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United States Air Force
Technical Order
Management System (AFTOMS)

December 1989

AFTOMS TECHNOLOGY ISSUES & ALTERNATIVES REPORT

FINAL REPORT

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U. S. Department of Transportation
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This report was prepared to document the findings from the Proof of Concept (POC) work done in FY89 and the early part of FY90 on the US Air Force Technical Order Management System (AFTOMS) project. The objectives of the POC work were: Further development of the system concept presented in the AFTOMS Automation Plan-Final Report, Dated February 1988; Evaluation of the economic feasibility of the system concept (findings documented separately in an FY89-FY90 Feasibility Study, dated December 1989); and Evaluation of the risks associated with the system concept, technologies required to implement AFTOMS, and identification of risk abatement strategies. This report is an important document in the definition phase of AFTOMS preceding the system's full-Scale Engineering Development (FSED); the report will influence the final requirements in the Request for Proposal (RFP), the source selection evaluation criteria, and the architectural design of AFTOMS. Any constructive comments or inputs are welcome so that this document will be accurate and useful for the program.

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PREFACE

This Technology Issues & Alternatives Report was prepared by the Transportation Systems Center (TSC) of the U.S. Department of Transportation (DOT) to document the findings from the Proof of Concept (POC) work done in FY89 and the early part of FY90 on the U.S. Air Force Technical Order Management System (AFTOMS) project. AFTOMS is the first major implementation resulting from the Air Force Computer-aided Acquisition and Logistic Support (CALS) program.

The objectives of the POC work were:

- Further development of the system concept presented in the *AFTOMS Automation Plan–Final Report*, dated February 1988;
- Evaluation of the economic feasibility of the system concept (findings documented separately in an FY89–FY90 Feasibility Study, dated December 1989); and
- Evaluation of the risks associated with the system concept, technologies required to implement AFTOMS, and identification of risk abatement strategies.

The POC work was performed under the direction of the Information Integration Division at TSC. TSC has drawn upon the skills, knowledge, and professional work of several organizations forming a multi-faceted team of experts, each of whom has made a vital contribution. TSC would like to extend its gratitude to the following organizations: EG&G DYNATREND Inc. and UNISYS Inc.

AFTOMS POC risk assessment and abatement was performed using a closely integrated dual approach: a hands-on effort to design and build a Demo System; and a hands-off effort to evaluate and assess AFTOMS, its technology, and integration needs.

This report is an important document in the definition phase of AFTOMS preceding the system's Full-Scale Engineering Development (FSED); the report will influence the final requirements in the Request for Proposal (RFP), the source selection evaluation criteria, and the architectural design of AFTOMS. Any constructive comments or inputs are welcome so that this document will be accurate and useful for the program.

This document is a typical product of the technical documentation management system that will evolve through the implementation of AFTOMS. Although this document does not conform to MIL-STD 1840, the Automated Interchange of Technical Information (AITI) standard, or incorporate Standard Generalized Markup Language (SGML) tags, it illustrates several of the system features that will be applicable for AFTOMS. These system features include:

- Integration of text, graphics and tables;
- Electronic storage and component configuration control;

- Revision capability and change control; and
- Computer-based printing on demand.

A 300 dpi laser printer was used to print this document; this printer resolution is the minimum recommended for on-request printing of digital technical orders (TOs) distributed and managed by AFTOMS.

EXECUTIVE SUMMARY

INTRODUCTION

This executive summary to the AFTOMS Technology Issues & Alternatives Report is broken down into the following headings:

- **CALS Program and TSC's Role**; a historical introduction covering the FY 85–FY89 time frame;
- **Existing (As-Is) TO System**; an overview of the current manually-oriented system and its problems;
- **Automated (To-Be) TO System Concept**; a brief introduction to the future automated AFTOMS;
- **AFTOMS Proof of Concept (POC)**; an overview of TSC's FY89–FY90 work; and
- **Key Conclusions and Recommendations.**

CALS PROGRAM AND TSC'S ROLE

This introduction covers the time period from inception of the Computer-aided Acquisition and Logistic Support (CALS)[1] Program in FY85 through planning for the FY89 AFTOMS POC work at TSC.

The CALS Program was established to improve weapon system reliability and maintainability, and to reduce the costs of weapon system acquisition and support. One major continuing objective of the CALS Program is to improve the delivery and handling of large quantities of technical data. CALS will significantly reduce the amount of paper and labor necessary to enter, manipulate, transfer, and interpret such data.

In June 1985, a joint industry/DoD Task Force on CALS issued a five volume report (IDA R-285), which presented the objectives and scope of the program, as well as a top-level management and implementation plan. On 18 October, 1985, Program Management Directive (PMD) 5260(1), Automation of Technical Information and Computer Aided Logistics Support (CALS), established the CALS program and chartered the Air Force CALS Management Integration Office (MIO) at Headquarters (HQ) Air Force Systems Command (AFSC) to coordinate the CALS program within the Air Force. The MIO is responsible for planning, developing, and implementing CALS initiatives.

Initially, the MIO identified three areas of technical information for review and improvement: Technical Orders (TOs), Product Definition Data (PDD), and Logistics Support Analy-

1. This is the current title of the program; originally, "Acquisition" was not in the title, the "A" in the acronym stood for "Aided", and Logistic was plural.

sis (LSA). In 1986, TSC was contracted by the AFSC MIO to provide systems engineering support to create automation plans for these areas.

The initial TSC support consisted of review and analysis of existing programs and standards. TSC developed a modular planning process, essentially an information engineering system approach, to perform the activities associated with automation planning. In 1987, it implemented this planning process in developing a 7–10 year automation plan for TOs, broken down into three distinct phases. These phases are listed below, along with the time frames in which they were conducted for TOs:

- **As-Is**. An examination of the existing environment (March–June, 1987);
- **To-Be**. A study of opportunities and initial formulation of a system concept for automation (May–August, 1987); and
- **Automation Plan**. Consensus building within the Air Force for refining the concept, mobilizing action on it, and developing a plan for future direction (July 1987–February 1988).

The AFTOMS concept that evolved from the modular planning process was a result of combining TSC analyses with ideas received from the Air Force and industry; this formed the basis for the TO automation plan, documented in DoD-VA 856-88-3, *AFTOMS Automation Plan* - Final Report, dated February 1988.

Responsibility for AFTOMS exploration, definition, development, and deployment was assigned in FY88 to the Air Force Logistics Command (AFLC); this command established an AFTOMS System Program Office (SPO), located at Wright-Patterson Air Force Base (WPAFB) in Dayton Ohio, to manage all necessary work to implement the AFTOMS Automation Plan. For the remainder of FY88, TSC supported the SPO in briefing the AFTOMS concept within the Air Force community and in planning the POC work which began in FY89.

The purpose of the POC is to investigate the AFTOMS concept more deeply and systematically, identify and assess its benefits and risks, find approaches for avoiding or abating those risks, and identify any previously overlooked opportunities; these will provide early technical input to the SPO that can be used to leverage and enhance AFTOMS success. Such input also provides a basis for supporting RFP technical requirements preparation, source selection criteria for evaluating RFP responses from contractors, and various AFLC and DoD program reviews.

EXISTING (AS-IS) TECHNICAL ORDER SYSTEM

The Air Force established the existing TO system in the 1940s. This system is the official medium for disseminating technical orders, instructions, and safety procedures for Air Force systems and equipment. According to AF Regulation (AFR) 8-2, TOs are military orders issued in the name of the Chief of Staff, U.S. Air Force (USAF), by order of the Secretary of the Air Force, and require mandatory compliance. The existing TO system is primarily a manual operation.

Currently, there are over 150,000 TOs in use. These TOs are managed by five AFLC Air Logistics Centers (ALCs) and the Aerospace Guidance and Metrology Center (AGMC); and are segregated by specific weapon system or commodity. The average TO document ranges from 100-to-150 pages in length, comprising 60% text and 40% graphics. The total TO inventory exceeds 20 million original pages of master copy (exclusive of working or distributed copies). Annual production of change pages averages about 2.3 million original pages a year. In addition, the current and growing backlog of unfilled requirements is estimated to exceed 2 million pages.

Four major USAF commands are involved in the creation, use, and management of TOs. AFSC acquires major systems, monitors product development contracts, and conducts test and evaluation efforts (including TO validation and verification) with the assistance of using and supporting commands. The major commands (MAJCOMs) that use the system provide functional requirements, some technical specifications, and participate in test and evaluation efforts. Within AFLC, the ALCs provide the logistics support, including TO maintenance and distribution required for effective operation and maintenance of the systems. Air Training Command (ATC) provides a wide range of training associated with the operation and maintenance of systems, including the use of TOs.

Currently, all USAF TOs are created, inventoried, and distributed as paper documents. Although many documents are created and maintained by contractor systems in paper and digital form, they are delivered to the Air Force as paper copies, since the current USAF TO system is incapable of accepting digital delivery. The Automated Technical Order System (ATOS), implemented at five ALCs and AGMC, selectively scans existing TO pages for digital storage and subsequent editing. However, digital change management using this technique affects only a small portion of the entire TO inventory and its change processing.

Maintenance technicians who need specific TOs, send a standardized TO Request Form (AFTO) to a TO Distribution Office (TODO) who then orders the requested TOs from the Oklahoma City ALC (OC-ALC) central distribution point. The OC-ALC sends a mailing label to the appropriate ALC, which mails the TO to the TODO. Revisions and supplements follow a similar procedure.

A June 1986 report of the HQ Air Force Audit Agency (AFAA) (Audit #5036410, Acquisition of Technical Orders from Contractors) cited several deficiencies in the existing system. These included:

- Contractors frequently fail to provide installation-level TOs in time for Air Force verification;
- Up to 500 days are needed to fully implement a routine change to a TO;

- Error-prone desk-top analysis and validation of TOs is frequently performed in lieu of actual performance of tasks;
- From 1977 to 1986, 47% of Cause Code 1 (Inadequate Technical Data) mishaps listed inaccurate TOs as a contributing factor with resulting equipment losses of about $86 million; and
- The Air Force does not separate the cost of TO preparation from the cost of a weapon system, making cost control difficult.

In conclusion, the present paper-oriented system is inefficient and is unable to meet the growing requirements of the USAF. A single modern weapon system, such as the B1-B, generates approximately 3500 new TOs, adding over a million original master pages to the current TO inventory. This additional volume cannot be managed by the present system in a timely fashion. All these facts brought about the formulation of a practical automation plan that would lead to a more efficient and powerful TO system; AFTOMS, capable of meeting the present needs and the future requirements of the USAF.

AUTOMATED (TO-BE) TECHNICAL ORDER SYSTEM CONCEPT

As discussed in Appendix A, the To-Be system concept was developed during the automation planning phase and refined with supporting detail early in FY89 as part of the POC. Essentially, the current To-Be model views, analyzes, and characterizes AFTOMS from six important perspectives:

- Operational environment;
- System functionality;
- User interfaces and system usability;
- System capacities and performance;
- Technologies needed to build the system; and
- System implementation issues.

The AFTOMS To-Be system requires acquisition of new TOs in digital form only, provides for paper-to-digital scanning conversion of the existing TO inventory, and manages a mixed inventory of TOs (including paper TOs). Since AFTOMS functionality is fully and most productively usable only on digital TOs the automation benefits increase proportionately as the total TO inventory moves closer to total digitization. A digital TO can simply be a computer-based display of a paper document, where individual pages are called up for screen viewing or printing. More useful possibilities include automated interconnection of related material and tailored content presentation based on technician experience level, maintenance task, aircraft tail number, etc. An even more advanced concept (e.g. Type C) would link individual TO data elements under the control of a database manager, which allows the maintenance technician to assemble related TO information on the screen interactively, as tasks require.

In developing a To-Be system concept to manage the acquisition and distribution of digital TOs, consideration was given to a modular functional framework that easily maps to the existing Air Force infrastructure. Modularity allows phased weapon system-based implementation (across ALCs and Air Force bases) at a pace consistent with Air Force requirements and appropriations. To meet the objectives of more accurate, complete, timely and cost effective TOs, the To-Be establishes clearly defined responsibilities and logical information flows.

AFTOMS consists of four tiers whose elements are distributed in functional and organizational location. The four tiers are hierarchical with centralized TO control from the top down. At the top, Tier 1 is a single organization/facility within the Air Force, called the Air Force Technical Order Management Administration (AFTOMA), responsible for the demonstration, implementation, and management of the entire automated TO system. Tier 2 is an expanding network of multiple TO Management Agencies (TOMAs); Tier 3 consists of Consolidated TO Distribution Offices (CTODOs) at base level; and Tier 4 has Work Areas (WAs). AFLC will staff Tiers 1 and 2, whereas the MAJCOMs will staff Tiers 3 and 4.

TOMA TO Centers (TOCs) are subfacilities of an ALC. Each TOMA/TOC is responsible for the management (i.e. acquisition, planning, development, distribution, and updating) of the complete suite of TOs for a single weapon system. It must be emphasized that the TOC's responsibility for the complete suite of weapon system TOs is a major departure from the existing organization. Currently, TOs for a weapon system are the responsibility of several ALCs, each with a different subsystem specialty. In the To-Be concept, the TOMA/TOC needs to acquire and distribute all TOs for a specified weapon system regardless of the TO source organization. Each weapon system will then be supported by a single TOC. This TOC retains all types of TOs in one location to control and improve TO management for that weapon system.

Since weapon systems share many common equipment items, such as engines and avionics, a need exists to create TOCs specializing in these commodities. Commodity TOCs will eliminate the duplication of effort that would occur if each weapon system TOC managed its own commodity TO inventory. Commodity TOCs will not distribute directly to the Air Force bases but only to weapon system TOCs requiring that commodity TO. The weapon system TOC will then place these TOs into its suite for bulk distribution (using optical disk media) to base-level CTODOs. All other functions (acquisition, management, production, etc.) for commodity TOs remain the responsibility of the commodity TOC. In addition to weapon system and commodity TOCs, there will be TOCs to support non-weapon system related TOs for such items as support vehicles, policy and procedures, indices, etc. The AFTOMA will have a non-weapon system TOC to support its administrative TO requirements. Therefore, an ALC will house a mix of TOMA/TOCs each with its own TO responsibilities.

In the AFTOMS infrastructure, each of the top three tiers contains data center facilities designed to provide centralized and distributed computer services/resources at each physical location for tier level organizational processing, communications, production and distribution. At the AFTOMA and TOMAs, these facilities are relatively extensive, providing computers, storage capabilities and printers networked via local-area communications. Each TOC has its own interconnected workstations that are networked to the ALC. Since CTODOs will support base-level requirements, the configuration of their data center will match required capacities. All CTODOs will need to provide administrative processing, TO storage, high speed printing, and communication to the AFTOMA. Configurations will range from Local Area Network (LAN)-based workstation computer systems to minicomputer systems, file servers, and high-speed laser printers.

Top-down data flow through the four tiers of AFTOMS is controlled by the AFTOMA and the associated hierarchy. The AFTOMA maintains a list of all active TOMA/TOCs and their associated weapon systems responsibilities. Therefore, the AFTOMA is ideally positioned to be the control point for TO distribution and authorization. When TO requests are registered by Work Area users in Tier 4, information flows up to the AFTOMA at Tier 1 and the response flows down through the tiers until it returns to Tier 4. This arrangement provides centralized control and distribution management.

Work Areas request technical information in the form of task definition profiles from the CTODOs, which then send the request to AFTOMA. The AFTOMA either responds to a request directly or distributes the request to a specific TOC (Tier 2). TOCs may then pass requested data (usually TOs) back to the CTODO for distribution to the Work Area. It is important to note that, in this top-down flow strategy, CTODOs do not request information directly from TOCs. Therefore, the CTODO need not know the location of TOs. This simplifies the ordering process, communications paths, and allows the AFTOMA flexibility in assigning TOC responsibilities.

In establishing the functional requirements of the AFTOMS system, an infrastructure was designed to serve the management and distribution of TOs regardless of their type. All TO types need a system that can provide the core activities of acquiring, archiving, cataloging, distributing, and updating (change management).

In summary, this AFTOMS To-Be concept supports an implementation strategy that involves:

- Capturing Type[2] A (paper) TOs using scanners;
- Using Type B (page-oriented, digital) TOs in the short term;
- Supporting Type C (pageless, digital) TOs for newer weapon systems when this technology becomes available (AFTOMS operational support requirements for Type C still need to be investigated in detail;
- Using new technology for scanning, cataloging, storing, and retrieving information;

2. The various types of TOs, their characteristics, as well as the AFTOMS infrastructure components are described more fully in the Key Terms section of this report, which precedes the List of Acronyms.

- Distributing TOs to CTODOs and automated Work Areas via optical disk media;
- Supporting sophisticated entry, modification, and on-line retrieval capabilities;
- Supporting efficient document management;
- Distributing information based on specific profiles of Work Area user groups;
- Storing all types of information (textual, graphical, tabular, etc.) in a unified manner;
- Preparing TOs concurrently during the development of weapons systems with interactive review of TOs in progress; and
- Establishing streamlined organizational and operating procedures.

The AFTOMS approach will lead to many long-term benefits for the Air Force including increased weapon system availability, reduced costs, and increased mission effectiveness. AFTOMS provides the flexibility needed to support the more sophisticated weapon systems of the future.

AFTOMS PROOF OF CONCEPT (POC)

The purpose of the POC is to investigate the AFTOMS concept more closely and systematically, identify and assess its benefits and risks, find approaches for avoiding or abating those technical risks, and identify any previously overlooked opportunities, thus providing early technical input to the SPO that can be used to leverage and enhance AFTOMS success.

TSC's POC Strategy

The POC strategy has three major and interacting activities, each of which has its own significant characteristics and deliverables:

- Prototyping a Demo System;
- Evaluating technologies and identifying risk abatement strategies; and
- Performing a Feasibility Study.

The Demo System focuses on understanding and implementing key aspects of the To-Be concept functionality, using technologies and products that are suitable for AFTOMS. In the process, a great deal of invaluable hands-on experience is gained in working with current and emerging state-of-the-art technologies, integrating technology products with critical AFTOMS functionality, finding and evaluating technological and operational problem areas, and developing a visible and dynamic basis for refining AFTOMS requirements. The deliverable is a packaged Demo System to be installed at the AFTOMS SPO, which could then be used to:

- Provide a model for refining RFP requirements and source selection criteria;
- Provide a system capability that can be enhanced to assess and develop critical technical issues (e.g., data conversion, data loading, Tier 4 interfaces, CALS standards, organizational infrastructure issues, etc.);
- Serve as a low-cost test bed (before and during AFTOMS FSED) for independently evaluating problems and alternative solutions, without disrupting the main AFTOMS development effort;
- Provide a training vehicle for prime contractor developers and IV & V contractor evaluators; and
- Demonstrate AFTOMS to managers and users from USAF, DoD, and industry.

The technology evaluation activity consists of a primary hands-off path that is supported by limited hands-on evaluations of selected technologies and/or products not incorporated into the Demo System. The primary path's evaluation focus is quite broad, including investigation of To-Be requirements, integration issues, advanced technologies, standards, system buildability and operational utility issues, as well as interoperability with other Air Force systems. This broad, systematic approach makes its findings particularly suitable for input into the RFP and source selection work being performed by the AFTOMS SPO, but its findings are also valuable to the AFTOMS prime and IV & V contractors. The deliverable for this activity is the *Technology Issues & Alternatives Report*. It should be noted that significant and relevant functionality and technology findings from the other POC activities (prototyping a Demo System and the Feasibility Study) are also integrated into this report.

The Feasibility Study activity, performed by TSC, focuses both on the As-Is environment and the To-Be concept to perform an operational and economic feasibility assessment of AFTOMS. The deliverable is the *Feasibility Study Report*, which is used by the SPO to develop and justify the AFTOMS program funding.

An adequately detailed To-Be model drives, focuses, and integrates these three activities (prototyping a Demo System, technology evaluation, and feasibility study). An initial, high-level To-Be system concept for AFTOMS was developed for the Automation Plan. However, more detail was required for the concept to be useful as a basis for either the POC work or the development of RFP requirements, and as a common, integrated, coordinated, and approved concept. The resulting To-Be Model (Appendix A in the Supplement) was coordinated within the AFTOMS community.

Risk Abatement Methodology

The core focus of AFTOMS POC methodology is risk abatement. Fundamentally, this is achieved by developing a thorough project understanding using a balanced combination of the following techniques:

- Through hands–off methods requiring detailed analysis:
  - Exploring the To–Be concept analytically and systematically to probe for logical needs, problems, and consequences; and
- Through hands–on Demo System or technology evaluation work:
  - Prototyping to test and verify the analysis, evaluate technologies and products relative to the specific needs of AFTOMS, and to investigate technical integration problems.

The value of obtaining such a thorough project understanding before defining and building the real system is practical and significant. It anticipates opportunities and resolves problems that could appear later, thereby reducing the total burden during FSED; and it provides a coherent, integrated, and AFTOMS–specific framework for quicker evaluation and resolution of problems and exploitation of opportunities that may arise in the future. The benefits of this framework involve the reduction of project risk by reducing:

- Surprises and unintended consequences downstream;
- Changes and iterations during development;
- Schedule slippages;
- Compromises in delivered functionality, performance, and system quality;
- Follow–on Engineering Change Proposals (ECPs) to fund after project completion; and by
- Providing a means to prototype high–risk options in a limited environment without burdening and jeopardizing the full–scale effort with avoidable problems.

This framework can also be used to train system developers, IV & V personnel, etc., to more quickly understand the AFTOMS requirements and technologies, thereby shortening their learning curves and providing a partial substitute for any lack of AFTOMS–relevant experience.

Prior to the start of the POC effort, the prevailing perception within the AFTOMS community was that reliance on state–of–the–art and emerging technologies posed the greatest risks to project success. However, the early part of the POC effort focused on refining the To–Be concept and evaluating numerous candidate technology products; and, it became apparent that there were more significant risks present in various integration dimensions. Therefore, the POC scope was amended to incorporate eight additional risk evaluations of integration issues in addition to the sixteen technology risk evaluations, thereby providing a more complete and thorough report (see Section 2.1 for the eight integration risk evaluations and Section 3.1 for the sixteen technology risk evaluations).

The FY89-FY90 POC methodology focuses on AFTOMS; its operating environment, important risk issues within two time frames: FY89 to develop a current assessment of technologies, products, integration problems, and other risks; and FY91-FY93 to project future assessments of these technology products, problems, and risks to the time frame when the full-scale AFTOMS system will be designed and built. Given its time and resource limitations, the POC approach is disciplined to focus on important issues of consequence to AFTOMS. It is a multi-dimensional approach that incorporates users, work procedures, operational constraints, technologies, and interfacing issues. It is also an integrated approach, making use of the comparative advantages of various techniques to explore different aspects of issues, then balancing and combining those investigations and results to get overall coverage and synergy. Finally, **it is an action-oriented methodology, designed to make its findings clear and easy to refine/update throughout the project life cycle.**

Technology Issues & Alternatives Report

Based on the work in designing and building the Demo System, conducting other hands-on technology evaluations, and completing the hands-off analytical approach demanded by POC, the *Technology Issues & Alternatives Report* documents the results of the following POC findings:

- Important AFTOMS requirements, risks, and opportunities;
- Technology and integration lessons learned; and
- Risk abatement recommendations.

The report structure is defined in Section 1.3.1.

KEY CONCLUSIONS AND RECOMMENDATIONS

Since the scope of the POC did not include evaluation of Air Force organizational issues, the risks associated with integrating AFTOMS into the Air Force culture were not evaluated. However, technologies for developing a high-quality, user-friendly, and easy-to-learn system were investigated, thereby indirectly reducing existing organizational risks. The following findings from the FY89-FY90 AFTOMS POC work that apply to the AFTOMS FSED (FY91-FY93) are extracted from the detailed evaluations in Section 2 and Section 3. They are organized into *Major Conclusions* and *Other Conclusions* (of a less critical nature).

MAJOR CONCLUSIONS

- No single Commercial Off-the-Shelf (COTS) product or turnkey integrated system will be available to satisfy AFTOMS requirements. Given the uniqueness of the requirements and the needed technology mix, specific capabilities of commercial products used selectively, and the customized software written to unify purchased COTS technology products into one seamless AFTOMS system, the integration risk could actually exceed the total technological risk associated with particular products. **However, this integration risk is still significantly smaller than that which would result if AFTOMS did not rely on commercial technology products, and instead attempted a totally customized solution approach.**

- The AFTOMS To-Be concept is operationally sound and can be built by integrating available or emerging technology products. There are residual risks associated with scanning conversion, defining a standardized CTO-DO-to-WA delivery interface to support heterogeneous WA delivery systems, and localized technical and scheduling problems. However, these localized problems should be manageable.

- The AFTOMS To-Be concept is sufficiently robust to manage a mixed paper and digital TO inventory, consisting of all types of paper and digital TOs.

- MIL-STD 1840 must be completed soon since timely development of an adequate set of consistent DTDs and OSs (to cover the range of new and existing TOs) is critical to AFTOMS success for:
  - *Scanning conversion of existing inventory of paper TOs (which, because of inconsistent standards historically have varying formats and styles);*
  - *Supporting MIL-STD 1840 compliant delivery of new digital TOs; and*
  - *Type B+ tagging for value-added delivery of TOs to Work Areas.*

- Scanning conversion of existing weapon system TO suites is important to load the digital database for AFTOMS. Otherwise, the automation benefits will fall short of the projections. An early start with a pilot operation is recommended to develop a good basis for planning and executing later conversions for each new TOMA before it becomes operational.

- Type B+ TOs provide a major enhancement to the original AFTOMS To-Be concept. Additional SGML tagging of newly authored or converted digital TO contents at the TOMA/TOC level can:
  - Mark text content by security level, technician skill level, aircraft tail number, etc.;
  - Interconnect related text references with referenced graphics, tables, or external TOs; and
  - Establish other suitable relationships.

Such tagging provides more usable TOs at Work Areas by displaying only the information needed for the maintenance task (free of extraneous details) and facilitating rapid, accurate retrieval of referenced or related technical data. Type B+ provides the Type C benefit of tailored views at Work Areas without the need for additional sophisticated AFTOMS software. From a Type B baseline, B+ tagging can be implemented gradually and incrementally. With Type B+, for example, additional tags can be introduced to supply new capabilities, or old ones removed to reduce tagging cost or risk if there are DTD/OS deficiencies.

- The existing inventory of paper TOs is extensive; up to 50% can be converted economically to Type B digital form. Weapon systems will acquire new TOs in digital form, primarily B or B+. Some new weapon systems (e.g. ATF) plan to acquire Type C TOs, as well as rely on a substantial number of existing, non-Type C commodity TOs. Conversion of such commodity TOs to Type C format would be costly because it would require a yet undefined, re-authoring approach. Prior to FY2000, Type C TOs will comprise a very small percentage of the Air Force TO inventory. With this in mind, there are several findings and recommendations:
  - AFTOMS must and will support Type C TOs when future weapon systems require TO management support, but initially, AFTOMS should focus on conversion and Type B support; and
  - A preliminary high-level POC assessment of providing Type C support shows that AFTOMS needs to develop additional sophisticated software systems. These systems require trained personnel to concurrently support two (Types B and C) significantly different approaches to: TO authoring; change implementation; verification of the database indexing infrastructure and all allowable Work Area views into the TO database; and delivery of these views from CTODOs to Work Areas. Work Area user access into the Type C neutral TO database would have to be restricted to formally verified predefined views.
- Technology will not support an AFTOMS solution that can handle both classified and unclassified TOs in a fully integrated, secure, and trustworthy fashion; therefore, a physically secured, separate (but functionally identical) mini-AFTOMS is recommended for handling classified TOs.

- Key undecided operational requirements for system usage (e.g., change management at Tier 2, TO information traversal at Tier 4) affect the design of AFTOMS in broad and fundamental ways and need early resolution.

- A standard AFTOMS interface between CTODO and Work Area delivery systems should be defined so that IMIS, ITDS, and other future MAJCOM systems can easily interface to AFTOMS.

OTHER CONCLUSIONS

- Graphical user interfaces developed in the Demo System appear to satisfy in "look and feel" the needs of all major user types across the four tiers; and are a major contributor to the seamless integration of AFTOMS; these benefits more than offset their additional development complexity and cost.

- Installation of AFTOMS must be coordinated with various Offices of Primary Responsibility (OPRs). For example, AFCC is the OPR for DDN support; on average, it takes at least 24 months from identification of a requirement for AFCC to install a DDN communications node.

- AFTOMS buildability risk can be lowered significantly with a quality set of technical and operational requirements in the RFP that suitably constrain any contractor's solution flexibility and provide an unambiguous basis for determining if a proposed and implemented solution meets AFTOMS, MAJCOM, and CALS long-term needs.

- Good operational utility can be built into AFTOMS to support its post-installation use and long-term upgradability, maintainability, and interoperability.

- Several key emerging technologies are evolving rapidly and should be monitored closely: DMS, Distributed RDBMS, ODS, and UIMS.

- TO distribution from TOMA to CTODO depends on bulk optical disks; the lack of standards increases the long-term economic risk of both optical reader assets obsolescence and spare parts availability when the technology changes. However, any necessary data conversions necessitated by new standards could be automated easily.

- Several incompatibilities exist between standards that may not be resolved and will require workarounds (e.g., optical disk media is not yet accepted by the government as trustworthy for archival storage of permanent records, C++ is not yet on the DoD list of approved higher-order languages, and ADA [Programming Language, MIL-STD 1815] has not been ported to an X-Windows environment, etc.).

- A few technologies were found to be inappropriate for use on AFTOMS before FY2000, either because they were too risky operationally, immature for interfacing with other needed technologies, or not the best direct approach to providing the needed capabilities accurately and predictably (e.g., OODM and Artificial Intelligence (AI)); however, AI may still be useful in providing localized capabilities (e.g., TO numbering based on content characteristics).

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KEY TERMS

GENERAL TERMS

Proof-of-Concept (POC) – An activity, commissioned by the AFTOMS SPO, to perform risk abatement. It includes a feasibility study activity, a technology assessment activity, and the development of an interactive demonstration system.

Demo System – The interactive demonstration system portion of the POC activity. The Demo System is a conceptual view of the major functionality of the AFTOMS system. It is composed of a representative set of hardware and software components, configured in a mini-version of the full-scale AFTOMS organization infrastructure, designed to demonstrate the major functional activities of the AFTOMS system and user interactions.

Weapon System TO Suite – The entire set of TOs required to fully operate and support a major weapon system (i.e., F-15, B-1B, C-17, ATF, etc.); in addition to system-specific TOs, this suite includes all commodity TOs needed by the weapon system.

Commodity TOs – TOs which describe common items that are used in multiple weapon systems.

User Delivery (or Presentation) System – A system that would be used in Work Areas to receive technical information from AFTOMS and present this information to end users.

ORGANIZATIONAL INFRASTRUCTURE TERMS

AFTOMA (Air Force Technical Order Management Administration) – Within the overall concept of a modernized Air Force TO infrastructure, the AFTOMA will provide the overall authority for all procedures and policies involved in administering the TO system. The AFTOMA is currently HQ AFLC/MM.

TOMA (Technical Order Management Agency) – Major centers within the Air Force that are responsible for acquiring, planning, developing, and maintaining TOs. Although specific weapon system-related TO duties are delegated to the MM_Rs, SPOs, and contractors, each TOMA provides the overall management, facilities, and computer resources for all TO functions. Currently, it is envisioned that the following 13 sites will be TOMAs: five ALCs (OO-ALC, OC-ALC, SA-ALC, SM-ALC, WR-ALC), five AFSC SPOs (ASD, BSD, ESD, MSD, SSD), AGMC, AFCC, and SPACECOM.

TOC
(Technical Order Center) – The TOC is a logical sub-element of the TOMA; and is the focal point for management of a specific suite of TOs (i.e., F-15, B-1B, C-17, ATF, etc.). During development of a system, the operation of a TOC is the contractor's responsibility while overall management is accomplished at the Air Force program office. After the TOs are formalized, TOC operations move with the TOs to the Air Force supporting command (usually an AFLC prime center).

MM_R
(Materiel Management Organization) – MM_R is the AFLC Engineering and Reliability sub-organization element of MM that is responsible for making content changes to TOs.

CTODO
(Consolidated Technical Order Distribution Office) – The CTODO is an AFTOMS component installed at each Air Force major installation as the single-point interface between AFTOMS and all the users of TOs and TO-related management information. The CTODO will provide the node at which users of paper TOs, digital TOs, and interactive (paperless) TOs will: (1) requisition TOs; (2) obtain TO management information; (3) obtain digital TOs, changes, supplements, TCTOs, etc., for local printing and/or distribution to automated workstations; (4) prepare and submit automated TO publication change requests (PCRs); (5) review PCRs at the MAJCOM and prime AFLC; and (6) receive, store, and distribute interactive TOs to workstations throughout the base.

WA
(Work Area) – A generic term that stands for any shop, office, maintenance station, work group, etc., at an Air Force installation that uses TOs.

FUNCTIONAL TERMS

Profile Registration – The functional process by which Work Areas will order TOs. Each work area will specify its group characteristics and requirements; and AFTOMS will deliver the appropriate sub-suites of TOs based on this group profile. Ordering of individual TOs will be replaced by this simplified process.

Cataloging	–	The functional process by which TOs entering the system are described in key fields of information in the database. This identifying information assists the TO managers in effectively managing all other AFTOMS functions.
Distribution	–	The functional process of delivering TOs to their ultimate destinations (i.e., Work Areas).
On-line Delivery	–	The functional process which makes TOs available in digital form for interactive access by the users.
Change Management	–	The functional process that encompasses all steps required to change a TO. It includes filing a change request, reviewing and approving the change request, authorizing a change, and making the change to a TO.
Conversion	–	The functional process of converting paper TOs to digital form or of converting from one digital form to the digital standard; the current digital standard is MIL-STD-1840.

TECHNICAL ORDER TYPES

Type A	–	Characterizes all TOs that currently exist in the Air Force inventory or will be delivered in paper form.
Type B-	–	Characterizes page-oriented TOs in digital image form (text and graphics are in raster form).
Type B	–	Characterizes page-oriented TOs in digital form.
Type B+	–	Characterizes page-oriented TOs in digital form containing tagging information to allow electronic display of variant documents with efficient access to internal and external reference points for easy retrieval of related information (i.e., graphics, tables, other TOs, etc.).
Type C-	–	Characterizes integrated, interactive data in digital form containing tagging information to allow efficient access via electronic display to views defined, controlled and verified at Tier 2.
Type C	–	Characterizes integrated, interactive data in digital form containing tagging information to allow efficient access

via electronic display to data views defined by each Work Area user (and therefore, not pre-verified at Tier 2).

LIST OF ACRONYMS

A

ACVC	Ada Compiler Validation Capability
ADA	Programming Language (MIL-STD-1815)
ADADL	Ada Design and Documentation Language
AF	Air Force
AFAA	Air Force Audit Agency
AFCC	Air Force Communications Command
AFCSA	Air Force Computer Systems Architecture
AFIS	Air Force Intelligence Service
AFLC	Air Force Logistics Command
AFR	Air Force Regulation
AFSC	Air Force Systems Command
AFTO	Air Force Technical Order
AFTOMA	Air Force Technical Order Management Administration
AFTOMD	Air Force Technical Order Management Data
AFTOMS	Air Force Technical Order Management System
AFTO22	Air Force Technical Order Form 22
AFTO252	Air Force Technical Order Form 252
AGMC	Aerospace Guidance and Metrology Center
AI	Artificial Intelligence
AITI	Automated Interchange of Technical Information
ALC	Air Logistics Center
ALCS	Airlift Control Squadron
ALS	Ada Language System
AMPE	Automated Message Processing Equipment
ANSI	American National Standard Institute
APSE	Ada Programming Support Environment
ASCII	American Standard Code for Information Interchange
ASD	Aeronautical Systems Division
ATC	Air Force Training Command
ATF	Advanced Tactical Fighter
ATI	Automated Technical Information
ATOS	Automated Technical Order System
ARPANET	ARPA Network

B

BBN	Bolt, Beranek & Newman, Inc.
BRI	Basic Rate Interface
BSD	Ballistic Systems Division
BSD	Berkeley Standard Distribution (of a UNIX operating system)

C

CAD/CAM	Computer Aided Design/Computer Aided Manufacturing
CALS	Computer-aided Acquisition and Logistic Support
CAMS	Core Automated Maintenance System
CASE	Computer Aided Support Environment
CATV	Community Antenna (Cable) Television
CCITT	Consultative Committee for International Telephone and Telegraph
CD-I	Compact Disk - Interactive
CD-ROM	Compact Disk-Read Only Memory
CGM	Computer Graphics Metafile
CNWDI	Critical Nuclear Weapon Design Information
COBOL	Common Business Oriented Language
CODASYL	Conference of Data Systems Languages
COMSEC	Communication Security
COTS	Commercial Off-The-Shelf Software
CPIN	Computer Program Identification Number
CPU	Central Processing Unit
CSMA/CD	Collision Sense Multiple Access with Collision Detection
CTN	CALS Test Network
CTOC	Commodity Technical Order Center
CTODO	Consolidated Technical Order Distribution Office

D

DACCS	Digital Access Cross Connect Systems
DBMS	Database Management System
DDL	Document Description Language
DDN	Defense Data Network
DDS	Digital Dataphone Service
DEC	Digital Equipment Corporation
DI	Document Instance
DMS	Document Management System
DoD	Department of Defense
DODIIS	Department of Defense Intelligence Information System (DIA)
DOE	Department of Energy

DOROFILE	Commercial Optical Disk Product Name
DOT	Department of Transportation
DRDS	Distributed Relational Database System
DTD	Data Type Definition or Document Type Definition
DTOMA	Development Technical Order Management Agency (pre-PMRT)

E

ECC	Error Checking and Correction
ECP	Engineering Change Proposal
EDI	Electronic Data Interchange
EMI	Electro-magnetic Interference
EOD	Explosive Ordnance Disposal
ESD	Electronic Systems Division

F

FD	Functional Description
FDDI	Fiber Data Distribution Interface
FMS	Foreign Military Sales
FORTRAN	Formula Translation Programming Language
FOSI	Formatting Output Specification Instances
FRD	Formerly Restricted Data
FSED	Full-Scale Engineering Development
FTAM	File Transfer, Access and Management
FTP	File Transfer Protocol
FY	Fiscal Year (October 1- next September 30)
4GL	Fourth Generation Language for DBMSs generally

G

GOSIP	Government Open System Interconnect Protocols
GO22	Logistics Management of Technical Orders System (USAF)
GUI	Graphical User Interface

H

HDLC	High-Level Data Link Control
HIPO	Hierarchical Input/Processing/Output
HP	Hewlett Packard, Inc.
HQ	Headquarters
HW	Hardware

I

IAW	In Accordance With
IBM	International Business Machines

IDE	Interactive Development Environments
IEEE	Institute of Electrical and Electronics Engineers
I/F	Interface
IGES	Initial Graphics Exchange Standard
IMIS	Integrated Maintenance Information System (USAF)
INFORMIX	Commercial RDBMS product name
INGRES	Integrated Graphics and Retrieval System a commercial RDBMS product name
IOC	Initial Operational Capability
IP	Internet Protocol
ISO	International Standards/Services Organization
ISDN	Integrated Services Digital Network
ITDS	Improved Technical Data System

J

JMEM	Joint Munitions Effectiveness Manual

K

KMC	Key Management Center
KMS	Key Management System

L

LAN	Local Area Network
LHITA	Long Haul Information Transfer Architecture
LITA	Local Information Transfer Architecture
LLC	Logical Link Control
LMTOS	Logistics Management of Technical Order System
LSA	Logistics Support Analysis

M

MAC	Military Airlift Command
MAJCOM	Major Command
MAU	Media Access Unit
MHS	Message Handling Services
MINET	Movement Information Network
MIO	Management Integration Office
MIS	Management Information System
MMEDU	OC-ALC Technical Order System Section – Central Management Office
MM_R	Materiel Management Organization
MPP	Modular Planning Process
MSD	Munitions Systems Division

N

NARA	National Archival and Repository Agency
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NBS	National Bureau of Standards
NC	Not Releasable To Contractors
NCSC	National Communications Security Committee
NFS	Network File System
NIST	National Institute of Standards and Technology
NOFORN	Not releasable to Foreign Nationals
NSA	National Security Agency

O

OC-ALC	Oklahoma City Air Logistics Center
ODA/ODIF	Office Document Architecture/Office Document Interchange Format
ODIFF	Office Document Interchange File Format
ODS	On-Line Delivery System
OLTP	On-Line Transaction Processing
OMG	Object Management Group
OO-ALC	Ogden Air Logistics Center
OODM	Object-Oriented Data Management
OOSD	Object-Oriented Structured Design
OPR	Office of Primary Responsibility
ORACLE	Relational Database Management System
OS	Output Specification
OSD	Office of the Secretary of Defense
OSF	Open Software Foundation
OSI	Open System Interconnection
OSS	Open Software Systems

P

PADs	Packet Assembler/Disassembler
PARC	Xerox's Palo Alto Research Center
PASCAL	A high-level programming language
PBX	Private Branch Exchange
PC	Personal Computer
PCF	Personal Computing Facility
PCR	Publication Change Request
PD	Product Data
PDD	Product Definition Data

PDES	Product Data Exchange Standard
PDL	Program Design Language, or Page Description Language
PDN	Public Data Network
PDP	Program Definition Phase
PIM	Product Information Management
PMD	Program Management Directive
PMP	Program Management Plan
PMR	Program Management Review
PMRT	Program Management Responsibility Transfer
POC	Proof-of-Concept
POSIX	Portable Operating System Interface
PRI	Primary Rate Interface
PROPIN	Proprietary Information

Q

QTR	Quarter

R

RAI	Risk Attention Index
RD	Restricted Data
RDBMS	Relational Database Management System
RFP	Request For Proposal
RFS	Remote File System
ROM	Read Only Memory

S

SA-ALC	San Antonio Air Logistics Center
SAC	Strategic Air Command
SACDIN	SAC Digital Information Network
SAR	Special Access Required
SATODS	Security Assistance Technical Order Distribution System
SCI	Sensitive Compartmented Information
SCTI	Single Channel Transponder Injector
SDNS	Secure Data Network System
SGML	Standard Generalized Markup Language
SM-ALC	Sacramento Air Logistics Center
SMTP	Simple Mail Transfer Protocol
SNA	System Network Architecture (IBM)
SON	Statement of Need
SORD	System Operational Requirements Document

SPACECOM	Air Force Space Command
SPDL	Standard PDL (Page Description Language)
SPO	System Program Office
SQL	Standard Query Language
SSD	Space Systems Division
SSE	Software Support Environment
STP	Software through Pictures
SW	Software
SYBASE	Commercial RDBMS product name

T

TAC	Tactical Air Command
TELNET	Telecommunication Network
TCB	Trusted Computing Base
TCP/IP	Transmission Control Protocol/Internet Protocol
TCTO	Time Compliance Technical Order
TI	Texas Instruments, Inc.
TMP	Technical Manual Plan
TO	Technical Order
TOC	Technical Order Center
TODF	Technical Order Distribution Facility
TODMP	Technical Order Development Management Plan
TODO	Technical Order Distribution Office
TOMA	Technical Order Management Agency
TOPS	Technical and Office Protocol Standard
TOS	Tactical Operations System (USA)
TSC	Transportation Systems Center

U

UIMS	User Interface Management System
ULANA	Unified Local Area Network Architecture
UNIX	Computer Operating System (BSD/OSF)
USAF	United States Air Force

V

VAN	Value-Added Network
VMS	Virtual Memory Storage
VSAT	Very Small Aperture Terminals
VTP	Virtual Terminal Protocol

W

WA	Work Area
WAN	Wide Area Network
WIN	Worldwide Military Command and Control System (WWMCCS) Intercomputer Network
WNINTEL	Warning Notice-Intelligence Sources of Methods Involved
WORM	Write Once Ready Many
WP	Workprocessing, or Wordprocessing
WPAFB	Wright Patterson Air Force Base
WR-ALC	Warner Robins Air Logistics Center
WSTOC	Weapon System Technical Order Center
WYSIWYG	What You See Is What You Get

X

X.25	Network Access Protocol
X.400	Message Handling protocol specified in OSI
XUI	X Window User Interface product from DEC

SECTIONS 1–4

INTRODUCTION

TECHNICAL ASSESSMENT OF TECHNOLOGY INTEGRATION DIMENSIONS: OVERVIEW

TECHNICAL ASSESSMENT OF INDIVIDUAL TECHNOLOGIES: OVERVIEW

SUMMARY OF RISK ASSESSMENT AND CONCLUSIONS

SECTION 1: INTRODUCTION

1.1 BACKGROUND

This section briefly presents a historical introduction to the Air Force Technical Order Management System (AFTOMS) Proof-of-Concept (POC) for FY89 through QTR1 FY90. Section 1 includes three main topics:

- Computer-aided Acquisition and Logistic Support (CALS) program and the role of the Transportation Systems Center (TSC);
- AFTOMS POC strategy and task approach in support of the Air Force Logistics Center (AFLC) AFTOMS System Program Office (SPO); and
- Structure and format of the Technology Issues & Alternatives Report, which documents the POC findings.

These topics provide a contextual basis for understanding the remaining portions of this Technology Issues & Alternatives Report.

CALS PROGRAM AND TSC's ROLE

The CALS program was established to improve weapon system reliability and maintainability, and to reduce the costs of weapon system acquisition and support. One major continuing objective of the CALS program is to improve the flow of technical information by introducing automated techniques. The automation process is intended to improve the delivery and handling of large quantities of technical data. CALS will significantly reduce the amount of paper and labor needed to enter, manipulate, transfer, and interpret this data.

In June 1985, a joint industry/Department of Defense (DoD) Task Force on CALS issued a five volume report (IDA R-285) which presented the objectives and scope of the program, as well as a top-level management and implementation plan. The task force concluded that the following objectives could be met:

- Design more supportable weapon systems;
- Support transition from paper-based to digital-based logistics and technical information for DoD operations; and
- Routinely acquire and distribute logistics and technical information in digital form for new and existing weapon systems.

The Joint Task Force recognized that in order to implement the target CALS program expeditiously, efforts within the armed forces must be coordinated to focus on the CALS architecture. The DoD directed each service to create a permanent CALS Management Information

Office (MIO) as the official focal point for coordination of its logistics automation strategies and programs.

On 18 October 1985, Program Management Directive (PMD) number 5260(1), Automation of Technical Information and Computer Aided Logistics Support (CALS), established the CALS program and chartered the Air Force MIO at HQ Air Force Systems Command (AFSC) to coordinate and manage the CALS program. In addition, the PMD identified the following tasks:

- Plan for the integration of all existing Automated Technical Information (ATI) projects within a standard information systems framework;
- Determine the full range of CALS objectives and management concepts;
- Plan large-scale demonstrations and implementation of CALS technology for a weapon system acquisition program;
- Ensure system structures are consistent and comply with Air Force guidelines;
- Perform a cost benefit analysis of replacing present technical information management methods with automated methods; and
- Prepare and maintain an ATI and CALS Program Management Plan (PMP), addressing program integration and consolidation of CALS procedures as well as incorporation of improved ATI capabilities.

The MIO identified three areas of technical information for review and improvement:

- Technical Orders (TOs);
- Product Definition Data (PDD); and
- Logistics Support Analysis (LSA).

In 1986, TSC of the Department of Transportation (DOT) was contracted by the CALS MIO to provide systems engineering support to create automation plans for these areas. These automation plans define a concept of operations, management strategies, implementation plan, and a cost-benefit analysis. The initial activity consisted of review and analysis of existing programs and standards. In 1987, the focus of this activity centered on developing a 7–10 year automation plan for TOs. Appendix A describes the modular planning process used and the resulting AFTOMS Automation Plan. This plan offers the reader a valuable overview of the As–Is problems, the proposed To–Be TO system concept, and an introductory description of TO data handling and AFLC infrastructure concepts needed to understand this Technology Issues & Alternatives Report as well as the POC findings.

1.2 AFTOMS PROOF OF CONCEPT (POC)

The MIO is responsible for initially investigating and planning CALS programs, exclusive of the implementation responsibility for any specific system, such as AFTOMS. Responsibility for AFTOMS definition, development, and deployment was assigned in FY88 to the AFLC. This command established an AFTOMS SPO, located at Wright Patterson Air Force Base (WPAFB), to manage all necessary work in implementing the AFTOMS concept. After publication of the *AFTOMS Automation Plan–Final Report, February 1988*, TSC supported the SPO in building consensus within the Air Force to support the AFTOMS To-Be concept and in planning the FY89 POC work.

The purpose of the POC is to investigate the AFTOMS concept in more depth, using the following approaches:

- Systematically identifying and assessing its benefits and risks;
- Finding approaches for avoiding or abating those risks; and
- Identifying any previously overlooked opportunities, thus providing early technical input to the SPO that can be used to leverage and enhance AFTOMS success.

Such input (perhaps repackaged by the SPO) could also support preparation of the Request For Proposal (RFP) technical data package, source selection criteria for evaluating RFP responses from contractors, and various AFLC and DoD program reviews.

1.2.1 POC Strategy

The resulting POC strategy for TSC support during 1 October, 1988 to 31 December, 1989 is graphically depicted in FIGURE 1-1. This strategy has three major and interacting activities, each of which has its own significant characteristics and deliverables:

- Prototyping a Demo System;
- Evaluating technologies and identifying risk abatement strategies; and
- Performing a Feasibility Study.

PROTOTYPING A DEMO SYSTEM

The Demo System focuses on understanding and implementing key aspects of the To-Be concept functionality using technologies and products that are suitable for AFTOMS in FY89. In the process, much invaluable hands-on experience is gained in working with current and emerging state-of-the-art technologies, integrating technology products with critical AFTOMS functionality, finding and evaluating technological and operational problem areas, and developing a visible and dynamic basis for refining AFTOMS requirements. The deliverable is a packaged Demo System to be installed at the AFTOMS SPO, which could then be used to:

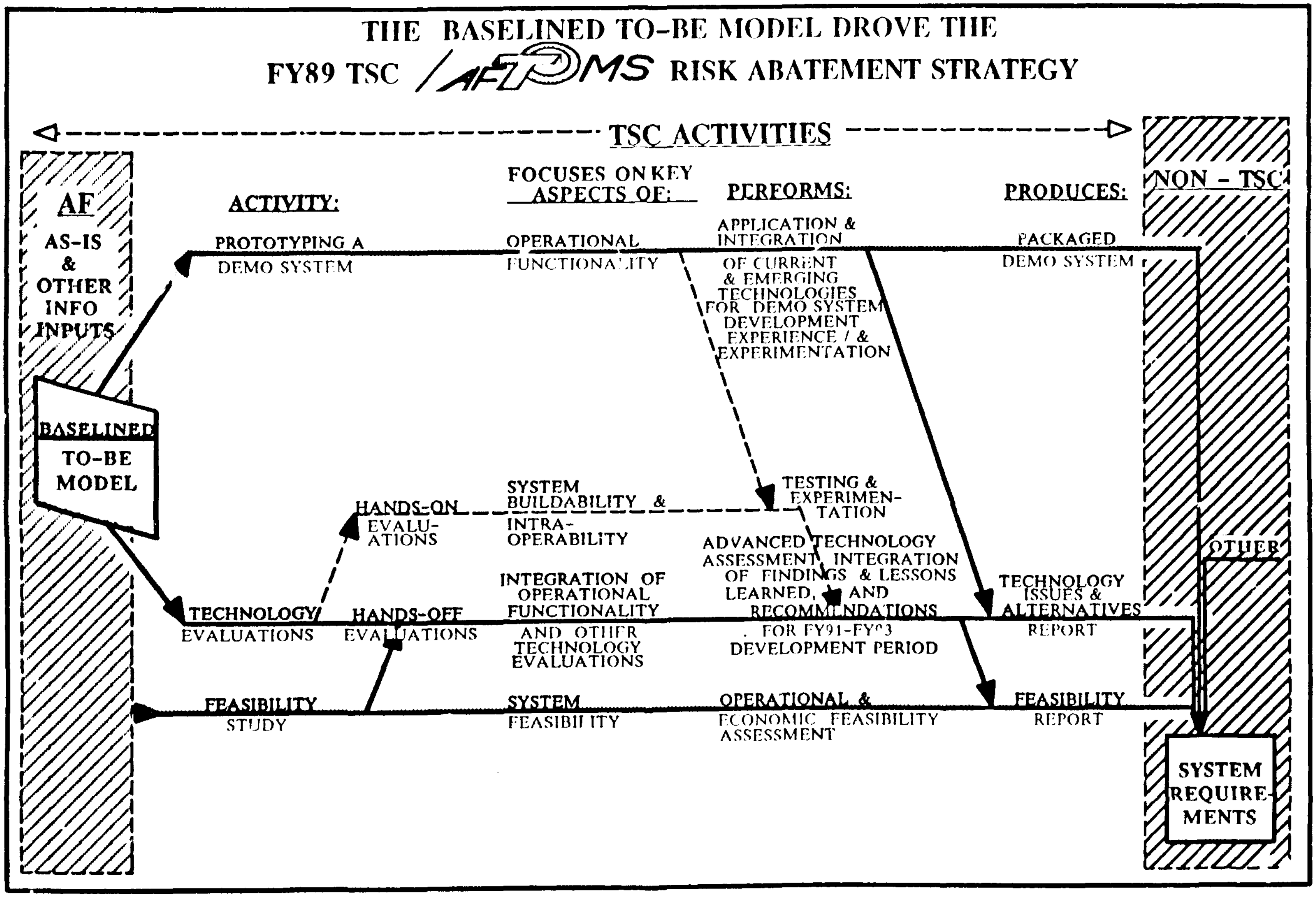

FIGURE 1-1. PROOF-OF-CONCEPT (POC) STRATEGY

- Provide a model for refining RFP requirements, user interfaces, and source selection criteria to reinforce a coordinated and tested view of AFTOMS;
- During AFTOMS FSED, serve as a low-cost system test bed for independently evaluating critical technical problems and alternative solutions without disrupting the main AFTOMS development effort;
- Provide a dynamic test bed for developing user training approaches and materials;
- Provide a hands-on training vehicle for prime contractor developers and IV &V contractor evaluators; and
- Demonstrate AFTOMS to managers and users from USAF, DoD, and industry.

TECHNOLOGY EVALUATION

The technology evaluation activity consists of a primary, hands-off path that is supported by limited hands-on evaluations of selected technologies and/or products not incorporated into the Demo System. The primary path's evaluation focus is quite broad, including investigation of To-Be requirements, integration issues, advanced technologies, standards, system buildability and operational utility issues, as well as interoperability with other Air Force systems. This broad, systematic approach makes its findings particularly suitable for input into the RFP and source selection work being done at the AFTOMS SPO, but its findings are also valuable to the prime development and IV & V contractors. The deliverable for this activity is the Technology Issues & Alternatives Report. Significant and relevant requirement and technology findings from the other two activities (prototyping a Demo System and the Feasibility Study) are also integrated into this Technology Issues & Alternatives Report.

Feasibility Study

The Feasibility Study activity, performed by TSC, focuses both on the As-Is environment and the To-Be concept to perform an operational and economic feasibility assessment of AFTOMS. The deliverable is a Feasibility Report which is used by the SPO to develop and justify the AFTOMS program funding. In addition, this document is part of the SPO's AFTOMS Economic Analysis Report.

An adequately detailed To-Be model drives, focuses, and integrates these three activities (prototyping a Demo System, technology evaluation, and Feasibility Study), and is described in Section 1.2.2. Use of the three POC deliverable products is a SPO responsibility.

1.2.2 To-Be Concept Elaboration into the To-Be Model

An initial, high-level, TO system concept for AFTOMS was developed for the Automation Plan and is described in Appendix A. However, more detail was required for the concept to be useful as a basis for either POC work or development of RFP requirements, and as a common, integrated, coordinated, and approved concept. Therefore, a Might-Be representation was developed in January 1989 for use in the POC work. In June 1989, the Might-Be was adopted as the high-level To-Be Model, serving as the core from which to develop AFTOMS requirements.

