The Interactive Electronic Technical Manual

by

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The Existing Technical Manual Problem

The Goal of true integration of DOD weapon-system logistic-support Technical Information (TI) systems, as required by the Computer-assisted Acquisition and Logistics Support (CALS) and Corporate Information Management (CIM) initiatives, is rendered impossible to obtain by the continued reliance of the Services on paper-based Technical Manuals (TMs) for the great bulk of this information.

In addition to contributing to the serious long-term logistics problems involved in producing, stocking, controlling, modifying, and using large quantities of paper, TMs as currently constructed are inherently incapable of incorporation into an automated, standardized, interactive, real-time system for the transfer and sharing of logistic-support information in a highly comprehensible form.

Specifically, paper Technical Manuals:

a. Are unnecessarily costly to produce and manage. Even though Industry is widely adopting the use of automated authoring systems, exploitation of many recent technological advances (involving data base management, information storage, and information display) is impossible with paper TMs. Thus, additional personnel and facilities are required for physical control of information which could be more efficiently handled.

b. Hinder full integration among many activities of required Technical Information during a given logistics process (ranging from a single maintenance action to a full-scale ship or aircraft overhaul) so seriously that paper-based Technical Information methods often badly degrade the effectiveness of the logistics-support action.

c. Are of such poor usability (e.g., in finding the required specific information needed) and comprehensibility (e.g., in complex fault-isolation processes), as to seriously slow up the maintenance process, increase false part-removal rates, and significantly increase training time.

Emerging Solutions

To reduce the magnitude of these problems, major efforts are underway within the DOD to automate the TM production and management processes. For example, once produced, TI can be raster-scanned, stored and transported in digital form, and printed out on paper at the using activity ("print-on-demand"). Usability can be increased to some extent by overlaying such page-oriented material with computer-readable "navigation" instructions to render location of desired specific information easier with luminous-screen display.

However, existing TM automation attempts of the above types, although they may provide limited improvements at specific points in the logistics-

support chain, cannot provide a full solution; in particular, they cannot satisfy the requirement for real-time integration of TI in standardized form among many participating activities. To achieve this capability, as well as eliminate the logistics bottlenecks represented by TMs in current form, adoption throughout the Department of Defense of the Integrated Electronic Technical Manual (IETM) is required.

The IETM Concept

An IETM is a Technical Manual composed from the start by an author using an automated (computer-controlled) authoring system designed and formatted for luminous-screen display, and which is made interactive so that the user can take full advantage of the capability of a computer-controlled display system for guidance in the performance of his tasks. Such display systems can also serve as communications nodes on Local Area Networks, so that all participating activities can contribute required process information (e.g., work status) in standard form, for immediate availability to other participating activities.

Relevant logistic-support Technical Information for a given weapon or hardware system can be constructed and displayed in such a way as to enable its full integration. To accomplish this objective, the information must be digitized, arranged, and transcribed in a standard form, and made available in real time to a number of users working simultaneously at different locations, some of whom have the capability (and authorization) to modify the information stream.

Technical Information can be packaged in a form known as the Interactive Electronic Technical Manual, which is defined in the newly released series of DoD IETM Specifications as follows:

> ***A Technical Manual, prepared (authored) by a Contractor and delivered to the Government, or prepared by a Government activity, in digital form on a suitable medium, by means of an automated Authoring System; designed for electronic-screen display to an end user, and possessing the following three characteristics:***
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> ***a. The format and style of the presented information are optimized for screen presentation to assure maximum comprehension; that is, the presentation format is "frame-oriented", not "page-oriented".***
>
> ***b. The elements of Technical Information constituting the TM are so interrelated that a user's access to the information he requires is facilitated to the greatest extent possible, and is achievable by a variety of paths.***
>
> ***c. The computer-controlled TM-Display device can function interactively (as a result of user requests and information input) in providing procedural guidance, navigational directions, and supplemental information; and also in providing assistance in carrying out logistic-support functions supplemental to maintenance.***

RDT&E Leading up to the IETM Concept

The recommended requirement that IETMs be adopted throughout the DOD is based securely on RDT&E carried out by all three Services during the 1970s and 1980s. User surveys within the DOD, technological analyses, design studies, laboratory experimentation, and, particularly, operationally realistic tests of IETM principles have been carefully performed. Measurable field results show not only that the great majority of Service technicians find the IETM approaches desirable, but that maintenance performance is significantly improved, particularly in complex areas such as troubleshooting. Of

particular interest is that with IETMs, the performance of inexperienced technicians shows significant improvement over performance with paper TMs. This has a substantial impact on training requirements.

