AN OBJECTIVE LOOK AT THE

MODULARIZATION AND STANDARDIZATION OF TRAINING SYSTEMS

by
Gary M. Kamsickas
Boeing Defense and Space Group
Simulation and Training Systems
Huntsville, AL

ABSTRACT

Trends indicate, and projections suggest, that the future focus of training system design is modularization, reusability, standardization, cost reduction and team or multiple cockpit training. Several programs are in progress which deal directly with these issues. The Modular Simulator Design Program, a tri-service program administered by the United States Air Force, deals with the modularization and standardization of a single weapons system trainer. The Universal Threat Simulation System Program, administered by the United States Navy, is concentrating on the standardization and reusability of the threat and electronic warfare environment. Project 2851, administered by the United States Air Force, has the goal of standardizing radar and visual databases. In the team training environment, the Distributed Interactive Simulation program, administered by the United States Army, is attempting to provide a standard method of networking multiple training devices to allow for a cost effective team training environment. How these programs interact with each other is crucial to obtaining the goals of standardization, modularization, reusability and the eventual cost reduction of training devices. This paper provides an objective look at the interaction of these programs from a technical perspective. Suggestions are presented for possible modification to these standards to allow for greater compatibility.

INTRODUCTION

Over the past decade, in an effort to reduce costs, maintain technological superiority, and make use of emerging technologies, the government has attempted to standardize several facets of simulation and training technology. An early example of this effort was the attempt at standardization of software languages with the inception of the Ada programming language (MIL-STD-1815A) as the standard software language for all future training systems. Initially this standard was met with some reluctance on the part of industry. However, as the benefits of using Ada and the design methodologies associated with the language were gradually realized, industry acceptance of the standardization effort occurred. Standardization was perceived less as a "hand tying" effort on the part of the government and more as a benefit in both cost savings and advancing the state of technology for the entire simulation industry.

The government's effort to enforce the Ada programming language as a standard did more for the simulation community than provide code in a common language. It fostered the development of a new attitude in both the government and industry. This attitude was based on the Ada design principles of modularity, reusability, cost reduction, and also on just plain good engineering design practices. Design concepts and goals were expanded beyond modular, reusable, low cost software to the modularization and standardization of specific components of training systems, simulators as devices in general, and the networking of multiple simulation devices.

There are several major DoD research and development programs currently concentrating on developing standards which will significantly affect the training systems of the future. As with Ada, the standards associated with these programs are about to become enforceable requirements on future training systems.

It is the government's hope that enforcing these standards will result in a reduction in the cost and increase in quality of training devices through the reduction or elimination of redundant development efforts and a higher degree of system maintainability in a time of decreasing military budgets. However, without a conscious analysis of how these various standards may interact when invoked together for a training system, the result cannot be determined. A concern is that the result could be a training system which has been patched together in order to meet the requirements of all standards.

This paper discusses the programs associated with the standardization efforts and how these programs interact. Where appropriate, suggestions are presented for possible modifications to these programs/standards to allow for a better interface among the standards.

THE PROGRAMS

There are currently four major programs associated with the standardization effort; the Modular Simulator Design Program (MSDP), the Universal Threat Simulation System (UTSS), the Distributed Interactive Simulation (DIS) Program, and the Standard DoD Simulator Digital Data Base Common Transformation Program (Project 2851). Each program is producing a military standard and/or standard process for developing a specific technical aspect of the simulation arena. The following paragraphs provide a short synopsis of each program including program status.

Modular Simulator Design Program

The MSDP is a tri-service research and development program administered by the United States Air Force. The intent of this program is to develop a military standard for modular simulators which defines/standardizes module functions and module communication interfaces with respect to hardware, software and data. The goals of this program are to shorten simulator development schedules by promoting concurrent stand-alone module design, development, and test, reduce simulator costs through an increased competitive base and increased reusability, and improving supportability via well defined module functionality and interfaces coupled with recognized good design practices. This has been accomplished through the partitioning of a generic Weapons System Trainer (WST) into eleven distinct hardware and software modules as shown in Figure 1. Each of these modules communicates using a standard communication architecture comprised of a serial data bus (FDDI) using a standard set of system interfaces and communication rules. The Modular Simulator System (MSS) is defined by a set of System/Segment Specifications which define the system level requirements and the requirements for each module. These specifications along with a tailoring guide will eventually become the standard for modular simulators.

This program completed its demonstration/validation phase in December 1990 with successful results from tailoring the generic specifications to an F-16C application and building a working modular simulator. The standard is expected to be released by the government in the first quarter of 1992.

Universal Threat Simulation System

The UTSS program is another tri-service research and development initiative administered by the United States Navy. The intent of this program is to develop a threat generation system for threat models and threat data bases capable of providing training systems with a central repository of validated threat and interactive mode simulations. The goal of UTSS is to address the costs of controlling, maintaining currency and validating threat models and threat databases in simulators. To this end, the UTSS program will ultimately produce a Military Standard to address standard, reusable, current and

