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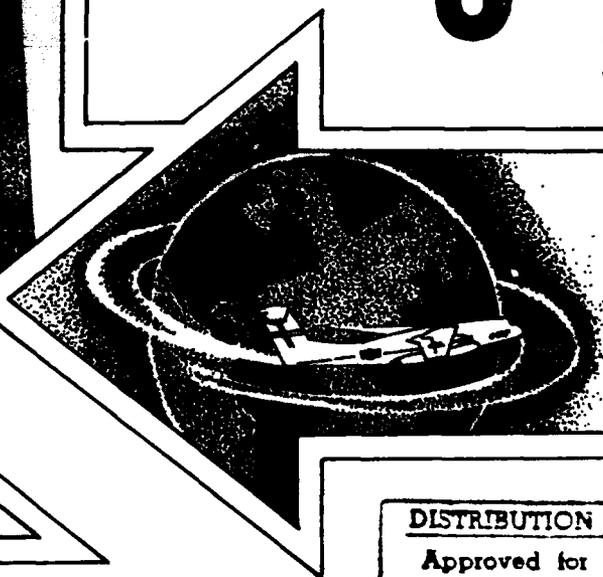
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# DEPLOYMENT AND AUTOMATED TECHNICAL ORDER SUPPORT

Lt Col Edward J. Higbee

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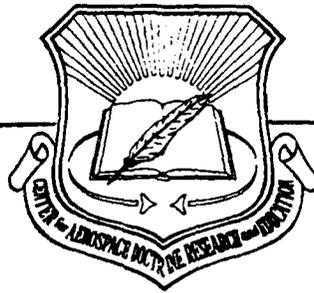
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DEPLOYMENT AND AUTOMATED TECHNICAL ORDER SUPPORT

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Research Report No. AU-ARI-88-7

DEPLOYMENT AND AUTOMATED TECHNICAL ORDER SUPPORT

by

EDWARD J. HIGBEE, Lt Col, USAF  
Research Fellow  
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Air University Press  
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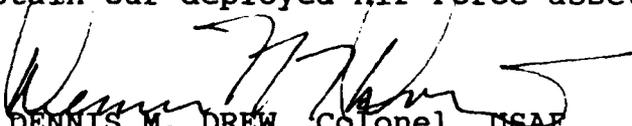
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FOREWORD

The future capability of the United States Air Force to deploy and sustain its forces successfully will depend as much on modern logistical support processes as it will on advanced weapon systems. Outmoded logistics support systems are a threat within, and they require balanced consideration with that given to improving our weapon systems. Far more important than initial force projection is our ability to sustain and even multiply those forces logistically until our national interest is served.

This study provides a rare glimpse of one such logistical support process--the Air Force technical order (AFTO) system. The AFTO system, a "paper-based system" with limited automation based on decades-old technology, is failing in its mission today. The sheer volume, complexity, and variety of technical orders and the massive bureaucracy required to support their accuracy and distribution, make dismal the prospects that the AFTO system will meet tomorrow's Air Force mission. Yet, as this study details, improvements through automation are being made to improve our outlook for the future.

To be sure, the progress that has been made by the initiatives summarized is enhanced by better understanding the environment under which a modern, automated technical order system must operate. And this study purposefully serves to improve this understanding by defining some very necessary considerations for determining the crisis management and wartime conditions which must be faced by such a system to sustain our deployed Air Force assets. (KP) ←

  
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and Education

## ABOUT THE AUTHOR

Lt Col Edward J. "Edd" Higbee completed this study while assigned as the Air Force Logistics Command-sponsored research fellow at the Air University Center for Aerospace Doctrine, Research, and Education (AUCADRE) at Maxwell AFB, Alabama, during academic year 1987-88. Colonel Higbee enlisted in the Air Force in 1960. In 1967 he was commissioned as a distinguished graduate of Officer Training School after completing a bachelor's degree in mathematics at Florida State University under the Airman Education and Commissioning Program. Following his commissioning, he attended Texas A&M University in a master of computer science program before entering service as an information systems professional. He completed two joint assignments with Department of Defense agencies, a tour of duty in Vietnam and Thailand, and an extended tour with the Standard Systems Center (SSC)--as currently designated--at Gunter AFB, Alabama. In 1981, while chief of Data Systems Support Division (SSC), he completed an MBA at Auburn University. Transferring to Headquarters Air Force Logistics Command (AFLC) in 1982, he was selected as program director of two major acquisition and development programs: the program management support system (PMSS), operating commandwide since early 1987; and the secretary of the Air Force-directed automated technical order system (ATOS), the initial phase of which was implemented operationally in 1985. Colonel Higbee is a graduate of Squadron Officer School, Air Command and Staff College, Military Officer Advance Cryptologic Course, Computer System Staff Officer Course, Professional Military Comptroller School, the Defense Systems Management College's Program Management Course, and the Air War College. He is married to the former Sharon Diane Smith of Birmingham, Alabama. They have two children: Dana Shanel, age 16, and Heather Diane, age 7.

## ACKNOWLEDGMENTS

The faults that may be found with this work are my own. The merits to be accorded must be shared with others who provided the essential patience, encouragement, and assistance required. First and foremost among these contributors is my adored wife, Sharon, for her friendly reminders of the need for progress. Also due great credit is the chairman of my reading group, Dr Lewis Ware. Credit must also be given to my editor, Preston Bryant.

Finally, special thanks are due two very important contributors: Lori Wofford, a dear friend and an extraordinary research assistant from the automated technical order system (ATOS), Program Management Office at Wright-Patterson AFB, Ohio; and Lt Col Phillip L. Harris, Air Force Logistics Management Center (AFLMC/LGM), for his thoughts and analytical approach to the "marriage" of computers and the deployment environment. Both were vital in a substantive way to the completion of this work.

## CHAPTER 1

### INTRODUCTION

"One thing common to every command is logistics. Air Force Logistics Command (AFLC) is a multifaceted command whose mission is essential . . . in the accomplishment of the combat mission, for without effective logistics support, the war-fighting capability of the Air Force is nil."<sup>1</sup> One facet of AFLC that is critical to the combat mission is the logistics support provided in the form of technical information, including technical orders (TOs).

Traditionally, weapon systems maintenance has been supported during both fully provisioned base deployments and bare base deployments with printed technical order information acquired from industry by AFLC as a part of the weapon system acquisition process.<sup>2</sup> Deficiencies in technical data have been met by changes in TO type, size, style, and content. This profusion of documents has added to the already unmanageable problems presented by the growing number and complexity of Air Force TOs.

Chapter 2 provides an overview of the management system devised by AFLC to deal with the problems inherent in providing worldwide TO support. This support is threatened by the large variety and number of TOs as well as the detail and complexity added by new weapon systems, new technology, and frequent modifications to the existing fleet. The current management system--the Air Force technical order (AFTO) system--is outmoded in terms of both its use of computer technology and its growing bureaucracy, which is needed to meet user requirements for TO accuracy and timely distribution.

Chapter 3 presents three major Air Force programs aimed at breaking the traditional "paper habit" for TO acquisition and use.<sup>3</sup> These programs--the automated technical order system (ATOS), an AFLC initiative; the improved technical data system (ITDS), under development by the Aeronautical Systems Division of Air Force Systems Command (AFSC); and the integrated maintenance information system (IMIS), a research and development effort being pursued by the Air Force Human Resources Laboratory (AFHRL)--promise improved availability and use of technical information. But they are designed primarily for use under circumstances found at stateside bases; the shallow understanding of requirements for use in Air Force deployments may jeopardize their acceptance by the ultimate user, the maintenance technician.

Chapter 4 details a framework for understanding the many considerations attendant to integrating an automated technical order system into Air Force deployments. Essential to the analysis is a definition of deployment that considers many factors directly related to warfighting capabilities as part of the larger situational environment. The physical environment must be realistically accounted for, as must cost, scheduling, technical performance, and--paramount to success--the users' needs.

Funding, scheduling, and technical performance are not addressed here, as they are rightfully details to be managed by individual program managers. What is addressed here are users' needs. In important ways, they are quite different under deployment conditions; therefore, an effective approach to defining "crisis management/wartime conditions," or as more generally stated, "deployment conditions," is necessary.<sup>4</sup>

At times, clarification benefits from reference to a specific weapon system platform; the F-15 Eagle is used here. Several factors make the F-15 a logical choice. First, it is the current air superiority fighter--the predecessor of the advanced tactical fighter (ATF); and like the ATF, it is a candidate for "near paperless" technical support. Second, the F-15 has a very significant and highly representative deployment mission. Third, the logistics challenge inherent in the F-15, described as "75,000 component parts flying in close formation," makes it exemplary.<sup>5</sup>

The major research assumptions are that the nondevelopmental items (NDI) approach currently used for the ATOS, ITDS, and IMIS programs will continue to be the most feasible in the fiscally constrained period of the late 1980s and that the goals of the NDI approach to systems acquisition--more rapid and cost-effective systems using off-the-shelf solutions--make it particularly suited to replacing the AFTO system.<sup>6</sup> These are important assumptions for two reasons: a proper approach to the definition of deployment, particularly "under crisis management/wartime conditions," is essential to the success of ATOS, ITDS, and IMIS; and the acquisition process determines to a great extent the success of fielded systems.<sup>7</sup>

The number one inhibitor to achieving NDI goals is overspecification of environmental conditions. To be successful, therefore, requirements for the ATOS, ITDS, and IMIS programs must be specified accurately. Harsh environmental conditions (temperature extremes, power variants, electromagnetic interference, etc.) and other challenges (e.g., chemical and nuclear warfare) do exist and

must be considered; but overspecified requirements such as too-wide operating temperature ranges and too-great shock tolerance levels can preclude the use of an NDI approach.<sup>8</sup>

This research leads to the conclusion that not only is an automated technical order system needed, but an NDI approach to the acquisition would be most effective. An NDI acquisition is therefore recommended as offering the opportunity to bring both the needed system into the Air Force inventory in the most timely manner and reasonably specify environmental conditions that meet user needs.

This research also leads to the conclusion that "retail"-level logisticians have a valid concern for loss of benefits derived from the current system and that these benefits must be factored into the overall understanding of the requirements for a replacement system. To accomplish this, a formal study of the evolutionary linkage between Air Force resource management systems and the AFTO system is recommended.

A further conclusion is that technician training across weapon systems is being jeopardized by "leakage" of technical data from the AFTO system. The recommendation in this instance also is to formally study the development of automated test equipment and other sources of weaknesses in the system.

In general, therefore, the conclusions and recommendations of this study support development and introduction of an automated technical order system for weapon system deployments. So this may be done successfully, encouragement is offered for both establishing a support bureaucracy more in concert with today's manpower realities and retaining the traditional linkages and strengths of the AFTO system.

#### Notes

1. Introduction to the Air Force Logistics Command (AFLC): AFLC Action Officers Guidebook, 2d ed. (Washington, D.C.: Government Printing Office, 1984), i.

2. Technical Order Acquisition and Management: Sys 230, Syllabus of Instruction (Washington, D.C.: Government Printing Office, 1985), 1-14; 1 for the date reference.

3. Automated Technical Order System (ATOS) Mission Element Need Statement (MENS) (Washington, D.C.: Government Printing Office, 1987), 3. The parenthetically added identifier (G022) is a data systems designator of little

meaning except for cataloging and reference purposes. AFR 8-2, Air Force Technical Order System, para. 1-3a, indicates that the office of primary responsibility is Headquarters AFLC/MMERD; however, I cite a supraorganization exercising significant authority: the Directorate of Reliability, Maintainability, and Technology Policy (HQ AFLC/MMT).

4. Program Management Directive for the Automated Technical Order System (ATOS) (Washington, D.C.: Government Printing Office, 29 April 1987), 2. Notably, the ATOS program begun by my predecessor that was continued by me in my two years as ATOS program director (June 1985 to July 1987) did not address itself to the harsh conditions inherent in weapon system deployments.

5. Lt Col William T. McDaniel, Jr., "Combat Support Doctrine: Coming Down to Earth," Air Force Journal of Logistics 11, no. 2 (Spring 1987): 14; and Franklin D. Margiotta and Ralph Sanders, eds., Technology, Strategy and National Security (Washington, D.C.: National Defense University Press, September 1985), 62.

6. Maj Gen Alan B. Salisbury, USA, as reported in the September 1987 issue of Signal magazine and excerpted from "Off-the-Shelf," Command Environment Course, Evaluation Exercise, Research Library, AY 1988 (Maxwell AFB, Ala.: Air War College, Department of Command and Leadership, Academic Year 1987-88), pt. 1, sec. G, 22-23.

7. Under secretary of the Army James Ambrose, as reported in the September 1987 issue of Signal magazine and excerpted from "Streamlining," Command Environment Course, Evaluation Exercise, Research Library, AY 1988 (Maxwell AFB, Ala.: Air War College, Department of Command and Leadership, Academic Year 1987-88), pt. 1, sec. H, 27.

8. Salisbury, 22-23.

## CHAPTER 2

### THE AIR FORCE TECHNICAL ORDER MANAGEMENT SYSTEM

This chapter provides an overview of the current Air Force technical order system. The discussion covers the system's regulatory basis, the bureaucratic structure, the nature of the technical information involved, and some of its weaknesses.