An overview of the baselined To-Be Model is shown in FIGURE 1-2. The To-Be Model views, analyzes, and characterizes AFTOMS from the six important perspectives listed on the left side of the figure. Each perspective is then decomposed in a modular, hierarchical fashion to the level of detail needed for the POC. In this way, the To-Be drives the POC work.

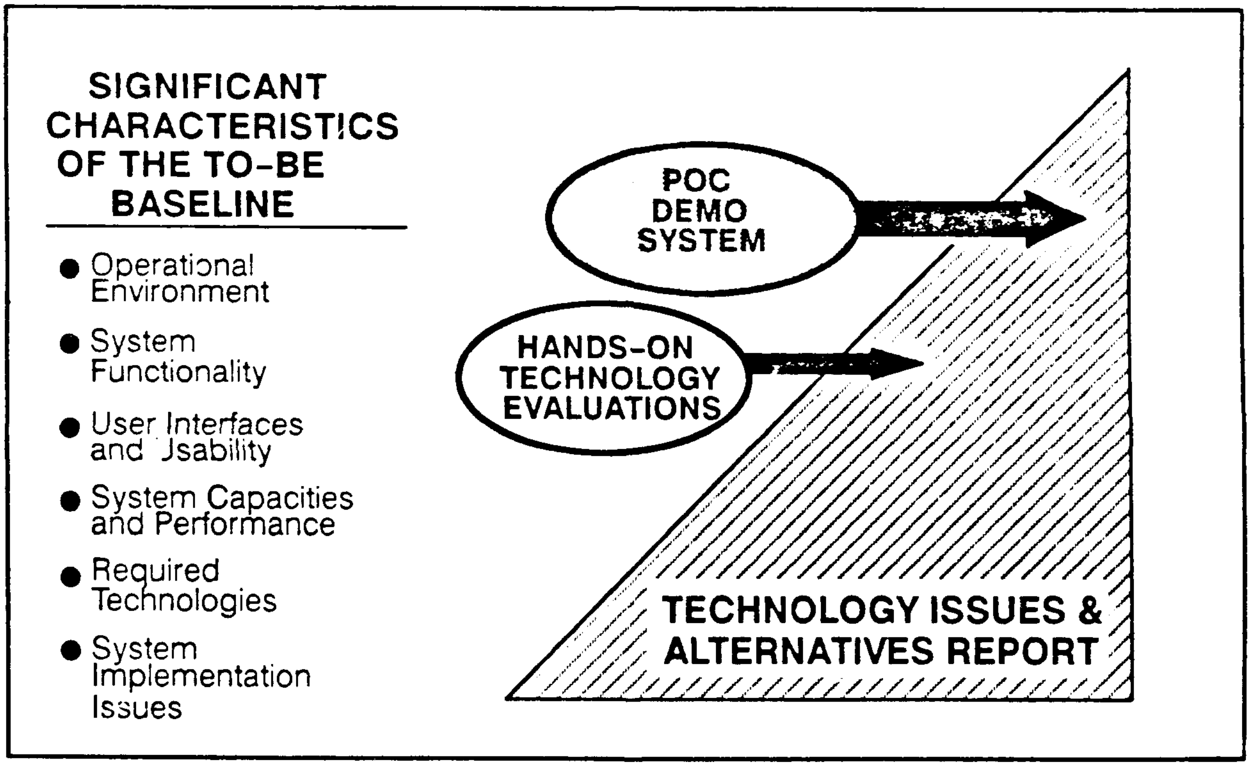

FIGURE 1-2. AFTOMS TO-BE BASELINE: STRUCTURAL OVERVIEW

This To-Be Model has been coordinated within the AFTOMS community, even though it is not a POC deliverable. Its predecessor, the Might-Be presentation, was presented at the January 1989 Program Management Review (PMR), then released for review and comment. Comments were received in March, incorporated, and the Might-Be presentation was re-released on April 1, 1989 as Appendix G of the Feasibility Study (first draft). Further refinements were made to obtain the current version provided separately to the SPO as a draft document, where it will reside for the remainder of the POC. The format and essence of the Might-Be document have not changed throughout this period.

1.2.3 Risk Abatement Focus

The focus of AFTOMS POC work is risk abatement. Fundamentally, risk abatement is achieved by developing a thorough project understanding using a balanced combination of the following techniques:

- Through hands-off methods requiring detailed analysis:
  - Exploring the To-Be concept analytically and systematically to identify and evaluate logical needs, problems, and consequences; and
- Through hands-on Demo System or technology evaluation work:
  - Prototyping to test and verify the analysis, evaluate technologies and products relative to the specific needs of AFTOMS, and to disclose subtle integration problems overlooked in the analysis.

The value of obtaining such a thorough project understanding before defining and building the real system is practical and significant. It anticipates opportunities and resolves problems that could appear later, thereby reducing the total development burden during Full-Scale Engineering Development (FSED). It also provides a coherent, integrated, and AFTOMS-specific framework for quicker evaluation and resolution of problems and exploits the opportunities that may arise in the future.

The benefits of this framework involve the reduction of project risk by reducing:

- Surprises and unintended consequences downstream;
- Changes and iterations during development;
- Schedule slippages;
- Compromises in delivered functionality, performance, and system quality;
- Follow-on Engineering Change Proposals (ECPs) to fund after project completion; and
- Providing a means to prototype high-risk options in a limited environment without burdening and jeopardizing the full-scale effort with avoidable problems.

This framework can also be used to train system developers, IV&V contractor personnel, and others, to understand the AFTOMS requirements and technologies more quickly, thereby shortening the learning curve and providing a partial substitute for any lack of AFTOMS-relevant experience; this will focus development activities and increase productivity.

To realize these significant benefits, however, the POC must be a continued effort throughout the AFTOMS pre-award, design, development, and deployment phases (FY89-FY95). It must be rightly conceived, well executed, and up-front in the project cycle to maximize its down-

stream leverage; POC findings must be integrated into all subsequent phases of the project so that there is a consistency of approach, and its detailed lessons observed when specific issues are worked on an on-going basis.

The FY89–FY90 POC approach focuses on AFTOMS, its operating environment, important risk issues, and two time frames: FY89 to develop a current assessment of technologies, products, integration problems, and other risks; and FY91–FY93 to project future assessments of these technologies, products, problems, and risks to the time frame when the full-scale AFTOMS is designed and built.

The POC approach is disciplined to investigate important issues of consequence to AFTOMS. It is a multidimensional approach that incorporates users, work procedures, operational constraints, technologies, and interfacing issues. It is also integrated, making use of the comparative advantages of various techniques to explore different aspects of issues, then balancing and combining those investigations and results to get overall coverage and synergy. **Finally, it is an action–oriented methodology designed to make its findings clear and easy to refine/update throughout the project life cycle.**

For example, consider the maturity and multidimensional productivity of this POC approach. Aside from the personal maturity and relevant defense industry and systems experience of TSC's POC staff, there is a general framework which can be and was used to evaluate the operational readiness of emerging technology products for use in AFTOMS. In this framework, every complex emerging technology follows a development path which is unique in its details, yet similar when normalized and viewed at a broader level. Thus, if the progress of that development path is charted over time as depicted in FIGURE 1-3, then a common general pattern emerges. The horizontal axis represents time measured in multiples of the average product generation duration for that technology; the vertical axis represents the scatter, diversity, or degree of uniqueness of functionality and performance advantage across the technology products.

When a technology concept is first formulated, it may be incomplete and its practical utility may not be initially obvious. If several independent people or organizations were to implement an important aspect of the concept, the resulting early product implementations would typically display large differences in functionality, performance, constraints, etc., when compared to one another. In addition, a good chance exists that these different products will be distributed informally or sold to other users, thereby exposing the products to two major types of conforming pressures:

- The demand-side conforming pressure from diverse users of each product who provide operational feedback to correct problems, add features, relax constraints, or suggest performance improvements to make the product more valuable to their needs; and

- The supply–side conforming pressure from the product marketers to out–do their competitors by offering competitive capabilities enhanced with a few extra discriminating capabilities.

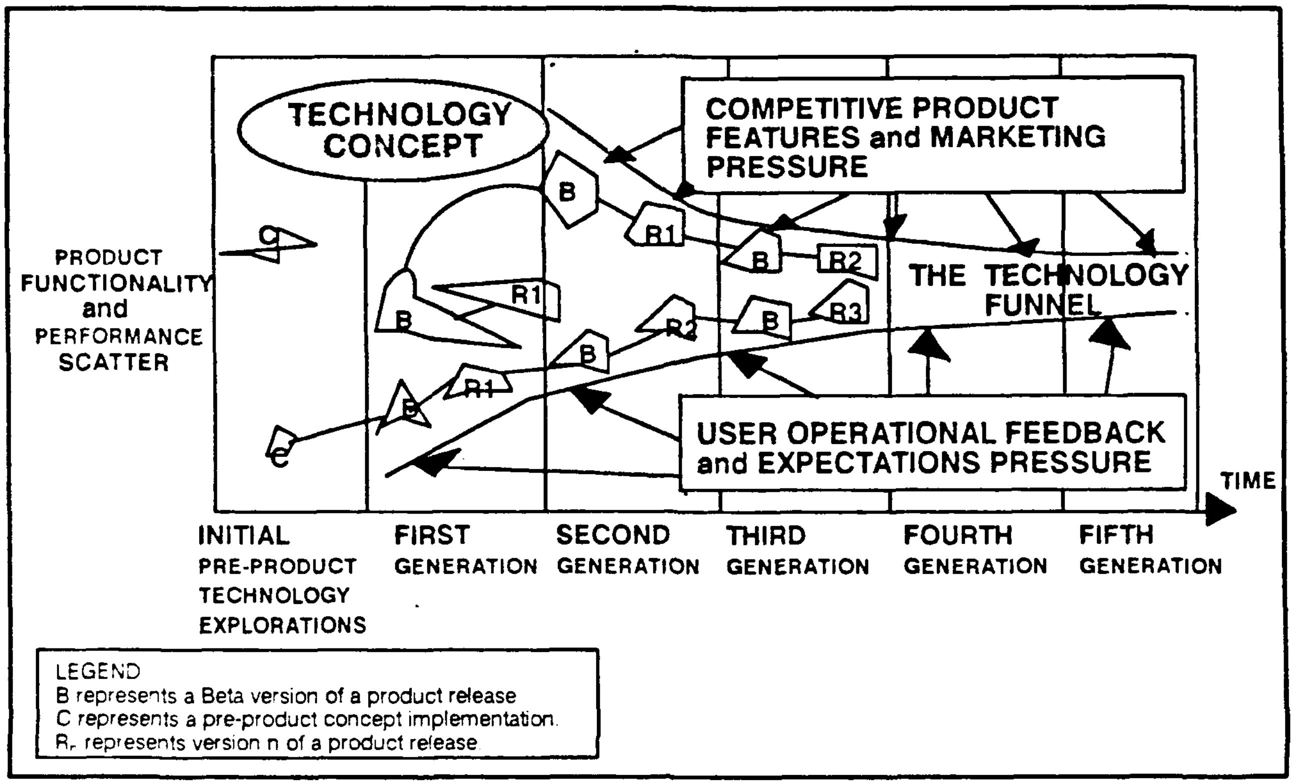

FIGURE 1-3. COMPETITIVE EVOLUTION OF PRODUCTS

Given these continuing pressures, and the fact that it takes at least two years to develop a next generation or major release of a new product in a complex technology, FIGURE 1-3 supports the following conclusions:

- It takes a few generations for competing products to offer common, solid, operationally tested, and useful capabilities; and
- Some degree of de facto standardization of capabilities emerges over time.

This framework and these principles can be used to assess the maturity of current technologies and project status of future generations of technologies.

In reference to POC productivity, FIGURE 1-4 summarizes the strengths of hands–off studies versus the strengths of hands–on Demo System development activities, and supports the fact that the two techniques have to be combined so an effective risk abatement approach can be obtained.

A PRODUCTIVE RISK ABATEMENT APPROACH

IS BEST REALIZED BY COMBINING THE STRENGTHS OF:

- **HANDS-OFF STUDIES**
  - EXPLORE ISSUES NOT POSSIBLE OR EASILY PERFORMED WITH A DEMO SYSTEM:
    - ALTERNATIVE TECHNOLOGIES OR PRODUCTS NOT USED IN THE DEMO SYSTEM
    - IMPACTS OF FORESEEABLE, BUT IMMATURE EMERGING TECHNOLOGIES /TOOLS
    - REQUIREMENTS NOT IMPLEMENTED IN THE DEMO SYSTEM
    - TRANSLATIONS TO DIFFERENT ENVIRONMENTS, CONSTRAINTS, USERS, TIME FRAMES
    - THE "ILITIES", E.G., MAINTAINABILITY, RELIABILITY, ETC.
  - EXPLORE BROADER ISSUES: INTEGRATION, INTEROPERABILITY, STANDARDS, ETC.
  - PROVIDE A REPORT FORMAT: FAMILIAR, CONTROLLABLE, AND USABLE PRESENTATION

- **HANDS-ON DEMO DEVELOPMENT**
  - IDENTIFY FALSE PATHS EARLIER BY EXPLORING COMPLETENESS AND CONSISTENCY OF THE REQUIREMENTS
  - EXPLORE SYSTEM INTEGRATION AND BUILDABILITY ISSUES CLOSER
  - PERFORM PRACTICAL EVALUATIONS OF PRODUCTS, TOOL KITS, AND STANDARDS
  - ELICIT AND EVALUATE USER REACTIONS TO DEMO SYSTEM FUNCTIONALITY and USER INTERFACE FORMATS
  - PROVIDE A MODIFIABLE TEST BED SYSTEM FOR EVALUATING PROPOSED CHANGES OR PROBLEMS ARISING DURING DEVELOPMENT
  - PROVIDE A DEMONSTRATION and TRAINING VEHICLE FOR MANAGERS, USERS, DEVELOPERS, AND OTHERS. (I.E., A MODERN INTERACTIVE COMMUNICATION VEHICLE)

FIGURE 1-4. RISK ABATEMENT APPROACH

1.3 TECHNOLOGY ISSUES & ALTERNATIVES REPORT

The Technology Issues & Alternatives Report documents the results of POC findings for the following:

- AFTOMS requirements;
- Risks;
- Opportunities;
- Technology and integration lessons learned; and
- Risk abatement recommendations.

These findings were based on designing and building the Demo System, conducting other hands-on technology evaluations, and completing the POC hands-off analytical activities. To make this report usable and actionable despite its length, it has been given a unique, modular structure.

1.3.1 Report Structure

The Technology Issues & Alternatives documentation package consists of two complementary reports:

- This **public report**, the Technology Issues & Alternatives Report dated December 1989, which is free of proprietary product mentions and, therefore, is suitable for general distribution; and
- **A private report**, the Supplement to the Technology Issues & Alternatives Report, **issued only in final draft form** for AFTOMS SPO use because it contains the remaining technology material that mentions proprietary products to help the SPO understand risk issues better.

THE PUBLIC REPORT

The high-level structure for the public Technology Issues & Alternatives Report is illustrated in FIGURE 1-5. The report consists of a main report, followed by two appendices:

- Appendix A--Contains background material and an overview of the To-Be system concept; and
- Appendix B—Contains eight sections, each of which explores an important dimension of integration.

These appendices do not focus on specific technology product details and comparisons to avoid biasing AFTOMS proposal responses.

AFTOMS TECHNOLOGY ISSUES & ALTERNATIVES REPORT STRUCTURE

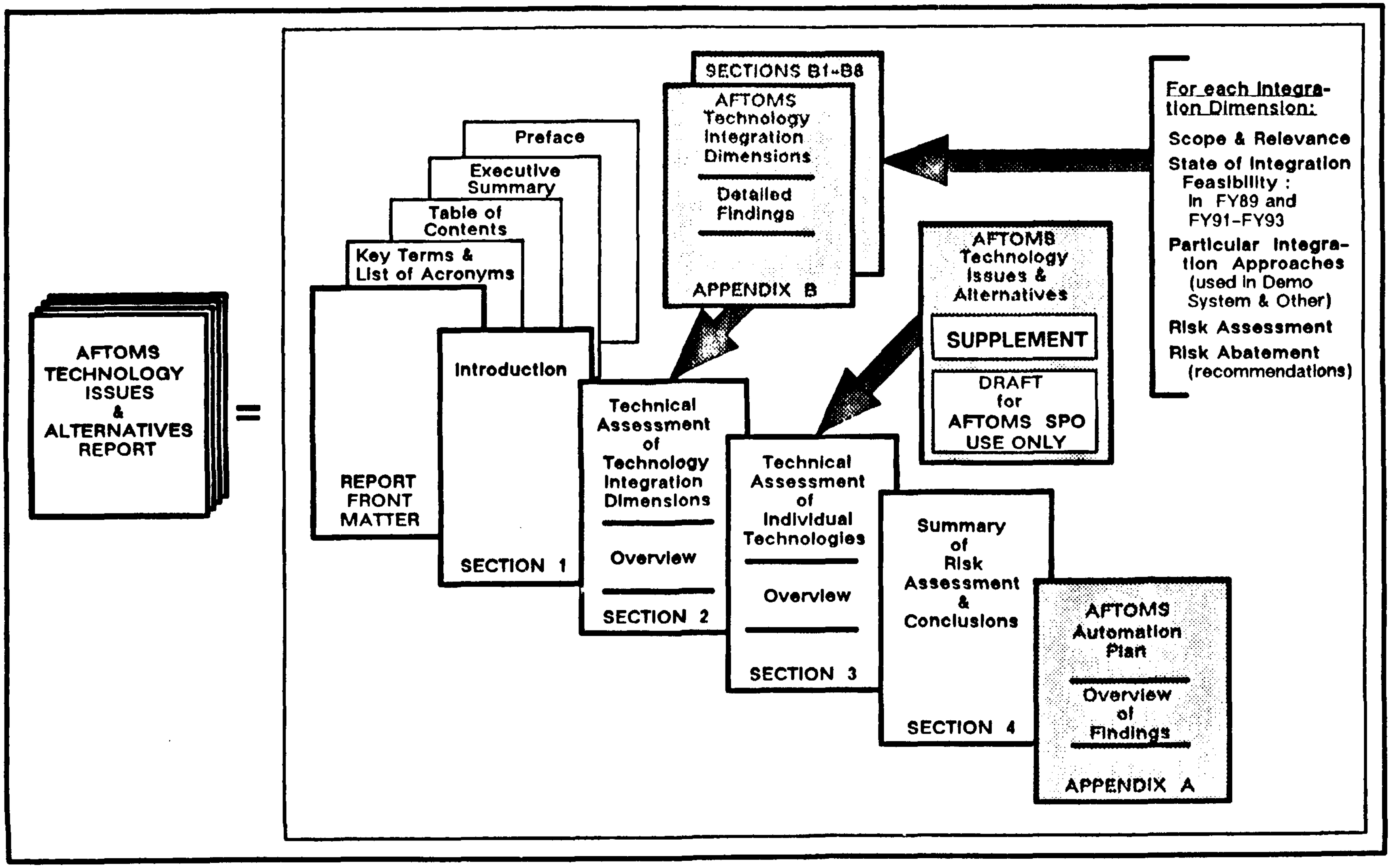

FIGURE 1-5. TECHNOLOGY ISSUES AND ALTERNATIVES REPORT STRUCTURE

The main report is short, general in the level of presentation, actionable in the presentation of risk abatement recommendations, and also free of specific product mentions. Consequently, the report can be read by managers, and can be used as an attachment to the RFP package or for general distribution. The core of this main report is contained in its Sections 2 and 3, which summarize in tabular form, the detailed findings in Appendix B and the separate draft Supplement report, respectively. Section 4 of the main report summarizes POC findings and conclusions.

THE PRIVATE REPORT

The high-level structure for the private Supplement is illustrated in FIGURE 1-6. This Supplement also consists of a main report, followed by two appendices.

- Appendix A--Contains the detailed POC-developed AFTOMS To-Be Model; and
- Appendix B--Contains sixteen sections, each of which explores an important area of technology.

These appendices include specific technology product details, comparisons, and findings which can be useful for evaluating AFTOMS proposal responses, but makes this Supplement unsuitable for general distribution.

The *main report in the Supplement* parallels the *main portion* of the public report to maintain:

- Similarity of structure, between public and private reports;
- Standalone usefulness of the Supplement; and
- Consistency of numbering in reused material.

The front-end material (i.e., Preface through the Introduction) in the Supplement, is an adapted version of that appearing in the public report; Section 2 is left intentionally blank since in the public report it overviews dimensions of integration which are irrelevant to this Supplement; and Section 3 is reused from the public report because it succinctly overviews the individual technology reports contained in Appendix B, thereby making this Supplement usable in a standalone fashion.

1.3.2 Risks Evaluated

Before the POC effort began, the prevailing opinion within the AFTOMS community was that reliance on state-of-the-art and emerging technologies posed the greatest risks to project success. However, the early part of the POC effort focused on refining the To-Be concept and evaluating numerous candidate technology products; and, it became apparent that there were more significant risks present in various dimensions of integration.

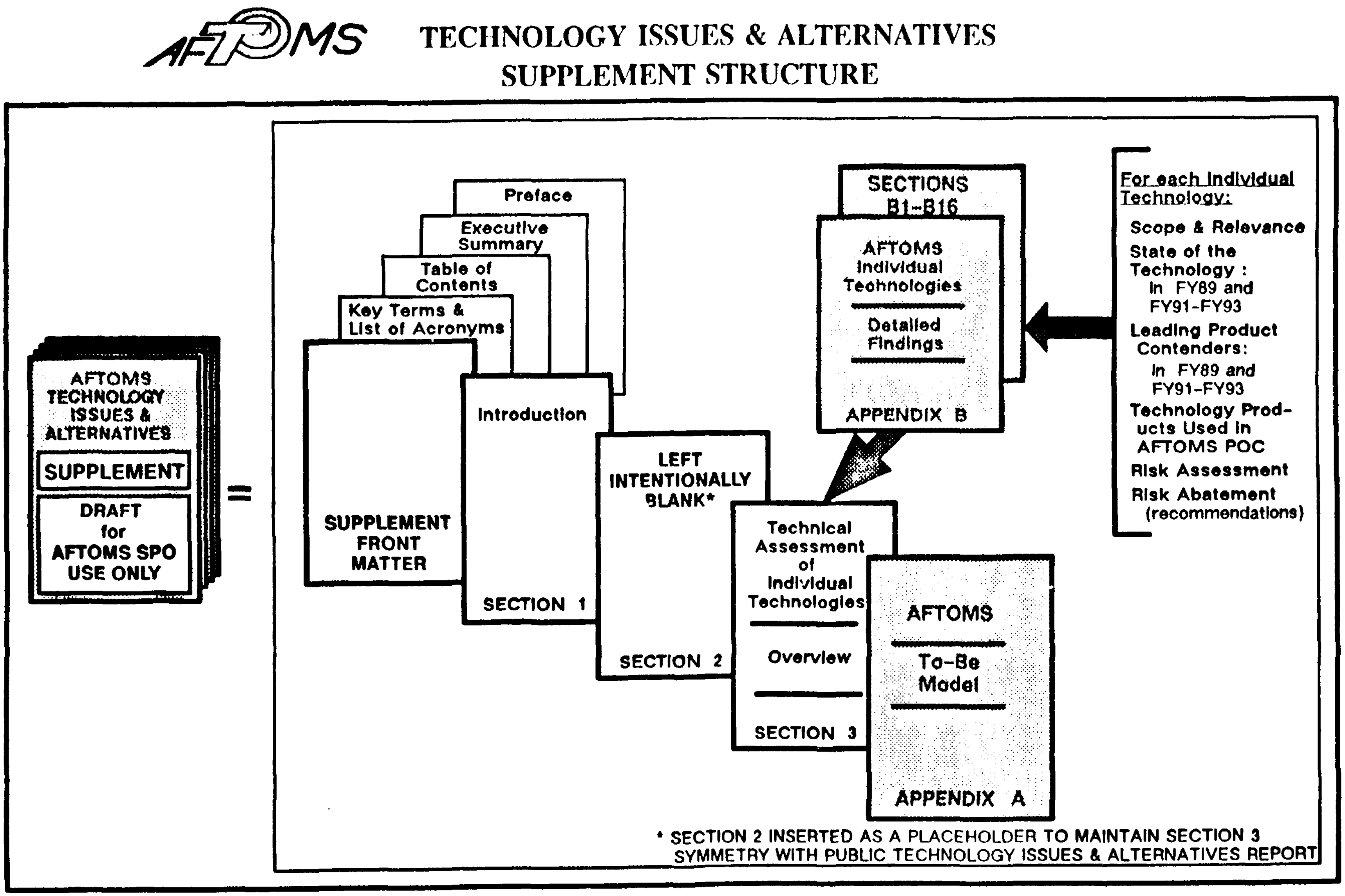

FIGURE 1-6. REPORT STRUCTURE FOR THE SUPPLEMENT TO THE TECHNOLOGY ISSUES & ALTERNATIVES REPORT

Therefore, the POC scope was amended to incorporate eight additional risk evaluations of integration issues in addition to the sixteen technology risk evaluations, thereby providing a more complete and thorough report. The eight dimensions of integration are listed in main report Section 2.1; and the sixteen individual technologies are listed in Section 3.1.

Each of these risk evaluation choices has a potential near-term or long-term relevance for AFTOMS. Other technologies were not evaluated since their unique capabilities were not needed to implement the To-Be concept. For example, initially it was thought that Artificial Intelligence (AI) technology could be used for profile registration; however, subsequent examination showed that proven relational database techniques could implement the concept, would be simpler and less risky to work with, more predictable in processing results, and easier to modify without the need for extensive reverification.

1.3.3 Format Modularity and Consistency

Evaluation of each of the sixteen technology risk areas and documentation of POC findings is focused on the needs of AFTOMS, and presented in a modular consistent format in Appendix B of the separate draft Supplement. For evaluation of each of the sixteen technologies, this format includes the following sections:

- **Scope and Relevance**: Addresses why this technology is important to AFTOMS;
- **State of the Technology**: Focuses on how the technology has developed, its FY89 state, and projections for FY91–FY93;
- **Leading Suitable Product Contenders**: Identifies a few leading product examples of this technology suitable for the AFTOMS environment, assesses their current state, and projects their potential state in FY91–FY93;
- **Technology Products Used in AFTOMS POC**: Summarizes significant findings from POC's hands-on experience with specific products;
- **Risk Assessment**: Summarizes the residual risks posed by this technology for use in AFTOMS; and
- **Risk Abatement**: Offers actionable approaches for avoiding, mitigating, or managing such risks.

Similarly, for evaluation of each of the eight integration dimensions, the loosely standardized format includes the following sections (with some variations):

- **Scope and Relevance**: Addresses why this integration dimension is important to AFTOMS;
- **State of Integration Feasibility**: Focuses on how integration feasibility has developed, its FY89 state, and projections for FY91–FY93;

- **Particular Integration Approaches Used in AFTOMS POC**: Summarizes significant findings from POC's analytical evaluation and hands-on experience with technology products;
- **Risk Assessment**: Summarizes the residual risks posed by this integration dimension for AFTOMS; and
- **Risk Abatement**: Offers actionable approaches for avoiding, mitigating, or managing such risks.

The benefits of such format standardizations include:

- Easy reading to find material of interest;
- Consistent level of coverage across topics;
- Ease of integration of the findings within the report; and
- Ease of translation of findings into specific RFP requirements.

SECTION 2: TECHNICAL ASSESSMENT OF TECHNOLOGY INTEGRATION DIMENSIONS: OVERVIEW

2.1 INTRODUCTION

Heterogeneity is at the heart of AFTOMS since AFTOMS supports heterogeneity in functionality, user location, user types, hardware, standards, and data; and provides interfaces to Air Force and contractor systems. Therefore, AFTOMS can be built either by:

- Custom developing and integrating all required capabilities; or
- Just custom integrating commercially-available technology products, each of which offers an integrated subset of different functionalities that partially satisfies AFTOMS needs.

The custom development alternative is not feasible given the AFTOMS development budget, ambitious project schedule, and the unacceptable levels of risk that would accompany any Air Force attempt to duplicate the functionality, performance, and operational reliability of major technology software products (such as DMS, RDBMS, UIMS, ODS, etc.).

The second alternative of custom integration is at least feasible if not easy and risk free. Thus, **AFTOMS should be developed by integrating relevant technology products**; much of the system's resulting uniqueness and operational usefulness will come from the choice and blending of technologies and products selected, and their subsequent integration into a seamless whole.

Such integration poses an extra layer of integration risk beyond the contributing technological risks posed by each technology (summarized in Section 3.3). Given the uniqueness of the technology mix, capabilities used selectively, and the custom software written to unify them into one seamless system, **the integration risk could actually exceed the total technological risk** associated with particular products. This viewpoint identifies the critical importance and contribution of integration risk to a proper and thorough risk abatement evaluation.

2.2 INTEGRATION RISK

Factors affecting the integration risk are numerous and complex as are the short and long term evaluations of their collective influences on AFTOMS. Integration risk must be evaluated from several points of view (dimensions). Within each dimension there are risks; these can be organized and evaluated based on their AFTOMS impact.

2.2.1 Dimensions

The eight dimensions in which integration risk is relevant to AFTOMS are as follows:

- **Management of distributed user functionality.** Focuses on reassessing the feasibility of the AFTOMS To-Be model in terms of its major functionality and how that functionality is distributed over networks and throughout the AFTOMS infrastructure;

- **Handling and conversion of heterogeneous technical order data.** Focuses on managing a large inventory of heterogeneous TO types (paper, digital page image, digital interactive, classified, unclassified, etc.) and TO conversion from paper to digital to maximize automation benefits;

- **Support of heterogeneous system users.** Focuses on providing automated support to a wide spectrum of system users whose functions, data, and information requirements vary significantly;

- **Use of electronic communication.** Focuses on an AFTOMS communication architecture for connecting major elements of the system and organizations, as well as passing TO content and management data among system users;

- **Interface to other Air Force functions/systems.** Focuses on interfaces and interoperability with other Air Force systems, organizations, and functions;

- **System buildability.** Focuses on factors affecting building an efficient, effective AFTOMS, and develops a framework for modeling project risk;

- **Reliance on conformance to standards.** Focuses on the influence of standards on system architecture, and defines a framework for viewing the integration of multiple standards and their associated risks; and

- **Operational utility.** Focuses on managerial and technological approaches for rapidly achieving automation benefits, promoting productive daily use, and supporting long-term effectiveness of AFTOMS.

2.2.2 Risk Evaluation

Within each integration dimension, risk can arise in several areas, such as:

- **Functionality.** The proposed integration cannot provide the functionality needed to integrate target capabilities because: they are logically inconsistent, the necessary knowledge foundation does not exist, available hardware cannot support that functionality, or the functionality becomes operationally unacceptable;

- **Performance.** The proposed integration produces unacceptable performance in: error rate, task completion time, predictability for a productive work process, or degradation under increased loading;

- **Seamlessness.** The proposed integration is: not smooth, difficult to learn, unproductive, error prone, and places an unnecessary operational burden on users;

- **Flexibility.** The proposed integration is logically too tightly coupled with potentially obsolete or proprietary methods and/or products, so it could present future problems in maintenance and upgradeability; and

- **Doability.** The proposed integration may not be accomplished successfully within the constraints of the project given the technology products, tools, and support available.

Each identified integration dimension was evaluated for its degree of integration risk relative to the particular needs and special characteristics of the AFTOMS concept. Evaluations were performed for two time frames:

- **FY89**, to determine its current feasibility and problems; and

- **FY91–FY93**, to forecast its feasibility and risk for the actual development and subsequent use of AFTOMS.

Risks were assessed for significance using the following judgmental scale:

- **High.** Characterizes those risks of wide-ranging impact that can significantly reduce automation benefits or jeopardize AFTOMS success;

- **Medium.** Characterizes those risks that can compromise important automated functionality (relative to the To-Be system concept) and degrade productivity somewhat, yet not jeopardize either the automation benefits or program success; and

- **Low.** Characterizes those risks that have small, limited impacts, and for which solutions will be defined during the normal development process.

2.2.3 Summary

The 35 integration risks (or classes of risks) identified during the POC for AFTOMS are organized by integration dimension and listed on the right-hand side pages of TABLE 2-1, as are corresponding suggested approaches for abating them. Of these 35:

- **None** prevent AFTOMS from being developed if the abatement recommendation is followed;

- **Twelve (12)** are very significant in severity:

  - The operational ability to perform Type A-to-Type B document conversion economically for a complete weapon system suite of TOs:

- Availability of MIL–STD 1840 supporting DTDs and OSs to help convert older paper TOs since the DTD/OS focus is on conformance of newly authored digital TOs;
- Slow buildup of the digital TO inventory due to economic considerations or technical/operational problems with paper–to–digital conversion or Data Type Definition (DTD) specification conformance;
- MIL–STD 1840 compliant digital TOs (from contractor authoring producers or converters) may not be standardized enough and thus may require additional Tier 2 labor to support productive TO use within AFTOMS;
- Premature integration of Type C capability into AFTOMS before its unique support infrastructure within AFTOMS is clearly understood and delineated;
- The POC did not establish whether a neutral database model like that needed to support Type C TOs can be built in time for AFTOMS IOC and then operated successfully on a large scale;
- Inadequate knowledge of the detailed interfacing or support requirements for PDD and Work Area TO delivery systems (e.g., IMIS and ITDS) can impair future AFTOMS interoperability with these and other Tier 4 systems;
- Technological and economic risks of developing a single integrated and secure AFTOMS far outweigh the benefits;
- Temptation may exist to use a funded AFTOMS program as a vehicle to incorporate additional CALS functionality, thereby increasing and diffusing the scope of AFTOMS beyond TO management and distribution, and jeopardizing AFTOMS success;
- AFTOMS buildability risk needs to be (and can be) lowered significantly with a quality set of technical and operational requirements in the RFP, that suitably constrain any contractor's solution flexibility and provide an unambiguous basis for determining if a proposed and/or implemented solution meets AFTOMS, MAJCOM, and CALS long–term needs;
- Failure to take full advantage of the FY89–FY90 POC work (as delineated in this report) to maximize the potential for total buildability risk reduction; and
- Standards have gaps important to AFTOMS e.g., Document Management Systems (DMS) technology products lack standards whose absence could increase AFTOMS life cycle costs; and optical media

are not yet accepted by the government as a standard for permanent storage of archival data.

- **Sixteen (16),** as marked, are significant in severity; and
- **Seven (7),** as marked, are merely localized in significance.

These integration risk findings are summarized in Section 4.

2.3 INTEGRATION FINDINGS

Using a standardized format, TABLE 2-1 summarizes the AFTOMS POC findings that are most relevant to each integration dimension.

Each integration dimension in the table consists of two facing pages:

- **Left Hand Page.** The page is structured into the headings of Integration Dimension and State of Feasibility.
    - **Integration Dimension.** A narrow vertical panel on the left side identifies the topic and capsules its relevance to AFTOMS.
    - **State of Feasibility.** Two vertically stacked horizontal panels on the right summarize the POC feasibility assessment. The upper panel summarizes the integration dimension's "State of Feasibility" as it exists in FY89 during the POC period; and the lower panel summarizes that integration dimension's forecasted state of practicality to support the full-scale development and deployment of AFTOMS between FY91–FY93. Each state description focuses on generally supported capabilities and significant deficiencies important to AFTOMS. Whatever is feasible in FY91–FY93 should remain so beyond FY93, unless major unforeseen changes occur. Consequently, only developments affecting the risk or deficiency areas need to be monitored and reevaluated if AFTOMS development is delayed.
- **Right Hand page.** The right hand page is structured into the headings of Integration Dimension and FY91–FY93 Risk.
    - **Integration Dimension.** A narrow vertical panel on the left side repeats the topic and lists the symbol legends used to code the significance of identified risks.
    - **FY91–FY93 Risk.** Assessments of Post-POC residual risks are summarized in the middle column. Then corresponding risk abatement recommendations (wherein a strategy or approach is proposed for each risk to avoid, minimize, or control it) are summarized in the rightmost column. These recommendations include no specific product mentions.

All the table entries of content on both facing pages are abstracted from the detailed integration reports contained in Appendix B; the integration dimensions in the table are sequenced in the same order as in the appendix. These appendices should be read to gain a deeper and more comprehensive understanding of individual dimensions of integration, assess their relevance to AFTOMS, review important specific issues, and appreciate the context for the POC findings.

This page in Section 2 is left intentionally blank to format the following table with facing pages.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS

I1 INTEGRATION DIMENSION	STATE OF FEASIBILITY
MANAGEMENT of DISTRIBUTED USER FUNCTIONALITY	**FY89:** This analysis shows that the AFTOMS To-Be Concept: ▪ Is internally consistent; ▪ Can be integrated to provide the major functionality; and ▪ Should satisfy the operational needs of the Air Force TO community. The Demo System work reinforces the quality and viability of the concept with respect to correctness, internal consistency, and buildability; also, the user interface prototypes demonstrated in the Demo System appear to match the needs of all major classes of users: data managers, maintenance technicians, publications personnel, and operations personnel. However, being a small-scale prototype which incorporates only essential functionality needed for the POC, the Demo System did not test usage conditions under a realistic TO database load; a pilot system installed at one ALC could provide this capability.
RELEVANCE: **To gain maximum benefits from the automation of technical order management, AFTOMS needs to implement the To-Be concept rather than merely automate the As-Is functionality.** **Given the POC work, this section reassesses the feasibility of the AFTOMS To-Be model in terms of its tiered architecture and major functionality.**	**FY91-FY93:** Additional ongoing work by the AFTOMS SPO for developing the detailed RFP requirements (to define carefully al[illegible]e necessary levels of the AFTOMS concept) should not degrade the [illegible]cept's feasibility provided its core structure is maintained while the supporting detailed needs and problems are analyzed relative to the core structure.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION 11 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
MANAGEMENT of DISTRIBUTED USER FUNCTIONALITY	**Residual concept-related risks are present in the following areas:**	**The Air Force could abate these risks by:**
	[HIGH] The operational ability to perform Type A-to-Type B document conversion economically for a complete weapon system suite of TOs.	☐ Instituting a pilot conversion activity on a representative suite of TOs as soon as possible.
	[HIGH] Availability of MIL-STD-1840 supporting DTDs and OSs to help convert old TOs since the DTD/OS focus is conformance of newly authored digital TOs.	☐ Investigating this risk as part of the foregoing pilot activity by using interim versions of DTD/OSs if necessary.
	[MEDIUM] Distribution management complexity in integrating commodity TOs with weapon system TOs for single point distribution from TOMAs to CTODOs.	☐ Investigating this issue further.
	[MEDIUM] Defining a "standard" layered interface between AFTOMS Tiers 3&4 which can support multiple Tier 4 delivery systems (e.g.,IMIS, ITDS, etc.)	☐ Investigating this issue further. ☐ Using the POC findings and the Demo System to: ▪ Solicit feedback continuously from potential AFTOMS users to refine & coordinate the concept; ▪ Update & extend the Demo System to explore the implications of this feedback; ▪ Use the Demo System as a training and educational tool within the AFTOMS community to focus activities and increase development productivity; and ▪ Incorporate Demo System concepts into the System Operational Requirements Document (SORD) and Functional Description (FD) to reinforce a coordinated and tested view of AFTOMS functionality.
	[LOW] Many residual integration risks exist locally within the sub-levels of the functionality; they are identified in the Appendix B Sections, B1-B8.	
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW		

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

I2 INTEGRATION DIMENSION	STATE OF FEASIBILITY
HANDLING and CONVERSION of HETEROGENEOUS TECHNICAL ORDER DATA **RELEVANCE:** **The entire growing Air Force inventory of 150,000-plus TOs, whose type is heterogeneous and content is dynamic, must be managed by AFTOMS over a prolonged time period.** **This section examines this issue by reviewing its 3 major aspects:** **▪ simultaneous management of unclassified TO Types A, B–, B, B+, and C;** **▪ conversion of Type A paper and contractor digital TOs to a standardized Type form; and** **▪ handling the currently small, but increasingly important and growing subset of classified or restricted TOs.**	**FY89:** Management of Type A, B–, B, and B+ TOs is readily integrated into the AFTOMS To-Be model. Detailed requirements for integrating Type C support capabilities into AFTOMS were not investigated; but full management of Type C TOs appears to require AFTOMS support in authoring, verification, change management, and on-line delivery. These capabilities appear challenging technically and operationally, thereby adding to the program development workload in the short term to meet AFTOMS IOC. AFTOMS is most productive in managing standardized digital Type B–/B/B+ TOs; therefore, the economic conversion of Type A TOs to Types B– or B should be a high near-term priority for the program. Current solutions are not sufficiently economical to handle the large bulk conversion requirements of the Air Force. A single integrated classified/unclassified AFTOMS is not now feasible. **FY91–FY93:** Feasibility of mixed inventory management is best maintained by adhering to the following practices: ▪ Implement existing To-Be authoring, distribution, and change management concepts to reduce AFTOMS complexity; ▪ Incorporate Type C concepts which are consistent with To-Be model constraints (e.g., reduce redundancy during cataloging, simplify view creation through tagging, allow only fixed views, etc.); and ▪ Accept new TOs in the format (B or C) to be managed and used, thereby eliminating unnecessary conversion or repeated translation. Type A-to-B conversion feasibility will increase significantly as the emerging, more intelligent, and automated conversion technology becomes installed and reduces the cost-per-page significantly. Acceptable trustworthy and secure technology for handling both classified and unclassified TOs in a single integrated system still will not be available to support the sophisticated commercial software products integrated to provide the full AFTOMS functionality.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION 12 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	**ABATEMENT**
HANDLING and CONVERSION of HETEROGENEOUS TECHNICAL ORDER DATA	**Residual concept-related risks are present in the following areas:** The POC did not establish whether a neutral database model like that needed to support Type C TOs can be built in time for AFTOMS IOC and then operated successfully on a large scale.	**The Air Force could abate these risks by:** ☐ **Performing a detailed operational evaluation of the Type C concept to establish the AFTOMS support requirements.** Recognizing that a minimal amount of Type C data will exist before FY2000, AFTOMS development should focus first on full Type B family management, followed by incorporation of Type C support. In the interim, as described in Section B2.2.2, Type B+ TOs provide the Tier 4 users with similar TO data display, navigation, and cross referencing benefits as offered by Type C- TOs.
	Technological and economic risks of developing a single integrated and secure AFTOMS far outweigh the benefits.	☐ Using a separate, physically secure, mini-AFTOMS to support the classified TOs inventory (less than 5% of all Air Force TOs now) either indefinitely or until practical technology is available to support an integrated approach. Scrubbed classified TO catalog information can still be merged into the unclassified AFTOMS system.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	Type A-to-B conversion will become economically affordable, although technological limitations may prevent a full conversion to Type B; but a subset of Type B- TOs is manageable. Also, direct conversion of contractor digital to AFTOMS digital may be an alternative conversion option for some sets of TOs.	☐ Not waiting until FY93 to begin the Type A-to-Type B conversion since early experimentation on a pilot basis will provide a better experience base for planning the full-scale conversion, which should: • Convert as much of the TO inventory as soon as possible on a weapon system and commodity basis using service bureaus; • Enhance the converted digital TOs to Type B+; and • Individually upgrade (later as needed) any problematic Type B- TOs to Type B status.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

I3 INTEGRATION DIMENSION	STATE OF FEASIBILITY
SUPPORT of HETEROGENEOUS SYSTEM USERS **RELEVANCE:** **Different classes of users (managerial, technical, editorial, production and Tier 4 maintenance) will coexist and need to be supported by the system. The goal is to make all AFTOMS users more productive through quality requirements definition and system design.** **This section examines key requirements for such heterogeneous user support, various user interface design approaches, standards, and the implications of B+ custom delivery of TO information to Tier 4 users in a more useful form. In summary, it explores the feasibility of building integrated user support.**	**FY89:** Relational databases handle management and conventional data well. Document management/publishing systems: handle textual/graphical/tabular data and TO configuration control well; and provide annotation, group review and other capabilities useful for TO change management. And hypertext capabilities are needed for TO navigation at Tier 4. None of these systems handle the others' data types well, but AFTOMS needs to integrate all three types of data handling. **The "software glue" that integrates these disparate elements into a seamless AFTOMS is consistency of user interfaces.** In the heterogeneous hardware and software environment of AFTOMS, feasibility of supporting system users is heavily dependent on the emerging de facto X-Windows standard and its commercial support, which is now inadequate. The visible "look & feel" of user interfaces is still not standardized; this can be overcome if AFTOMS incorporates graphical windowing-style user interfaces, not character-based ones. Use of SGML is essential (but difficult) for document tagging and synchronization of changes across TOs because SGML is currently designed for batch systems, incorporates over 350 individual codes, and is difficult to integrate internally into an interactively-oriented system like AFTOMS. New, more flexible, and easier-to-use SGML products are beginning to emerge so that present difficulties should slowly become less problematic. Products for customized presentation of TO views, navigation within or across views, are just emerging, and will need further development.
	FY91-FY93: Significant advances are expected in hardware and technology areas of concern to AFTOMS: user interface products, maturing of standards, data transparency in a distributed and varied data type environment, on-line distribution/display of TOs to WAs, groupware and conferencing for Tier 2 change management, and technology integration tools. Specifically: ▪ For user interfaces, X-Windows products should be production grade in reliability and performance, the X-protocol will be supported by products likely to be integrated into AFTOMS, the "look & feel" confusion largely resolved, and programming graphically-based user interfaces made easier; ▪ Emphasis will remain on standards-based open architecture systems that are more easily upgraded technologically; ▪ Techniques for interactive SGML validation will appear and receive widespread acceptance, providing more powerful tools for handling tags more productively and transparently; ▪ More integration will be embedded in database, document management, and on-line delivery products to handle more easily and transparently the various data types important to AFTOMS and provide a better basis for supporting Type C (neutral data) TOs; and ▪ Tools and integration capabilities will be available to design AF TOMS to take advantage of advanced hardware likely to appear after FY93, during the TOMA/CTODO installations.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION I3 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
SUPPORT of HETEROGENEOUS SYSTEM USERS	**Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	Technical integration of database, document management, and hypertext on-line delivery technologies with their inherently different underlying data models to support Type B digital and future Type C neutral data.	Simplifying and phasing in requirements: a data model sufficient to support B+ requirements should be built, anticipating later conversion or use of the TO data in a new, post-B+ neutral model.
	Current SGML models are based on structural rather than semantic analysis, so automatic identification of related but not identical technical material (within the same TO or across TOs) is difficult; an operator-assisted approach to SGML tagging of TOs will be needed, adding some operational complexity and cost.	There are at least 20 times as many steps as tasks/subsections in TOs. Therefore, using larger taggable units for TO granularity (or lowest level of information to tag separately) vastly simplifies SGML tagging and verification operationally and will reduce the conversion cost of existing TOs.
	Separate developments/procurements of AFTOMS and MAJCOM's Tier 4 TO delivery systems will increase integration problems.	Working closely with Using Commands to define the standard interface requirements for AFTOMS that they can support.
	Key undecided operational requirements for system usage (e.g., change management at Tier 2 and TO traversal at Tier 4) affect the design of AFTOMS in broad and fundamental ways.	Baselining broad-ranging process decisions (e.g., those involving job functions, neutral data support, interactive vs. batch publishing, support of existing equipment, etc.) early for the RFP.
	Possible requirements for implementation of AFTOMS on existing HW platforms (e.g. z248s) will add to design, implementation, and operational complexity.	Developing one version of the SW and user interfaces that will run on all (possibly upgraded) HW platforms since reconfigurable SW is usually problematic.
	Delivery of TO data to WAs with sufficient flexibility to permit display of information on portable devices with relatively small screens and low amounts of memory will add complexity.	Working with Using Commands to define such specialized display requirements; may need to deliver TO data in other than full-page form.
	Design of consistent, easy-to-use user interfaces for all classes of AFTOMS users will pose some problems.	Using standardized protocols and tools such as X-Windows and whatever "look & feel" toolkit is widely supported.

