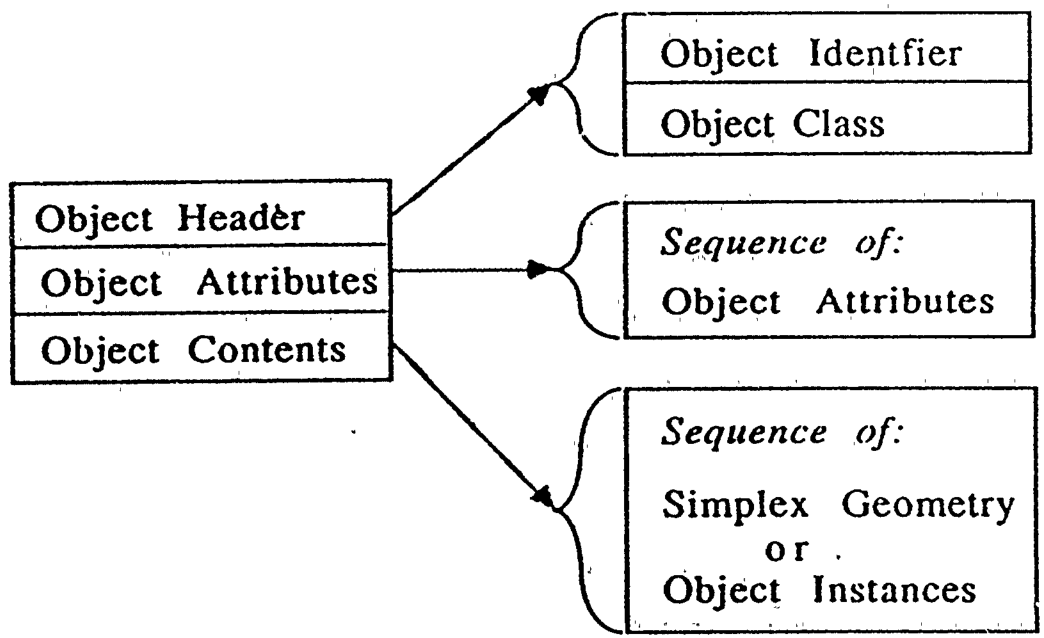
Discussion Group: ISODE@SRI-NIC.ARPA
(Mail List: ISODE-Request@SRI-NIC.ARPA)

Distribution: ($365)
User's Manual (~900 pgs) + 1600 Bpi Tar Tape
David J. Farber 215-898-8560
Dept. Computer and Information Science
University of Pennsylvania

Feature Representation

Real World Entity	Tree
↓	
Conceptual Model	A point object with Attributes: Species, Height, Radius.
↓	
Object/Attribute Representation	<u>Appendix B:</u>
	Object Class Index: 7
	Object Name tree
	Location Dimension 2
	Content: Set of 0-simplex
	Attributes: species (12), avgHeight (23), avgRadius (24)
↓	
ASN.1 Representation	<u>Appendix C.</u> Object and ObjAttribute expressed in accordance with ISO 8824
↓	
ASN.1 Physical Encoding	Encoded on Physical Media in accordance with ISO 8825

Object Structure



Spatial Reference Systems

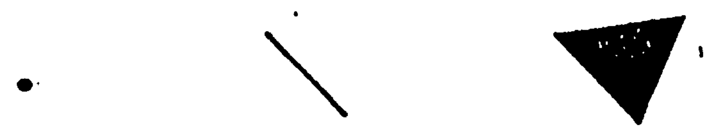
- Object Location and Orientation
  (Expressed within Reference Frame)

- Frame of Maximum Scope (Fixed Reference)
  Nested Frames (Relative Reference)

- Reference Frame Types
  - Local: Euclidean 2,3-space
  - Grid: UTM, State Plane Coordinates
  - Geodetic: WGS83
  - Geocentric
  - Topocentric

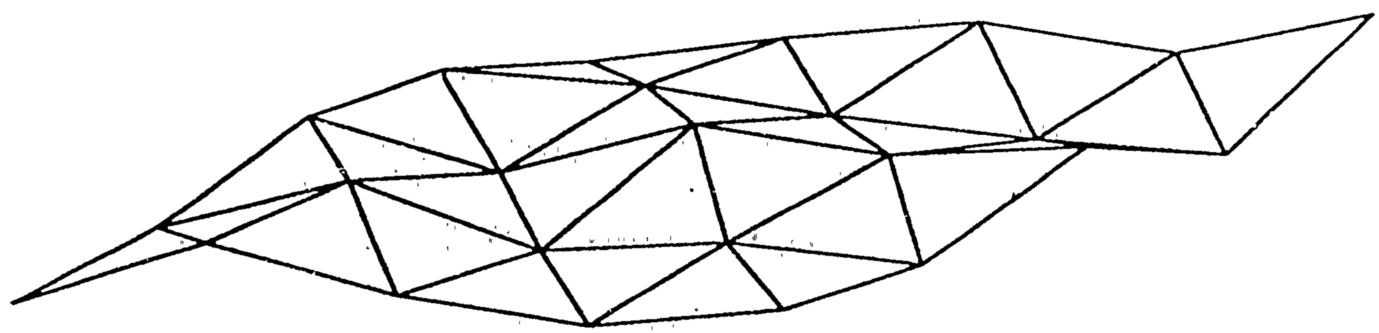
- Location Class Types
  - Cartesian
  - Polar
  - Parametric