#### Overview of the Current System

Authorization for the AFTO system is provided by Air Force Regulation (AFR) 8-2, Air Force Technical Order System, which "applies to all activities using the AFTO system" and "explains the system, describes the devices and data to be included, and assigns basic responsibilities."<sup>1</sup> Numerous other official documents also detail compliance with the system. The following TOs, for example, were issued as military orders of a technical nature in the name of the Air Force chief of staff and by order of the secretary of the Air Force:

TO 00-5-1:	Air Force Technical Order System
TO 00-5-2:	Technical Order Distribution System
TO 00-5-15:	Air Force Time Compliance Technical Order System
TO 00-5-16:	Computer Program Identification Numbering System (CPIN)
TO 00-5-17:	Computer Program Identification Numbering System (CPIN)
TO 00-5-18:	USAF Technical Order Numbering System
TO 00-5-19:	Managing Technical Orders in Support of Foreign Military Sales (FMS) <sup>2</sup>

In addition, AFLC Regulation 8-4, Air Force Technical System, sets forth a detailed description of responsibilities; process flow; and procedures to fund, produce, confirm, review, and keep TOs current. The system's main goal is to provide timely data to all using activities. Other goals include:

- a. Give concise but clear instructions for safe and effective operation and maintenance of systems and all supporting equipment; and provide a means of directing and reporting modifications and equipment behavior.

b. Make sure that all hazardous aspects of the system (operations, processes, etc.) are highlighted and that all pertinent procedures are included to adequately eliminate, minimize, and/or control hazards.

c. Make sure that only essential TOs are procured.

d. Provide TOs that contain adequate coverage at the least cost to the government.

e. Stress reduction in cost of TOs used.

f. Tailor TOs to the tasks and needs of the using and supporting commands. Ensure that TO data is clear enough to permit system support at the operational level (by the using command, by AFLC, or by contractor personnel) and to allow competitive bidding for contract support.

g. Give support to the software program according to AFLCR 800-21 [Management and Support Procedures for Computer Resources User in Defense Systems].

h. Make sure that commercial technical data is procured (instead of specification data) when it is useful, available, and determined adequate by the technical content manager and the using command.

i. Make sure that obsolete TOs are purged from the system on a continuing basis.

j. Provide modification instructions according to specifications.

k. Prevent duplicating TOs by making sure that technical instructions do not exist in other DOD documents.<sup>3</sup>

Management of the AFTO system is the principal responsibility of the Directorate of Reliability, Maintainability, and Technology Policy (HQ AFLC/MMTI).<sup>4</sup> The process flow is shown in appendix A at figure A-1. As it suggests, an extensive bureaucracy has been established to address TO acquisition, accuracy, stock control, distribution, and use.<sup>5</sup> But to detail this bureaucracy exhaustively would unnecessarily lengthen this report and detract from its main purpose, so only the roles of the

major participants within the materiel management (MM) and maintenance (MA) communities will be described--and then only in a very summary fashion.

Technical order acquisition follows a very definite life cycle, as does systems acquisition in general. The process forges an inseparable bond between equipment and the technical information required to operate and maintain it. Technical order development involves four principal stages: (1) a preconcept phase in which the concepts for operational use and maintenance are determined from the user's statement of need; (2) task identification, where logistics support analysis is initiated as the backbone of systems engineering and technical order development; (3) validation and verification of the preliminary technical orders, conducted first by the contractor(s) against requirements and then by the government against the system or equipment itself; and (4) printing and distributing the final technical orders.

At all stages of technical order development, AFLC has a major role to play: "AFLC is responsible for determining and establishing TO requirements for AFLC and the using commands."<sup>6</sup> This responsibility is delegated to the "center" level, which includes the five air logistics centers (ALCs) and the Aerospace Guidance and Metrology Center (AGMC).

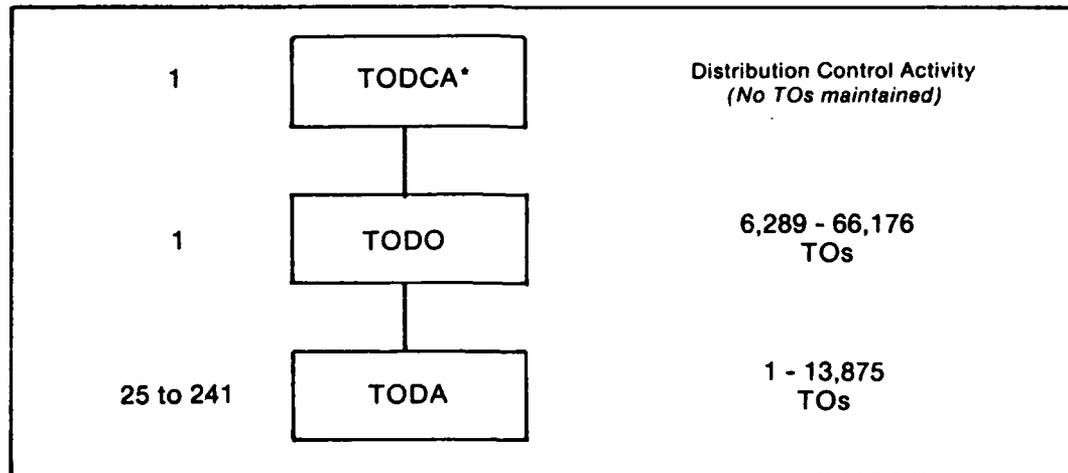
Each affected center assigns overall responsibility for a defense system to a system manager (SM) or system program manager. It assigns individual equipment item responsibilities to an item manager (IM). System managers and item managers are then assigned to the affected ALC/MMED or AGMC/MLM organizations. For example, the ALC source of repair--the designated depot level maintenance activity--for the F-15 is Warner Robins ALC (WR-ALC). Therefore, a system manager at WR-ALC is assigned overall responsibility for all logistics matters relating to the F-15 from "birth to death."<sup>7</sup> Several item managers are assigned equipment item responsibilities.

Then, normally late in the systems acquisition process, after program management responsibility transfer from AFSC to AFLC, the system manager or item manager organization becomes the technical order management agency (TOMA) for the system and equipment transferred. In this capacity, the system managers and item managers are clearly important for effective TO acquisition and management from the initial stage of requirement definition until system/equipment disposal.

The SM or IM organization becomes totally responsible for TO accuracy and for maintaining an adequate stock of technical manuals, changes, and revisions. Oklahoma City ALC (OC-ALC/MMEDU) is particularly crucial to maintaining TO stockpiles, printing additional TOs, and initiating TO distribution. Primarily, this is because OC-ALC/MMEDU operates the automated logistics management of technical orders system (G022). Special weapons TOs are managed at San Antonio ALC (SA-ALC/SWPPT).<sup>8</sup>

At the depot maintenance level of each ALC, TOs are managed by a number of technical order distribution accounts (TODAs). These TODAs service a number of technology repair centers (TRCs). Figure 1 provides a look at the consolidated center bureaucracies that support stock control, distribution, and use of technical orders within the AFTO system.<sup>9</sup>

This bureaucracy has been mirrored and extended at base level throughout the Air Force. Research conducted by the Air Force Logistics Management Center (AFLMC) in 1985 led to



\*In addition to the TO distribution office (TODO) function, each MAAT had a unique organizational element called a technical order distribution control activity (TODCA).

Figure 1. Consolidated ALC/AGMC AFTO System Support Bureaucracy.

the conclusion that "an extensive bureaucracy has evolved to maintain and distribute TOs at base level."<sup>10</sup> The final AFLMC report identified the focal point of the base-level AFTO system as the TODOs. These TODOs establish requirements for the base and report them to the ALCs. They also distribute TOs around the base and keep a record of TOs requested and received from the ALCs. Figure 2, compiled by AFLMC, pictures the base-level TO bureaucracy.

Three levels [of accountability] are authorized [below the TODO]: TO distribution accounts (TODAs), TO distribution subaccounts (TODSSs), and TO distribution sub-subaccounts (TODSSSs). The number and level of TO distribution activities falling under a TODO is based on TO usage requirements and geographic dispersion of AF organizations using TOs.<sup>11</sup>

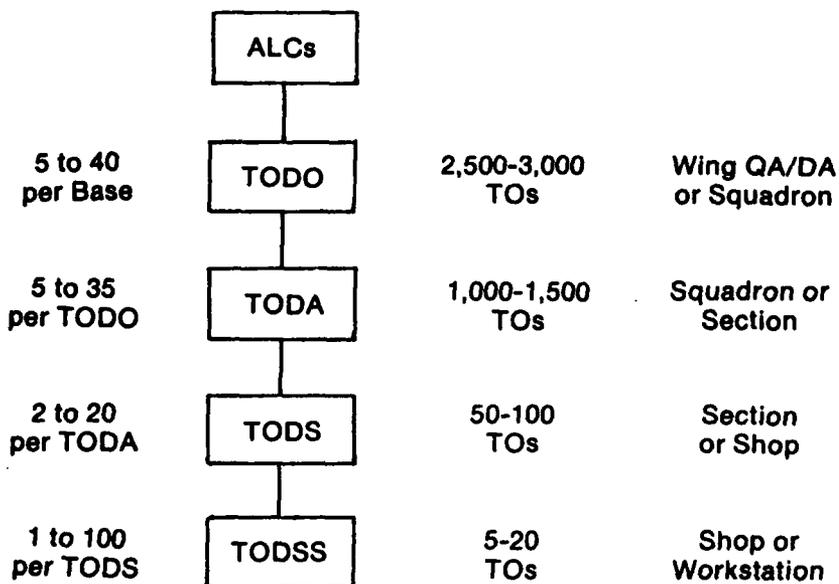


Figure 2. Technical Order Distribution Office Organization.

### The Nature of Technical Orders

Several factors have contributed to the growth of the bureaucracy: the ever-increasing number of TOs; the complexity that new technology fosters; and the staggering differences in size, format, and content standards applied in TO development.

The number of technical orders in the Air Force inventory in late 1985 was in excess of 130,000 unique titles comprising over 15 million pages. The growth rate was approximately 10 percent, and approximately 2.3 million change pages were being generated annually to maintain TO accuracy.<sup>12</sup> By July 1987 there were "in excess of 150,000 different TOs containing more than 20,000,000 pages [requiring] approximately 2,500,000 change pages per year."<sup>13</sup>

As for the TO volumes required to maintain today's sophisticated weapon systems, the AFLMC study provides a pictorial explanation (fig. 3).<sup>14</sup> To appreciate future impacts, consider the B-1B bomber:

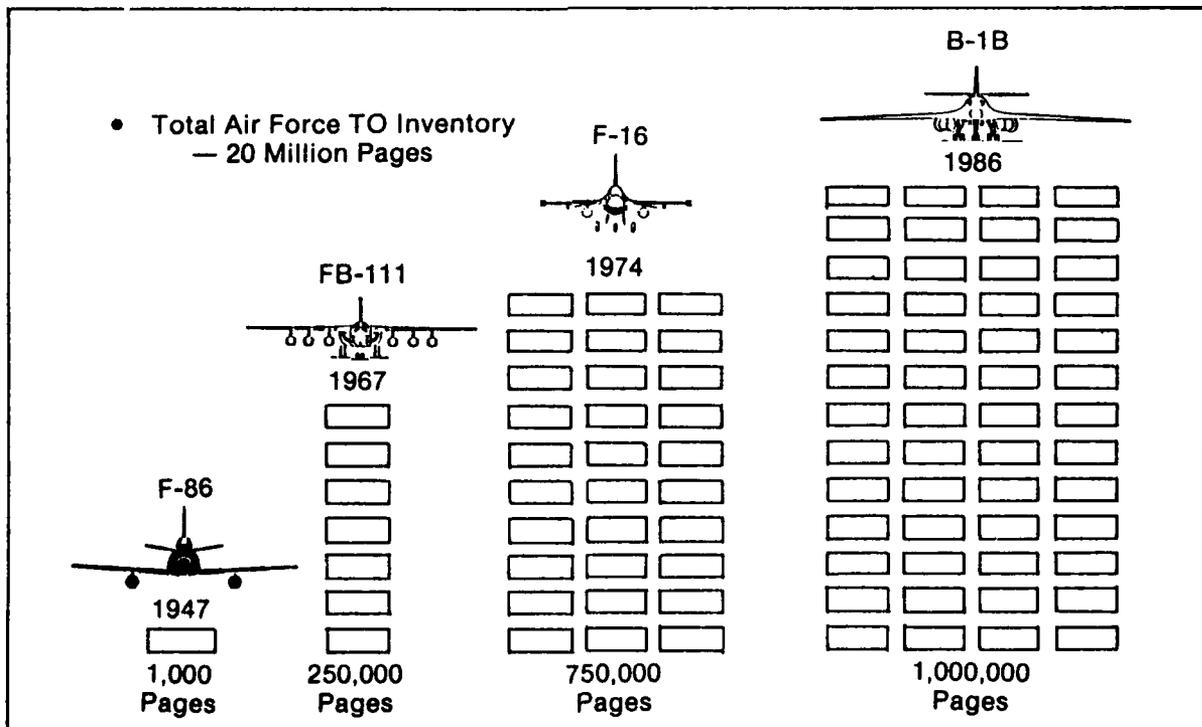


Figure 3. Volume of TOs.

[It] will add over 7,000 TOs containing approximately 1,000,000 pages. In today's environment of retaining existing weapon systems, these addition[s] will burden the TO system to a state of unacceptable support and response to readiness requirements and economic conditions.<sup>15</sup>

Then there is the factor of TO variability, including authorized differences in size, form, and content, as well as the fact that a number of other publications are incorporated into the AFTO system.<sup>16</sup>

One important TO category encompasses the technical manuals (TMs), the most widely and regularly used TOs in the AFTO system. They provide the essential information necessary for Air Force personnel "engaged or being trained in the operation, maintenance, service, overhaul, installation, and inspection of specific items of equipment and materiel."<sup>17</sup> TMs for aircraft and missiles, for communications, electronics, and meteorology systems, and for other aerospace equipment include instructions for:

- Assembly; Ground Handling
- Organizational Maintenance
- Job Guides
- Structural Repair
- Illustrated Parts Breakdown
- Scheduled Inspection & Maintenance
- Cargo Aircraft Loading and Off-loading
- Power Package Buildup
- Work Unit Codes
- Operating Procedures
- Servicing Procedures
- Repair
- Intermediate Maintenance
- Overhaul
- Fault Reporting
- Fault Isolation
- Reconditioning
- Calibration
- Facility, Subsystem, and System Installation-Engineering
- General Engineering and Planning
- Standard Installation Practices

A second major category comprises the methods and procedures technical orders (MPTOs). These TOs, general in nature, are not related to specific aerospace systems or equipment.

