TRAINING ANALYSIS REVIEW & COMMENT SYSTEM (TARCS): A CONCURRENT ENGINEERING APPROACH TO TRAINING SYSTEMS DEVELOPMENT

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ABSTRACT

The Training Analysis Review & Comment System (TARCS) is being developed to furnish the F-22 and other follow-on weapon systems with a CALS-compliant, user-friendly capability of reviewing completed Instructional Systems Development (ISD) data generated by the use of Joint Services ISD/LSAR Decision Support System (DSS) software. TARCS will also give users the ability to provide feedback on data reviewed to the weapon system training team.

TARCS will allow the user to:

1) Review Training Determination information (i.e., training requirements), including weapon system and training system concept information.

2) See the logic used by the ISD Analyst in the Task and Media Models to arrive at the training requirements for each task.

3) Read supporting comments or other information entered by the analyst.

4) Perform "what-if" scenarios on responses to decision model responses.

TARCS will be a multi-platform, client-server software application utilizing a Graphic User Interface (GUI), and is designed to be easily adaptable to future training system development projects that use the Joint Services ISD/LSAR DSS software as the ISD decision support tool.

To ensure the "integrated, concurrent design of products and their related processes" in training systems development (IDA Report R-338, cited in Gorman, 1991), TARCS is designed to provide customer access to training products. This approach helps accomplish what all good programs should accomplish: the ability to meet the customer's requirements while building in quality at the outset.

ABOUT THE AUTHORS

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INTRODUCTION

In the current defense contractor environment, there is a need for computer integration of the various support systems disciplines to improve efficiency and capability. The Department of Defense (DoD) is also making new requirements for computer integration a part of all new weapon systems contracts. To remain competitive in today's world market, contractors must have access to computer data and must use software tools to accomplish labor-intensive, time-consuming tasks.

In recognition of these new technologies and requirements, Lockheed Aeronautical Systems Company (LASC) has established an Integrated Systems Support (ISS) project to analyze the computer integration needs of the various support systems disciplines and develop capabilities to meet these needs.

The F-22 Advanced Tactical Fighter, a weapon system currently under development by LASC, Boeing, General Dynamics, and Pratt & Whitney, is the Air Force's lead program for implementation of Computer-Aided Acquisition and Logistics Support (CALS) compliance. Lockheed, as the prime contractor, is storing and providing access to F-22 team data for customer and contractor team use. The LASC ISS effort is currently focusing on the F-22 program requirements.

COMPUTER-ASSISTED ISD DECISION SUPPORT

In the F-22 training world, one of the significant data integration issues centers around the PC-based Joint Services Instructional Systems Development (JS ISD) / Logistics Support Analysis Record (LSAR) Decision Support System (DSS) software. The F-22 Training Systems Team will be utilizing this software decision support system, fed with LSAR data, for ISD. This system utilizes LSAR data as a foundation for analysis of training requirements based on the entire weapon system's supportability requirements. Because this PC-based software tool is used to create its own database, there is a need for integration of this data with the F-22 Team Database to allow the customer to review and provide feedback on the ISD data. The Contractor Team will also need to produce deliverables based on the ISD data.

However, the requirements for the data to be stored in a central data repository, the requirement for customer review and feedback capability, and the decision support system software's internal structure all precluded the possibility of utilizing the ISD/LSAR DSS as the means for providing this review and comment capability. The Training Analysis Review and Comment System (TARCS) is being developed to provide this capability. Additionally, TARCS will be the ultimate data management system for F-22 Team development data, of which the DSS generated data is a subset.

Understanding of TARCS and its capabilities is enhanced by basic knowledge of the Joint Services LSAR/ISD Decision Support System (DSS) software, LSAR, and CALS. What follows is a brief description of these topics, and how each area relates to TARCS.

ISD/LSAR DECISION SUPPORT SOFTWARE

The JS ISD/LSAR Decision Support System, developed by Armstrong Laboratories and Dynamics Research Corporation (DRC), is a

