SOURCE-DATA IMPERATIVES FOR CONCURRENCY

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ABSTRACT

The timely development, fielding and support of training systems, media, devices and courseware is critically dependent upon the quality and currency of the information (source-data) that describes the characteristics of the real-world environment for which training is required. Unfortunately, many military training programs for operators and maintainers have been, and continue to be, seriously compromised by the lack of awareness, commitment and resolve to ensure that the essential training source-data is provided as a product of the weapon system.

The solution to this problem is based on successful commercial practices and is rooted in the acquisition and systems engineering management of both weapon and training systems. The key to the solution is the implementation of structured processes that develop and maintain quality source-data products configured to both the weapon system and training system. This approach will substantially reduce the problems, risks and related costs of:

♦ Acquiring quality source-data in the weapon systems,

♦ Implementing source-data in the training systems, and

♦ Maintaining concurrency of the training system components.

The concurrency of the training system will be significantly improved since the required training system source-data is an integrated product development embedded in the systems and logistics engineering of the weapon system. As the weapon system design evolves, the training system source-data products will reflect the changes.

This paper provides insight into the basic source-data acquisition and implementation processes and requirements to support concurrency. Also, the paper addresses the philosophy, practices, and cost-effective methods of achieving significant improvements in source-data applicable to a variety of training programs.

ABOUT THE AUTHOR

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INTRODUCTION

Most training system and training equipment developers are seriously handicapped by shortfalls in the information (source-data) that describes the various characteristics of the weapon system and the real-world environment. The shortfalls impact the initial development, currency and life-cycle costs of the training programs.

Training system source-data is the training oriented information that describes the real-world weapon system functionality and performance within its operating environment(s). This information is the knowledge-base for the training program and training system. Source-data is the foundation upon which the curriculum, courseware, media, training devices, associated training materials and training program decisions are developed.

The quality, timeliness and currency of the source-data is determined by the organizations that are responsible for the weapon system. In the early phases of weapon system development, the origins of source-data can be found in the engineering disciplines used in the analysis, design, manufacture, test and logistics support of the various systems and sub-systems. As the weapon system matures and is deployed, the origins of source-data are replaced and additional disciplines become involved. Unfortunately, the maturing of the weapon system does not necessarily result in improvements in the source-data.

The training system and training equipment developers find themselves in the dubious position of being critically dependent on the exclusive resources of the weapon system contractors. The dependency and associated risks are further exacerbated as the weapon system goes through the inevitable design changes. Unfortunately, in most cases, the weapon system contractors and related organizations are not motivated to provide the quality and timeliness of the source-data needed by the training organizations.

This dilemma has handicapped most military training system and training equipment acquisitions, including those programs where the prime weapon system contractor has the full responsibility for the deliverable training system. The fundamental cause is the lack of incentives for the weapon system contractors to provide the required support to the training system developers.

This paper reviews this difficult problem and discusses the recent initiatives to develop an improved approach to solving not only the initial shortfall in source-data, but also the long term concurrency implications.

SOURCE-DATA AND CONCURRENCY

One of the principle issues associated with the development, fielding and effectiveness of training systems is the proverbial problem of concurrency. Concurrency, for the purposes of this discussion, is defined as "The condition of being ready for training on the training need date."[1] In the case of emerging weapon systems, the compelling requirement is to deploy the fully developed training system at the same time that the weapon system is fielded. In the case of mature weapon systems, concurrency is driven by the objective to maintain and improve the capability of the training system components, consistent with the changes to the weapon system and the training system. Establishing and maintaining concurrency of the various components of training systems is not a trivial task and in many programs the results have been less than satisfactory.

The parallel development of an emerging weapon system and its associated training system will typically encounter concurrency

problems in the digital based systems such as avionics, weapons, flight control computers, engine controls, etc. Due to the nature and flexibility of these systems, and the typical weapon system development schedules, the change level activity becomes highly dynamic at the point in time that the training system development has reached it's crucial delivery milestones. In this environment, source-data is one of the critical factors that contribute to the success or failure of concurrency.