All of the Services have conducted extensive surveys which assessed the needs for logistic-support Technical Information among operational personnel. For example, in 1978, the Navy conducted[1] a survey involving 22 Activities and more than 400 technicians, which defined existing TM defects and pointed to the need for an IETM type of Technical Information System. Results of this survey were widely circulated throughout the Services.

Results of this survey (and other surveys performed subsequently) were confirmed more than 12 years later by a survey[2] carried out for the Navy under the A-12 program. During the latter survey, some 900 technicians in 20 Activities were interviewed.

As a result of such user surveys and recognizing the potential of IETMs, all three Services established in the 1980s RDT&E programs which have assessed the applicability, technological availability, and cost effectiveness of the IETM concept in satisfying the logistic-support needs of the Services; for example:

a. The comprehensive Navy Technical Information Presentation System (NTIPS) Program, an effort carried out under the direction of DTRC, which formulated, designed, and tested the procedures and technology required to acquire, use, and support IETMs in the Navy[3].

b. The Air Force Computer-based Maintenance Aid System (CMAS)[4] and the Integrated Maintenance Information System (IMIS)[5] program, both under the direction of the Armstrong Laboratory, Human Resources Directorate (AL/HRG), formerly named the Air Force Human Resources Laboratory (AFHRL).

c. The Army Miniaturized Electronic Information Delivery System (MEIDS)[6] - an early effort by the Army carried out under the direction of PM-TRADE, Fort Eustis, Virginia.

Measurable Benefits Resulting from Use of IETMsMeasurable Benefits Resulting from Use of IETMs.

Studies and tests performed both by the DOD and by Industry have conclusively and frequently demonstrated the existence of technology which can solve any one of the Technical Information flow problems at any point in the logistics chain, and which can provide the overall integration needed for a standard interactive ILS system. Repeated field tests by the Navy, Army, and Air Force have documented, under operational conditions:

a. increases in user performance resulting from electronic presentation of Technical Information, particularly in areas where it is most needed, such as the troubleshooting of complex systems.

b. reduced need for training. (Performance by inexperienced technicians approaches that of experienced technicians after brief introductions to the new interactive forms of TI.)

c. the enthusiasm of maintenance technicians for this mode of information presentation and their impatience for its introduction into the organizational maintenance community.

DTRC, the Navy's Lead Lab for TM automation, conducted an operational test[7] to evaluate the effectiveness of IETMs in supporting maintenance of the flight-control system of the F-14A aircraft. Carried out at Miramar Naval Air Station, the test involved active-duty enlisted technicians (AEs) from 10 Squadrons and other activities. In this test:

a. All test subjects located an inserted fault using electronically

delivered TI. (Only 5 out of 12 were successful with paper TI.)

b. In Remove/Replace/Checkout procedures, there were 35% fewer errors by inexperienced technicians who used electronically delivered TI than those who used paper TI.

c. 90% (18 out of 20) of the technicians preferred electronically presented TI.

DTRC also performed similar tests[8], using automated Technical Information for the AN/SPA-25D shipboard radar repeater, in a maintenance shop at the Naval Sea Combat Systems Engineering Station in Norfolk, Virginia. Test subjects consisted of 24 active-duty Fleet technicians (ETs) from the US Atlantic Fleet, both experienced and inexperienced. The results were consistent with the F-14A test results.