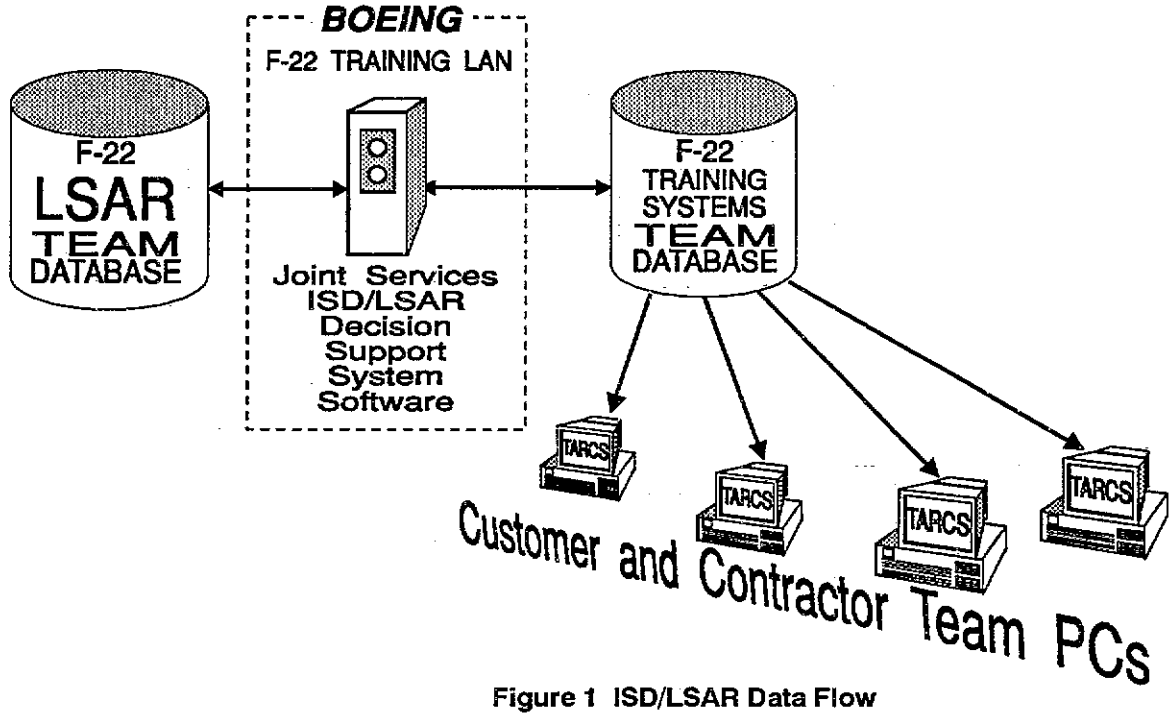


Figure 1 ISD/LSAR Data Flow

DoD effort to improve support of ISD decision-making and to harmonize training system development with other weapon system design undertakings. The system has been the topic of many presentations at I/ITSC and other conferences.

The key to concurrency of the DSS with other weapon system activities is the LSAR-to-DSS data interface, which provides users with appropriate and consistent LSAR data. The ISD-to-LSAR link is a powerful method of integrating LSA and ISD analysis efforts. This connection allows the ISD analyst more time to evaluate weapon system training requirements effectively by drastically reducing labor-intensive hard-copy data handling tasks. It is the data output from this software that provides the foundation for TARCS. See **Figure 1** for a graphic depiction of the F-22 ISD/LSAR data flow.

CALS

CALS is a government initiative to apply common sense to computer integration. In 1985, the DoD established the CALS program in an effort to improve efficiency, initially aiming at production of technical manuals in digital form. The CALS initiative has grown over recent years to encompass the objective of establishing a highly automated and integrated method of operation for defense systems acquisition, design, manufacture, and life-cycle support.

The CALS concept is not limited to DoD, but is a joint DoD and Industry initiative to improve weapons systems quality and reduce development time thus improving competitiveness in world markets.

Implemented CALS initiatives will capitalize on the power of the computer by consolidating the separate and redundant databases of the past into an Integrated Weapon System Data Base (IWSDB). The Integrated Systems Support (ISS) project at Lockheed seeks to accelerate the inevitable CALS-compliant automation of weapon system support.

LSA DATA INTERFACE

The LSAR incorporates logistics-oriented technical information in conjunction with data for various engineering disciplines and Integrated Logistics Support (ILS) elements, reducing redundancy and enhancing consistency

between data elements and disciplines. The LSAR is important for training because the quality and efficiency of the ISD process is enhanced when LSA data is used as a principal data source.

TARCS

TARCS is an initiative of the Lockheed Aeronautical Systems Company Integrated Support Systems (ISS) group to provide a CALS-compliant means of collecting and distributing ISD-related data electronically. The primary objective of TARCS implementation is to provide a capability for accessing ISD data, and improve the interface between all weapon system organizations involved in the training development effort, the customer in particular.

TARCS was conceived as a result of the requirement to integrate LSAR, DSS, and other F-22 Training Team data into a central training data repository for the weapon system. TARCS applications will facilitate data viewing, downloading of report files to the user's PC, and output of MIL-STD-1379D formatted data for delivery to the Air Force. Furthermore, TARCS may be used in lieu of some data deliverables, saving time and money for the SPO and the Contractor Team. The transition from paper to electronic data delivery will be evolutionary, with the first electronic deliveries selected on a