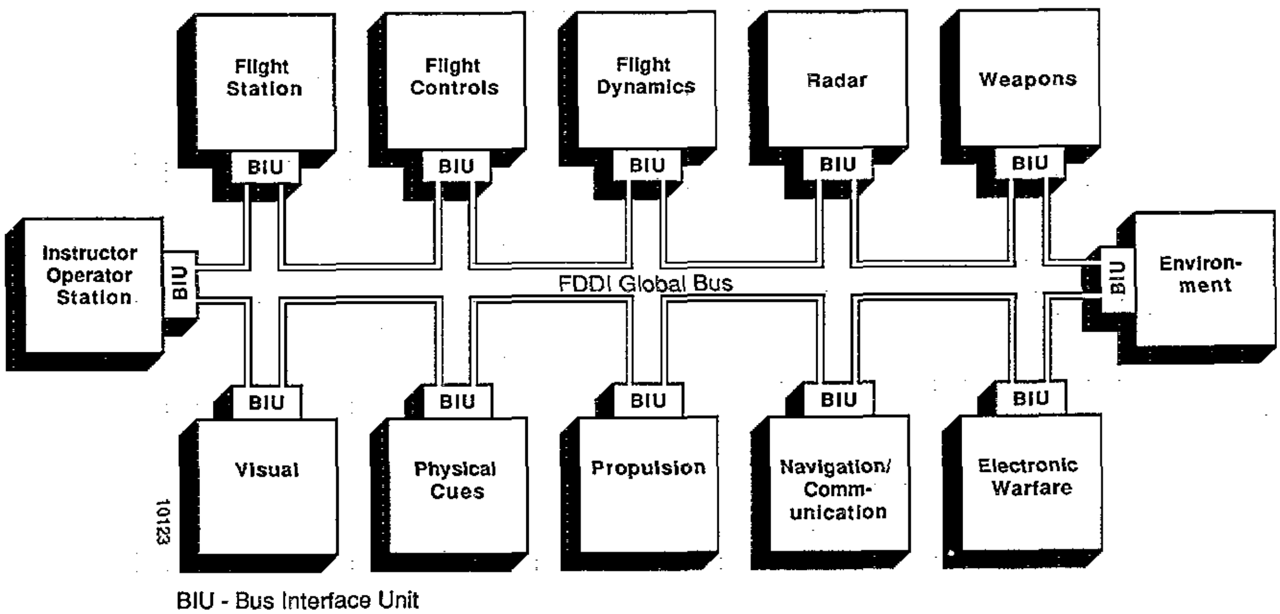

FIGURE 1
Modular Simulator Architecture

validated threat models and threat databases. In addition to the creation of the threat models and databases the UTSS will also provide a service or support facility responsible for the maintainence, update, validation and distribution of threat models and data bases to the simulator community. A concept for this support mechanism is shown in Figure 2.

The UTSS program recently completed its Front End Analysis (FEA) phase. The intent of the FEA was to define user training requirements and specify the level of threat fidelity to satisfy those requirements. These functional requirements will then be the basis of the UTSS performance specification and follow-on Full Scale Development effort. Preliminary results of the FEA indicated that users had identified a need for improved interactive threat models, current, accurate and validated threat data/models and an interface to the MSDP and DIS programs.

Distributed Interactive Simulation

The DIS program is a tri-service research and development program administered by the United States Army. This program addresses the standardization problems associated with interoperability among interconnected or networked simulators. This effort started in August of 1989 using the work of the Defense Advanced Research Projects Agency (DARPA) SIMulator NETwork (SIMNET) program as a baseline. The goal of this effort is to provide cost effective team training and developmental testing capabilities by using the current inventory of single operator trainers and future training systems. These trainers will be networked via Local Area Networks (LAN) and Wide Area Networks (WAN) as shown in Figure 3. In order to accomplish this goal the DIS standard must completely define the communication protocol between simulators in a distributed interactive simulation environment.

There is currently a draft Military Standard for the DIS. This standard identifies the DIS communication protocol as a set of International Organization for Standardization/Open Systems Interconnection (ISO/OSI) Application layer based Protocol Data Units (PDU). The PDUs are the communication messages for the DIS network. Each simulator (entity) participating in a DIS exercise is described to other participants via the PDUs. The DIS program currently has the basic PDUs defined to allow for entity interaction in a distributed environment. Interfaces such as network management, sophisticated electronic warfare, variations in fidelity among networked devices, and a common simulation environment remain undefined with the standard providing only basic guidance or recommendations in these areas.

Project 2851

Project 2851 is a tri-service research and development program which is also administered by the United States Air Force. The objectives of this program are to eliminate duplicative data base generation and redundant software development while improving database