There are two classes of MPTOs:

- a. Those that involve policy, methods, and procedures relating to the TO system; maintenance, administration, or inspection of Air Force equipment; and control and use of reparable assets and configuration management. Examples are the

00-5 series, 00-20 series, and 00-35A and D series publications.

b. Those that involve policies, methods, and procedures relating to ground handling of aerospace vehicles; management of precision measurement equipment; and the safe use of Air Force equipment. Examples are "weight and balance," "welding practices," and "conservation, segregation, and disposal of critical alloys and precious metals."<sup>18</sup>

A third category consists of abbreviated technical orders. Designed to simplify maintenance tasks and other procedures, these TOs include:

a. Inspection workcards that prescribe minimum requirements for performing an inspection.

b. Inspection sequence charts, provided primarily for scheduled inspections, that depict a basic planned work schedule or sequence in which the inspection workcards can be used.

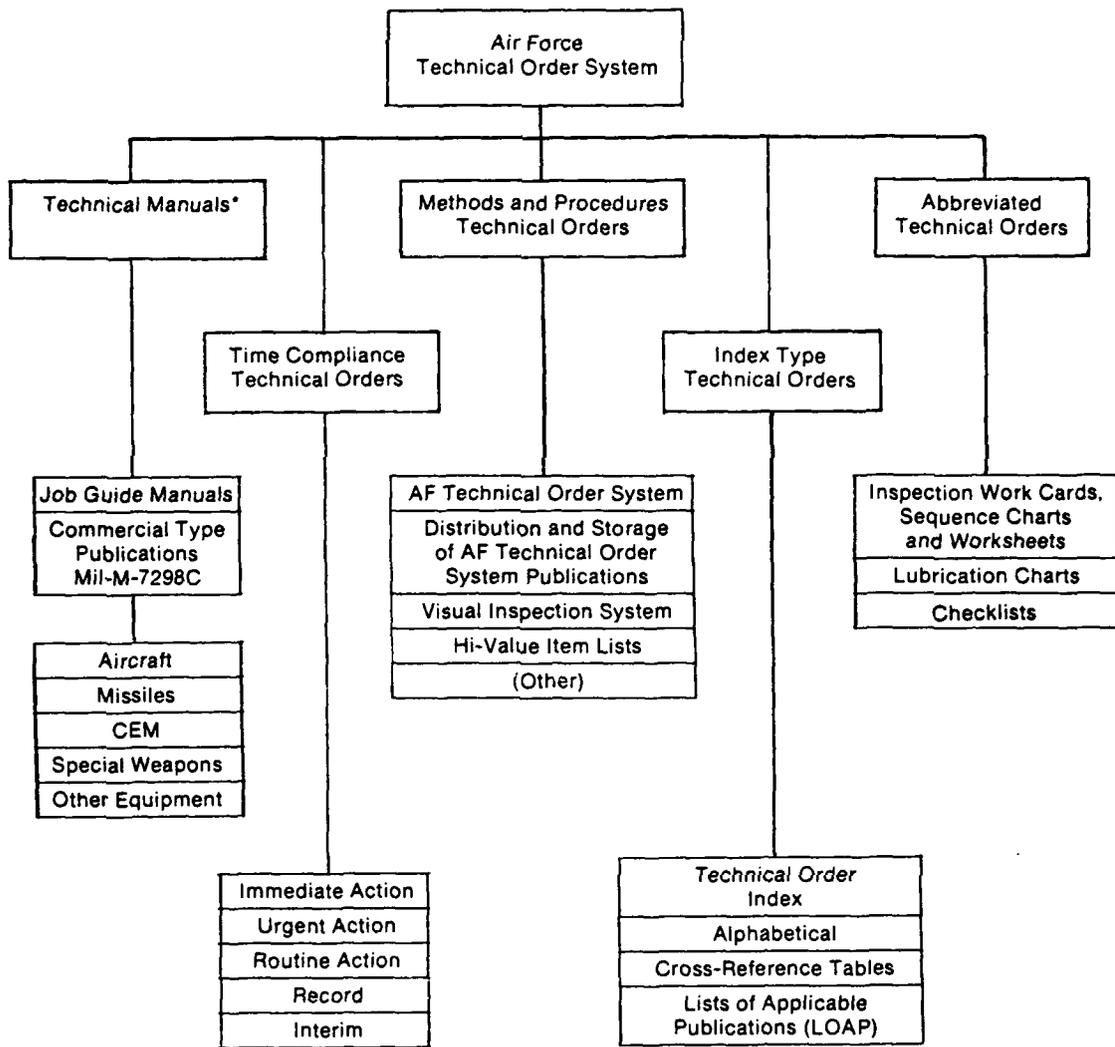
c. Checklists of items in abbreviated form for use in performing various tasks or operations to ascertain operational readiness and minimum serviceable conditions.<sup>19</sup>

A fourth major category encompasses the time compliance technical orders (TCTOs). In general,

A TCTO sets forth instructions for accomplishing a modification to equipment, performing or initiating special "one time" inspections, imposing temporary restrictions on aircraft flight, missile launch, or usage of airborne ground communications-electronics equipment and support equipment. Three types of TCTOs are authorized: immediate action, urgent action, and routine action.<sup>20</sup>

The final major category consists of index type technical orders. These TOs "show the status of all TOs, provide a means of selecting needed TCs, and group TOs pertaining to specific items of equipment."<sup>21</sup>

In addition to the five major TO categories, a number of other publications are maintained within the AFTO system.<sup>22</sup> These include but are not limited to:



\* Conventional TMs may also be used for intermediate and depot level maintenance when prepared according to applicable technical content specifications.

Preliminary TOs are not considered a type of TO, but are prepared in limited quantity to test and verify the procedures therein. They are not normally used for operation and maintenance unless they have been verified and approved by Headquarters major command, AFSC, and AFLC.

Partially verified TOs. Formal military specification TOs on which critical, safety/essential verification has been completed and are acceptable for use in the operational environment when using the two-phase verification plan.

Figure 4. Types of Publications in the Air Force TO System (adapted from TO 00-5-1).

1. Preliminary technical orders. These TOs are supplied with early test and production models of aerospace systems and equipment. Generally not authorized for use in the operation and maintenance of supported systems and equipment, they establish the basis for an extensive validation and verification process from which final TOs result.

2. Joint nuclear weapons publications. Resulting from memoranda of understandings between the Department of Defense and the Department of Energy, these technical publications relate to nuclear devices and substances (their operation, maintenance, transportation, safety, etc.).

3. Interservice publications and manuals. Primarily as a cost-reduction initiative, the Air Force uses TMs from other services and governmental agencies when AFLC determines that they satisfy Air Force needs. TMs acquired under the auspices of joint procurement programs fall within this category.

4. Commercial manuals, contractor data, and packup data. When Air Force technical information needs can be met through available commercial manuals and contractor data, this alternative is used instead of contracting for TOs developed to Air Force specifications.

Training manuals are not included in the AFTO system, but they are used by Air Training Command (ATC) for training purposes. They may be either preliminary TOs or final TOs, depending primarily on the development of special ATC courses for their use.

#### System Weaknesses

As a result of low priority, inattention, and extreme obsolescence, the AFTO system is more liability than asset. Unquestionably, it is inadequate for the Air Force of the future. And the Gramm-Rudman-Hollings Act mandates reductions in manpower and funding levels, necessitating a hard look at the bureaucracy required by the AFTO system. The Air Force of the future can ill afford a support system that redirects significant numbers of maintenance personnel to perform essentially administrative duties, as the AFTO system currently does. And the AFTO system's cost is immense while it continues to become less and less responsive to its users' needs.

Logistics Command's Directorate of Reliability, Maintainability, and Technology Policy published a mission element need statement that detailed a number of serious deficiencies in the system and assessed the importance of correcting these deficiencies: It "is of the highest priority to the Air Force due to the nature of the problem and the fact that the entire Air Force is impacted by the stated deficiencies."<sup>23</sup> These system deficiencies were identified principally in terms of their impact on system users and the Air Force of the future.

The current system is seen as extremely archaic (based on 1940s technology)<sup>24</sup> and is described as a paper- and manpower-intensive system that requires "45 days [to] extremes of 120 days or more" for a TO requisition to complete the cycle, and "thirteen (13) organizational processes and . . . an average of 270 days" for a routine change to reach the users. "The only automated portion of the entire process is performed by the logistics management of technical orders system (G022)," which is itself "a 1960s era batch-processing system."

The G022 system is in serious condition and spends a lot of time in a down status. The operational demise of the system is variously projected from six (6) months to two (2) years.<sup>25</sup>

From the standpoint of the future, when more sophisticated weapon systems and aerospace equipment will increase the demands placed on it, the AFTO system is equally discouraging. A specific example is the B-1B strategic bomber, which is already inadequately served.

Finally, consider the impact of the AFTO system on its principal users, the base-level maintenance technicians. They manually post changes, supplements, and revisions to TOs--usually as an additional duty, but often as a full-time assignment. AFLMC noted, for example, that one tactical fighter wing had "twenty-three maintenance personnel assigned full time, or nearly full time (75% of duty activity) to maintain and distribute TOs, [and the] posting of distribution records alone required 1,083 man-hours each year."<sup>26</sup>

In summary, most of the deficiencies are a direct result of the paper-based, page-oriented nature of the system. And the widespread duplication of TOs further multiplies the problems experienced at base level.<sup>27</sup>

## Notes

1. AFIT, Technical Order Acquisition and Management: Sys 230, Syllabus of Instruction (Washington, D.C.: Government Printing Office, 1985), 15.

2. Ibid.

3. AFLCR 8-4, Air Force Technical Order System (Washington, D.C.: Government Printing Office, 25 May 1983), 4.

4. Ibid. Due to an AFLC reorganization not yet reflected in the regulation, the office symbol and the directorate's name differ slightly from that provided by AFLCR 8-4.

5. Ibid., 16-19. The reader might prefer or, as in my case, need to use magnification in order to relate the narrative flow with the diagram provided. The quality of figure A-1 is better than or equal to that provided in the regulation. The block descriptions have been enhanced.

6. Ibid., 10-17. The quote is taken from page 10.

7. Introduction to the Air Force Logistics Command (AFLC): AFLC Action Officers Guidebook, 2d ed. (Washington, D.C.: Government Printing Office, 1984), III-6.

8. RJO Enterprises, Inc., Automated Technical Order System (ATOS), Phase II, Economic Analysis (Washington, D.C.: Government Printing Office, 1985), 2-1.

9. RJO Enterprises, Inc., untitled and unpublished analysis produced under contract F33600-85-C-7045, WO 2274-02, for the ATOS Program Management Office as a correlate to the AFLMC study conducted at base level (see note 10), 3 July 1986. In addition to data provided in the figure, the analysis also determined that TO sub- or sub-subaccounts--respectively, TDS and TODSS--are not used by the centers.

10. AFLMC Report LM850403, ATOS Phase 3 Concept of Operation (Gunter AFS, Ala.: AFLMC, 1986), 5.

11. Ibid., 6. The original source for the information--Technical Order Distribution System, TO 00-5-2 (Washington, D.C.: Government Printing Office, 1983), 2-2--is faithfully preserved.

12. Maj Edward J. Higbee, "Automated Technical Order System (ATOS)," address to the Sixth Aerospace Industries Association Symposium on Mature and Emerging Technology, San Diego, Calif., 25 September 1985.

13. Headquarters AFLC/MMT, Automated Technical Order System (ATOS) Mission Element Need Statement (MENS), 15 July 1987, 2.

14. ATOS Phase 3 Concept of Operation, 4.

15. Headquarters AFLC/MMT, Automated Technical Order, 3.

16. AFIT, Technical Order Acquisition and Management; 21.

17. Ibid., 19-20. Multiple quotes are taken from this source to detail the purpose and content of technical manuals (TMs). Certain liberties have been taken to remove redundant punctuation in the tabular list of TMs, while substantive content is preserved.

18. Ibid., 23.

19. Ibid., 24.

20. Ibid., 23.

21. Ibid.

22. Ibid., 25-27. Credit for the description of each publication is given to this source; however, paraphrasing was employed in the interest of conciseness.

23. Headquarters AFLC/MMT, Automated Technical Order, 2.

24. Ibid., 2-3.

25. Ibid., 3.

26. ATOS Phase 3 Concept of Operation, 7. Numerous examples of the types of problems inherent in the current paper-based, page-oriented AFTO system were uncovered by AFLMC during their visits to a number of Air Force bases in 1985.

27. Ibid., 5.

## CHAPTER 3

### AUTOMATION INITIATIVES TO IMPROVE THE SYSTEM

The close relationship that has existed between the aerospace industry and the Air Force for over four decades has resulted in a number of changes in each. The observed advantages of automation in industry and the substantial reductions in cost, manpower, and time anticipated with the introduction of automated systems in the Air Force dictate an end to the cumbersome systems in use today. Senior leaders have therefore directed the Air Force to take measured steps in automating today's logistical support processes. Several initiatives are already under way.

#### Automation and the Future

The early history of technical order development was dominated by numerous procedural, format, and content changes to correct deficiencies. The Job Guide, implemented first with the C-141 in 1970, is a well-recognized example of such an improvement.<sup>1</sup> In addition, a number of procedures were automated to enhance productivity. Unfortunately, they have produced little overall improvement.<sup>2</sup>

In 1981 the Joint Committee on Printing (JCP) authorized the Air Force to develop a prototype automated technical order system that could comprehensively address AFTO system deficiencies.<sup>3</sup> The success of this prototype has ushered in at least three significant automation developments. Collectively, they represent the intent of the Air Force to ultimately replace the AFTO system.

These three automation initiatives are the automated technical order system (ATOS), the improved technical data system (ITDS), and the integrated maintenance information system (IMIS). They are separately directed and managed, but each deals with many of the same environmental conditions that must be met by the others; and DOD's computer aided acquisition and logistics support (CALs) initiative clearly contemplates fusion of these three systems.<sup>4</sup> Eventually, System Command's CALs Management Integration Office will integrate management and acquisition of these systems. The degree of importance placed on CALs, and thereby on ATOS, ITDS, and IMIS, is documented in a report by the Committee on Appropriations referenced in the Department of Defense Appropriations Bill of 1987.