Geometric Primitives



0-simplex 1-simplex 2-simplex

Terrain Surface



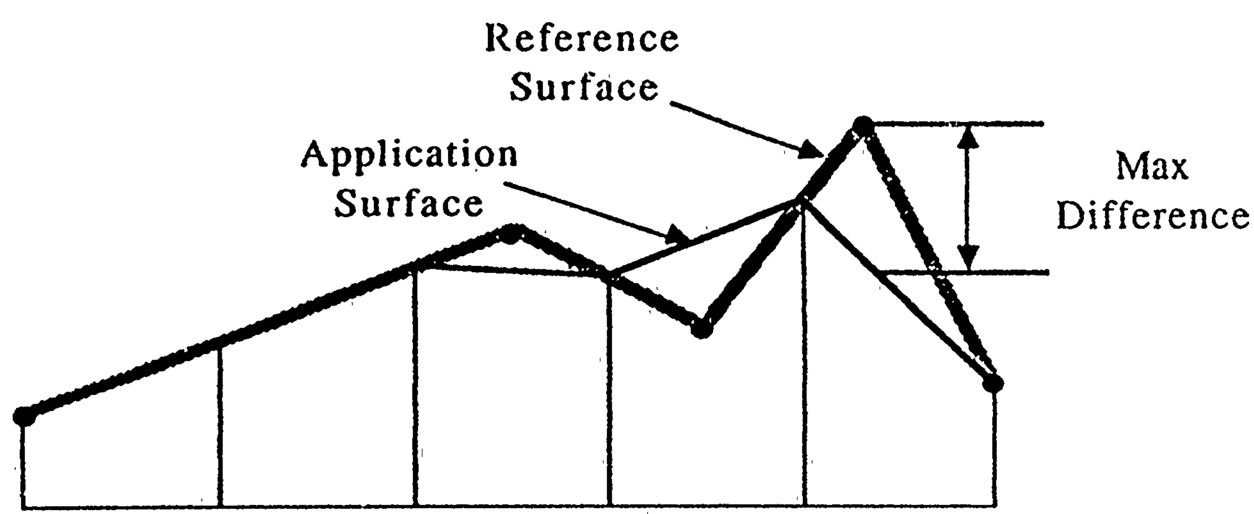
Triangulated Irregular Network

Interchange Growth & Revision

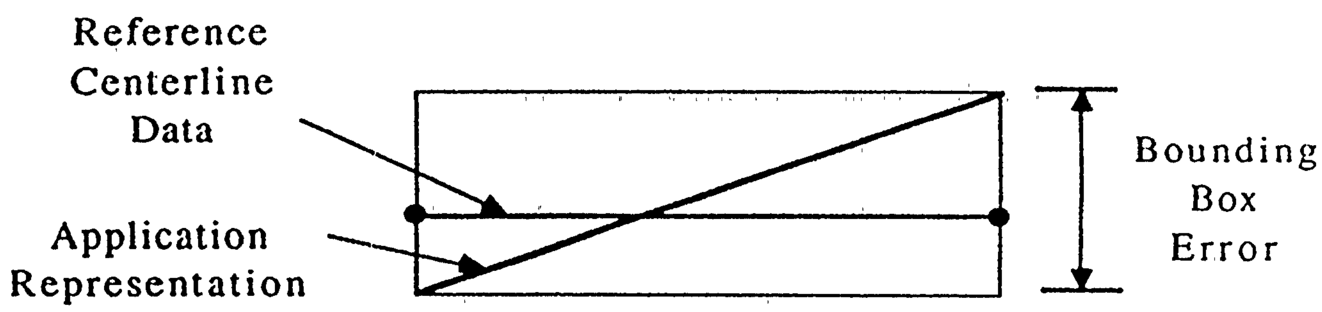
- Change Size of Data Type Primities
- Attach New Attributes to Objects
- Create New Object Classes
- One Vs. Multiple Feature Representations
- Specification of Procedures