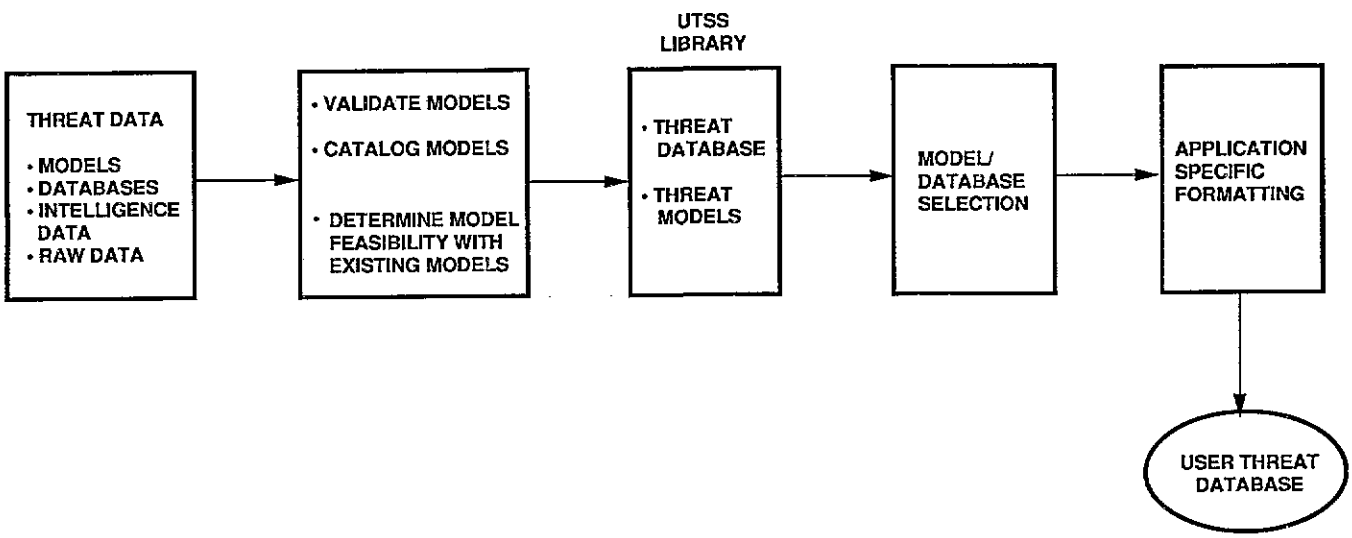

FIGURE 2
Universal Threat Simulation System Architecture

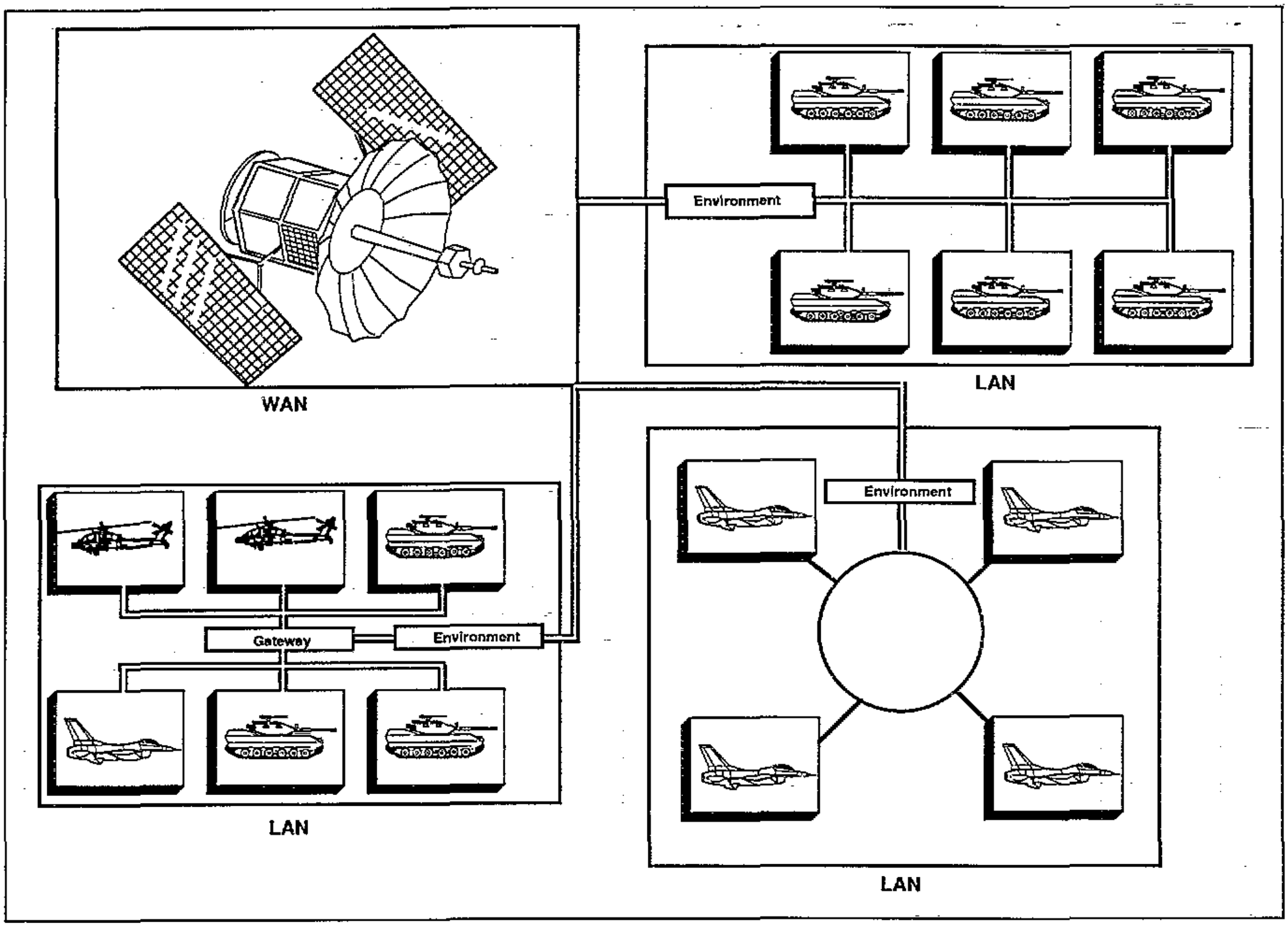

FIGURE 3
Distributed Interactive Simulation Architecture

consistency and correlation for visual and radar data bases. The end product of this program will be a data base production system/facility for visual and radar databases. This system will maintain Standard Simulator Data Bases (SSDB) for terrain, culture, models, and texture maps in the Project 2851 central libraries. The system will also provide a mechanism whereby externally created databases can be validated and entered into the SSDB (via the SSDB Interchange Format (SIF)). Generic Transformed Data Bases (GTDB) can be extracted from the SSDB for use in specific training system programs. Figure 4 provides a top level flow for the Project 2851 data base system.

This program is currently completing development of the Project 2851 data base production system. Draft military standards and handbooks for the SIF and GTDB have been produced and distributed to industry. The database system is expected to be operational in mid 1992.

THE GENERIC PROGRAM STRUCTURE

The government has executed each of these contracted research and development programs with the same basic structure. Although each program has tri-service support, one branch of the service is usually responsible for administering the program. The programs typically follow the schedule shown in Figure 5. Each program transitions through the same basic phases; concept development, concept design, demonstration/validation and finally standardization. The key element that all of these programs share is a heavy emphasis toward industry involvement in the standardization process. The government has in most cases mandated that the prime contractor for each program provide industry with a vehicle to provide constructive technical input into the design effort and the development of the standard. This is accomplished primarily through two methods, subcontracting of program effort and Industry/Service Working Groups (I/SWG). The latter, in the form of I/SWG meetings, are prevalent in all programs and allow industry a significant voice in the design/development of the associated standard.