The DOD Computer Aided [Acquisition and] Logistics Support program is crucial to the effective use of paperless design and logistics information for improved weapon systems support. The Committee expects to see substantial near-term progress to establish compatibility for already-developed systems within DOD, such as engineering drawing repositories and automated technical manual systems [such as ATOS, ITDS, and, later on, IMIS], together with common interfaces with industry.<sup>5</sup>

Progress for the Air Force will be evaluated in terms of the direction provided by Deputy Secretary of Defense William Howard Taft IV and former Air Force Vice Chief of Staff John L. Piotrowski. Direction from Secretary Taft came in a memorandum dated 24 September 1985. The objective was

to transition from the current paper-intensive logistic support process to a largely automated mode of operation for weapon systems entering production in 1990 and beyond.

The most significant near-term objective is to apply as many CALS elements to the Advanced Tactical Fighter (ATF) program [which] may serve as the "lead" weapon system for systems of the 1990 era.<sup>6</sup>

On 10 September 1986 General Piotrowski set forth the Air Force objectives in support of CALS in a letter to MAJCOM commanders. He required that all efforts be directed toward "achieving a 'near paperless' operation by 1992."<sup>7</sup> Beyond this, Air Staff and unit commanders have directed consideration of such target systems as B-1B, F-15, F-16, and C-17, in addition to the ATF, for early support by automated logistical support systems.

#### Automated Technical Order System

The first of the three automation developments is ATOS, a description of which is provided in appendix B. It evolved from the initial prototype authorized by the JCP in 1981. AFLC has managed ATOS as a single system; but because of fiscal constraints and technological risks, it has been necessary to acquire ATOS in accordance with a phased development plan. Originally designed as a system with three phases, ATOS is currently being acquired in two. Phase I, an acquired improvement of the Ogden ALC prototype, was completed with full operational capability in March 1987. It has been installed and is operational at all five

ALCs and at the Aerospace Guidance and Metrology Center. The second phase will be acquired and tested as a pilot system before full implementation. It is currently in the requirements development stage. Acquisition will be sought in fiscal year 1989.<sup>8</sup>

Phase I automates the previously all-manual preparation of TO changes and the publication process at the ALCs. This is accomplished through preparation of camera-ready page masters for printing and distribution.

Requirements for the second phase have changed repeatedly over time, and fiscal realities suggest that further change should be expected. Currently defined as a pilot program, it accepts digital input from both ATOS phase I and aerospace contractors and distributes it in digital form. Air Force users at depot and base level may use these TOs in digital form or reduce them to paper (the system will have print-on-demand capabilities).

As currently planned, the ATOS pilot program will consist of central processing units at two ALCs--Oklahoma City and Sacramento--and remote computers at four Strategic Air Command bases--Dyess AFB, Texas; McConnell AFB, Kansas; Ellsworth AFB, South Dakota; and Grand Forks AFB, North Dakota. Electrical, hydraulic, and air-conditioning subsystems maintenance of the B-1B will be supported by TOs presented on computer terminals or printed on demand. One base will be supported digitally to the shop level.

Following a successful pilot acquisition and test period,

future ATOS acquisitions will automate and digitize the development, acceptance, storage, and configuration management of technical orders and their distribution and presentation to Air Force bases around the world.<sup>9</sup>

Also significant to the ATOS pilot program is the requirement to "incorporate ITDS type technology." This will probably entail the use of ITDS data, software, and hardware, since the ITDS user system has been proposed as "the Air Force Standard Technical Order Presentation System."<sup>10</sup>

#### Improved Technical Data System

The second automation development is ITDS. Similar in basic functionality to ATOS, ITDS extends the usefulness of technical data (TD). The ITDS user system, the proposed Air

Force standard for presentation (i.e., video display of TD optimized for intended use), also extends digital TD from the shop environment to the flight line.

The ITDS producer system is basically a publication system like ATOS phase I, though there are a few significant differences. In terms of hardware, the functional similarity is close. The major difference is that the producer's system has a direct two-way digital link to the developer's logistical support analysis (LSA) data base, the logistics support management information system (LSMIS). Since LSA is the principal source from which TOs are derived, having the linkage with LSA data allows for early detection of conceptual errors in TOs. This capability provides for cost-effective remedies in the design stages of system and support equipment development. Two other differences between ATOS phase I and the ITDS producer system involve the added software and data capabilities available with ITDS.

Producer system software permits a closer integration of related TO data by introducing added intelligence into the data itself. Data produced by the ITDS producer system is for new weapon systems acquired with an all-digital support concept--the ATF, for example. ITDS data contains embedded control codes, referred to as tags and hooks, that link together procedure-related data elements (e.g., paragraphs with illustrations). This permits maintenance tasks to be completed through use of displayed data with minimal use of computer keyboard or through use of touch-sensitive display. To facilitate user training and acceptance of this form of improved access, TO data is also coded to permit printing as required.

Data is entered into the producer system through the system terminal, through computer-aided design (CAD)/computer-aided manufacturing (CAM) workstations, or through text scanners and graphics scanners. Optical character recognition (OCR) scanners scan textual data, illustration scanners convert graphic images into digital form. The producer system manages access to the file manager, where TO data is stored, and provides for printing or transfer of data to the user system, which is located in a base-level shop or section (fig. 5).<sup>11</sup>

The user system then stores data and associated changes in a local library, which controls distribution to the requesting users. Distribution records are maintained to assure that TO changes are sent to all users. The user system also provides print-on-demand capabilities and interfaces with those embedded systems that are capable of displaying ITDS-compatible data (e.g., onboard aircraft

systems, automated test equipment, and training systems). The user system also distributes data to networked delivery devices, which provide it to technicians in sheltered environments, and to portable delivery devices, which provide it to remote locations and severe working environments (fig. 6).<sup>12</sup>

When fully implemented in fiscal year 1990, ITDS will also provide environmentally hardened extended memory modules (EMMs) that can be transported to the point of use. The EMM is to be designed for loading on the crew (or bread) trucks normally used for transportation on the flight line today.

### Integrated Maintenance Information System

The last of the three automation initiatives is IMIS, a research and development program managed by the Air Force Human Resources Laboratory. IMIS, as its name implies, was designed to integrate the myriad information systems that are inundating Air Force maintenance personnel. It is intended to become the single maintenance aid by the late 1990s.

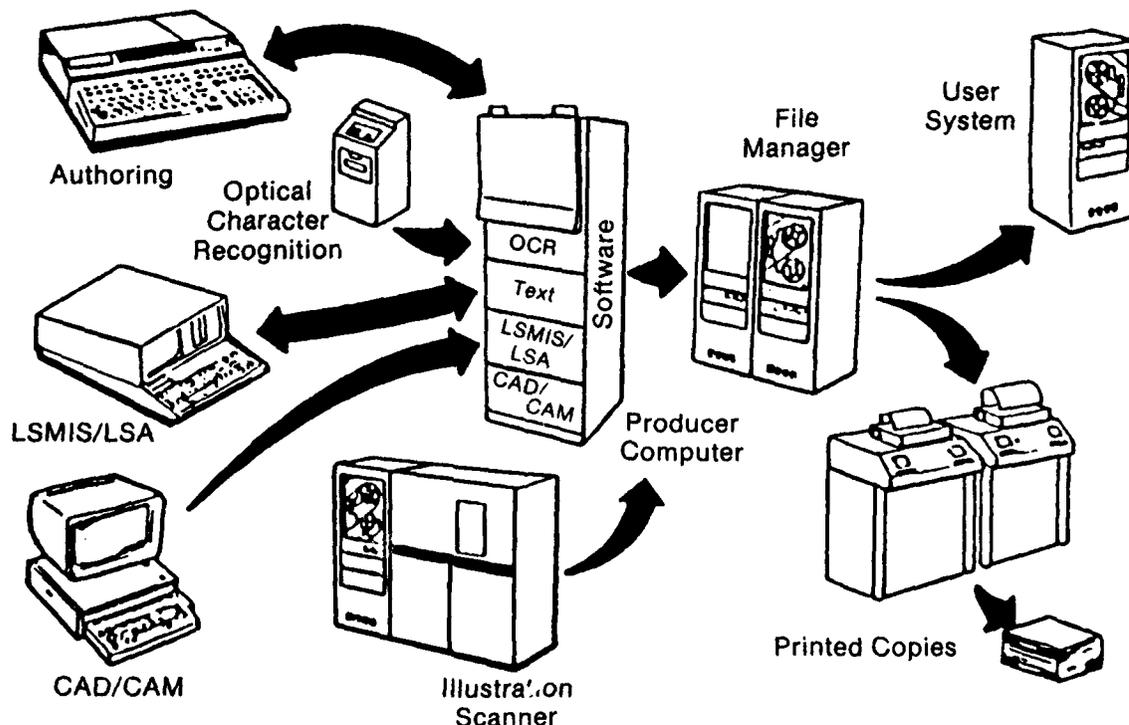


Figure 5. The ITDS Producer System.

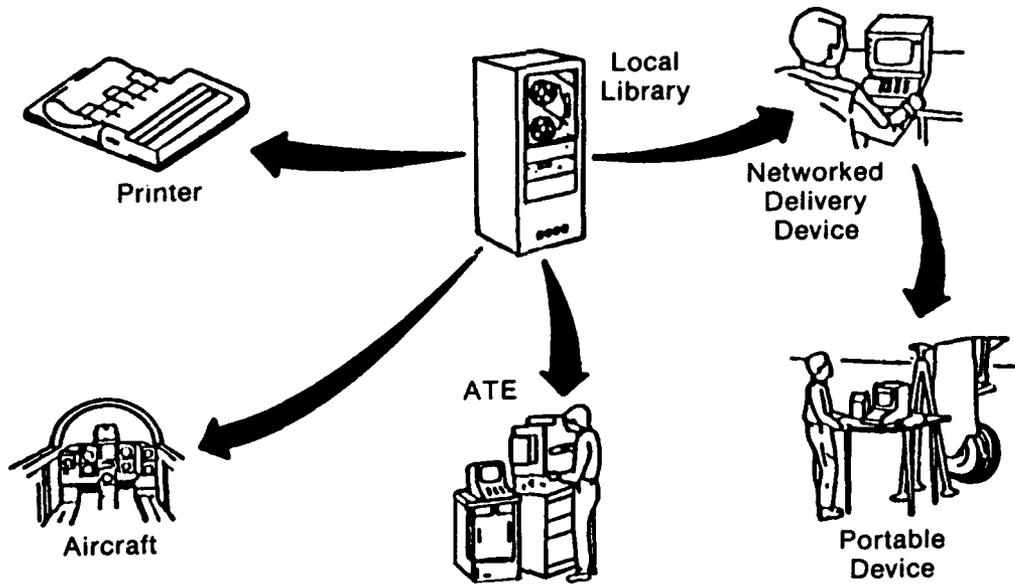


Figure 6. The ITDS User System.

IMIS will interface with ATOS and ITDS. The first two of IMIS's three research stages are well under way (fig. 7).<sup>13</sup> Stage I, the computer-based maintenance aids system, involves two separate prototypes established in intermediate maintenance facilities during 1984-85. These prototypes were designed to discover the basic requirements for an automated technical order system. Stage II, the portable

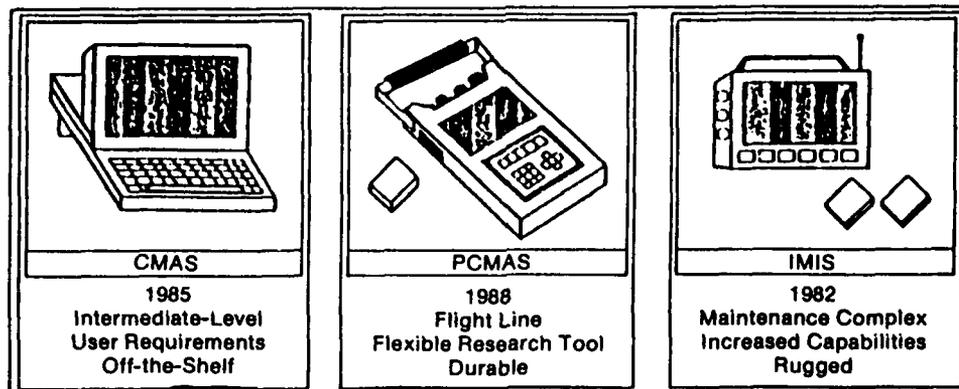


Figure 7. Three Stages of IMIS.

computer-based maintenance aids system, was designed to (1) implement the stage I TO presentation on the flight line and (2) demonstrate interactive diagnostics and aircraft battle damage repair assessments. Stage II will also be used to test the feasibility of these concepts during a field test. Stage III, full IMIS demonstration, will extend the concepts specified in stages I and II. Emphasis will be placed on information system integration throughout the maintenance complex.<sup>14</sup> Appendix C, provided by the Air Force Human Resources Laboratory (AFHRL/LRC), completely details stage III of IMIS which is currently scheduled for 1992.

#### Notes

1. AFLMC Report LM850403, ATOS Phase 3 Concept of Operation (Gunter AFS, Ala.: AFLMC, 1986), 4.

2. Headquarters AFSC/PLX, U.S. Air Force Plan for Implementation of Computer Aided Logistics Support, 1 July 1986, 1. The DOD initiative described in this plan has since undergone a name change to better represent its full range of applicability. It is now called the Computer Aided Acquisition and Logistics Support (CALs) initiative.

3. Headquarters AFLC LMSC/SMIA, "Automated Technical Order System (ATOS)," LOGSARC Milestone 0 briefing, Headquarters AFLC, Wright-Patterson AFB, Ohio, 22 July 1987.

4. Mark Hollobaugh, Headquarters AFLC/MMT, "Computer Aided Technical Order Strategy," briefing to Office of Secretary of Defense action officers, Headquarters AFLC, Wright-Patterson AFB, Ohio, 28 August 1987.

5. United States Air Force Computer Aided Acquisition & Logistics Support (CALs) Strategic Requirements Document (Washington, D.C.: Government Printing Office, 1987), 12. Interpolations have been included to clarify the current name for the CALs initiative and to indicate where the general systems reference is applicable to the Air Force programs cited. The reader will also note the futuristic implication attached to IMIS, which at this writing is more an engineering study than a developed program.

6. Ibid., 1-4. The block quotation is combined from a reference to the DOD "goal" on page 1 and a reference to the role of the ATF on page 4.