Suggested Approach
to
Problem of Correlation

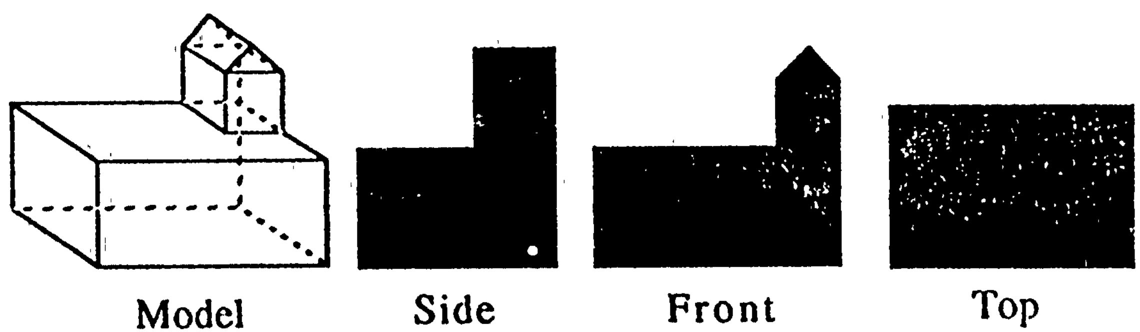
Terrain Correlation Measure



Linear Correlation Measure



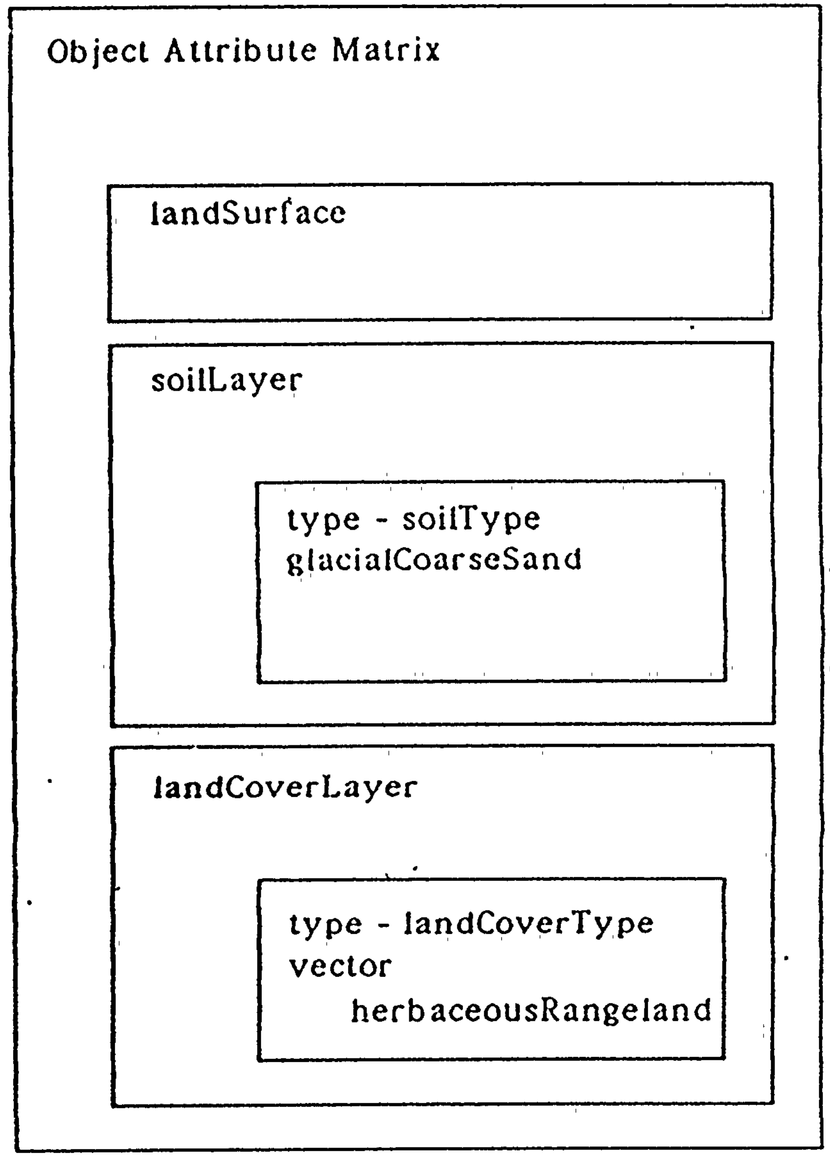
Model Correlation Measure via Silhouettes



Interchange Implementation

Object Attribute Matrix

```
OAMatrix =
(
    OAMatrixRow =
    (
        objectClass = 0.0
    ),
    OAMatrixRow =
    (
        objectClass = 0.1,
        templates =
        (
            objAttrClass = 1,
            objAttrValue = Uint = 21
        )
    ),
    OAMatrixRow =
    (
        objectClass = 0.2,
        templates =
        (
            objAttrClass = 1,
            objAttrValue = Vector =
            (
                Uint = 31
            )
        )
    )
)
```



Dataset Production

- Determine Real-World Entities to be Represented
- Determine Form of Interchange Object & Attribute Class
  - Extend Appendix B Definitions (Semantics) and Appendix C (Syntax) if Required
- Convert to ASN.1 Representation
  - Determine Size of Data Type Primitives
- Prepare Interchange Medium (Appendix A)