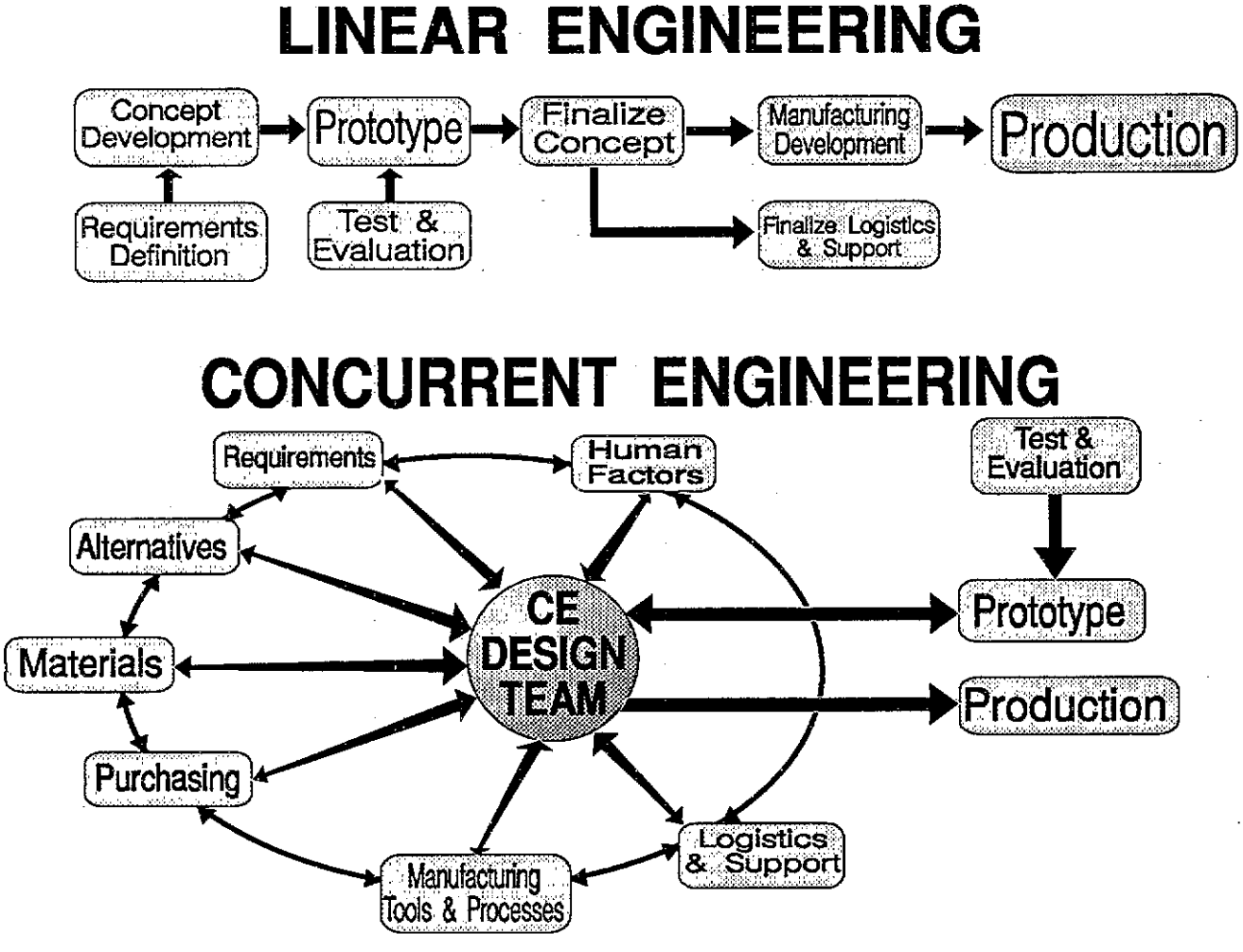


Figure 2 Linear and Concurrent Engineering Process Comparison

practical basis and coordinated with the contractor team and customer.

TARCS AS A CONCURRENT ENGINEERING METHOD

Concurrent engineering (CE) can be defined as "a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support" (Institute for Defense Analysis, Report R-338). The purpose of the approach is to ensure the participation of all relevant parties in the development and use of a product throughout the life cycle of that product. By including all developers and customers in the development process, from the planning stages through the disposal of the system, product developers help to ensure that the product is effective and is produced as efficiently as possible.

The CE process is therefore not linear, as is traditional engineering, in that the development process is not contingent on the completion of previous sequential steps. Concurrency mandates that all participants provide information to all other affected activities and parties, thus avoiding the potential problems which can occur with traditional, linear approaches to engineering and development. **Figure 2** depicts the concurrent engineering process in comparison with linear engineering.

Concurrent engineering teams or groups are often called Integrated Product Development Teams (IPDTs). Work performed by one of the F-22 team members as part of the development process must be planned and performed with and evaluated by the other team members; under the IPDT/CE approach, the customer is a very important part of the development process and becomes a member of the team.

If the customer is to be a valued participant in the CE process, the customer's staff must be kept informed of work performed to date, just as they must be consulted on the requirements to be met by the product being developed.

In the training development process, training requirements are derived through the performance of the ISD process. The results of this process are the courseware and specifications for training media to be used for pilot and maintenance training. The tool that is being used to assist training developers in the ISD process is the ISD/LSAR DSS, described above.