The relative significance of source-data with respect to concurrency was characterized in a 1989 survey of Air Force using commands. A Major representing the Tactical Air Command was asked what he considered to be the most significant components that contribute to the concurrency problem. His response was "There are two inter-related components - contracting difficulties and inadequate source-data." He further commented that each of the two components had an equal impact on concurrency.

> The traditional practice of placing and accepting full responsibility for source-data on the user of the data instead of the producer of the data is fundamentally flawed in todays environment.

Further discussion in this area indicated that some of the "contracting difficulties" were, in fact, deficiencies in cost estimating attributed to the lack of weapon system engineering source-data needed to define the changes to the training system and training equipment.

Another example of this problem was indicated by an Air Force organization responsible for the acquisition of modifications for deployed training devices. This organization indicated that the modification contracts would typically involve considerable time and money just to collect the source-data needed to scope the changes to the training device(s).

Concurrency of the training system components is not exclusively effected by the design or performance of the weapon system. Changes to mission(s) of the weapon system, changes to the training environments, operational procedures, or curriculum may dictate the requirements for previously undeveloped training materials, media and revisions to training devices. Accordingly these changes in the training system will invoke the requirements for certain source-data that may not have been needed previously.

SOLUTION: DATA PRODUCTS

The recent initiative by the Air Force to establish a process for the concurrent development of training source-data as an integral part of the weapon system (and the training system) has elevated source-data to a deliverable product. Much in the same way that the weapon system contractor has been traditionally responsible for developing ground support equipment, maintenance tools, operations manuals and various other documentation, the Air Force process will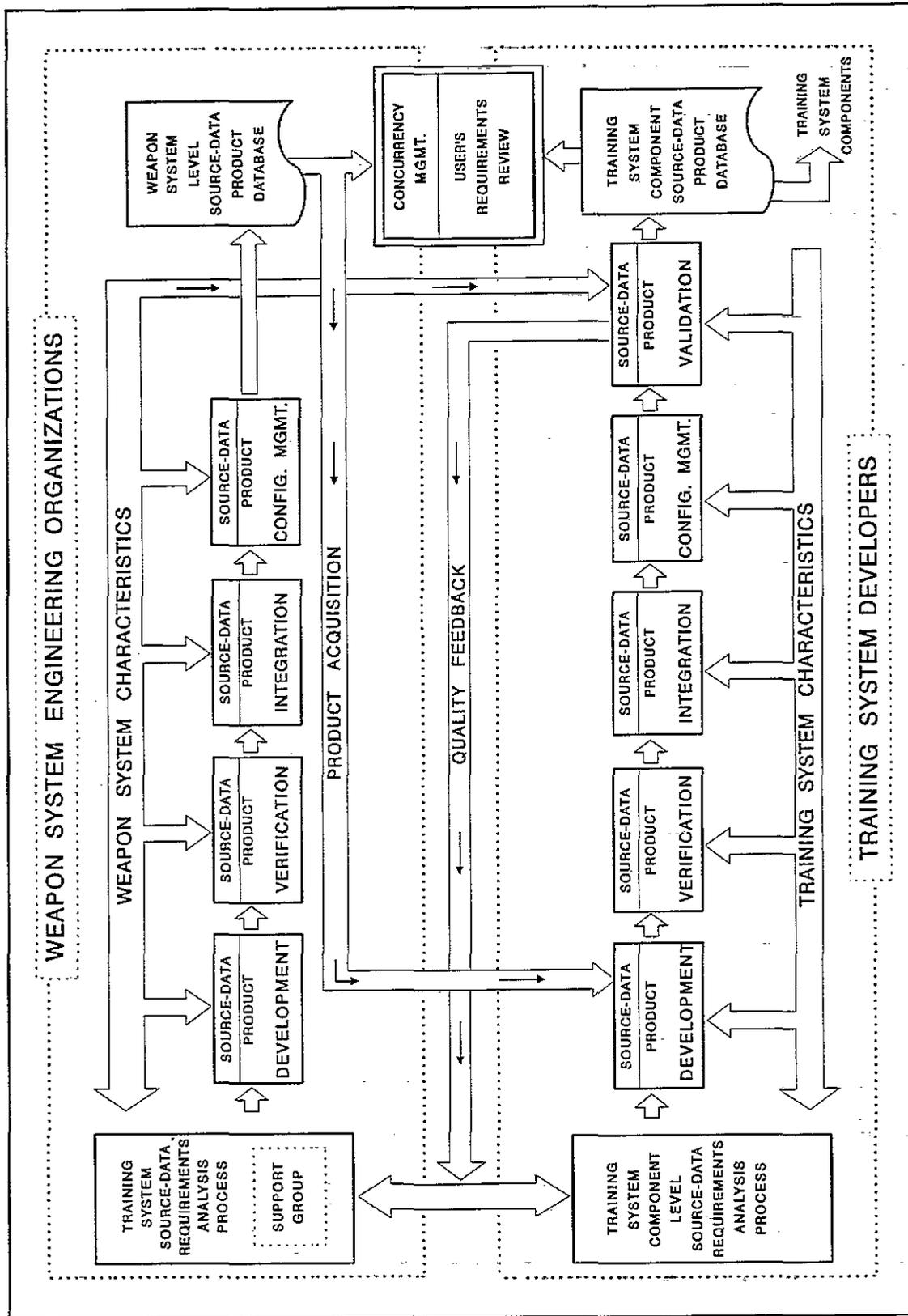 develop and maintain training oriented source-data as fully configured and supported products of the overall weapon system.