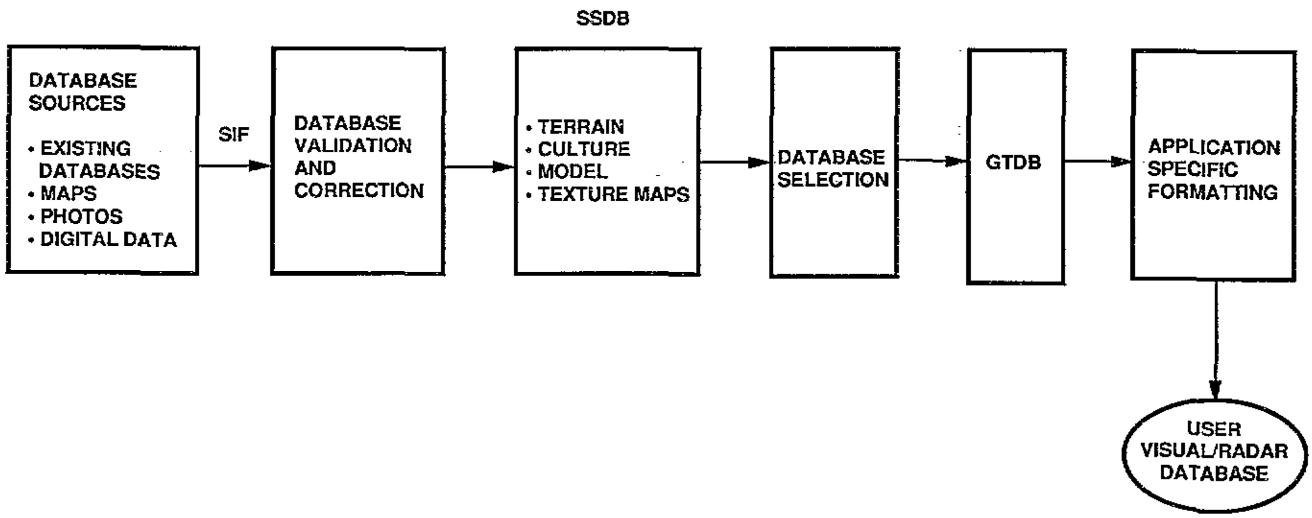

FIGURE 4
Project 2851 System Architecture

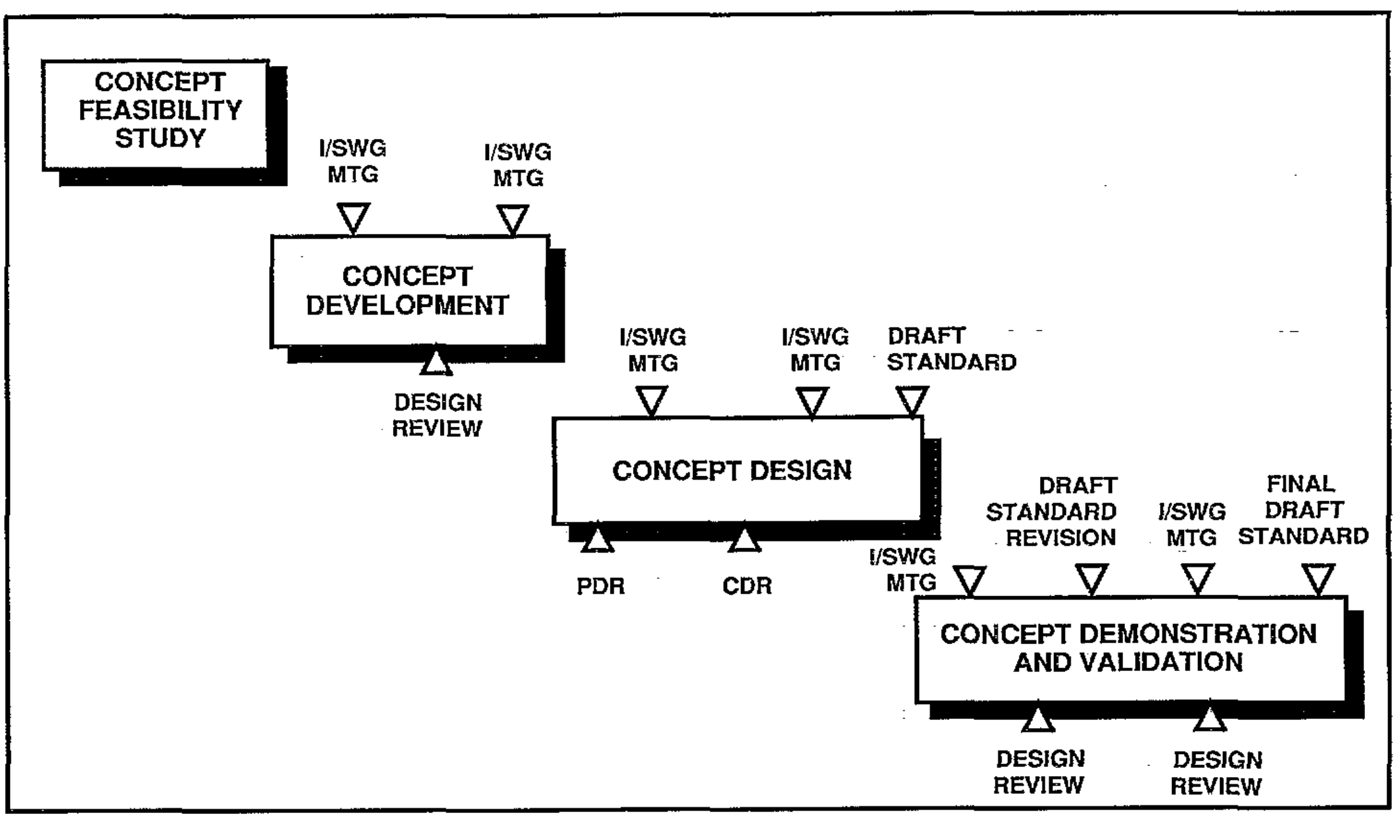

FIGURE 5
Generic Program Schedule

The I/SWG meeting concept has both positive and negative aspects. These aspects are shown in Figure 6. With the exception of the slow "design by committee" drawback associated with the I/SWG meetings, the remainder of the disadvantages are overcome by the positive aspects. With this in mind, one of the most difficult tasks of the I/SWG is to arrive at a consensus decision to resolve technical issues. Several methods have been employed including open debates/discussions, voting on issues, and the preparation of position papers. The best method is the requirement for a position paper to provide technical inputs for consideration. This accomplishes several objectives; 1) It forces the writer to clearly think through a technical issue instead of providing an off-the-cuff input, 2) It eliminates a great deal of redundant, and in most cases, circular discussion of an issue thus allowing for more effective and productive meetings, 3) The requirement to write a paper weeds out the people who are genuinely concerned about an issue from those who just want to debate, and 4) It allows for a paper trail of the inputs which caused the evolution of the design for future reference.

INTERACTION AMONG THE STANDARDIZATION PROGRAMS

One of the major problems with the standardization programs is the lack of coordination and interface between programs. Each program has its own requirements and in most cases is not required to investigate or comply with the other standard initiatives. This is due in most respects to the relative timing of the programs. As shown in Figure 7, the concept development phases and requirements analysis do not align among the programs. This causes difficulty in determining the impact of future, as yet undefined, standards on present standards initiatives except in a "prediction of the future" manner. For example, the impact of UTSS or DIS on the MSDP was difficult to assertain during the MSDP concept development and initial design phases. In most cases, each of the standards programs is aware of the other programs and make a fair attempt to consider them in the design. However, each program is usually in some state of flux. Therefore, when the scope or direction of one program changes all other programs must either realign or ignore the change.