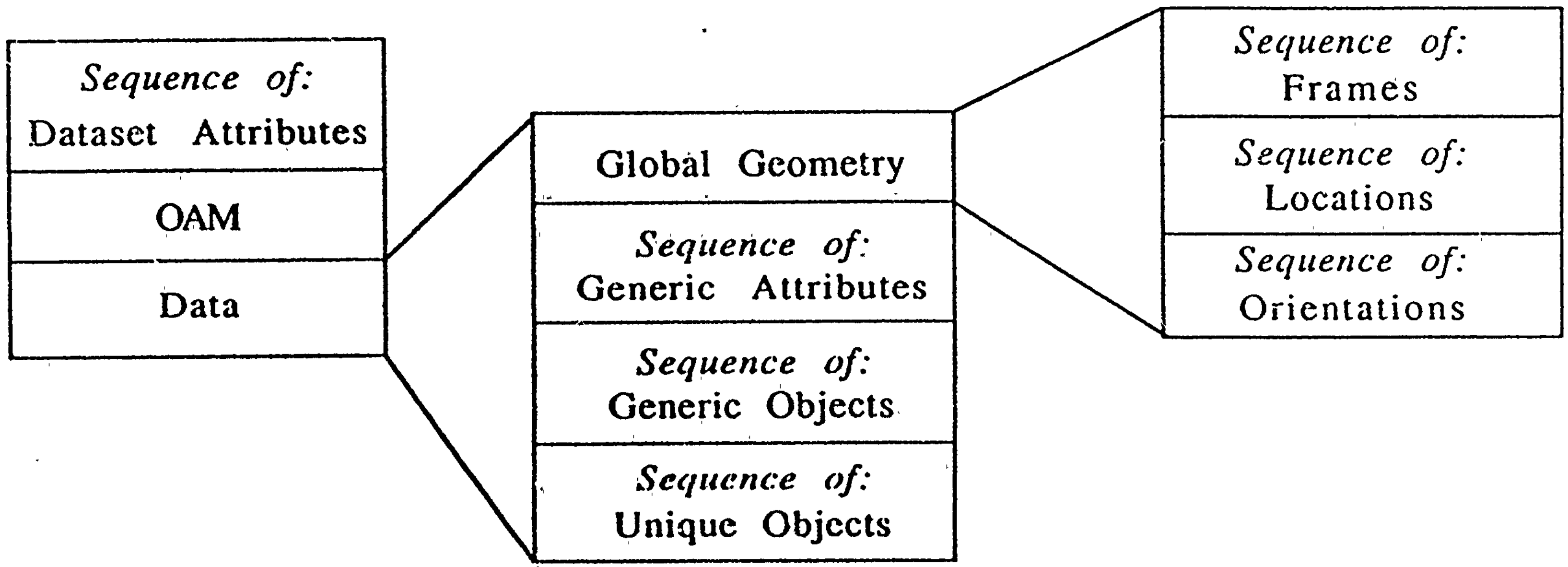
Dataset Use

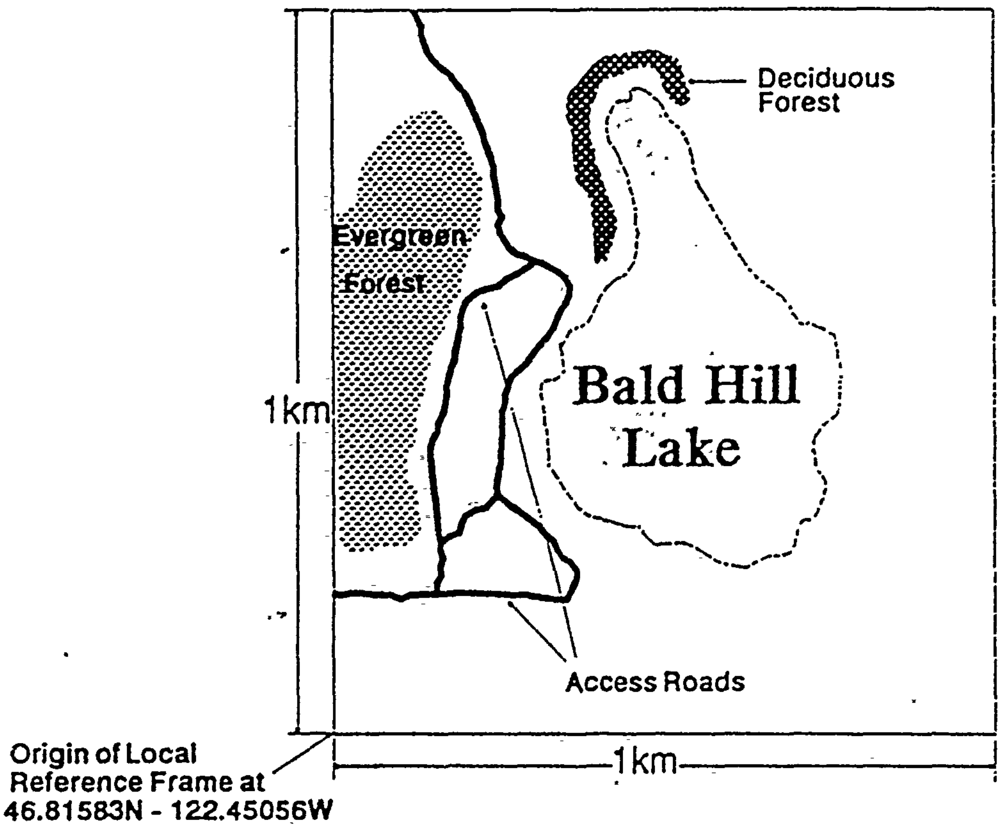
- Understand Appendicies A, B and C to Read and Interpret Dataset
- Develop Software Tools to Convert Dataset into Application Specific Represenation
- Measure Correlation of Converted Database with Interchange Dataset

Physical File Structure

File 1: Database Interchange Specification in ASN.1 (Appendix C Binary Encoded)
File 2: Data Stream (Binary Encoded)

Data Stream Structure





Bald Hill Lake Example

SIMNET Interchange Dataset

Bald Hill Lake Example

1 Km x 1Km

0 terrain
- 0.1 landSurface
- 0.2 landCoverLayer
  - 32 shrubBrush
  - 41 deciduous
  - 42 evergreen
  - 52 lake