TARCS is the method that will be used to keep the customer informed concerning the progress made on the first stages of training development (i.e., the analysis and design stages). TARCS will allow not only the review of training data by the F-22 System Program Office (SPO), it will complete the information loop with feedback to the developers. **Figure 3** shows the inter-relationships among the databases, developers and reviewers.

JS ISD/LSAR DSS, LSAR, CALS, TARCS: HOW THESE TOOLS FIT WITHIN THE F-22 PROGRAM

The JS ISD/LSAR DSS tool meets the program requirements for an off-the-shelf software tool to aid in the decision-making process associated with ISD, while offering the capability of utilizing current LSA data to support effective ISD decision-making. TARCS satisfies the CALS-compliant requirements of the F-22 program for a central repository of all data, accessible by the customer and contractor team members. The TARCS portion of the F-22 Team training database will be populated by data exported from the DSS tool.

The design of TARCS application user-interfaces and outputs will correspond as closely as possible (and practical) to that of the DSS software. This is in accord with the original TARCS design philosophy that TARCS should be a follow-on and enhancement to the DSS software data from the user point-of-view, and should require as little training and familiarization as possible for the F-22 Training Team. For this reason, TARCS utilizes the same ISD-term nomenclature as the DSS software for menu and report selections. The actual appearance of the screens in TARCS however, will not be the same as the DSS screen displays.

One significant difference between using the

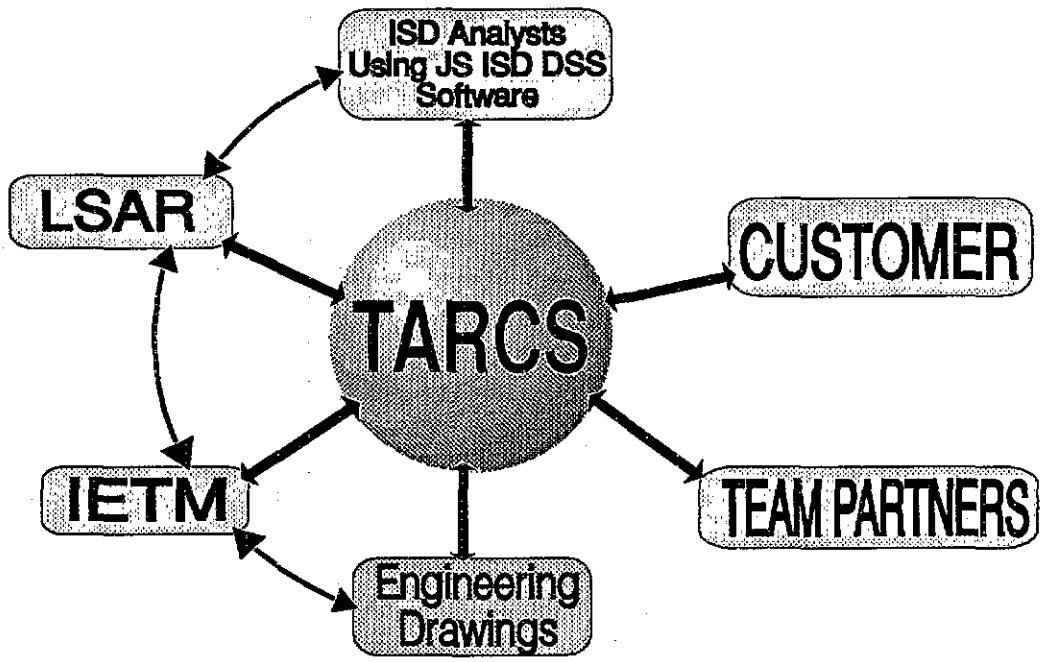


Figure 3 TARCS Components and Interrelationships

DSS to review the ISD data, and using TARCS to review data is the internal access levels incorporated in the DSS tool. Three types of personnel are permitted access to the DSS for performing training development: the Database Administrator (DBA), the Training Development Manager (TDM), and the Instructional Analyst (IA), of which there are Subsystem Leads, Task Leads, and Task Analysts. Additionally, a Quality Assurance Reviewer (QAR) is permitted to review the development data. The goal of the DSS is to provide design requirements for the training system that are direct functions of the tasks selected for training.

TARCS users, on the other hand, can access the entire Team training development database (which includes the ISD/LSAR DSS data) for review of virtually any training development data in the system. The goal of TARCS is to complete the information loop in the CE process by providing the Team and customer the ability to review training development data and provide the means to enter feedback or "comments" on the various data elements. TARCS will dispense the feedback to the F-22 Training Team management electronically for disposition.

TARCS ELEMENTS

Concepts

As a means of providing a context for this process, however, the DSS also allows users to describe and document two important aspects of the training system: the weapon system description/concept and the training concept used to train operations and maintenance of the weapon system. We will address these two portions of the DSS and TARCS separately, in turn.