I/SWG Advantages	I/SWG Disadvantages
• Industry provides input to the standard (get a vote in the creation)	• Design by committee is slow
• Industry experts provide experience to design process	• Some companies may attempt to bias design
• Differing viewpoints throughout industry avoids biased design	• Companies not paid to participate (some voices not heard)
• Industry and vendors aware of program direction and are better prepared with products when standard is enforced	• Companies attend to make an "appearance" (information gathering only)
• Foster a "Team" attitude between government and industry	• Company representative always changing (knowledge base and continuity of I/SWG always in a flux state)

FIGURE 6
I/SWG Comparison

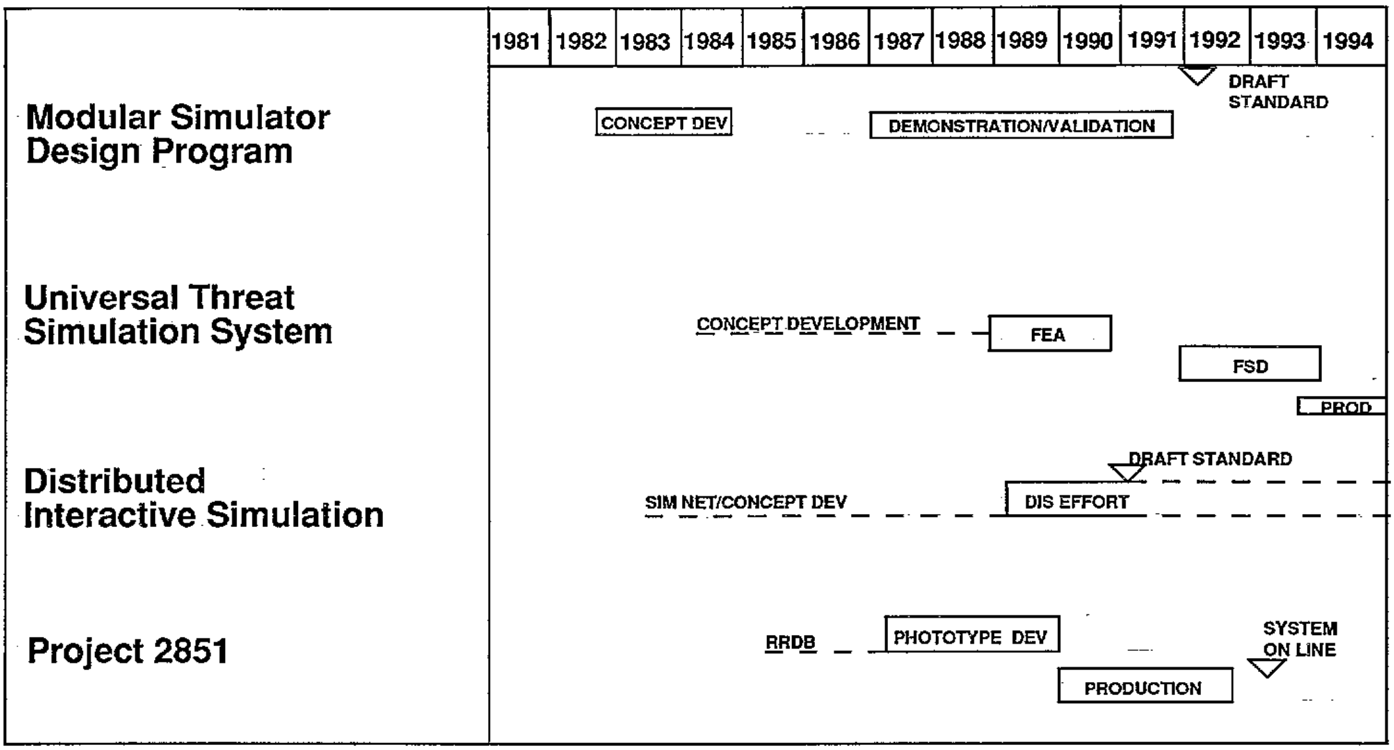

FIGURE 7
Standardization Program Development Schedule

Another problem among the standardization programs is redundancy in solving technical problems which are common to the programs. An example of this is the determination of data units for interfaces. One of the goals of each standardization program is to provide a standard interface for data to the external world. Each program has developed this interface and each program has defined a standard set of data units for the interface. The development and definition of data representation and data units was a significant and highly debated issue in each program. However, in most cases the units among the programs don't match. This will cause data conversions to be performed when more than one of the standards is invoked for a single program. These data conversions are a needless waste of valuable computational resources. As part of a study, a one to one correlation was conducted between the MSDP interfaces and the DIS interfaces. It was found that almost all data units required some conversion.

In some cases there is a specific reason for the data units to be defined as they are for a certain program, such as packet size, data latency, etc., but the determination of units on several programs were based on the standard developer's initial input.

<u>**The Environment**</u>

The lack of correlation of data units among the programs is of minor importance when compared to how the technical aspects of the programs will interact when their associated standards are used together. What is needed is a global view of the programs to determine how the standards produced by the programs may eventually interact.