1 network
- 1.0 road
  - 14 transportCommunicationsUtility

Available: Early September
IBM 360 Kbytes floppy with
Revised Appendices A, B, C

PWEVER@BBN.COM
206-746-6800

SIMNET Prototype Sample Dataset

- Approx. 8 Km x 8 Km
- Edited Subset of Existing Database
- C Source + Dataset: Read, Decode, Print
- Configured for Apollo, SUN
- Revised Interchange Specification Document
- Available in November Timeframe

Project 2851 Standard DOD Simulator Digital Data Base/Common Transformation Program

Project 2851:
Support for Networked Simulators

UCF/Institute for Simulation and Training Workshop on Standards for the Interoperability of Defense Simulations
22 August 1989

Tony DalSasso
ASD/ENETV
(513) 255-2431

Overview

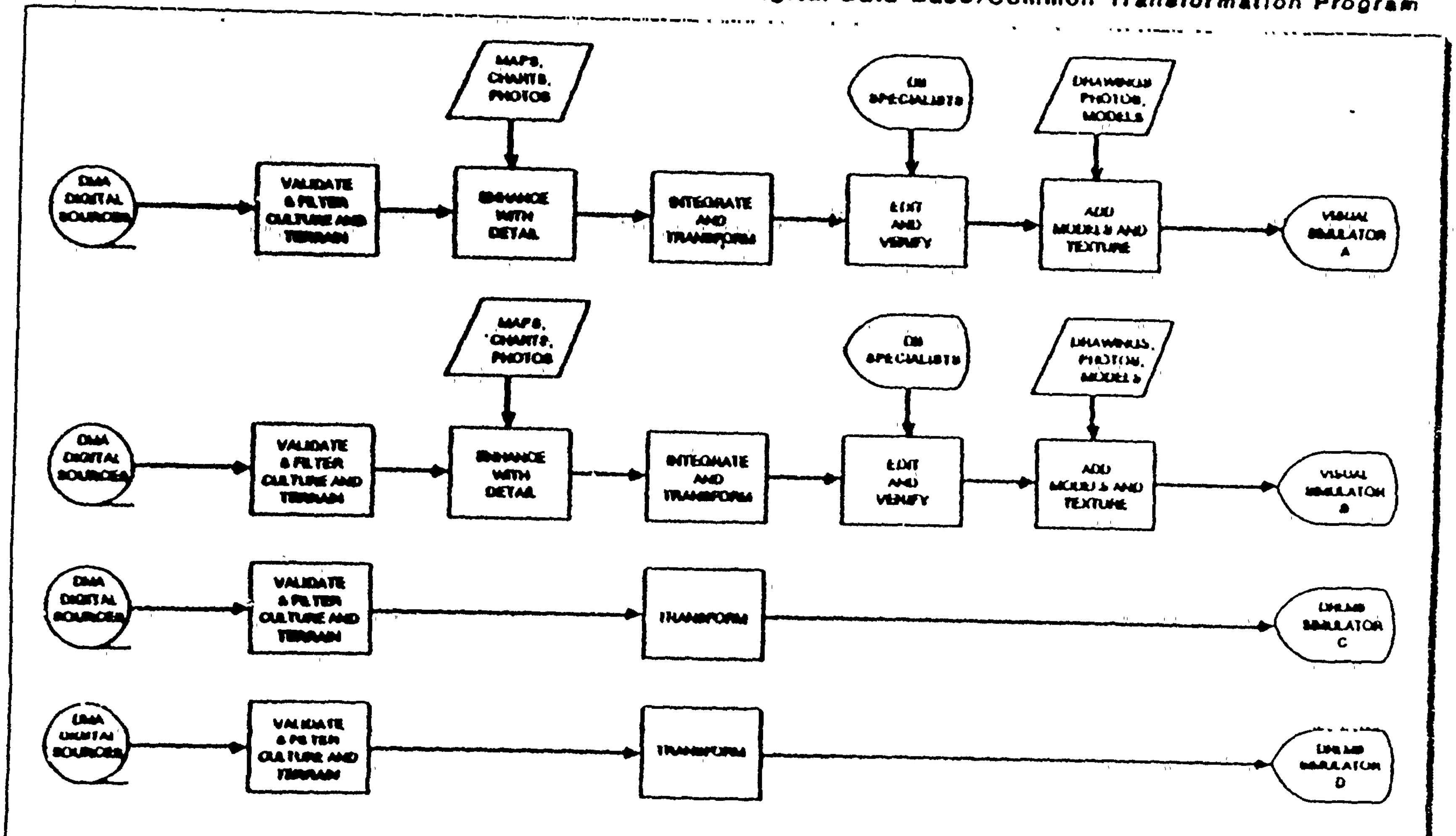
- Project 2851 Description
  - Background
  - System Design
  - Current Status
  - System Improvement Initiatives
- Data Bases for Networked Simulators
  - Issues
  - Project 2851 Approach
- Summary

Background

- Simulator Image Generators Require Geographic Data
  - Visual (Out-the-Window)
  - Landmass Radar
  - Infrared Sensors
- Defense Mapping Agency Digital Data Base
- Transformation Program
- Data Base Editing and Enhancement
- 3-D Object Modeling
- Problems
  - Redundancy
  - Incompatibility
  - Correlation
  - Training vs. Cartographic Requirements