The Weapon System Concept Menu - provides a means of documenting the weapon system characteristics and features, which provide a baseline for analysts. This menu also provides options for documenting the operations and maintenance concepts that define the program and drive the training requirements.

The Training Concept Menu - provides sub-menus for documenting training issues that follow from the descriptions provided in the Weapon System Menu. These include the following:

Training Support Issues - provides a forum for documenting unresolved issues and questions related to providing training, (i.e., to whom, at what levels, in which facilities, etc.)

Target Population Description - provides a description of the people to be trained in terms of skill and knowledge prerequisites, courses completed, and any constraints that may preclude individuals from training (e.g., "must have been certified in NVG usage within the six months prior to training").

Training Implementation Plan - provides documentation for the start up and continued operation of the training program, including schedules, resources, and methods for integrating the training program with existing training systems.

Scenarios and Devices - provides:

1) the types of options or possible conditions under which training may be conducted.

2) possible devices that meet those conditions.

Reference Information - provides sources of information related to the function, operation, maintenance and logistic support of the weapon system and any other pertinent training data.

Task Information

The DSS task and training information that can be accessed by the TARCS user is summarized below:

Task Report - provides a list of all tasks for the weapon system indexed on logistic control number (LCN) or alternate logistic control number (ALCN) with the task code and task identification .

Task Selection for Training - displays a list of tasks selected for training, sorted on the LCN/ ALCN and task code, and indicating the LCN/ ALCN, task code, task selection model value, and a train/no train decision.

Task Listing by Skill Specialty Code (SSC) - displays a task listing by subsystem, including the SSC and task description, sorted in that order.

Task Devices/Media - displays a listing of training devices/media, subsystem, and task description, sorted in that order.

Task Instructional Setting - displays a listing of tasks indexed on task code, including LCN/ ALCN, task code, task identification, and the instructional setting.

Task Elements - displays a listing of task elements (i.e., statements of the tasks) by subsystem, including the LCN/ALCN and reference number.

Job Performance Aid (JPA) Candidate Tasks - provides a listing of all subsystem tasks and the results of their qualification analysis (i.e., the determination of whether a JPA would be required to improve performance), including task code, task identification, and JPA qualifications. In TARCS, JPA qualifications are two letter designations of the answers to a series of questions concerning task appropriateness for a JPA answered by the analyst.

Final JPA List - displays a listing of JPA tasks by subsystem that have been approved for JPA assignment, sorted on task code, including the JPA task description, JPA requirements, and any comment/rationale made by the analyst.

Training Media - provides a list of training devices determined for use in the selected subsystem.

Skill Specialties Assigned - provides a listing of SSCs used in the selected subsystem(s), including SSC number, SSC title, subsystem number, and system name (this report is not available through the DSS).

Training Determination - provides a listing that summarizes the training that has been determined for each subsystem, including task by subsystem, LCN/ALCN, task code, task identification, training location rationale, and training recommendation.

Learning Objectives - displays a list of learning objectives by SSC, course, and lesson.

Course Control Documents - provides a listing of training tasks by course and lesson hierarchy.

TARCS DESIGN PHILOSOPHY

The software application and user-interface for TARCS will be designed for maximum ease of use, and intuitive operation by the user. The intent of the design is to make TARCS an extension of the ISD analyst's/reviewer's thought processes.

Client-server architecture will be utilized for quick response to user operations. The application will be developed for use on multiple user platforms (i.e. DOS or Macintosh).