7. Gen John L. Piotrowski, Headquarters USAF/CV, letter, subject: Acquisition and Use of Air Force Weapon Systems Technical Information in Digital Form, 10 September 1986.

8. Headquarters AFLC LMSC/SMIA, Automated Technical Order System (ATOS) Pilot Program, Communications-Computer Systems Program Plan (CSPP), 7 August 1987, 5-2. Future fiscal realities may alter ATOS acquisition plans.

9. Program Management Directive for the Automated Technical Order System (ATOS), PMD 72501(1)/71112F/72895F/78012F, 29 April 1987, 1.

10. Ibid., 4; and message, 271904Z FEB 87 (U), issued by Headquarters AFSC/PL, subject: Automated Technical Order Working Group Minutes, 27 February 87, 4.

11. Maj Thomas D. Brown, Jr., ITDS program manager (ASD/AL-1), "Improved Technical Data System (ITDS)," briefing, Wright-Patterson AFB, Ohio, 15 May 1987. The description of figure 5 is based on the figure and on experience with ITDS.

12. Improved Technical Data System (ITDS) User System Type A System Specification (Washington, D.C.: Government Printing Office, 1987), 3-4.

13. AFHRL/LRC, "IMIS: Integrated Maintenance Information System, A Maintenance Information Delivery Concept" (Wright-Patterson AFB, Ohio: AFHRL, 6 August 1986), 1-3.

14. Ibid., 2, 6-8. Quotes and appendix C were drawn, respectively, from the page references indicated.

## CHAPTER 4

### DEPLOYMENT--THE TRUE TEST OF TECHNICAL ORDER AUTOMATION

Only deployment can provide a true test, of course--in particular, deployment under crisis management/wartime conditions. And the first task here is to define the working environment, "particularly with regard to the automated data processing (ADP) equipment which would be used at a bare base . . . because we should buy hardware and design software capable of operating efficiently and reliably under wartime conditions [and] because we should practice in peace the way we expect to operate in war."<sup>1</sup>

Whenever the term deployment is used, almost everyone has an understanding. Whether the understanding is a shared one, though, often depends on the existence or nonexistence of a common deployment experience. Deployment is essentially a rebasing operation. It can occur for a number of reasons and under a wide variety of circumstances. Some of the more usual reasons for undertaking deployments are presented here.

1. Weather avoidance. Weather is a frequent reason for unit deployments. Deployments such as Snow Bird for Guard and Reserve units and similar deployments for active units occur several times a year to avoid severe weather.

2. Training exercises. Environmental concerns such as noise abatement, restricted flight profiles over populated areas, and the locations of limited and specialized ranges are other reasons for deployments. There are two principal scenarios for aircraft deployment in training. The first is deployment of single flights for short periods, possibly a day or less. The second is deployment of entire units, including support personnel, for longer periods of time--usually a week or more. Examples include Combat Echo, Green Flag, and Copper Flag at Eglin and Tyndall AFBs, Florida, and Red Flag at Nellis AFB, Nevada.

3. Practice wartime tasking. Deployment missions are also conducted in order to experience basing conditions similar to those anticipated at locations to which units are assigned for contingency operations. Examples include: Checkered Flag and Crested Cap.

4. Military or political employment. When national leaders direct the employment of forces in support of a diplomatic mission, or to enter a conflict to resolve a crisis, deployment is an obvious and essential consideration.<sup>2</sup> Unquestionably, the latter instance is the more difficult of circumstances and the one with which the term crisis management/wartime conditions is most likely associated.

Crisis management/wartime conditions appear more readily acceptable as a range of conditions than as a discrete set of conditions. The term is defined here as "a crisis or conflict that involves the deployment of forces, whether or not such forces are actually used in resolving the crisis or conflict--for example, a natural disaster, a national contingency, or a war." If the crisis involves an adversary, the act of deploying forces may be a sufficient deterrent; but the definition requires the presence of a real crisis or conflict, thus eliminating routine training deployments and planned readiness exercises. These latter deployments usually involve limited training for ground-support personnel--logistics implications are either not planned or are "simulated away";<sup>3</sup> an automated technical order system should be used as soon as it is practical.

#### Deployment Considerations for Automation

Deployments involving an automated technical order system introduce a set of additional considerations, including the extent of automation required and how survivable that automation is. A situational model developed by the Air Force Logistics Management Center is presented here to establish some of the basic considerations. It is not intended to be exhaustive in its treatment.<sup>4</sup>

#### Situational Environment

Frequently bypassed and overlooked in a rush to consider the harsh effects introduced by conditions in the physical environment are the who, what, when, where, why, and how questions of deployment.

The tendency to think of logistics support as an afterthought is as disturbing as are the results of doing so. For example, AFLMC researchers reviewing the support of deployed aircraft maintenance units in the early 1980s reported:

While deployed, if a phone line is available, daily calls are made to relay flying time, maintenance problems, and engine data . . . to the home base's data collection system. Other maintenance data is generally collected for input upon return from the deployment; unfortunately, large amounts of data are frequently lost. [And] for small deployments, 12-14 aircraft for 15-30 days, the aircraft AFTO Forms 781 series are the only historical records generally taken along, necessitating almost total reliance on the home station. . . .<sup>5</sup>

It is clear, then, that logistics support consideration after the fact creates significant communications costs and causes the loss of valuable maintenance data.

AFLMC was tasked to develop an interim deployable maintenance system (IDMS) that essentially duplicates certain functions of the maintenance management information and control system (MMICS) and the core automated maintenance system (CAMS). An IDMS was fielded, but AFLMC noted certain unacceptable results:

Although IDMS and MMICS produced the same desired results, the user interface to obtain these results is significantly different. The input and output screens for IDMS and MMICS are totally different. The keyboard functions and set up for the UTS40 (MMICS) and the Z120/248 (IDMS) are also different. The user is therefore required to learn two systems; one for everyday use, and a second system for use while deployed. This is not an acceptable method of operation.<sup>6</sup>

This after-the-fact logistics support resulted in separate systems to support different levels of maintenance. This, of course, carries its own penalties in terms of human errors and inefficiencies.

A final example illustrates a more tangible consequence of neglecting deployable logistics support as a matter of up-front design. The avionics intermediate shop (AIS) is a test bench used to diagnose electronic warfare equipment and avionics (black box) systems for the F-15, the F-16, and a number of other aircraft. In theory, the AIS is an improvement in avionics maintenance; but the improvement has a significant price where deployment is concerned:

The F-15's dependence on an Avionics Intermediate Shop (AIS) is symptomatic of [a] current need for large amounts of specialized support. At least three C-141s are required to transport an AIS, and when in operation this AIS requires 4500 ft<sup>2</sup> of level, air-conditioned floor space. . . . In sum, deployment of a typical F-15 squadron currently requires 13 to 18 C-141s to carry flight-line equipment and spares just to set up operations at a prepared MOB--and much more equipment and spares to set up at an unprepared base.<sup>7</sup>

The F-16 AIS is different from the F-15 AIS, of course, so the problems of inflexible manning, training costs, and other maintenance issues add to this price. And, too, the AIS concept of maintenance is quite different from the concept for maintenance typically performed at a home base.

The bottom line of the combat logistician regarding how we deploy says a "deployable" anything--by itself--makes no sense; it's a "poor and costly concept."<sup>8</sup> Deployability should be a consideration in up-front design, not an afterthought. "Engineers must be indoctrinated so they do not design an aerospace vehicle. Instead, they must design an aerospace system. Their specific objective should be to reduce the people, materiel, facilities, and information needed to employ a vehicle in war."<sup>9</sup>

Next comes the criteria for levels of automation required for deployment. Three sets of criteria are offered: criteria that serve to define deployment levels, criteria established by level of conflict, and criteria for the automated equipment required. The first criteria suggested are the number of aircraft to be deployed, the anticipated duration of the deployment, the maintenance capability needed at the site, the availability of communications, and the level of intensity (fig. 8).

The least requirement for automation exists when the deployment involves: (1) the fewest number of aircraft; (2) the shortest anticipated time; (3) minimum maintenance capability; and (4) the least amount of communications support combined with high intensity. For example, a scenario could readily be envisioned wherein three or four aircraft are dispersed to an unimproved site (such as the autobahn in West Germany) for a couple of days to conceal their presence.<sup>10</sup>

The only occupants of the aircraft are the pilots and the crew chiefs, and the only communications available are through the aircraft radios. Intensity is high due to

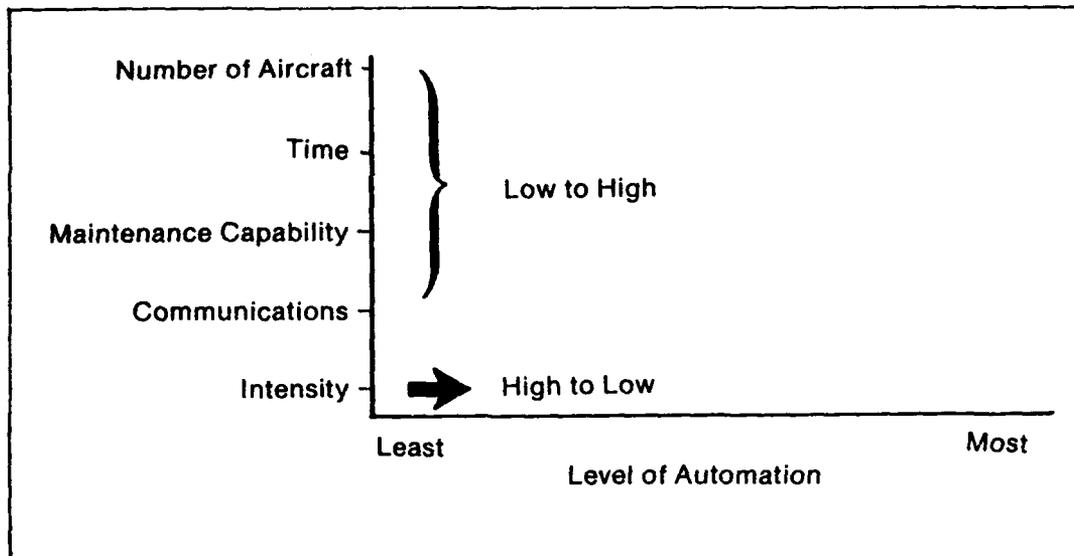


Figure 8. Criteria for Determining Levels of Deployable Automation Required.

multiple overflights each day by enemy fighter and reconnaissance aircraft. In this situation, there are few requirements for automation and maintenance--just for "guns and gas." These pilots need to get airborne and deliver ordnance (fig. 9).<sup>11</sup>

Consider now a different scenario. Assume that the number of aircraft increases to between 18 and 20, a squadron-sized deployment. The time on site is expected to be several weeks. Now there is a need for equipment specialists--perhaps even an aircraft maintenance unit. A mobile communications team may be set up. This deployment constitutes a basic show of force. It represents a totally different environment from the first scenario, and its informational demands will be numerous and systematic. Where previously all one really needed to know was whether the airplane could fly and deliver ordnance, now one needs to know the hydraulic work load level. And one needs status information in aggregates and percentages, not simple yes or no answers as in the earlier scenario. One wants to know technical things in more detail--and one wants better technical performance, which requires automated tracking.

Further along the continuum, a wing of 40-50 aircraft is deployed for months or years. Now, national resources are brought to bear; many kinds of communications equipment--HF, VHF, UHF, SATCOM, and possibly DDN and AUTOVON--are put in place; the deployment tends to peak in terms of requirements and available resources; and automation is called upon to enhance information and provide productivity across the board. Reporting in proper formats, with automatic distribution, typifies the scene.

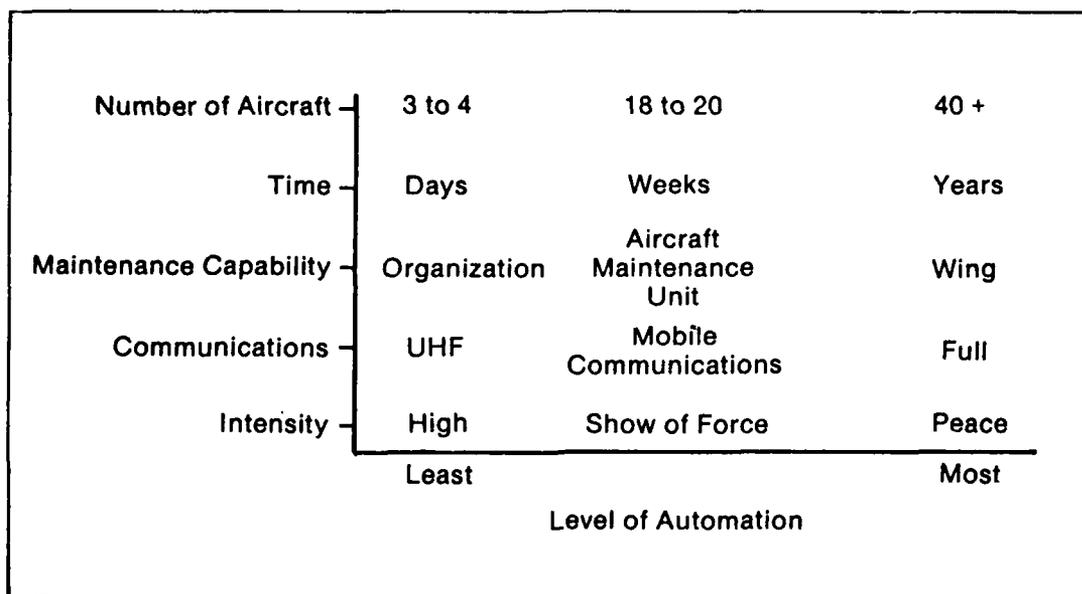


Figure 9. Levels of Automation Scenarios.

Clearly, deployment isn't a single, well-defined entity but a multitude of possibilities with varying requirements for automation support. This is true whether or not the support is an automated technical order system and whether or not the deployment has a conflict orientation.

The remaining criteria, which deal more specifically with level of conflict and level of equipment, will be dealt with together. Deployment need not involve conflict; but where conflict is involved, key automation issues like process criticality and the availability of manual alternative processes become more pressing. These issues notwithstanding, there will always be instances where logic of a higher order imposes use of automation and exposure to risks deemed acceptable. Then there is the question of how much automation is enough. Greater distance raises the premium on supportability; that is, more spares and supplies are required. And certain physical environment extremes place restrictions on operations, reliability, and maintainability (fig. 10).