LEGEND

RISK ASSESSMENT SYMBOLS:

HIGH

MEDIUM

LOW

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

I4 INTEGRATION DIMENSION	STATE OF FEASIBILITY
USE of ELECTRONIC COMMUNICATION **RELEVANCE:** **AFTOMS will require electronic communication to provide embedded transport and routing functions to support distribution of users, hardware, data, and functionality both within and across the tiers.** **This section examines the key issues for defining a communication architecture which offers responsive performance and adequate capacity while appearing to be transparent to users, supporting heterogeneous platforms and software systems, and adhering to evolving government communication standards.**	**FY89:** To meet AFTOMS performance objectives, selection of communication standards and vendor hardware/software products for system integration must be directed with **distributed rather than centralized operations in mind**. The supporting, distributed AFTOMS network architecture should provide embedded electronic data transport and routing functions, and consist of: Local Area Networks (LANs) servicing intra-tier requirements; and long-haul Wide Area Networks (WANs) providing paths between tiers or remote sites within tiers. The primary types of communication traffic on this network will be electronic mail, file transfers of technical data, management database transactions, and on-line conferencing during group technical content reviews. To reduce the overall traffic load, the primary bulk distribution medium for TOs will be optical disk because a typical TO page (consisting of 60% text and 40% graphics) on average will require 30 Kbytes of digital storage or electronic transfer. Other than electronic conferencing applications (which are now restricted to a homogeneous workstation population), hardware and software is currently available to support AFTOMS communication requirements and current DoD communication protocols. Available LAN (at 10 Mbps) and high-speed WAN (exceeding 56 Kbps) technologies support transaction query/ response times of less than 5 seconds and TO transfer times of 5-to-10 minutes. **To support AFTOMS operationally, additional LAN installations and WAN connections will be required in the AF.** **FY91–FY93:** The AF has published new system implementation guidelines, including its long-range plans for the Local Information Transfer Architecture (LITA) and the Long Haul Information Transfer Architecture (LHITA), as part of its AF Information System (AFIS). Both sets of guidelines call for transition from current DoD protocols to Government Open Systems Interconnection Profile (GOSIP) conforming ones. GOSIP will become mandatory after August 1990. AFTOMS can comply by requiring strict adherence to DoD standards in the near term and following the AFIS migratory path in the long term; for example, selection of AFTOMS communication equipment should be based on Unified LAN Architecture (ULANA/LITA) and Defense Data Network (DDN/LHITA) specifications. A reliable, GOSIP compliant and DoD approved replacement for the current Transmission Control Protocol (TCP), called TP4, may not be available to support internet routing, reliable transport, and electronic conferencing, so TCP will have to be used in the interim. If needed, DoD E3 devices can provide multi-level security for data transmission through the DDN. Data transfer rates are adequate to support AFTOMS. If additional performance is needed along specific links of the AFTOMS network architecture, then LAN transmission rates of 100 Mbps are possible with a Fiber Data Distribution Interface (FDDI) offering response times comparable to disk access, and T1 rates of 1.544 Mbps are available for WAN links. Adequate planning leadtime is needed to implement all these links.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION I4 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
USE of ELECTRONIC COMMUNICATION	**Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	Communications protocol selection may not allow full compliance with GOSIP.	Selecting system vendors that offer full support and upgrade plans to GOSIP. Implement the full DoD protocol suite (ULANA I & II for LANs and DDN/LHITA for long haul) through TCP/IP; this will facilitate future upgrades and allow GOSIP compliance except for the TP4 transport protocol. Use software products that support TCP/IP with LAN and X.25 DDN protocols which will facilitate interoperability and support DoD E3 security devices; use of Network File System (NFS) in addition to the DoD suite is recommended for transparent file transfer among heterogeneous systems.
	DDN resources may not be available for AFTOMS wide area networking.	Subscribing to the DDN requires at least 24 months of leadtime to coordinate their service requests through the AF Communications Command (AFCC) for the DDN; this application will require a detailed quantitative communications usage study to support it. Or, dial-ups and leased circuits may be used to meet some WAN link requirements.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	AFTOMS traffic loads cannot be carried by specified transmission facilities because of improper sizing and protocol selection, resulting in bottlenecks, delays, and unreliable user service.	During architectural planning and design, model the anticipated message characteristics and traffic loads between and within the AFTOMS tiers; adjust AFTOMS design as necessary. This traffic loading information is required for subscription to the DDN and can define base-level LAN needs.
	Existing TO systems (e.g., ATOS) may pose interoperability issues that restrict their integration with AFTOMS.	Examining such systems to determine their needed levels of integration and communication interfacing to AFTOMS local and long-haul services.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

I5 INTEGRATION DIMENSION	STATE OF FEASIBILITY
INTERFACE to OTHER AIR FORCE FUNCTIONS/SYSTEMS RELEVANCE: **Long term, CALS modernization will require deployment of several new auto-mated systems for managing and handling technical data. AFTOMS, dedicated to TO data, is only the first such system. Interoperability between new systems and with existing systems is an important requirement for CALS.** **This section examines how AFTOMS will interoperate and interface with: existing TO systems like LMTOS and ATOS; varied contractor owned TO producer systems; unique and incompatible TO delivery systems at Tier 4 like IMIS and ITDS; and future CALS technical data systems like PDD.**	FY89: CALS refocuses the logistics modernization effort toward sufficiently integrating separate systems (whether already in place or being developed now or in the future) so that [illegible] will interoperate. Near-term emphasis thru the mid-1990's is on interfacing systems; thereafter, emphasis will shift toward integration. Interoperability must be carefully planned for in every new system if the CALS goal is to be achieved. Several systems and classes of systems must be considered for interoperability with AFTOMS. For existing TO systems, it is feasible for AFTOMS to: • Replace and improve the TO management functionality being provided by the 20-year old Logistics Management of Technical Order System (LMTOS), also known as G022; and • Use the Automated Technical Order System (ATOS) to provide TO change processing on the diminishing set of paper TOs managed by AFTOMS but not yet converted to digital form. For the many different contractor-owned producer systems that will author and deliver new TOs to AFTOMS, a well-defined standardized receiving interface is needed and feasible based on MIL-STD 1840 and its supporting sets of specifications. Input into AFTOMS of converted TOs should satisfy the same data interchange requirement even though this may require funding the considerable amount of trained labor needed to clean up TOs after automatic conversion processing. Then full AFTOMS functionality can be applied to any digital TO, no matter what its source. This standardized receiving interface is not yet operationally feasible because the enabling technologies are just being developed into usable products. For interoperability with varied TO delivery systems operating in WAs, a standardized interfacing approach is also feasible. The delivery requirements for most weapon systems will be met using a single standard base-level User System that integrates with AFTOMS; there is an AF initiative to define, acquire, and deploy such a system. For other weapon systems that develop unique delivery systems (e.g., IMIS for ATF, and ITDS for the B2), **AFTOMS can support a standardized output interface that each can adapt to**; this standard interface is not yet defined. Interoperability of AFTOMS with other technical data systems (e.g. PDD) is not yet feasible because the interfacing requirements are undefined. FY91-FY93: Normal progress in the enabling technologies should facilitate the technical feasibility of developing the interfaces needed to support AFTOMS interoperability with TO producers, TO users, and base-level technical data systems. Economic feasibility, which is less certain than technical feasibility, may limit the usage level of those standardized interfaces (e.g., fewer paper TOs are converted because of cost). A more tightly integrated approach that does not rely on standardized, layered interfaces will be less feasible. A more informed feasibility assessment requires detailed definition of the interfacing requirements for each class of interface.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION 15 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	ABATEMENT
INTERFACE to OTHER AIR FORCE FUNC-TIONS/SYSTEMS	**Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	Temptation exists to use a funded AFTOMS program as a vehicle to incorporate additional CALS functionality, thereby increasing and diffusing the scope of AF-TOMS beyond TO management and distribution, and jeopardizing AFTOMS success by: ▪ Delaying definition of stable requirements; ▪ Adding functionality to be developed; and ▪ Enlarging the AF community that must be coordinated and satisfied to complete AFTOMS.	Maintaining the present limited and clear scope of AFTOMS to get it developed and fielded suc-cessfully as the first CALS system, but provide standardized inter-faces and design flexibility to sup-port interoperability with other CALS and user technical data de-livery systems.
	Inadequate knowledge of the de-tailed interfacing or support re-quirements for PDD and Using Command's TO delivery systems (e.g., IMIS and ITDS) can impair future AFTOMS interoperability with these and other systems.	Working with the PDD project as needed to ensure AFTOMS/PDD interoperability; and Developing as soon as possible, a standardized AFTOMS interface specification to MAJCOM User Systems by: ▪ Forming a team comprised of AFTOMS and IMIS person-nel to define in detail the AF-TOMS/IMIS requirements; ▪ Forming a team comprised of AFTOMS and ITDS person-nel to define in detail the AF-TOMS-ITDS requirements; and ▪ Working with the team that is defining a base-level standard User System.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	New digital TOs (from contractor authoring producers or conver-ters) may not be standardized enough to support productive use within AFTOMS.	Working with all participating or-ganizations to solidify and **opera-tionally verify** the MIL-STD 1840 interface details and specifications for acceptance of TO data into AFTOMS.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

I6 INTEGRATION DIMENSION	STATE OF FEASIBILITY
SYSTEM BUILDABILITY **RELEVANCE:** **System buildability addresses the integration of individual dimensions and commercial technologies to the task of building a high quality AFTOMS system that fully realizes the AF requirements. Since these are not yet available, the AFTOMS To-Be model is used as an interim surrogate of the requirements to evaluate system buildability.** **This section examines buildability risks and develops a framework for modeling the project risk, identifying key risk contributors, evaluating the overall risk, and finding opportunities for risk reduction.**	FY89: A useful and not overly complex framework was developed for quantitatively modeling project risk. Using this framework, the total project risk was: • First decomposed into a cascading, tri-level, hierarchical set of contributing risk factors; • Each of these risk factors was then judgmentally assessed and weighted both for the factor's importance to AFTOMS and its residual riskiness; and • Finally, all these weighted contributions were consolidated (by working up the hierarchical decomposition structure) into an integrated total for the AFTOMS project. This framework captured risk factors arising from the task (what is being built), technologies and tools (to be used in building AFTOMS), project resources and constraints (which limit project flexibility), and the teams (SPO, Prime and IV&V contractors) involved in building AFTOMS. The **organizational risks associated with mapping specific AFTOMS functionality and responsibility to existing or new Air Force elements were not considered** to be within the scope of the POC assessment. This risk modeling approach shows **the pre-POC buidability risk for AFTOMS to be high, but capable of being reduced significantly**.
	FY91–FY93: This risk model demonstrates that **the AFTOMS buildability risk can be reduced** to an acceptable residual level in this time frame by integrating the POC findings and recommendations into the remaining phases of the project, to: • Improve the quality of RFP requirements and source selection criteria; • Provide an analytical framework and functioning Demo System for understanding development problems, evaluating possible solution alternatives, assessing their risks; and • Demonstrate dynamically and interactively key AFTOMS capabilities and prototype user interfaces to interested parties in the AFTOMS and DoD communities.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION 16 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	ABATEMENT
SYSTEM BUILDABILITY	**Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	[HIGH] "Loose" RFP: awarding the contract on the basis of a short, non-detailed technical and operational specification; thereby relying on the contractor to develop the full set of detailed specifications required to build, test, and validate AFTOMS. Given the tight project development schedule, this approach would present developers with a moving requirements target, increase parallelism of activities to keep to schedules, add to integration risks, continually pose configuration control problems, increase the number of interim problems to solve, and probably result in a lower quality system that will require follow-on engineering changes to make acceptable.	☐ Using the POC findings, focus resources in the time available on particular problematic or risky specification areas, thereby selectively tightening up and detailing RFP requirements to reduce and localize downstream uncertainty. Also, a more intensive FY90 and post-award demo system activity could be used to assess risk areas further dynamically e.g., AFTOMS requirements for full Type C support can be evaluated and integrated into the Demo System first to determine the best approach for Type C integration into the full-scale AFTOMS. Similarly, **other important issues could be investigated in parallel with the main AFTOMS activity.**
	[HIGH] Misuse or non-use of POC results: failure to take full advantage of the FY89-FY90 POC work (as delineated in this report) to maximize the potential for total buildability risk reduction.	☐ Reducing this risk by fully integrating the POC findings into both the pre-and-post contract award activities. Concentrate resources on areas of higher risk and/or higher benefit to AFTOMS.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[MEDIUM] AF organizational issues: incorrectly or inappropriately partitioning AFTOMS functionality and assigning responsibility for the partitions to existing or new organizatonal elements can affect the acceptance and operational success of AFTOMS.	☐ This risk was outside the scope of the FY89-FY90 POC effort at TSC, but the risk should be assessed by the AFTOMS SPO since it can impact RFP requirements, training requirements, and the strategy for installing AFTOMS. **Use the Demo System to get a dynamic feel for how the functionality operates and interacts before partitioning the functionality based on historical patterns.**

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

17 INTEGRATION DIMENSION	STATE OF FEASIBILITY
RELIANCE on CONFORMANCE to STANDARDS **RELEVANCE:** **AFTOMS conformance or nonconformance to standards can impact development complexity, system performance, operational usefulness after installation, and lifecycle costs. These costs arise from post-installation maintenance, enhancement, modification, and upgrading efforts. Each standard has its particularly unique mix of advantages and disadvantages.** **This section examines general considerations about standards, defines a framework for viewing the integration of standards, evaluates the risks and feasibility of conforming to selected standards.**	**FY89:** De facto or de jure standards, used properly, offer AFTOMS: ▪ A smaller, less complex integration burden overall; ▪ Standardized, sophisticated, commercially available functionality; ▪ Higher reliability and quality from the outset using widely used and tested products; and ▪ Flexibility for upgrading standardized functionality and supporting heterogeneity requirements. Reliance on standards also has several potential disadvantages: ▪ Tendency to sacrifice performance and freeze the state of technology below the maximum level achievable with a tuned approach; ▪ Unneeded overhead present in a generalized standard and mismatch in functionality between requirement and that offered by the standard; ▪ Potential for instability and obsolescence of any standard that's not widely supported by industry and government; and ▪ Unpredictable or negative interaction effects of integrating multiple and sometimes conflicting standards. More than 30 individual standards relevant to AFTOMS were evaluated independently and for interoperability problems. **Not all the key standards (e.g., DMS, ODS, UIMS) are sufficiently complete** in definition or implemented in commercial technology products to readily support an open system architecture for AFTOMS in FY89.
	FY91–FY93: **AFTOMS should pursue an open architecture design approach.** This open approach argues that conformance to standards is a sensible system development strategy. It acknowledges that the traditional goals of using the latest technology, maximizing performance, minimizing resource utilization, and customizing functionality to support cosmetic variants (while still important to some degree) are now outweighed by the long-term goals of operational and maintenance productivities as well as interoperability with other present and future systems. Therefore, a long-lifecycle, heterogeneous, and user-intensive system like AFTOMS should take advantage of the benefits of particular standards, while neutralizing, managing, or balancing associated problems. A framework for integrating multiple standards can be used to control their disadvantages. This framework organizes the individual standards by subject and scope, characterizes them by compliance (required or optional), short-term benefit (in building or operating AFTOMS), long-term benefit (for maintenance or integration), and comments regarding maturity level and potential integration or interaction problems. **The analysis shows that an open system architecture is largely feasible for AFTOMS** in this time period as progress in standards development and their partial or total support in commercial products matures. However, some selective tradeoffs and workarounds will still be needed to manage the residual risks.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION 17 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	**ABATEMENT**
RELIANCE on CONFORMANCE to STANDARDS	**Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	[HIGH] Standards have gaps important to AFTOMS e.g., Document Management Systems (DMS) technology products lack standards which could increase AFTOMS lifecycle costs; and optical media are not yet accepted by the government as a standard for permanent storage of archival data.	☐ If DMS technology is used, select a DMS product that supports the complex technical publishing and document configuration control requirements, yet is on a less proprietary development path. Until optical media are accepted as trustworthy for permanent archival storage, sample archived TO data periodically and rewrite it automatically to resolve any deterioration in quality. **Development and validation of standardized DTDs and OSs for MIL-STD 1840 compliance should remain a high priority issue.**
	[MEDIUM] Standards interact to produce problems or fail to support each other e.g., the ADA language does not yet support the Portable Operating System Interface (POSIX) or X-window standards, which would complicate AFTOMS development if ADA were mandated.	☐ Not using ADA at all, or using it only as a design language to gain design portability; then using C or C++ to implement the portable design description.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[MEDIUM] Standards are changing and unstable e.g., the evolving POSIX standard affects UNIX; and the maturing and settling down of several emerging technologies: optical media and devices, Computer-Aided Software Engineering (CASE) environments, User Interface Management Systems (UIMSs), and On-line Delivery Systems (ODSs).	☐ Minimizing dependence on unstable or unpredictable standards, and when that is not possible, then designing in flexibility using interfaces, logical objects, or software layering to absorb changes in these standards. **Avoid tight integration by showing willingness to sacrifice some performance to achieve this flexibility.**
	[LOW] Standards become obsolete e.g.., TCP/IP, IGES, NFS will be superceded sometime in the future by TP4/IP, PDES, RFS or an upgraded equivalent, respectively.	☐ Designing for upgradeability by constraining standards to independent functional areas, separating them by system element location, layering them, or through system administration.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

18 INTEGRATION DIMENSION	STATE OF FEASIBILITY
OPERATIONAL UTILITY **RELEVANCE:** **The focus of operational utility is actual use of AFTOMS after it is built; specifically, how can AFTOMS: realize its automation benefits as quickly as possible after IOC; become more productive in day-to-day operational use; and support future enhancements and integration with other TO or technical data systems that emerge from CALS.** **This section examines managerial and technological approaches for increasing operational utility by: accelerating startup activities, promoting productive daily use, and supporting long-term effectiveness of AFTOMS.**	**FY89:** AFTOMS will operate most optimally and maximize its automation benefits in a fully digital TO environment. Therefore, its **operational utility is enhanced through any measures that accelerate the transition and progress toward a fully digital environment**. Such measures include: ▪ Intelligent system packaging and rapid installation of TOMAs using a **weapon system configuration planning tool** which defines the AFTOMS resources (equipment, functionalities, capacities, staffing) needed to support the weapon system's TO goals & plans; ▪ Paper-to-digital conversion of existing TOs and B+ tagging of digital TOs to provide superior information customization and control to individual Work Area users; and ▪ Adequate staffing, communications and training support. Measures that **provide productive daily use** include: ▪ Incorporating an integrated service quality monitoring program; ▪ Enhancing TO database quality and capacity incrementally through added levels of B+ tagging and a distributed system architecture; ▪ Building in practical functionality which provides operational simplicity, error recovery, predictable performance, and confidence that the user is in control; and ▪ Periodic training. Measures that **promote long-term effectiveness and viability** include: ▪ Flexible design, intelligent integration, and interfacing with other systems; and ▪ Reliance on standards in support of an open architecture approach. All these measures are technically feasible in FY89; however, conversion and B+ tagging (both being labor intensive even though partially automated) are not yet economical on a large scale. Integration requirements for support of MAJCOM Work Area user systems and other CALS systems are not defined sufficiently to assess their impact on operational utility. **FY91-FY93:** Per page unit costs for conversion and B+ tagging will decrease as more intelligent and sophisticated technology products running on faster hardware platforms become available and reduce the needed labor time. As the integration and interfacing requirements for other TO and CALS systems become defined, the feasibility in this timeframe should be enhanced unless the requirements are extraordinary. Other measures noted above are feasible to define, plan, develop, and implement successfully. If adequate organic staffing for AFTOMS becomes a problem, then the Air Force can turn to service contractors to operate the non-critical portions of AFTOMS without compromising performance or delaying periodic technology upgrades.

TABLE 2-1. SUMMARY OF INTEGRATION FINDINGS FOR AFTOMS (CONT'D)

INTEGRATION DIMENSION I8 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	**ABATEMENT**
OPERATIONAL UTILITY **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**Residual risks are present in the following areas:** Slow buildup of the digital TO inventory duc to economic considerations or technical/operational problems with paper-to-digital conversion or Data Type Definition (DTD) specification conformance. Premature integration of Type C capability into AFTOMS before its unique **support infrastructure within AFTOMS** is clearly understood and delineated. Difficulty in defining a standard Tiers 3-to-4 interface to anchor the AFTOMS TO distribution function and support IMIS, ITDS, and other future Tier 4 technical data delivery systems. Unavailability of adequate communications support due to scheduling problems for base-level LANs or DDN WAN connections. Capacity or performance problems associated with full-scale operations that were not visible in a limited POC environment. **Development of a TOMA configuration tool** for planning the AFTOMS support, conversion, data loading, and contingency disaster recovery requirements for each weapon system.	**The Air Force could abate these risks by:** **Using the following three principles to abate them:** **First,** perform modeling, additional POC, or small-scale pilot operations to gather and **learn from specific experience** to develop sound approaches and plans for: ▪ Conversion; ▪ Configuration planning; ▪ Capacity sizing; ▪ Performance balancing; ▪ Level and types of B+ enhancement tagging; and ▪ Type C integration and operational support **Second,** base AFTOMS architecture and design only on commercially available technology products that: ▪ Are proven, production grade; ▪ Adhere to important standards (see I7); and ▪ Integrate well. **Third,** in developing the software components to integrate the commercial products, use: ▪ Object-oriented design techniques; ▪ Standard languages (e.g., ANSI SQL and C, etc.); and ▪ Sacrifice performance and non-essential functionality (if necessary) to obtain system upgradeability, flexibility, extensibility, quality, ease of use, and maintainability.

SECTION 3: TECHNICAL ASSESSMENT OF INDIVIDUAL TECHNOLOGIES: OVERVIEW

3.1 INTRODUCTION

Technologies, which include software, hardware, and standards representation, are critically important to AFTOMS. First, because the overall functionality required to implement the AFTOMS concept is so wide ranging, with key aspects of that functionality at or near state of the art for available Commercial Off-The-Shelf Software (COTS) products. Then, given the broad scope, range of expertise required, and the ambitious FY91–FY93 schedule, it is not feasible to develop a customized version of such functionality, even if it made sense to do so. For reasons of long-term cost, upgradeability, maintainability, and interoperability with future CALS systems, the most effective strategy for AFTOMS is to limit customized development to providing needed:

- Unique functionality not available in those COTS products which support an open system architecture; and
- Software linkages to integrate the purchased COTS technology products into a single seamless AFTOMS system.

3.2 TECHNOLOGY RISK

The technology risk is described below by identifying the areas of technology explored in the POC, the approach used for evaluation of the risks in each technology area, and a capsule numeric summary of the overall technology risk facing AFTOMS.

3.2.1 Areas of Technology

Sixteen areas of technology have been identified as relevant to AFTOMS, either in the short or long term:

- **Object-Oriented Data Management (OODM).** Focuses on a promising, newly emerging technology that integrates the management of a wide diversity of simple and compound data objects including data items, text, graphics, tables, audio, video, etc.;
- **Technical Publishing: Document Management Systems (DMS).** Focuses on a rapidly evolving technology that integrates large-document technical publishing capabilities for group authoring, change and version control, annotation, variant documents, SGML tagging, archiving, document history auditing, tex-

tual/graphical/&tabular data input, layout control, composition, and all other standard word processing functions;

- **Distributed Relational DataBase Management Systems (RDBMS).** Focuses on an evolving technology that distributes established RDBMS data management capabilities (e.g., offering efficient data access structures, a hardware-independent logical basis for formulating queries to retrieve desired data combinations, etc.) over LANs or WANs to provide partitioning of databases and transparent data access throughout the network, and to support heterogeneous hardware platforms;

- **User Interface Management Systems (UIMS).** Focuses on making AFTOMS users more productive through intelligent design and implementation of user interfaces that represent AFTOMS to users, and assesses the capabilities of this technology for building and modifying the various types of hardware-independent user interfaces needed in AFTOMS;

- **On-Line Delivery Systems (ODS).** Focuses on improving the productivity of Tier 4 maintenance technicians through effective use of hypertext-tagged TOs with such advanced capabilities as: TO views customized for task/configuration/and experience level, graphical zoom and rotation manipulation that focuses on specific data, branching/referencing links to quickly navigate relevant portions of the data, etc.;

- **Local Area Communications.** Focuses on the electronic transfer of digital information within work groups, departments, buildings, and bases using Local Area Network (LAN) technology, and assesses LAN technology, its standardization and ability to support hardware heterogeneity and the intra-tier and intra-base distribution of AFTOMS functionality;

- **Wide Area Communications.** Focuses on the long haul transfer of selected digital information between AFTOMS tiers and to external contractors, and assesses several WAN-related issues for AFTOMS suitable communication technologies. Based on the POC scope and the co-location of its equipment suite, WAN data transfer was not included in the Demo System;

- **Optical Disk.** Focuses on a convenient, high capacity, inexpensive, portable, and stable data storage and data transfer medium both for repositing TOs and TO-associated data at Tier 2, and bulk distributing digitally encoded weapon system TO document suites from TOMAs to CTODOs;

- **Demand Printing.** Focuses on selective printing (in CTODOs or Tier 4 Work Areas) of specific TOs, pages within a TO, or other TO-associated and management data; and the key technology that allows this flexibility, demand printing;

- **Workstation Platforms.** Focuses on high-performance, bit-mapped graphic workstations as a key technology for processing TOs (which requires integrated display and processing of text and graphics as well as authoring, tagging, change processing, and verifying TOs), and for support of X-window based graphical user interfaces (needed to integrate diverse technology products, make AFTOMS able to run on heterogeneous HW platforms and easier to use via consistent user interfaces);

- **Document B+ Enhancements.** Focuses on B+ extensions to Type B TOs (defined in a general sense, as those extensions that provide all the TO-related functionality envisioned for a Type C system, except storage of data in neutral form), and assesses possible B+ capabilities, their relationship to a future Type C approach, and technologies needed to provide B+ functionality;

- **Software Design/Implementation Languages.** Focuses on software design and implementation language issues to successfully accomplish a seamless integration of several large-scale, commercially-developed, state-of-the-art systems (that individually exploit particular technologies and focus on specific areas of functionality) into a productive AFTOMS system; and provide the necessary design flexibility to support long-term objectives of lower lifecycle costs for AFTOMS and CALS interoperability;

- **Government Data Interchange Standards.** Focuses on the technology needed to implement the automated solutions for the standard input-side interface to AFTOMS, based on MIL-STD-1840. This standard is the only interface between TO creation (primarily performed by contractors) and TO management performed in the Air Force by AFLC/MM. It brings standardization, consistency, and discipline to both the TO product and the management processes; without its successful implementation AFTOMS cannot succeed;

- **De facto and De jure Computer Industry Standards.** Focuses on a basis for identifying and understanding AFTOMS-relevant computer industry standards (their scope, current state, interdependence with other standards, and likely evolution); the choice of standards and their implementation significantly affects: ease of integration during development and better quality and cost of subsequent maintenance (which includes correcting problems, enhancing existing or adding new functionality, avoiding obsolescence, and upgrading operational performance);

- **Training Technologies and AFTOMS Assimilation.** Focuses on recent major advancements in training technologies which can benefit AFTOMS (in terms of reduced training time, fewer required training resources, increased trainee achievement, lower attrition rates, and increased job proficiency), and in particular, assesses the relevance of two major areas of training: HW–SW training technology and its underlying training methodology. No specific training products were incorporated into the Demo System; and

- **Document Scanning and Conversion.** Focuses on the key technological, operational, and economical issues associated with conversion of the large Air Force paper TO inventory because: AFTOMS is most effective in handling digital TOs; management of TOs is a recurring operational cost which is reduced when TOs are in digital form; TOs are used for many years (e.g., 20–30 years) and are changed and reissued many times during their life cycle, a dynamic process which is better controlled and facilitated through automation; and TO conversion represents a large, but one–time non–recurring cost.

In most of these technology areas vendors have invested highly specialized, not easily acquired expertise and tens–to–hundreds of years of professional effort to develop and refine their products. Many of these products have benefited tremendously from extensive usage in varied operational circumstances. This has resulted in valuable feedback that has been used to correct errors, add new functionality, smooth out rough edges, and generally make the products operationally useful. Moreover, given the dynamic nature of these technologies, vendors continue to enhance and improve their products to stay competitive and to make their products work in a wider variety of circumstances and configurations. These are strengths that AFTOMS can exploit; they provide leverage for developing a quality system sooner as well as maintaining and refining its quality longer.

3.2.2 Risk Evaluation

Within each technology, risk can arise in several areas, such as:

- **Functionality.** The technology does not provide the specific functionality needed in AFTOMS (which then has to be custom developed) or the technology incorporates excess functionality that is problematic (e.g., not needed in AFTOMS, difficult to deactivate or isolate from the desired functionality, and actually or potentially troublesome for the design or operation of AFTOMS);
- **Performance.** The technology is too limited or immature in its multi–year development cycle to provide adequate performance for supporting the anticipated AFTOMS operational environment (e.g., capacity, transaction rate, overhead processing burden, reliability, error recovery, ease of use, etc.);
- **Compatibility.** The technology has severe incompatibility restrictions on its use in an integrated system solution such as AFTOMS (e.g., doesn't support needed hardware platforms, operating systems, or other software products being integrated, etc.);
- **Standards.** The technology is short–lived or dead–ended for use in the open system architecture design approach proposed for AFTOMS since the technol-

ogy adheres to: no standards (is highly customized and insular); unpredictable or highly contentious standards; or inappropriate standards for AFTOMS; and

- **Viability**. The technology will not be widely commercialized in product form (i.e., little demand for it, few suppliers, products not well supported, and limited commercial interest for future development) or the technology is likely to be displaced (thus limiting its long-term usefulness for AFTOMS) by a better, emerging, or established alternative technology.

Each identified technology area was evaluated for its degree of integration risk relative to the particular needs and special characteristics of the AFTOMS concept. Evaluations were performed for two time frames:

- **FY89**, to determine its current feasibility and problems; and
- **FY91–FY93**, to forecast its feasibility and risk for the actual development and subsequent use of AFTOMS.

Risks were assessed for significance using the following judgmental scale:

- **High**. Characterizes those risks of wide-ranging impact which can significantly reduce automation benefits or jeopardize AFTOMS success;
- **Medium.** Characterizes those risks which can compromise important automated functionality (relative to the To-Be system concept) and degrade productivity somewhat, yet not jeopardize either the automation benefits or program success; and
- **Low**. Characterizes those risks which have small, limited impacts, and for which solutions will be defined during the normal development process.

3.2.3 Summary

The 59 technology risks (or classes of risks) identified during the POC for AFTOMS are listed in TABLE 3-1 as are corresponding suggested approaches for abating them. Of these 59:

- **None** prevent AFTOMS from being developed if the abatement recommendation is followed;
- **Seven (7)** are very significant in severity:
  - OODM technology provides inadequate support of distributed, multiuser systems that must run on heterogeneous hardware platforms;
  - Maintaining data consistency and integrity is problematic if heterogeneous RDBMS products are networked in a distributed and integrated CALS architecture;

- Selection of the main underlying data model for AFTOMS must provide for Type B, Type B+, and Type C support, or several data models must be very carefully integrated;
- Availability of verified DTDs, Output Specs (OSs), and thorough testing of the MIL-STD 1840 interface are critical to AFTOMS success since major AFTOMS components and TO contractors rely on the integrity of this interface;
- Large-scale TO conversion not sufficiently accurate in scanning, requiring costly manual labor for post-scan checking and cleanup, thereby reducing the number of converted TOs and AFTOMS automation benefits;
- Large-scale TO conversion not sufficiently integrated as an entire multi-step process, requiring costly manual labor to provide linkages and data adjusting between individual processing steps, thereby reducing the number of converted TOs and AFTOMS automation benefits; and
- Large-scale TO conversion not readily adaptable to old TOs, requiring costly manual labor to retrofit old documents to new standardized and MIL-STD 1840 compliant DTDs and OSs, thereby reducing the number of converted TOs and AFTOMS automation benefits.

- **Thirty (30)**, as marked, are significant in severity; and
- **Twenty-two (22)**, as marked, are merely localized in significance.

These technology risk findings are summarized in Section 4.

3.3 TECHNOLOGY FINDINGS

Using a standardized format, TABLE 3-1 summarizes the significant AFTOMS POC findings that are most relevant to each area of technology.

Each area of technology in the table consists of two facing pages:

- **Left Hand Page**. The page is structured into the headings of Individual Technology and State of the Technology.
  - **Individual Technology**. A narrow vertical panel on the left side identifies the technology and capsules its relevance to AFTOMS.
  - **State of the Technology**. Two vertically stacked horizontal panels on the right summarize the POC feasibility assessment. The upper panel summarizes the "State of the Technology" as it exists in FY89 dur-

ing the POC period, and the lower panel the forecasted state of practicality to support the full-scale development of AFTOMS between FY91-FY93 or its subsequent deployment. Each state description focuses on generally supported capabilities and significant deficiencies important to AFTOMS; it mentions no specific products. Whatever is feasible in FY91-FY93 should remain so beyond FY93, unless major unforeseen changes occur. Consequently, only developments affecting the risk or deficiency areas need to be monitored and reevaluated if AFTOMS development is delayed.

- **Right Hand page.** The right hand page is structured into the headings of Individual Technology and FY91-FY93 Risk.
  - **Individual Technology.** A narrow vertical panel on the left side repeats the topic and lists the symbol legends used to code the significance of identified risks.
  - **FY91-FY93 Risk.** Assessments of Post-POC residual risks are summarized in the middle column. Then corresponding risk abatement recommendations (wherein a strategy or approach is proposed for each risk to avoid, minimize, or control it) are summarized in the rightmost column. These recommendations include no specific product mentions.

All the table entries of content on both facing pages are abstracted from the detailed technology reports contained in Appendix B of the Supplement to the *Technology Issues & Alternatives Report*. This Supplement is a draft document for AFTOMS SPO use only since it contains material not suitable for general distribution.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS

T1 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY

OBJECT-ORIENTED DATA MANAGEMENT (OODM)

RELEVANCE:

AFTOMS needs to store and manage a variety of complex data types. OODM is a promising, newly emerging technology that (in an integrated manner) can store, retrieve, and manage both simple data and diverse compound data objects (*e.g., text, graphics, tables, audio, video, etc.*). Without OODM, AFTOMS must integrate at least three data models: RDBMS, DMS, and ODS.

Given the POC work, this section assesses the OODM concept and its suitability and feasibility for providing integrated data management support to AFTOMS.

FY89:

Conceptually, OODM is very appealing, but in currently available OODM products, basic limitations important to AFTOMS exist in:

- Optimization of object-oriented queries;
- Methods of version control;
- Limited standardization of capabilities across products;
- Integrity of constraints checking, and updating of multiple views when data is modified;
- Partitioning of databases across distributed, heterogeneous platforms; and
- Ability to handle replicated data objects and maintain database integrity and consistency.

Also currently, there are development and performance penalties to pay in using the few available OODM products:

- Longer technology learning curve, design time, and more complex implementation;
- Increased dependence on documentation and development tools, which are still immature; and
- Performance degradation from dynamic binding of objects during runtime.

FY91–FY93:

Not likely that a general-purpose OODM product suitable for large-scale, distributed systems operating on heterogeneous platforms will be operationally ready to satisfy AFTOMS' needs.

OODM technology is not a necessity for AFTOMS success as an advanced DMS or an AFTOMS-integrated DMS/RDBMS/ODS combination will provide all the needed data storage and management capabilities. In fact, DMS technology is evolving to better integrate distributed RDBMS and ODS capabilities.

As technology matures, complementary tools for working together with OODM products and object-oriented languages will appear: languages will continue to emphasize processing, complex structuring, and local data capabilities, whereas, OODMs will emphasize large databases of varied and shared data outside the application.

Except for specialized new applications, transition in database usage from RDBMS to OODM is likely to be slow because of the high cost of redesign and implementation to take advantage of the object-oriented approach. This will constrain the rates of OODM market growth and product maturation for several years.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T1 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
OBJECT-ORIENTED DATA MANAGEMENT (OODM) **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**An effort to incorporate OODM technology into AFTOMS presents serious residual risks in the following areas:** Inadequate support of distributed, multiuser systems that must run on heterogeneous hardware platforms. Uncertainty about the effectiveness of object-oriented query optimization techniques and the impact of the runtime overhead of dynamic binding on resulting OODM performance. Limited standardization of core OODM capabilities across products and adherence to government or de facto standards. Limited commercial presence in terms of installed customer base and number of operationally mature products.	**The Air Force could abate these risks by:** **Not using early generation OODM products.** The AFTOMS data management requirements can be addressed by DMS vendors using an RDBMS possibly enhanced with embedded, carefully optimized, limited-purpose object-oriented capabilities (i.e., for textual/graphical/tabular data, but not for audio, video, etc.). Therefore: ▪ Monitor the development progress of OODM systems to assess their value as a potential technology upgrade for AFTOMS; ▪ Review new versions of DMS and RDBMS systems for incorporation of selected object-oriented techniques and characteristics; and ▪ Use an object-oriented design approach for AFTOMS and implement AFTOMS (wherever feasible) in modular fashion to provide flexibility for upgrading modules or subsystems with new technology once the technology matures (provided the new technology offers practical operational benefits which can be evaluated in a pilot environment).

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T2 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
TECHNICAL PUBLISHING: DOCUMENT MANAGEMENT SYSTEMS (DMS) **RELEVANCE:** **TOs are large, technically complex, updatable documents whose contents have to be managed over long time periods. DMS technology, introduced in 1987, offers all the standard publishing functions and the most advanced large-document technical publishing capabilities, including: group authoring, change & version control, annotation, variant documents, SGML tagging, archiving, document history auditing, and textual/graphical/tabular data input.** **Given the POC work, this section assesses the practicality of using DMS technology in AFTOMS.**	**FY89:** DMS is a new technology that integrates key elements of established technologies, and which is being expanded further to extend its integration to include RDBMS and even ODS capabilities. Although there is extensive core functionality that in some form is common to most or all DMS vendors (e.g., the types of text manipulation supported by publishing software, WYSIWYG processing, annotation features, support of laser printer and typesetter output devices, etc.), there are also major proprietary differences among DMS products in hardware platforms supported, change control management functionality, file & data formats, and workflow management. MIL-STD 1840 compliance of DMS-authored documents is still not fully verified although no critical problems are foreseen. SGML processing support is beginning to be integrated into DMS products, but is not yet user friendly. Given the additional functionality and power that is incorporated in DMS technology (and needed for TOs), somewhat more training is required with DMS products than with word processing products for effective document authoring. **FY91-FY93:** DMS is a rapidly maturing technology whose further development is being focused and stimulated by CALS requirements as follows: • Major products should all support distributed heterogeneous platforms once they are ported to X-window & UNIX, thereby eliminating proprietary hardware issues; • Integration of RDBMS or a limited object-oriented data management capability into DMS will better support the management of document authoring, editing, annotations, change control processing and SGML tagging so that these features will become more standardized and universally available; • DMS technology will remain document focused for awhile so it will not readily or efficiently support Type C, non-document authoring; • MIL-STD 1840 SGML support will continue to evolve towards a productive WYSIWYG interface, and WYSIWYG itself will continue to improve to allow on-screen, interactive fine tuning of quality work without batch runs; and • Advanced technical publishing functionality, such as full text search, will appear in DMS products.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T2 (CONT'D)	FY91–FY93 RISK ASSESSMENT	FY91–FY93 RISK ABATEMENT
TECHNICAL PUBLISHING: DOCUMENT MANAGEMENT SYSTEMS (DMS)	**DMS is a key AFTOMS technology for document management and change control which still could have troublesome residual risks in the following areas:**	**The Air Force could abate these risks by exploring more thoroughly:**
	Incomplete integration with an RDBMS (or OODM) to readily support cataloging, tagging, B+ enhancements, change control, minimally-redundant data storage and fast TO retrieval.	Using DMS products that integrate DMS and RDBMS technologies into a single document publication, management, and distribution product which would simplify AFTOMS design and maintenance; also, considering partitioning and distributing TO documents and associated data for each TOMA over multiple database servers to balance the weapon system database load to improve AFTOMS performance.
	Limited integration with an ODS so that B+ tagging performed in the DMS is not fully used by the ODS in the Tier 4 WAs.	Determining from analysis and experience, the level and types of tagging required to support the Tier 4 users to reduce the tagging load on the Tier 2 DMS operators and the database.
	Limited integration with a scanning system so that converted Type A TOs cannot benefit from B & B+ capabilities without requiring undue manual labor to perform the tagging.	The continuing evolution of intelligent scanning/editing systems that are (or can be) integrated with a DMS product which will facilitate smooth, interactive processing of scanned TOs into Type B or B+ form.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	Inadequate support for interactive SGML authoring, and its difficulty, productivity, and accuracy implications for downstream AFTOMS functionality.	Completing the SGML DTDs in modules: basic requirements for separation of content & format, then additional attributes and tags for effective display of TOs as documents, and finally more additional tags for B+ hypermedia display capabilities.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T3 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
DISTRIBUTED RELATIONAL DATABASE MANAGEMENT SYSTEMS (RDBMS) **RELEVANCE:** **RDBMS technology was developed during the 1970s to provide: efficient data access structures; a logical basis for formulating queries to retrieve desired data combinations; and physical data independence (*so that database-using programs need not incorporate logic that describes the hardware-dependent physical scheme used to store the data*). Network distributed versions of RDBMS, offering partitioning of databases and transparent data access throughout the network, emerged during the 1980s.** **Given the POC work, this section assesses RDBMSs.**	**FY89:** RDBMS is a mature, yet robust database technology of choice that has a large installed base and is being developed further, as follows, to make it even more productive: ▪ All major products support the TCP/IP networking standard for interconnecting their RDBMS on distributed heterogeneous workstations, and vendors are working on their X-window support; ▪ Products are being ported to popular hardware platforms, but some proprietary workstations are not yet (or won't be) supported; ▪ Access transparency across different RDBMS products on the same network is still problematic unless ANSI SQL is used by all products to send transactions to each other; ▪ Scope and integration of supporting development tools, 4GL languages, SQL extensions, etc., and quality of query optimization varies among the products, but is being improved; and ▪ All major products still must solve the distributed database update problem to assure database integrity at all times, even when some equipment malfunctions during processing of a data update. **FY91-FY93:** During this period, only heterogeneous, workstation-based RDBMS products running under UNIX in a X-window distributed environment are relevant to AFTOMS; and a good choice of competing quality products will be available. Products from major vendors should all: ▪ Be compliant with POSIX, OSI, and ANSI SQL standards; ▪ Offer extensive integrated development and end-user toolkits that exceed today's best; ▪ Have fairly well solved the distributed database update problem for their own products, **but problems (in coordinating data dictionaries, data search path optimization, etc.) will probably remain if different RDBMS products are used in the AFTOMS or CALS-integrated architecture; and** ▪ Respond to the OODM challenge by providing comparable, but somewhat limited object-oriented capabilities that offer better price/performance.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T3 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	**ABATEMENT**
DISTRIBUTED RELATIONAL DATABASE MANAGEMENT SYSTEMS (RDBMS)	**Unless obviated by an advanced DMS which incorporates or supports all the necessary data models, distributed RDBMS technology running in a heterogeneous, X-window and UNIX-based environment is a key integrating mechanism for TO-related data and for future integration with CALS. In a well-integrated and locally-distributed environment, RDBMS technology should pose no significant buildability or usability obstacles in handling the required AFTOMS data types and functionality. Distributed RDBMS technology may have residual risks in the following areas:**	**The Air Force could abate these risks by exploring the following architectural and design options:**
	[HIGH] Maintaining data consistency and integrity if heterogeneous RDBMS products are networked together in a distributed and integrated CALS architecture.	☐ Defining standardized interface requirements for other TO and CALS systems to meet; and using only baselined, standards-conforming technologies (e.g., SQL) to assure adequate interoperability.
	[MEDIUM] Degraded performance if RDBMS processing and data are distributed over a wide-area network.	☐ Limiting replication of data & processing, message & data traffic between selected wide-area AFTOMS nodes, batching of queries and using delayed off-peak turnaround response.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[LOW] Inadequate performance under full-scale AFTOMS data/operator/and communications loading if the system architecture cannot provide adequate data, communications, and hardware capacities.	☐ Database partitioning, and specialized search algorithms to take advantage of the AFTOMS tiered structure/TO characteristics/or associated data to maximize performance if necessary.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

<table>
<tr><th>T4 INDIVIDUAL TECHNOLOGY</th><th>STATE OF THE TECHNOLOGY</th></tr>
<tr><td rowspan="2">USER INTERFACE MANAGEMENT SYSTEMS (UIMS)

RELEVANCE:

Different classes of users (managerial, technical, editorial, production and Tier 4 maintenance) will coexist and need to be supported by AFTOMS. The goal is to make all AFTOMS users more productive through intelligent requirements definition and system design. A key element of that system design involves the user interfaces which represent AFTOMS to users.

Given the POC work, this section assesses UIMS technology and its capabilities for building and modifying the various types of hardware-independent user interfaces needed in AFTOMS.</td><td>FY89:

Fundamentally, the UIMS-developed interface performs three major tasks:
• Mediates control of the dialog between the user and the application software that's processing inside the computer;
• Acquires user-entered commands, data inputs, and validates them, thereby defining the use of keyboard, function keys, mouse buttons, and other pointing devices for the application system; and
• Handles all the user-visible portions of the interface including the placement and appearance of all messages, data, and graphic objects, cursor movement, scrolling, window management, etc.

Using the UIMS approach produces a superior quality traditional character-oriented or a modern graphically-oriented user interface (GUI); it avoids potentially serious design flaws; and it lowers the cost of design and future maintenance changes. X-Windows allows user interface portability across heterogeneous hardware platforms.

A UIMS is an integrated set of tools for rapid construction of UIs; these tools are integrated with runtime libraries and macros for specifying standard interface features. Currently, most UIMS products are not really sufficiently standardized, general, or flexible enough to be design tools or to be easily programmable since they:
• Offer a limited set of capabilities and a programming language at most;
• Don't support user interface transition from prototyping to final product development; and
• Don't share consistent meaning with the applications code.

UIMS technology is just emerging into commercial use, and the available products reflect the immaturity of the technology and the lack of application developer feedback from building and using large-scale systems. Other limitations include need for powerful workstations with high-resolution color monitors to support the heavy processing and graphics of GUIs.</td></tr>
<tr><td>FY91-FY93:

Current GUI market fragmentation, product immaturity and stability, lack of common functionality coverage, and performance problems typical of an emerging technology should resolve themselves in the next few years as the technology matures. De facto standards will emerge. The Open Software Foundation (OSF) UI framework will probably become the underlying model for X-Windows, UNIX-compatible, distributed GUIs as major competitors (e.g., AT&T and SUN) add their support to it.

Next-generation advances in hardware performance will help improve GUI performance in terms of speed and graphical resolution at a lower cost. Specialized graphics servers, X-terminals, and adapted personal computers will also become available to run GUIs. Extensions for support of multimedia, new pointing devices, and widget classes will undoubtedly emerge.</td></tr>
</table>

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T4 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	ABATEMENT
USER INTERFACE MANAGEMENT SYSTEMS (UIMS)	**Next generation high-resolution graphic workstations provide AFTOMS developers the opportunity to refine and design productive UIs for AFTOMS. However, designing and developing good UIs has become more complex and difficult as the designer must be concerned with multiple windows, the use of color and shading, graphical objects and icons, networking, heterogeneity in hardware platforms, and various on-screen selection techniques. Thus, residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	Available UIMS toolsets will not fully support productive development of GUIs, thereby increasing the cost and reducing the flexibility of refining the initial GUIs.	Selecting a UIMS technology product that offers a set of integrated software tools for the definition and execution of GUIs, and a high-level specification language for describing the dynamic events and interactions that make up each AFTOMS GUI; also, by defining early a common GUI executive that abstracts a consistent core of GUI services and user dialog techniques which can then be adapted to each specific GUI.
	GUI designers may opt to under-design AFTOMS' UIs settling for traditional approaches which result in hard to learn and use UIs: and which can impact user productivity, training, initial acceptance, and future upgrading of AFTOMS.	Keeping the GUIs independent of the application programs, building on the POC Demo System GUIs, and using a flexible prototyping approach that integrates feedback from potential users should result in good quality GUIs.
	GUIs may not be feasible on all AFTOMS or Tier 4 hardware platforms.	Cost and performance obstacles to bit-mapped GUI workstations are falling rapidly, so design GUIs for future not past hardware.
	Performance of networked GUIs may be somewhat slow.	Improved X-Windows, X-Server, and other specialized products, network balancing, and overall advances in HW will overcome a short-term performance problem.

LEGEND

RISK ASSESSMENT SYMBOLS:

HIGH

MEDIUM

LOW

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T5 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
ON-LINE DELIVERY SYSTEMS (ODS) **RELEVANCE:** **An important goal of AFTOMS is to improve the productivity of Tier 4 maintenance technicians through effective use of TOs. ODS technology can provide the TO user: task/configuration/&experience level customized views of the data, graphical manipulation capability to access the data better, branching/referencing links to navigate quickly to relevant portions of the data, etc. These advanced capabilities require insertion of hypertext tag elements into TOs.** **Given the POC work, this section assesses the capabilities of ODS technology and its relationship to DMS technology.**	**FY89:** ODS, currently offers advanced on-line display capabilities, such as: ▪ The display of fully composed pages (containing text and graphics) on a high resolution graphics display or laser printer; ▪ Multiple windows for displaying multiple pages and/or TOs; ▪ Graphic manipulation (zoom, rotate); ▪ Hypertext links; ▪ Translation of references in text to links; ▪ Maintaining the integrity of complex manuals (text, graphics, tables, external and internal references); ▪ Optical disk access; ▪ Fast page access through page caching; and ▪ Annotation capabilities. With additional work, an ODS can display customized views, such as skill level or configuration variants. Some ODS user interfaces are also programmable, allowing customizable interfaces with the user. The display of multiple pages and the ability to turn two pages at a time is also possible. There is presently only partial automation of hypertext link implementation, which is essential for a cost effective solution to Type B+ TOs. Vendors are continuing to develop annotation capabilities and version control mechanisms. The development of a direct link between a DMS and ODS is essential to enable AFTOMS users to submit AFTO22s productively. **FY91-FY93:** ODS will continue to mature with improvements in performance, better display quality, more B+ functionality, better search and retrieval algorithms and a link between the ODS and a DMS; the access time for page viewing and hypertext linking will also decrease. As workstation costs decrease and more X-terminals become available, ODSs will better exploit the potential for Fault Isolation based expert systems; and ODSs be distributed more frequently with commercial and technical publishing systems. These advancements will allow DMS vendors to investigate the incorporation of more B+ functionality into their on-line delivery systems. By FY93, an ODS should be able to deliver all the functionality needed to support a Using Command delivery system, resident at Tier 2 (for TO verification) and Tier 4 (for maintenance), that includes all the advanced capabilities listed above for ODS. Therefore, the AFTOMS system will be able to display Type B documents at a minimum; and implementation of Type C will also require some form of ODS technology to display TO views at Tiers 2 and 4.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T5 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	**ABATEMENT**
ON-LINE DELIVERY SYSTEMS (ODS)	**ODS is a key AFTOMS delivery mechanism for TOs in FY91–FY93. The POC Demo System activity showed that ODS technology is developing in a productive direction for on-line delivery of TOs and customized views. Residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	The link between the ODS and a DMS may not be adequately integrated. The links and tags that are used to traverse a TO in the ODS must be embedded in the TO text prior to delivery. In the POC, a DMS was used to insert these tags manually using both SGML and other tagging mechanisms. Automation of such tagging is being developed today and should be available in the early 1990s. Integration of publishing systems and ODSs is also being undertaken. During TO creation, DMSs allow multiple authors to add content inputs in the form of graphics, text, tables, data, and composition. For ODS, an easy way for multiple authors to add hypertext links to documents will also need to be devised.	☐ Monitoring integration of ODS and DMS products into a single document publication & delivery product, and looking for developments in the: • Ability to create customized views and display them in a user "friendly" manner using low light colors or whiting out to mark inappropriate text and graphics; • Cataloging and retrieval capabilities needed for the end-user to access the appropriate TO and task information; • Possibility of ODS support of limited data entry for AFTO22s; and • Possibility of SGML external and internal reference tags being automated into hypertext tags. To accept Type B+ TOs from the contractor **the MIL-STD-1840 standards will need to have element types for hypertext links.** Otherwise AFTOMS will need to enhance Type B documents internally upon acquisition and as part of change processing.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	Validation and Verification must be performed on all ODS customized views as well as TOs, thereby adding to the Tier 2 workload.	☐ Reducing workload by verifying only the TOs and views shown at Tier 4.
	The size and complexity of each TO could cause performance problems in the delivery and display of TOs on MAJCOM's delivery systems. Full-scale AFTOMS data, operator, transaction, change control, loading, and performance could not be evaluated in the Demo System.	☐ Considering distribution of TOs and data over multiple database servers and increasing workstation memory. *Note that ODS benefits to the Air Force outweigh initial Tier 2 labor & system performance costs.*

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T6 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
LOCAL AREA COMMUNICATIONS **RELEVANCE:** **The electronic transfer of digital information within workgroups, departments, buildings, and bases has become the domain of Local Area Network (LAN) technology. Advances in this technology and its standardization offer great promise in supporting the AFTOMS intra-tier and intra-base communications needs. Adherence to the AF Unified LAN Architecture (ULANA) standards will ensure interoperability and the latest technologies available.** **Given the POC work, this section assesses LAN technology and its ability to support HW heterogeneity and the distribution of AFTOMS functionality.**	**FY89:** **Installation of LANs** in place of traditional minicomputer/terminal architectures has continued to increase. Ethernet and Token Ring, now considered as mature LAN access protocols, have emerged as the most popular protocols. Ethernet has enjoyed growth because of its lower cost and favor with workstation manufacturers. Currently, Ethernet has the greatest installed base with approximately 50% of the market versus Token Ring's 12%. **The Fiber Data Distributed Interface (FDDI)** which standardizes the physical interface to optical fiber for 100Mbps transmission is emerging. FDDI is viewed as the coming standard for fiber optic communication backbones and will offer support for both Ethernet and Token Ring protocols. **Bridge and gateway technology** has continued to increase performance. Bridge performance for either LAN protocol is considered equally robust. Link Access or Medium Access Control (MAC) layer bridges have become popular in connecting geographically separated LANs using a wide area link such as a telephone, T1 line (1.544 Mbps) or satellite link. For casual terminal access, a 9.6 Kbps dial-up line is enough. For large file transfers like TOs, a 56 or 64 Kbps leased line is necessary. Very heavy traffic (or video and voice) will require a T1 line. **The commercial and DoD development environments** (using RDBMS systems) have continued to rely on TCP/IP and IP host sockets as the basis upon which distributed applications are built. All leading workstation vendors have increased their support for TCP/IP. **User-friendly front-end packages** for Unix mail have been scarce, but support for X-Window and the X.400 standard will change this soon.
	FY91-FY93: **The popularity of both Ethernet and Token Ring LANs** will continue through this period. FDDI will be pursued heavily as a backbone for bridging Ethernets or Token Ring LANs. The growth of fiber optic bridging technology matches the Air Force LITA goals which specify fiber optic cable for interconnection of departmental LANs. Heavy traffic LANs, used where requirements exceed standard 10 Mbps rates, undoubtedly will transition to fiber optics. Fiber optic cabled LANs will also be used to reduce the effects of electromagnetic and radio interference. **The interconnection of geographically remote LANs** will increase as the popularity of layer bridges exceeds that of traditional gateways. ISDN will start to become popular as a LAN-WAN transport specification during this timeframe. Bridge performance will approach a filtering and transfer rate exceeding T1 (1.544Mbps). **Support for ISO protocols** will become more widely available from most vendors. However, the acceptance of TP4 in place of TCP will be a long and difficult transition so in this area the government's push for GOSIP may need to go slow even though GOSIP guidelines will begin to be strictly adhered to for new system acquisitions. **Gateways between existing DoD protocols and ISO will become a reality.** X.400-based electronic mail and Message Handling Services (MHSs) will become the standard. **User-friendly windows and menus** based on X-windows will allow graphical front-ends to be built for the UNIX-environment increasing usability.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T6 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
LOCAL AREA COMMUNICATIONS **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**The functional capability of LAN technology is considered a low technological and cost risk. Some other residual risks are present and the following points need to be considered in assessing the risks in LAN technology selection:** Providing adequate LAN performance is the greatest risk in selecting a LAN for AFTOMS. Ethernet appears to offer adequate speed for file transfer and transaction processing for departmental LANS (generally 10–20 workstations) with less than 60% utilization. Heavy traffic LANs should consider deterministic access methods such as Token Ring. Commercial application software to be integrated into AFTOMS may not run on all LANs or HW platforms thereby setting some constraints that need to be met. DoD protocols are being replaced with ISO, therefore, a migratory upgrade path needs to be considered in selecting any LAN products.	**The Air Force could abate these risks by:** Traffic analyses and modeling should be performed on AFTOMS tiers with a full weapon system suite of TOs to determine proper LAN loading parameters for each tier. A fully-featured Network Operating System should be investigated for its capabilities to support file transfer, security, distributed processing, network management, and diagnostics. Key software such as DMS and RDBMS needs to be evaluated and selected before selecting workstations and LANs. The existing physical environment at each AFTOMS tier and location should be surveyed to determine backbone LAN availability, cabling constraints, bridges and gateways. Then: • ULANA I and II guidelines should be used to select LAN systems and vendors; • CTODO and Work Area LANs should be designed in consideration of the LITA plan for that base; • TCP/IP is the best choice for transport layer protocol over the next five years until TP4/IP matures; • Since inter-tier long-haul traffic will consist primarily of database transactions and electronic mail, gateways rather than bridges offer mature solutions in connecting to wide area X.25 networks such as the DDN; and • X.400 support for mail and NFS support for HW heterogeneity should be required as part of the Network Operating System that is selected.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T7 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
WIDE AREA COMMUNICATIONS **RELEVANCE:** **Wide area Network (WAN) technology provides for long haul transfer of digital information between AF-TOMS tiers and to external contractors. WAN transfer of all TOs is not considered feasible because of excessive communications expense and inadequate performance. Instead, only transactions (e.g., status, AFTO22s, profiles, etc.) and time-compliant TOs will be transferred this way.**	**FY89:** **Long-haul transmission facilities** include TelCo circuit offerings as well as Value-added Networks (VANs). All carriers are upgrading backbone networks with T1 (1.544 Mbps) facilities in anticipation of greater demand. Fractional T1 services are emerging which allow switches to utilize 64 Kbps increments of T1. VANs are continuing to upgrade services. The costs of packet switched services are stabilizing to offer an attractive alternative to building private networks or leasing private lines. Communication access products include modems, bridges and gateways that offer connectivity between the AFTOMs host or LAN and a long haul transmission facility. **Bridge and gateway technology** has improved and offers transparent services between LANs. Link layer protocol bridges have become popular since they allow higher level protocols to be transported transparently over the network. X.25 and TCP/IP gateway services are readily available. The combined use of TCP/IP over X.25 links is not considered a high technology risk. X.25 and asynchronous boards are available which install in PCs or the LAN communications server and offer remote long haul connectivity. Most gateway vendors offer support for transmission rates to 64 Kbps while a few offer T1. **Advanced data compression/error control, fall-back speeds, and dial-back-up features** have made V.32 modems popular for high speed dial up connections and a rising star in modem technology. Under ideal circumstances these modems have provided 19.2 Kbps full duplex operation. **ISDN offerings** have been primarily testbeds for implementation on a small scale. Carriers have been increasing their ISDN switch upgrades but few vendors are offering full ISDN support for customer premises equipment. **Fiber optic lines** by TelCos will become widespread and their use for local and premise wiring will increase. Fiber optic cable and modems are decreasing in price along with the growth of Fiber Distributed Data Interface (FDDI) products.
Based on the POC scope and its co-located equipment, WAN data transfer was not included in the Demo System. This section assesses the WAN-related issues for AFTOMS communication technology needs.	**FY91-FY93:** **Modem product offerings** in this timeframe will decrease the cost of V.32 and V.22 modems and increase throughput performance. **ISDN access services** will be offered in almost all major city markets by local and interexchange carriers. ISDN phones and computer interface cards compatible with the ISDN Basic Rate Interface will increase in numbers as premise ISDN PBXs and TelCo access services will grow in number and cost effectiveness. ISDN and X.25 host interface cards will be popular items. ISDN gateways will be offered as a common solution for connecting remote LANs. Even with increased digital services, dial-up and leased analog lines will continue to be the predominant long-haul transmission resource for small to medium sized users. **Competition between CATV and telephone carriers** for local transport services will increase. Both video and wideband data services will be offered given bandwidth availability and advances in compressed video technology.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T7 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
WIDE AREA COMMUNICATIONS **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**Wide area long-haul communications is considered a low technological risk since networks and equipment are available to support the transaction–oriented traffic planned for the AFTOMS inter-tier network. Expected residual risks are associated with proper planning and provisions for network security:** ☐ Implementation must be timed to take advantage of existing or planned long-haul resources at the base level; this includes dial-up service, leased line, and DDN or PDN services. ☐ Response time and throughput performance may not be adequate with existing or planned resources. ☐ Expense containment must be considered; costly high-bandwidth long-haul telecommunications, T1 carrier or subrate T1, should only be considered for high volume traffic such as that between ALC Data Centers; the communications architecture should restrict traffic to updates and queries until technology and costs justify near-real time transfer of bulk TOs. ☐ Interoperability between systems will remain a risk. ISO protocols should be used wherever possible for long haul transmission: this includes ISDN, TP4/IP, and X.25 as well as application layer protocols of X.400, FTAM, and VTP; ISO, however, will not be widely implemented throughout the AF during the initial fielding of AFTOMS. ☐ Providing adequate security for both the network and classified TO information will depend on near term technology developments.	**The Air Force could abate these risks by proper planning:** ☐ Due to the LHITA upgrade of AF facilities, it is expected that X.25 gateway services, ISDN, and virtual private line services will be available for access by AFTOMS; the schedule and status of these upgrades must be closely factored into planning for AFTOMS wide-area connectivity. ☐ Communications modeling of the AFTOMS architecture should be performed to forecast traffic loading figures needed for the operational network design and simulation; initial investigation of the potential traffic and geographic dispersion of sites indicates that: ▪ Use of a packet network service such as the DDN or PDN is feasible for providing long-haul interconnectivity; ▪ Dedicated leased lines should be considered for the high volume of expected traffic which will occur between ALCs for exchange of TOs and TO review information; ▪ TCP/IP is the best choice of transport layer protocol over the next five years due to its strong vendor support and embedded base of DoD users for both local and long-haul communications; and ▪ ISO should be first choice at all other protocol layers with utilization of NIST–developed gateways to exchange information with DOD protocol based systems. ☐ Communication planners need to consider multi-level security as an option in transmitting classified TO information; this includes investigating the interim use of Blacker and the future DOD Secure Data Network System.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T8 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
OPTICAL DISK **RELEVANCE:** **AFTOMS requires a convenient, high capacity, inexpensive, portable, and stable data storage and data transfer medium both to reposit its TOs and TO-associated data at Tier 2, and bulk distribute the digitally encoded weapon system document suites from TOMAs to the CTODOs. Optical disk technology provides the necessary medium.** **Given the POC work, this section assesses the practicality of using optical disk technologies (CD-ROM, WORM, Erasable Disk, etc.) in AFTOMS; and concludes that the WORM technology offers the best trade off.**	**FY89:** Each TOMA will be responsible for managing, repositing, and distributing the TO suite and associated data for a single weapon system - a maximum equivalent of about 1.2 million pages (at 30 kbytes per page that's 36 Gigabytes of digital data). Reposited data storage requirements will grow cumulatively over time as newly acquired TOs and each distribution cycle are archived; whereas, the size of each successive distribution will only grow slowly based on AFT022 changes and new mods to the weapon system. The AFTOMS system itself will produce additional TO-associated data (e.g., profiles, AFT022s, abstracts, cross-referencing, content tags for B+ capability, SGML codes, component reusability linkages, printer control codes, etc.) to make the TOs more accurate and usable at Tier 4; such associated data will also be reposited and distributed, adding maybe 20% to the TO inventory. Also, for planning of Type C TOs, it can be assumed that the storage impact of reduced redundancy in TO components will be offset by increased storage for database view descriptions and the linkages required to reuse database components. Of the various types of optical media available, the Write Once Read Many (WORM) times technology is feasible and especially suited to the needs of AFTOMS. Generation of data on WORM optical disks is done with WORM read/write devices which attach to the computer. Software provides a transparent interface which allows the user to access the WORM device as if it were an additional hard drive. This software also provides file allocations on the optical disks and file name serialization for maintaining modified versions of the same file. Data is written by using a laser to melt pits in a metallic reflective layer embedded in the optical disk. Data is read by detecting reflectivity differences with a reduced power laser beam. This results in a stable image which is immune to radiation and magnetic influences. The media disk is secured within a protective carrier to prevent marring of the surface by careless handling. The following are the key issues which (as a group) set this technology apart from other optical disk technologies: ▪ Ease and low cost of single disk creation and duplication; ▪ Inherent audit trails; ▪ Data longevity and stability; and ▪ Growing acceptance in the commercial market. Its only practical current deficiency is lack of format standardization
	FY91-FY93: In this timeframe, WORM will have become an established optical disk technology; it is converging slowly on the need for developing and adhering to standardized formats. Media information density should improve by a factor of 2-to-4 per disk, and increased commercial acceptance and widespread usage should reduce costs for media and WORM hardware. Technology advances will also improve media stability and longevity, making WORM even more acceptable for archival as well as temporary and medium term use.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T8 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
OPTICAL DISK	**Industry and POC experience with Write Once Read Many (WORM) times optical disk technology has demonstrated that TOs and TO–associated data can be written, read and printed with a reliability which meets AFTOMS needs. Data accuracy is assured within the WORM technology by multi-level error recovery techniques which can be supplemented with additional data security techniques to any confidence level required. Residual technological risks exists in the following four areas:**	**The Air Force could abate these risks by:**
	Acceptability: will the media be acceptable under existing standards for data transfer and/or archiving?	Even though technological attributes and usage experience indicate that optical media are trustworthy for long-term data storage. the technology is too recent and not well–enough established to have been accepted by the government for permanent data archiving purposes; therefore, it will be necessary to provide archival copies by currently acceptable (paper or microfilm) methods until the optical medium is established and accepted.
	Obsolescence: in a changing technology, how long will specific proprietary technology products available today remain on the market or be supported in the future? At issue are both disk format compatibility and availability of disks and spare parts for the hardware.	The rate of change of optical and other storage technologies is such that no technology available today can be expected to persist unchanged for the life of a typical weapons system. Adherence to industry standards will maximize the effective life of WORM based data, and planned automated transcription of that data to new generations of hardware under future standards will preserve its ready availability indefinitely.
	Practicality: the masses of data which must be stored on WORM disks require an effective and workable means of gathering the data at Tier 2 for writing and a practical method of extracting and securely storing the data for distribution at Tier 3.	
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**Ease of use:** does the system support productive use by typical computer operations staff both at Tier 2 and Tier 3? Is field installation and/or replacement a viable undertaking?	Design of the AFTOMS system and associated operational procedures can provide the necessary levels of practicality and ease of use.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T9 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
DEMAND PRINTING **RELEVANCE:** **Today, TOs are printed at the ALCs and then distributed or mailed to depots and operating bases. AFTOMS will reverse these functions: first, bulk distributing TOs digitally from Tier 2 to Tier 3, then selectively printing TOs or pages within them in CTODOs or in Tier 4 Work Areas. This approach also permits printing TO–associated and management data. A key technology that allows this flexibility is demand printing. Adequate demand printing support at tiers 3 and 4 is critical to the success of AFTOMS.** **Given the POC work, this section assesses demand printing issues.**	**FY89:** By acquiring TOs in digital form and manipulating their digital representation, the decision of when and what to print on demand becomes an economic and operational one, rather than a technological decision. **Computer-based printing devices** are generally divided into two categories: impact printers and non-impact printers. Impact printers, which include dot matrix and daisy wheel printers, produce the printed character on the paper through direct contact. In general, impact printers have limited graphics capability, which is a critical shortcoming for AFTOMS, and produce lower quality print than non-impact printers. In addition, since impact printing involves the coming together of paper, ribbon and molded characters, the printing speed is much slower, and as such will not provide the necessary throughput for TO operations. **Non-impact printers** use electrostatic forces to form a full-page bit-mapped image from digital information and then transfer that image to the page using toner and heat. Such printers, which can be implementations of several physical principles, offer higher speeds and lower noise levels than impact printers. One disadvantage of non-impact printers is that they can print only one copy at a time whereas impact printers can print multiple copies simultaneously. A need for multiple copies makes it necessary to repeat the printing cycle many times when using a non-impact printer. This, however, should not be a problem for AFTOMS since demand printing is usually single copy oriented. Non-impact printers require a **Page Description Language (PDL)** to tell the printer what information to print, where to print it on the page, and what special effects to produce. A PDL uses mathematical descriptions of graphic and symbolic elements to compose a page containing images, allow mixing of text and graphical elements on the same page, and print a document at various resolutions on different quality printers without modifying the document. All non-impact printers are rated by the pages which can be processed by their imaging equipment. The throughput is a function of how quickly the supporting processing, which is the current limitation, can render the image from the incoming PDL file. For example, affordable laser printers now offer 6-to-12 pages per minute at 300-to-400 dpi resolution. **FY91–FY93:** **Technology will provide faster printer throughput by processing PDL with more powerful and faster processors.** This will allow throughput to approach the speed ratings of the hardware imaging devices. Developing PDL standards will probably converge around a superset of PostScript, the current de facto standard. Increasing numbers of printer manufacturers will support PostScript because of user demand, while PostScript interpreter "clones" will evolve as alternatives. This will stimulate PostScript performance gains. High speed printers using Ionography will become more numerous, reducing printing costs due to the reliability of the technology.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T9 (CONT'D)	FY91–FY93 RISK ASSESSMENT	FY91–FY93 RISK ABATEMENT
DEMAND PRINTING	**Graphical printing technologies are mature, having been in wide commercial acceptance for over five years. Early difficulties have been overcome and the present generation of laser hardware and driving software is noted for reliability and proven performance. The current typical 300–to–600 dpi output quality is sufficient for AFTOMS purposes. There is little technological risk associated with the printing resources selected. Other residual risks are present in the following areas:**	**The Air Force could abate these risks by:**
	Printing capacity will not be adequately matched to needs.	☐ Developing a planning and sizing tool to define printing resources required for any TOMA, TOC, CTODO, or WA installation based on its profile and volume of AFTOMS work. Printing resources are essentially modular in nature and their capacities additive, as entire printers can be moved from one computer to another in response to user demands or to equipment downtime. Additional printers can be acquired as printing requirements increase.
	Printer unreliability can degrade AFTOMS productivity.	☐ The risk of laser printer failure in service is minimal, and recovery from failure straightforward. Repair is typically by a specialist and involves board changes—a task similar to copier service. Expendable spares such as toner cartridges and paper must be kept on hand and are user installable. The large established user community will lead vendors to maintain stocks of these expendable items for the foreseeable future.
	DoD and the Industry at large are converging on a new Standard Page Description Language (PDL) which could require conversion of previously–encoded PDL digital files.	☐ PostScript is likely to remain the de facto PDL standard for convenience laser printers. As PostScript evolves into or is replaced by the Standard PDL of the future it is expected that a converter or translater will be made available to automatically translate PostScript encoded files to the Standard PDL.