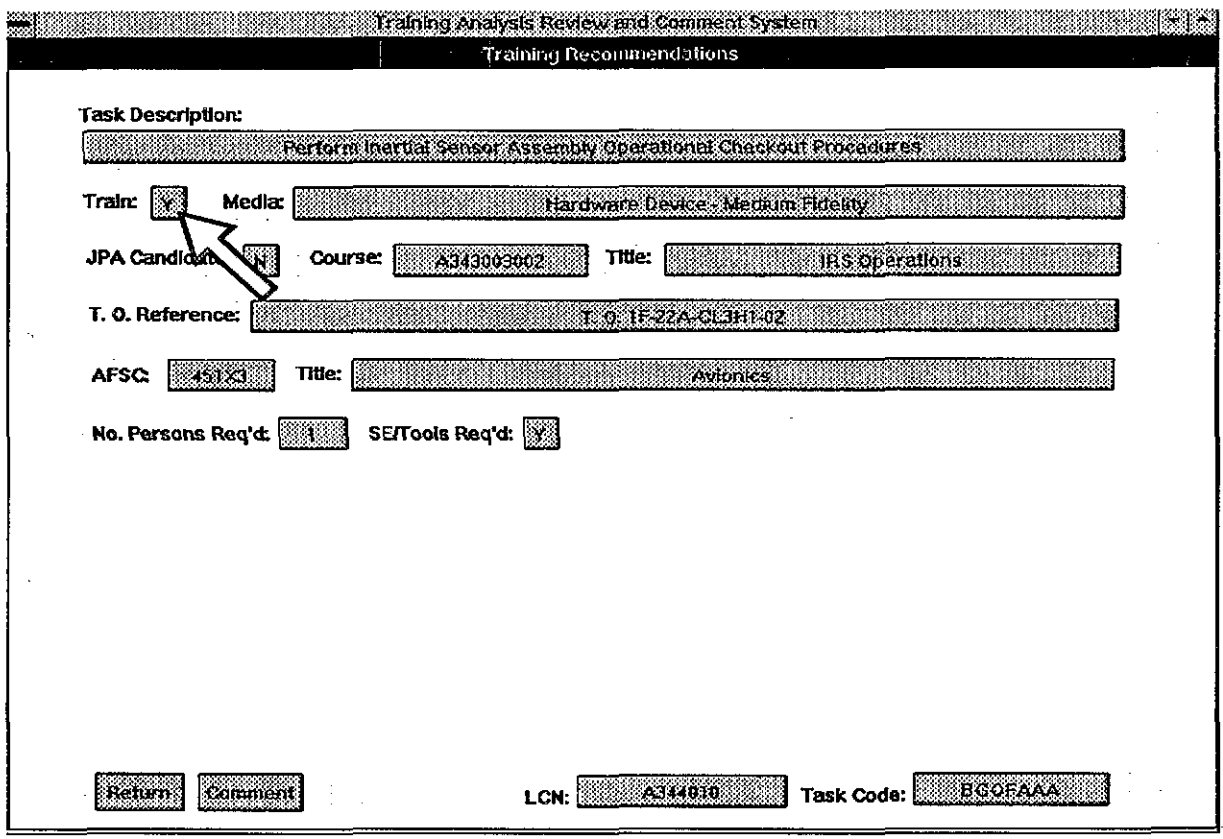
TARCS will be an extension of the DSS tool for the Training Team, and will also incorporate data links necessary to interface with computer systesms and applications to be in place later in training system development.

USING TARCS

TARCS is designed to be an intuitive tool for the ISD-familiar user. The Windows graphic user interface (GUI) accommodates users with a minimum computer usage skill level.

As an example, consider the data displayed in the TARCS screen in **Figure 4A.** In this case, the analyst has determined that the task should be trained, as indicated by the "Y" in the "Train:" field. If the reviewer would like to see how that decision was made, he or she would place the mouse cursor on the "Y" box as shown, then

Figure 4A Training Analysis Screen



click the mouse.

This action would cause the "Train/No-Train" Criteria window to be displayed as shown in **Figure 4B.** This window displays the questions asked of the analyst by the decision model (in this case, the Difficulty, Importantance, Frequency model). Furthermore, this window provides the reviewer the option of performing "what-if" scenarios with the data by entering different responses to the decision model's questions.

This is only one example from the many possible operations to be performed in TARCS, but is indicative of the nature of the program and how it works.