If a comparison is made between the real world and the simulated world, a simple correlation can be derived as shown in Figure 8 for a single simulation device. The simulation can be abstracted into three major components in the simulated world, 1) The control function or Instructor Operator Station (IOS) in most simulators can be compared in a simplistic sense to God who has the power to control the environment and anything in the environment including the ownship, 2) The environment function which is defined as anything external to the ownship, and 3) The ownship itself which contains all ownship parameters specific to the aircraft being simulated. One concept behind cost reduction is to maximize reusability by identifying those areas of the simulation which are generic (reusable) and those areas which are application specific (non-reusable). An

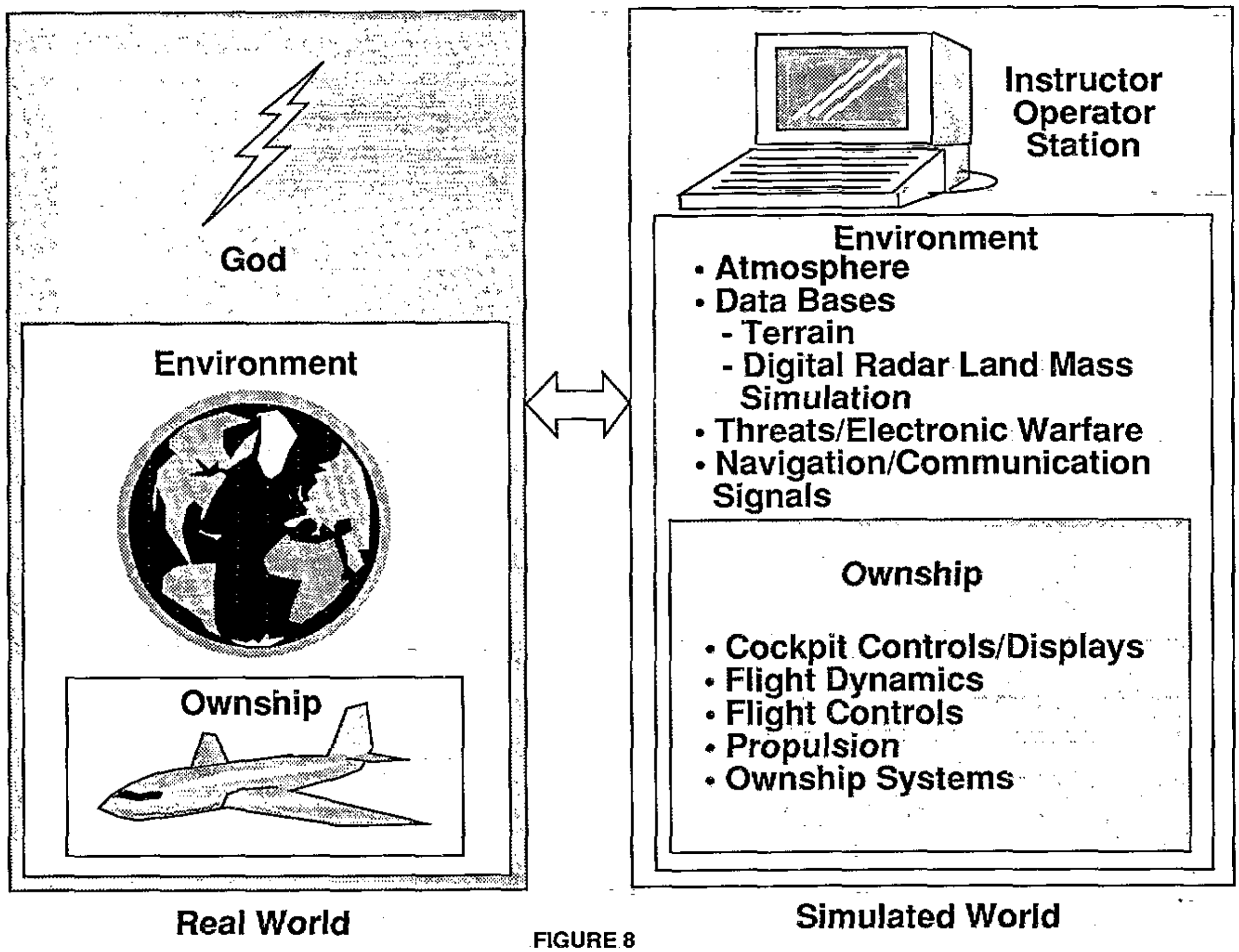

FIGURE 8
Real World to Simulated World Comparisons

environment simulation could be considered reusable for any ownship. The environment simulation can remain constant, whereas the ownship simulation is application specific and must be replaced for a particular application. If the interfaces between the three major components are clearly defined and included as part of the standards, this partitioning would allow a great deal of flexibility among the standards programs.

To align to the common environment concept a Modular Simulator could be partitioned as shown in Figure 9. In this configuration an Environment module has been added to the current Modular Simulator standard allocation. The functions internal to the modules have been reallocated such that the remaining modules with the exception of the IOS module contain only the ownship unique functions. The entire environment would reside in the environment module. This environment would include the tactical realm of threats and electronic warfare as well as the natural atmospheric environment. In this partitioning the Modular Simulator would get the environmental simulation from an internal environment when in a stand-alone simulation mode and from the DIS when in a networked, or multiple simulator, simulation mode. Also when in the stand-alone mode the UTSS would be a part of the Environment module. In the DIS or networked mode the Environment module would serve two primary functions. The first function would be a translator between DIS messages (PDUs) and the appropriate Modular Simulator internal message structure. The second function would be to provide those environment functions not available on the DIS network. Currently the DIS only provides entity states and a limited electronic warfare capability. As DIS grows and these functions are added then the Modular Simulator Environment module can be modified.

An additional benefit to this partitioning is that changes in the DIS and UTSS standards have been isolated to a single module in the Modular Simulator. The interface from the Environment module to the MSDP global bus can be completely defined and should not be affected by changes in the other standards.