LEGEND

RISK ASSESSMENT SYMBOLS:

- HIGH
- MEDIUM
- LOW

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T10 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
WORKSTATION PLATFORMS **RELEVANCE:** **AFTOMS uses sophisticated publication SW *(which requires integrated display and processing of text & graphics)* for authoring, tagging, change processing, and verifying TOs; also, AFTOMS needs X-window based graphical user interfaces to integrate diverse technology products, make AFTOMS easier to use, and able to run on heterogeneous HW platforms. These requirements make character-oriented displays unacceptable, and high-performance, bit-mapped graphic workstations a key technology for processing TOs.** **Given the POC work, this section assesses workstation platform technology.**	**FY89:** AFTOMS functional requirements make character-oriented displays unacceptable; and high-performance, high-resolution, bit-mapped graphic workstations the fundamental technology for processing and displaying TOs. All engineering workstations and most sophisticated personal computer applications are also moving away from character-oriented display systems and implementing graphical user interfaces based on windowing software (e.g., the X-window standard). Workstations, originally called engineering workstations, emerged as a new hardware technology in the early 1980's as an outgrowth of the engineering design and manufacturing community. These platforms offer high-speed processing and graphics, and large memory and hard disk capacities to store memory-intensive graphics. Early workstations did not support common standards (e.g., UNIX, X-window, TCP/IP, etc.), but were based on proprietary operating systems and protocols to support specialized application activities. With more sophisticated users and software applications competing in the market the workstation trend now is toward open architectures and support of standards. With the advent of new architecture microprocessors, workstation performance has increased dramatically making real-time graphics available on most workstations. Currently, competitively-priced workstations generally process more than 5 million instructions per second (MIPS), support 1-2 megapixel displays, contain 4-32 megabytes of memory, have gigabytes of diskspace, support multiple users and concurrent processing, and provide LAN access. This workstation technology is primarily aimed at supporting engineering and publication applications, with growing but still limited support in other application areas (e.g., DBMS, spreadsheet, and management applications). These workstations can support AFTOMS requirements now although faster graphics processing would benefit user productivity. **FY91-FY93:** Workstations will continue to increase in performance and decrease in price over the next 5 to 8 years. It is expected that in FY93 commercially-available workstations will process at speeds up to 100 MIPS, have 50-75 megabytes of memory, support 2-4 megapixel displays, and have fast access erasable optical disk drives containing 400+ megabytes of disk space. At the low end, 5 MIPS workstations should be between $5,000 - $10,000 by FY93; such workstations will also have dedicated, enhanced (32-bit, 16 MHz) graphics co-processors, and high-performance (32-bit, 20 MHz) input/output (I/O) co-processors. The limiting factor for workstation technology growth is the expected development of inexpensive fast memory.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T10 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
WORKSTATION PLATFORMS	**Residual risks are present in the following areas:** Unavailability of portable and militarized versions of high-performance workstation platforms that could support AFTOMS functionality (which will be obtained largely from integration of large-scale commercial software products). Of the workstations examined, few if any were found to meet important military operating requirements adequately. The problem areas are: ▪ Use on aircraft where size, power requirements, physical and weather ruggedness, display quality, and memory are important constraints or considerations; ▪ Use in shopwork where the environment may be problematic in terms of dust, dirt, grime, grease, temperature, humidity, electromagnetic interference, etc; ▪ Portable platforms; ▪ EMP protection; and ▪ Nuclear hardening.	**The Air Force could abate these risks by:** Maintaining paper copies of critical TOs at the Tier 3 CTODO or in Tier 4 Work Areas partially overcomes the risk of using commercial-grade workstations in the near term. For the long term, development of high performance workstations for use in special environments should be fostered. Detailed AFTOMS performance requirements (e.g., monitor size, color, resolution; memory; processor speed; LAN interfaces, etc.) for these workstations can be specified by key work area within each tier.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	Compatibility of AFTOMS workstation requirements with other Logistics Modernization System (LMS) requirements (e.g., DMMIS, REMIS, etc.) or standard Air Force purchased computers.	Needs further investigation to establish any requirement incompatibility problems; if any serious ones are found, the general guiding principle for resolving them should be that AFTOMS flexibility and its open systems architecture not be compromised in the long term to make use of existing hardware in the short term.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T11 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
DOCUMENT B+ ENHANCEMENTS **RELEVANCE:** **Type B TOs are digital, electronically-stored, fully editable, page-based documents. Type B+ is an enhanced version of Type B; in a general sense, the B+ extensions to B are defined as those extensions that provide all the TO-related functionality envisioned for a Type C system, except storage of the data in neutral form.** **Given the POC work which incorporated several B+ capabilities into the Demo System, this section assesses possible B+ capabilities, their relationship to a future Type C approach, and technologies needed to provide B+ functionality.**	**FY89:** B+ enhancements are defined to encompass the following functionality: ▪ **Use (at Tier 4)**: customized views, branching logic and referential links, custom work packs, synchronized text and figure viewing, and links from specific TO positions to external systems and databases; ▪ **Cataloging**: ability to enter and retrieve management information about TOs below the TO level, i.e., cataloging and indexing of TO subject matter, including related material across TOs especially for purposes of controlling changes to related sections; and ▪ **Document Component Management**: management of components of like material that are shared across multiple TOs, including management of changes to those components. Type C **also provides such functionality and conceptually is far better suited than Type B+ for handling the integration of all types of technical data. However, Type C operational requirements for AFTOMS and the availability of technologies to support them need to be investigated further.** Type B+ is understood well; requires few process changes over Type B, mostly involving the addition of a few more tags to Type B data and some additional sophisticated software; and commercial technologies are becoming available to support B+ for AFTOMS deployment. The Type C storage of data in neutral (rather than document) form significantly impacts the design of AFTOMS, which must then accomodate several data models. **Several different technologies, established or emerging in FY89, can be applied to support B+ capabilities**, including: Hypertext, Relational databases, Object-oriented databases, Hypermedia information servers, Full-text retrieval systems, On-line Delivery Systems, Page Previewers, and Document Management Systems. Product integration is in progress, and it is anticipated that many of these technology products will be better integrated within the next one to two years. By then, these products will also be much more mature operationally. **The areas of highest risk include document conversion (see T16), tagging, and management of changes.** Using today's technology, **the tagging process can only be automated in a limited way**. Isolation of simple structural elements such as paragraphs is within range of "auto-tagging" software, but recognition of complex table cells with embedded graphics, spanning heads, etc. is not automated. **Document component management is a complex area especially regarding management of changes to shared variable components.** These components are somewhat difficult to isolate from the surrounding text, and also difficult to manage once they are created. DMS products are beginning to deal with this problem, but they have a way to go toward a complete solution. **The other areas of B+ functionality such as cataloging and customized display at Tier 4 are well within the capabilities of current technology.**
	FY91–FY93: The cited technologies are expected to develop sufficiently by this time to allow implementation of a useful B+ capability, which can be expanded logically and in stages as needed based on the operational experience of a fielded AFTOMS. Limitations and risks are noted on the following page. An AFTOMS-integrated operational Type C capability will be difficult to achieve in this timeframe (see TABLE 2-1, B2).

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T11 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
DOCUMENT B+ ENHANCEMENTS **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**Residual risks are present in the following areas:** **Selection of the main underlying data model** for AFTOMS: either a single dominant one (Type B, Type B+, or Type C); or several integrated, coexisting data models. e.g., the trade off in complexity of implementation, risk, and benefits associated with B+ data differs from other data models. **Difficulty of automating all B+ tagging**: e.g., recognition of complex table cells with embedded graphics, spanning heads, etc.; recognition of references such as "see Figure 2-18" embedded in the text; customized view tagging for skill level, etc. **Complexity of document component management:** especially the management of changes to shared variable components. These components are difficult to isolate from the surrounding text, and also difficult to manage once they are created. Moreover, these components do not map to the SGML entities as currently defined in the DMS. The same procedure described in a Job Guide and in a Fault Isolation manual typically has few entire steps or paragraphs in common, the vast majority of steps have only **portions of the step** in common. Document Management Systems are beginning to deal with this problem, but in an incomplete manner. Other areas of B+ functionality such as cataloging and customized display at Tier 4 are well within the capabilities of the technology and as such pose only localized, resolvable risks for AFTOMS development.	**The Air Force could abate these risks by:** An advantage of Type B+ over Type C is that B+ can be phased in gradually over time. e.g., older stable TOs could be scanned and stored as B- (raster images); and TOs that are seldom referenced, or not used for maintenance could be treated as B without adding any B+ tags. It is even possible to mix Type B, B-, and B+ in the same TO. **By selective use of B+ tagging, the cost and risk of the tagging is reduced** because more elapsed time is provided to refine the B+ tagging process, procedures, and policies. Monitor technology products closely to determine which new tagging capabilities are operationally sound. Also, phase in B+ tagging, initially limiting the amount of tagging data to be stored with each TO by selecting a coarse granularity for tagging (e.g., section or subsection rather than task or step) **until experience is gained in what type and how much tagged data is really needed, providing a balance between the tagging effort at Tier 2 and data usefulness at Tier 4.** Risks involved in the management of changes to components are not unique to a B+ environment because **change management is an issue no matter what data model is used**; but these risks can be reduced by a phasing-in approach. That is, create shared components only from the parts of existing TOs that change as these changes are implemented; and for newer weapon systems, shared components can be defined more easily during TO authoring.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T12 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
SOFTWARE DESIGN / IMPLEMENTATION LANGUAGES **RELEVANCE:** **AFTOMS will be developed by seamlessly integrating several large-scale, commercially developed, state-of-the-art systems that individually exploit particular technologies and focus on specific areas of functionality.** **Given the POC work, this section assesses software design and implementation issues to: successfully accomplish this integration to build a productive TO system; and provide the necessary design flexibility to support long-term objectives of lower lifecycle costs for AFTOMS and CALS interoperability.**	**FY89:** Software development is bedeviled by complexity; this is seen in the ever increasing size and complexity of the problems it is being asked to solve as well as in the proliferation and complexity of the tools it has to solve them with. Furthermore, because of the interoperability trend toward integrating systems to make their functionality and data more useful as well as the interactive nature of each system internally, complexity increases much more rapidly than system size alone might suggest. **AFTOMS exhibits these characteristics and so will be a complex system to develop well.** Drawing on successful concepts and results from mathematics, engineering, management science, psychology, and real-world experience, software engineering principles have been developed and should be used to develop AFTOMS; these principles are being incorporated into modern: ▪ Design techniques; ▪ Programming languages; and ▪ Development environments. **Object-oriented design methodology best embodies and enforces the entire set of software engineering principles.** Tools are becoming available to support modern design methodologies. **Prototyping is an important supplementary dynamic design tool that is useful for improving system requirements and design quality, and is particularly valuable for complex systems with breakthrough functionality.** Available programming languages incorporate varying degrees of software engineering principles, including object-orientation. **Most of the commercial technology products that AFTOMS will consider for integration probably will have been written in either the C or C++ language**; and C++ is a suitably enhanced, compatible alternative for C. Therefore, use of these languages plus SQL for database access, and others for their domain of specialization (e.g., PDL for printing), could ease initial integration and offer lifecycle maintainability benefits. **Development environments help enforce standardization and increase development productivity by providing automated support.** Tools for expressing object-oriented designs are emerging so this technology is not yet mature. Because of DoD support, ADA-based tools are most appropriate and adequate enough to design large-scale systems. For example, ADA tools have been used to design systems that were ultimately coded in C, JOVIAL, ADA and even Assembly Language. The FY89 prototyping activity didn't require a formal MIL-STD-compliant development environment so it was carried out informally. **FY91-FY93:** The maturity of the object-oriented design technology, wider availability of tool sets and language implementations, and emphasis on integrating them should adequately, if not optimally, support the design and implementation needs of the actual AFTOMS system using either ADA or C+, given: ▪ The current activity in the object-oriented market (for design methodologies, languages, and development environments); ▪ DoD's commitment to software engineering; and ▪ Increasing use of these technologies in text and graphics based applications.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T12 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	**ABATEMENT**
SOFTWARE DESIGN / IMPLEMENTATION LANGUAGES	**Full-scale development of AFTOMS is planned during FY91-FY93. System requirements may not be very detailed so an iterative development process should be expected. Several COTS products (probably UNIX-based and written in C or C++) will be integrated on a heterogeneous set of platforms running UNIX. Development will have to conform to MIL-STD 7935A (and its AFLC amendments) so an ADA/PDL design approach is mandated. Implementation is preferred in ADA but not mandated. Therefore, residual design/language technology risks are present in the following areas:** Maintaining control (quality/reliability, configuration, accuracy, and consistency between the design, code, test results, and documentation) in an iterative development environment while still adhering to an ambitious, paralleled, task-intensive schedule. Mixing ADA as an implementation language with commercially-acquired, non object-oriented application products being integrated, and the UIMS language which will pervade AFTOMS to produce a hybrid system that is less maintainable (e.g., X-Window is: needed by the UIMS, not available yet for an ADA environment, and at best will be an immature product in FY91). Sacrificing future modifiability with other TO and CALS systems. Relying on an immature UIMS technology implementation. Reduced productivity during development because of the learning curves associated with ADA, C++, other language and CASE tool products.	**During or before the FY91-93 AFTOMS development period, the Air Force could abate these risks by:** ☐ Tightening up the RFP to reduce later requirements revisions, selecting a CASE or APSE environment early (even if not ideal), and sticking with one set of conventions and tools to maximize team productivity with that environment; AFTOMS shouldn't get sidetracked into improving acquired tools or developing new ones since that will expend resources and lead to future maintenance & incompatibility headaches. ☐ Using ADA as a design language for design portability, then reevaluating whether the implementation language should be ADA, C++ or even C. The integrity of this design approach should also reduce the future modifiability risk, and use of C++ over ADA could provide improved productivity because of C++'s less complex capabilities. Also, other commercial products being integrated into AFTOMS are more compatible with C++ than ADA. However, the class inheritance incompatibility between ADA and C++ would have to be accounted for in the design. In addition, **C++ will have to get added to DoD's list of approved High Order Languages (HOLs).** ☐ Developing a flexible, open architecture design. ☐ Understanding the limitations of UIMS and modifying the design to fit within those limits unless they are readily correctible. ☐ Providing training early in these technologies.

LEGEND

RISK ASSESSMENT SYMBOLS:

HIGH

MEDIUM

LOW

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T13 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
GOVERNMENT DATA INTERCHANGE STANDARDS **RELEVANCE:** **Conceptually, the AFTOMS model is simply: Create, Manage, and Use TOs. TOs are created primarily by contractors; whereas, they are managed in the AF by AFLC/MM. MIL-STD-1840 is the only interface between these activities. It brings standardization, consistency, and discipline to both the TO product and the processes. Without the successful implementation of this standard input-side interface, AFTOMS cannot succeed.**	**FY89:** Even though the CALS Initiative began in FY86, very little operational software to support CALS exists in industry. Early on, industry was not sure of the direction of the program, nor were there any approved or stable specifications to build products against. This was especially true in the MIL-STD 1840 and SGML areas. In FY88, CALS momentum increased dramatically which stimulated industry vendors/suppliers to participate significantly in the various standards committees (to define and build consensus for detailed specifications) and to begin product development. While the specifications are far from complete, significant product development occurred in FY88 and FY89, culminating with several initial versions of MIL-STD 1840 and SGML products. CALS-compliant TO products fall mainly into three categories: • CALS Support Package; • Productivity Tools; and • Integrated CALS TO System. **In the CALS Support Package category**, most of the products (both standalone and embedded) offer significant functionality for MIL-STD-1840 Tape Generation and Tape Processing even though they are only first or second releases. Interactive SGML Editing functionality is not nearly as far along. Very few, if any, production-quality products exist today; however, several pre-release products have surfaced with announced product availability dates in FY89-FY90. Smaller software companies are producing many of the specific integrated modules (e.g., an SGML parser); whereas, large publishing vendors are producing solutions with embedded CALS support. **In the Productivity Tools category**, a significant number of such tools (both standalone and embedded) are entering the marketplace in FY89-FY90. Many of these tools exist on personal computers (PCs) and are being migrated to larger micro and mini-computer based publishing systems. While the availability of individual tools is plentiful, they have only marginal use at this time because of integration deficiencies requiring manual intervention. If they can be linked to the previous and succeeding automated steps in the TO process, their value increases greatly. **In the Integrated CALS TO System category**, this capability is essentially non-existent in FY89. Some integration has been accomplished across a few areas, but more importantly, all of the large vendors and system integrators recognize the value and need to link these supporting technologies. **In summary**, while much progress has been made over the past two years, available products cannot be used in a production environment due to lack of adequate testing, minimal integration of the component modules, and lack of well defined MIL-STD-1840 DTDs and Output Specs.
Given the POC work, this section assesses the technology needed to implement the automated solutions for this interface.	**FY91-FY93:** The outlook for availability of integrated solutions for TOs in this time frame looks very promising for the following reasons: • CALS growing momentum and acceptance in industry; • Transferability of products developed for CALS to other sectors; • Assistance of CALS Test Network (CTN) for testing; and • Track record of electronic publishing industry during FY83-FY89 indicates ability to produce AFTOMS solutions by FY93.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T13 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
GOVERNMENT DATA INTERCHANGE STANDARDS **LEGEND** RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	**MIL-STD 1840 has been designated as the only standard for digital delivery of TOs to DoD from the contractor. The software products that support automated preparation and acceptance of TOs in digital form are vitally important to the success of this data interchange standard. These products will be used to accept converted as well as newly created TOs into AF inventory. Without these products it will be impossible to load the AFTOMS database and shift over to digital operations (i.e., distribution, repositing, demand printing, change management). These products need to be considerably along in their product development cycle to mesh with the AFTOMS deployment schedule. Residual risks are present in the following areas:** The biggest risks in TO data interchange lie in two areas: availability of DTDs and Output Specs (OSs); and thorough conformance and performance testing of this interface and its associated operational procedures so contractors, vendors, and AFTOMS developers have full confidence in the component parts of the solution. Vendor-achieved integration of CALS product offerings (which are needed for AFTOMS) may be more partial than expected when deployment of AFTOMS begins. Slower than predicted progress in developing and marketing usefully integrated productivity tools. Interactive SGML Editing functionality may not be mature and robust enough.	**The Air Force could abate these risks by:** ☐ Progress in both of these areas has been proceeding at a very slow pace. AF should work to: ▪ Complete the DTDs currently in development; ▪ Develop companion OSs for DTDs (including both paper and display output); ▪ Test the data interchange interface with these specs; and ▪ Develop the DTDs/OSs for Type C TO data. ☐ The Integrated CALS TO solution is complex and not far along. While large-scale publishing solution vendors are beginning to work this problem, it is difficult to predict how much progress will be made in the next few years. The risk here is more one of timing than technology. However, by the end of the deployment period, this capability should be available for production use. Work closely with vendors to make this happen. ☐ Productivity tools will continue to become available in increasing numbers over the next few years to reduce the labor intensive nature of the processing and reduce the risks in digital exchange of TOs. Slower progress in this area will not be catastrophic, but rather will make this processing less efficient. Select specific tools and work with vendors to improve them. ☐ Interactive SGML Editing functionality is in the process of being added to many systems in FY89–FY90 and should be available in operational form when needed. Work with vendors to make this happen.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T14 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
DE FACTO and DE JURE COMPUTER INDUSTRY STANDARDS	

DE FACTO and DE JURE COMPUTER INDUSTRY STANDARDS

RELEVANCE:

A long-lifecycle, integrated HW-SW system such as AFTOMS is helped tremendously by the choice and implementation of standards for: ease of integration during development; better quality; and lower cost of maintenance *(which includes correcting problems, enhancing existing or adding new functionality, avoiding obsolescence, and upgrading operational performance).*

Given the POC work, this section provides the basis for identifying and understanding the AFTOMS-relevant computer industry standards: their scope, current state, interdependence with other standards, and likely evolution.

FY89:

Standards are neither preordained, nor static, nor free of conflict and tradeoffs. In fact, their development and acceptance is quite frustrating and messy. The end result is rarely final or fully satisfactory, but they are necessary to reduce complexity to manageable proportions and support interdependencies in and between organizations, people, information handling, software systems, and hardware equipments.

Standards rarely precede an important technology. That's because the importance of the technology and its many applications is difficult to gauge at the outset, and there are usually alternative variants of the technology being developed, each with its own unique mix of virtues and problems. Premature standardization can misdirect the development of the technology onto an unproductive path. Sometimes this risk must be taken if there is an overriding dimension to the technology (e.g., safety, total compatibility for market acceptance, etc.); but for most technologies this is not the case.

As a technology develops, the proponents of its variants establish different degrees of acceptance for various uses. This gets reflected in the market success of individual companies or product categories. If one technology variant becomes dominant in acceptance (e.g., PostScript in device-independent Page Description Languages for integrated text-graphics printing), then that variant becomes a **de facto** standard for that technology; most users demand it, and new competitors don't want to deviate too far from it and risk market failure. A de facto standard will evolve over time as the technology is refined and usage is modified. De facto technology standards (which represent the actual core of the technology without having any legal standing) are relatively easy to transform into **de jure** technology standards (which enjoy a legal standing) because the technology is reasonably well understood, there are entrenched groups of users and providers who don't want major disruptions, and there is relatively little disagreement on the important aspects of the technology. DoD and AF, as important active users (technically, legally, and financially) of technology products, can influence standards of either standing. For the foreseeable future, technology standards will continue to be developed and amended using this basic approach; the design of AFTOMS should reflect this reality.

Twenty Nine (29) major standards expected to be relevant to AFTOMS in FY91-FY93 were evaluated using the following common template:

- Identifier (name, #, sponsoring org. & last issue date);
- Capsule Summary of the Standard;
- Its relevance & importance to AFTOMS;
- Its state (usefulness, completeness, stability):
  in FY89; and by FY91-FY93.

Nineteen (19) of these standards were also used in the Demo System.

FY91-FY93:

Rather than summarize the states of each of these 29 standards, many of which present no significant risks for AFTOMS, only the problematic standards are categorized and listed on the next page.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T14 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	**ABATEMENT**
DE FACTO and DE JURE COMPUTER INDUSTRY STANDARDS	**Residual risks are present in the following areas:** [MEDIUM] The following standards offer moderate risk because they are **immature or still under development** and could, therefore, provide some surprises: PDES, OSI, GOSIP, POSIX, CASE concept, Display PostScript, WORM, X-Window, and Hypertext.	**The Air Force could abate these risks by:** ☐ These immature, moderate risk standards need to be monitored for further developments and re-evaluated in FY91 by the AFTOMS prime contractor as they will affect details of the design solution.
	[MEDIUM] The following standards offer moderate risk because of **uncertainties related to precedence, scheduling and residual incompatibilities**: ADA vs. POSIX, SCSI-2, Token Ring, CCITT Group 4, and CGM.	☐ The remaining moderate risk standards need to be evaluated by the AFTOMS SPO for the RFP since they affect the AFTOMS architecture or other important trade-offs that can shape specific requirements.
	[MEDIUM] The following standards offer some risk because they **may require modifications to the AFTOMS concept**: the Government does not yet recognize optical media as trustworthy for permanent repositing of data; and UNIX V.5 may not be certified as a secure operating system adequate for handling classified TOs.	☐ Use optical media for normal AFTOMS distribution functions and semi-permanent repositing of TOs and other AFTOMS data; the latter may require future automated data conversion to permanent media when they are certified. Otherwise, permanent repositing must use currently certified media (i.e., paper or microfilm).
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[LOW] The ODA/ODIF standard is **not required for CALS now, but it will be required** by the next version of GOSIP.	☐ AFTOMS will be GOSIP compliant so review the impact of ODA/ODIF once the standard is defined and GOSIP is amended.
	[LOW] The following standards offer **minimal or no risk because of their stability or predictability**: ASCII, ANSI SQL, WYSIWYG, Ethernet, X.25, X.400, NFS, ANSI C, C++, and SGML. In addition, IGES and TCP/IP may be obsoleted by PDES and TP4/IP, respectively.	☐ Minimal or no risk grouped standards can be ignored for risk abatement; specific issues can be dealt with during development as they arise.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T15 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
TRAINING TECHNOLOGIES and AFTOMS ASSIMILATION **RELEVANCE:** **In the past ten years, major advancements in training technologies have occurred which can benefit AFTOMS. Some of the potential benefits include: reduced training time, fewer required training resources, increased trainee achievement, lower attrition rates, and increased job proficiency.** **Given the POC work, this section assesses the AFTOMS relevance of two major areas of training: HW-SW training technology and its underlying training methodology. No specific training products were incorporated into the Demo System.**	**FY89:** **Training technology risk assessment was not within the original scope of the FY89 AFTOMS POC effort undertaken at TSC** so the POC did not include the investigation of actual training technology products. Therefore, a detailed assessment of training technology risks was not undertaken and will need to be done by the AFTOMS SPO before FY91. However, since the POC work touched on issues that would also impact training, the following preliminary assessment of training risks was made. In FY89, there are many recently introduced technologies that appear to have unique training capabilities. Some of the key functionality that has been introduced recently includes: • More interactive training capabilities through the use of videodisc and hypermedia; • The ability to easily combine documents, images, video playback, voice, and system processes; • Self learning packages that can be monitored and evaluated for changes; • Communications capabilities, such as telecommunications, that allow easy access to distributed resources and facilitate the distribution of knowledge; • Use of the existing large distributed base of personal and micro computers for training purposes; and • New networking capabilities for sharing training materials across the network. The DoD has a long history of pioneering new technologies for training its personnel. Trainers have become more familiar with new training technologies and are beginning to use them more frequently in the development of training curricula. As technology costs decrease and such experience increases, more information will be available about technology potential, applicability, and effectiveness for training. The cost of computer equipment and software is also declining. This should have a direct impact on the increased use of computer technology in the training community.
	FY91–FY93: The use of technology in training will continue to mature and improve in performance and cost. As computers continue to become more powerful, they will incorporate and integrate more functionality into a single training program. Training technologies also appear to be increasing their emphasis on interactive training. With the introduction of videodiscs and hypertext media in the 1980's, it appears possible for users to interact in a more realistic manner with training materials. Use of remotely located experts to solve specific training issues will also increase as telecommunications continues to evolve, standards are established, and costs become acceptable.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T15 (CONT'D)	FY91-FY93 RISK	
	ASSESSMENT	ABATEMENT
TRAINING TECHNOLOGIES and AFTOMS ASSIMILATION	**Training Air Force personnel in the use of AFTOMS is essential to the success of the overall program. The POC has shown that simple, friendly user interfaces help users quickly assimilate the functionality of the overall system with less initial and followup training. By standardizing the "look and feel" of AFTOMS user interfaces across all four tiers in the POC it became simpler for a Tier 2 user to understand how to use Tier 4 functionality. In terms of training impacts for AFTOMS, there are several residual risks to avoid:**	**During or before the FY91-FY93 AFTOMS development period, the Air Force could abate the risks by exploring more thoroughly the following strategies:**
	[MEDIUM] The design of the AFTOMS functionality and user interface is so unwieldy that it slows down (or even jeopardizes) productive use of AFTOMS, whether users receive comprehensive, quality training or not.	☐ Users should have input into AFTOMS design at the earliest time possible. **The POC Demo System could be used in this manner: various users could be allowed to interact with the Demo System, explore its capabilities dynamically, and give constructive feedback to designers.** This would also help build early support for AFTOMS with actual users.
	[MEDIUM] Training costs become prohibitive for a large system if specialized training is needed for each individual user; if AFTOMS is not designed and implemented using a standard interface approach, it will require individual and costly training design and implementation.	☐ A standard and consistent user interface design should be developed for all the tiers. This will promote easier use of the system and facilitate a group approach to the training design. Then, a basic core training package could be designed for all the users, supplemented with smaller specialized packets for each tier.
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[MEDIUM] The time needed for comprehensive training detracts from the productivity of the users on tasks they are presently responsible for.	☐ The training curriculum should be modularized to reduce extended absences from existing tasks for AFTOMS training. Shorter training, based on self-learning CBI software using videodisc technology, could be employed. Training time can also be reduced by using focused Job Aids such as on-line help or teleconferencing to designated AFTOMS user experts.

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

T16 INDIVIDUAL TECHNOLOGY	STATE OF THE TECHNOLOGY
DOCUMENT SCANNING and CONVERSION **RELEVANCE:** **Current AF inventory of TOs is held in paper form, but AFTOMS is most effective in handling digital TOs. Management of TOs is a recurring operational cost which is reduced when TOs are in digital form. TOs are used for many years (e.g., 20 –30 years) and are changed and reissued many times during their life cycle, a dynamic process which is better controlled and facilitated through automation. Conversion is a one time non–recurring cost.** **Given the POC work, this section assesses key technological, operational, and economical issues associated with conversion of a large TO inventory.**	**FY89:** Conversion of paper databases into digital form is one of the more challenging endeavors in the computing world today. An economically viable approach to apply automated technology to massive amounts of often complex technical information in paper form (e.g., AF TOs) is the key factor. Over the past few years, there have been significant developments in conversion and conversion-related products. An earlier widespread view, seen in existing hardware solutions, that the bulk of the conversion effort and complexity exists in the physical scanning part of the total conversion process is now being modified to recognize that the scanning portion of the process is only a small part. **The major challenges are in recognition software development and this is where most of the complexity lies and new activity is taking place.** This flurry of activity can best be described as development of "niche" products which focus on specific areas of the process. Much of this activity is being done by innovative small software companies and start-ups. These niche products can be integrated with other products and manual labor to build a total conversion solution. In fact, many competing partially integrated solutions use the same basic component products. **Fully integrated solutions are not currently available in the marketplace.** Thus, in FY89, the burden of integrating niche products into a total solution lies with the user. Current and future technical capabilities of scanning devices and recognition techniques were reviewed in the context of a process to understand the conversion issues. In FY89: ▪ Document scanning is furthest along in product maturity: many scanners exist at all price ranges (as low as $2000) that can scan paper documents and produce page image files; ▪ Text character (OCR) and graphics recognition products usually work as embedded post-processors to scanners; while others are standalone products that accept scanned raster or dot image files as input; ▪ Auto tagging of scanned regions as laid–out document elements is not nearly as far along as OCR recognition in terms of product availability and maturity; and ▪ SGML support produced very little product development activity until recently: the emergence of the CALS Initiative has fostered some development of products that just recently became available; in some cases, this capability can be embedded in auto tagging products where products can exist either as enhanced versions of auto tagging modules, which tag directly in SGML or convert existing tags to SGML tags, or as standalone products. **FY91–FY93:** During the next few years, a tremendous amount of effort will occur in the electronic publishing industry to produce useful conversion products. This effort will concentrate on making significant strides in 3 areas: ▪ Developing integrated solutions for the total conversion process; ▪ Improving autochecking, error detection/correction capabilities;and ▪ Developing robust, production–oriented products requiring minimal user labor (**thereby reducing costs below $1 per page,** which should be economically acceptable for the Air Force conversion).

TABLE 3-1. SUMMARY OF TECHNOLOGY FINDINGS FOR AFTOMS (CONT'D)

INDIVIDUAL TECHNOLOGY T16 (CONT'D)	FY91–FY93 RISK	
	ASSESSMENT	ABATEMENT
DOCUMENT SCANNING and CONVERSION	**The electronic publishing industry sector has now been in existence for over five years and most of the basic capabilities have been developed by many vendors. Most publishers and distributors of technical documentation have some amount of inventory that existed before they cut over to in-house electronic publishing. Over the next few years, conversion of data from paper to digital form most likely will be a high priority issue in the electronic publishing industry. The availability of largely-automated conversion products, both standalone and integrated into publishing systems, is needed for a total solution to the publishing problem. A review of the different conversion strategies and the associated technologies shows that a considerable amount of risk lies in the following areas:**	**Most of the identified conversion risks focus on the fact that industry has had very little practical experience in applying conversion technology to large-scale, production-based conversion efforts for complex technical documents such as TOs. While many of the technology components are becoming available, a better understanding of the operational issues of using these conversion products is needed. Such experience would also supply a lot of realistic financial details needed to plan and operate a successful conversion operation. The following activities are recommended as abatement strategies to mitigate the identified collective conversion risks:**
LEGEND RISK ASSESSMENT SYMBOLS: HIGH MEDIUM LOW	[HIGH] A tremendous amount of trained manual labor is required in currently available conversion processes. This labor is required for: ■ **Post-scanning checking and cleanup;** even though scanning success ratios exceed 98%, the entire document must be checked to identify and correct the small percentage of scattered residual errors; ■ **Integration of the entire process is still a problem;** since most capabilities are "niche" solutions, a considerable amount of work is needed to support a productive process; and ■ **Retrofitting old documents to new standardized and compliant formats (MIL-STD-1840 DTDs and OSs)** can be problematic and thus requires detailed human judgment.	☐ Perform conversion planning based on real Air Force experience by: ■ Starting to use the technology as soon as possible; ■ Applying the technology in a limited operational effort to a representative suite of TOs; ■ Identifying and quantifying all costs (operational and hidden) that are part of the conversion process; and ■ Doing as much testing, evaluation, and tuning as possible before entering into full-scale production conversion for remaining weapon systems.

SECTION 4: SUMMARY OF RISK ASSESSMENT AND CONCLUSIONS

4.1 INTEGRATED RISK ASSESSMENT OF AFTOMS

The focus of the AFTOMS POC work is risk assessment and risk abatement. Fundamentally, this activity is performed by developing a thorough project understanding using a balanced combination of techniques. First, through using hands-off methods that require detailed analysis: exploring the To-Be concept analytically and systematically to probe for logical needs, problems, and consequences. Secondly, through hands-on Demo System or technology evaluation work: prototyping to test and verify the analysis, evaluating technologies and products relative to the specific needs of AFTOMS, and disclosing subtle integration problems overlooked in the hands-off analysis.

Prior to the start of the POC effort, the prevailing perception within the AFTOMS community was that state-of-the-art and emerging technologies posed the greatest risks to project success. **However, by the end of the first three months of POC work, which focused on refining the To-Be concept and evaluating numerous candidate technology products, it became apparent that there were more significant risks present in various dimensions of integration.** In retrospect, this is not surprising since a complex system's behavior and quality is often influenced more by the quality of the interfaces and interactions between its components than by the individual performances of the components. Therefore, the scope of the POC was amended by TSC with SPO concurrence, to incorporate eight additional risk evaluations into the list of sixteen technology risk evaluations, thereby performing a more complete and thorough POC.

TSC's FY89–FY90 POC approach focuses on AFTOMS, its operating environment, and important risk issues within two time frames: FY89 for an assessment of the current status of technologies, products, integration problems, and other risks; and FY91–93 to project the future status of the same items for the period when the full-scale AFTOMS is designed and built. The POC approach is a disciplined one that evaluates important issues of consequence to AFTOMS, rather than getting sidetracked onto trivial or interesting ones. It is a multidimensional approach that incorporates users, work procedures, operational constraints, technologies, and interfacing issues. It is also integrated, making optimum use of the comparative advantages of various techniques to explore all aspects of an issue, then balancing and combining those investigations and results for overall coverage and synergy. Finally, it is an action-oriented, mature approach designed to make its findings clear and easy to use during the rest of the project life cycle.

The following summary assessment covers the FY91–FY93 time period. The objective is to focus the reader's attention on the greatest Post-POC risk contributors using a Risk Attention Index (RAI).

4.1.1 Integration Dimensions

Eight dimensions of integration were identified in Section 2.2.1 as relevant to AFTOMS, either in the short or long term. The Post–POC risk contribution of each dimension can be assessed in terms of its five component risks, defined in Section 2.2.2: functionality, performance, seamlessness, flexibility, and doability. Using these five risk category definitions, TABLE 4-1 summarizes the risk assessment against each risk category for each of the eight dimensions of integration. This assessment is based on applying judgmental weighting factors (1, 2, and 3 for low, medium, and high, respectively) to the detailed findings described in Appendix B.

TABLE 4-1. RISK INDEX FOR INTEGRATION DIMENSIONS

INTEGRATION DIMENSION		RISK CATEGORIES					
		Functionality	Performance	Seamlessness	Flexibility	Doability	TOTAL
I1	Management of distributed user functionality	1	1	2	1	1	6
I2	Handling and conversion of heterogeneous TO data	2	3	2	1	1	9
I3	Support of heterogeneous system users	1	1	3	1	1	7
I4	Use of electronic communication	2	1	2	3	2	10
I5	Interface to other Air Force functions/systems	3	2	3	2	2	12
I6	System buildability	2	2	3	1	1	9
I7	Reliance on conformance to standards	3	1	2	2	3	11
I8	Operational utility	3	3	2	2	2	12

L = 1
M = 2
H = 3

The TOTAL column in TABLE 4-1 adds the component risk values for each dimension of integration; in effect, weighting each component equally against the others. This produces the Risk Index, an estimate for the residual risk present in that dimension. The importance of that dimension to AFTOMS is again judgmentally weighted on a scale of 1–to–5, low–to–high in increasing importance, respectively, shown under the Contribution column in TABLE 4-2. The Risk Attention Index for each dimension of integration is therefore the product of its Risk Index and Contribution value (see TABLE 4-2). Thus, if either or both the Risk Index and the Contribution is high, the resulting Risk Attention Index (RAI) is also high, signalling that more attention should be paid to that dimension of integration instead of another one whose computed RAI is much lower. The maximum RAI is 15 x 5 or 75.

This model shows that the **top four RAIs belong to: Operational utility (60), System buildability (45), Interface to other Air Force functions/ systems (36), and Handling and conversion of heterogeneous technical order data (36).** Those dimensions requiring the least attention are: Use of electronic communication (20) and Support of heterogeneous system users (21).

Conclusions and recommendations related to these attention–requiring dimensions of integration are presented in Section 4.2.

4.1.2 Individual Technologies

Sixteen individual technologies were identified in Section 3.2.1 as relevant to AFTOMS, either in the short or the long term. The Post–POC risk contribution of each of these technologies can be assessed in terms of its five component risks, defined in Section 3.2.2: functionality, performance, compatibility, standards, and viability. Using these five risk category definitions, TABLE 4-3 summarizes a risk assessment against each category for each of the sixteen technologies.

The TOTAL column in TABLE 4–3 adds the component risk values for each individual technology; in effect, weighting each component equally against the others. This produces the Risk Index, an estimate for the residual risk present in that technology. The importance of that technology to AFTOMS is again judgmentally weighted (on a scale of 1–to–5, low–to–high in increasing importance, respectively), shown under the Contribution column in TABLE 4-4. The RAI for each technology is therefore the product of its Risk Index and Contribution value. Thus, if either or both the Risk Index and the Contribution is high, the resulting RAI is also high, signalling that more attention should be paid to that technology than another one whose computed RAI is much lower. The maximum RAI is 15 x 5 or 75.

This model shows that the **top six RAIs belong to: Document Scanning and Conversion (50), Optical Disk (36), Government Data Interchange Standards (36), User Interface Management Systems (35), Technical Publishing: Document Management Systems (32), and Object–Oriented Data Management (26).** Those technologies requiring the least attention are: Demand Printing (12), Workstation Platforms (15), and Communication: LAN (15) and WAN (18).

Conclusions and recommendations related to these attention–requiring technologies are presented in Section 4.2.

TABLE 4-2. RISK ATTENTION INDEX FOR INTEGRATION DIMENSIONS

*RISK INDEX (RI) * CONTRIBUTION (C) = RISK ATTENTION INDEX (RAI)*

	RI	C	RAI	INDEX RANKING
I1	6	4	24	
I2	9	4	36	3
I3	7	3	21	
I4	10	2	20	
I5	12	3	36	3
I6	9	5	45	2
I7	11	3	33	
I8	12	5	60	1

RISK ATTENTION INDEX (Top 4)

1. (I8) Operational utility	60
2. (I6) System buildability	45
3. (I5) Interface to other AF functions/ systems	36
4. (I2) Handling and conversion of heterogeneous TO data	36

TABLE 4-3. RISK INDEX FOR INDIVIDUAL TECHNOLOGIES

	TECHNOLOGY	RISK CATEGORIES Func-tionality	Perfor-mance	Seam-lessness	Flexi-bility	Doa-bility	TOTAL
T1	Object-Oriented Data Management (OODM)	2	3	2	3	3	13
T2	Technical Publishing: Doc't. Management Systems (DMS)	1	2	2	2	1	8
T3	Distributed Relational Database Mgt. Sys.(RDBMS)	1	1	1	1	1	5
T4	User Interface Management Systems (UIMS)	1	2	1	2	1	7
T5	On-Line Delivery Systems (ODS)	1	2	2	2	1	8
T6	Local Area Communications	1	1	1	1	1	5
T7	Wide Area Communications	1	2	1	1	1	6
T8	Optical Disk	1	1	3	3	1	9
T9	Demand Printing	1	2	1	[illegible]	1	6
T10	Workstation Platforms	1	1	1	1	1	5
T11	Document B+ Enhancements	1	2	1	2	1	7
T12	Software Design/ Implementation Languages	1	1	2	2	1	7
T13	Government Data Interchange Standards	2	1	2	1	3	9
T14	De facto and De jure Computer Industry Standards	1	1	2	2	2	8
T15	Training Technologies and AFTOMS Assimilation	1	2	2	1	1	7
T16	Document Scanning and Conversion	2	3	2	1	2	10

L = 1, M = 2, H = 3

** T1-T16 refer to appendices in the draft SPO Supplement Report (see Section 1)*

TABLE 4-4. RISK ATTENTION INDEX FOR INDIVIDUAL TECHNOLOGIES

*RISK INDEX * CONTRIBUTION = RISK ATTENTION INDEX*
(RI) (C) (RAI)

	RI	C	RAI	INDEX RANKING
T1	13	2	26	6
T2	8	4	32	5
T3	5	4	20	
T4	7	5	35	4
T5	8	3	24	
T6	5	3	15	
T7	6	3	18	
T8	9	4	36	2
T9	6	2	12	
T10	5	3	15	
T11	7	3	21	
T12	7	3	21	
T13	9	4	36	2
T14	8	3	24	
T15	7	3	21	
T16	10	5	50	1

RISK ATTENTION INDEX (Top 6)

1. (T16)	Document Scanning and Conversion	50
2. (T8)	Optical Disk	36
3. (T13)	Government Data Interchange Standards	36
4. (T4)	User Interface Management Systems (UIMS)	35
5. (T12)	Document Management Systems (DMS)	32
6. (T1)	Object-Oriented Data Management (OODM)	26

4.2 CONCLUSIONS AND RECOMMENDATIONS

Since the scope of the POC did not include evaluation of Air Force organizational issues, the risks associated with integrating AFTOMS into the Air Force culture were not evaluated. However, technologies for developing a high-quality, user-friendly, and easy-to-learn system were investigated, thereby indirectly reducing existing organizational risks somewhat. The following findings from the FY89-FY90 AFTOMS POC work that apply to the AFTOMS FSED (FY91-FY93) are extracted from the detailed evaluations in Section 2 and Section 3. They are organized into *Major Conclusions* and *Other Conclusions* (of a less critical nature).

MAJOR CONCLUSIONS

- No single COTS product or turnkey integrated system will be available to satisfy AFTOMS requirements. Given the uniqueness of the requirements and the needed technology mix, specific capabilities of commercial products used selectively, and the customized software written to unify purchased COTS technology products into one seamless AFTOMS system, the integration risk could actually exceed the total technological risk associated with particular products; **however, this integration risk is still significantly smaller than that which would result if AFTOMS did not rely on commercial technology products, but attempted a totally customized solution approach.**

- The AFTOMS To-Be concept is operationally sound and can be built by integrating available or emerging technology products. There are residual risks associated with scanning conversion, defining a standardized CTO-DO-to-WA delivery interface to support heterogeneous WA delivery systems, and localized technical and scheduling problems. However, these localized problems should be manageable.

- The AFTOMS To-Be concept is sufficiently robust to manage a mixed paper and digital TO inventory, consisting of all types of paper and digital TOs.

- MIL-STD 1840 must be completed soon since timely development of an adequate set of consistent DTDs and OSs (to cover the range of new and existing TOs) is critical to AFTOMS success for:

  - *Scanning conversion of existing inventory of paper TOs (which because of inconsistent standards historically have varying formats and styles);*
  - *Supporting MIL-STD 1840 compliant delivery of new digital TOs; and*
  - *Type B+ tagging for value-added delivery of TOs to Work Areas.*

- Scanning conversion of existing weapon system TO suites is important to load the digital database for AFTOMS. Otherwise, the automation benefits will fall short of the projections. An early start with a pilot operation is recommended to develop a good basis for planning and executing later conversions for each new TOMA before it becomes operational.

- Type B+ TOs provide a major enhancement to the original AFTOMS To-Be concept. Additional SGML tagging of newly authored or converted digital TO contents at the TOMA/TOC level can:
  - Mark text content by security level, technician skill level, aircraft tail number, etc.;
  - Interconnect related text references with referenced graphics, tables, or external TOs; and
  - Establish other suitable relationships.

  Such tagging provides more usable TOs at Work Areas by displaying only the information needed for the maintenance task (free of extraneous details) and facilitating rapid, accurate retrieval of referenced or related technical data. Type B+ provides the Type C benefit of tailored views at Work Areas without the need for additional sophisticated AFTOMS software. From a Type B baseline, B+ tagging can be implemented gradually and incrementally. With Type B+, for example, additional tags can be introduced to supply new capabilities, or old ones removed to reduce tagging cost or risk if there are DTD/OS deficiencies.

- The existing inventory of paper TOs is extensive; up to 50% can be converted economically to Type B digital form. Weapon systems will acquire new TOs in digital form, primarily B or B+. Some new weapon systems (e.g. ATF) plan to acquire Type C TOs, as well as rely on a substantial number of existing, non-Type C commodity TOs. Conversion of such commodity TOs to Type C format would be costly because it would require a yet undefined, re-authoring approach. Prior to FY2000, Type C TOs will comprise a very small percentage of the Air Force TO inventory. With this in mind, there are several findings and recommendations:
  - AFTOMS must and will support Type C TOs when future weapon systems require TO management support, but initially, AFTOMS should focus on conversion and Type B support; and
  - A preliminary high-level POC assessment of providing Type C support shows that AFTOMS needs to develop additional sophisticated software systems. These systems require trained personnel to concurrently support two (Types B and C) significantly different approaches to: TO authoring; change implementation; verification of the database indexing infrastructure and all allowable Work Area views into the TO database; and delivery of these views from CTO-

DOs to Work Areas. Work Area user access into the Type C neutral TO database would have to be restricted to formally verified predefined views.

- Technology will not support an AFTOMS solution that can handle both classified and unclassified TOs in a fully integrated, secure, and trustworthy fashion; therefore, a physically secured, separate (but functionally identical) mini-AFTOMS is recommended for handling classified TOs.
- Key undecided operational requirements for system usage (e.g., change management at Tier 2, TO information traversal at Tier 4) affect the design of AFTOMS in broad and fundamental ways and need early resolution.
- A standard AFTOMS interface between CTODO and Work Area delivery systems should be defined so that IMIS, ITDS, and other future MAJCOM systems can easily interface to AFTOMS.

OTHER CONCLUSIONS

- Graphical user interfaces developed in the Demo System appear to satisfy in "look and feel" the needs of all major user types across the four tiers; and are a major contributor to the seamless integration of AFTOMS; these benefits more than offset their additional development complexity and cost.
- Installation of AFTOMS must be coordinated with various Offices of Primary Responsibility (OPRs). For example, AFCC is the OPR for DDN support; on average, it takes at least 24 months from identification of a requirement for AFCC to install a DDN communications node.
- AFTOMS buildability risk can be lowered significantly with a quality set of technical and operational requirements in the RFP that suitably constrain any contractor's solution flexibility and provide an unambiguous basis for determining if a proposed and/or implemented solution meets AFTOMS, MAJCOM, and CALS long-term needs.
- Good operational utility can be built into AFTOMS to support its post-installation use and long-term upgradability, maintainability, and interoperability.
- Several key emerging technologies are evolving rapidly and should be monitored closely: DMS, Distributed RDBMS, ODS, and UIMS.
- TO distribution from TOMA to CTODO depends on bulk optical disks; the lack of standards increases the long-term economic risk of both optical reader assets obsolescence and spare parts availability when the technology changes. However, any necessary data conversions necessitated by new standards could be automated easily.