The basic philosophy is to develop and maintain training oriented source-data as life-cycle products, not incidental information that may be useable in the training environment. This philosophy and the processes recommended by the Air Force are adopted from the highly successful methods used by the airline industry to develop, and maintain the source-data required for aircrew and maintenance training purposes.

The process, as described in Military Standard: Training Systems And Equipment Source-data Process, MIL-STD-XXXX (USAF), evolved from an earlier study that concluded that shopping lists for training source-data were not effective without a means of assuring quality, timeliness and concurrency of the information (products) provided.

Initially, the development of MIL-STD-XXXX focused on the objective to improve the performance, training effectiveness and delivery schedules for aircrew training simulators acquired for training programs for

WEAPON SYSTEM ENGINEERING ORGANIZATIONS

WEAPON SYSTEM CHARACTERISTICS

WEAPON SYSTEM LEVEL SOURCE-DATA PRODUCT DATABASE

CONCURRENCY MGMT.

USER'S REQUIREMENTS REVIEW

TRAINING SYSTEM COMPONENT SOURCE-DATA PRODUCT DATABASE

TRAINING SYSTEM COMPONENTS

SOURCE-DATA PRODUCT CONFIG. MGMT.

SOURCE-DATA PRODUCT INTEGRATION

SOURCE-DATA PRODUCT VERIFICATION

SOURCE-DATA PRODUCT DEVELOPMENT

TRAINING SYSTEM SOURCE-DATA REQUIREMENTS ANALYSIS PROCESS

SUPPORT GROUP

PRODUCT ACQUISITION

QUALITY FEEDBACK

SOURCE-DATA PRODUCT VALIDATION

SOURCE-DATA PRODUCT CONFIG. MGMT.

SOURCE-DATA PRODUCT INTEGRATION

SOURCE-DATA PRODUCT VERIFICATION

SOURCE-DATA PRODUCT DEVELOPMENT

TRAINING SYSTEM CHARACTERISTICS

TRAINING SYSTEM DEVELOPERS

TRAINING SYSTEM COMPONENT LEVEL SOURCE-DATA REQUIREMENTS ANALYSIS PROCESS

SOURCE-DATA PROCESS FLOW

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new, emerging weapon systems. During the preliminary fact-finding and analysis phases for the preparation of the process standard, it became increasingly obvious that the source-data problem was not isolated to aircrew training equipment. A consensus of the industry and military representatives participating in the development of the standard indicated that the process should support courseware, training materials and media for both new and existing operator and maintenance training programs. The commonality of source-data needed to support generic operator and maintainers training media and courseware requirements was examined and found to exceed 50% in most areas and above 70% in the training equipment design and performance areas. The expanded scope for source-data applications does not change the general process. It will, however, increase the requirements for the consistency, integrity, commonality and currency of source-data products.