As usual, the most significant improvement was shown in the more complex tests. Specifically[10]:

a. With electronically delivered TI, all technicians (11 experienced and 13 inexperienced) correctly isolated the fault. (With paper TI, only 58% of the technicians, 7 inexperienced and 7 experienced, were able to isolate the fault without help from test monitors.)

b. Troubleshooting time with electronic delivery was 24% faster than with conventional paper TM.

c. 92% of the technicians preferred electronically presented TI.

Operational tests on US Air Force systems using IETMs displayed by several versions of their Computer-based Maintenance Aid System (CMAS) have also produced similar results (see Ref 6). In particular, an Air Force test carried out at Offutt Air Force Base in 1984, and supplemented in 1985 at Grissom AFB, using a joint-Service radar system, produced the following results:

a. 100% success in fault isolation (including inexperienced technicians) using IETM technology. With a paper Technical Order (TO), 25% could not fault-isolate.

b. 77% preferred IETMs; 20% preferred IETMs supplemented by paper-based schematics; 3% preferred paper TI.

c. Average fault-isolation time, to locate faulty card, halved by IETMs.

d. There were no false removals with IETMs.

More recently (May 1989), as part of the IMIS program, the Air Force conducted field tests on IETM approaches at Homestead AFB, Florida, using the fire control radar of the F-16 aircraft as test bed. Results[9] showed:

a. Small portable computers can interface directly with the MIL-STD-1553 Multiplex control bus of the F-16, and can act as bus controllers, initiate built-in tests, read and analyze resulting fault data, provide diagnostic advice to maintenance technicians, and present automated technical procedures in performing tests and corrective maintenance.

b. Technicians using the IMIS Diagnostic Module (DM) were successful in solving all troubleshooting tasks used in the test. The test report concluded that the IMIS IETM-Diagnostic Model "will provide the basis for significant improvements in the ability of Air Force personnel to perform diagnostic tests".

In summary, operational tests performed by the three Services comparing

interactive electronic delivery of Technical Information to paper TMs have shown potential for the following improvements in hardware-system support:

a. Increased overall comprehensibility and ability to locate required information, leading to greater effectiveness in maintenance performance.

b. Decrease in false removal rates of good components.

c. Increased effectiveness in successful fault isolation.

d. Reduced time in integrating maintenance actions with collateral functions (e.g., with maintenance reporting).

e. Improvement in maintenance management procedures.

f. Increased enthusiasm shown by technicians for IETM use vs paper-TM use in performing logistic-support functions.

g. Potential for significant decreases in technician ("schoolhouse") training time for individual systems, prior to assignment to O-level work centers.

h. The availability of EDS equipment in work centers suggests a potential for significant improvement in automated on-the-job-training (both system-related and other types). (Courseware for this type of interactive, electronically displayed training material is currently being developed extensively by all three Services for schoolhouse training.)

All three Services considered that the programs cited above, supplemented by the operational tests, have proven the feasibility and the desirability of using IETM systems to support military technicians in the operation, maintenance, and logistic support of weapon systems. As such many efforts are now underway in the DoD to develop some type of IETM or IETM-like capability. A serious problem now arising is the non-standard nature of these, largely, spontaneous, activities. The need now is to develop a meaningful strategy to manage the evolution to IETMs[10]. A key factor necessary to manage this evolution is the establishment of common IETM DoD standards and the accompanying Military Specifications. This is the subject of the remaining portion of this paper.

The Development of IETM Specifications for DoD.

In 1989, the three Services started an ad-hoc working group to determine the best way to develop standard specifications for the acquisition of IETMs. The particular driving force for this working group was the anticipated procurements of IETMs by the Air Force ATF (F-22) and the Navy ATA (A-12) and the desire that these two trend-setting efforts would develop commonality in their IETM specifications. Shortly after the group was established and meeting, the OSD (P&L) learned of the activity and officially charted the group as the Tri-Service Working Group for IETMs with the specific task to develop the specifications for IETMs. The chartering OSD organization has changed name several times since the charter, but was eventually merged into the OSD CALS office and now the working group reports to the Defense CALS Executive.