- Several incompatibilities exist between standards that may not be resolved and will require workarounds (e.g., optical disk media is not yet accepted by the government as trustworthy for archival storage of permanent records, C++ is not yet on the DoD list of approved higher-order languages, and ADA [Programming Language, MIL-STD 1815] has not been ported to an X-Windows environment, etc.).
- A few technologies were found to be inappropriate for use on AFTOMS before FY2000, either because they were too risky operationally, immature for interfacing with other needed technologies, or not the best direct approach to providing the needed capabilities accurately and predictably (e.g., OODM and Artificial Intelligence (AI)); however, AI may still be useful in providing localized capabilities (e.g., TO numbering based on content characteristics).

Other less significant conclusions and recommendations are contained in Sections 2 and 3, with supporting detail found in the referenced Appendix B sections.

4.2.1 Recommended Followup for Risk Abatement

The value of conducting a POC-type risk abatement activity to develop a thorough project understanding before trying to define and build the real AFTOMS is practical and significant. It anticipates and resolves opportunities and problems that could appear later, thereby reducing the total burden during full-scale development; and it provides a coherent, integrated, and AFTOMS-specific framework for quicker evaluation and resolution of future problems and opportunities.

The risk abatement benefits of this framework are numerous, provided they are used as leverage over the remaining phases of the project. The framework reduces project risk by reducing:

- Surprises and unintended consequences downstream;
- Changes and iterations during development;
- Schedule slippages;
- Compromises in delivered functionality, performance, and system quality;
- Follow-on Engineering Change Proposals (ECPs) to fund after project completion; and
- Providing a means to prototype high-risk options in a limited environment without jeopardizing the full-scale effort with avoidable problems.

This framework can also be used to train system developers, IV & V contractor personnel, and others, to understand the AFTOMS requirements and technologies more quickly, thereby reducing their learning curves and providing a partial substitute for any lack of AFTOMS-relevant experience; this will focus development activities and increase productivity.

The Demo System focused on understanding and implementing key aspects of the To-Be concept functionality using technologies and products that are suitable for AFTOMS. In the process, much invaluable hands-on experience was gained in working with current and emerging state-of-the-art technologies, integrating technology products with critical AFTOMS functionality, finding and evaluating technological and operational problem areas, and developing a visible and dynamic basis for refining AFTOMS requirements. This valuable knowledge and experience base can be built upon to provide additional risk abatement value to AFTOMS. The packaged Demo System, installed at the AFTOMS SPO, can be enhanced further and used as follows:

- Provide a model for refining RFP requirements, user interfaces, and source selection criteria to reinforce a coordinated and tested view of AFTOMS;
- Provide a system capability which can be enhanced to assess and develop critical technical issues (e.g., TO conversion automation, database model selection, distributed data loading, system performance, Tier 4 interfaces for selected MAJCOM TO delivery systems, DTD/OS and other CALS standards testing, organizational infrastructure issues, etc.); see Summary Sections 2.2.3 and 3.2.3 for a more details;
- Serve as a low-cost test bed before and during AFTOMS FSED for independently evaluating problems and alternative solutions without disrupting the main AFTOMS development effort (e.g., integration of Type C support into AFTOMS, or using the Demo System to get a dynamic feel for how the functionality operates and interacts before partitioning the functionality across organizational elements based on historical patterns);
- Provide a dynamic test bed for developing user training approaches and materials; and
- Demonstrate AFTOMS to managers and users from USAF, DoD, and industry to support the CALS Initiative.

APPENDICES

AFTOMS AUTOMATION PLAN

AFTOMS TECHNOLOGY INTEGRATION DIMENSIONS

Air Force Technical Order Management System (AFTOMS)

Technology Issues & Alternatives Report

APPENDIX A: AFTOMS AUTOMATION PLAN

Overview of Findings

December 1989 – Final Report

DoD–VA–

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APPENDIX A

INTRODUCTION

AFTOMS MODULAR PLANNING

AFTOMS AUTOMATION PLAN

SECTION A1:
Introduction

A1.1 INTRODUCTION

Under AFSC CALS MIO sponsorship in 1987, TSC developed a 7–10 year automation plan for TOs, published in the *Air Force Technical Order Management System (AFTOMS) Automation Plan*, Final Report, dated February 1988, document number DOD–VA–856–88–3. This appendix presents overviews from that report of the:

- Modular Planning Process (MPP) (Section A.2) used to:
  - Examine the As–Is environment;
  - Study opportunities for TO automation; and
  - Plan the direction.
- AFTOMS Automation Plan (Section A.3) in terms of its:
  - Scope;
  - As–Is Findings; and
  - Proposed To–Be TO System Concept.

In addition to providing general and valuable background material, the To–Be System Concept in Section A.3.4, taken from the AFTOMS Automation Plan, provides an introductory description of important TO and AFLC infrastructure concepts required to understand this AFTOMS Technology Issues & Alternatives Report and the POC findings. The organizational terminology previously used in the Automation Plan has been recently updated to reflect current thinking within the AFTOMS SPO.

SECTION A2:
AFTOMS Modular Planning

A2.0 AFTOMS MODULAR PLANNING

TSC developed and implemented the MPP, an information engineering system planning approach, to perform the activities associated with the CALS initiatives. The principal requirements of the MPP were to:

- Focus on technical plans that would not become outdated before implementation;
- Incorporate existing transition systems;
- Meet the information distribution requirements of the user community; and
- Interface with a variety of organizations responsible for weapon systems acquisition and logistics support.

The MPP has three distinct phases listed below with the timeframe noted in which they were conducted for AFTOMS:

- **As–Is**: an examination of the existing environment (March–June, 1987);
- **To–Be**: a study of opportunities and initial formulation of a system concept for automation (May–August, 1987); and
- **Automation Plan**: consensus building within the Air Force for refining the concept, mobilizing action on it, and developing a plan for future direction (July 1987–January 1988).

The TO planning team consisted of systems engineers and technical staff with strategic planning and organizational skills. Team members met with different groups within the Air Force and industry to discuss the existing system (its characteristics, dimensions, problems, etc.), technology options, and viable alternatives.

An overview of the MPP is presented in TABLE A2-1 to give the reader an indication of the steps needed to complete this process. Using the framework of the MPP, TSC developed an automation plan for TOs.

The AFTOMS concept that evolved from this process was a result of melding this analysis with ideas received from the Air Force and industry, which formed the published *AFTOMS Automation Plan* – Final Report, dated February 1988.

TABLE A2-1. MODULAR PLANNING PROCESS – OVERVIEW

EXAMINE THE ENVIRONMENT	STUDY THE OPPORTUNITIES	PLAN THE DIRECTION
<u>Initiate the Process</u> Perform Initial Assessment · Create Preliminary Description of Environment · Identify Organization Expectations · Establish Priorities Develop Specific Procedures · Establish Management Plan · Identify Advisory Group · Prepare Project Plans <u>Conduct Structured Analysis</u> Describe Current Environment · Create Functional Model · Identify Major Data Elements · Describe the Organizational Infrastructure · Identify Major Information Flow Parameters Assess Transitional Projects · Identify Objectives · Describe Functions and Data · Identify Technologies · Identify Infrastructure Affected	<u>Assess Technology</u> Identify Existing Technologies · Review Current Environment · Review Ongoing Projects · Identify Existing Technologies Research Future Technology Opportunities · Select Technology Areas · Consult with Technology Experts · Examine Similar Applications · Review Development Trends Establish Technology Alternatives · Quantify Directions · Specification of Implementation Issues · Examine Benefits and Costs <u>Project Future Requirements</u> Forecast Requirements · Review Applicable Scenarios · Conduct Discussions with MAJCOMs · Forecast Process Changes · Assess Infrastructure Constraints Examine Feasible Alternatives · Determine Feasibility Issues · Review Industry Trends <u>Define Future State</u> Describe Future Environment · Define the Impact of Technology on Current State · Define Projected Organizational Responsibilities · Define Relevant Interface Requirements Create Future Functional Model · Develop a Description of Future State · Identify Projected Major Information Flow Parameters	<u>Formulate Alternatives</u> Assess Critical Issues · Examine Objectives · Identify Technologies · Review Organizational Issues Propose Initial Alternatives · Select Future Requirements · Identify Technologies · Structure Proposals Review and Modify Alternatives · Review Criteria · Identify Relationships with Transitional Projects · Define Policies and Organizations Involved <u>Develop Consensus</u> Review Progress with Advisory Group · Identify Discussion Topics and Priorities · Evaluate Current Environment · Establish Objectives · Provide Access to Information Develop Common Understanding · Review Future Requirements · Evaluate Recommended Solutions · Examine Feasibility Issues Expand Advocacy Network · Identify Implementation Agencies · Select Appropriate Forums · Communicate the Plans <u>Prepare Implementation Plan</u> Define Activity Descriptions · Establish Implementation Guidelines · Establish Evaluation Criteria · Develop Implementation Procedures Develop Organization Plan · Confirm Major Milestones · Establish Transition Plan · Identify Organizational Responsibilities Establish Constituency · Gain Management Acceptance of Plan · Obtain a Commitment for Execution Create Documentation · Establish Goals · Define Resource Requirements · Recommend Technologies Define Organizational Impacts · Establish Financial Parameters

SECTION A3:
AFTOMS Automation Plan

A3.1 AFTOMS AUTOMATION PLAN

The CALS MIO, with guidance from the Air Staff and MAJCOMs, established and implemented several key objectives for the AFTOMS Automation Plan which included:

- Acquiring an operational system by the mid–1990s;
- Defining a modular strategy which allowed for phased introduction of automation and associated organizational changes; and
- Defining an approach which addresses the major deficiencies of the current system while accommodating the need to effect a smooth transition by:
  - Incorporating as many existing assets as possible (automation projects, organizations, facilities);
  - Allowing parallel operations to proceed until the implementation is completed; and
  - Providing for conversion of the existing inventory of TOs to digital form and subsequent management of these TOs in an automated fashion.

Long term goals were also considered. These included:

- Developing a flexible, modular system concept to provide a strong foundation for the long term (25 years);
- Preparing the Air Force for paperless use and processing of digital TOs and related management information; and
- Integrating TO data with other types of technical information, both from system automation and organizational perspectives.

A3.2 SCOPE OF THE PLAN

The AFTOMS plan addressed:

- Strategic issues such as the broad characteristics of the final system, managing the transition process, and establishing centralized procedures for several activities;
- Organizational issues such as establishing an organizational infrastructure for future system functions with responsibilities of each organizational layer; and
- Technical issues such as types of automation systems, communication links, and level of automation.

The above issues are interdependent, and the plan defined priorities within strategic, organizational, and technical areas.

The resulting AFTOMS Automation Plan is a synthesis of the tasks performed and includes:

- Analysis of existing TOs and data flows;
- Examination of applicable technology trends and standards;
- Analysis of organizational and strategic issues;
- Description of the future TO system; and
- Key organizational, technical, financial, and programmatic recommendations.

A3.3 SUMMARY OF THE AS–IS TECHNICAL ORDER SYSTEM

The Air Force established the existing TO system in the 1940s. This system provides the official medium for disseminating technical information, instructions, and safety procedures pertaining to Air Force systems and equipment. According to Air Force Regulation (AFR) 8–2, TOs are military orders issued in the name of the Chief of Staff, USAF, by order of the Secretary of the Air Force, and require mandatory compliance. The existing TO system is manually oriented. See FIGURE A3-1 for the current TO functional structure.

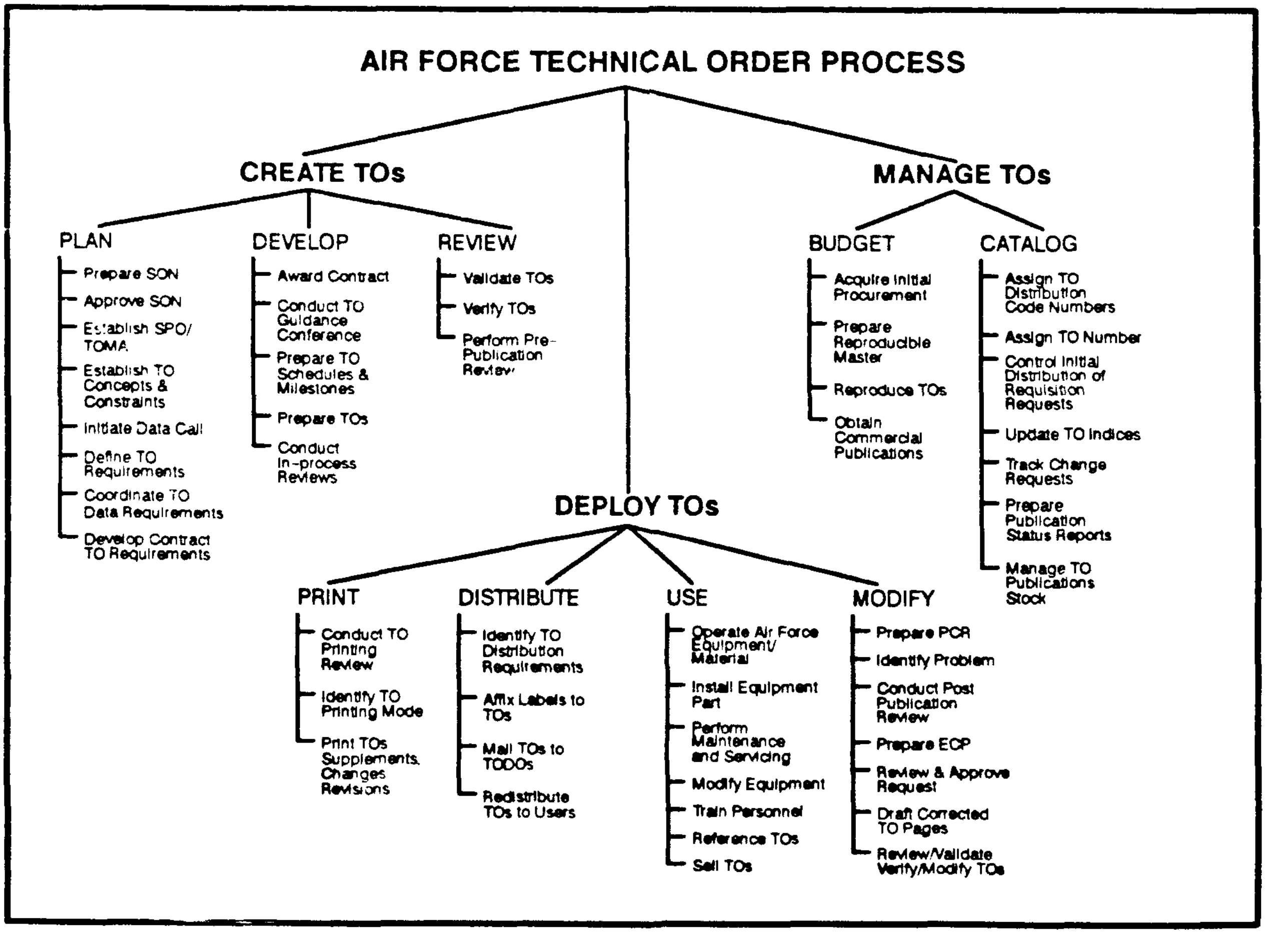


FIGURE A3-1. CURRENT TECHNICAL ORDER FUNCTIONAL STRUCTURE

Currently, there are over 150,000 TOs in use. The TOs are managed by five (5) ALCs and an Aerospace Guidance and Metrology Center (AGMC), which are divided by specific weapon system or commodity. The average TO ranges from 100 to 150 pages in length, is 60% text, and 40% graphics. The total TO database exceeds 20 million original pages of master copy (exclusive of working and distributed copies). Annual production of change pages averages approximately 2.3 million original pages. In addition, the current and growing backlog of unfilled change requirements is estimated to exceed 2 million pages.

A3.3.1 Existing Technical Order Generation And Distribution

In general, AFSC is responsible for the acquisition and preparation of TOs. AFSC, through the SPO for each major system acquisition, establishes a Technical Order Management Agency (TOMA) to oversee the development and acquisition of TOs. The TO Center (TOC) of the ALC, which has been designated as the prime support base for the weapon system, provides the technical support. The contractor-prepared Technical Manual Plan (TMP), which is compatible with the Air Force Technical Order Development Management Plan (TODMP), is used to produce a draft TO. The TOMA conducts an in-process review. The final version of the TO set must be validated by the contractor and verified by appropriate Air Force commands, such as, Military Airlift Command (MAC), Tactical Air Command (TAC), and Strategic Air Command (SAC). The ALC is responsible for storing, printing and distributing the verified TO.

Four major USAF commands are involved in the creation, use, and management of TOs. AFSC acquires major systems, monitors product development contracts, and conducts test and evaluation efforts (including TO verification and validation) with the assistance of using and supporting commands. The major command or commands (MAJCOM) that use the weapon system, also provide functional requirements, technical specifications, and participate in test and evaluation efforts. Within AFLC, the ALCs provide the operational logistics support, including TO maintenance and distribution required for effective operation and maintenance of the weapon system. Air Training Command (ATC) provides a wide range of training associated with the operation and maintenance of systems including the use of TOs. FIGURE A3-2 illustrates the procedures for generating, ordering, and distributing TOs.

Users requiring specific TOs send an Air Force Technical Order (AFTO) Request, Form 187, to a Technical Order Distribution Office (TODO). The TODO orders the requested TOs from the Oklahoma City ALC (OC-ALC) central distribution point. The OC-ALC center sends a mailing label to the appropriate ALC which is responsible for the specific TO, and mails the TO to the TODO. Revisions and supplements follow a similar procedure.

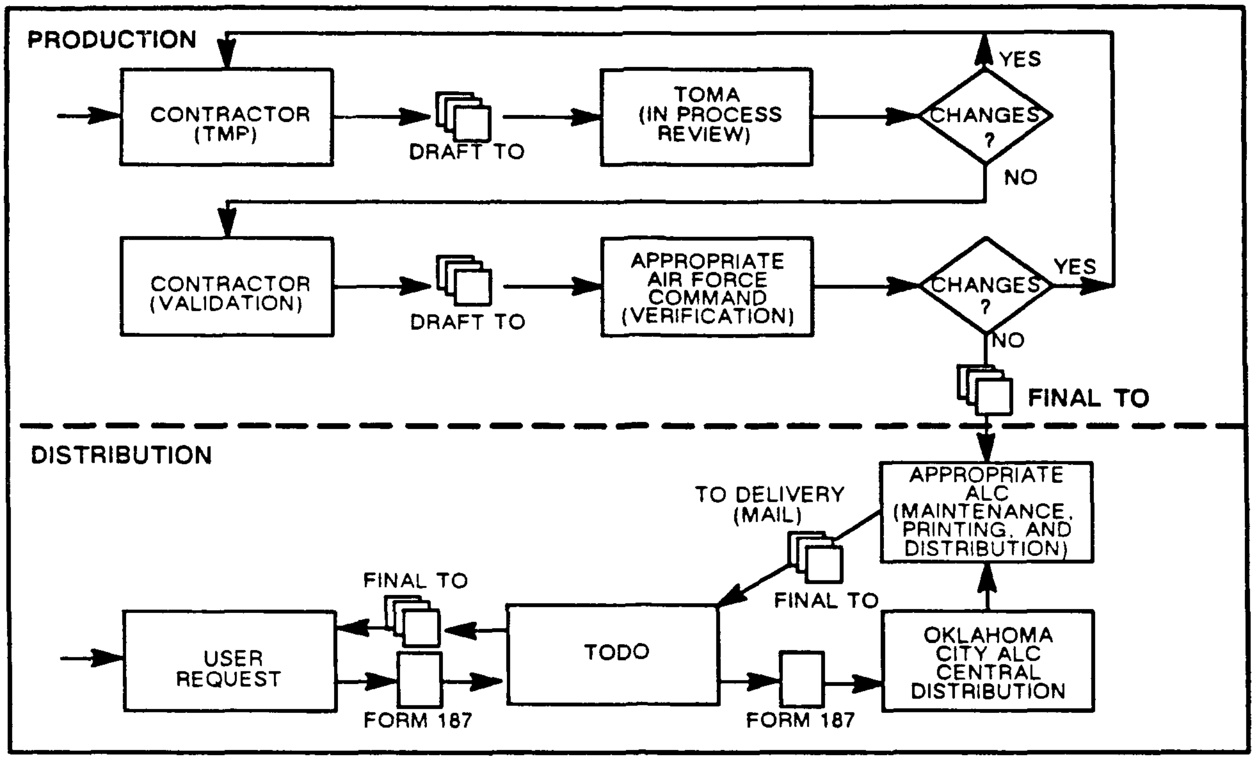


FIGURE A3-2. TO GENERATION AND DISTRIBUTION

A3.3.2 Existing System Deficiencies

A report of the Headquarters (HQ) Air Force Audit Agency (AFAA) (Audit #5036410, Acquisition of Technical Orders from Contractors, dated 24 June 1986) cited several deficiencies in the existing system. These included:

- Contractors frequently failed to provide installation-level TOs in time for Air Force verification;
- At times, 500 days are needed to fully implement a routine change to a TO;
- Desk-top analysis and validation of TOs is frequently performed in lieu of actual performance of tasks;
- From 1977 to 1986, 47% of Cause Code 1 (Inadequate Technical Data) mishaps listed inaccurate TOs as a contributing factor with resulting equipment losses of about $86 million;
- The upfront cost to develop and publish a TO is estimated to exceed $1,000 per page on recent weapon systems (i.e., B1-B, F16-C/D, and KC-135R); subsequent TO maintenance costs for storage, distribution, management, changes, etc., increase this cost per page estimate; and
- The Air Force does not separate the cost of TO preparation from the cost of a weapon system, resulting in difficult cost control.

Therefore, the present paper-oriented system is inefficient in meeting the growing requirements of the Air Force. A single weapon system, such as the B1-B, generates approximately 3,500 new TOs, adding one million pages to the current TO database. This additional volume cannot be managed by the present system in a timely fashion. These specific facts were the basis of motivating the formulation of a strategic plan that would lead to a more efficient and powerful TO system, capable of meeting the present needs and the future requirements of the Air Force. Key characteristics of this future TO system are integrated and described in the AFTOMS To-Be concept, Section A3.4.

A3.4 THE TO-BE TECHNICAL ORDER SYSTEM CONCEPT

In developing a To-Be system concept to manage the acquisition and distribution of digital TOs, consideration was given to a modular framework that would easily map to the existing Air Force infrastructure. Modularity allows phased implementation at a pace consistent with Air Force requirements and appropriations. An analysis of the To-Be system concept is described in the following sections:

- Types of Technical Orders;
- Organizational Structure;
- Information Flows;
- Interconnectivity;
- Major Functionality; and
- Concept Highlights and Benefits.

A3.4.1 Types Of Technical Orders

From a functional view, Air Force TOs are currently divided into the following application categories:

- Technical manuals;
- Abbreviated TOs;
- Time compliant TOs;
- Methods and procedures TOs;
- Index TOs.

The basic characteristics of each category of TO vary widely with sub-divisions existing within each category.

In formulating the AFTOMS Automation Plan which focuses on management as well as use of TOs, it was necessary to classifiy TO types based on delivery format (digital versus paper) rather than based on the above application categories. Presently, all Air Force TOs are created, inventoried and distributed as paper documents. Although many of these documents are created and maintained by contractor systems in digital form, they are delivered to the Air Force as paper copies since the current Air Force TO system is incapable of accepting digital delivery. The existing Automated Technical Order System (ATOS), implemented at the five (5) ALCs and AGMC, supports selective conversion of paper documents to digital files, text and illustration file creation, maintenance and storage, and reproduction mastering capabilities, for the production of TO change pages. However, the ATOS system is used to handle only a small portion of the overall TO maintenance workload, which is itself only a component of the overall process.

Once digital acceptance capabilities are provided by the Air Force (using MIL-STD-1840 supported by standardized Data Type Definition (DTD) and Output Specifications (OS)), systems can be designed to display and manipulate the TO data in a variety of ways. A digital TO can be a computer based display of the paper document where individual pages are called up for display or printing. Other value-added possiblities include automated interconnection of related technical material and tailoring its content presentation to the specific maintenance task, technician experience level, aircraft tail number, etc. A more advanced concept would link individual TO data elements under the control of a database manager which allows the user to assemble related TO information on the screen interactively as tasks require. To develop a system concept that serves all kinds of TOs (present and future) and their relevant automation issues, it was necessary to create broad delivery categories into which all TOs could be subdivided. These delivery categories are as follows:

- *Type A*: characterizes all TOs in the Air Force inventory that currently exist or will be delivered in paper form. Digitization of these TOs for computer applications will require selective scanning.
- *Type B*: characterizes TOs that will be delivered to the Air Force by the contractor in editable digital form, and then to the end user in read-only, page-oriented form. A user, sitting in front of an electronic display, will be able to view and/or print any desired page(s) of the TO and to scroll sequentially across pages. The ability to directly access the required page on the electronic display will reduce both the need for and the volume of printed information. Two variants of Type B have also been defined:
    - *Type B(-)*: Type B minus is a Type A that has been raster scanned and is editable only at the dot level, not as text or vectorized graphic illustrations; therefore, changes are more difficult to make to a Type B(-) TO than to a Type B TO, even though both appear the same to the user;
    - *Type B(+)*: Type B plus is also editable, but incorporates invisible tags in the content that facilitate TO use by allowing tailoring of displayed material to be specific to the task, aircraft tail number, technician experience level, and links up related material within or across TOs.

- *Type C*: characterizes TOs that will offer the highest level of technological innovation. These pageless TOs will be delivered by the contractor to the Air Force in neutral digital database form. The resulting database is characterized as neutral since technical data is stored in a form that is:
  - Fragmented to facilitate reusability and minimize redundancy;
  - Independent (or neutral) of any application software that subsequently uses it; and
  - Independent of any style or form used to output such data to a screen display or a printout.

  Such neutral data is more easily reusable in future integration requirements that can develop from the CALS initiative. The maintenance technician will be able to use an electronic display to search and retrieve required information from a neutral database. User access will be provided to related windows of information, regardless of data location in the TO or the database. In reality, Type C TOs have no page orientation and are significantly different from Type A and Type B TOs. There is one variant of the Type C:

  - *Type C(–)*: Type C minus restricts user access to Air Force verified fixed views only, so that arbitrary combinations of user–defined database elements will not be retrieved.

A3.4.2 Organizational Structure

To meet the objectives of more accurate, complete, timely, and cost–effective TOs, it is necessary to establish clearly defined responsibilities and logical information flows.

The AFTOMS organizational structure is designed to serve the natural functional entities that must reside in any documentation production and distribution system. These functional groupings include general administration, acquisition and production, ordering and distribution, and application use. AFTOMS has four–tiers with each tier mapped to a functional grouping.

The four tiers are hierarchical, with centralized control coming from the top down. Each tier is subordinate in function and responsibility to the one above it. The functional groupings and their related AFTOMS tier–level organizations are listed in TABLE A3-1 and depicted hierarchically in FIGURE A3–3.

TABLE A3-1. AFTOMS FUNCTIONAL GROUPINGS AND RELATED TIER-LEVELS

FUNCTION	TIER	ORGANIZATION
General Administration	1	AFTOMA
Acquisition and Production	2	TOMA
Ordering and Distribution	3	CTODO
Application Use	4	Work Areas

- *Tier 1: Air Force Technical Order Management Administration (AFTOMA)* – This top tier is a single organization/facility within the Air Force that is responsible for the demonstration, implementation, and management of AFTOMS. The AFTOMA establishes Air Force–wide TO policy and standards and provides coordination between Air Force commands and all participating organizations and users of AFTOMS.

- *Tier 2: Technical Order Management Agency (TOMA)* – This tier consists of multiple TOMAs, each of which is responsible for the acquisition, planning, development and maintenance of TO suites for weapon systems, commodities, or specialized equipment sets. Although specific system related TO duties are delegated to subfacilities called Technical Order Centers (TOCs), the TOMA provides the overall management for all TOC functions. TOC functions will be supported by Materiel Management Agencies (MM_R) for TO content change control, and TO regional data centers for distribution. It is expected that during development of a new weapon system or a major modification of an existing system, a development TOMA will exist to acquire and develop new TOs.

- *Tier 3: Consolidated Technical Order Distribution Office (CTODO)* – The third tier represents service organizations/facilities located at each base (geographic location) that provide centralized TO ordering and distribution services for an entire base, regardless of its command orientation. The CTODO is a specialized facility, which may be staffed, managed, and operated under either AFTOMA or MAJCOM control.

- *Tier 4: Work Areas (WAs)* – Work Areas represent end user communities requiring TOs for the performance of their mission objective. Work Areas consist of using command personnel and are not managed by the AFTO-

MA. Examples of Work Areas are: wing, squadron, shop, office, single user, and the aircraft itself.

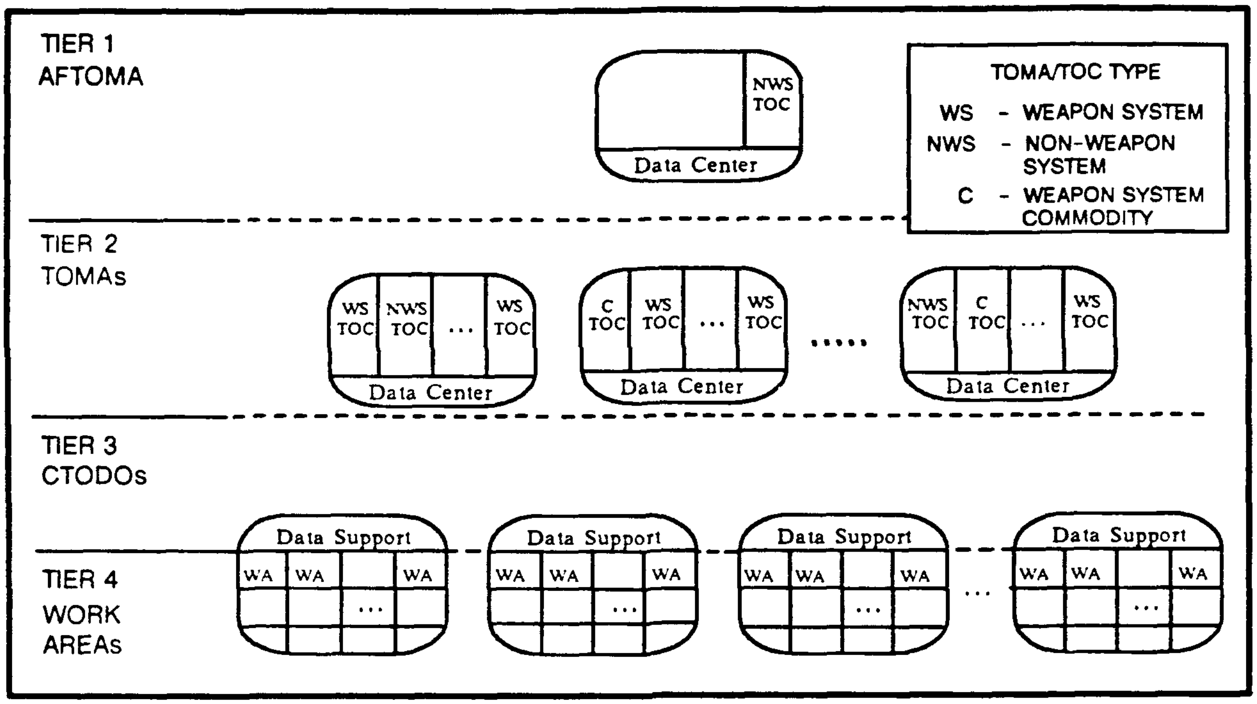


FIGURE A3-3. AFTOMS TIERS

TOCs and data support centers, subfacilities within the tiers, are established to consolidate some staffing and equipment requirements for common functions, and add operational efficiency to the system by limiting unnecessary fragmentation. TOCs at Tier 2 are subfacilities of an ALC regional center.

Each TOMA/TOC is responsible for the management (i.e., acquisition, planning, development, distribution, and updating) of the complete suite of TOs for a single weapon system. It must be emphasized that the TOC's responsibility for the complete suite of weapon system TOs is a major departure from the existing organization. Currently, TOs for a weapon system are the responsibility of several ALCs, each with a different subsystem specialty. In the To-Be concept, the TOMA/TOC needs to acquire and distribute all TOs for a specified weapon system regardless of the source organization. Each weapon system will then be supported by a single TOC, which has all TOs (of whatever type) in one location and a clear mandate to manage the TOs of that weapon system.

Since weapon systems share many common equipment items, such as engines and avionics, there will be a need to create TOCs specializing in these commodities. TOMA Commodity TOCs (CTOCs) would eliminate the duplication of effort that would occur if each weapon system TOC managed its own commodity TO inventory. A weapon system TOC will need to acquire commodity TOs directly from their respective TOCs. The weapon system TOC will then place these commodity TOs into its suite for base distribution. Commodity TOCs will not distribute directly to the CTODOs but only to weapon system TOCs requiring that commodity TO. However, all other functions (acquisition, management, production, etc.) remain the responsibility of the TOMA/CTOC. In addition to weapon system and commodity TOCs there will also be TOCs to support non–weapon system related TOs for such items as support vehicles, policy and procedures, indices, etc. The AFTOMA will have a non–weapon system TOC to support its administrative TO requirements. Each ALC will therefore, house a mix of TOMA/TOCs each with its own TO responsibilities. The types of TOCs defined and their responsibilities are listed in TABLE A3-2.

TABLE A3-2. TECHNICAL ORDER CENTERS AND RESPONSIBILITIES

TYPE	TECHNICAL ORDER RESPONSIBILITY	DISTRIBUTES TO:
Weapon System TOC (WSTOC)	All TOs for a major weapon system (e.g., F–16, B–1B)	CTODOs
Commodity TOC (CTOC)	Subsystem TOs (e.g., pneudraulics, engines)	Weapon System TOCs (WSTOCs)
Non–Weapon System TOC (NWSTOC)	Remaining TOs (e.g., policy, support vehicles, equipment, offices systems)	CTODOs

Each of the top three tiers contains distributed and centralized data center facilities designed to provide computer services/resources at each physical location. For tier–level organizational processing, communications, production and distribution at Tier 2, centralized facilities are appropriate, and consist of several different–range computers, storage capabilities and printers networked via a Local Area Network (LAN), such as the AFLC LAN. Each TOC has its own LAN–based workstations which are bridged to the ALC data center. Since CTODOs will support base–level requirements, the configuration of their data centers will match required capacities and support levels. All CTODO data centers will need to provide administrative processing, TO storage, high speed printing, and communication to Tiers 1 and 2. Configurations will range from LAN–based workstation super–micro to mini–computer systems, file servers, and high–speed laser printers. FIGURE A3-3 shows the relationship of subfacilities within the tier level organizations.

A3.4.3 Information Flows

Top–down data flow through the four tiers of AFTOMS is controlled by the AFTOMA and the associated hierarchy. The AFTOMA maintains a list of all active TOMA/TOCs and their associated weapon system responsibilities. Therefore, the AFTOMA is ideally positioned to be the control point for TO distribution and authorization. Once TO requests are registered by Work Area users in Tier 4, information flows up to the AFTOMA at Tier 1 and the response flows down through the tiers until it returns to Tier 4. This arrangement provides centralized control and distribution management.

Work Areas request information in the form of task definition profiles from their CTODO which, in turn, sends the request to AFTOMA. The AFTOMA either responds to a request directly or distributes the request to a specific TOMA/TOC (Tier 2). TOCs may then pass requested data (usually TOs) back to the CTODO for distribution to the Work Area. It is important to note that, in this top–down flow strategy, CTODOs do not request information directly from TOCs. The CTODO, therefore, need not know the location of TOs. This simplifies the ordering process,communications paths, and allows AFTOMA flexibility in assigning TOMA/TOC responsibilities.

FIGURE A3-4 shows the main information path flows from Work Area to CTODO, CTODO to AFTOMA, AFTOMA to TOMA/TOC, and TOC to CTODO.

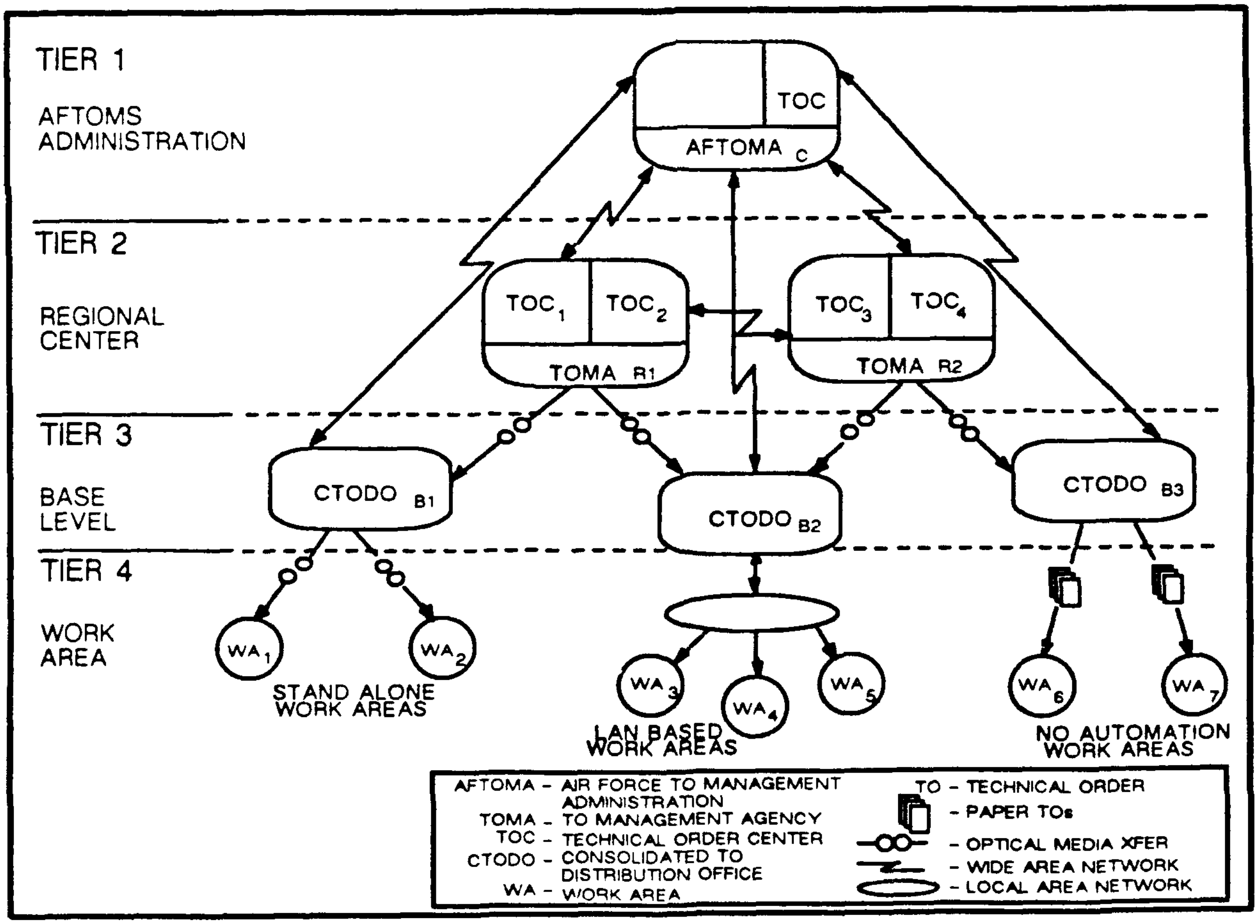


FIGURE A3-4. AFTOMS INFORMATION FLOW

A3.4.4 Interconnectivity

The flow of information requires communication paths that meet the functional demands of the system to be defined. The AFTOMS concept builds upon the current implementation of LANs taking place in the Air Force. Since the AFTOMA and TOMA/TOCs are expected to reside at ALCs, the workstations and gateways to the ALC data centers will be supported by the AFLC LAN. Local base communications at the CTODO (required) and Work Areas (optional) will be provided by Unified Local Area Network Architecture (ULANA) specified LANs.

FIGURE A3-5 shows the main points of interconnection and projected communication resources. Transfer of complete suites of TOs to the bases requires media exchange; for this type of bulk data transfer optical disc is recommended. Individual TO transfer among TOCs and the SPO/MAJCOM/Contractor community will be via the wide area Defense Data Network (DDN) dedicated line and media exchange. Communication of information other than TOs, such as change requests and user profiles, will be via interactive transaction traffic, best served by a Wide Area Network (WAN) such as the DDN.

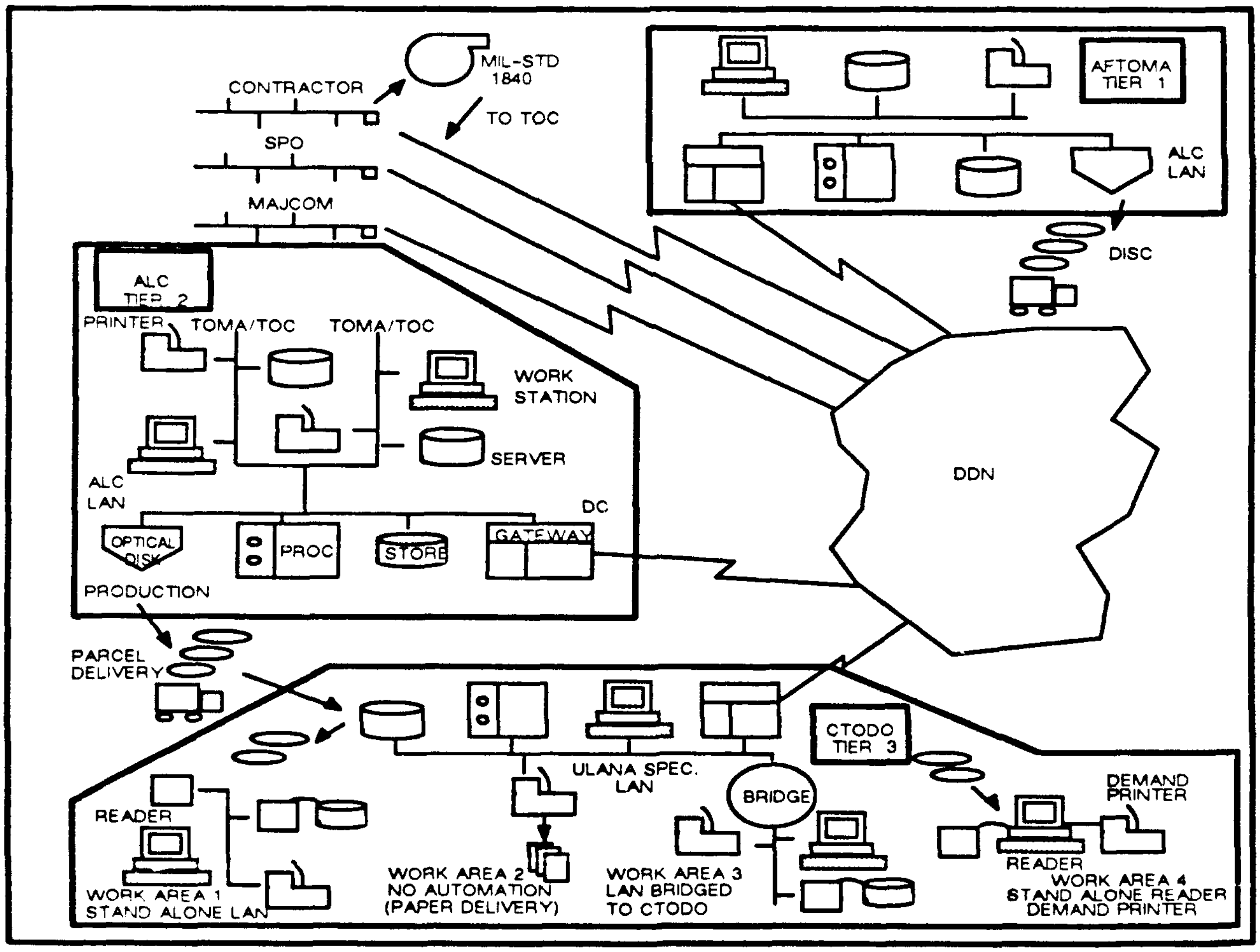


FIGURE A3-5. PROJECTED COMMUNICATION RESOURCES

A3.4.5 Major Functionality

In establishing the functional requirements of the AFTOMS system, the infrastructure was designed to serve the management and distribution of TOs regardless of their type. All TOs, whether Type A, B, C, or their variants, require a system that can provide the core activities of acquiring, archiving, cataloging, distributing, and change management. These activities were mapped to the AFTOMS To-Be concept according to the following six basic functions:

- User Profile Registration and Maintenance;
- TO Cataloging and Archiving;
- Master Catalog Maintenance;
- Distribution;
- TO Planning, Development, and Review; and
- Change Management.

When TO data is brought into the system in digital form, the AFTOMS system functions should be similar for all TOs to make the system operationally simple. Paper TOs (Type A), designated for AFTOMS automation, will be scanned and brought into the system as digital, page-oriented TOs (Type B). Pageless Type C TOs, which will be delivered in specialized digital form, should share the common system functions provided for Type B, except that they may require different software processing. From a high-level system perspective, the difference between TO types remains functionally transparent until actual distribution to a workstation. Due to the difference in delivery formats, Type B TOs will require workstations configured with hardware and software that enable the user to display, scroll, and print TO pages, whereas full support of Type C TOs will require specialized delivery systems.

FIGURE A3-6 is a flowchart that shows the system functions shared by all digital TOs. This use of common integrated functions to provide core applications will eliminate automation of isolated functionality. In addition, since the system is functionally modular, hardware and software updates to any given function can be made without disrupting or replacing the system as a whole. Until their withdrawal, paper TOs (Type A) that are not converted to digital, page-oriented TOs (Type B) will be assigned to TOCs to be ordered, cataloged, and distributed through use of the AFTOMS common functional applications.

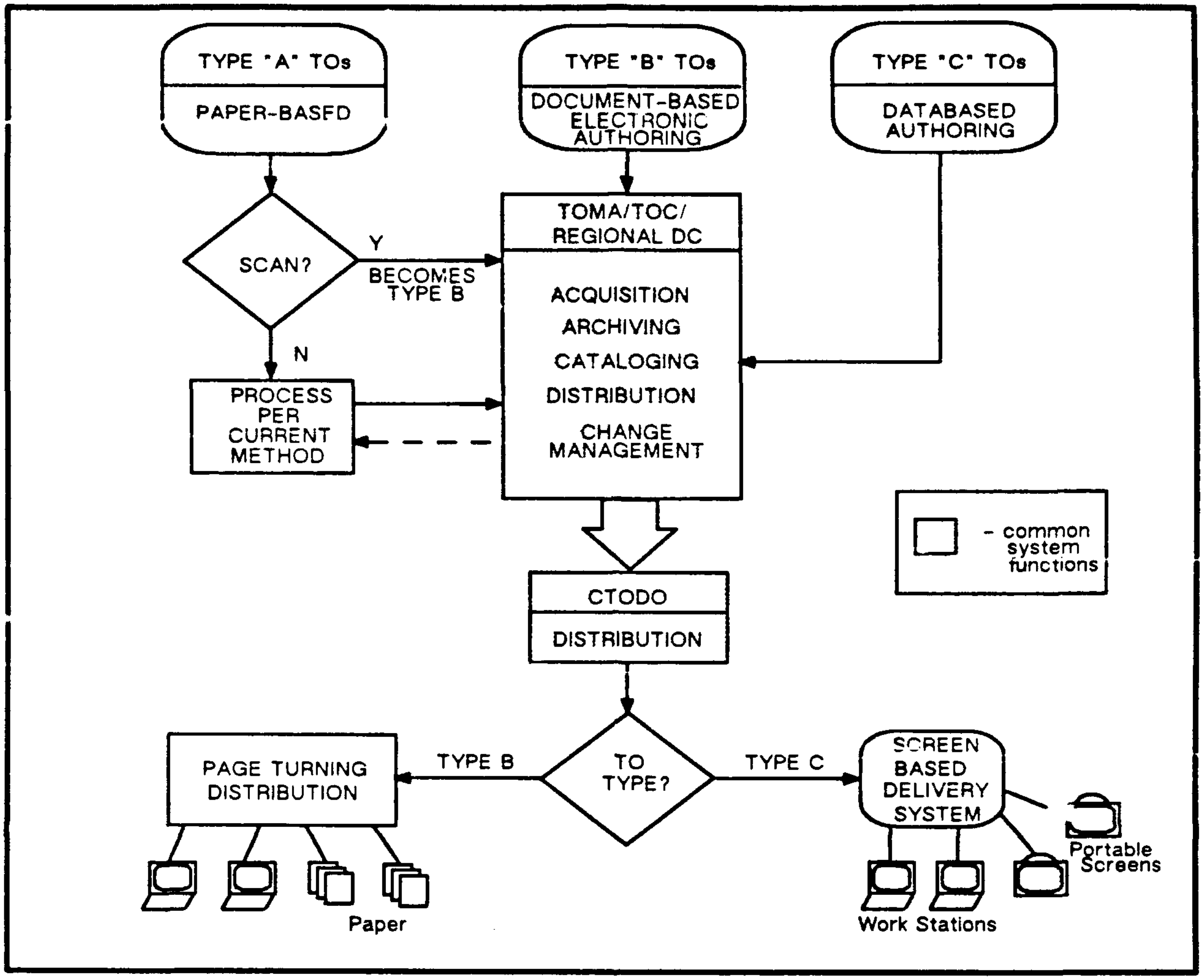


FIGURE A3-6. COMMON SYSTEM FUNCTIONS

A3.4.6 Concept Highlights & Benefits

In summary, this AFTOMS To-Be concept supports an implementation strategy that involves:

- Capturing Type A TOs on a limited and economical basis by using scanners;
- Using Type B TOs in the short term;
- Introducing Type C TOs in a later phase once the Type C operational support requirements are better understood;
- Using new technology for scanning, cataloging, storing, and retrieving information;
- Distributing TOs to CTODOs and automated WA users via optical disks;
- Supporting sophisticated entry, modification, and on-line retrieval capabilities;

- Supporting efficient document management;
- Distributing information based on profiles of individual user groups;
- Storing all types of information (numeric, textual, pictorial, and others) in a unified manner;
- Preparing TOs concurrently during the development of weapon systems with review of TOs in progress; and
- Establishing modified organizational and operational procedures.

The AFTOMS approach will produce many long-term benefits for the Air Force including increased weapon system availability, reduced costs, and increased mission effectiveness. AFTOMS provides the flexibility needed to support the more complicated weapon systems of the future. Specifically, AFTOMS will:

- Reduce overall cost of TO acquisition, distribution, and maintenance;
- Improve the timeliness, accuracy, completeness, and currency of TOs;
- Provide a single Air Force adminstrating agency which will have optimal management responsibility for the entire TO process and all TO types;
- Provide specific management responsibility for suites of related TOs by weapon system, commodity, or other classification;
- Provide clear lines of authority and accountability for all TO functional activities; and
- Enhance control and impose standardization across TOs, especially at the stage of receipt from contractors.

APPENDIX B:
AFTOMS TECHNOLOGY INTEGRATION DIMENSIONS

Overview of Findings

APPENDIX B

MANAGEMENT OF DISTRIBUTED USER FUNCTIONALITY

HANDLING AND CONVERSION OF HETEROGENEOUS TECHNICAL ORDER DATA

SUPPORT OF HETEROGENEOUS SYSTEM USERS

USE OF ELECTRONIC COMMUNICATION

INTERFACE TO OTHER AIR FORCE FUNCTIONS/SYSTEMS

SYSTEM BUILDABILITY

RELIANCE ON CONFORMANCE TO STANDARDS

OPERATIONAL UTILITY

SECTION B1:
Management Of Distributed User Functionality

B1.1 SCOPE AND RELEVANCE

The *AFTOMS Automation Plan, dated February 1988*, contains a concept of the Technical Order To-Be System. The intention of the AFTOMS program is to apply automation to the TO process in the most efficient manner, making use of state-of-the-art technology. The basis of the AFTOMS concept is to gain maximum benefits from automation, by automating the AFTOMS To-Be Concept rather than merely applying automation to the As-Is functions.

The To-Be Concept consists of seven major functions:

- Profile Registration;
- Acquisition;
- Cataloging/Repositing;
- Distribution;
- Change Management;
- Management; and
- Conversion.

The AFTOMS Automation Plan identified three additional program phases beyond To-Be development to fully deploy AFTOMS:

- **Initial Development Phase** – Issue an RFP, perform source selection preparation and evaluation, and award the contract;
- **Final Development Phase** – Build and deploy a Pilot System; and
- **Deployment Phase** – Deploy AFTOMS Air Force-wide.

FIGURE B1-1 depicts a representation of the depth of planning and investigation that was applied to develop the To-Be Concept. An entire level of detail, described in the lowest-level rectangle, was not addressed due to the early stage of the effort. However, as the program proceeded into the next phase (Initial Development), it became necessary to address specific issues more fully at that next level of detail to attain the proper level of thoroughness for completion of the Proof-of-Concept (POC) activity.

This section of the report: reviews the major functions of the AFTOMS To-Be Concept (addressing them in more detail as needed); identifies any modifications, restructuring, added or diminished implementation risks; and thereby provides an overall framework for the To-Be concept as it exists at the completion of the Initial Development Phase of AFTOMS.

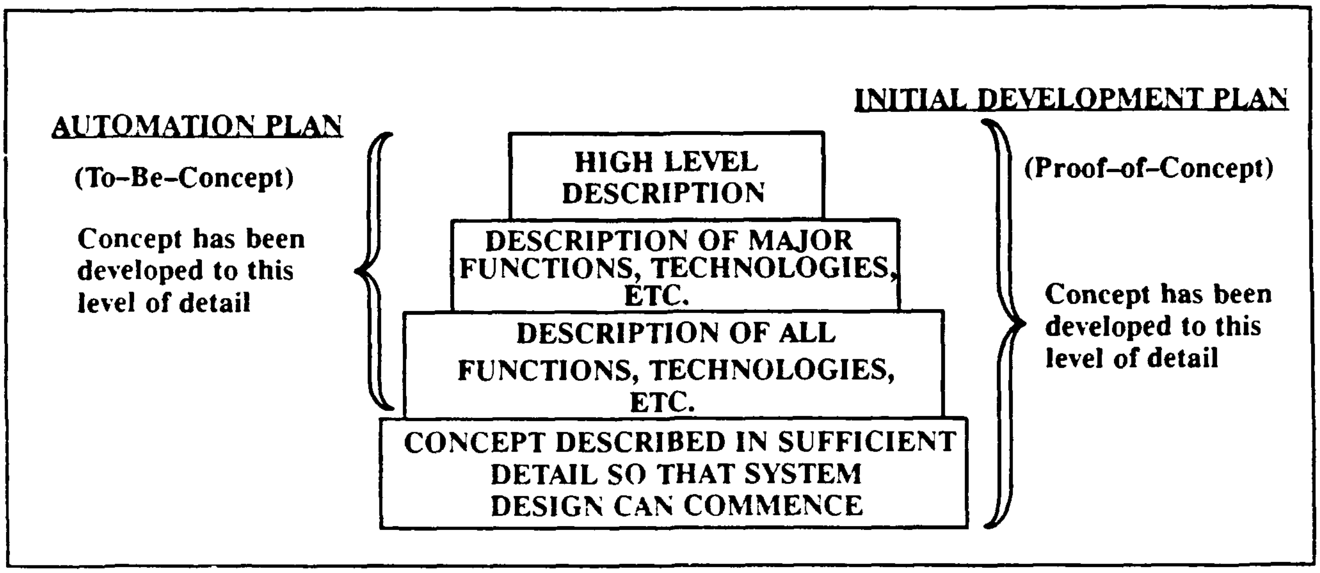


FIGURE B1-1. LEVEL OF DETAIL

B1.2 STATE OF INTEGRATION FEASIBILITY

B1.2.1 Profile Registration

In the To-Be concept, Profile Registration was envisioned as a simplified approach for ordering and distributing TOs. From a functional and integration point of view, Profile Registration is closely coupled with Distribution, Cataloging, Repositing, and Management. Storing TO content and TO management information in one database for access by other functions is indeed viable. The types and amount of information that need to be stored for effective distribution is approximately what was planned in the concept, thus keeping it simple for the user community.