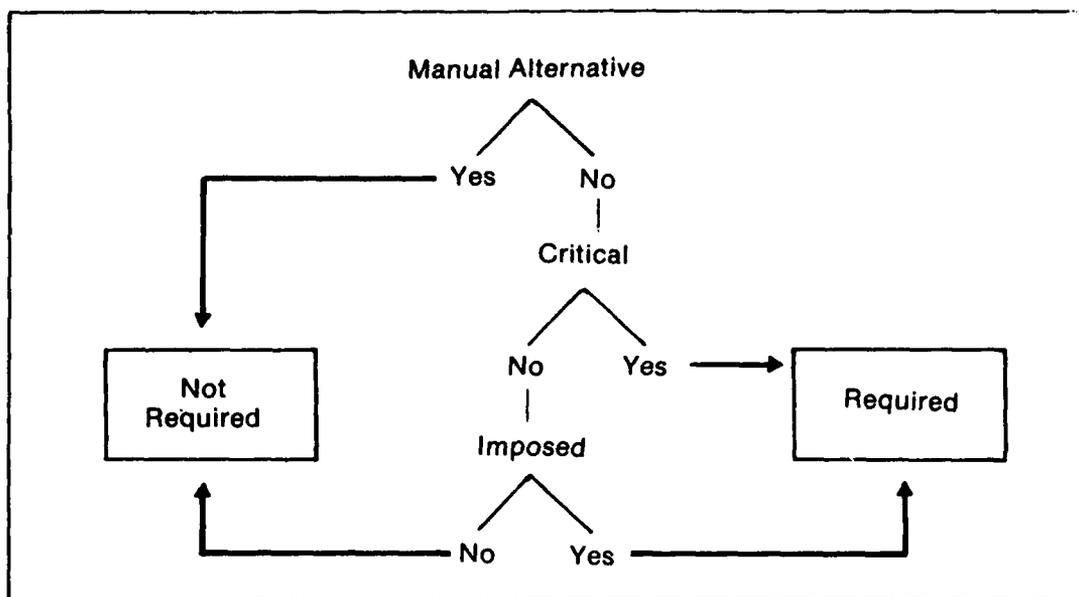


Figure 10. Logic Tree for Assessing Level of Conflict and Levels of Equipment Criteria.

Regardless of the level of conflict, reality requires some automation for deployments that involve appreciable degrees of self-sufficiency. And that certainly applies to European deployments due to conflict. The conclusion of the Project RELOOK study team was that "successful logistics support had to be based upon US installations in Europe being self-sufficient to the maximum extent possible."<sup>12</sup> Also, even though automation isn't accepted as a panacea in all cases where technical data are used, it is an essential for engine maintenance. It has either become physically impossible to perform some engine maintenance functions manually or it is impractical to do so. Today's engines, for example the F-110 and the F-220, cannot be interrogated without specially developed automated test equipment.

If the answer concerning the availability of a manual alternative is "yes," then both methods must be measured against the deployment continuum in figures 8 and 9 to assess the level of automation required. As a practical matter, manual alternatives probably will not exist for many automated procedures at the extremes of the continuum. At the low end, where intensity is high, it may simply be a matter of deploying the automated procedure and having it work or else. At the opposite extreme, sufficient manpower

will normally be available to develop and implement a manual alternative. Nevertheless, ample redundancy or repair for the automated system should be available to assure its continued use.

If no manual alternative exists or can exist, then whether the automated procedure is critical to operations must be determined. If the procedure is deemed critical, then it has to be deployable. In this case, the physical environment must be measured against the automated system and the mission profile. The key for acquiring an effective automated logistical support system is to tailor it to the user's intended use and work environment; the limiting factor is man, not machine.<sup>13</sup>

If the system is not critical, then the question is whether its use is to be imposed. For reasons that may not be obvious, higher authority may determine that an automated system should be deployed. When this occurs, the deployment situation will establish the appropriate level of automated support.

The automation industry provides a broad range of hardware options: from highly portable laptop computers such as the Air Force and Navy standard, the Z-184, to stand-alone microcomputer systems; from a local area microcomputer network to a mobile device with a built-in radio; and from minicomputers to mainframe computers.

### Physical Environment

Probably cited for its effects on automation more than any other element is the physical environment. As a combat logistician recently commented,

The system has got to work where the maintenance technician has to work, and this is critical where no manual alternative exists. Yet, if you're in a situation such as we are today with "black box" maintenance, where you simply cannot fix a "black box" in a non-air conditioned place because you have to have humidity control, etc.; then it makes no sense to get a support device that takes three pounds of nuclear over-pressure, works under three feet of water, and will take 500 G's. A human can't survive 500 G's and a technician won't normally work under water in the Air Force. It has got to make sense! If the computer won't work in dust; well, now you've got a problem. For a technician can work in dust and normally does.<sup>14</sup>

Echoing the same sentiment in different words, a major manufacturer of computers built to military specification says:

Why pay extra for survivability features that enable the equipment to withstand battlefield conditions that their human operators cannot endure? For example, it seems redundant on some programs to require an operating temperature range of  $-55^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$  [the common military requirement for operations] for equipment that will be configured within an air-conditioned S-250 or S-280 ground-based shelter, a surface ship's combat information center, or an aircraft's crew compartment.<sup>15</sup>

What is needed, then, is a balance between the environment, logistics-support possibilities, and the basic underlying requirement that "the system . . . work where the maintenance technician has to work."<sup>16</sup>

An example of how a deployment can be accomplished without requiring the stringent specifications of MIL-E-5400, MIL-E-4158, and MIL-E-16400 comes from an actual deployment of the 21st Tactical Fighter Wing's F-15s to Alaska during Cobbler Freeze '87.

Ambient temperature was minus fifty-one degrees Fahrenheit. Wind chill factors brought the apparent temperature down to 100 below zero. "We were working under the barest of bare-base conditions," said CMSgt James Helms, 21st TFW maintenance supervisor. "We had absolutely no aircraft hanging facilities. So all maintenance, no matter how extensive, had to be performed on the flight line. In order to maintain the aircraft, we had to do some innovative things. For example, . . . we borrowed some parachutes . . . and rigged a shelter. . . . We used cargo straps to pull the chutes across the aircraft wings, then put sandbags around the bottom. Then we piped heat in with a hose. It was surprisingly warm; the kids could take off their parkas and work barehanded to complete the repairs."<sup>17</sup>

Yet, even with this situational evidence, determining whether an automated technical order system requires full military specification, hardening of commercial equipment, or acceptance of commercial hardware at the expense of some survivability, remains a difficult choice.

But consider the implied question, "what constitutes a balanced environmental concern?" Appendix D contains the relevant excerpt of environmental considerations in the August 1987 multimillion-dollar contract for the standard Air Force and Navy lap-held microcomputer system. It was acquired because it can operate in many deployment situations. Temperature, humidity, and power were key considerations.<sup>18</sup>

About the power problem, it "is not one of availability, but rather one of reliability and quality (consistent in terms of voltage and cycles)."<sup>19</sup> AFLMC recognizes that power in deployed locations outside the United States, particularly during wartime, will not meet standards to which US consumers are accustomed. But the availability of power was not considered a problem:

If we intend to go to war with microcomputers and depend on them to increase mission capability, then we must procure and stock standby, uninterruptible power supplies (UPS) to ensure we have continuous, reliable electrical power.<sup>20</sup>

In addition to these basic considerations, a number of others exist. They are detailed here as concerns for battlefield survivability involving mechanically, radiologically, biologically, and chemically induced failures.<sup>21</sup>

The easiest battlefield concerns to address are the mechanically induced computer failures.

Mechanical failures can occur in one of two ways. The most obvious [way] is that attacking forces could damage a computer. However, the daily abuse that any electronics used on the battlefield would receive is also a concern.<sup>22</sup>

The former factor is largely an unknown. The general tendency is to "harden" computers used for deployment. Hardening is expected to protect against mechanical failures induced by the operational environment and those induced by mishandling. But hardening requires the user to bear a weight penalty and additional penalties may be paid in ease of use and maintainability. Yet, this need not be the case.

Many computers intended for tactical use have been manufactured to military specifications which improve their reliability. Because of expense . . . and an increasing tendency to use NDI (nondevelopmental items), there has been a recent trend away from Mil-Spec computers. . . . Instead, the DoD is purchasing ruggedized versions of commercial computers, ranging in complexity from PCs to mainframes. In many cases, the ruggedized version actually has been smaller and lighter than its commercial counterpart. [And] it is probably safe to state that mechanical survivability is no longer a severe concern.<sup>23</sup>

"Nuclear survivability, however, is a concern."<sup>24</sup> Our basic understanding of hardening against radiologically induced failures is the direct result of our experience in space. But there have been few space systems to consider, and the cost is prohibitive when the number of computer devices needed in deployment situations is considered.

It is most likely that hardness requirements will be defined at levels comparable to ones personnel can tolerate. With minimal shielding, these levels should be achievable with standard CMOS [configuration management operating system] devices.<sup>25</sup>

Electromagnetic pulse (EMP) is a much more difficult problem than radiation. A destructive form of energy, EMP is released with a nuclear explosion. It is particularly damaging to computers, communications equipment, and radars.

Personnel can tolerate levels of EMP that will destroy electronic circuits, and the susceptibility of integrated circuits to EMP increases as feature sizes shrink.<sup>26</sup>

Protecting against EMP can be accomplished to a degree by increasing the fault tolerances of computer devices and replacing conventional wiring with optical fibers.<sup>27</sup> And an Arlington, Virginia, firm has done extensive testing of an "isolator electronic equipment shelter" that apparently provides a high degree of EMP protection.<sup>28</sup>

The difficulty of the hardening task depends upon several factors--the dose rate level, most obviously, the circuit configuration and the types of components required or available for the application.<sup>29</sup>

Finally, an understanding of biologically and chemically induced failures is needed. The Air Force "obviously need[s] research into the possible effects of such agents upon electronic equipment."<sup>30</sup> Nevertheless, it appears likely that the protection necessary for an automated technical order system will be driven more by the level of protection necessary for the system's operator. "This would be accomplished through shelter design."<sup>31</sup>

On the whole, the prognosis for battlefield survivability is good, but we must reassess threats in all four areas [mechanical, nuclear (radiological), biological and chemical] to ensure that they are anticipated in tactical computer designs.<sup>32</sup>

#### Notes

1. Capt Vaughn D. Wassem, "Taking Microcomputers to War: What Transporters Have Learned," Air Force Journal of Logistics 10, no. 4 (Fall 1986): 2.

2. Lt Col Thomas E. Thurston, "Tactical Basing Issues," Research Report No. AU-AWC-87-213 (Maxwell AFB, Ala.: Air War College, March 1987), 47-48.

3. Lt Col Thomas C. Nettles, "Project RELOOK: The Case for Base Self-Sufficiency," Air Force Journal of Logistics 11, no. 4 (Fall 1987): 7.

4. Lt Col Phillip L. Harris, Air Force Logistics Management Center (AFLMC/LGM), "Deployed Automation Requirements," briefing, Headquarters USAF/LEX, 17 February 1988.

5. Lt David M. Crippen, Maj Susan E. Alten, and James K. Shaw, Deployable Core Automated Maintenance System (DCAMS), AFLMC Project No. LM831215 (Gunter AFS, Ala.: AFLMC, August 1984), 2.

6. Capt Donald C. Fandre, Interim Deployable Maintenance System (IDMS), AFLMC Final Report LM840302 (Gunter AFS, Ala.: AFLMC, June 1987), 5.

7. M. B. Berman and C. L. Batten, Increasing Future Fighter Weapon System Performance by Integrating Basing, Support, and Air Vehicle Requirements, Rand Note N-1985-1-AF (Santa Monica, Calif.: Rand Corporation, April 1983), 3.

8. Lt Col Phillip L. Harris, Capt Gary Gemas, and Larry Hartman, interviews with author, 17 February 1988.

9. Lt Col William T. McDaniel, Jr., "Combat Support Doctrine: Coming Down to Earth," Air Force Journal of Logistics 11, no. 2 (Spring 1987): 14.

10. Lt Col Phillip L. Harris, briefing, Air Force Logistics Management Center (AFLMC/LGM), 17 February 1988.

11. Ibid.

12. Nettles, 5.

13. Comments from several qualified AFLMC logistics personnel indicate intention to advocate and support automated system developments using Air Force standard microcomputer systems; that is, Z-248 and Z-184 (17 February 1988).

14. Lt Col Phillip L. Harris, Air Force Logistics Management Center (AFLMC/LGM), interview with author, 17 February 1988.

15. William Morrison and David M. Russell, "C<sup>3</sup>I Programs Demand Cost-effective Data Processing Solutions," Defense Science & Electronics 6, no. 1 (January 1987): 30.

16. Harris interview.

17. Rana Pennington, "Eagles Over the Icepack," Air Force Magazine 70, no. 7 (July 1987): 88.

18. Air Force Computer Acquisition Center (AFCAC), AFCAC Project No. 275, Contract No. F19630-86-R-0011, 21 July 1986 (the date is the date of Request for Proposal [RFP] issue); according to Jerry Goodwin, acting branch chief, Test and Evaluation Branch, Small Computer Acquisition Office, Standard Systems Center (SSC/SSMCT), Gunter AFB, Ala., interview with author, 17 February 1988 (the contract was awarded on 12 August 1987).

19. Capt Vaughn D. Wasseem, "Taking Microcomputers to War: What Transporters Have Learned," Air Force Journal of Logistics 10, no. 4 (Fall 1986): 2.

20. Ibid.

21. "Computer Survivability on the Battlefield," Defense Science & Electronics 5, no. 5 (May 1986): 58.

22. Ibid.

23. Ibid.

24. Ibid.

25. Ibid., 59.

26. Ibid.

27. Ibid.

28. Dr Norman J. Rudie, "Hardening Techniques," Defense Science & Electronics 5, no. 4 (April 1986): 63.

29. Ibid.

30. "Computer Survivability," 59.