Project 2851

Standard DOD Simulator Digital Data Base/Common Transformation Program



Before Project 2851

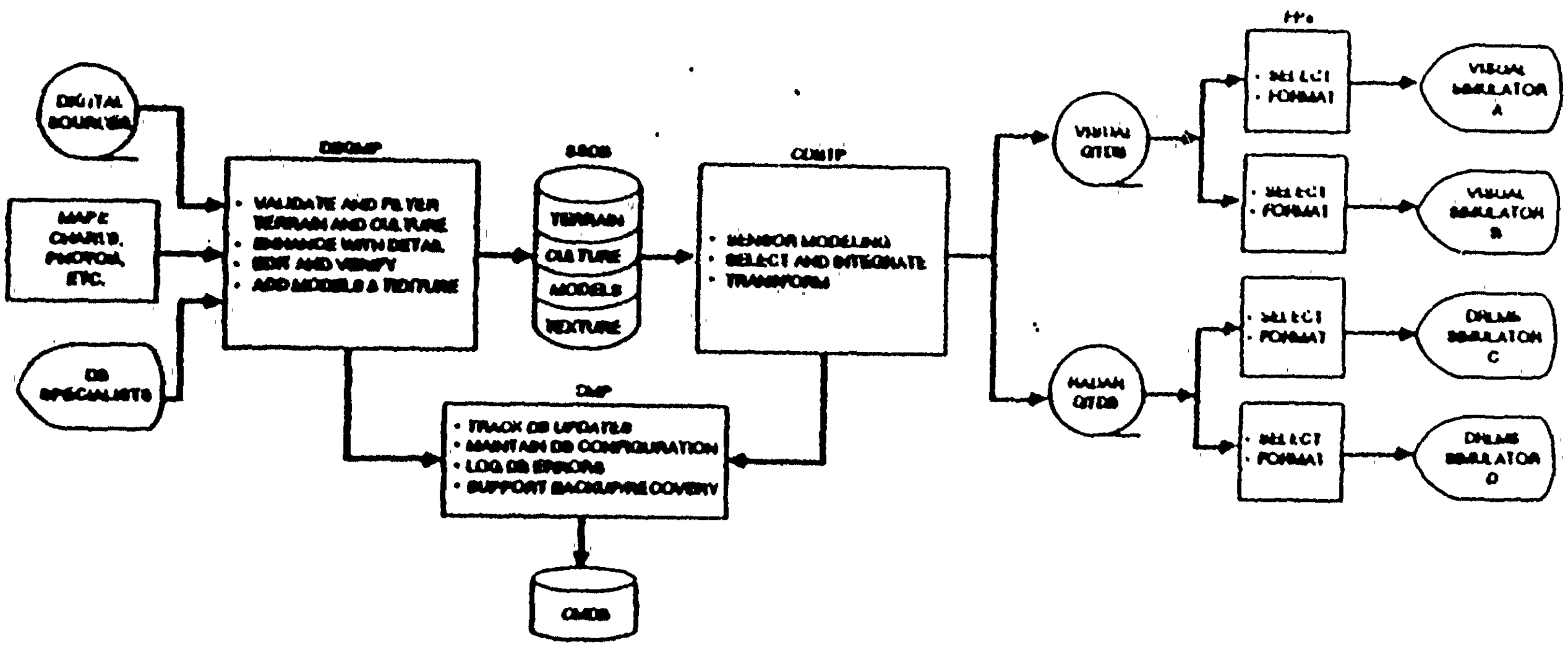
Background (Cont'd)

- Triservice Program Established by Joint Technical Coordinating Group in 1983 With ASD as Lead Agency
- Program Objective: Reduce Simulator Acquisition and Lifecycle Costs by Eliminating Data Base Redundancy
- Early Program Activities
  - Data Collection
  - Cost/Benefit Analysis
  - Transformation Efficiency Study
  - Data Base Definition Study
- Development Contract Awarded May 1987
  - Prime Contractor: Planning Research Corporation
  - Two Phased Effort
    - Prototype System Development
    - Interim Production and Concept Validation

System Design

- Central Simulator Data "Library"
- Source Exploitation, QC, and Maintenance Software
- Universal Transformation Program
- "Generic" Products
  - Standard Format
  - Custom Content
- Configuration and Production Control Software

After Project 2851



Standard Simulator Data Base

- Wide Variety of Source Materials
  - Digital
  - Cartographic
  - Photographic
  - Synthetic
- Standard Format
  - Structure Based on DMA DLMS
  - FACS Attribution
  - Simulator-Unique Attribution
- Components
  - Culture
  - Terrain
  - Models
  - Texture

Common Data Base Transformation Program

- Performs Conversion of SSDB into Generic Transformed Data Base Format
- Input Parameters for Custom Tailoring of GTDB
  - Simulation "Lambda Class"
  - Level of Detail Mapping
  - Terrain Representation and Resolution
  - Assign Model References to Culture Features
  - Culture Feature Keep/Delete Lists
  - Etc.
- Can Generate Gridded from Polygonized Terrain
- Update Function Minimizes Retransformation
- Benefits Include Improved Correlation, Reduction in Software Acquisition and Maintenance Costs

Project 2851 Operations Concept

- Simulator Data Base Production Facility (SDBPF) Will:
  - Acquire Source Materials
  - Populate and Maintain Standard Simulator Data Base
  - Operate Common Data Base Transformation Program
  - Provide GTDBs to Users
- Simulator Developers/Users Will:
  - Provide Training System Requirements to SDBPF
  - Develop and Operate GTDB Formatter Programs
  - Perform Site-Specific Enhancements
  - Provide Feedback to SDBPF