B1.2.2 Acquisition

In the To-Be concept, delivery of TOs was expected to be in accordance with MIL-STD 1840. There has been no change in this expectation. However, there is considerable concern over subsets of MIL-STD 1840, most notably the MIL-M 28001-based employment of the Standard Generalized Markup Language (SGML). **Use of SGML requires availability of Document Type Definitions (DTD), Document Instance (DI) subsets of DTDs, Output Specifications (OS), and Formatting Output Specification Instances (FOSI).** The net assessment is that, while schedules for development of SGML components are of concern, the approach is technologically feasible.

B1.2.3 Cataloging/Repositing

In the area of cataloging, the concept has been greatly expanded and enhanced to allow for much additional functionality in distribution and delivery (specifically, on-line delivery). In the initial To-Be concept, the main purpose of the cataloging function was to store a set of descriptive fields of information in a database, to be used for storing and retrieving TOs. During the POC effort, it became apparent that the maintenance and operational user community (located primarily at Tier 4) needed delivery of the TO information in many alternate and more sophisticated forms, as opposed to merely printed or displayed pages on a workstation screen. For example, TOs were not always used individually but often were used in conjunction with other TOs to complete a task whose technical information spanned several TOs. Various data was configuration-specific and suited to a specific maintenance experience level. Many other similar data-usage requirements arose that could increase the productivity of the Tier 4 user if the presentation of TO data was suitably customized.

It was discovered that if the cataloging function was expanded to add and/or generate additional descriptive information about a TO or relationships across TOs, then such tagging information could be embedded within the distribution and used by the delivery system to offer the users much additional functionality.

The Change Management function could also benefit from catalog tagging. During the POC effort, it was found that changes in one TO often caused changes to related TOs. By cross-referencing TOs in a suite using catalog tagging, related TOs can be found efficiently and accurately to allow for all changes spawned by a change request.

B1.2.4 Distribution

In the original concept, the assumption was made that TOs would be distributed on a system-by-system basis. This assumption was based on two major premises:

- All TOs associated with a weapon system would be of a specific type (paper, digital page image, interactive digital, etc.); and
- A single organizational element would manage and control all TOs associated with the system.

An analysis of these premises indicated both were incorrect. **Practically all new and emerging weapon systems will consist of a variety of TO types, with a variety of AFLC and AFSC organizations responsible for their management and control.** Further, a determination was made that the suite of TOs supporting a weapon system consists of system-unique TOs (e.g., B1, F16, etc.), support equipment TOs (e.g., power carts, maintenance stands, etc.), and commodity TOs (e.g., altimeter, radio, engine, etc.).

The concept was expanded to take into account both realities. AFTOMS will provide a single point management responsibility, called a Technical Order Center (TOC), for each system. The TOC is a sub-element of a TOMA. The TOC's role is to manage and distribute its mixed suite of TOs. The TOCs which manage commodity and support equipment TOs will only distribute them to the system-specific TOCs for incorporation into complete weapon system TO suites and subsequent distribution to users.

The concept also entailed a two-tiered distribution strategy. The first level was full suite distribution from Tier 2 (TOMA) to Tier 3 (CTODO). The second level was customized distribution, based on Work Area profiles, from Tier 3 (CTODO) to Tier 4 (Work Area). The simple form of second-level distribution is paper or digital delivery to Tier 4 users. However, in most instances, a more complex environment exists at Tier 4. At this time, a standardized, proven base-level, digital TO delivery and presentation system has not been established. Several delivery systems, such as ITDS, IMIS, etc. will exist that merge TO data with other technical data, and then deliver the information to users in a more integrated fashion.

An AFTOMS requirement is to support linkage to these systems. However, AFTOMS cannot afford to develop a customized interface to every existing and future system at Tier 4. The initial To-Be concept was expanded to provide a standard interface (see Section B5, Interface to Other Air Force Functions/Systems) from AFTOMS (at Tier 3) to other base-level systems. This interface will control a two-way flow, receiving profiles and change requests from Tier 4 and delivering TOs and updates of TOs to Tier 4.

B1.2.5 Change Management

The AFTOMS To-Be change management concept focuses on a change request-based processing function using the following procedure:

1. Fill out an AFTO22 change request form at the Work Area (Tier 4);
2. Forward the request to the CTODO (Tier 3) for consolidation with other requests;
3. Route the request through the AFTOMA (Tier 1) to the appropriate TOMA/TOC (Tier 2) for review and approval for action; and
4. Approve authorization for any changes to be made.

There is a lengthy quality assurance review process that occurs within a command (Base level and Command HQ) before the change request is reviewed at an ALC. This part of the process was not accounted for in the initial concept.

After a detailed look at this review process, the concept has been expanded to accomodate automatic routing on a sequential cycle, based on profile information, to all review participants at command level. This is performed without the need for paper transfer of the change request and transcribing of the information to additional forms. In fact, the user filling out the request, as well as all intermediate reviewers, do not have to fill out the exact replica of the AFTO22 form. This can be left until the last review step and then automatically generated by AFTOMS, thus saving a significant amount of time and tedious effort for users and reviewers. After command level review, the request can be routed to the AFTOMA and then to the appropriate TOMA/TOC for processing.

B1.2.6 Management

AFTOMS is primarily a management system. Paramount to its success is having access to sufficient amount of data regarding TOs, users, change requests, production statistics, scheduling and tracking information, etc.. The current manual system is slow and inefficient because of its inability to make this type of database available. In the initial To-Be concept, these data management functions were not addressed in detail.

After understanding the details of the existing manual system, an acute awareness developed for the need to incorporate the LMTOS management data into AFTOMS, and add new data for effective management control. Effective interactive functionality and proper batch-generated reports are essential for improved operational performance. This management data must interact with the cataloging information and document management data to help coordinate all of the AFTOMS functions.

B1.2.7 Conversion

There are over 150,000 Air Force TOs in existence today. Over the next five to six years when AFTOMS is deployed, only a small percentage of new TOs will enter the inventory in comparison to those now in existence. An economically and operationally successful automated TO process is dependent upon converting as many TOs as possible to digital form. This allows for application of the greatest degree of automation to the processing of TOs in the downstream functions of distribution, on-line delivery, and change management.

In the initial To-Be concept, several conversion strategies were presented. Conversion of Type A TOs (paper) to Type B (digital), and delivery of those TOs to AFTOMS in MIL-STD 1840 is the most desirable alternative. However, it is also the most challenging alternative for the following reasons:

- Converting old TOs according to newly specified DTDs and OSs requires reformatting;
- The amount of trained labor needed to inspect and assure that the integrity of the content of each converted TO is not altered is significant;
- All the TOs in the suite need to be converted to maximize efficiency in the distribution process; and
- The huge volume of TOs that need to be converted means a sizable investment both in time and dollars.

Detailed investigation of the paper TO inventory shows TOs having inconsistencies, standardization differences, and poor publication quality (especially in older TOs). The technology to automate this conversion process more completely is progressing and presents less of a problem than the operational issues enumerated above.

B1.3 PARTICULAR INTEGRATION APPROACHES USED IN THE DEMO SYSTEM

In the development of the Demo System, the main thrust was to acquire application software modules and integrate those modules to produce the desired functionality. The main activities in the Demo System were:

- Developing interfacing software to link up the acquired application software modules;
- Developing a common user interface style to make the integration appear seamless;
- Customizing and enhancing the acquired application software functionality to support AFTOMS needs; and
- Integrating all the hardware, software, and communications components into the system.

The conceptual architecture of the Demo System is shown in FIGURE B1-2.

As the design and development of the user functionality progressed, a key point continued to surface. To implement most user functions (and subfunctions), it was necessary to draw on a combination of data elements that resided in the Relational Data Base Management System (RDBMS) and the Document Management System (DMS). Multiple sequential steps existed, in both access and update transactions, where the access of a data element from the RDBMS became an input parameter or link to the DMS in a succeeding step. In fact, a very tight coupling existed between the RDBMS and the DBMS to provide effective data management within AFTOMS. Traditional electronic publishing systems, which attempt to embed data management services within their product, do not have a rich enough set of data management services to support the robust user requirements of AFTOMS. However, when coupled with data management services supplied by database products, the desired functionality can be supported.

Another related type of issue also became apparent. There is a very tight coupling between additional B+ tagging and the functionality that becomes available to the user of the On-line Delivery System (ODS). The ODS has the ability to provide different data presentation and hypertext navigational features to the user. However, the power of ODS is severely limited unless the additional tags are added to the documents.

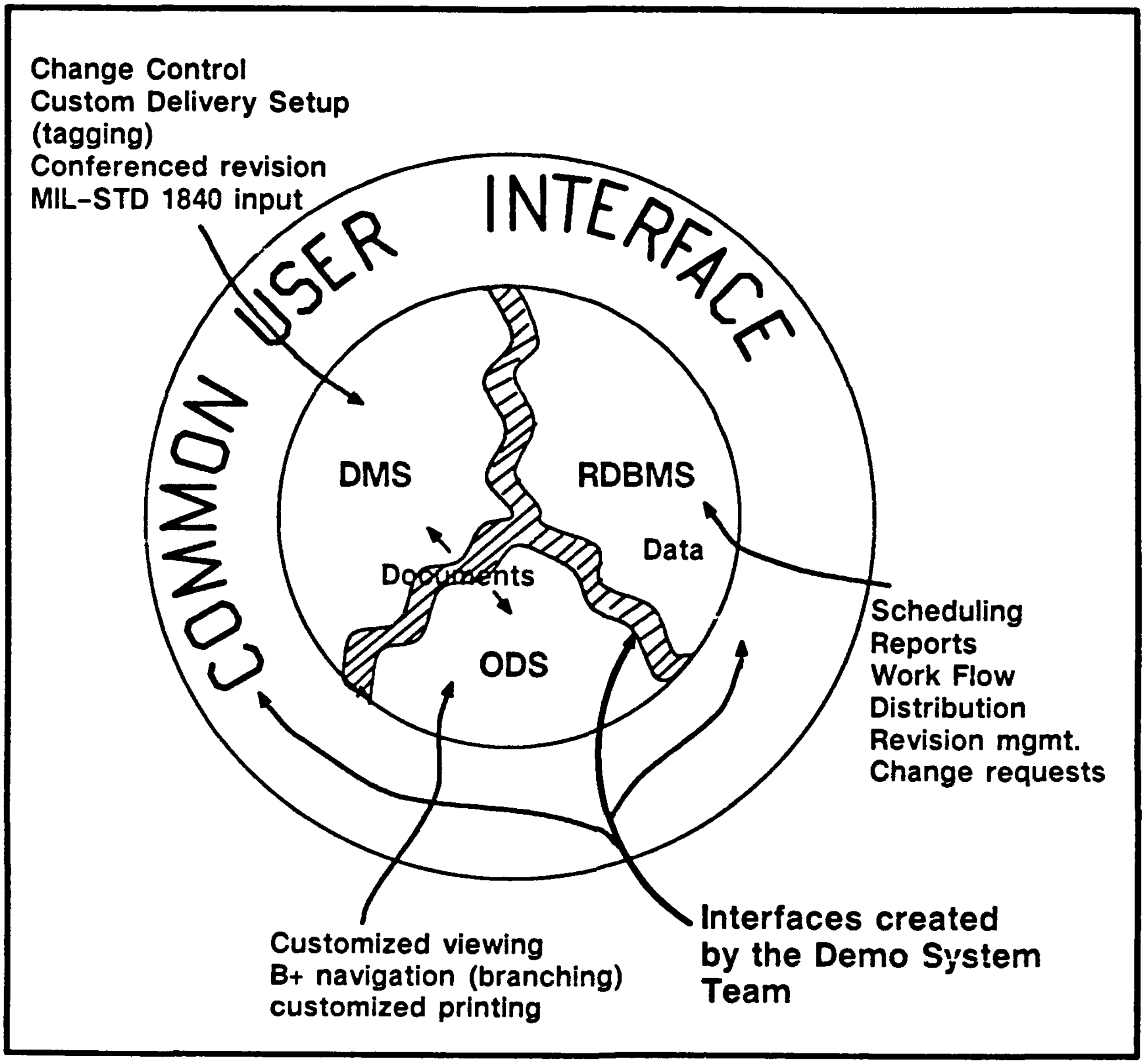


FIGURE B1-2. DEMO SYSTEM CONCEPTUAL ARCHITECTURE

With respect to tagging, some degree of flexibility is available. When additional B+ tagging is required, appropriate tags can be added:

- While the TOs are being prepared;
- During the Cataloging process; or
- During the Change Management process, if additional ODS functionality is desired.

While testing and debugging the ODS, an additional branch, link, reference, etc. capability was observed that would make a displayed TO more usable by making it easier to locate and retrieve related information. To effect this capability, the addition and/or modification of a few tags at the tagging step was required. When AFTOMS is deployed, it is possible that a significant number of change requests will address tagging changes as opposed to requests for content changes. This tagging flexibility allows introducing additional display capability long after the TOs are authored and cataloged in the inventory.

B1.4 RISK ASSESSMENT

After developing the next level of detail shown in Figure B1-1, the AFTOMS To-Be concept continues to be viable, especially at the major functional level. The concept is robust enough to support detailed modifications if needed.

The AFTOMS Demo System reinforces the viability of the concept with respect to correct and tightly coupled functions. Also, the user interfaces demonstrated in the AFTOMS Demo System appear to match the needs of all major classes of users: data managers, maintenance and operations users, and publications personnel.

Within some functions, the current unavailability of specific details presents the highest risk. The major residual risks are present in the following areas:

- The ability to perform conversion on entire suites of TOs;
- Availability of DTDs and OSs to assist the conversion process;
- Integrating support TOCs and commodity TOCs with system TOCs for effective TO suite distribution; and
- Defining a standard AFTOMS interface to base-level systems.

B1.5 RISK ABATEMENT

The following abatement activities should be performed to minimize the above risks:

- Institute a pilot conversion activity on a representative suite of TOs as soon as possible;
- Obtain continuous feedback on user interface details and AFTOMS functionality from potential users via Demo System review;
- Update and extend the Demo System to reflect user feedback;
- Use the Demo System as a training and educational tool; and
- Incorporate Demo System concepts into the System Operational Requirements Document (SORD) and Functional Description (FD) to ensure a synchronized view of AFTOMS functionality.

SECTION B2:
Handling and Conversion of Heterogeneous Technical Order Data

B2.1 BACKGROUND

This section identifies and analyzes the problems of managing the entire mixed TO inventory in the Air Force. It includes TOs currently in existence, TOs that are under development, and TOs that will be generated and acquired in the near and long term future. Three major topics are discussed:

- **Management of Mixed Technical Order Suites** – This topic evaluates the current and near–term makeup of the TO inventory, and the management approach needed to manage it;
- **Conversion of Technical Orders** – This topic evaluates conversion of the current TO inventory in paper form to digital form, if technically and economically feasible, to take advantage of the management techniques proposed in the first topic;
- **Classified Technical Orders** – This topic adds the complex issue of classified data to the previous topics since a portion of the TO inventory is classified at various levels. Classified TOs must be managed as well as unclassified TOs.

B2.2 MANAGEMENT OF MIXED TECHNICAL ORDER SUITES

This section describes the realities of the current and near–term makeup of the TO inventory by TO type and the management approach needed to manage this heterogeneous inventory.

B2.2.1 Scope and Relevance

AFTOMS is an all–inclusive TO management system for the Air Force. Currently, the inventory contains approximately 150,000 TOs and is rapidly increasing as newer and more sophisticated weapon systems are developed. It is unrealistic to implement a management technique to manage each and every TO as a separate entity. Also, it is operationally unrealistic to apply a technique that tries to manage the entire inventory as one enormous, homogeneous entity.

A strategy is required to divide the inventory naturally into TO suites (groups of related TOs); and then a consistent management technique needs to be applied to each suite. The strategy chosen is one that **divides the inventory on a weapon system basis** supported by reusable commodity TO sub–suites. It should be noted that the term "weapon system" refers to major systems in the Air Force (e.g., F16, C5, B1B, ATF). These weapon systems are not the only systems generating TOs; other TOs are written to cover administrative procedures, support equipment, and commodity subsystems used in several weapons systems. (In this report, technical issues and solutions will be presented in the context of major weapons systems since they require the most complex management strategy.)

TOs within the framework of a weapon system present an added dimension to the management problem. TOs can be Type A (paper), Type B (page–oriented, digital), or Type C (integrated, interactive data in digital form). If consideration is given to a weapon system suite for a medium-to-large program, there is a high probability that the TO suite will be a mixture of all types of TOs. This is likely to continue in the future because of TO reuse (i.e., for commodities). Also, if an assumption is made that Type A TOs in the suite have been converted to Type B TOs, then a mix of Type B and Type C TOs would still exist requiring TO management as an entity.

TOs are used for a variety of purposes. These include maintenance, operations, training, support, etc. However, the majority of TOs in a weapon system suite are used in the maintenance activity. There are three types of maintenance activities in the Air Force:

- On-Equipment (O-level);
- In-Shop (I-level); and
- Depot (D-level).

Each of these maintenance activities for a weapon system program has separate maintenance strategies that will directly affect the type of TOs (B or C) developed.

TO management, which is the primary function of AFTOMS, includes various sub-functions:

- Authoring (usually performed by the prime contractor);
- Acquisition (includes verification);
- Cataloging and Repositing (includes cross-referencing across suites);
- Distribution;
- Change Management (includes change authoring); and
- Usability (user level responsibility).

In considering the above dimensions along with the realization that there are many weapon system programs (approximately 50), the complexity of the management problem that confronts AFTOMS is evident. However, the premise that **AFTOMS is the all-inclusive TO management system for the Air Force mandates that it must perform the TO management function for all programs**. For efficiency, it must do so in as standardized a manner as possible. Both requirements are critical to the success of AFTOMS.

B2.2.2 Understanding the Different TO Types (A, B, B–, B+, C)

The following list identifies and describes each TO type:

- **Type A**: All TOs that currently exist in the Air Force inventory or will be delivered in paper form;
- **Type B**: Page-oriented TOs in digital form;
- **Type B–**: Page-oriented TOs in digital image form (text and graphics are in raster);

- **Type B+**: Page-oriented TOs in digital form, containing tagging information to allow electronic display of variant documents with efficient access to internal and external reference points; this makes related information (graphics, tables, other TOs, etc.) easily retrievable; and
- **Type C**: Integrated, interactive data in digital form containing tagging information to allow efficient access via electronic display to required data.

FIGURE B2-7 is a high-level summary of the characteristics of the different TO types.

Non-Digital	Digital			
	BIT-IMAGE EDITABLE	INTELLIGENTLY EDITABLE		
TO Type: A	B^-	B	$B^+ = C^-$	C
• Paper Document	• No Components	• Controllable components	• Finer Components	• Finest Components
	• Viewable as Document	• Viewable as Document	• User views controlled	• User views dynamic
	• Shows information extraneous to specific need	• Shows info not needed for current task	• Usability Enhanced by: – Showing only necessary info specific to Task, Config., Skill Level, etc. – Powerful navigational & Connective capabilities	• Extremely powerful access features
	• Scrolling-based navigation	• Scrolling-based navigation		

FIGURE B2-7. THE AFTOMS DOCUMENT TYPE CONTINUUM

Type B+ and Type C have the same basic similarities and differences. A major difference exists in the **authoring** approach. Type B+ authoring, or document authoring, is performed in the traditional manner for creating technical manuals. In this approach, engineers and technical writers organize their thoughts and ideas, and write them in a narrative or descriptive manner that approximates the sequential order that is most usable to the reader. This is called the **primary view.** Additional views could be generated from the primary view by adding more tagging information with such qualifiers as configuration, skill level, security access, etc. However, the primary view retains the order in which it was authored (document form). **The primary view is also the manner in which the information is stored in the data repository.** Therefore, some level of data redundancy is inevitable, although major tagged components are reusable.

To reduce data redundancy to a minimum, Type C information is authored in a different manner. There is not a concept of a primary view and certainly not one of sequential authoring of information. Views are created by linking together components of information (i.e., paragraphs, warnings, tables, diagrams) that exist in the database. These components are authored or created independent of any predefined view. They are also authored with the idea of becoming reusable information elements within the discipline in which they will be used (i.e. maintenance strategy). The components are stored in the database and can be selected for insertion into one or more views; these views are created after components are generated. This Type C authoring process is referred to as database authoring. The Type C authoring process creates more difficulties than the Type B+ authoring process. Some of these major difficulties are:

- Cultural changes that writers experience;
- Shortage of adequate tools and systems to assist writers in generating reusable text and illustration components; and
- Locating appropriate existing components for compilation into TOs without increasing data redundancy in the database.

Similar authoring issues apply during change management, some of which will be performed organically by the Air Force.

Whether the authoring process is document-oriented or database-oriented, both approaches provide the capability to create equivalent predefined multiple views from the same information base. **The Type C approach, which closely resembles true hypertext, is far more dynamic in the number and types of different views which can be created.** The Type B+ approach is oriented toward a smaller but adequate number of predefined views that key off the primary view. **In the Air Force environment, it is important to have only predefined views accessible by users to ensure safety, precision, and regulatory control over critical and life-threatening maintenance and operating procedures.** Both approaches (Type C and Type B+) can be used to create the views that the Air Force requires. However, when the Type C database is constrained to such controlled views (resulting in Type C–), much of the flexibility and benefit of Type C goes unused.

A related issue to authoring is verification. Verification is the organic process that is used to check the clarity, completeness and usability of views to complete a specific task. Information in the Type B+ process is delivered as a document in its primary view. Verification is performed by traversing the document with this primary view. Subsequently, all additional views are checked in a similar manner.

Verification of Type C data is a more complicated process that has two steps. Type C information is delivered in database form. However, once the database is stored, the second step of the verification process is similar to Type B+ verification Every predefined view must be checked for correctness, completeness, and clarity. However, before the views can be verified, the individual components must be verified, the structure and composition of the database checked to ensure that all linkages between components and views are correct and consistent, and view access limits tested to ensure that only authorized views can be accessed at each corresponding level of maintenance. Such a process, while possible from a technical viewpoint, will be complex, time consumming, and expensive.

One of the primary goals of Type C is the elimination of redundant information. In its most optimum form, there would be no redundant information in a Type C database. Since views are created after the components are authored by stringing the components together, redundant information should not enter the database. However, Type B+ authoring consists of creating the primary view and reusing the components as additional subset views are created. Thus, the reduction of redundant information with Type B+ will not be as great as in Type C.

Items such as illustrations, tables, warnings, cautions, and boilerplate text are prime examples of components that can be reused many times in a document suite or database. However, with items such as section heads, paragraph text, etc., the issue is more complex. The thoughts or content may be similar but not exact, since paragraph text is written and read in the context of what preceded it in the view stream. There will be other costs accrued in the areas of authoring, verification, etc., to eliminate this additional redundancy. In the assessment and evaluation of some of the typical TO suites for programs like the F16, C5, etc., it was observed that similar information existed, but only a minimum amount of duplicate information. In Type C authoring, redundancy control will require considerable operator discipline as the pressure of time will work against the need to search the database for duplicates or near duplicates.

The following major issues exist when using Type B+ or Type C authoring:

- *How to author and manage the data to support the functionality required by the users*--The largest group of end users (maintenance and operations personnel) are not concerned with the amount of data redundancy or the method used in authoring, acquiring, managing, or changing the information. These functions are transparent to them. When the users indicate a preference for Type C data, what they are really saying is that they need multiple views into the data base; and

- *The system must be designed/developed in the FY91–FY93 time frame and deployed in the FY93–FY95 period*--Thus, one must factor in the pace and availability of the technology components needed. Even a Type B+ system has never been fully developed and tested, let alone a more sophisticated Type C system.

Factoring all of this information into the decision making process, the strategy for managing a heterogeneous suite of TOs is evident. If Type C concepts can be integrated into a baselined Type B+ management approach without preventing or slowing down a full Type C solution in the future, maximum functionality and flexibility can be realized with minimum risk.

B2.2.3 Type B (B, B–, B+) Management Approach

TO management spans the functions of authoring, acquisition, cataloging, repositing, distribution, change management and usability of the TOs. In this section, each of these functions will be described with respect to the Type B Management Approach.

AUTHORING

Authoring can exist in the contractor environment or can be performed organically. It will be performed in the traditional manner utilizing current electronic publishing systems. Tagging of the data can be accomplished during the authoring step or can be added during a post-processing stage. Two major type of tags exist: **structural tags**, which identify the components of the document (i.e., titles, section heads, paragraphs, warnings, etc.) and **content or qualifier tags** (i.e., configuration, skill level, security access, etc.). The qualifier tags are the mechanisms that allow users to obtain Type B+ functionality from Type B data. The Document Type Definitions (DTDs) that are currently under development in the Air Force will support both types of tagging. Therefore, the content or qualifier tags can be entered by the contractor during authoring and acquired by the Air Force, or the TOs could be acquired without content tags which can be added organically at a later date.

ACQUISITION

Acquisition of the TOs will take place according to the procedures defined by the CALS program. The TOs will be delivered to the Air Force in accordance with MIL–STD 1840. The DTDs will be the official document types that these TOs will be checked against. These DTDs will support all Type B TOs (B–, B, B+).

CATALOGING AND REPOSITING

Once the TOs have been acquired, they must be cataloged and stored into the repository. Cataloging is the step that adds relevant identifying information on the TO to the database. If content tagging is incomplete, content tags will be added. Tags to support branching and linking to other TOs within the system suite or outside the system suite would be added during the cataloging process. Branches and links that occur across TOs in a suite provide cross-referencing information. Tags for cross-referencing also can be added during the cataloging process.

Another major part of cataloging is reducing the redundancy of information within the database. The managers of the TO suite can identify and eliminate the redundant information during the cataloging process, using the automated capabilities of document management systems. When cataloging is complete, TOs will be stored in the repository.

DISTRIBUTION

A key element of the management strategy is dividing the inventory on a weapon system basis. The biggest functional beneficiary of this approach is distribution. A bulk media distribution of the entire suite is the primary way in which TOs will flow from the TOMAs to the CTODOs. All TOs acquired in Type B or Type B+ form already will be in the proper format for inclusion in this bulk distribution. However, most weapon system programs have a portion of their TO suite in Type A form. These TOs can be image scanned into Type B– form to be included in the digital distribution. Since AFTOMS manages all TOs in the inventory, it already has cataloging information on the TOs before they are imaged scanned. After scanning, AFTOMS has digital page representations that can be viewed and printed.

CHANGE MANAGEMENT

The core technologies needed to manage TO suites effectively are Document Management Systems (DMS) tightly coupled with Relational Database Management Systems (RDBMS). Data elements such as change requests, authorization forms, versions, revisions of TOs, and scheduling and tracking of data, all work together to support automated change management. DMS and RDBMS are emerging technologies that can be used in the near future for data management. In the long run, these technologies will coexist with object data management or may fully integrate with object data management systems to accomplish data management functions.

USABILITY

Once the bulk distribution has been delivered to the CTODO, another set of management functions needs to be performed to deliver the TOs to maintenance and operations users. These functions include:

- Loading the distribution into the CTODO database;
- Identifying the TOs that changed since the last distribution;
- Building the customized distributions for Work Areas based on their profiles;
- Delivering the TOs in the requested form (via LANs, media, or printed copies); and
- Keeping track of ordering, distribution, and feedback (change requests) information.

RDBMS technology is central to supporting these management functions.

When the TOs reach their ultimate destination (shops and flight lines) they will have the tags and related information embedded within them to be used in a Type B or Type C manner by the On-Line Delivery System (ODS). Even though the management techniques used were Type B, the end result at the destination point is similar to Type C.

B2.2.4 Type A Management Approach

Even with the most optimistic view on the amount of existing inventory to be converted to digital form, a significant number of Type A TOs will remain and have to be managed by AF-

TOMS. These paper TOs will exist in their current form as page masters, and be reposited as they are today. However, the information that identifies and tracks these TOs will be entered in the cataloging step for AFTOMS (so that AFTOMS can manage these TOs).

Management of Type A TOs is not as sophisticated as Type B. Printing will take place at Tier 2. Distribution will be in paper from the ALC (Tier 2) to the bases. Change management will occur similarly to today's environment, except that the AFTO22 processing will be automated. No on-line delivery capability will exist.

B2.2.5 Type C Management Approach

Type C data (C- or C) will exist in the AFTOMS repository in database form. A basic difference between Type C- and C is the dynamics of view creation. Type C data allows for an unlimited number of views to be created by users on demand. Type C- data delivery restricts the set of predefined views to the same set as Type B+. From a management perspective, Type C- is similar to Type B+ except for the underlying data management tools.

Type C could be managed within the AFTOMS structure given the additional sophisticated functionality in authoring, verification, change management, and on-line delivery. Also. Type C information extends beyond the technical data included in TOs. There can be linkages to other types of related and supporting information residing in other databases or systems. This information is merged at the delivery system (e.g., Integrated Maintenance Information System (IMIS)).

A key difference in the management of Type C and Type C- data would exist in the distribution function. To allow views created on demand and by merging Type C data with other databases, AFTOMS must distribute the database to the delivery system. With Type C- requirements for end users, AFTOMS need only deliver the predefined views.

B2.2.6 Summary of TO Management

In the previous section, the approach to management of a heterogeneous TO suite was described on a function-by-function basis. Key points of this integrated approach for the **FY91-FY93 system implementation** are summarized below:

- Keep the authoring process as it exists today;
- Eliminate some redundancy in the TO suite during the cataloging function (i.e., graphics, warnings, tables, etc.);
- Prevent unauthorized views of the data;
- Incorporate Type C concepts within AFTOMS constraints;
- Reduce Distribution and Change Management complexity;
- Deliver TOs in a form that can be used like Type C data;
- Identify at least one of the new weapon system programs that will be developing the full Type C capability, and whose deployment schedule is planned for the mid 1990s; and

- **Plan and develop a parallel management capability within AFTOMS for this TO suite, thus allowing many of the difficult technical and interface issues to be worked out in a time frame that coincides with the availability of the full set of Type C technology components.**

In the near term, the end users will acquire most of the desired functionality without placing any additional burden on authors or managers of TOs.

B2.2.7 Risk Assessment

For management of the Air Force digital TO inventory, several key issues affect the AFTOMS approach to acquiring a total management capability. They are:

- Percentage of the inventory of Type B and Type C TOs in the FY95 timeframe;
- Availability of commercial off-the-shelf solutions for Type B and Type C TOs in the FY95 timeframe;
- Similarities and differences in all the supporting operational techniques of the functions that are part of the management of TOs;
- Availability of conversion technology solutions for Type A to Type B or Type C data; and
- Solidification of the data interchange standards.

Development of Type B solutions for the management of TOs (including all supporting functions) is much further along than is development of operational Type C solutions. Also, the required data management approaches are significantly different for Types B and C, so that they will not converge into one, all-encompassing solution in the near term. The same is true in the conversion technology and data interchange standards areas. Trying to develop a single management strategy for all types of TOs in the near term would leave the Air Force with a high risk option.

B2.2.8 Risk Abatement

Perform a detailed operational evaluation of the Type C concept as soon as possible to establish the AFTOMS support requirements. Recognizing that a minimal amount (percentage wise) of Type C data will exist before FY2000, AFTOMS development should maximize the realization of TO automation benefits by focusing first on full Type B family management, followed by incorporation of Type C support for those new weapon system programs that will employ the full Type C concept. For non-Type C weapon systems, Type B+ TOs would provide the Tier 4 users with similar TO data display, navigation, and cross referencing benefits as offered by Type C- TOs (as described in Section B2.2.2).

B2.3 CONVERSION OF TECHNICAL ORDERS

This section describes the conversion of the current TO inventory existing in paper form to digital form.

B2.3.1 Scope and Relevance

In Section B2.2, the functions that make up TO management (i.e., distribution, change management, etc.) were defined in a manner to take advantage of automated techniques and technologies using digital data. The CALS Initiative states that all new programs that are scheduled to come on-line in 1990 and beyond are required to deliver their TOs in digital form to the Air Force. Thus, the proliferation of new paper TOs (Type A) will be halted once this regulation is adhered to. Also, as some of the aging weapon systems are retired, paper TOs will be removed from the inventory. Still, the fact remains that the majority of TOs in the 1990s will still be Type A unless they can be converted into digital form.

The real payback of digital TO management is when the majority of the inventory exists in digital form and all of the functions that are embodied in AFTOMS can be applied. For example, no on-line delivery capability would exist for paper TOs. By converting the TOs from Type A to Type B, the distribution function (including demand printing at base level) can be totally automated. Also, change management can be fully automated if the TOs are in Type B (excluding Type B-) form. Once the TOs are in Type B form, additional tags can be added during the cataloging step to upgrade these TOs to Type B+. Type B+ TOs offer much greater functionality in on-line delivery and presentation of predefined multiple views. The benefits of AFTOMS can be accelerated in proportion to the amount of TO inventory that gets converted and subsequently enhanced through tagging and cataloging.

B2.3.2 Conversion Approach

TO management will be performed on a weapon system basis. Each program requires a uniform management approach. Fragmentation of the TO suite (by mixing paper and digital types) will complicate the management process, especially in the distribution and change management functions. However, AFTOMS can support heterogeneous TO data. To maximize benefits, **a primary goal for a weapon system would be to convert the entire TO suite.** Although isolated conversion of individual TOs in a suite will solve specific management problems, it will also create problems.

Specific issues concerning the conversion process are critical to its success: who should perform the conversion; what technical support resources are required; and the time frame to accomplish the task. There are 3 basic options for performing the conversion:

- *Service Bureau* – The task can be contracted out to conversion service bureaus having the automated hardware and software components and the expertise in this area. They usually charge on a per-page basis depending on the number and complexity of the TO pages;

- *Contractor* – If the weapon system program has not yet reached PMRT, the responsibility for conversion can be assigned to the prime contractor (along with the appropriate funding); and
- *Organic Conversion Center(s)* – The Air Force could institute one or more conversion centers (perhaps at selected ALCs) to convert suites of TOs.

Based on the non–recurring, one–time need for conversion, the fast pace of this technology, and the intricacies of the conversion process, the most beneficial option for the Air Force would be the Service Bureau approach.

Regardless of the option chosen, Air Force technical data specialists will be needed to assist conversion personnel in the conversion process. Many inconsistencies and irregularities exist in any TO suite, especially in the older weapon systems, that cannot be identified and corrected by total automatic conversion. Specific issues will arise requiring review and decision making by TO experts (i.e., "Which DTD and OS should the TO be mapped into?" and "Should one merge the changes in the supplements into the TOs they augment?"). It is strongly recommended that a small "tiger team" accompany the TOs and monitor the quality of the process.

The conversion of TOs for a weapon system suite should take place in a short chronological time span. Business continues as usual while TO masters in the suite are collected and brought to the conversion location. During this conversion period, the changes must be carefully recorded and subsequently added to their digital counterparts. This period of overlap must be minimized. A reasonable goal would be to accomplish the conversion of a weapon system's suite of TOs in six months.

B2.5.3 Summary

AFTOMS is a system that will apply the latest automated techniques and technologies to the management of TOs. This approach is geared to a digital repository of TOs. Key conversion points are summarized below:

- Convert as much of the inventory as soon as possible;
- Convert on a weapon system basis and a commodity basis;
- Enhance the converted TOs to Type B+ form; and
- Use the Service Bureau approach.

B2.5.4 Risk Assessment

The entire area of document conversion is in a rapid state of development and change. The solutions that are available today and in the next couple of years are not sufficient to handle the large bulk conversion requirements of the Air Force. However, by the time AFTOMS is fielded in FY93, technology advancements will significantly reduce the cost and risk of this activity.

B2.3.5 Risk Abatement

AFTOMS cannot wait until FY93 to begin using this technology for document conversion. Understanding the details of the conversion process, the characteristics of the inventory, the limitations of the technologies, etc., and estimating the associated costs should be completed before large scale conversion efforts begin. Experimentation should begin as soon as possible on a small scale.

B2.4 CLASSIFIED TECHNICAL ORDERS

This section discusses classified or restricted TOs and their management in AFTOMS.

B2.4.1 Scope and Relevance

AFTOMS security implies that technical data/information be easily accessible to the users, but that certain sensitive information/data have limited user accessibility. Security, accessibility, or integrity are interrelated terms that imply policies, procedures, and mechanisms to protect the Air Force sources and assets from governments or from outside sources (contractors, and friendly/unfriendly governments). In the context of AFTOMS, **security** refers to the protection of information and assets in order to prevent exploitation through interception, unauthorized access, or other related intelligence threats. **Accessibility** refers to the non-disclosure of information to those without a need-to-know. **Integrity** refers to the assurance that the information has not been altered by unauthorized individuals. All three are applicable to AFTOMS and must be considered within the overall system architecture.

AFTOMS security policy must ensure the neutralization and mitigation of security threats by employing cost-effective security procedures, and utilizing secure hardware, software, communications, and facilities to protect the system and the information resident within the system. Security can be divided into three distinct elements:

- *System Resource Security* – Primarily concerned with the computer systems and the information maintained. System resources include firmware, software, and hardware for standalone systems, but also includes network system components such as transmission signals and lines, network/communication software, and various components of communications equipment and hardware. Hardware, software, and firmware, whose function it is to protect system resources, is termed a Trusted Computing Base (TCB). A typical TCB consists of an operating system, system files, and data. There are six guidelines to evaluate TCB security:
  - *Security Policies*--Access rules;
  - *Document Marking*--Labels and categories;
  - *Identification*;

- *Accountability*--Audit information for who, what, and when;
- *Assurance*--Ability of the system to verify the above four guidelines; and
- *Continuous Protection*--Guards against tampering, unauthorized modification of data, and accidental alternation/destruction.

- *Security Procedure* - Concepts, techniques and specific measures used to protect automated systems and the information contained. Security procedures must embody the various regulations and directives governing physical, administrative, and technical security.
  - *Physical Security*--Focuses on controlling access to the system;
  - *Personnel Security*--Controls accessibility clearance of personnel using the system;
  - *Administrative Security*--Establishes standard operating procedures;
  - *Hardware Security*--Ensures continuity of the system;
  - *Software Security*--Secures compliance of the operating system; and
  - *Communication Security*--Protects and controls all information transmitted.
- *Security Threats* - Situations or conditions that could affect system resources, specifically the information contained. Generally, threats can be grouped into two categories: human and environmental. Human threats can be intentional or unintentional while environmental ones are either fabricated or natural.

B2.4.1.1 Security Policy Within DOD/Air Force

Computer system security needs to be viewed within the overall context of DoD security specified for DoD elements and contractors. Overall policy is specified in DoDR 5200.1 and 5220.22 for internal and external users. The external aspect must also be considered since AFTOMS data will, at times, be shared with contractors and other governments. Three security issues associated with technical data in a shared environment arise:

- Data classification by levels and categories;
- Data aggregation into information sets that on the whole are more sensitive than any individual element by itself; and
- Contractor data proprietization.

INFORMATION/DATA CLASSIFICATION

There are four basic information classification levels within DoD: Unclassified. Confidential, Secret, and Top Secret. These levels have been further restricted by the application of restrictive labels for controlling personnel accessibility based on a need-to-know. Access authorization is granted by the possessor of the classified information in accordance with AFR 205-1. Restrictive labels or categories can also be applied to unclassified information which is considered to be sensitive in accordance with AFR 205-16. Most technical manuals are considered to be sensitive. Aggregating unclassified technical data presents a unique problem. The aggregated data may require a higher level of protection than the individual data. The set of restrictive labels includes:

- *RD (Restricted Data)* - Information defined in the Atomic Energy Act of 1954. Usually this label is associated with nuclear weapons;
- *CNWDI (Critical Nuclear Weapon Design Information)* - Nuclear weapon information containing critical nuclear weapon design information;
- *FRD (Formerly Restricted Data)* - Usually information pertaining to nuclear weapons that is no longer restricted but accessibility must be still controlled;
- *WNINTEL (Warning Notice-Intelligence Sources of Methods Involved)* - Information that contains data involving intelligence gathering/equipment;
- *COMSEC (Communication Security)* - Information that usually involves data involved with cryptological equipment;
- *NOFORN (Not Releasable to Foreign Nationals)* - Information or data that is not releasable to foreign nationals;
- *PROPIN (Proprietary Information)* - Contractor or government information or data that is proprietary;
- *NC (Not Releasable To Contractors)*; and
- *EOD (Explosive Ordinance Disposal).*

In addition, information or data that is not covered by the above special labels, and whose accessibility must be further controlled on a special need-to-know basis, is included in the Special Access Required (SAR) or the Sensitive Compartmented Information (SCI) Programs, in accordance with DoDD 5100.55. Within the above classification levels, categories, and programs, accessibility to information or data can be further controlled by functions to be performed on the information (i.e., reading, writing, creation, modification, or deletion of data).

SECURITY DIRECTIVES

DoD has published documentation to assist security managers in determining the scope of their needs and the criteria for developing an information system that satisfies those requirements. The documentation is sometimes referred to as the rainbow series because of its color. For the purpose of this analysis, the yellow book (CSC-STD-003 and 004) was used, which addresses computer security requirements. It gives the method/formula for determining individual clearance against data sensitivity to develop a risk index and determine the class of TCB needed to resolve security threats (see TABLE B2-4). The orange book DoD 5200.28–STD was used to determine the criteria for that class of TCB. A TCB is a system (hardware, software, firmware, and communications) that has been certified by the National Communications Security Committee (NCSC) for some level of functionally. The set of criteria contained in the orange book defines seven classes of TCBs, from class D which offers no protection, through class A1 which verifies system design. These criteria address the hardware, software, and firmware, but do not address applications executed on a TCB. The criteria evaluate four main areas: Security Policy, Accountability, Assurance, and Documentation. Each class builds on the evaluation criteria in the previous class.

TABLE B2-4. TCB COMPUTER ENVIRONMENT MATRIX

		CLOSED ENVIRONMENT MAXIMUM DATA SENSITIVITY						
		U	N	C	S	TS	1C	MC
MINIMUM USER CLEARANCE	U	C1	B1	B2	B2	A1	*	*
	N	C1	C2	B1	B2	B3	A1	*
	C	C1	C2	C2	B1	B2	B3	A1
	S	C1	C2	C2	C2	B2	B2	B3
	TS (B1)	C1	C2	C2	C2	C2	B2	B2
	TS (SB1)	C1	C2	C2	C2	C2	B1	B2
	1C	C1	C2	C2	C2	C2	C2	B1
	MC	C1	C2	C2	C2	C2	C2	C2

Trusted Computer Base (TCB) Classes

- *Class (D)* Minimal Protection – Reserved for those systems that have been evaluated but fail to meet the requirements for a higher class;
- *Class (C1)* Discretionary Security Protection – Nominally satisfies the discretionary security requirements by providing separation of users and data/information. It incorporates some of the controls capable of enforcing access limitations on an individual basis. This class is for cooperating users processing data at the same levels of sensitivity;
- *Class (C2)* Controlled Access Protection – This class enforces a more finely tuned discretionary access control by making individual users accountable for their actions through the utilization of login procedures, auditing, and resource isolation;
- *Class (B1)* Label Security Protection – Requires all the features of a Class (C2). In addition, an informal statement of the security policy model, data labeling,

and mandatory access control over named subjects and objects must be present;

- *Class (B2)* Structured Protection – Includes all the features of Class (B1). In addition, it addresses covert channels. The TCB must be carefully structured into protection–critical and non–critical elements. The TCB interface is well defined and can be subjected to more testing and review. Authentication mechanisms are strengthened, trusted facility management is provided for administration and operator functions, and stringent configuration management controls are imposed. System is relatively resistant to penetration;
- *Class (B3)* Security Domains – In addition to the features contained in Class (B2), this class mediates all accesses of subjects to objects, is tamperproof, and small enough to be subjected to analysis and tests. The system is highly resistant to penetration; and
- *Class (A1)* Verified Design – System in Class (A1) is functionally equivalent to those in Class (B3) in that no additional architecture or policy has been added. The major difference is in analysis, which is derived from formal design specification and verification techniques and the resulting assurance that the TCB is correctly implemented.

SECURITY TERMS

The following terms are considered relevant to the security analysis:

- *Least Privilege* – Requires that each user in a system be granted the most restrictive set of privileges needed for the performance of authorized tasks. This limits the amount damage that can result from accident, error, or unauthorized use;
- *Discretionary Access* – Method of determining and limiting who has what access (write only, read only, or all privileges) to the information or data;
- *Labeling* – Ability of the system to tag all information and users with labels that describe the sensitivity of the information and the need–to–know privileges of the users;
- Multilevel Security – The capability to simultaneously process multilevel sensitive data by users with different need–to–know requirements, using a single integrated system;
- *Mandatory Access* – Ability of the system to match user access rights with the sensitivity of the information, and deny or permit access;
- *Accountability* – Ability to audit system unique events for real time and/or later analysis. It provides a record of who, when, how long, and what information was accessed;

- *Assurance* – Term used to described how comfortable the Air Force is with the security mechanisms of the system;
- *Integrity* – Assurance that the information has not been illegally or accidently modified or changed;
- *System High* – A mode of operation in which the system hardware and software is only trusted to provide need-to-know protection between users. All system components must operate commensurately with the highest classification/sensitivity of the data. Furthermore, all users must be cleared for access to the highest level of data contained in the system;
- *Identification/Authentication* – Requires that the users identify themselves with a password or code prior to gaining access to the system; and
- *Audit* – Records of who, what, and when system entrance was made or attempted.

B2.4.1.2 Classified Technical Data

Classified technical data can be divided into data/information that is: managed by Oklahoma City Air Logistics Center/Technical Order System Section–Central Management Office (OC-ALC/MMEDU) through the LMTOS system and distributed by the responsible ALC TO manager; or technical manuals that are managed and controlled by individual MAJCOMS, Separate Operating Agencies, or external non-Air Force agencies.

OC-ALC MANAGED TECHNICAL DOCUMENTS

OC-ALC manages 209,500 Air Force technical documents through the LMTOS. **Less than 1% of the documents are classified.** Classified data content in these documents ranges from a high of 90% to a low of 10%. As more technically sophisticated weapon systems are developed and acquired, classified data will increase considerably. Strategic Air Command (SAC) estimates that 40% of the TOs for the B2 aircraft will be classified, and a higher percentage will require **special access.** The B2 System Program Office (SPO), however, estimates that percentage to be lower (10–15%). The Advanced Tactical Fighter (ATF) SPO estimates that 60–90% of TOs for that weapon system will be classified, and that most of the unclassified TOs will require **special access** reflecting the increasing complexity, sophistication, and sensitivity of the systems. OC-ALC manages four different technical document programs: Air Force TOs, Joint Munitions Effectiveness Manuals (JMEMs), Computer Program Identification Numbers (CPINs), and Foreign Military Sales (FMS) technical manuals. Further complicating the issue of classified TOs is the application of special labels or categories in accordance with 205-1 and 205-16. Most TOs must be protected as sensitive information. The estimate of 148,000 TOs managed by LMTOS does not include the 200,000 inactive TOs. The number of classified TOs is as follows:

- *Air Force* – 148,000 TOs (487 Confidential; 333 Secret; and 1 Secret Special Access Required (SAR));

- *JMEMs* – 1,070 TOs (604 Confidential; and 134 Secret);
- *CPINs* – 60,350 TOs (695 Confidential; and 582 Secret); and
- *FMS* – Not evaluated since they are managed and distributed by the Security Assistance Technical Order Distribution System (SATODS).

MAJCOM AND SPECIAL AGENCY MANAGED TECHNICAL MANUALS

TOs in this category are created, distributed, reviewed, and managed by the individual MAJCOMs, other services, agencies, or contractors. They comprise specific MAJCOM supplemental data, data on unique command systems being acquired, systems not managed by AFLC, or technical data for systems that are managed by other agencies (National Aeronautics and Space Administration (NASA), Department of Energy (DOE), DOT, National Security Agency (NSA), etc.) or other services. The impact of the North Atlantic Treaty Organization (NATO) and mutual defense treaty organizations was not evaluated. MAJCOM and special agency managed technical manuals include the following:

- *Special Weapons*– 2000 TOs (100 Confidential; and 200 Secret);
- *Communication Equipment*:
    - *Cryptologic Aides* – 500 (35 Confidential; 10 Secret; and 5 Top Secret); and
    - *Maintenance Bulletins* – 2700 (50 Confidential; and 50 Secret).
- *Joint Explosive Ordinance Disposal* (EOD) – 4000 TOs (3600 are classified); and
- *Compartmented Programs* – Number is unknown and most of the TOs are managed by the contractor with very limited access granted. These TOs should not be included within AFTOMS.

CLASSIFIED MANUAL CONTENTS.

Classified information is either dispersed within the basic manual, prepared as a classified supplement (containing the classified paragraphs or data), or is included as an addition to the basic unclassified manual and includes complete system functionality for the classified and unclassified data needed to accomplish the maintenance or operations tasks. Requests for technical data changes of non–AFLC technical data is governed by the infrastructure.

REQUISITION AND DISTRIBUTION OF CLASSIFIED TECHNICAL MANUALS

Requisition and distribution of classified TOs is handled similarly for each of the above TO types in either an automated or a manual operation. Requisition is accomplished by completing an AFTO Form 43 which certifies that a need exists for classified TOs. This form also depicts the signature of the individual who is authorized to request these TOs. The AFTO Form 187 is used to order the required manual and the signature is compared against the

AFTO Form 43. However, in most instances the AFTO Form 187 is electronically transmitted which negates the value of depicting the signatures on the AFTO Form 43. Both the AFTO Forms 43 and 187 are unclassified. Classified TOs and changes are distributed by certified/registered mail or by pouch, depending upon sensitivity level and delivery location.

CHANGE REQUESTS

Technical manual change requests are accomplished using an AFTO Form 22 or 27 in the same manner as unclassified change requests, except when they contain classified data. In these instances they must be afforded the protection needed for the sensitivity level of the data.

MASTER LIBRARY

At the user level, classified TOs are not stored in the master organizational library. They are stored and maintained by the individual shops/users in classified storage containers or in a secure room/facility. The TOMA handles classified data in a similar way; the specific users/managers store and maintain these documents in secure locations.

B2.4.1.3 AFTOMS Security Options Evaluated

The following security concepts were reviewed and will be described later in the section:

- **Option One:** **Multilevel Security at all Levels;**
- **Option Two:** **Multilevel Security at the TOMA and CTODO Levels;**
- **Option Three:** **Multilevel Security at the CTODO Level Only; and**
- **Option Four:** **Isolation of Classified Technical Manuals.**

B2.4.2 State of the Technology

TRUSTED COMPUTER BASE (TCB)

There is considerable activity in the TCB environment with many vendors involved in certification efforts with NCSC and the National Institute of Standards and Technology (NIST) to offer TCBs that provide various levels of protection.

Many companies are hard at work developing secure systems to include LANs/WANs, software, hardware, firmware, etc. Some have been developed and are being certified, while others are in the development stage. There are only two UNIX **certified C2 TCBs** currently available and no UNIX-based secure **certified** systems meeting (B1/B2/B3) criteria. Although vendors have developed and certified B2 TCBs and higher, they are equipment and operating system-specific, and therefore, could possibly cause problems for the AFTOMS SPO during the procurement process.

ENCRYPTION CAPABILITIES

There are many encryption products and algorithms presently available that can be used either internally or externally to a system to provide a wide array of security services. AFTOMS would require a Type I capability. There are also chip sets that have been developed for the Commercial COMSEC program and endorsed by the NSA. Encryption products/devices offer the following services:

- *Privacy of Information* – Cannot be unscrambled without the key or keys;
- *Integrity of the Information* – Assures that the information can not be changed; and
- *Digital Signatures* – Technique used to compute a checksum of the information, encrypt the checksum, and attach the checksum to the information. This allows the information to remain unscrambled and eliminates the concern that someone will alter the contents.

SUBSYSTEMS

Subsystems address one or more of the following functions: Discretionary Access Control, Identification and Authentication, Object Reuse, and Audit. Subsystems include such devices as smartcards, access control software, etc.

When users logon to a system, they identify themselves as proper/legitimate users. Smart cards go one step further. The user will be asked to furnish a fixed number available on the card and a random number. Like a password, this validates the user as a legitimate user by the number on his/her card and a number of the user's choice. This approach will allc v a profile to detail all the access rights of each user.

B2.4.3 Security Considerations

Computer security is only one piece of the final solution that includes:

- User authentication;
- User limitation (least privilege);
- Use of labels to reflect proper sensitivity;
- Limitation of access privileges to specific terminals, (i.e., removable hard drives, secure locations, etc.);
- Multiple functions on same terminals, (i.e., management, change and review functions,.etc.);
- Auditing in real time and after the fact;
- Limitation on the number of unsuccessful logons;
- Encryption of data;
- Secure facilities;
- Level of user clearances (personnel screening practices);

- Physical security of the equipment;
- Use of Tempest equipment;
- Communications privacy/protection; and
- Active and passive security systems (i.e., alarms, guards, locks, cameras, etc.).

Currently there are approximately 7000 classified technical documents (confidential and secret). This evaluation did not consider Top Secret or SCI documents since they were few in number (less than 50) and would require higher security TCBs. Although the highest classification level considered was Secret, the application of special labels and a minimum user clearance level of unclassified (with special category access) requires a B2/B3 TCB rating. An additional consideration was made to prime users (Base and Depot level maintenance) and how best to satisfy their needs. The majority of the classified technical documents encompass the maintenance instructions needed to maintain Air Force weapon systems; these user functions will be implemented on an on-line TO presentation system using optical storage disks. The evaluation for each option includes a system overview, assumptions, and feasibility.

B2.4.3.1 Option One--Mutilevel Security at all AFTOMS Tiers

SYSTEM DESCRIPTION

AFTOMS is B2/B3 TCB at all tiers. Therefore, all tiers can store, distribute, review and manage classified TOs.

SYSTEM OVERVIEW

Option 1 permits AFTOMS to create, deploy, and manage TOs throughout all three tiers (see FIGURE B2-2). Classified multi-category documents would be stored, changed, and managed within a single system. It would require that the entire system be rated B2/B3 to be able to store and distribute classified technical documents which comprise less than 1% of total documents managed by LMTOS.

ASSUMPTIONS:

- Classified and unclassified TOs would be stored in the same database;
- AFTOMA would store a back-up master digitized TO file;
- AFTO Form 22 change requests including classified ones would be transmitted electronically via LAN and/or Defense Data Network (DDN);
- Personnel assigned to AFTOMA, TOMAs, and CTODOs would possess at least a Secret clearance; and
- All traffic would flow through the AFTOMA.