31. Ibid.

32. Ibid.

## CHAPTER 5

### CONCLUSIONS AND RECOMMENDATIONS

This research built a framework for understanding the many considerations attendant to integrating an automated technical order system into Air Force deployments. The need for an automated technical order system, which stems from weaknesses in the current system, was detailed in chapter 2. The three major development programs--ATOS, ITDS, and IMIS--that are addressing the need and the deployability requirements were summarized in chapter 3. In chapter 4, with a focus on deployment under crisis management/wartime conditions, several environmental variables were related to the use of computer systems. This chapter covers conclusions and recommendations concerning the use of an automated technical order system for Air Force deployments. Implications for further research are also discussed.

The first conclusion apparent from this research is that a replacement of the AFTO system is long overdue. That the replacement should be an automated system is supported by both DOD and the Air Force, especially as they are associated with the computer aided acquisition and logistics support (CALS) initiative. There is a need to expedite distribution and eliminate the intolerable loss of maintenance time to administrative overhead. For even though the processes have been improved by innovations in document design and new technologies, the system is no longer responsive to its users; nor is it fulfilling its mission intent.

Although aware of the need for a better system, users at the "retail" level are nevertheless concerned that the AFTO system's replacement will fail to consider and properly account for all the benefits derived from the current system. These benefits include the resource management standards and the technical data content standards that give the system universal applicability and make standard training possible. In addition, these users indicate that standardized training and the capability of Air Force maintenance technicians to troubleshoot equipment are threatened by a "leakage" of technical data from the AFTO system.

Tech data [is] being siphoned out. . . . The first place we saw it was in the AIS, an intelligent test bench used in the intermediate shop, with the intelligent part being the tech data. . . . The bench holds the data for assessment, and the AIS makes the assessment. So,

we called it automated test equipment (ATE). We didn't call it test equipment that has tech data buried in it, so it escapes this whole discipline of the AFTO System. Now it is AIS for the F-15 and F-16, Comprehensive Engine Management System (CEMS) for engines, and things coming up like the Computerized Fault Reporting (CFR) System. So, what you've got now is that the poor user sees no standards.<sup>1</sup>

Yet another danger exists in replacing the AFTO system, however: The undocumented but essential relationships that have evolved between this system and others could be misinterpreted or ignored.

We fail to perceive the true relationship between the technical order process--the AFTO System--and our resource management system. The two have been invisibly, yet carefully, lashed together. It was never written down. . . . Now, automation is just shredding that interaction--that mutual dependence that one system has on the other.<sup>2</sup>

It is clear, then, that environmental considerations go far beyond those posed by the physical environment. They must include the purpose and nature of the deployment, the size of the force deployed, the duration of the deployment, technical data requirements, maintenance and communications capabilities, and intensity. In addition, careful consideration must be given to protecting automated equipment against environmental effects by means other than imposing military specifications for device hardening.

This research suggests that the nondevelopmental item approach should be pursued in the development of an automated technical order system. A system that is adaptable to the factors in the deployment environment discussed in chapter 4 is recommended as a minimum consideration. Development of a deployable system as an afterthought to a "wholesale" logistics system should be avoided, as should a system that is distinct in size and function from that required and used at an established and fully functional base.

A formal and complete study should document the current AFTO system and its relationships with existing resource management and training systems. The knowledge gained should be utilized in replacing the AFTO system in an evolutionary, across-the-board process.

Future research should also focus on environmental standards and the performance limits of maintenance personnel. The research results would be helpful as a guide for developing realistic environmental constraints for computer hardware and software.

The technical data support problem is important not only to our own forces; with increased sales of frontline systems to our allies, it may yet prove to be a foreign policy disaster.

#### Notes

1. Lt Col Phillip L. Harris (AFLMC/LGM), interview with author, 17 February 1988.
2. Ibid.

## APPENDIXES

## APPENDIX A

### TECHNICAL ORDER SYSTEM LIFE CYCLE

Air Force Regulation 8-2 authorizes the current Air Force technical order (AFTO) system. The technical order (TO) life cycle from preconcept analysis through printing and distribution to the end user is shown in figure A-1 on the following page. A block-by-block description of the flow chart accompanies figure A-1.

#### DESCRIPTION OF EVENTS SHOWN IN FLOW CHART

Block 1--Maintenance Concepts. Planning for TOs to support a system and associated equipment begins with the integrated logistic support plan. This document includes the maintenance concept and shows the type of maintenance to be performed, the levels of maintenance, skills type and level, etc. From this information, TO needs can be decided.

Block 2--Technical Order Planning Conference. For major systems and equipment, a TO planning conference is held. Within 60 days after the award of the system contract [sic], the system manager (SM)/item manager (IM), Air Logistics Center (ALC) requests the HQ AFSC program manager to conduct the conference. During this meeting, HQ AFSC, HQ AFLC, using command, ATC, and contractor decide specific TO requirements for support of the system and associated equipment.

Block 3--Procurement of Technical Orders. MMEDT documents TO requirements through use of numbered AFAD 71-531 series and the Contract Data Requirements List (DD Form 1423). Military specifications are used to provide the instructions for preparation of TOs. The applicable specifications are listed in Data Item Description DI-M-3407; current dates, amendments, and revisions are contained in the Department of Defense Index of Specifications and Standards (DODISS). When requirements have been properly documented, HQ AFSC funds and procures the TOs. Once TO requirements are established, the HQ AFSC program office won't alter any requirements without agreement of the SM/IM.

Block 4--CFAE/CFE Notice System. The contractor-furnished aerospace equipment (CFAE)/contractor-furnished equipment (CFE) notice method is used when large numbers of TOs are involved or the TOs can't be predetermined. The contractor submits CFAE/CFE notices as equipment is developed or



selected. Recommendations for TOs are included. The SM/IM ALC decides if the recommended TOs are needed and, if so, approves the notice for inclusion in the contract.

Block 5--ALC Approves TO Requirement. ALC-approved TOs are placed on contract. If conflicts occur between HQ AFSC and HQ AFLC agencies relating to TO requirements, they are elevated to the necessary level for resolution.

Block 6--Contractor Prepares Technical Orders. The same contractors who sell the equipment to the Air Force usually prepare the TOs using proper military specifications. Commercial manuals may be furnished when it is more economical, practical, or timely, and if the commercial manuals are considered adequate by MMEDT, MM\_R, using command, and the SPO. (Note: The "-" is commonly used to generalize the functions performed by a number of organizations with office symbols that only change where the symbol is used.) When technical data is needed from two or more associate contractors, one is given prime responsibility. Through the procuring agency, MMEDT assists the contractor in TO preparation with interpretation and clarification of requirements or specifications.

Block 7--Validation and Verification Reviews. All TOs are subject to review. Provisions for reviews are merged in the contract. The reviews are accomplished in a manner that ensures the Air Force receives the highest quality technical orders. The reviews are done prior to delivery at the contractor's plant or on site. The reviews ensure compliance with military specifications, work statements, contractual documents, and adequacy of technical content.

Block 8--Contractor or Local Printing. TOs are printed either by Government Printing Office (GPO) contractor or in the ALC printing plants using reproducible copy or negatives delivered by the contractor.

Block 9--Technical Order Distribution System and Block 10--TO Using Activities. Initial distribution of TOs is made according to instructions established through the G022 system/TO 00-5-2 at Oklahoma City Air Logistics Center (OC-ALC/MMEDU). (Special weapons TOs are excluded from the G022 system. Initial distribution is made according to instructions provided by SA-ALC/SWPPT.)

Block 11--ALC Obtains Technical Order Number from OC-ALC. When the SM/IM ALC approves the TO requirements in block 5, a separate series of actions begins at the central TO distribution organization at OC-ALC. OC-ALC centrally assigns numbers to all Air Force TOs except special weapons TOs. San Antonio Air Logistics Center (SA-ALC/SWPPT) is the

central TO distribution organization for special weapons TOs and assigns these TO numbers.

Block 12--OC-ALC Lists Technical Order in TO Index and Block 12A--OC-ALC Prepares Indexes. OC-ALC and SWPPT lists TOs in the TO index from which using activities may identify their TO requirements.

Block 13-19 (respectively)--Using Activities Furnish TO Quantitative Requirements, OC-ALC ADP Machine Output, Listing of ID Quantities, AFTO Form 273 ID, ALC Review of Requirements and Backup Quantities, Total Printing Requirements, Approved AFTO 273. The using activities' requirements are machine processed by OC-ALC and SWPPT to set up printing quantities and shipping labels. AFTO Form 274, Initial Distribution Label, applies to classified shipments. The SM/IM ALCs review these requirements and decide backup stock requirements. These collective actions decide the total printing requirement. The publications are then normally distributed directly from the printer.

Block 20--Using Activity Requisition. If using activities have requirements in addition to those previously established (block 13) they submit increased requirements with requisition or one-time requisitions through the G022 system at OC-ALC and SWPPT.

Block 21--OC-ALC Prepares AFTO 273 Requisition. The G022 system outputs requisitions at the prime ALC.

Block 22--Prime ALC. Prime ALC fills requisitions from backup stock to using activities (block 20).

Block 23--Backup Stock. The prime ALC keeps a backup stock of TOs from which to satisfy requisitions.

Block 24--Reprint Backup Stock Quantity. Reprints are done as needed to keep a backup stock.

Block 25--Command Reviews. After the TOs are in use, there are several ways they may be changed or completely revised. Some TOs, particularly flight manuals, are subject to periodic command reviews. These reviews may result in changes to the TOs based on operational experience.

Block 26--AFR 66-1, Maintenance Management Policy, and AFR 66-5, Single Manager for Modification, Major Maintenance and Test Programs on Air Force ICBM Systems, Data. The maintenance data collection system (MDCS) may show deficiencies that require correction through the TO system.

Block 27--AFTO 22 System. Using activities submit TO improvements on AFTO Form 22, which may result in TO updates.

Block 28--ECPs and MIPs. Modifications generated through [sic] engineering change proposals (ECPs), and materiel improvement projects (MIPs) result in many changes to TOs. The impact of a modification is sometimes greater on TOs than on the equipment itself.

Block 29--Technical and Engineering Review. All proposed TOs are processed through a technical and engineering review to preclude negative impact on other systems and ensure positive Air Force impact.

Block 30--Publication Change and TCTO. MMED publishes changes to applicable Time Compliance Technical Orders (TCTOs).

Block 31--Prepares Data and Fabricates Kits. Modification kits and TCTO information must be available for mod proofing and must be released concurrently.

Block 31A--AFLC Form 874, Supply Information. AFLC Form 874, TCTO supply data requirements, contains vital information to ensure parts availability and to preclude overrequisitioning of parts no longer required. MM\_P must closely monitor each modification to ensure proper preparation and distribution of the form.

Block 32--Mod Proofing. All modifications must be proofed to ensure that TCTOs are accurate and understandable and that all required parts are available.

Block 33--ALC Concurrent Release. TOs, TCTOs, and modification kits are released at the same time by the ALC. Printing and distributing TO changes associated with modifications are done in the same manner as the basic publications (blocks 8-10).

Blocks 34-36 (respectively)--Kits, Drawings, Stock Lists, etc.; Other Distribution Systems; TO Using Activities. Kits and other materiel are distributed by the appropriate systems to the using activities.

## APPENDIX B

### AUTOMATED TECHNICAL ORDER SYSTEM WORK FLOW

When a technical order (TO) change request is received, the production manager enters the change package as a "job" into ATOS at the production control system (PCS) terminal. If the TO pages affected by this change are not in the ATOS data base, a review session is held to determine the most efficient method of entering the data into ATOS. New data can be captured using the Capture Subsystems or created on text entry or computer-aided design (CAD) graphics workstations. The type of information on the page, the quality of the copy, and the current operator work loads are factors which determine the methods to be used. PCS routes the text and graphics data files to the operators assigned to the job. The workstation operators enter the change indicated by the production manager and print copies of the changed pages for review and approval.

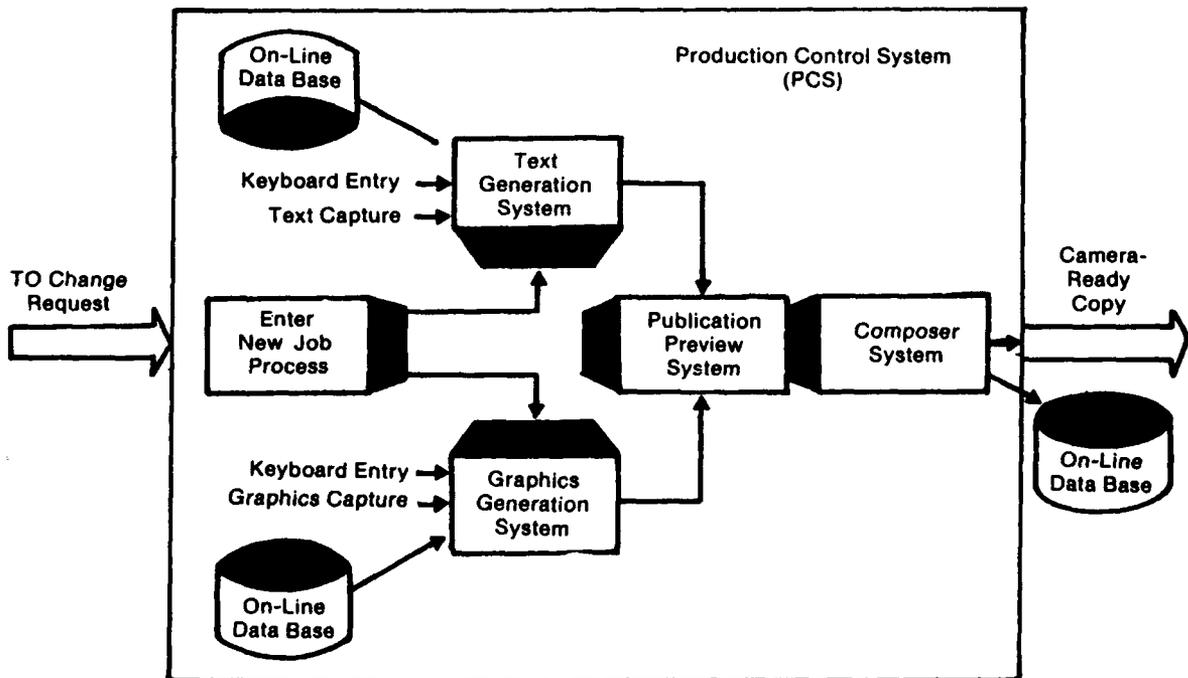


Figure B-1. ATOS Work Flow.