The IETM Working Group took the output of several Government and Industry activities as the primary starting point for the IETM specifications. The principal input came from the Navy's Navy Technical Information Presentation System (NTIPS) Program, The Air Force Integrated Maintenance Information System(IMIS) Program, the CALS Industry Steering Group (ISG) Paperless Technical Manual Committee, the Navy A-12 Program, The Air Force ATF Program, and the Army PMDE Program's IETM Style Guide. This working Group took three years to prepare and formally issue the first set of three IETM

specifications, but there were two intermediate versions distributed for comment and initial planning and use by acquisition programs considering IETMs. The first unrestricted distribution was in July 1990, the second in April of 1991, and the final official Military Specifications were issued in November of 1992. The official members of the IETM working group at the time the Specifications were actually issued were the Army's Material Readiness Activity in Lexington KY, The Air Force Material Command (ENC) at Wright Patterson Air Force Base OH, and the Navy's Carderock Division (DTMB), Naval Surface Warfare Center in Bethesda MD.

The IETM Specifications are designed to set standards in three areas. The first is the overall general specification for the IETM itself, effectively an electronic replacement for MIL-M-38784 (the paper TM Specification). The general IETM specification has requirements for several areas. The first includes requirements for the administrative information and certain generic content required for any IETM, no matter what the subject matter. Then it includes the style requirements for the information elements (e.g., text blocks, graphics, warnings, audio displays, etc.) in a form that applies when the element is added into the unformatted source data base but also holds when the elements are displayed on a computer screen. A third area of requirements is for the format of the IETM displayable information when it is displayed on an electronic display screen, and a forth requirement area sets the standards for user interaction to the displayed information. These later two areas of requirement are often referred to as the "look and feel" of the IETM. This specification actually applies to least two critical aspects of the IETM procurement process: it sets the standards for authoring the IETM data base, and it also sets the standards for the development of (or the selection of) the IETM presentation system software.

The second area in which the IETM specifications were developed to set standards is that of the Quality Assurance (QA) process for the creation of the IETM itself. This area reflects a basic perspective that it is more important to have accurate and correctly presented information, even if sub-optimally presented, than it is to have the ultimate presentation system for the IETM information. While the Quality Assurance Specification does outline requirements for a QA Program, it does so indirectly. The specific requirement is for the providing contractor to develop a Quality Assurance Program Plan (QAPP) and present it to the Government for approval. The specification outlines areas which are to be detailed by the QAPP, but the responsibility to develop the detailed procedures for the Program is placed on the contractor. A particular thrust of the QA Specification is to provide more controls on the IETM creation process itself as the actual deliverable is in electronic form and not easy to subject to a one time acceptance test. It also stresses the need for a final validation on the actual display device to be used by the eventual end user maintenance technician.

The third area for IETM specification is the Data Base that is used to develop the IETM and reflects an emphasis area substantially different from that specified with conventional paper-based TMs. As the IETM Data Base is a new and emerging concept, the Data Base Specification has been constructed to apply to many different situations. The underlying nature of some IETM implementations is that the IETM is a mechanism for viewing information from an integrated data base which contains more information than actually needed for a particular application. The IETM viewer presents only the data actually required for a particular application and only that data needed at a particular point in time. In other applications the Source Data Base is critical because IETM information is being authored once but may be displayed out in several different applications, using different presentation systems, and in certain cased for differing customers. The Data Base must therefor be developed in a form which contains all the logical content but without tying it to a particular presentation format.

For all applications, there is the apparent reality that information will be developed with a life span of several decades, where as, the time between one generation of presentation system and the follow-on which renders the previous generation obsolete is on the order of two years. To avoid

reauthoring the information for the new generation, it is desirable to use a data base format which is neutral of the actual presentation system employed.

The Data Base Specification defines a base set of Elements and Attributes which can define IETM content and provide the attributes necessary to allow the interactive processing of the IETM information by a computer controlled presentation system.

Status of the DoD IETM Specifications

The three IETM Specifications were prepared by the DoD Tri-Service Working Group for IETMs, approved by all three Services, and issued on the 20th of November 1992. The official titles and specification numbers are as follows.