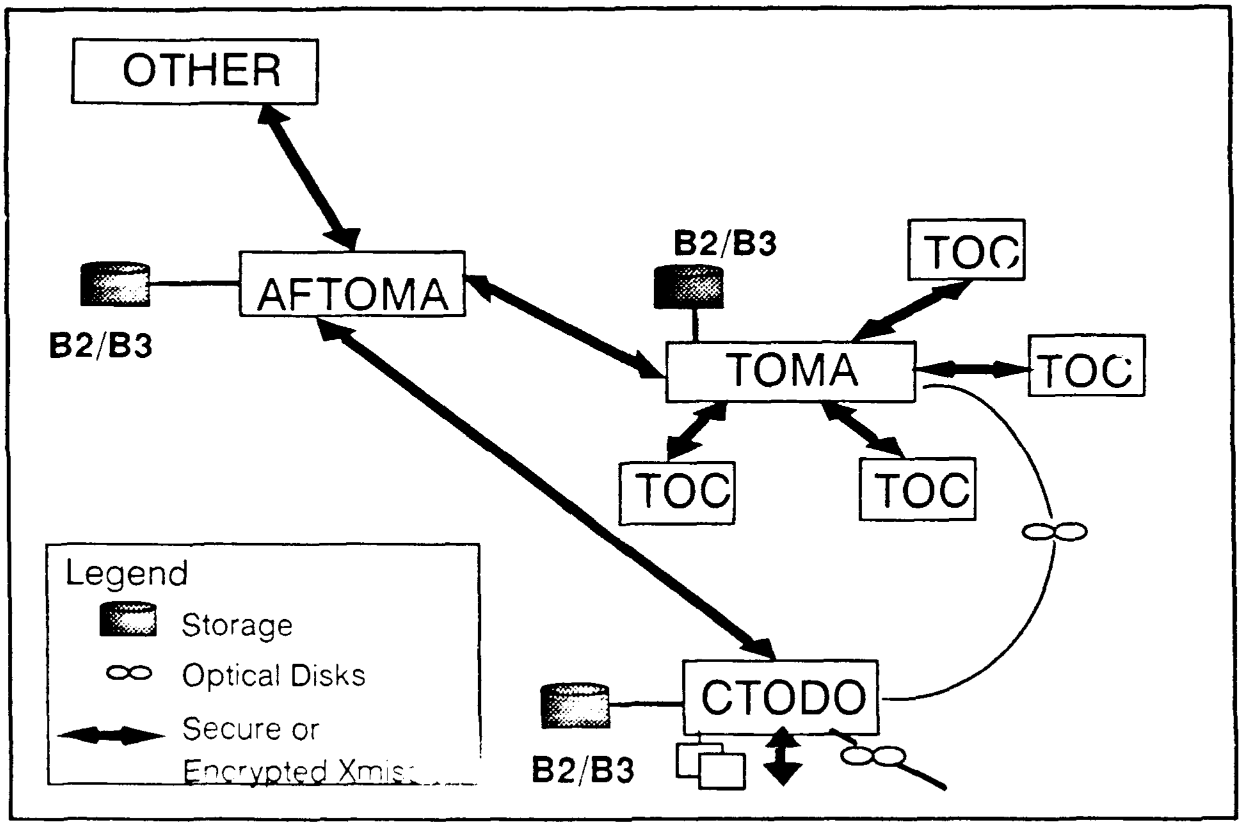


FIGURE B2-2. OPTION 1--MULTILEVEL SECURITY AT ALL AFTOMS TIERS

FEASIBILITY

Although Option 1 meets some of MAJCOM's desires, it is not practical, feasible, or cost effective at this time. A (B2/B3) TCB that operates on the UNIX operating system is not presently available. In addition, since the primary users in Tier 4 are maintenance technicians, on-line availability of TOs should not be required. The maintenance users' presentation system as presently planned will require loading the TOs via a recorded media (i.e., optical disk, removable magnetic hard disk, or magnetic tape).

B2.4.3.2 Option Two—Multilevel Security at TOMA and CTODO Levels

SYSTEM DESCRIPTION

AFTOMS is C2 TCB at the AFTOMA, B2/B3 TCB at the TOMA and CTODO levels. This would allow a mixture of classified and unclassified digitized TOs at Tier 2 and 3, and would permit users to directly interface on-line with the CTODO. The management function for all TOs would be performed at all tiers in an unclassified mode.

SYSTEM OVERVIEW

Option 2 allows on-line access to both classified and unclassified TOs at the TOMA and CTODO (see FIGURE B2-3). Repositing of classified and unclassified multi-category TOs within a single system would be accomplished at the TOMAs. The AFTOMA would retain all profiling and indexing functions and also give Tier 4 users on-line access to technical data from the CTODO using secure LANs. Implementation of this option would require the AF-TOMA to be C2, and the TOMAs and CTODOs to be B2/B3.

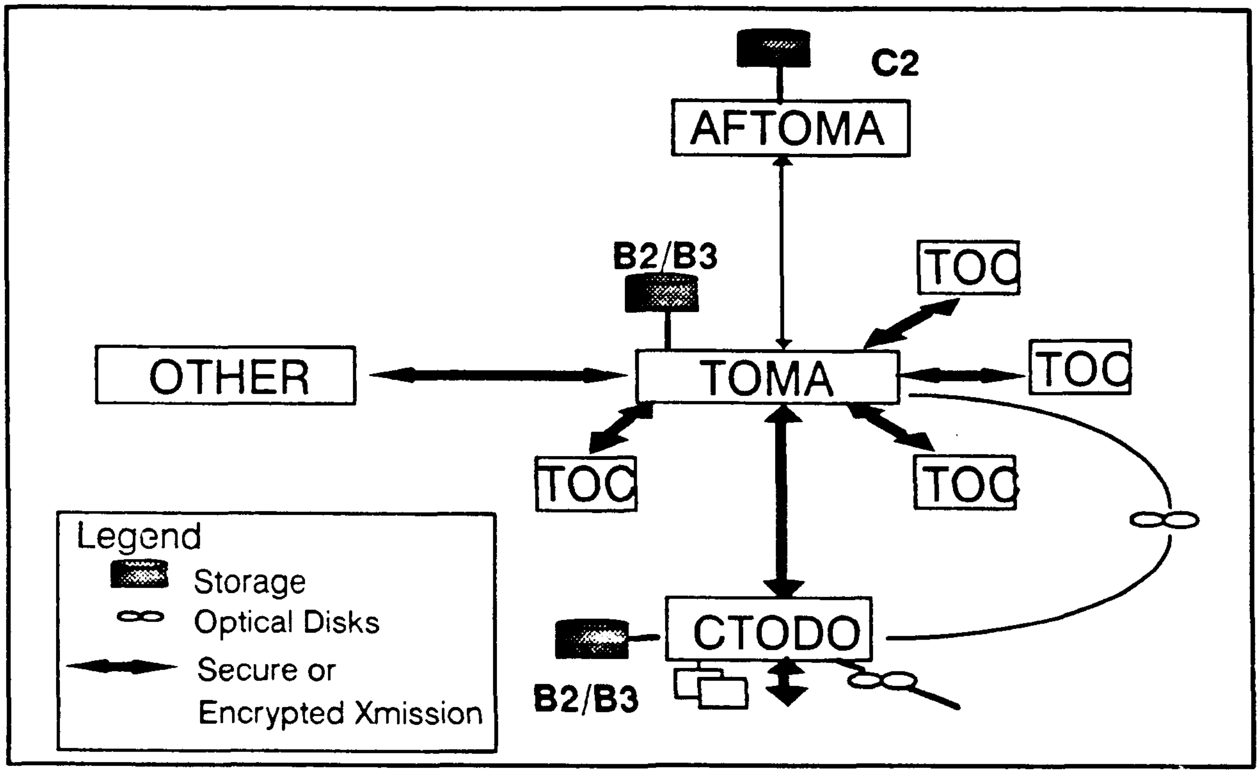


FIGURE B2-9. OPTION 2--MULTILEVEL SECURITY AT TOMA AND CTODO LEVELS

ASSUMPTIONS:

- Classified and unclassified TOs would be stored in the same database;
- AFTO Form 22 and 27 change requests including classified ones would be transmitted electronically via LAN and/or DDN to the TOMA;
- Personnel with access to the TOMAs and CTODOs would possess a Secret clearance;
- TOMAs and CTODOs would manage their own addressing and distribution of traffic;
- TOMA endurability back-ups would be maintained by all or specific TOMAs;
- A concept for CTODO endurability back-ups would be developed in conjunction with the MAJCOM user presentation system group; and
- AFTOMA and TOMA databases would not be interconnected electronically.

FEASIBILITY:

Although Option 2 meets MAJCOM's desires, it is not considered to be practical, feasible, or cost effective at this time. A B2/B3 TCB that operates on the UNIX operating system is not presently available. Since the users in Tier 4 are primarily maintenance technicians, on-line availability of technical data from the CTODO should not be required. The maintenance users' presentation system would require loading TOs via a recorded media (i.e., optical disk, removable magnetic hard disk, or magnetic tape).

B2.4.3.3 Option Three--Multilevel Security at the CTODO Only

SYSTEM DESCRIPTION

AFTOMS is (C2) TCB at the AFTOMA, (C2) TCB at the TOMA, and (B2/B3) TCB at the CTODO level. This would permit classified disks to be mailed to the CTODO and stored within the CTODO computer system. Users could have on-line access from the CTODO. The management function would remain unclassified. Individual TOMAs, TOCs and users would have secure tempest qualified workstations to handle classified data.

SYSTEM OVERVIEW:

Option 3 allows only on-line access to unclassified technical data at the TOMA (see FIGURE B2-4). TOMAs with classified TOs would have secure workstations with removable media for classified storage. This allows the rating of the TOMA TCB to be lowered to C2. The CTODO would retain B2/B3 rating to allow on-line access at the base.

ASSUMPTIONS:

- The TOMA would not have on-line repositing of classified TOs;
- Classified change requests would be transported by other means than LAN or DDN (i.e., via registered mail, classified electronic mail);
- Personnel at CTODO with access to CTODO data bases would possess a secret clearance;
- Although secure workstations may be on the TOMA LAN, the TOC work stations could only be in local mode when processing classified TOs;
- MM_Rs handling classified TOs would ship classified technical data via recorded media to the TOMA publishing center;
- Weapon system TO suite integrity would not be maintained;
- TOMA endurability back-ups would be maintained by copies of classified disk and hard drive;
- AFTOMA, TOMA, and CTODO databases would not be interconnected electronically; and

- Delivery of classified TOs by the contractor would be accomplished by disk, tape, etc., through applicable TOMA to the Work Areas.

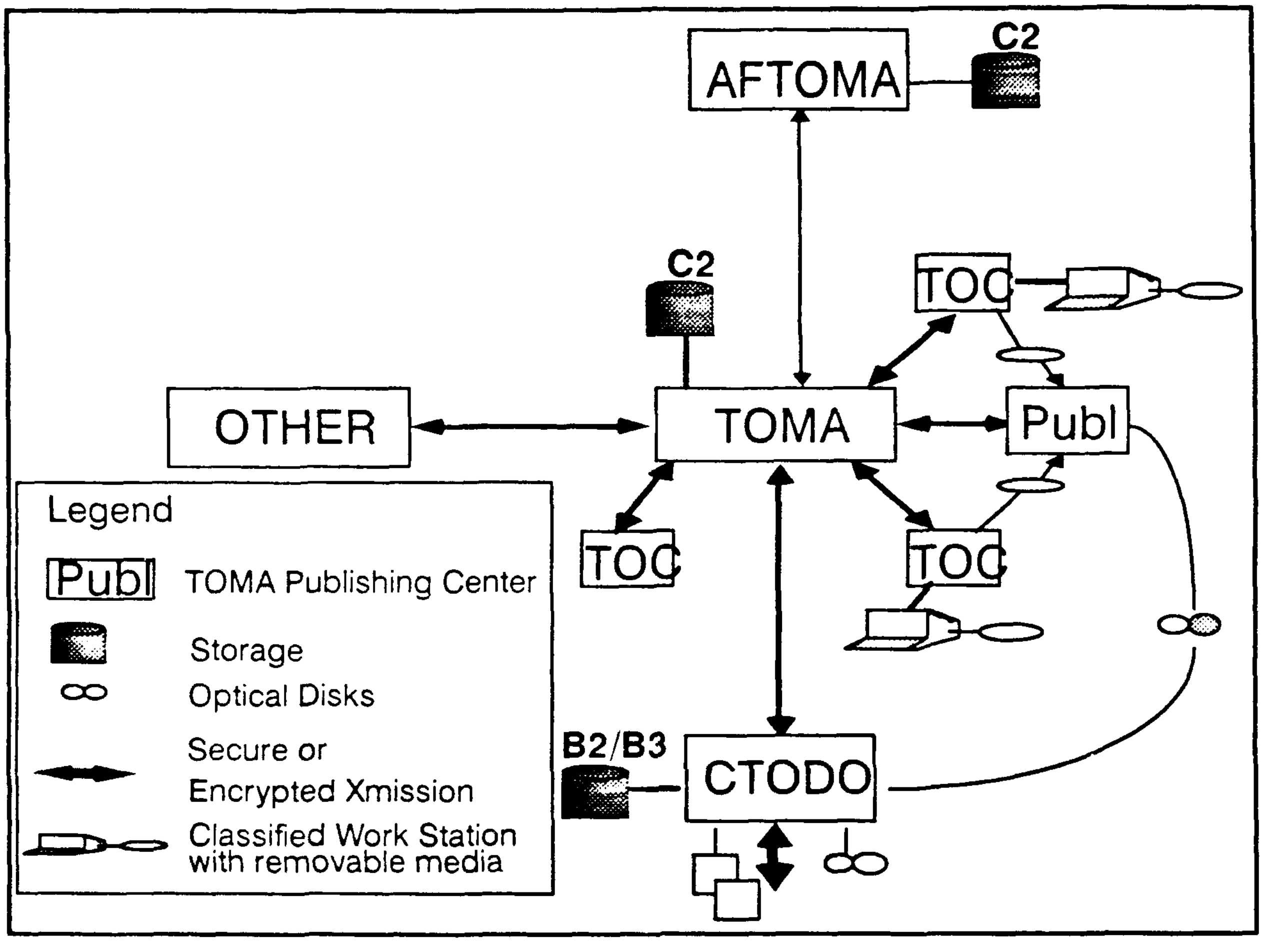


FIGURE B2-4. OPTION 3--MULTILEVEL SECURITY AT THE CTODO ONLY

FEASIBILITY:

Although Option 3 meets MAJCOM's desires, it is not considered to be practical, feasible, or cost effective at this time. A B2/B3 TCB is not presently available that operates on the UNIX operating system for the CTODO. Since the predominant users in Tier 4 are maintenance technicians, on-line availability of technical data from the CTODO should not be required. The maintenance users' presentation system would require loading of TOs via a recorded media (i.e. optical disk, removable magnetic hard disk, or magnetic tape).

B2.4.3.4 Option Four—AFTOMS is Not Classified

SYSTEM DESCRIPTION

AFTOMS is a (C2) TCB at all levels. This would allow management functions to be performed for all TOs. However, classified TOs would be distributed to approved users and content managers only on paper or on a separate classified optical disk for use on a user presentation system; and classified TOs would not be stored within AFTOMS. This would require user presentation systems to be graded to meet the appropriate TCB level. Additionally, a C2 TCB would be capable of distributing sensitive unclassified technical data in accordance with 205-16.

SYSTEM OVERVIEW:

Option 4 allows on-line access of unclassified TOs at all levels (see FIGURE B2-5). TOCs and TOMAs handling classified technical data would use secure workstations. This lowers the rating of all TCB levels to C2. Classified TOs would be distributed strictly by recorded media throughout the AFTOMS infrastructure.

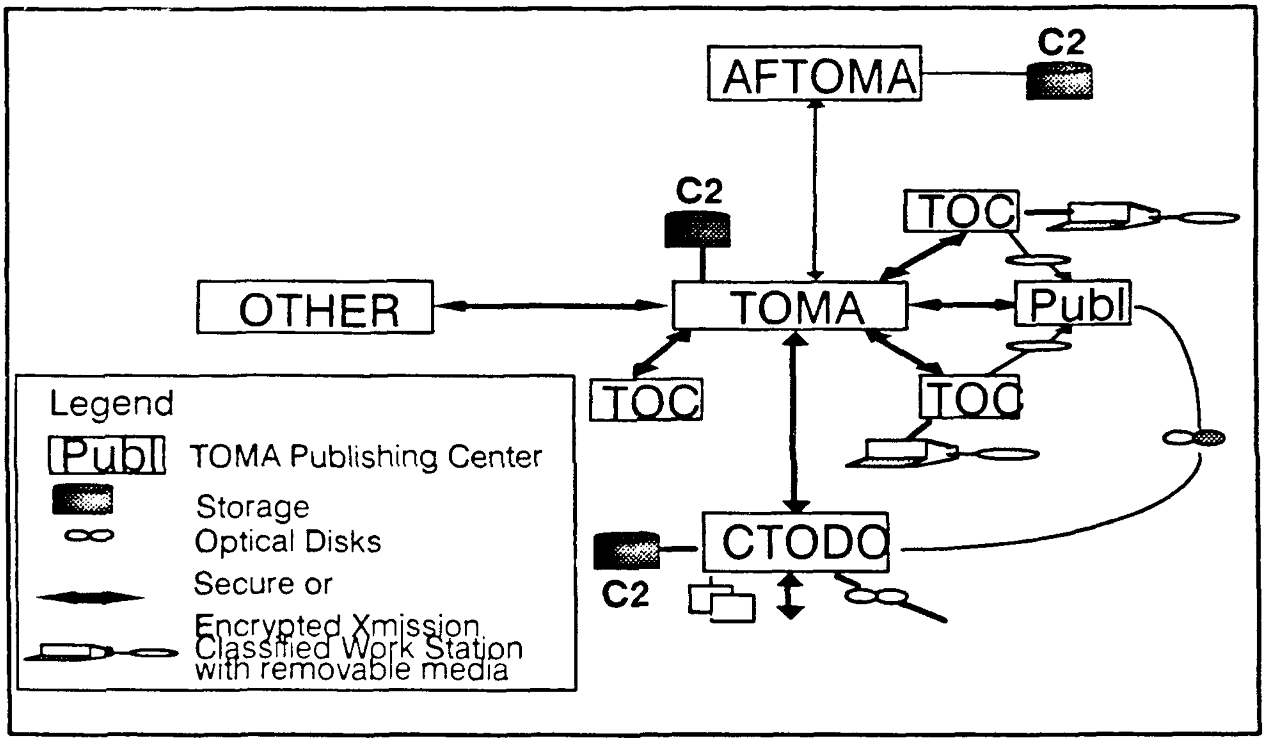


FIGURE B2-5. OPTION 4--AFTOMS IS NOT CLASSIFIED

ASSUMPTIONS:

- The TOMA would not have on-line repositing of classified TOs;
- Classified change requests would be transported by other means than via LAN or DDN (i.e. registered mail, classified electronic mail);
- The CTODO would distribute classified TOs on recorded media directly to the applicable work centers;
- Although secure workstations could be on the TOMA LAN, they could only be in local mode when processing classified TOs;
- A concept for CTODO endurability back-ups would be developed in conjunction with the MAJCOM user presentation system group;

- TOCs and TOMAs handling classified TOs would ship classified technical data via recorded media to the TOMA publishing center; and
- The TOMA database and the TEMPEST workstations would not be interconnected electronically.

FEASIBILITY:

Option 4 is the most practical and cost effective approach for handling classified TOs. Some functionality is lost in removing on-line capability for classified technical data, primarily in handling AFTO Forms 22 and 27 and maintaining TO suite integrity. End-user presentation systems would be able to integrate information from classified and unclassified media.

B2.4.4 Recommended Approach

It is recommended that Option 4 be accepted for AFTOMS development. This option specifies that on-line access to TOs from the TOMA and/or CTODO databases be relegated only to unclassified data, and allow for all TOs to be listed in the master database. This option meets the requirement of AFR 205-16 for sensitive data. The recommendation is based upon the following factors:

- Less than 1% of more than 200,000 technical documents managed by LMTOS (i.e., TOs, JMEMs and CPINs) and used within the Air Force are classified;
- TCB technology has not yet reached a point where off-the-shelf security systems and software certified at the B1 TCB and above levels are readily available. The small number of UNIX-based security operating systems may severely impede the competitive procurement process. A contractor-developed security package (B2/B3 TCB or above) would require NCSC certification, a process that could take years. It is also possible that the prime contractor would not be able to achieve certification before AFTOMS Initial Operational Capability (IOC);
- The cost of a multilevel B2 or above system will be much greater than a C2 controlled access with TEMPEST workstations. This higher cost is attributed to the cost for software, encryption devices, physical security, secure databases and hardware, etc.;
- System upgrade to a multilevel mode could be accomplished when TCB technology matures and becomes cost effective for small quantities of classified data. This position should be re-evaluated if a significant increase in classified TOs is realized with the introduction of the B2 and ATF aircraft. At this time the B2 and ATF SPOs are forecasting 10-15% and 50-70%, respectively. The ATF percentage appears to be very high; however, comparison of the B2 during the same stage of its development reflects similar percentages; they were later reduced drastically;

- The TCB concept will be retained for unclassified TOs to preclude technology transfer and protection of proprietary and sensitive data. An audit trail (both in real time and after the fact) would be available to permit the following mechanisms to be incorporated: identification and authentication, prevention of objects being introduced into user address space, deletion of data, and audit trail. Implementation of a C2 TCB would afford greater protection of technical data than is presently available;
- It would permit the use of security sub-systems that have such additional protections as: discretionary access control, prevention of object reuse, protection from external interference or tampering, system integrity, and user identification;
- Classified TOs will be managed by AFTOMS using either no titles or unclassified titles; and
- Implementation of a TCB, regardless of class, does not completely resolve the technical data aggregation problem. Implementation of access control, user authentication codes, audit programs, continuation of present AFLC TO distribution and requisition codes, and the use of automated profile registration, will provide greater protection for unclassified sensitive technical data than is presently provided. This approach meets the objectives contained in AFR 205-16.

B2.6.5 Risk Assessment

The area of secure systems is extremely complex since many factors, issues, constraints, etc., contribute towards an acceptable solution for the situation. After much evaluation, the AFTOMS SPO produced four options, each with varying degrees of security mechanisms. During the detailed assessment of each option, many risk factors surfaced. Options 1, 2, and 3 each had a very high level of risk due to some of the following issues:

- Secure systems are costly to develop and operate;
- The technology is not mature, standardized, and approved in UNIX environments; and
- Access checking and user interfaces for such systems are very complex.

Given the above issues and the fact that approximately 3000 TOs presently managed by LMTOS are classified, it seemed appropriate to select Option 4, which has much less risk than Options 1, 2, or 3.

B2.6.6 Risk Abatement

Option 4 does have a significant amount of added risk over a system that supplies no capability for handling classified TOs. To keep this risk to a minimum, it is essential to finalize the selection of this security approach within AFTOMS as soon as possible. Once this decision is reached, all subsequent functional requirements and system design activity must be worked on to account for this level of security. Security features are an integral part of the system, not an afterthought, and must be built into the system from the beginning.

SECTION B3:
Support of Heterogeneous System Users

B3.1 SCOPE AND RELEVANCE

This section focuses specifically on user support issues related to AFTOMS functionality. The requirements for support of different classes of users within AFTOMS are examined. In particular, various user interface approaches are discussed along with the implications of Type B+ custom delivery of TOs to users. Technologies and products appropriate to this area of system integration are explained and analyzed, both from a current perspective and from a projected view of the near future.

Design of an appropriate model for a user environment in AFTOMS requires examination of the system as a whole from several different dimensions. A tabular summary of relevant dimensions is presented in Section 2.3. Aspects of some of these dimensions are discussed in greater detail below.

The first issue is the overall characterization of the nature of the AFTOMS system. This issue is important to user support since that characterization can greatly influence the resulting user model. For example, if the system is principally defined as a data management system, then the user model will be oriented around data objects and data-oriented manipulations. If the system is primarily defined as a text or document management system, then it is likely that the user model will be much more document-oriented. If the system is viewed as largely batch-oriented rather than interactive, then that will affect the user environment by structuring its use. **The POC work indicates that AFTOMS should be characterized as primarily an interactive information management and delivery system, wherein the information takes on many forms, the most important of which is the TO itself (i.e., the document).** In particular, this definition is extended beyond the traditional view of the document to focus on the relationships among parts of different TOs in a weapon systems suite for the purposes of:

- Control of changes to "like contents" in different documents; and
- Delivery of complete and accurate task or subject-specific technical information that can transparently traverse document boundaries.

The information contained within AFTOMS should be characterized as mostly document-like, but the access to that information should not be constrained by document boundaries, nor by traditional document processing techniques. It is important to keep in mind that Tier 4 requirements strongly influence both the data model requirements within the management part of the system and also the resulting user support requirements for authoring, editing, cataloging, and verifying TOs.

The second issue focuses on AFTOMS users. Different classes of users will coexist in AFTOMS and will need to be supported by the system. These user classes include the following:

- Management subtypes:
  - Tier 1 AFTOMA Administrator;
  - Tier 2 TOMA Technical Order Manager;
  - Tier 2 Distribution Suite Manager;
  - Tier 3 CTODO Manager; and
  - Tier 4 Work Area Designated Manager.
- Data Technician/Specialist subtypes:
  - Tier 2 Publications Technician;
  - Tier 2 Production Technician; and
  - Tier 3 CTODO Distribution Technician.
- Work Area User subtypes:
  - Tier 4 Maintenance Technicians (depot, in-shop, and on-aircraft).

The goal of AFTOMS is to make all AFTOMS users more productive. This goal is dependent on the design and the quality of AFTOMS implementation and integration. AFTOMS can either enhance or reduce this productivity.

For AFTOMS the key aspects of support for a heterogeneous user base include the following:

- Enhanced availability and usefulness of technical information:
  - Type B+ tagging of TO information to present only task relevant data, facilitate navigation, and link related data;
  - Use of abstracts, cross-referencing, and other indexing to support more efficient searches and interoperability; and
  - Linkage of related sections across TOs to support more accurate change management across the TO suite.
- Enhanced availability and usefulness of management information:
  - Flexibility in presentation of management data for report schedule generation in both textual and graphical form; and
  - Richness of access paths to management information along the lines of typical database queries.
- Data access control:
  - Allow need-to-know access for all user classes;
  - Enable use of predefined technical information "views" at Tier 4; and

- Use work area and base CTODO profiles for automatic distribution of technical information targeted to individual or organization's needs.

- Intelligent but simplified user environments, despite the complications resulting from concurrent handling of heterogeneous data and reliance on heterogeneous hardware and software platforms:
  - Focused tasks for easier learning, lower training costs, faster processing, fewer steps and checks, fewer errors, and less rework;
  - Reduced environmental complexity and clutter to promote understanding through use of predefined selection options, Air Force terminology, small choice sets, intuitive branching during selection, etc.;
  - Consistency of the interface within a user class (at least) and consistency between displayed and printed information;
  - Emphasis on interactive modes rather than batch;
  - Implementation of interactive interfaces and use of modern, intuitive, direct-manipulation graphical user interfaces (GUIs) rather than traditional character-oriented interfaces; and
  - Tradeoff performance where necessary to gain user friendliness and data accessibility.

- Data access transparency:
  - Transparent access within user class across a distributed database and heterogeneous server platforms; and
  - Transparent access within user class (at least) from heterogeneous workstations.

- Improved work flow:
  - Use of tools and mechanisms such as in-boxes, work queues, project management programs, and the like to afford managers greater control over task assignments and work flow; and
  - Streamlining of existing manual processes into more efficient automated processes.

- Interoperability of AFTOMS with other systems and programs:
  - Requirements for AFTOMS to interface to other systems may impose constraints on the user environment at Tiers 3 and 4; and
  - To maximize use of workstations, AFTOMS should coexist on the same workstation with other programs and personal productivity tools al-

ready in use or anticipated to be used in the future. These tools could include electronic mail, spreadsheets, wordprocessors, and other office automation programs.

- Data accuracy and system reliability:
  - Overall system reliability (reduced downtime, reliable and easy-to-use backup and archiving techniques, etc.) enhances user confidence in the system and leads to greater acceptance and maximized use; and
  - Accurate, up-to-date technical and management data also increases user confidence in the system and improves overall productivity.

The critical aspects for AFTOMS are data control (accuracy and delivery of relevant data) and availability of the necessary data to get each task done. The remaining aspects are important only to the extent that they enhance system acceptance and increase user productivity.

The available technologies and standards also have an impact on the quality of the user interface in that:

- Use of standards can provide for more consistency, but can also lead to the "least-common-denominator" effect;
- Lack of standards can increase development costs and make it difficult to provide a consistent user interface, and modifications and upgrades at a later date; and
- Available user interface technologies will affect the user interface design by providing both possibilities and limitations to the designers.

B3.2 STATE OF INTEGRATION FEASIBILITY

In the subsections below, characterization of AFTOMS from a user perspective is discussed, classes of users within AFTOMS are defined, some key aspects of user support are elaborated upon, and selected relevant technologies and standards are introduced.

B3.2.1 The Nature of the AFTOMS System

AFTOMS is a large system covering a broad range of functions. Since the topic of user support is so broad, the nature of the AFTOMS System should be perceived and analyzed as a whole system.

The concept of a TO management system in the Air Force can be perceived in many ways. However, AFTOMS is clearly not a classic Management Information System (MIS), nor is it an On-Line Transaction Processing (OLTP) system. Even though AFTOMS does generate transactions and manages information, MIS and OLTP are not adequate as models for AFTOMS. The three primary reasons for this include:

- Conventional data management systems are not designed to handle large documents;
- Conventional data management systems are not designed to handle text and graphics; and
- AFTOMS is primarily concerned with maintaining, altering, managing, cataloging, and distributing TOs, which are essentially very large technical documents.

Conventional data management systems are not designed to incorporate text and graphics. Instead they are optimized to manage small structured items of data, principally numbers and short text strings. OLTP is structured to manage high-volume, time-critical, relatively simple transactions such as bank account updates or other financial transactions. The management of large technical documents, as opposed to data, using conventional data management systems creates some very difficult problems. The typical output form of a technical document consists of a fully-composed, complex manual with hundreds of pages, table of contents, index, etc.; updates require specialized text and graphical editors rather than form-based programs; changes are made over extended time periods. These are just a few of the many differences between managing documents and managing data.

Large corporations and government agencies have long wrestled with the problem of managing high volumes of large documents in their computer systems. Most of these systems have been primarily concerned with problems in output or publishing. Various corporations and government agencies have tackled the indexing and retrieval problems using large library management systems. Current designers of document-oriented systems are focusing on the use of new technologies to help handle text and graphics in new ways that allow a greater freedom in delivery of customized "views" of textual and graphical data. There is a strong movement away from statically composed page images and toward a dynamic end-user interactive environment. **As was mentioned at the recent "Expert Communications '89" conference, new terms for this style of environment include "hyperpublishing" and "knowledge publishing". Perhaps a better term is "content-oriented publishing", as the new emphasis is on content rather than on form.**

New trends are supported by: new technological advances in workstations, memory, and printer hardware; new standards such as SGML; and new software technologies such as hypertext and object-oriented programming. Techniques adopted from older text management systems (such as electronic publishing systems and library management systems) are being combined with new technologies and techniques. Publishing system vendors are learning how to handle specific issues with data management systems, such as project management and work flow. Database system vendors are also finding ways of storing text and graphics in their databases. However, these disparate models have not yet coalesced as an integrated unit to be used as a single model for the entire AFTOMS system.

A general model representing the AFTOMS system must be defined in order to create a viable and consistent user model. Selection of the underlying system model is extremely important since it influences not only the user view but also the fundamental design priorities. For example, if AFTOMS is viewed primarily as a data management system that must also manage documents, then that view tends to favor one type of system; conversely, if AFTOMS is viewed primarily as a document management system with some data management capability, then that approach favors a different internal system design.

The POC established that AFTOMS should be characterized primarily as a high volume, document management system, with strong controls in the areas of work flow and access rights. However, given the constraints of the Air Force environment, the system should emphasize dynamic and tolerable delivery of documents to the end user. An individual user should have quick and easy access only to the data and documents (or parts of documents) that are task-oriented. Every user should have readily available, the data, text, and graphic-handling tools required to perform their job. Both public and private data entities should be part of every user's functions. The data "types" that the user can manipulate, and the access paths made available, should take on a form that is meaningful in the environment in which that user works. For example, fault codes would provide a meaningful access to TOs for a mechanic, and distribution schedules would provide meaningful data types to a Tier 2 distribution manager at a data center.

In summary, the user view of AFTOMS should relate as directly as possible to the user's micro-environment, maintaining a paradigm for those items that have meaning, such as TOs and Change Requests; however, the AFTOMS environment should enhance the user's productivity by providing new tools and techniques for accessing those familiar items.

B3.2.2 Class of Users Within AFTOMS

This section takes a look at the types or classes of users the AFTOMS system is likely to serve. Within the classes of users, many current user job functions will undoubtedly change when AFTOMS comes on-line, a situation common among environments where automation is introduced. For example, the managing of warehouses of paper storage is a job requiring skills and abilities different from those required for managing electronic document distribution on optical disks.

The four-tier AFTOMS model presumes some basic user type classifications. Three distinct categories of users emerge from implementation of the AFTOMS model:

- Class 1: Manager/administrator;
- Class 2: Data technician; and
- Class 3: Maintenance technician.

The Class 1 manager/administrator users require access to work flow control tools to allow them to monitor schedules, do planning and work allocation, etc.; technicians need rapid access to the data relevant to their particular jobs, such as portions of TOs, change recommendations, schedules, and other related data. Both managers and technicians need access to communications facilities and other general utilities.

It is apparent that the set of functions and data types required to support the various manager–users of AFTOMS is quite similar at all tiers, although the actual data available to each type of manager may be quite different. Job functions of this user category include tracking of the TO change process, system administrative functions, work flow and project management, and the managing and scheduling of TO production and distribution.

The Class 2 data technician users work primarily at Tiers 2 and 3. These users can be divided into two sub–categories:

- Distribution technicians at Tiers 2 and 3 – Tasks focus mainly on production, distribution, and data center–related system administration (data management–oriented tasks); and

- Publications technicians at Tier 2 – Tasks focus mainly on altering and republishing TOs (document–oriented tasks).

The tools that the distribution technician requires to perform the job are similar to (or a subset of) those tools that the AFTOMS manager needs, namely tools for facilitating the flow of work, scheduling, distribution, and other administrative tasks. In contrast, the tools needed by the publications technician are very different.

At the TOMA, the TOs are prepared for eventual use at Tier 4 by the publications technician. There are at least three possible types of publications technicians:

- Technicians involved in publications tasks such as adding or correcting tags, links, style changes, etc.;

- Writers or editors who review and correct for reading level or editorial style; and

- Engineers or technicians who comprehend TO content ramifications and alter the content of TOs to reflect the authorized change completing a change request.

To alter technical content of TOs, an engineering technician often requires coordination with the contractor. The engineering technician could effect the change by using a form requesting the change, and submitting it to a separate publications department staffed by publications technicians of the other two types. This process is similar to that employed in the current paper–based system (AFTO252). The publications people would then implement the designated changes to each affected TO and perform the steps required to generate a composed and paginated new version of the documents.

With FY89 technology, this process seems cumbersome and unnecessary. It is more feasible and efficient for the engineering technician to decide on changes made to text, implement the changes and generate a newly composed and paginated TO. Except for considerations of readability or other editing factors, this would imply that there is no need fo. a separate job function to implement a change (analogous to the "word processing" or "technical publication" center that exists in many corporations). The engineering technician could make the changes as well as publish the TO. This type of user is often referred to as a "knowledge worker". Serving knowledge workers requirements is a major focus of "knowledge publishing".

The Class 3 maintenance technician users (at Tier 4) represent a very different situation. Whether in the depot. on the shop floor, or on the aircraft, the main job of the Tier 4 maintenance technician as it relates to AFTOMS, is to access and read the parts of TOs that are pertinent to their job. Computer tools must be optimized for fast access and rapid traversals across documents rather than for editing, publications, or administrative considerations.

The Tier 4 user interface has different requirements from those of the managers or technicians of other tiers. **Since the AFTOMS boundary of responsibility ends at the Tier 3 CTODO, the user interface chosen for the Tier 4 technician is not a direct responsibility of AFTOMS.** However, since the TOs must be prepared and verified by AFTOMS at Tier 2, AFTOMS system designers must be concerned with the requirements for Tier 4 TO delivery. That is, TOs must be delivered by AFTOMS in a form that is useful to the Using Commands. Given the recent rapid advances in such delivery system technology, this has non-trivial consequences for the Tier 2 preparation stage inside AFTOMS.' For example, if the Tier 4 user model is implemented with hypertext-style links for navigation through TOs, those navigation paths must be set up inside the TOs at Tier 2. The navigation paths must also be verified within the AFTOMS domain. In a broad sense, the requirements of Tier 4 drive the functionality required at Tier 2, especially for the publications technicians and all persons involved in the actual preparation and verification of the contents of the TOs.

The method of Change Request processing at Tier 4 could also impact all AFTOMS tiers. Examples of issues encountered in the Change Request process include:

- Would the maintenance technician at Tier 4, who finds an error in a TO, fill out an electronic version of an AFTO22 form (to initiate the change process) and transmit it to the appropriate parties for approval; once coordinated and approved, would the change finally reach the engineering technician at Tier 2 who would make the TO changes? or

- Should the maintenance technician simply annotate the TO (electronically) and directly transmit a copy of the relevant pages and his annotation to Tier 2 for review and controlled implementation?

The latter approach to the Change Request process is more direct and has less chance of miscommunication, but is a radical change to current Air Force procedures. This approach would include implementation of an appropriate model for Change Recommendations such as an evolution from an electronic AFTO22 form and approval process to an integrated, interactive, direct communication between Tier 4 and Tier 2 technicians. This approach would include automated techniques for eliminating data duplicates. MAJCOM and other approvals could be incorporated into the process either before or after the change was actually made. Fast, interactive tools in the hands of the knowledge worker could save several steps in the Change Request process and elapsed time could be eliminated.

In summary, various types of tools are required by different classes of users in the AFTOMS environment. The manager/administrator at any tier needs good data management, administrative, and planning tools, as does the distribution technician; the Tier 2 publications technician needs good interactive TO editing and publications tools; and the Tier 4 maintenance technician needs a flexible-and-interactive access mechanism to TOs. Many process issues such as those revolving around change approvals and change management have a direct influence on the user model since they can profoundly affect what tasks need to be accomplished in an electronic TO environment. Tier 4 TO usage, while not a direct concern of AFTOMS, has nonetheless, a profound indirect effect on the TO preparation and verification stages within AFTOMS Tier 2.

B3.2.3 Key Aspects of Integrated User Support

The key to the support of heterogeneous users in AFTOMS is incorporation of several overall principles and specific technical aspects. In addition to adherence to general standards for good user interface design that should be part of any system, AFTOMS particularly needs to address the following overall requirements:

- Enhanced availability and usefulness of technical information (B+ data):
  - Enhancement of TOs with B+ tagging to support the Tier 4 user, specifically:
    - The addition of links to support rapid navigation to text and figure references, to sections from Table of Contents entries, and through branching paths;
    - Provision for views customized to the profile of the user especially in regard to security classification, skill level and configuration variant;
    - Generation of custom work packs for specialized tasks such as isolation of a particular fault;
    - Convenient synchronized viewing of related textual and graphical material;
    - Demand printing of tasks and custom work packs;

- Synchronization of screen images and printed pages; and
- Identification of changed sections within TOs as well as replaced TOs in a distribution.

- Use of abstracts for easier location of particular TOs. Use of cross-referencing, and other indexing to support more efficient access to points internal to the document. Such methods could include full text search, hypertext links, and/or indexing of documents at the section and task level; and
- Linkage of related material across documents to provide for more accurate change management. Such material may be related either tightly or loosely, but when one instance changes, the other should be checked to see if a corresponding change is needed. Identical material shared across documents such as Warnings, Cautions, and Notes, should be handled by storage of that data once in a central location.

- Enhanced availability and usefulness of management information:
  - Flexibility in presentation of management data, for report and schedule generation, in both textual and graphical form; and
  - Richness of access paths to management information along the lines of typical database queries. An example of such a query is "Find all F-16 TOs with outstanding Change Requests on the Fuel System." An easy-to-use interface to such queries is an important requirement in the user model.
- Data access control:
  - Access to public data should be controlled with passwords and other security measures applied where appropriate. Direct access should be provided only to data relevant to the particular user. Implementation of customized access might require customization of menus and other user interfacing mechanisms;
  - Use of only predefined "views" at Tier 4. Although the Tier 4 user should be provided with tools for navigation through TOs, the user should not be allowed to define those navigation paths, nor to alter them; and
  - Use of Work Area and base profiles for automatic distribution of technical information targeted to the individual or organization's needs. A Work Area profile, for example, would specify the particular weapon systems assigned to that Work Area. When a new TO distribution is sent to Work Areas, a particular Work Area receives only those TOs whose systems and subsystems match those in its profile.

- Intelligent but simplified user environments despite the complications resulting from concurrent handling of heterogeneous data and reliance on heterogeneous hardware and software platforms, including:
  - An imaginative design that provides an environment to support higher user productivity and efficiency, rather than blind automation of existing manual processes. Such an environment should aim at streamlining some processes, possibly eliminating others, and reducing manual intervention to a minimum;
  - Use of a similar user model within AFTOMS proper (Tiers 1, 2, and 3), across different user types and within one class, to keep development cost low and allow for some degree of job interchangeability. Different tools may need to be available for different user classes;
  - Simplification of the user interface to reduce total training investment, and account for varied skill levels of users. Some allowance for an "expert mode" might be helpful to enhance efficiency for more skilled users;
  - Flexibility in user interface customization for individual skill levels and personal preferences, without sacrificing overall coherence, consistency, and design integrity;
  - Reduced environmental complexity and clutter to promote understanding through use of predefined selection options, Air Force terminology, small choice sets; intuitive branching during selection, etc.;
  - Consistency between displayed and printed information. Since the reliance on printed versions of TOs will continue to exist for some time, and the same technician may view the same data either electronically and/or on paper, it is important to maintain some kind of correspondence between the two output forms. Display of electronic TO data at Tier 4, using page images with embedded links and customizations (the B+ model) is one way to accomplish this goal;
  - To implement interactive interfaces, use of modern, intuitive, direct-manipulation graphical user interfaces (GUIs) rather than traditional character-oriented interfaces; and
  - Emphasis on interactive modes rather than batch. The overall thrust of the user interface should be interactive and user-friendly, and batch programs should be used by the AFTOMS user where appropriate to the job at hand (e.g. for certain data format conversions).

    "Interactive" should not imply an overemphasis on manual intervention, however. For example, authors generally prefer interactive What-You-See-Is-What-You-Get (WYSIWYG) text editors to other types since they are intuitive and easy-to-use, and can receive immediate feedback on the "look" of their document. WYSIWYG text editors directly interact with the software to produce the formatted document. This WYSIWYG advantage translates especially well to technical documentation such as TOs because of the importance of accurate coordination of related text and figures, and will become increasingly important as B+ linking is added to TOs.

However, some WYSIWYG publishing systems, such as desktop publishing, require the user to make all page layout decisions. These particular programs do not have the capability of making page layout decisions. High-end technical electronic publishing systems, on the other hand, perform page layout decisions automatically for the user. This does not make these programs any less "interactive" since the user can override program decisions at any time, but they are less "manual" and more automated. Electronic publishing programs are simply more powerful than their desktop equivalents. "Interactive" should imply meaningful interaction between the software and the user without overburdening the user with manual tasks or decisions.

- Data access transparency:
  - Transparent access within user class across distributed system data and across heterogeneous server platforms. Transparent does not imply instantaneous, rather that the process required to access data at a remote site should be substantially the same as that required to access local data; and
  - Transparent access within user class (at least) from heterogeneous workstations. This is difficult to achieve if the workstations vary in fundamental capabilities, such as the presence or absence of a windowing interface. As will be discussed later in this document, windowing stanAs discussed above, tdards such as X-Windows help alleviate this problem.
- Improved work flow:
  - Use of tools and mechanisms such as in-boxes, prioritized work queues, user-definable states of work progression, project management programs, etc., to afford managers greater control over task assignments and work flow; and

- Streamlining of existing manual processes into more efficient automated processes. Using new technologies to implement more efficient processes is preferable to running traditional programs faster.

- Interoperability of AFTOMS with other systems and programs:
  - Requirements for AFTOMS to interface to existing computer systems may impose constraints on the user environment at Tiers 3 and 4. Linkage from TO data to data in other systems should follow a similar model as linkage among TOs (e.g., some embedded TO links could access parts information data from a parts database). This information should be presented in the AFTOMS environment rather than switching to a different paradigm, if possible. Some accommodation to existing systems may have to be tolerated, however; and
  - To maximize use of workstations, AFTOMS should coexist on the same workstation with other programs and personal productivity tools already in use or anticipated to be used in the future. These tools could include electronic mail, spreadsheets, wordprocessors, and other office automation programs. Implementation of this environment is facilitated by multitasking operating systems and windowing environments.

- Data accuracy and system reliability:
  - Overall system reliability (reduced downtime, reliable and easy-to-use backup and archiving techniques, etc.) enhances user confidence in the system and leads to greater acceptance and maximized use; and
  - Accurate, up-to-date technical and management data also increases user confidence in the system and improves overall productivity.

B3.2.4 Relevant Technologies and Standards

Available technologies and standards can have a significant impact on the nature and quality of the user environment. Use of standards can provide for more consistency as well as lower development cost, but can also lead to the "least-common-denominator" effect. For example, X-Windows is fast emerging as the industry standard windowing system and with good reason: it allows different workstations running different vendor's operating systems to execute the same program with the same user interface over a network. But it has several documented problems and deficiencies, not the least of which is performance. Another problem with standards is the difficulty of achieving interoperability. For example, many relational database systems (RDBMSs) supply an interactive query interface called "query-by-form"; but this is a character-based interface which does not take advantage of state-of-the-art user interface environments such as those based on X-Windows. The particular problems pointed out here will be remedied well before AFTOMS is deployed; they are mentioned only to illustrate the point that at any given moment in time, even widely-accepted standards are not panaceas and may not operate well in combination with one another.

Another dimension of the standards issue related to user environments is the current lack of a specific user interface standard. This problem should be resolved in the very near future based on recent developments in this area. The following subsections discuss this issue in more detail.

One standard that is sure to be part of AFTOMS is Standard Generalized Markup Language (SGML) since it is an important part of the MIL-STD 1840 specification. There are user interface implications here, too. SGML was designed in the 1970s, and in publishing environments it was used to mark up text with structural tags. The marked up text was then processed through several batch programs such as parsers which validated the SGML markup and composition pagination programs that typeset the text according to pre-defined style specifications for each SGML tag. These processes required operators highly skilled in both SGML and typesetting. In the 1980s the environment of electronic publishing went through a significant transformation. Word processing, personal computers, laser printers, and desktop publishing influenced publishing vendors to move to more interactive systems supporting property sheets, popup menus, and WYSIWYG editing. Style and formatting became more integrated with text and graphical editing. It is now the task of the publishing system vendors to adapt SGML to these interactive environments.

In terms of user interface-related technologies, important developing trends include hypertext and hypermedia, on-line help and information, full-text retrieval systems, voice, video, animation, new graphical database interfaces, and optical disk technologies.

Another area of technology that profoundly affects TO delivery at Tier 4, but only indirectly affects AFTOMS, is the area of portable and laptop computers. This area is developing so rapidly that it is difficult to gauge the future of FY89 state-of-the-art technology. Although flat panel display technology is developing rapidly, **it is prudent to assume that less screen area will be available for on-equipment maintenance than at other user sites within AFTOMS; thus, the Tier 4 user interface must be flexible in its design to accomodate smaller screens.** Environmental considerations will dictate the use of simple user input mechanisms, such as limited keystroke commands. Hypertext can be used to reduce fundamental operations of an environment to a few commands. Implications for TO delivery of AFTOMS include the delivery of TO data in a way that can be retrieved by Tier 4 hypertext-based systems.

B3.3 FEASIBILITY OF INTEGRATED USER SUPPORT

This subsection is an overview of the various issues, problems, risks, tradeoffs, and feasibilities involved in building an integrated system to support AFTOMS' heterogeneous user base. The focus is on two time frames: current (FY89), and full-scale development (FY91–FY93).

B3.3.1 In FY89

In this time frame, several areas are of particular interest in terms of the feasibility of building integrated user support. These include user interface developments, industry and de facto standards, data management and access control, work flow modeling, and B+ enhancement.

B3.3.1.1 User Interface Developments

Recent rapid improvements in price/performance of personal computers and workstations, including better screen resolutions and inexpensive memory, have provided the platform for user interface software to advance to new levels of functionality. The mouse-and-icon-based, direct manipulation user interface (originally developed at Xerox Parc on the Star and commercialized by Apple with the Macintosh) has now come into its own on more standard platforms. The advent of X-Windows has greatly aided this transition. Almost all UNIX vendors as well as many vendors supplying other operating systems such as Digital's VMS, are basing their user interfaces on an X-Windows environment. The availability of this environment even on low-cost X-terminals is influencing vendors to build their new software products on X-Windows-based GUIs.

But X-Windows provides only the lowest level of windowing standard which results in hardware independence. The standards issue is now being debated at the higher levels of the interface: that is, at the programming language interface, and at the direct user interface level, known as the "look-and-feel". Digital's XUI toolkit is rapidly gaining momentum as the programming interface of choice and has been adapted by the Open Software Foundation (OSF) as Motif. The "look-and-feel" battle has reduced to two principal players: OSF's Motif, and AT&T/Sun Microsystems' Open Look. In fact, these two interfaces are quite similar from a user perspective. One of the advantages of X-Windows is that programs written for one "look-and-feel" environment will run on a different "look-and-feel" environment. The user interface standards issue should resolve itself quite soon, and even if both "look-and-feel" environments continue to persist, a system could be built using either one, or both environments, without serious negative impact. **A larger issue concerning buildability is that this windowing style of interface is more difficult to program than a character-based interface, and software development groups are reporting longer times initially to develop and market new products.** Later subsections of this document will discuss the Demo System experiences with development of a user interface for AFTOMS based on XUI and X-Windows.

B3.3.1.2 Industry De facto Standards

As a result of the CALS Initiative, SGML support is being integrated into word processing and publishing environments as a de facto standard. However, vendors are finding it difficult to make the transition to SGML for the following principal reasons:

- SGML is complex;
- SGML is a language designed for batch systems; and

- It is difficult to retrofit an external SGML model to an existing internal product model.

Despite these problems, SGML is slowly being integrated into publishing products, and several new products designed explicitly for SGML have been recently introduced. These new products cover the areas of authoring/editing, auto-tagging or "optical structure recognition", interactive validation, and batch parsing. Since the current SGML situation is unsettled, it is difficult to acquire and integrate a suite of software tools to automate SGML-related processes within AFTOMS.

B3.3.1.3 Data Management and Data Access Control

In terms of data management issues within AFTOMS, current available relational database technology appears to handle the requirements adequately. Relational databases are well-proven in the areas of managing high volumes of data, and providing users with flexible access to that data. In terms of transparent data access, RDBMSs provide location transparency to data which is stored at different physical sites. Most vendors supply location transparent, read access: updates are more difficult and are not handled as well. For the user interface, there are performance considerations associated with the use of location transparency, particularly across a wide area network (WAN). When a database access will be delayed due to travel over a WAN, the user needs to be notified. Other mechanisms to distinguish slower access paths from faster paths should also be employed to warn the user ahead of time that certain queries will take a great deal longer than others.

In the current environment of GUIs, databases are quite lacking. No vendor has integrated all of their end-user tools into a windowing environment, although all of them intend to do so. This transformation is not a matter of making existing tools run under X-Windows, or of supporting mouse input, but rather it extends to the development of some new user interface paradigms in order to make the most out of the GUI. There are no technical problems with interfacing databases to GUIs.

Selection of an underlying data model for AFTOMS is difficult, yet it has important implications for the user environment. Relational databases handle data well just as document management/publishing systems handle documents well. However, each system cannot adequately handle the other's data. Progress is being made in integrating the two types of environments; however available options are limited. In order to extract the maximum functionality from existing software in FY89, systems with requirements such as AFTOMS must use some combination of relational databases and document management/publishing systems. Document management systems work best for the publication technician users; RDBMS's work best for the manager class of users; and Hypertext, or on-line delivery systems work best for the maintenance technician class of users. Systems that integrate all three technologies may become available in time for AFTOMS deployment. The POC experience in building such a hybrid system is summarized in Section B3.4.1. The feature which brings this hybrid system together is the user interface built on a standard X-Windows platform. Retrieval of TOs stored internally as documents, and retrieval of TO Change Requests stored internally as database forms, become identical to the user. This is an implementation of an object-oriented paradigm: TOs and Change Recommendations are objects with much of their behavior in common, but with occasional differences. This paradigm is independent of the underlying data models and could be implemented using a variety of different data models.

Another aspect of an appropriate user interface paradigm design is related to data access control. The notion of public and private data, although not a new idea, is beginning to take on some new value in graphical user interface environments. Users are accustomed to having private disks, disk areas, or directories as well as some sort of access to more public, shared directories and/or databases. In AFTOMS, Tier 2 technicians may have private copies of TOs or sections of TOs in the process of being changed. These TOs would be considered private data. Other examples of private data include electronic mail messages. Public copies of the most recent TO distributions are examples of public data at the TOMA data center. The user interface model designed for the Demo System represents specific private and public data entities as graphical icons on the screen. If a user does not have access to a particular public database, then upon entry to the system, the icon for that database does not appear. This simplifies the local environment. Limiting access to specific functions rather than to data sets is another dimension of data access control. Functional access limitations can be obtained by building customized menus for each user class. Current windowing environment toolkits provide tools to create these customizations.

B3.3.1.4 Work Flow Modeling

There is increasing awareness, especially by the document management/electronic publishing system vendors, for a requirement of tools to assist managers and other users in managing the flow of work. Intergraph has implemented a scheme for assigning stages to documents as they progress through various development and revision cycles. In the Demo System, the concept of an electronic "in-box" was introduced to handle queued input requests among users of the AFTOMS system. Change Requests can be initiated by one user and automatically routed to another user's in-box. The contents of in-boxes can be viewed or manipulated, and priorities can be assigned to items. Managers with appropriate privileges can view the in-boxes of their staff as part of the process of monitoring work allocation. The idea of task allocation aids is not new, however; newspaper systems often include such software for handling allocation of work from an editor to the staff. Modern GUIs make such software much easier to use.

B3.3.1.5 B+ Enhancement

Enhancements to TO data, combined under the name "B+", can be obtained with FY89 technology. These enhancements generally fall into two distinct categories in AFTOMS:

- Customized views and data navigation for Tier 4 maintenance technicians; and

- Extensive cross-referencing across TOs to provide for better control over development and change management at Tier 2.

Hypertext technology can aid both of these categories. In FY89, commercially available end-user hypertext-based systems are mostly aimed at on-line help in computer systems. There have also been experiments in using hypertext for navigation through reference material by students and even for general office communication and interaction. Within the past year, there has been a great deal of activity centered around adding hypertext capability to page viewing systems. Pre-published pages in Page Description Language (PDL) form can be enhanced with hypertext links to allow for navigation through pre-defined pathways. Using the latest caching techniques, traversal across links is swift. Speed will also improve with faster workstation hardware. These page-oriented hypertext systems fall under the category called "on-line delivery systems". On-line delivery systems are beginning to address the problem of displaying customized views of pages; however this capability is not yet commercially available.

Hypertext can also assist in control of changes and general cross-referencing and indexing. Related sections of different documents can be connected via hypertext links. Table of Contents and indexes can have hypertext links on every item, allowing the reader to jump immediately to the desired section or index reference. While Table of Contents and index links can be generated automatically, related section links generally require manual set up. Unfortunately, most systems providing the hypertext capabilities just described do not also include the features for data and document management required by AFTOMS. The solution to this lack of integration in the Demo System was to supply these hypertext capabilities only in the on-line delivery system and provide access to that software from all tiers, including Tier 4. Access to Tier 4 software by Tier 2 is desirable, since verification of Tier 4 views must be performed at Tier 2. In the Demo System there is a utility program which inserts most reference links (as well as custom view information) automatically when it prepares TOs for delivery. Once the TOs are prepared for delivery, they can no longer be edited. One of the consequences of this limitation is that the Tier 2 publications personnel cannot simultaneously edit the TO contents and jump the links.

Despite the presumed advantages of using hypertext in many parts of AFTOMS, analysis of Air Force-provided TOs for current weapon systems has shown that the attainment of true synchronized control of changes to related or similar sections occurring in different TOs requires more powerful tools than hypertext. The feature known as "change control", now available in one vendor's Document Management System (DMS) and soon to be available in others, provides at least a partial solution to this complex problem. Change control allows multiple users to contribute "suggested" changes, as well as add in the document notations or other explanatory material attached to the change. Each user's change can be separately named and individually accepted or rejected as part of the final document. This process takes place within the context of the fully composed and paginated document on the workstation screen, that is, in a WYSIWYG environment.