**Source:** SYSCON Corporation, prime contractor for ATOS phase I, developed this diagram to illustrate the system of their design.

When all of the changes to text and graphics have been approved, PCS routes the pages to the publication preview subsystem for final review prior to phototypesetting on the composer subsystem. Completed pages are camera-ready copy ready for printing.

The text and graphics files stored in the ATOS data base provide the data necessary to produce additional changes or a revision of an entire document. The ATOS data base also contains the data necessary to reproduce camera-ready copy of previous changes so that the change can be reproduced if the original copy or the plate made from it is damaged.

## APPENDIX C

### STAGE III: FULL INTEGRATED MAINTENANCE INFORMATION SYSTEM DEMONSTRATION

The IMIS concept consists of four major subsystems: (1) the technician's portable computer/display; (2) an aircraft maintenance panel connected to on-board computers and sensors; (3) a maintenance workstation connected to various ground-based computer systems; and (4) sophisticated integration software which will combine information from multiple sources and present the data in a consistent way to the technician.

The technician's primary interface with IMIS will be the extremely portable battery-powered unit, which is rugged enough for flight line use (fig. C-1). A library of removable memory cartridges will store all the technical order information and diagnostic aids needed for one weapon system. The memory cartridges will be designed for fast, easy, and accurate updating. A high resolution, flat panel display will clearly display data under all lighting conditions. The man-machine interface will be designed for ease of operation to eliminate the need for the user to have typing skills. The portable computer will have the processing power to quickly display complex graphics and provide rapid response to the technician's request. Interactive troubleshooting routines and artificial intelligence-based diagnostic aids will provide advice for difficult fault isolation problems. (It is important to point out that the portable computer will function independently to display most of the information the

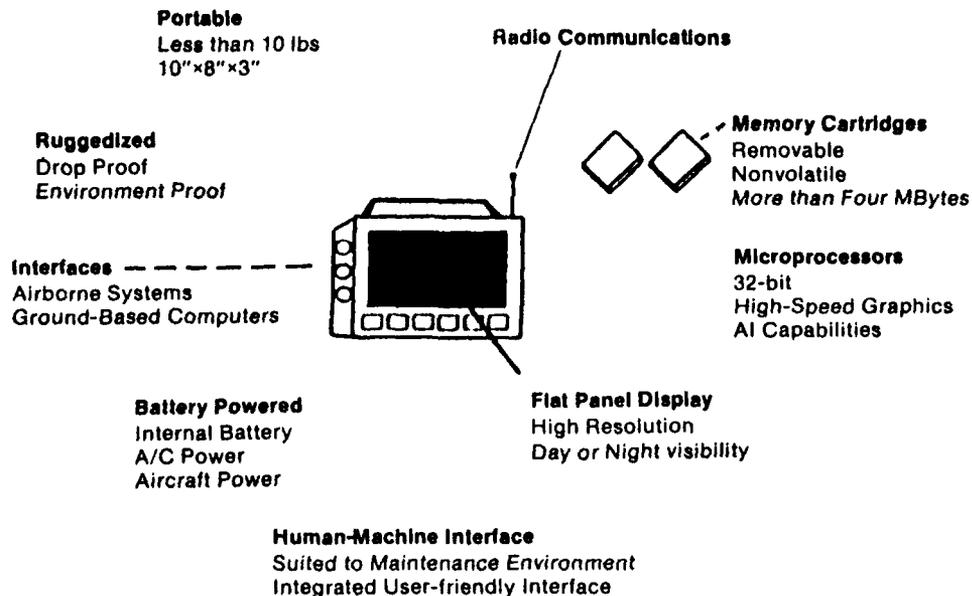


Figure C-1. Portable Maintenance Computer Concept.

technician needs for on-equipment maintenance. Even if the base-level computer systems are unavailable or the aircraft systems are malfunctioning, the computer will be able to display technical order information and diagnostic aids to the technician.)

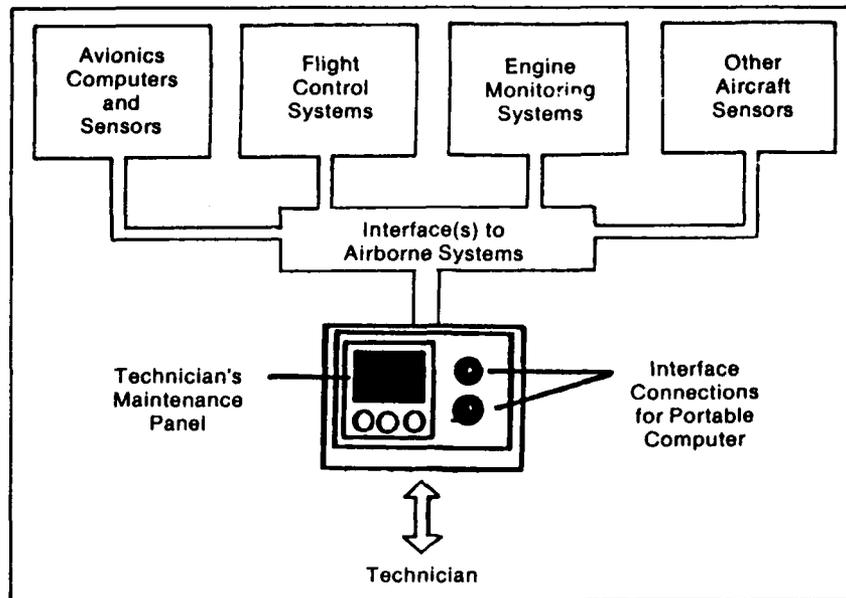


Figure C-2. Aircraft Maintenance Panel.

The technician will be able to perform most aircraft maintenance tasks without climbing into the cockpit. An aircraft maintenance panel on the outside of the aircraft will provide the interface with onboard systems (fig. C-2). The portable computer will be able to retrieve and analyze flight information, interrogate or control available built-in-test systems, or input test signals for diagnostics. The interface panel will also be used to upload or download mission configuration/capability information.

The technician will interface with ground-based systems through a maintenance workstation (fig. C-3). The desktop workstation will include a keyboard, a printer, and a computer interface. The interface will have the protocol software required to access the other available data system. The portable computer will connect to the workstation and provide the display and processor for the workstation. The technician will then be able to access and exchange information with systems like the core automated maintenance system (CAMS) and the automated technical order system (ATOS).

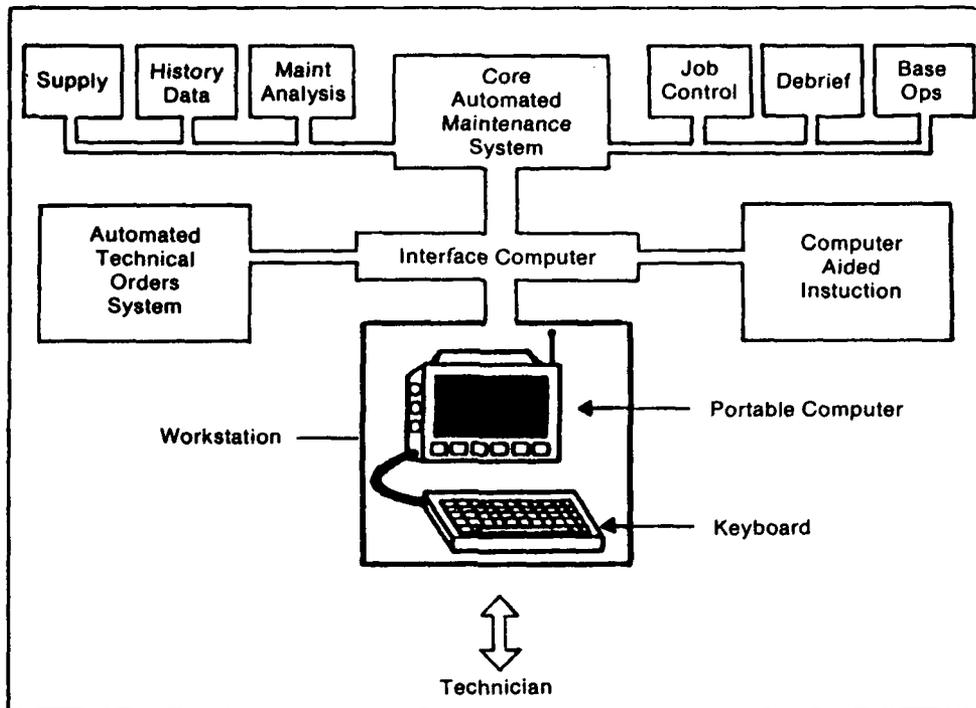


Figure C-3. Maintenance Workstation.

The most beneficial feature for the technician will be the integration of information. Instead of dealing with several automated systems and accessing separate groups of information through several devices, the technician will access all information through one device (fig. C-4). At a

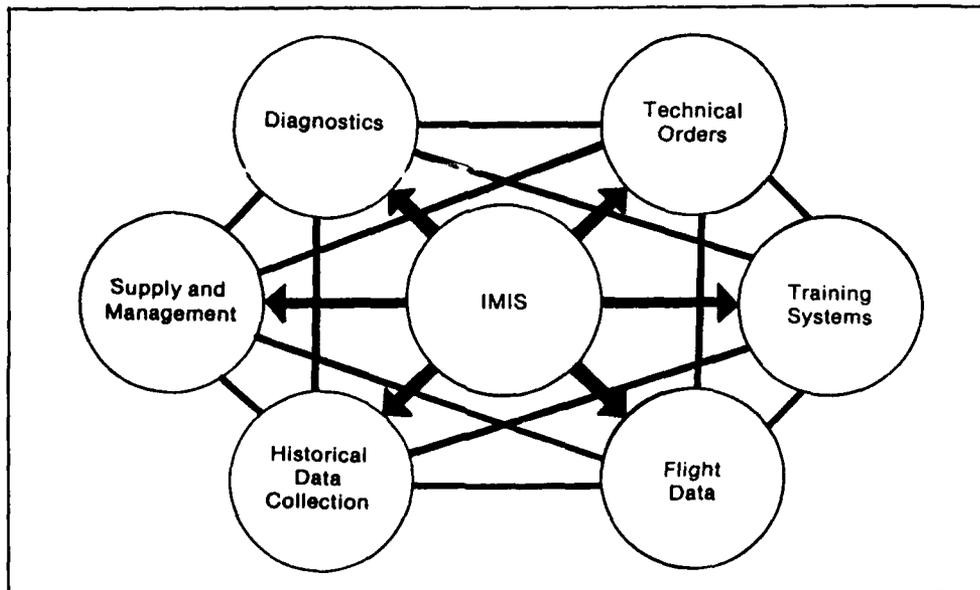


Figure C-4. IMIS Information Integration.

superficial level, the system will integrate information by employing standard commands and display formats. At a deeper level, through sophisticated software, the system will integrate information from all available sources to provide a coordinated maintenance package.

The development of the full IMIS demonstration will proceed in four phases. During the first phase, a structured analysis methodology will be used to determine an information system architecture. This architecture will define requirements for users' information needs, for interfaces, and for functional implementation. The second phase will be the hardware and software analysis, design, and review. Hardware fabrication and software programming, along with system tests and reviews, will occur during the third phase. Finally, in the fourth phase, the system will be evaluated in the operational environment by Air Force maintenance technicians. The product of the IMIS effort will be field tested and validated so that specifications for implementing this maintenance concept on Air Force weapon systems can be drafted.

## APPENDIX D

### EXCERPT OF DOD CONTRACT F19630-86-R-0011, DOD STANDARD LAP-HELD MICROCOMPUTER SYSTEMS

Note, although a DOD standard was established by this contract, only the Air Force and Navy are bound to use the standard. The Army may do so, as it wishes. The environment-related conditions are extracted verbatim, with intervening references eliminated where unrelated to environmental conditions to be met by the lap-held microcomputer acquired.

Environment and Physical Facilities. The system shall be capable of normal operation within the physical facilities and throughout the range of power and environmental tolerances stated below.

#### a. Facilities:

(1) Power. All equipment must have the ability to operate from a 105-125 VAC, 50 and 60 Hz Single Phase Power source. The equipment must also have the capability to operate with 210-240 VAC, 50 and 60 Hz single phase power. This capability can be switchable on the equipment or be supplied separately. . . .

(2) All equipment must meet the National Electrical Code (AFOSH Standard 127-11).

b. Environment Conditions. No site air conditioning or environmental conditioning will be provided. The system will be used in offices, public and private transportation, commercial, establishments, homes, submarines, ships, trucks, aircraft, and other environments. All equipment must operate under the following environmental conditions:

(1) Operating temperature: 10 to 40 degrees Celsius (50 to 104 degrees F).

(2) Storage/Transport temperature: -25 to 56 degrees Celsius (-13 to 140 degrees F).

(3) Humidity: 20 to 80 percent (noncondensing).

(4) After the lap-held microcomputer has been removed from the storage/transport environment, the system must be capable of full, normal operations within 60 minutes.

n. Power. The lap-held microcomputer . . . must operate with and include the following power devices:

(1) Rechargeable battery pack. The battery pack shall power the lap-held microcomputer for a minimum of 3 hours of continuous use (prior to any low battery indication) with 20-percent dual-drive disk usage (with only one of the two drives in use at any one time). . . .

(2) AC/DC adaptor. The adaptor must:

(a) Accept power from 100 to 130 VAC at 50/60 Hz.

(3) Step down power converter. The step down power converter must:

(a) Convert power from 190-240 VAC 50/60 Hz to 105-125 VAC 50/60 Hz.

(4) Line conditioner/stabilizer. The line conditioner/stabilizer must:

(a) Convert power from 96-138 VAC 50/60 Hz to 105-125 VAC 50/60 Hz.