MIL-M-87268 Manuals, Interactive Electronic Technical: General Content, Style, Format, and User-Interaction Requirements

MIL-D-87269 Data Base Revisable: Interactive Electronic Technical Manuals, for the support of

MIL-Q-87270 Quality Assurance Program: Interactive Electronic Technical Manuals and Associated Technical Information; requirements for

The Future for IETMs

At this point in time, the potential benefits of IETMs are widely recognized and major acquisition programs are moving to procure them in place of conventional paper Technical Manuals. The question now is how standard these IETMs and IETM-like products will be. The DoD Specifications will definitely provide a basis for standardization, however, they are, by design, general specifications intended to include a variety of implementations. Detailed guides or additional specification is needed to assure either an identical "look and feel" for multiple presented IETMs or for any real degree of interoperability, that is for an IETM for one system to be displayable on another Program's display system.

The IETM technology is new and relatively immature. Vendors are just now beginning to bring useful product to the market place and much of that is untried and often incomplete. The next few years will be a time of testing and much trial and error. The IETM concept works, there is little dispute on that issue. However, how to use available technology and even more difficult how to achieve a meaningful level of commonality and interoperability among differing IETMs are issues still needing resolution.

The authors of this paper are from an RDT&E organization and are actively advising several major Navy programs in their development of IETMs. However, the cultural change and the required infrastructure modernization must be managed by others who in most cases are not familiar with the details of IETM technology or the implications it will have on the mainstream Navy operations. In spite of the problems, the opportunities with IETMs are immense and with patience and perseverance, the DoD will move into this new era with the paperless maintenance in its operational entities.

1. ***Navy Technical Information Presentation Program. NTIPP Fleet Survey of Technical Manual Users***, prepared by Hughes-Fullerton under Navy Contract N000600-76-C-1352. 16 Jan 1978.

2. A-12 CALS Technical Manual Program. ***TM Utilization Analysis Report***. 86PR0610A, 1 Mar 1990, prepared under Navy Contract N00019-88-C-0050 by General Dynamics/Fort Worth Division and McDonnell Aircraft Co., St. Louis.

3. Rainey, Samuel C,; Joseph J. Fuller; and Eric L. Jorgensen. ***The Electronic Delivery of Automated Technical Information for Logistics Support of Navy Weapons Systems: Potential, System Description, and Status***. DTRC-89/007. February 1989.

4. Thomas, D.L.; and J.D. Clay. ***Computer-Based Maintenance Aids for Technicians, Project Final Report***. AFHRL-TR-44, Wright Patterson AFB, OH; Air Force Human Resources Laboratory, Logistics and Human Factors Division. August 1988.

5. Link, William R., 2LT, USAF; Joseph C. Von Holle, CAPT, USAF; and Dwayne Mason, 2LT, USAF. ***Integrated Maintenance Information System (IMIS): A Maintenance Information Delivery Concept***, AFHRL-TR-87-27, November 1987.

6. ***Technical Information Utilization by the Army and Its Implications for MEIDS***, Computer Sciences Corp., 30 Sept 1987.

7. Fuller, Joseph J.; Theodore J. Post; and Anne S. Mavor. ***Test and Evaluation of the Navy Technical Information Presentation System (NTIPS), F-14A Field Test Results***. DTRC-88-036, September 1988.

8. Fuller, Joseph J.; Raymond L. LeBeau; Anne S. Mavor; Theodore J. Post; and Charles S. Sawyer. ***Test and Evaluation of The Navy Technical Information Presentation System (NTIPS), AN/SPA-25D Test Results***. DTRC-88-035, September 1988.

9. Link, William R., CAPT, USAF; Janet E. Murphy, 2LT, USAF; Eric N. Carlson, 2LT, USAF; Donald L. Thomas; James Brown; and Reid Joyce. ***Integrated Maintenance Information System, Diagnostic Demonstration***. AFHRL-TR-90-41, AFHRL Logistics and Human Factors Division, WPAFB. Aug 1990.

10. Rainey, Samuel C. and Joseph J. Fuller. **The Interactive Electronic Technical Manual: Requirements, Current Status, and Implementation - Strategy Considerations.** DTRC-91/016 July 1991.