To expand the common environment concept further, an Environment module could be

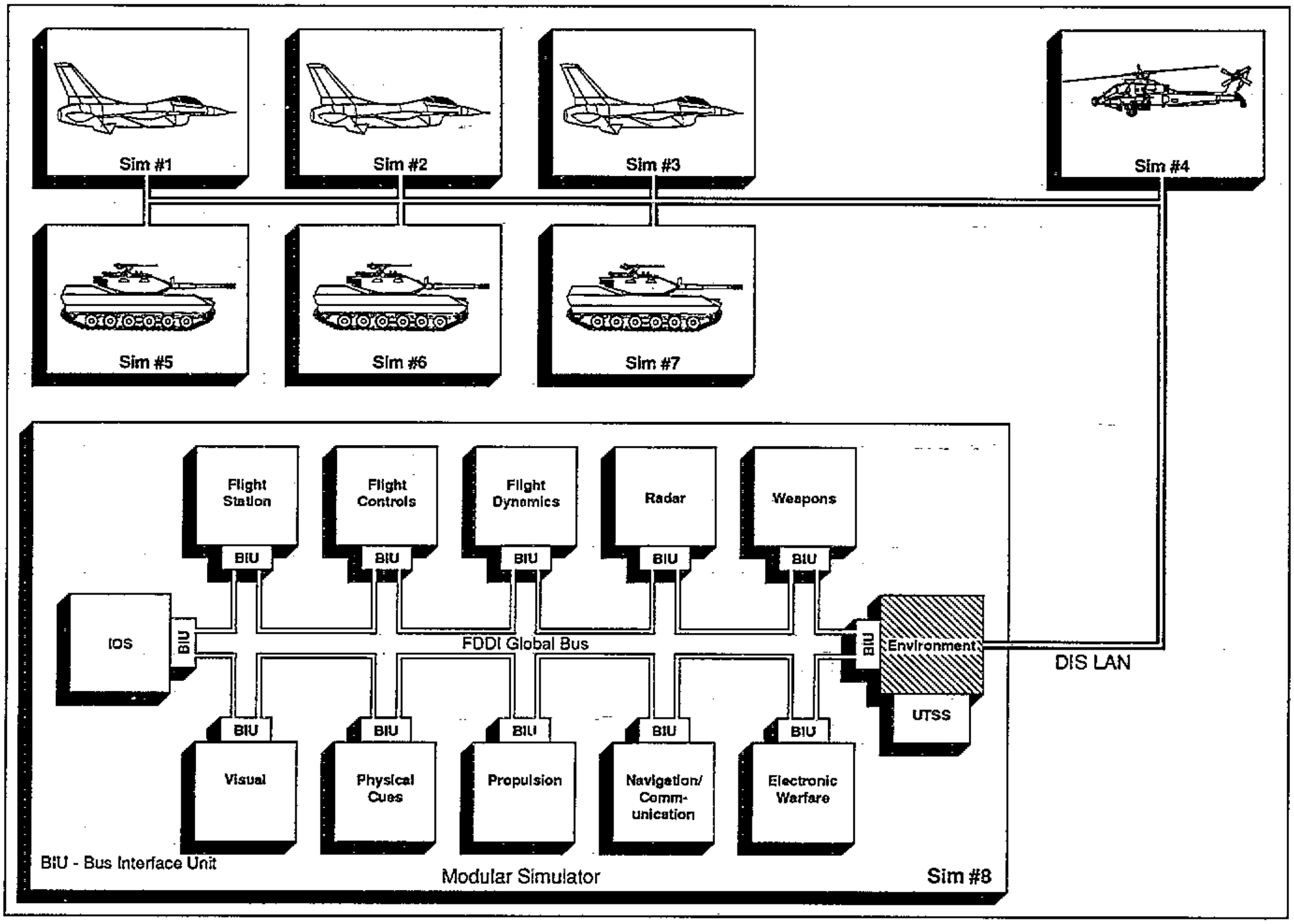

FIGURE 9
Modular Simulator Environment Concept

added to the DIS network as shown in Figure 10. In order to demonstrate this, assume that the DIS would provide the complete system including ownships and the environment. In a networked mode each ownship simulator would view other ownships as part of the environment and would receive common environmental information from the DIS Environment module. The UTSS data base could be added to the DIS Environment module if a threat environment was required in addition to the ownships connected to the DIS network. Furthermore, standard data bases from Project 2851 could be stored in the DIS Environment module to be used in the DIS exercises. With respect to the use of Project 2851 two methods could be employed. The data bases could be shared and accessed during run time for dynamic changes to the data base or the data bases could be copied with copies residing at each ownship and dynamic changes transmitted via the DIS network. The latter would probably be the most feasible solution. However, both methods would require further study to derive a sound technical solution.

This concept does not take into account two issues; the incorporation of existing simulators into the DIS network, and the relative fidelity of training devices that are interacting in the DIS network.

Many existing simulators are not partitioned in the same manner as a Modular Simulator and do not have a discrete Environment module to act as the system interface. This will cause a significant rework to the existing simulator. However, in all fairness many existing simulators cannot easily accommodate an interface to UTSS or DIS without a considerable amount of rework. Therefore, the common environment concept would not impose any additional rework to an existing simulator over what is now required to interface to these systems.

The relative fidelity issue, simulators of high and low fidelity operating in the same training exercise and communicating with a common environment, is also not impacted to any greater degree by this design concept. The relative fidelity issue will probably not be completely solved by any standards program. The simple truth is that mixing devices of varying fidelity will be a very difficult if not impossible task without some rework of the devices to allow multiple fidelities to interact.