The process described in the standard is intended to be fully integrated within the systems engineering approaches that are used to develop the weapon system and the training system. The fundamental objective is to imbed the development of source-data products within the weapon systems contractors (and sub-contractors) engineering and testing process. This approach capitalizes on the irrefutable fact that the weapon system designers and evaluators are the exclusive source of the knowledge base upon which the training source-data products must be based. This approach is consistent with the "Concurrent Engineering" and "Integrated Product Development" initiatives of the DOD. In the large commercial aircraft programs, this approach has evolved during the last 10 to 15 years, and is institutionalized within the design and test engineering organizations.

SHARED RESPONSIBILITY

Traditionally, in those military programs where the training system or training equipment are procured independent of the weapon system, the training system and training equipment developers are obligated to assume the total responsibility for source-data that must be generated by other sources that have little or no vested interest in providing data. Even in some programs where the "Prime-builds-all", the training system sub-contractors are obligated to accept full responsibility for source-data that must be acquired from other organizations (including the prime) that are not motivated to provide what is needed. Typically the priorities of weapon system contractors are focused on the "big ticket" items. The associate contract agreements between the weapon system contractors and the training system/ training equipment developers cannot compete for the engineering resources. Consequently, source-data are relegated to resources that are outside the mainstream of the weapon system engineering effort. The traditional practice of placing and accepting full responsibility for source-data on the user of the data instead of the producer of the data is fundamentally flawed in today's environment.

Implementing a source-data program similar to that prescribed in MIL-STD-XXXX requires that the weapon system community accept limited responsibilities for developing and maintaining quality source-data products that are ultimately used for training the operators and maintainers of the weapon system. Likewise, the training system and training equipment developers accept certain responsibilities for their role in the overall process. The weapon system prime contractor's responsibility for the development of concurrent source-data products involves a management commitment at a sufficient level to ensure the mainstream engineering resources are applied to the effort. An example is the co-development of real time training simulation models of the weapon system dynamics as a subordinate product of the weapon system engineering simulation. A key factor is the capability of the weapon system prime contractor to effectively interface between the requirements of the training community and the weapon system engineering and test community.

PROCESS FLOW - OVERVIEW

It is not the intent of this discussion to engage in a detailed review of the process standard. However, an appreciation of the general functional flow, relationships and interfaces is necessary. The figure, Source-data Process

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Flow, is a generalization of the flow model that is in MIL-STD-XXXX. The upper half of the diagram depicts the weapon system process starting with the Source-data Requirements Analysis. The weapon system level source-data products are maintained in the database, and acquired by the training system developers. The lower half of the diagram contains the training system source-data process, also starting with the training system component level source-data requirements analysis. The required weapon system source-data products form the foundation for the development of the source-data products to be used in the training system process. The source-data product validation process takes place in the training environment. The validated products flow into the training system component level source-data product database. In addition, a quality feedback is provided to support improvements and integrity of the products. The developers and maintainers of the training system components acquire the source-data products from the database. The information that resides in both databases is reviewed by the training system users as part of the concurrency management process.

The key to providing concurrent source-data products is embedded in the configuration management process of both the weapon system and the training system. In its simplest form, the source-data products developed by the weapon system contractors are weapon system configured items (CIs). As the weapon system design matures and is changed, corresponding changes are required to those source-data products effected by the modification. This applies throughout the life of the weapon system. Also, as indicated in the flow diagram, the contents of the source-data products is determined by the characteristics of the training system. For example, if the maintenance training curriculum requires that additional hydraulic failure modes be incorporated in the training courseware, then the requirements and specifications for the designated source-data product(s) will be revised. Likewise, if the hydraulic characteristics of the weapon system are changed, then the configuration of the source-data product is affected.