Project 2851 Standard DOD Simulator Digital Data Base/Common Transformation Program

Program Status

- Prototype System Nearing Completion
- Early Demo Validated GTDB/Formatter Program Concept for DRLMS
- Visual Demo Currently in Progress
- Testing Commences Late September
- Program Activites Following Acceptance
    - Interim Production
    - Production Facility Preparation
        - Facility Modification
        - Hardware Upgrade
        - Production Operations Contract
- Production Capability May 1991

Project 2851 Standard DOD Simulator Digital Data Base/Common Transformation Program

System Improvement Initiatives

- Rapidly Reconfigurable Data Base Enhancement
- SSDB Prepopulation Activities
- XDFAD Interim Product Definition
- Product Application Support Function
- Networked Simulator Capability

Rapidly Reconfigurable Data Base (RRDB) Enhancement

- Upgrade to Baseline Project 2851 Capability
  - Reflects Changing Simulation Technology Base
- Supports Mission (Rehearsal) Training
  - Increased Utilization of Photographic Sources
    - Feature Extraction
    - Photo-Texturing
  - Streamlined Production Process
- Schedule
  - Top-Level Design Task
    - Army (PMTRADE) Funded ECP
    - Task Startup Pending Negotiations
    - Scheduled Completion Nov 1990
  - Detailed Design and Integration to Follow
  - Operational Capability Mid-1992

Data Base Networking Issues

- Physical Location
- Real-Time Update
- Correlation
- Security

Physical Location

- Centralized
  - Single Data Base Shared by All Nodes
  - Minimum Data Storage
  - Simplifies Dynamic Update; Best Correlation
  - Bandwidth Requirement Probably Unrealistic
- Distributed
  - Each Node Supports Portion of Data Base
  - Shares Benefits of Centralized Data Base
  - Network Traffic Slightly Less Than Centralized
- Replicated
  - Entire Gaming Area Resides on Each Node
  - Least Efficient Storage
  - Redundant Retrieval and Update
  - Minimizes Network Traffic

Real-Time Update

- Static
  - Data Base Loaded at Initialization
  - Individual Nodes Cannot Modify Environment
  - Minimizes Network Traffic
  - Limited to "Non-Destructive" Scenarios
- Dynamic
  - Initial Data Base Modified by Player Actions
    - Terrain
    - 3-D Objects
    - Photo-Based Texture ???
  - Centralized Data Base Can Minimize Complexity
  - Replicated DB Approach Requires Nodes to Modify
- Effective Training Will Probably Require Dynamic DB

Correlation

- Greatest Challenge Facing Networking of Different Vendors' Simulators
- Required to Some Degree for Effective Training
  - Not Necessarily One-to-One Correspondence
  - Dependent on Application
- Data Base Implications
  - Common Source Materials
  - Common Processing Algorithms

Security

- Factors
  - Data Base Classification
  - Network Certification
  - Access Level of Individual Trainees
- Requirement for Access to Classified Information May Vary from Node to Node
- Comprehensive Security Program Necessary

A Project 2851 Approach to Address Issues

- Physical Location - SDBPF Can Produce Single, Comprehensive GTDB or Multiple Subsets to Support any Method
- Real-Time Update - SDBPF Can Provide Multiple Representations of Various Data Base Features to Ensure Correlated Modifications
- Correlation - SSDB Acts as Common Data Source; CDBTP Provides Single Control Point to Ensure That GTDBs Meet Training Requirements
- Security - SDBPF Security Review Procedures Will Ensure That Transformed Data Bases Meet Program Requirements and Restrictions

What We Need to Know to Build Inexpensive 3D Visual Simulators In the Future

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Talk Outline

-- Graphics Workstation-Based 3D Visual Simulation Systems

-- Terrain Modeling

-- Terrain Visualization

-- Issues in Effective Graphics Workstation Utilization

-- Educational Deficiencies

-- "Playing on the Terrain"

-- The Need for Autonomous Vehicles

-- Issues in Driving Correctly
-- Issues in Fighting Correctly

-- Educational Deficiencies

What We Need to Know to Build Inexpensive 3D Visual Simulators in the Future

-- Graphics workstation-based, 3D visual simulation systems.