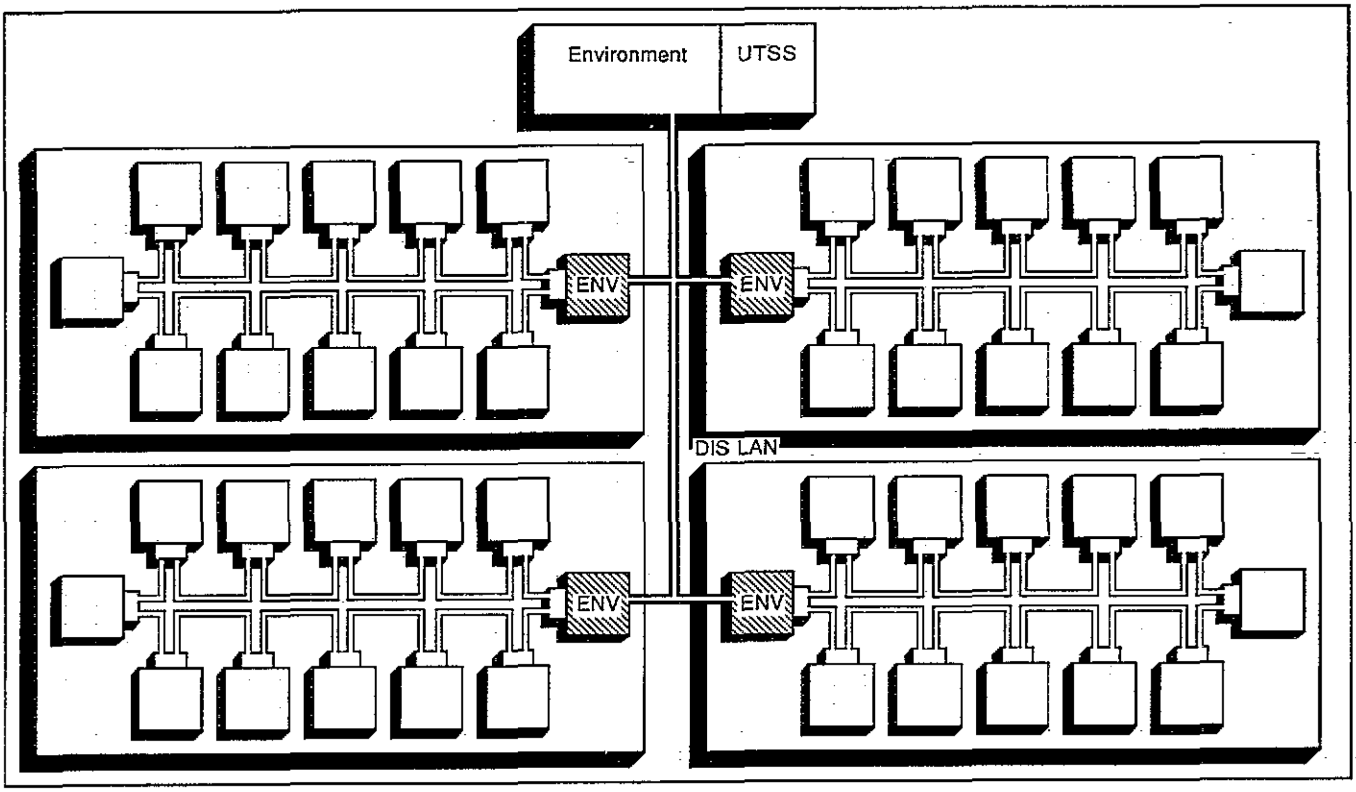

FIGURE 10
Distributed Interactive Simulation Environment Concept

What the common environment concept does provide is the isolation of change in the interface between all standards efforts. All changes in the DIS or UTSS standards have been isolated to the Environment module in the Modular Simulator standard. Changes to the UTSS or Project 2851 standards have likewise been isolated to the common environment of the DIS standard.

RECOMMENDATIONS

Based on the data presented in this paper several recommendations can be made for changes or considerations for change in the various standards programs. This is not intended to be an exhaustive list but a starting point for further analysis of the interaction and interface among the various standards programs.

Modular Simulator Design Program

To better align with the team training/multiple networked simulator environment supported by the DIS standard, it is suggested that the existing Modular Simulator functions be repartitioned and new functions be added as required to allow for an Environment module. This would allow for a single point of connection to a DIS environment and a more flexible design with respect to changes in both the emerging DIS and UTSS standards. The remaining modules should be repartitioned to reflect only ownship functions with the exception of the IOS module which would retain its current functionality.

Universal Threat Simulator System

The UTSS is still early in its development cycle. This allows UTSS to make use of the existing designs and lessons learned from MSDP, Project 2851 and DIS to develop an interface that is compatible with the standards produced by these programs and still meets the unique requirements of UTSS. Since UTSS will be dealing with the same type of entities already defined in the DIS standard, it is suggested that UTSS attempt to conform to the DIS PDU structure for entity descriptions and units wherever possible to allow for an interface which does not require a significant amount of data transformation. This would also allow UTSS to directly connect a threat environment to the DIS network in a seamless manner. For the sake of consistency among standards, UTSS should also consider using the Project 2851 system methodology for the threat models and database generation.

Distributed Interactive Simulation

Although the DIS standard has defined the basic PDUs for the interoperability of training devices there is still a great deal of work to be accomplished before DIS is a complete standard. It is recommended that DIS consider the environment module concept in its design along with the *ability to interface directly* with the UTSS and Project 2851 standards.

Project 2851

There are no recommended changes to the Project 2851 standard. This standard does not have a global interface impact to the other standardization efforts. The interfaces to this standard have been defined and the process of using the Project 2851 system for storage and validation of existing database information and generation of databases for future trainers is established. The Project 2851 standard should be invoked as soon as possible to take advantage of the system.

Common I/SWG

It is suggested that as the draft standards become available, a central organization should review the standards for mismatches. If possible, this organization should attempt to resolve *disconnects including redundant* specifications and areas where further specification is required. Such work promises to provide a well - defined interface among the standards. This task could be the effort of the joint or common I/SWG. What is needed is a technically competent group that has a good technical *working knowledge of each program and can* take an open minded, objective look at each program to ensure that the programs mesh together.

This I/SWG could be composed of individuals from the standardization programs, selected members of industry and the government. The members should be "active" participants in the existing I/SWGs if possible to provide an interface between the common I/SWG and the program I/SWGs. If possible this I/SWG should be funded so that the members might consider their efforts a part of their regular jobs and not an extracurricular activity.

CONCLUSION

The government and industry efforts to standardize certain aspects of simulation and training technology will eventually lead to improved training and simulation tools. The end result would be improved operational readiness with less technical risk and lower training costs. In most respects the four standardization programs identified in this paper interface quite well at their current state. However, these programs should be periodically reviewed to ensure that they continue to interface with each other to provide viable standards. *If conflicting* standards are produced it is possible to unintentionally increase the technical *risks* and costs associated with future training systems.

The concepts of a common I/SWG and development of a common environment should be seriously considered in the creation of these standards, particularly for the MSDP and DIS programs. These programs will derive the *greatest benefit from a common* environment, particularly the DIS standard, which deals with combined forces operations. By incorporating these emerging technologies into the standards produced today it will be possible to sustain and continue to improve training technologies within the decreasing defense *budgets of the future.*

ABOUT THE AUTHOR

Mr. Gary M. Kamsickas is a Software/Systems Engineer with the Simulation and Training Systems *organization of Boeing Defense and Space* Group in Huntsville, Alabama. He has been responsible for software design, code, test and integration on several Boeing simulator projects, including the Ada Simulator Validation Program (ASVP) and the Modular Simulator Design Program (MSDP). He is currently the Principal Engineer for the MSDP and involved in the design validation of the modular simulator concept. Mr. Kamsickas holds a Bachelor *of Science* degree in Electrical Engineering from Michigan Technological University, Houghton, Michigan.