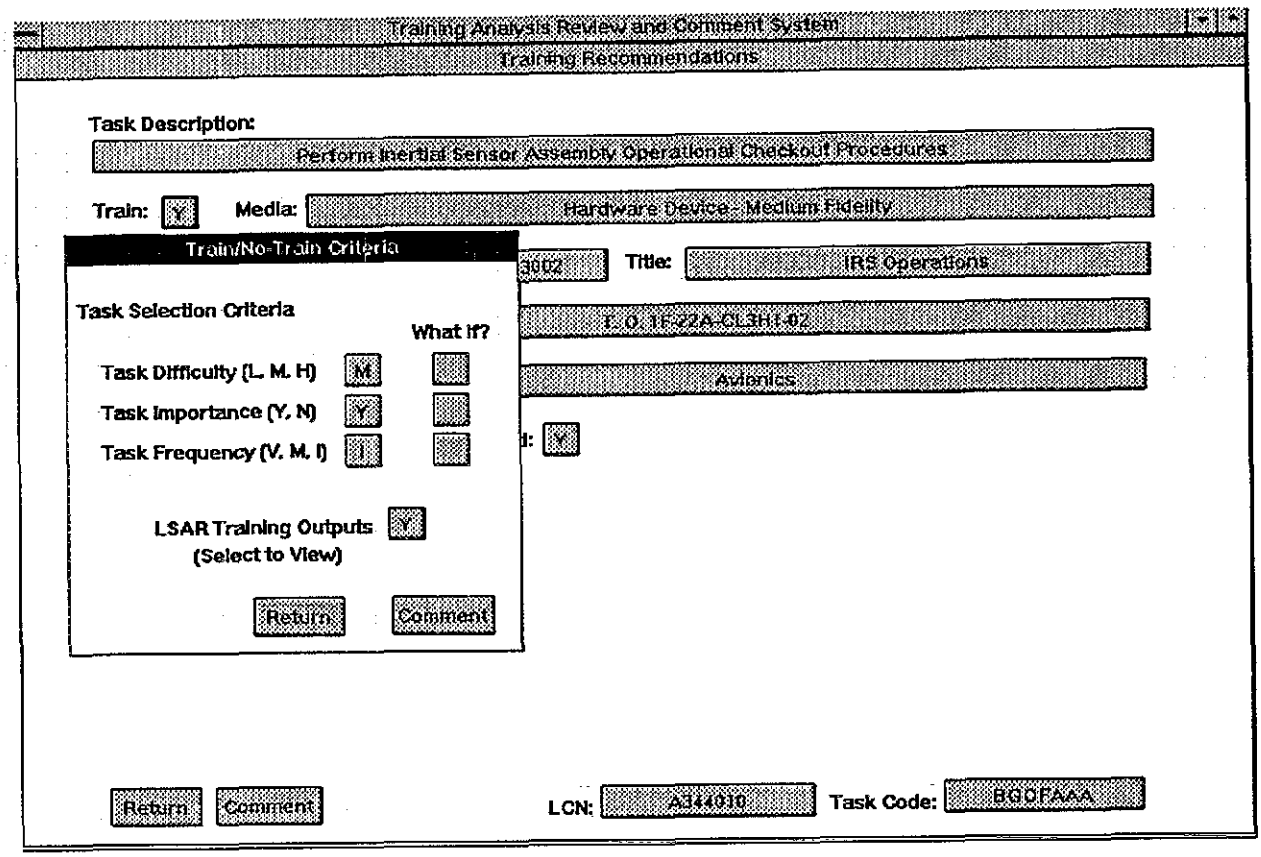
TARCS ARCHITECTURE

TARCS is being developed as a Windows application in "C" for portability across the various platforms which will be used in current and future weapon systems contracts. The design of TARCS had to incorporate the flexibility to accommodate diversified user hardware, user location, and user connectivity issues.

The ideal situation would be a distributed processing approach utilizing on-line access to the central training development database residing at LASC. However, some of the user sites on the F-22 program were unable to meet the connectivity requirements for on-line access. For this reason, a distributed database approach was taken to provide the necessary flexibility in user site selection.

Using this approach, TARCS will be a PC stand-alone, or PC network application utilizing a locally installed database which is a mirror image of the central training development database at LASC. This will allow faster access time for the user and provide the needed flexibilty in connectivity by allowing multiple data transfer methods ranging from: 1) on-line to 2) modem connection to 3) mailing of diskettes (not the preferred method.).

Figure 4B Task Selection Criteria Window



TARCS IS A SYSTEM IN DEVELOPMENT

Implementation of TARCS will continue to evolve as new technologies and software applications are developed, and as weapon system programs progress.

On the F-22 program, one of the challenges in the development of the TARCS and integration of LSAR-to-DSS data is the evolution of the LSAR from the MIL-STD-1388-2A format, to the MIL-STD-1388-***2B*** format. The current version of the JS ISD/ LSAR DSS is compatible with data element definitions and relationships in MIL-STD-1388-2A LSAR. The evolution of the F-22 program LSAR to the MIL-STD-1388-***2B*** LSAR format will require a corresponding development of a MIL-STD-1388-2B version of the DSS tool. To accommodate the F-22 Training Team requirements for an uninterrupted flow of LSA data, it was necessary to develop a program to capture MIL-STD-1388-2B LSAR data, and format it as MIL-STD-1388-2A import files to the DSS tool. This interim solution provided the LSAR data to allow ISD to continue on-schedule until release of the MIL-STD-1388-2B version of the DSS .

MIL-STD-1388-2A / MIL-STD-1388-2B: What's the Difference?

While the MIL-STD-1388-2A LSAR consists of card images, the MIL-STD-1388-2B LSAR uses a relational table structure of functional data element groupings. The importation of LSAR data into the JS ISD/LSAR DSS tool from the MIL-STD-1388-2A LSAR is accomplished by utilizing the Systems & Logistics Integration Capability (SLIC) LSA tool reports containing the LSA Control Number (LCN) Master File, and the Task Narrative Master File.

The F-22 Program MIL-STD-1388-2B LSAR data will be on an IBM DB2 platform. The import for the LSAR MIL-STD-1388-2B data will be developed at Lockheed as a custom application.

To provide a smooth uninterrupted transition from the MIL-STD-1388-2A to the MIL-STD-1388-2B version of the DSS, it was necessary to apply the CE concept to the Lockheed development of TARCS. Work on both TARCS and the DSS -2B version had to be closely coordinated with a mutual exchange of data structure-related information, since both software applications are interdependent.

WHERE WE ARE NOW

The initial implementation of TARCS will target review and comment capabilities for review and comment on development data, and contract deliverable capabilities as defined by the F-22 program. A pivotal issue awaiting resolution at the time of this writing is the extract of data from the DSS tool database. This capability will be necessary to populate the Team training development database at LASC.

Prototyping of the TARCS application and user interface are being accomplished using Computer Aided Software Engineering (CASE) tools. The results of CASE tool protyping will result in usable code for further development.