Within the training system, configuration management of source-data products is allocated to the appropriate training system components, i.e., training programs, courseware, CBT, Training Devices, etc. Changes to the weapon system source-data products that will impact the currency of the training components are tracked continuously through advisories generated by the weapon system contractors. Accordingly, as the configuration of the training system is changed, corresponding advisories are provided to the cognizant weapon system offices.

Ultimately, under ideal conditions, these processes will establish and maintain a database of verified and validated source-data products that will:

♦   be consistent with the configurations of the weapon system and training system,

♦   conform to the quality requirements of the training system/equipment developers and operators, and

♦   support the decision making process of the training system organizations for acquisition, development and modification of the training system components.

The overall process prescribed by MIL-STD-XXXX is a quality based continuum that begins as early as possible in the life of the weapon system and continues throughout the life cycle. The training and weapon system developers, operators and life-cycle support groups establish and maintain the interface(s) required to meet their mutual objectives. Likewise, the relationships between prime and subcontractors for both the weapon system and training system should be structured for the long term life-cycle requirements. As the programs evolve, the quality, concurrency and integrity of the source data-products will be substantiated through verification and validation as applied in the training environment.

GOVERNMENT ROLE

To effectively implement a program of this type in the military environment, it is imperative that weapon system program offices establish the appropriate priorities required to ensure the ultimate success for concurrent development of source-data products. The Systems Engineering Management Plan (SEMP) for the weapon system should include the MIL-STD-XXXX process for the development of source-data products at a high enough level to sustain the inevitable pressures from competing program elements.

The key commitment to be extracted from the weapon system prime contractor is the establishment of a "training-smart" management position responsible for the development of quality, concurrent source-data products. This position should have adequate clout to ensure that the engineering resources within the main stream of the weapon system program are properly applied to the source-data objectives. Also, the commitment should obligate the weapon system sub-contractors to provide the same level of engineering support. Last, but not least, is the commitment of the weapon system contractors to ensure the *verification of the source-data products.*

The most critical step in the process of developing source-data products is the initial source-data requirements analysis, which translates the training system needs into *weapon system product specifications.* To aid in the requirements analysis process, the Air Force has developed a military handbook[2] that provides guidance for the identification of source-data requirements. The government program offices for the weapon system and training system components should cultivate a highly motivated Source-data Requirements Analysis Support Group that represents not only the weapon system and training system contractors but the military using command. The value of this working group should not be under-estimated. Properly supported by the government, they will provide cost-effective solutions for the constraints and limitations placed on the weapon system and training system. As a practical matter, the working group should serve to reduce the cost of source-data development by maintaining cost/benefit objectives.

The source-data requirements analysis is an iterative process that continues throughout the life-cycle of the weapon system. The source-data requirements support group is the catalyst for maintaining the quality, timeliness and, above all, the training objectivity of the overall effort. If the interests of the ultimate end-users, i.e, the deployed training system organizations, are not adequately represented in the support group, the effectiveness will be seriously compromised.

The acquisition planning for source-data products must support the short term implementation requirements and the critical long-term, life-cycle support for the weapon system and training system. In today's environment some weapon system platforms and associated training components are exceeding 35 years of operation. During the life span of these systems, major changes in functionality, mission and operating requirements have occurred. The lessons-learned are that the development of second and third generation of training system components is seriously compromised by the inadequate and poorly supported source-data. The long term planning factors should include the potential transfer of weapon system engineering responsibility to other organizations such as military logistics support depots and contractors other than the original developer. Likewise, the long-term support of the training system components may be absorbed in other training organizations. The long-term planning should ensure the integrity of the source-data products, processes and interfaces required to support concurrency.