-- Key Problems/Concerns in Developing 3D Visual Simulators

-- (1) Terrain Modeling

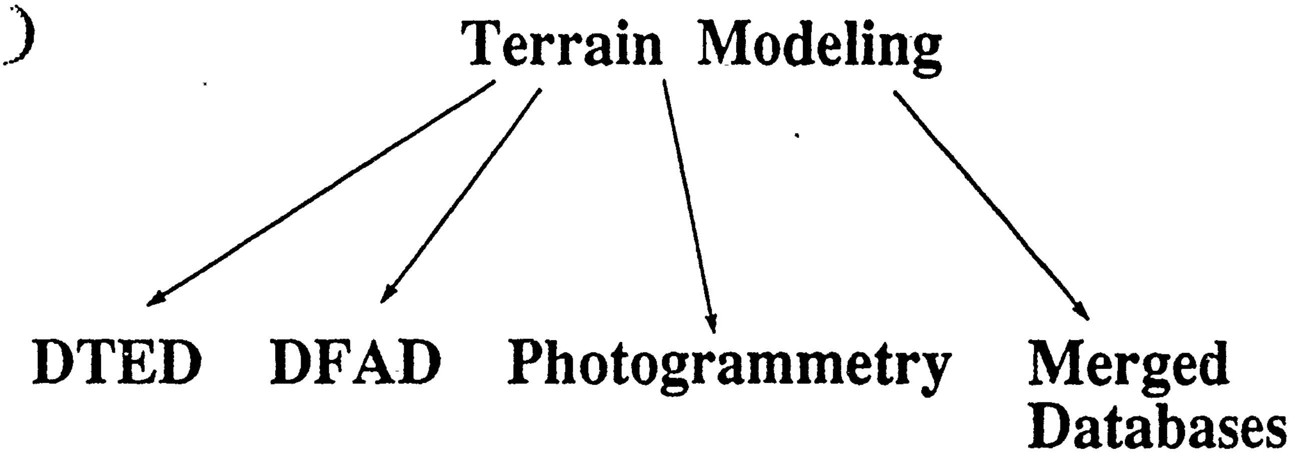
-- (2) Terrain Visualization

-- (3) "Playing on the Terrain"

(1) Terrain Modeling

-- **Most of this appears "solved" or "fixable" with some more work.**

-- **Today we can go to DMA and check out data for most areas of the globe.**



(2) Terrain Visualization

-- We have commercially available, low-cost graphics workstations with high-performance 3D polygon transformation, polygon fill, lighting and hidden surface elimination.

-- and each year we get greater graphics performance with software compatibility using commercial workstations!

-- we have seen this over the last 5 years and will continue to see this probably for the next 5 years.

-- What we haven't completely solved are the issues involved with effectively utilizing such workstations for our 3D visual simulation systems.

-- A lot of this is due to unfamiliarity with such systems, i.e. graphics workstations are rather new to the 3D visual simulation realm.

-- Previous attitudes in the industry have been towards contractors designing proprietary, special-purpose hardware.

-- Education is also lacking on high-performance graphics workstations.

- -- Few schools teach their beginning graphics courses utilizing systems such as the Silicon Graphics, Inc. IRIS 4D/70GT...

- -- Few companies purchase education on effective use of such systems for their employees.

- -- They expect their employees familiar with static graphics to just "pick-it-up".

-- What are the hard problems in 3D terrain visualization on commercially available graphics workstations?

- -- Determining the minimal set of polygons to deliver to the graphics pipeline of the workstation.

- -- Field-of-view/view volume computations.

- -- Terrain display distance attenuation techniques.

- -- CPU/Graphics Hardware Balance Issues

  - -- i.e. can we off-load some of the graphics to the CPU to get better overall performance.

- -- Realistic Performance Measurements and Predictions for Commercially Produced Graphics Workstations

- -- 3D Icon Production and Usage

- -- Vehicle Dynamics/Terrain Interaction

(3) "Playing on the Terrain"

-- We can network multiple workstations together, drive individual vehicles, and dead-reckon others but that doesn't give us all the players we need to simulate realistic engagements.

-- We must integrate autonomous vehicles into our systems.

-- Autonomous vehicles must behave and act like real players.

-- Such autonomous vehicles must
(a) drive correctly and
(b) fight correctly,
using rules/knowledge similar to that utilized by real human drivers.

(a) Issues in Driving Correctly

-- Goal Directed Driving

-- Group Dynamics (multiple vehicle actions/decisions)

-- Physically-Based Vehicle Modeling

-- Terrain/Vehicle Interaction

(b) Issues in Fighting Correctly

-- Weapons Modeling

-- Physical Modeling of Fighting

-- Ballistics (ranges/human interface...)

-- Intervisibilities

-- Planning

-- Dynamic Route Planning

-- Levels of Detail in the World Model

-- Group Interactions

-- Autonomous Vehicle/Interactive Vehicle
Interactions

-- etc...

Where do we get the techniques for the autonomous vehicles?

-- They may not all be there and available.

-- We can borrow techniques from the AI/Robotics community.

-- If we do, we again face the issue real-time graphics people face daily, i.e. how much of the technique can we implement in real-time with the hardware we have or will have...

-- This is assuming that the technique is decomposable into a cheaper, less computation-intensive technique that we can "live with".

-- We are also assuming that we will have hardware for this.

This makes me think of multiple CPU graphics workstations with software architectures like:

-- 1 CPU for Graphics Delivery

-- 1 CPU for Network Monitoring/World State Monitoring

-- 1 CPU for Vehicle Dynamics

-- 1+ CPUs for Intervisibility Computations

-- 1 CPU for Weapons Firing

-- 2+ CPUs for Modeling the Autonomous Vehicles

-- i.e. the autonomous vehicles that are part of "my actions", i.e. the rest of my convoy.

-- ++ CPUs for better and better models...

-- Fortunately, such graphics workstations are readily available today.

-- Again, with an even greater education problem:

-- i.e. Can I just give a multiple processor IRIS 4D/280 GTX to the guy who programmed the Tektronix on the VMS system?...

-- Issues of:

-- AI/Robotics

-- Parallel & Distributed Processing

-- Vehicle Modeling & Dynamics

-- Weapons Modeling & Firing

-- Real-Time, 3D Graphics Techniques...

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