The PC-to-Mainframe gateway has been installed at LASC and will be utilized initially for the LSAR 1388-2B-to-DSS 1388-2A data input capability for the F-22 ISD effort.

WHERE WE WILL BE AT COMPLETION

After implementation of TARCS initial capabilities, users will be surveyed and proposed enhancements identified for incorporation in the second phase of TARCS development.

The other significant improvements targeted for phased implementation into TARCS are:

1) The capability to access Integrated Electronic Training Manuals (IETMs) from TARCS.

2) The capability to access LSAR data directly from TARCS.

3) The capability to display engineering drawings from TARCS.

4) The capability to access other relevent Integrated Support Systems applications or data from TARCS.

5) The capability to store large formatted

documents including graphics for viewing and downloading.

6) Refined data interfaces to improve concurrency and ease of user access.

TARCS will continue to evolve and be enhanced throughout its initial implementation on the F-22 program, and will benefit from lessons-learned on the next weapon system program requiring TARCS capabilities.

SUMMARY

TARCS is a CALS-compliant system for accessing training system development data. The data is created by training developers using the JS ISD/LSAR Decision Support System, which provides not only the training database but also an audit trail of decisions made in the analysis and design process. TARCS development has been driven not only by weapon system program requirements for a centralized data repository, but also by the need to involve the customer in the development process in accordance with the practice of concurrent engineering.

Using TARCS, the customer will be able to review any product that resides in the ISD database or any process (e.g., decision criteria, task selection model, media selection model) created by the weapon system Training Team. TARCS also provides the capability for generating "what-if" scenarios related to specific training task or media selection decisions.

Customer review inherently results in more efficient and effective training, by increasing customer participation. TARCS can therefore increase customer ownership of the products developed to support the weapon system.

TARCS is but one tool in the growing collection of systems, devices and programs that are being applied to the weapon system development process. As system, subsystems and organizations become more electronically and functionally integrated, there will be more systems like TARCS developed and used. **Figure 5** shows how integrated systems, inspired by concurrent engineering or Integrated Product Development Teams, will be linked to bring all elements and phases of the system development process together in an efficient, quality-driven relationship.

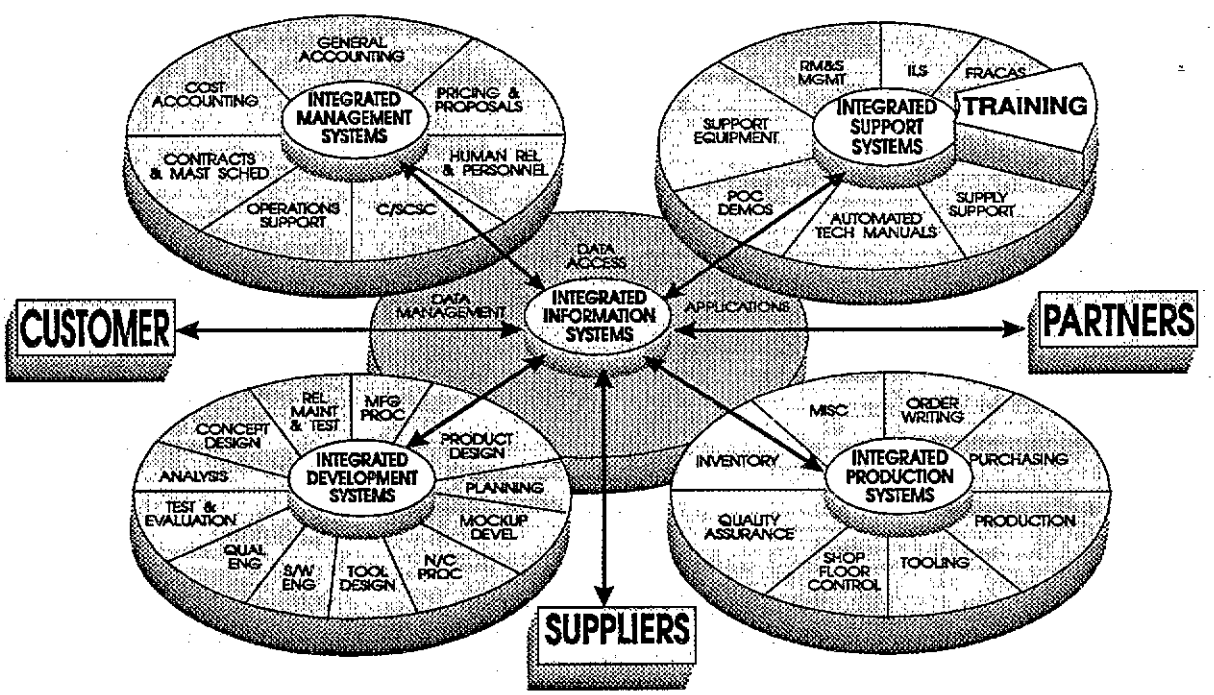


Figure 5 Integrated Systems and Organizations

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