MECHANIZING THE PROCESS

The overall implementation and control of the source-data process is rooted in the information management systems that are widely employed in both the commercial and military environments. Once the initial training requirements are effectively translated into real-world functional characteristics, and the appropriate resources are committed, the

remaining steps are commonly used in weapon systems engineering. This structure is intended to be tailored by the weapon system organization to achieve the most cost effective integrated product development that will support the quality and concurrency objectives. The co-development of the weapon system and source-data products within the same engineering groups will ensure the highest level of commonality. As the weapon system design matures, the corresponding source-data products will be developed, integrated, verified, and placed under configuration control. This process establishes the essential foundation for the initial development and life-cycle concurrency of the training system. The concurrency of the source-data products is an extension of the configuration control of the weapon system and the training system.

The source-data products in the weapon system database represent the baseline configuration of the integrated weapon system. These weapon system source-data products are selected and acquired by the training system developers.

The training system developers will then produce component level source-data products that are derived from the weapon system baseline. Integral to this effort is the source-data validation process accomplished in the training system environment. The validation process also provides a quality feedback to the source-data requirements process, so that defects in source-data are identified and appropriate changes are made to improve the source-data products. The source-data products in the training system database represent the baseline configuration for each of the training system components.

The composite of the two databases provides the critical information needed for the training system users reviews to support the concurrency management decision process, planning, acquisition, development, quality, and currency, of the training system.

TAILORING THE PROCESS

The basic process as described in MIL-STD-XXXX is designed to be tailored for a variety of applications. The core elements as illustrated

in Figure 1. can be adapted to most military applications ranging from the primary training programs to the emerging advanced tactical weapon systems. The tailoring objectives must focus on the:

♦ Training system requirements (short and long term),

♦ Weapon system program requirements, and

♦ Weapon system contractor's approach including:

- Subcontracting
- Engineering, and
- Testing

The most demanding requirement is the effective integration of the source-data product development process within the mainstream of the weapon system contractor's systems engineering and testing organizations. The determination of what engineering group, or groups, are best suited to support the development of source-data is driven by the level and type of information that is identified in the source-data requirements analysis. For example, in the case of source-data needed to develop training simulation models, it would be appropriate to assign the responsibility to the engineering simulation resources.

In most cases, the tailoring or adaptation of the process will be driven by the weapon system development and test schedules. The limited windows of opportunity to collect certain critical data will influence the process and resources. The tailoring process involves the various sub-contractor's engineering and test organizations. These factors, and others, should be taken into consideration as part of the source-data requirements analysis.

In the case of previously developed weapon systems or platforms, the tailoring and adaptation may involve the use of resources and methods that would not otherwise be cost effective. For example, if the flight test program for a previously developed aircraft will not cover the areas of the performance envelope needed to support training simulation, then alternative data collection methods should

be considered. In this case, the overall process including the source-data requirements analysis should accommodate these alternatives.

CONCLUSIONS

Military training system developers are reliant on the resources of weapon system organizations for the quality and timeliness of the source-data that describes the performance and functional characteristics of the weapon system. The lessons learned and the successes of the airline industry are the foundation for the Air Force initiative to establish the processes required to develop and maintain quality source-data as configured products of the weapon system and the training system. The processes are imbedded in the mainstream of systems engineering and integrated product development of the weapon system and training system. These processes will provide the database necessary to support concurrency of the training system.

To be effective, the government must provide the program incentives necessary to implement and institutionalize the source-data process. The weapon system contractors and sub-contractors will provide the source-data products and associated services if the requirements are reasonably definitive and integrated within the overall program requirements.

The responsibility for the quality and timeliness of the source-data products is properly placed and shared by the weapon system and training system organizations. The end-result is substantially improved concurrency, quality and cost-effective training systems.

------- REFERENCES -----

1.   Guide for Management of Air Force Training Systems - AF Pamphlet 50-11 (DRAFT), 2 April, 1992, Glossary of Terms.

2.   Military Handbook, Aircrew Training Equipment Source-data Requirements - MIL-HDBK-ATESR (DRAFT) 14 September, 1992.