Another feature available in a DMS environment provides for automatic inclusion of boilerplate text and graphics from a source outside the document itself. POC experiments have demonstrated that by combining the change control and boilerplate inclusion features (along with some customizations), a system for management of identical or similar material across documents can be attained. The disadvantage of such a system is that like material must be reauthored or at least reorganized into components so that the software can keep track of it throughout years of changes. It is not practical to perform wholesale changes on all existing TOs although it may be practical to reorganize existing TOs in a limited manner (e.g., separate out all warnings, cautions, and notes that multiply-occur, since these can be easily identified by their SGML tags). However, material that is related in some manner, or material that describes the same procedure or task in a slightly different format (such as, material in a Job Guide or a Fault Isolation manual) is much more difficult to identify, and thus, more difficult to separate. Manual tagging to support such a process would undoubtedly involve prohibitive costs, and automated techniques are not yet available.

In summary, graphical user interfaces based on X-Windows in FY89 are state-of-the-art, and provide a possible solution to the problem of running new software on existing hardware platforms due to the increasing availability of X-Windowing upgrade packages. Performance may be an issue with X-Windows, however. SGML support is only partially available. Data management and distributed data access tools are available but generally lack integration with standard GUIs. No one data model stands out as the model for all AFTOMS data. B+ enhancement capabilities are within reach, although the technologies required are not as integrated as needed. Change control is a difficult technical problem to which document management systems in FY89 provide at least a partial solution.

B3.3.2 In FY91-FY93

Key areas to examine in the FY91-FY93 time frame include: user interface technologies; standards; data transparency, distribution over networks, and model integration; groupware and conferencing technologies; and hardware advances.

B3.3.2.1 User Interface Technologies

User interfaces in the early nineties will gravitate toward the multiple-windowed, mouse-based, graphical interface that developed from the Xerox Star-Macintosh heritage. GUIs will become the accepted standard and will be a vehicle for hiding the command language of the underlying operating system. This is important for heterogeneous government computing environments such as AFTOMS because it allows operating system differences to be hidden from the user. With an operating system such as UNIX, which is not known to be user-friendly, it is particularly important. Many people believe that the advent of GUIs will continue to promote the acceptance of UNIX than any other single factor. As UNIX matures and new features are added, these changes can be more easily hidden from the end-user than was previously possible.

The difficulty of programming these multi-layer windowing GUIs will be alleviated in the early nineties by the advent of more advanced toolkits and User Interface Management Systems.

New user interface paradigms will likely emerge in the FY91-FY93 time frame. Current indications are that these paradigms will take the desktop metaphor to new and broader concepts. This development is aimed towards encompassing more of the user environment while tailoring the user interface to the user's micro-environment. "Agents" or "assistants", already in use in some systems, will come into more common usage, both to automate repetitive tasks and to allocate network-based resources.

B3.3.2.2 Standards

The current emphasis in the computer industry on open systems and standards will continue over the near future. This will enchance the effectiveness of large systems, such as AFTOMS, which must depend on standards to maintain consistency and keep life cycle support costs low. The increasing complexity of software in addition to market pressures is forcing vendors to cooperate more with each other. Even relatively small software vendors in FY89 are finding it necessary to purchase software from other vendors to use in conjunction with their own products. CALS contributes a great deal to this trend. It is hoped that required developments in this environment, such as techniques for interactive SGML validation, will appear and receive widespread acceptance.

By the FY93 time frame, a great deal more expertise will have been developed in the area of SGML, and more powerful tools will have become available to handle it in a more transparent manner.

B3.3.2.3 Data Transparency, Distribution and Integration of Technologies

DMS and RDBMS technologies are beginning to overlap capabilities. DMS vendors are using data management techniques to manage documents. Current trends in relational databases toward a more object-oriented approach, allowing more than traditional data to be stored (including large blocks of text, graphics, and video), will become more important and more mature in this time frame. Significant for AFTOMS, the distributed technology being developed currently by RDBMS vendors should by FY93 become well integrated into object-oriented database systems. The distributed technology will have advanced to being closer to "truly" distributed; updates over disparate sites will be handled more efficiently. This trend contributes to improving data access transparency to the user.

In addition to general purpose object-oriented databases, improved data models will be developed by this time frame suitable for AFTOMS. For example, a new type of database currently being developed is the "hypermedia server"; at least one product has been announced for early FY90. Such systems have built-in linkage capabilities, can handle multiple media forms, and are network-based. Designing AFTOMS around such a model could mean that the navigational capabilities provided at Tier 4 could be made available at all tiers, and could be used for indexing and retrieval as well. Such technology also could provide a basis for support of true Type C data. The AFTOMS design must allow for future incorporation of this neutral data for new weapons systems, and thus the underlying data model must be prepared to accomodate it.

B3.3.2.4 Groupware, Conferencing Technologies

The contractor-Air Force interface may be aided in this time frame by further advances in "groupware" technology. With the rapid growth in networked systems, the problem of multiple users working together on design problems, documentation, etc., is receiving more attention. Advances in wide area communications should provide better environments for developments in electronic conferencing as well.

B3.3.2.5 Hardware Advances

The rapid advances now taking place in computer hardware technology show no signs of letting up. The implications for AFTOMS are profound. Plans must be made now for vastly increased capability in the near future. This fact has important implications for the incorporation of existing hardware into AFTOMS because the faster that advancements take place, the faster the existing systems become technologically (but not necessarily operationally) obsolete. Another consequence of rapid hardware advances is in software design. **AFTOMS should tradeoff current performance (if necessary) to incorporate advanced software functionality; that is, it should be designed to take advantage of hardware that is likely to appear two or three years out (e.g., in FY94; not what is available in FY91). Failure to do so will result in a lower-quality system that will not take full advantage of the latest off-the-shelf software.**

B3.4 APPROACHES TO INTEGRATED USER SUPPORT

This section explains lessons learned from working with various vendor solutions to problems similar to those presented by AFTOMS. First, the experiences in developing the Demo System will be discussed, followed by a discussion of lessons learned from other hands-on technical evaluations.

B3.4.1 In Demo System

Appendix A identifies the major functionality of the AFTOMS system. This section summarizes the major lessons learned applying user interface approaches to link the user with the AFTOMS functions. These observations are based on limited viewing and usage of the Demo System by developers and typical Air Force users.

An important design goal was to develop a user interface that would run in a standard windowing environment. This would make it easy to run the software on multiple platforms (or switch to additional platforms at a later date). Also, it would minimize the training time for AF personnel. X-windows was used as the windowing environment and both these benefits were realized. Use of the same software running on a standard windowing platform (X-windows) makes it easy to switch hardware platforms and use the system with no new training. It really does behave the same across the different platforms. In the future, all major workstation and terminal vendors will support X-windows and AFTOMS will be able to select the best hardware solution for its wide-ranging user community.

Color workstations were used in the Demo System. Experimentation was performed regarding how to make the best use of color in the user interface. AFTOMS has a few major data types (i.e., TOs, Change Requests, etc.). Each one was assigned a specific color. Major data types were identified and accessed via icon selection (which was color-coded) which seemed intuitive and easy to learn. Color coding the major data types (e.g., TOs = blue, CRs = green) and carrying the color schemes throughout the user interface to maintain consistency and familiarity worked very well.

With a large, heterogeneous, multi-function system such as AFTOMS, simplicity of the user interface is essential. Several complicated applications, such as DMS and ODS, have to be learned and used. These commercial applications were general purpose in design, not developed just for AFTOMS; thus, some of their commands and options were not relevant for AFTOMS use. To keep the DMS and ODS user interface simple enough, the functionality was reduced by disabling and/or hiding many commands. This also reduces clutter and is a good technique for increasing user productivity.

Finally, information presentation techniques and screen cosmetics have a subtle, but profound effect on the acceptance of the system by the user community. Color can be very beneficial in this area if used properly. Experience showed that the percentage of the screen in non-neutral colors, especially bright colors, should be small. Large areas of bright colors are jarring, distracting, generally hard on the eyes, and unpopular with users. Small areas, such as buttons or stripes of color for accenting information are useful and popular with users.

B3.4.2 In Other Hands-on Technology Evaluations

Several commercial software products incorporating GUI technology and AFTOMS-useful functionality were evaluated; these included:

- A DMS product that integrated full RDBMS capability in a Publishing System;
- A database user interface product; and
- A hypertext product

B3.4.2.1 DMS Product

This software system provided a user interface model for work flow control and document management as well as a WYSIWYG electronic publishing system. The work flow model is implemented by incorporation of a commercially-available RDBMS, but as the internal protocol is SQL, other SQL-based databases could have been used as well.

In this system, documents are assigned states through which they must pass on their way from inception to publication. Any amount of information about documents can also be stored in the database. Intuitive retrieval techniques are supplied for accessing documents, and users are not required to use a query language. Representation of data is a combination of graphical icons and menus of textual options, field values, etc. The interface is a GUI which will eventually be implemented on top of X-Windows.

When the user requests to view a document's contents, the GUI/database environment transitions to the normal electronic publishing software. When the document viewing or editing is completed, the user closes the document, and is returned to the original GUI screen; the transition between the two environments is relatively smooth.

B3.4.2.2 Database User Interface Product

This software product was the result of a joint development effort between a Unix workstation vendor, and a RDBMS vendor. It incorporates a proprietary GUI for database querying of management information. However, this GUI does not support the X-Windows environment and so it is not clear that the product will remain on the market in its current form. However, it does demonstrate nicely how a GUI can be used to integrate technology products and simplify system use.

B3.4.2.3 Hypertext

Hypertext-based on-line help systems are becoming popular add-ins with many new software products. With such a help system, the operator can use the mouse to move the pointer to the special help icon. By selecting the icon, the system displays the hypertext help text discussion of the program relevant to the point where it is currently running. The help text display includes links to other related material; and graphics also appear in the help text.

Hypertext languages are also becoming available. Some store user-defined text and graphics in electronic "cards" which make up "stacks" of information. They incorporate an interactive GUI interface to allow the user to insert or change links, and provide text and graphical editing tools for manipulation of the contents of the cards. Such languages offer sufficient flexibility to be used for many purposes such as prototyping of user interfaces, which is how this capability was used in the development of the Demo System user interface.

B3.5 RISK ASSESSMENT

This section outlines the risks still present in the FY91-FY93 time frame regarding the issues related to user support discussed above. First technological risks are examined followed by a discussion of business issues.

B3.5.1 Technological - System Buildability, Usability, and Intra-operability

The major technical challenges in AFTOMS overall include:

- Development of a coherent data model that will support requirements for incorporation of future neutral data;
- Incorporation of SGML and conversion of existing TOs;
- Support of the high volume of data across wide area networks;
- Development of portable devices for on-aircraft maintenance; and
- Support for cross-TO control of changes that span several TOs.

Design of an easy-to-use, consistent user interface for all classes of AFTOMS users is also a challenge, but technically it is less of a challenge than those outlined above.

The selection of an underlying data model for AFTOMS has profound implications for user data access, both in capability and in performance. It is difficult to envision the perfect data model especially since the operational concept of neutral data has not yet been clarified. There are considerable technical risks with trying to integrate DBMS, DMS, and hypertext/ODS technologies with their inherently different underlying data models. However, such integration may be a lower risk alternative than inventing a special-purpose, completely new data model that will support the features of all three.

Although there is some risk that sufficient standards will neither become available nor interoperate well in this time frame, it looks as though X-Windows-based GUIs will help stabilize the overall situation in time. SGML is something of a greater risk because of its inherent complexity. It is not a standard chosen by a wide customer base, nor by industry. There is a substantial risk (at least during the initial deployment of AFTOMS) that the imposition of SGML will complicate the publications process. It is sometimes assumed that SGML tagging will take care of many indexing and linking problems automatically, but it is likely that most of these tags will have to be manually entered at considerable cost. There are artificial intelligence research groups working on semantic analysis of text, but this technology is still in its infancy. An additional problem related to change control of "like material" in existing TOs is the identification of related matching, but not identical, material. **The POC analysis of current TOs has shown that SGML tagging along the lines of the new Air Force DTD's based on MIL-STD 28001 will not be sufficient to identify this type of non-identical but related material.** The reason is that current SGML models are based on a structural, rather than a semantic approach. This problem could become exacerbated with the conversion to neutral data needed to support Type C TOs.

Support of a high volume of data within AFTOMS does not particularly relate to user support, except through its impact on data availability and performance (See Section B8, Operational Utility).

The portable delivery device problem relates to AFTOMS only indirectly in that the delivered TO data must be flexible enough to be displayed on devices with relatively small screens and low amounts of memory. For in-shop workstations as well as portable computers, the user interface should be designed to be extremely simple, requiring very few keystrokes (and possibly no mouse) to operate. This is not a high technical risk in and of itself. The risk occurs in the development of a portable system that is really viable to use. For example, if so much scrolling is required to reference one figure that the technician spends more time striking keys than reading the information, then the solution is not viable. In FY89 it is probably impossible to build a viable portable system for TOs that meets all other operational requirements of the Using Commands. Given that by the early 90's technology will have advanced far enough (especially in high-resolution, flat-panel displays) to support a viable portable device, then it remains for AFTOMS to be able to deliver TO data in other than full-page form. This is easily attainable even with current technology and current data models. All document management systems, for example, can produce SGML files which retain all of the tags necessary to reformat the text to different-sized displays.

In summary, although there are many technical risks for AFTOMS overall, those related to user support are not among the highest.

B3.5.2 Long-Term Viability/Supportability

There are several process issues that pose risks for timely deployment of AFTOMS. Some of these issues are intermixed with technical issues.

Separate specification and acquisition of an Air Force standard or unique TO presentation system could have a negative impact on the overall integration of AFTOMS systems at all tiers. For example, accurate verification of multiple views of Tier 4 data, which must be accomplished at Tier 2, may require retrofitting AFTOMS with the TO presentation system(s) used at Tier 4. The problems will compound if more than one TO presentation system is implemented.

There are risks involving decisions on some critical overall directions. **Certain decisions on the system model for AFTOMS will affect the job functions of personnel.** Whether technical publications technicians directly implement TO changes themselves or not profoundly affects how the system is designed. Whether Tier 4 technicians can communicate directly with Tier 2 technicians about the nature of a TO change also affects how the system is designed. Whether support for a direct interactive interface between Tier 2 personnel and the contractor should be included, and whether that support should include interactive TO editing, affects the system design. If these decisions and others are delayed too long, it will be difficult to predict what type of system will in fact be built.

There are some process implications involved with adopting a model of TO traversal at Tier 4 which is based on customized views. These implications are difficult to anticipate within the current environment. There is also a lack of experience elsewhere with this idea to test its viability. It could especially be a problem regarding coordination with paper copies.

Requirements for implementation of AFTOMS on existing hardware platforms should be very carefully considered and approached with some degree of caution, as there is risk involved here, too. It is always tempting to state that a more limited version of the software and therefore of the user interface can be implemented on more limited hardware. Features can be omitted, slower speed can be tolerated, programs that cannot run at all due to memory and other limitations can be made unavailable, etc. There are some problems with such an assumption:

- **In general, software is not designed such that pieces can be removed easily.** If the software is designed from the beginning to be modular enough to allow such massive reconfiguration, and object-oriented techniques can certainly aid in this process, the associated costs should be carefully weighed against the supposed advantages; and
- A more subtle problem results from the fact that **separate user interfaces may have to be designed for the separate environments** thus increasing complexity in the user interface and adding integration risk.

The second requires further explanation. For example, there might be an expectation that once a full GUI implementation on state-of-the-art workstations is operational, that it would be easy to implement a subset of that interface on character-based terminals. Unfortunately, that is not generally the case unless the interface is very simple. The reason is that the two environments are so different in capability that a dynamic user interface paradigm designed for the high-end environment will simply not translate well to lower-end platforms (e.g., graphical icons cannot be displayed on a character-based machine). Even if the icons could be represented in some fashion using characters, the tools to perform the dynamic GUI-like manipulations are not available to the software developer in the older environment. In summary, using older environmental models to drive new system design can lead to lost opportunities, especially given the rapid pace of technological advancement. Moreover, integration of existing environments and platforms into a new design has to be done carefully in order to avoid creating an inferior overall design, as well as accumulating high software development and support costs.

B3.6 RISK ABATEMENT

Since dynamic interaction is so important, a proven method for risk abatement for user interface design is early prototyping. It is very difficult to evaluate user interfaces described on paper, but it is very easy to evaluate working models.

Another general approach to risk abatement in complex systems is to simplify, or phase-in the requirements. For example, it may be too early to try to anticipate the needs of a complete neutral data TO management system. A data model sufficient to support current B+ requirements could be built in anticipation of later conversion of the data to a new neutral model.

This simplification could extend to SGML. If the decision could be made on how much data about TO structural elements such as sections, tasks, and steps were really needed, it might turn out that less tagging than currently anticipated is actually required. Related to this issue is the granularity question; that is, what granularity is required to retrieve TO information, not at Tier 4, but by manager-users at Tier 2. **For example, if the task or subsection level is sufficient granularity (rather than the individual step), then that decision vastly simplifies tagging and therefore conversion of existing documents; there are easily twenty times as many steps in TOs as there are tasks.** (Identical components such as boilerplate paragraphs can be handled inside a document management environment using different mechanisms and do not need to be tied to Tier 2 retrieval requirements.)

Another simplification to abate risk involves restriction of customized view options in order to simplify verification. The more important views could be selected and implemented first, then the other view options could be phased in later once experience is gained and benefits are evaluated.

Flexibility should be built into the system to allow for unanticipated problems and alterations. For example, authorization chains for Change Requests should be fully editable by authorized users. It may prove prudent to allow multiple data models to coexist in the system.

Standards should be used wherever possible and practical, although not to the extent that they constrict the system.

Regarding the concern of developing an integrated system despite separate development activities for AFTOMS and end-user presentation systems, the risk can be reduced by defining a standard AFTOMS data interface to Tier 4 and by working closely with the Using Commands, rather than in isolation.

There are risks associated with the incorporation of existing equipment into AFTOMS. Design of a different user interface using a different paradigm for the existing equipment is often the approach taken. This can, however, lead to higher development costs as well as the presence of multiple user models within the same system. **A better solution to both the multiple user model problem and the higher-cost reconfigurable software problem is to develop one version of the software and user interface that will run on all hardware platforms in the system.** This solution requires upgrading the existing hardware where practical to a point where it can run the standard system software unmodified. Such upgrade possibilities are available and practical even in FY89, mostly due to the prevalence of standards such as UNIX and X-Windows.

The broad-ranging process decisions such as those involving job definitions, neutral data support, interactive vs. batch publishing, incorporation of existing equipment, etc., need to

be made before the RFP is published, as they are critical to the definition of AFTOMS as a system as well as to the definition of its user model.

SECTION B4:
Use of Electronic Communications

B4.1 SCOPE AND RELEVANCE

AFTOMS is a system of systems that will require electronic communications to support data distribution both within and between tiers. The communications architecture providing this function must be designed to offer responsive performance and throughput capacity while at the same time appearing to be transparent to the user.

B4.1.1 Communication Requirements Overview

The resulting AFTOMS computer hardware and software configuration is expected to be an integrated blend of heterogeneous systems. These will include: newly AFTOMS-acquired systems running document management, data administration, and other applications; existing systems, including the IBM/Amdahl-based LMTOS and DEC-based ATOS (until absorbed or replaced); user work area systems based on Z-248 and successor PCs; and probably advanced digital TO presentation systems based on a future, still-undefined architecture. Ensuring data transfer and interoperability will require strict adherence to DoD and emerging ISO standards and comprehensive advanced planning.

Communications can no longer be treated as a standalone service which is designed to support applications externally such as file transfer. New applications developed for AFTOMS will require communications to provide embedded transport and routing functions for distributed applications. These include database applications involving multiple, distributed processors. Each of these applications will require definition of pre-established and adhoc client-server relationships. **Selection of standards and vendor offerings for both hardware and software must be directed with distributed rather than centralized operations in mind.**

The AFTOMS network will consist of LANs serving intra-tier requirements and long-haul, wide area communications providing paths between tiers. FIGURE B4-1 illustrates local and wide area communication requirements within the four AFTOMS tiers.

B4.1.2 Traffic

AFTOMS communication traffic will be derived from the functions that need to be performed within and between tiers. The primary traffic types will be electronic mail, file transfer, transaction processing, and on-line conferencing.

ELECTRONIC MAIL

Electronic mail provides formal (record) and informal messaging services between all AFTOMS personnel and facilities. Electronic mail is expected to expand into other services which include the ability to append binary files and graphic images to the main text transmission for routing via the mail network.

FILE TRANSFER

File transfers will consist of technical order document files. Short file transfers (under 100K bytes) include change request packages, time-compliant TOs (TCTOs) and administrative database summaries. Long file transfers (over 100K bytes) will include TOs where the average TO file size is 3MB for 100 pages, composed of 60% text and 40% illustrations.

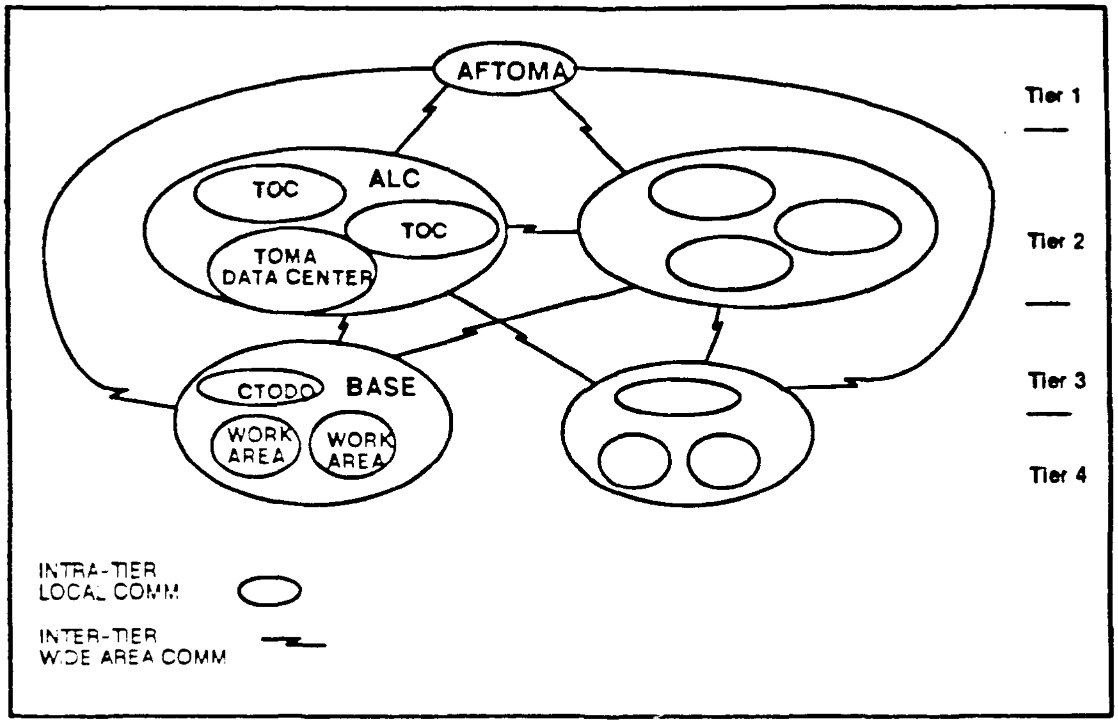


FIGURE B4-1. AFTOMS LOCAL AND LONG-HAUL COMMUNICATION REQUIREMENTS

TRANSACTION PROCESSING

Database queries, postings associated with profile registration, and program management applications (plans, schedules, status report, and directories) will require network support of on-line transaction processing.

CONFERENCING

Conferencing will allow AFTOMS personnel and contractors to review and comment on documents while on-line with all responsible parties. Proposed TO edits can be distributed and marked on screen for all to review. Electronic conferencing is considered an alternative to face-to-face meetings.

FIGURE B4-2 shows the intra and inter-tier traffic types which will traverse the AFTOMS networks.

B4.1.3 Connectivity

The network topology required to support AFTOMS will require intra and inter-tier components.

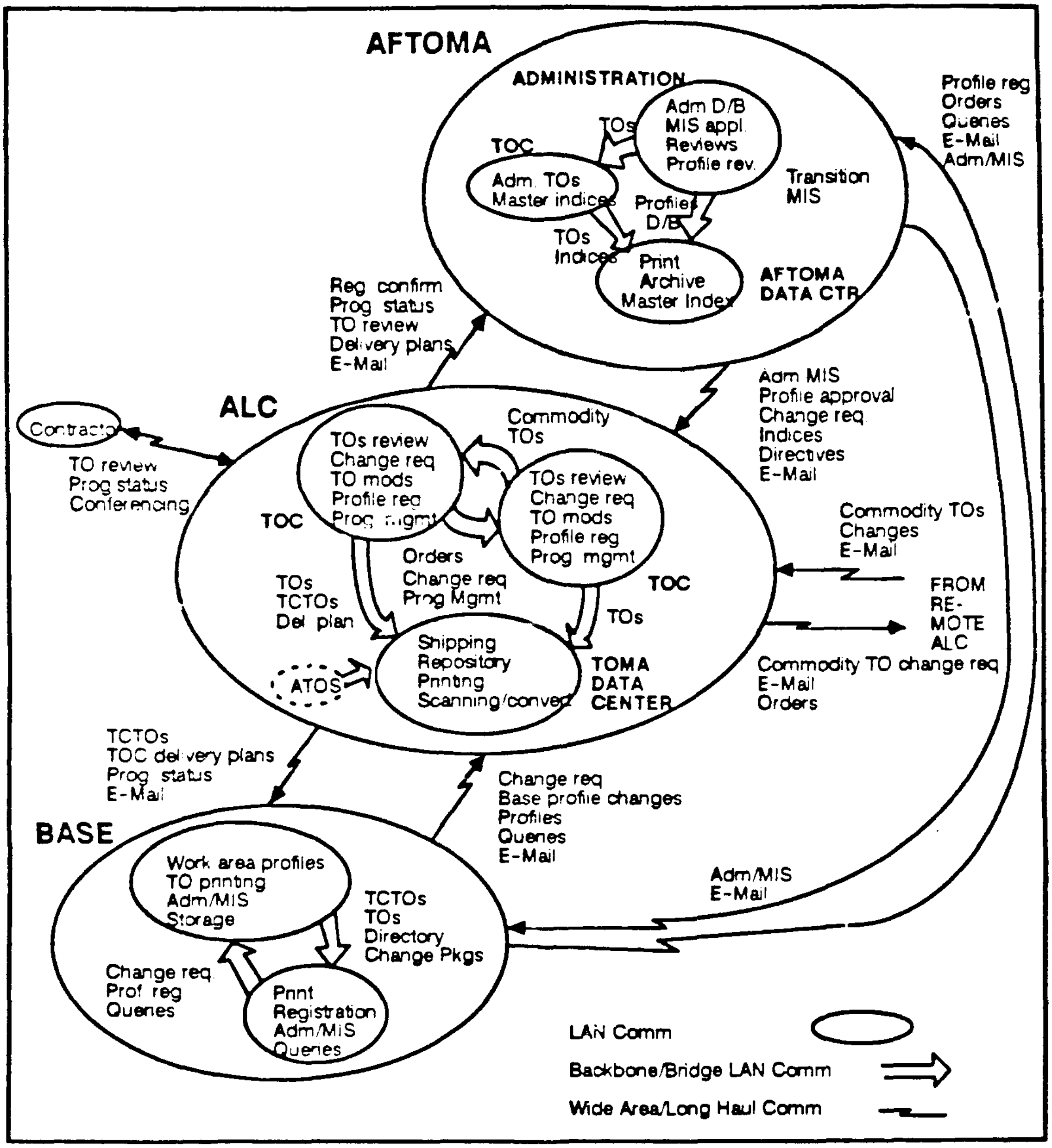


FIGURE B4-2. AFTOMS TRAFFIC TYPES

B4.1.3.1 Intra-tier Connectivity

Intra-tier connectivity will be provided by LANs and/or standalone systems at that tier. It is expected that AFTOMS will require the installation of departmental LANs (generally under 10 workstations) within most tiers to support the AFTOMA, TOCs, TOMA Data Centers, CTODOs, and automated work areas. New LANs will adhere to Air Force Unified Local Area Network Architecture (ULANA) I and later ULANA II specifications. In addition, connection between LANs, within the same tier, will require a bridging service using existing base backbones. In the case of ALCs, a broadband LAN (LOGLAN) is already in place to provide such a service. AFLC has also installed a similar LAN to support HQ AFLC. Base facilities will need to be examined on a case-by-case basis to determine their current and planned communications facilities and services. Intra-tier communications will consist of the following:

TIER 1 (WITHIN AFTOMA):

Provides AFTOMS-related management information functions for the support of the total administration of AFTOMS as well as the creation of policy TOs, and centralized directory production.

TIER 2 (WITHIN AND BETWEEN TOMAs):

TOMAs will require the capability to store, retrieve, and edit individual TOs within their department work group as well as exchanging TOs and information with other TOMAs at the same location (i.e. ALC). This capability will also support incoming and outgoing communications to the CTODOs and contractors. Connections to the AFTOMS Data Centers serving AFLC TOMAs will be extremely critical components. The connections will be the principal means by which the individual TOMAs will transfer their TO suites to the Data Center for selective printing, archiving, directory services, creation of optical media for distribution, and other means of transferring TO management and content data to the CTODOs. In some cases the Data Center may also provide a centralized communication gateway function to other tiers.

TIER 3 (WITHIN THE CTODO):

The base level CTODOs are expected to vary in size and complexity since their function will be related to the role of the base or depot which it supports. In all cases, however, there will be a required baseline capability for an administration workstation, printing, communications, and on-line access of TO suites. The CTODO will process profile registrations, coordinate, log, and transmit change requests on behalf of its work areas and offer on-line access to its TO database for automated work areas.

TIER 4 (WITHIN WORK AREAS):

Automated work areas at Tier 4 will use their LAN to accept TOs (via optical disk or CTODO downloads), perform directory searches, and print TOs on site. Additionally, the work area users will be able to coordinate change requests and registrations within the work area prior to contacting the CTODO.

B4.1.3.2 Inter-Tier Connectivity

Inter-tier communications will provide connectivity between remote locations. Since bulk transfer of TOs will be accomplished by physical distribution of optical disks, the long-haul communications resource will be used to transmit electronic mail, transactions, short file transfers, and occasionally complete TOs. The nature of this traffic is ideally suited for a packet network such as the Defense Data Network (DDN). The use of the DDN for long-haul data traffic coincides with current Air Force and DoD directives. Alternatives to the DDN would be use of dial-up and/or leased circuits. In the case of heavy traffic circuits such as those between ALCs, dedicated trunks may prove to offer greater performance for large file transfers at a lesser cost. Inter-tier communications will consist of the following:

FROM TIER 1:

The AFTOMA will need to distribute profile registrations, policy TOs, and coordinate TO status and change requests with all Tier 2 TOMAs. The AFTOMA will also communicate directly with the base CTODO on administrative issues which include profile registration, status reports, and on-line master directory services.

FROM TIER 2:

All Tier 2 facilities will need to communicate with the AFTOMA in response to administrative issues involving registration acknowledgements, status reports, program plans, and change notices. In addition TOMAs will require long-haul connectivity to other TOMAs that contribute TOs to their weapon system suite. Tier 2 TOMAs will communicate with Tier 3 CTODOs to coordinate profile registrations and distribute TCTOs and change packages.

FROM TIER 3:

Tier 3 CTODOs will transmit profile requests, administrative data, and database queries to the AFTOMA. Change requests, status, and configuration reports will be sent to Tier 2 TOMAs. TOs, TCTOs, change packages, and change request acknowledgements will be transmitted to automated Tier 4 work areas that have LAN access to the CTODO.

FROM TIER 4:

Automated Tier 4 systems that have telecommunications access to the CTODO will provide on-line profile registration, change requests, and database queries (for TO status, directories, availability dates, etc.)

FIGURE B4-3 shows network standards and transmission resources that offer the potential of meeting AFTOMS data communications requirements.

B4.1.4 Performance

Required performance will drive the final communications architecture selected to support AFTOMS. Formal analysis of expected user requirements in this area were not undertaken. However, it is reasonable to use widely accepted benchmarks established for commercial data network design. Transaction query/response transit times under five seconds and short file transfers under five minutes are reasonable targets and within reach of current technology for wide area communications. Transmission time of average sized TOs should be in the range of 5-10 minutes to be considered reasonable to a typical user. This would require a dedicated transmission channel of at least 56 Kbps. Bulk transfer of average TOs would swamp low-to-medium speed (under 56 Kbps) communications resources. Off-peak transmission of TOs, when needed, may be feasible at these rates. Transmission of bulk TOs would require high bandwidth (T–carrier) in order to accommodate regular delivery in minutes rather than hours. LAN transmission rates for both Ethernet (10Mbps) and Token Ring (4 and 16 Mbps) offer greater-than-specified performance for intra–tier communications. Consideration should be given to keeping LANs populated at a department size (under 10 workstations) for demanding traffic associated with CAD/CAM and document management systems. LAN transmission rates of 100Mbps promised by Fiber Data Distribution Interface (FDDI) will offer a response time comparable to magnetic hard disk access.

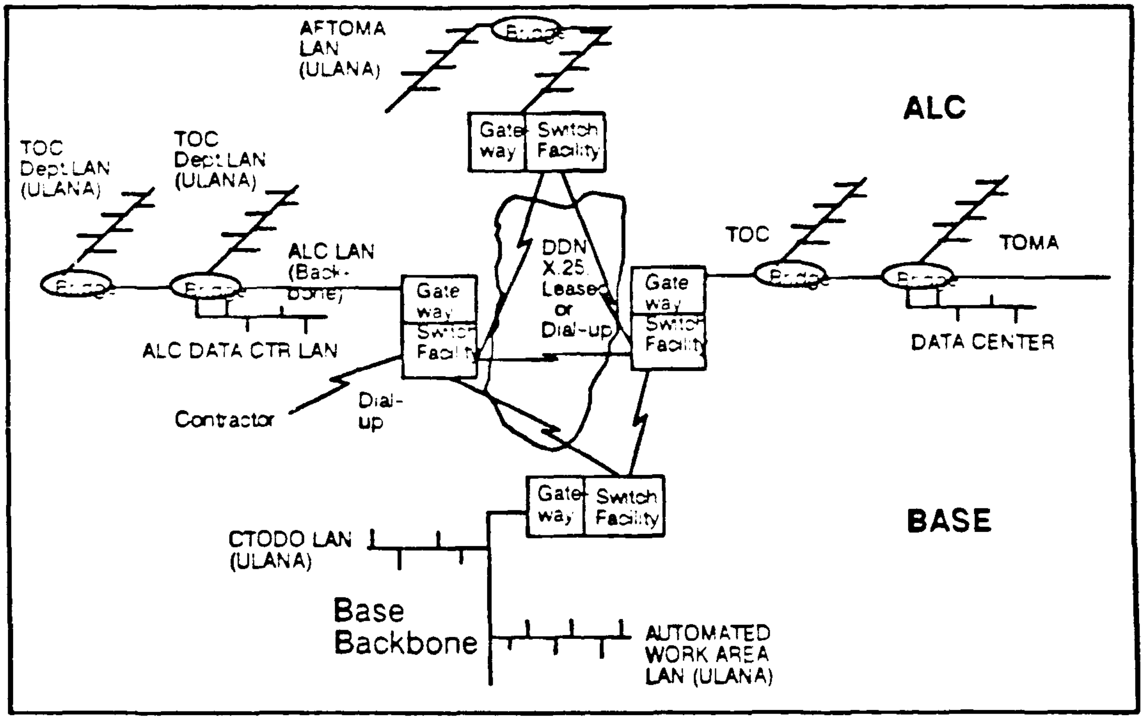


FIGURE B4-3. NETWORKS SUPPORTING AFTOMS COMMUNICATIONS

B4.2 STATE OF INTEGRATION FEASIBILITY

Telecommunications standards and technology available today offer the capability to support projected requirements of AFTOMS. This is due, in part, to the commercial availability of a relatively mature set of DoD communications protocols and the current technology drive towards distributed processing amongst both local and remote LANs.

B4.2.1 Standardization and Interoperability Issues

The Air Force has established new system implementation guidelines by publishing its long range plans for the Local Information Transfer Architecture (LITA) and the Long-Haul Information Transfer Architecture (LHITA) as part of the Air Force Information System (AFIS).

Both documents call for a transition from the DoD protocols to the ISO suite as specified in the Government Open Systems Interconnection Profile (GOSIP). GOSIP will become a mandatory Federal Information Processing Standard (FIPS) for agencies in August 1990. Plans include upgrading base switching and transmission facilities as well as long-haul networks such as the DDN and DSN. All future automation systems such as AFTOMS will need to be developed in concert with these initiatives. This will require strict compliance to DoD standards (near term) with a clear migratory path to ISO. Systems should be selected that support all digital switching and transmission as well as common access to digital services such as ISDN. The Air Force and the National Institute of Standards and Technology (NIST) are currently validating ISDN and ISO standards at Mather AFB.

Selection of AFTOMS communications equipment should be based on the ULANA/LITA and DDN/LHITA requirements. This direction will allow AFTOMS to be in-line for interoperability with new systems and network upgrades via planned gateways being developed by NIST.

Standard protocols which define physical connectivity through the transport layer are mature and offer wide vendor support. These include IEEE 802.3 (Ethernet), 802.4 (Token Bus) and 802.5 (Token Ring) as well as CCITT X.25. The DoD TCP/IP suite supports internet routing and reliable transport. TCP/IP is strongly recommended above LAN and X.25 protocol implementations.

DoD standards for E-Mail, file transfer (FTP), and virtual terminal (TELNET) are widely available and are often bundled with the UNIX operating system. ISO has established CCITT X.400, file transfer, access and management (FTAM), and virtual terminal protocol (VTP) for these services. Application developers have been quick to endorse X.400. ISO products in this area are just beginning to be offered by a limited number of vendors. **Near term (FY 91–FY93) AFTOMS systems may require adherence to a subset of the DoD suite until suitable ISO-compliant software meets DoD approval.** This is particularly true for the replacement of TCP by the ISO TP4 transport protocol.

B4.2.2 State of the Technology

Other than electronic conferencing applications, hardware and software is currently available to meet AFTOMS communications requirements. Electronic conferencing application software, although offered, is generally restricted to a homogeneous workstation population.

IEEE LAN standards are used by most workstation vendors with Ethernet being the most popular. The UNIX operating system environment usually includes TCP/IP service on top of the LAN protocols. Similarly SMTP, TELNET, and FTP are provided as part of the application layer suite. The Internet Protocol (IP) socket mechanism is commonly used to support distributed applications.

Bridges and gateways used to connect LANs offer X.25 and asynchronous communications support for connecting remote locations. The ULANA I product list includes several vendor products in this area. Standalone X.25 host interface cards to connect single hosts or workstations are available from most vendors. Full service interoperability with other DDN hosts will require DDN Standard X.25. DDN Standard X.25 provides additional features which allow communications with existing hosts using BBN 1822 protocol. DDN X.25 allows subscribers to use the network; however, TCP/IP will be required for systems to communicate across multiple subnets of the DDN allowing TCP connections to cross IP gateways.

An alternative to the DDN is using dial-up or leased lines to connect AFTOMS tiers. This restricts performance and accessibility to all sites. Using the DDN, all AFTOMS facilities would be networked together and communicate as required. Hardware products, which include modems, bridges, gateways, and X.25 cards, are commercially available to support this alternative in either an asynchronous or synchronous X.25 mode. ISDN host interface cards offering basic rate interface (64 Kbps) data service are being tested and will provide an additional network access alternative when ISDN is fully supported by the local telephone companies (telcos).

B4.2.3 Security

Secure facilities, secure networking and possibly trusted computer systems will be required for protecting classified TO data. Local facilities will have physical access control devices, software passwords and access codes, and perhaps, TEMPEST-certified facilities and workstations. Separate secure networks could be developed to fulfill transmission requirements; however, current communication trends are to integrate this service into a single multi-level secure environment. TCP/IP subscriber systems can utilize DoD E3 devices (e.g., BLACKER). BLACKER will allow multi-level security for data transmission through the DDN. BLACKER does not encrypt the traffic on the local loop, or in this case, the LAN. The use of BLACKER on the DDN appears to be the most appropriate secure networking solution for AFTOMS during the next 3-5 years. Use of the Secure Telephone Unit (STU)III offers near-term security for connections made over dial-up or leased circuits. The NSA Secure Data Network System (SDNS) initiative offers much promise in the area of offering a total end-to-end solution for both local and remote communications. Hosts or LANs with SDNS devices can communicate securely over any transmission medium or network by mutually exchanging keys. Host systems which use SDNS devices will be required to use GOSIP protocols including TP4. Further study in this area may indicate that classified TO data should be distributed physically using courier delivery (see Section B2, Handling and Conversion of Heterogeneous Technical Order Data, for more detail).

B4.3 PARTICULAR INTEGRATION APPROACHES USED

B4.3.1 In Demo System

The communications requirements of the Demo System were met by department-sized LANs representing AFTOMS tiers. Inter-tier communications were provided by the same LAN.

Wide area transmission using dial-up, leased lines, or packet networks was not included in the Demo System configuration.

TCP/IP on top of Ethernet and Token Ring was used as the standard transport protocol for the Demo System. Performance provided by the Ethernet to satisfy intra-tier communications proved to be within stated requirements.

The major workstation vendors used in the Demo System offered networking software and products that supported DDN X.25 connectivity. Several third parties have similar products. The Network File System (NFS), an industry de facto standard, was available from all vendors and was used successfully throughout for transparent file access across all workstations/servers on the LAN.

B4.3.2 Other Assessments for FY91–FY93

Major workstation vendors used in the Demo System, as well as several others, were researched to determine their support for the ISO protocol suite. Each manufacturer is continuing DoD protocol products and has plans to fully develop a complete ISO capability in parallel. The most significant effort has been the development of X.400 compliant software for E-Mail and message handling services needed for the group work environment. Manufacturers were found to be pushing the development of FDDI LAN products for 100Mbps transmission rates.

B4.4 RISK ASSESSMENT

The following issues are considered risks that need to be addressed by AFTOMS communications planners:

- **Traffic loads cannot be carried by specified transmission facilities.** Improper sizing and protocol selection of the transmission facilities will cause bottlenecks, delays, and unreliable user service. Network planning will require simulating or modeling AFTOMS projected traffic loads both within and between tiers. Traffic loading information will also be required as part of the User Requirements Data Base (URDB) that needs to be submitted for subscription to the DDN.

- **Existing systems cannot interoperate with AFTOMS applications.** Protocols and communications software used by existing systems may be incapable of integration into the planned AFTOMS communication architecture. Existing TO systems, such as ATOS, will need to be examined to determine their level of integration and communications interfaces to AFTOMS LAN and long-haul services.

- **DDN resources may be unavailable for AFTOMS wide area networking.** Subscribers to the DDN need to coordinate their request for service through

AFCC and DCA. The DCA Defense Communications System Data Systems (DCSDS) requires accurate and complete system information to properly plan and implement DDN service. The process of host subscription to the DDN is approximately a 24-month process. FIGURE B4–4 shows the steps required for host subscription to the DDN.

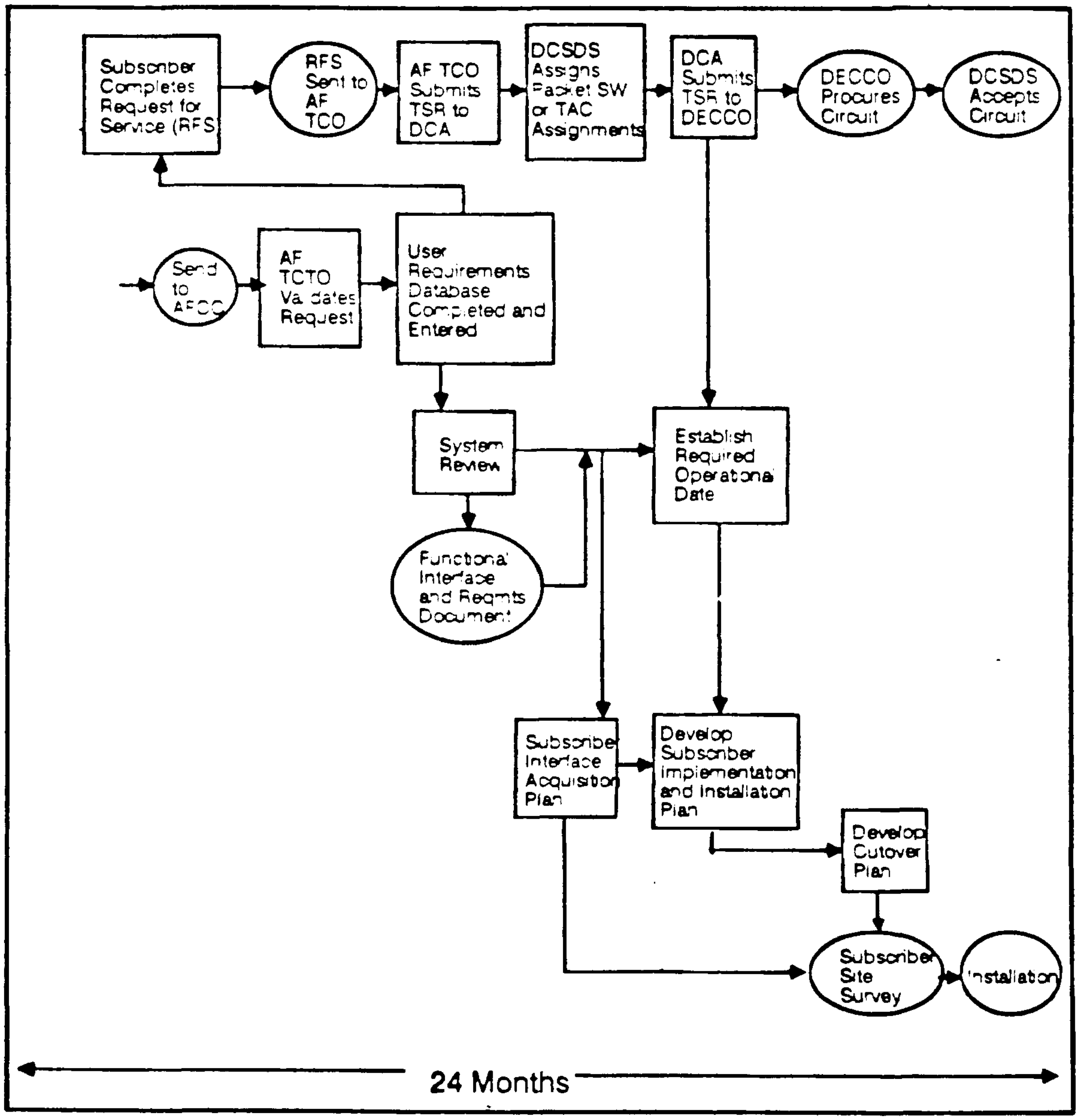


FIGURE B4–4. STEPS REQUIRED FOR HOST SUBSCRIPTION TO THE DDN

- **Protocol selection may not allow full GOSIP compliance.** During the transition to GOSIP, the DoD protocol suite will provide the most comprehensive vendor support and DoD host interoperability for the near term. Planners must be careful to select system vendors that offer full support and upgrade plans to ISO and should use compliant ISO products wherever feasible.

- **Base-level communications facilities may not provide sufficient access or backbone transmission services.** AFTOMS base installations run the risk of fielding state-of-the-art systems at bases undergoing significant upgrades to their premise wiring, switching systems, and long-haul transmission resources.

- **New applications software may be unable to address underlying communications protocols.** Applications developed for AFTOMS will need to interoperate in a distributed environment. Development without a clearly specified communication protocol suite during the GOSIP transitional period can impair future integration with other CALS systems.

B4.5 RISK ABATEMENT

- **Perform network management traffic study.** Message lengths and sizes, frequency of transmission, and destination should be projected and modeled for proper link sizing. LAN hardware and long-haul access should be specified as a result. In addition, performance requirements should be confirmed through adequate human factors testing.

- **Develop interface specifications.** An AFTOMS system interface specification should be developed in-line with the ULANA, LITA, and LHITA objectives. Existing systems integration studies should be conducted. In the case of those systems retained as part of AFTOMS, protocol converters, gateways, and communications software must be examined for connecting these systems. Part of this effort should determine the cost and benefits associated with integrating the system or leaving it in a standalone mode.

- **Undertake initial discussions with AFCC and DCA.** AFTOMS planners should initiate discussions with AFCC and DCA over the requirements and planning associated with DDN subscription. Use of dial-up or leased facilities and/or WANS may be needed to meet some requirements.

- **Implement DoD protocols from physical layer through TCP/IP.** AFTOMS should select implementation of the full DoD protocol suite through TCP/IP. This will allow GOSIP compliance except for the TP4 transport protocol. Conversion to TP4 may be done at a later date once the current debates over its merits are settled. It is recommended that TCP/IP on top of the LAN and X.25 protocols be required. This will allow full interoperability on the DDN and allow initial secure systems to use BLACKER devices. Use of X.400, FTAM, and VTP standards should be implemented for those applications closed to AFTOMS. NIST is creating software gateways which will allow these ISO application protocols to interoperate with hosts running existing DoD protocols. In all cases, it is recommended that communications equipment and protocols selected for AFTOMS be based on ULANA I and II for LANS and the DDN and LHITA for long haul. This will insure compatibility with future equipment and network upgrades.

- **Prepare base facility site plans.** All AFTOMS sites need to be closely monitored for current and planned base network upgrades. Planning and delivery of AFTOMS systems must be synchronized with this schedule. Equipment selection should be compatible with planned enhancements at the base.

- **Create software development specifications.** All new software required for AFTOMS should expect TCP/IP or TP4/IP services as a common communications protocol baseline. Utilization of NFS in addition to the rest of the DoD suite is highly recommended for transparent file transfer amongst heterogeneous systems.

SECTION B5:
Interface to Other Air Force Functions/Systems

B5.1 SCOPE AND RELEVANCE

The Air Force CALS initiative began in late 1985 in response to a directive from the Office of the Secretary of Defense (OSD). The directive called for a long–overdue modernization of logistics systems and related processes. Automation was viewed as the major strategic approach to accomplish the modernization. Implementing the necessary level of automation is a task that intersects almost all of the commands, every weapon system program in existence, countless acquisition and support groups, and the entire contractor sector.

Automation in the logistics world did not just start as a result of this directive and it will not end when the stated modernization goal is reached. Many systems were already in the process of being acquired and deployed when the CALS initiative gathered momentum. Future systems will come on-line that will further improve the logistics process for existing and emerging weapons programs. There will always be new and enhanced systems coming on-line, and the long–range goal of CALS is that they all interoperate.

However, this automation goal is easier to state than to achieve. Interoperability must be carefully planned if it is to be realized operationally. This is extremely difficult, even if the *clean sheet of paper* approach is used to establish the best approach to automation. When the added constraints of reusing existing assets and retrofitting current or emerging systems are imposed, it becomes a monumental long–term task. However, it is not an impossible task.

AFTOMS is a system that was initiated after the CALS directive. In fact, AFTOMS is the first program commissioned as a direct result of the CALS initiative; and it is important to the CALS initiative that AFTOMS succeed. Therefore, the needs and risks associated with integrating AFTOMS into the Air Force logistics environment must be assessed and timely actions taken to maximize AFTOMS' value to the Air Force.

B5.1.1 Existing Systems

The Logistics Management of Technical Order System (LMTOS) and Automated Technical Order System (ATOS) are two existing systems that currently perform some automation of TO functions. This subsection briefly describes their current role and identifies their changed role once AFTOMS is deployed.

B5.1.1.1 LMTOS

LMTOS has served as the management system for TOs for the past twenty years. LMTOS consists of six subsystems that not only provide the processing support for controlling automatic distribution of TOs and TO updates to the user community, but also provide several TO management information reports. Input and output is predominantly via a batch–processing operation; therefore, provisions for user interaction with the system are limited. Output products, which are printed and distributed as paper copy, include management reports, forms, mailing labels, and error information.

The system is limited in its functionality, severely overloaded, outdated, and is extremely difficult to support due to a lack of up-to-date documentation and the fact that very few programmers are familiar with the software. Given these LMTOS problems and the fact that the LMTOS management functions will be an integral part of AFTOMS, the clear decision is that AFTOMS should undertake an aggressive schedule of replacing the LMTOS system by FY93 (corresponding to the AFTOMS IOC timetable). By FY93 or soon after, LMTOS will cease operations and its interface to AFTOMS will not need to be considered. The data resident in LMTOS for managing paper TOs (whether or not they stay in paper format permanently or are converted to digital form) will be imported and consolidated into AFTOMS; thereafter, AFTOMS will manage these TOs. **An automated approach (i.e. utility program/module) will be developed as part of the AFTOMS program to acquire, create, reformat, and load the necessary and sufficient data structures in the AFTOMS system.**

B5.1.1.2 ATOS

ATOS is essentially an organic publication system for the production of change pages to paper TOs. The ATOS system has been deployed at the five ALCs and AGMC since the mid-1980s. When changes to existing TOs are approved, ATOS generates digital text and graphics from the original page masters using a combination of conversion and/or rekeying. Changes to these pages can be made digitally on the system and page masters can be output from the system. These page masters are then printed and delivered to the user community.

When AFTOMS is initially deployed, the ATOS system will be approximately ten years old and at least two technology generations behind current capabilities. It can be seen as another system whose functionality will be displaced by AFTOMS. If possible, it would make sense to phase out ATOS during the initial deployment of AFTOMS. At the very least, ATOS should become a subsystem of AFTOMS with usage restricted to forever-paper TOs. For interoperability purposes, ATOS will not be considered a system that must interoperate intimately with AFTOMS, except that AFTOMS will provide the management function for work allocated to ATOS.

B5.1.2 AFTOMS Role

AFTOMS has been designated as the all-inclusive TO management system for the Air Force. In short, this means that all TOs in the Air Force inventory (existing and new) will eventually fall under the management responsibility of AFTOMS. Management consists of several functions (acquisition, cataloging/archiving, distribution, and change management), all of which must be adequately supported by AFTOMS.

B5.1.2.1 Near Term

AFTOMS is scheduled to be deployed in the FY93–FY95 time frame. When deployment occurs, the big challenge will be how quickly and smoothly can the transition to digital operations occur. This section addresses the following issues:

- New weapon programs coming on-line in this time frame;
- Assimilation of management responsibility on a system-by-system basis from LMTOS (GO22); and
- Conversion efforts on a weapon system-by-weapon system basis.

At a policy level, the CALS directive by Deputy Secretary of Defense Taft states that all weapons programs coming on-line after 1990 will deliver TOs to the Air Force in digital form. These new TOs will immediately come under the management direction of AFTOMS. This situation is straightforward since these programs were never involved with any other existing systems. In this time frame, there will only be a few new programs coming on-line.

Other situations require synchronization of activities. If existing technical orders on a program remain forever paper but AFTOMS assumes management responsibility from LMTOS, a need exists for future production of change pages. Perhaps, the ATOS system (as a subsystem to AFTOMS) could continue to perform this function.

Another situation that could occur is when existing paper TOs for a weapon system are converted to digital form (see Section B2.3 for details). Once the conversion is completed, all management functions become the responsibility of AFTOMS.

In its first few years of deployment, AFTOMS will have partial management responsibility for the TO inventory. All LMTOS management information should be assimilated at initial deployment. Depending on the strategy and pace of conversion, more and more TOs will be archived in AFTOMS each year. However, from the mid-1990s to the year 2000, AFTOMS will not have full functional responsibility for the complete Air Force inventory.

B5.1.2.2 Long Term

After AFTOMS has been operational for several years, it should attain the all-inclusive TO management objective. By that time, there should be no traces of prior TO systems and management techniques.

B5.2 STATE OF INTEGRATION FEASIBILITY

B5.2.1 Interoperability (Interface vs. Integrate)

For TOs, as well as for all aspects of CALS, there is a strong desire to end up with an integrated solution. However, as TO automation is worked on, it is evident that achieving full integration requires a major effort, and that full integration may not be possible given the constraints of time, money, parallel development, etc. The question that remains is what can be accomplished realistically in the area of TOs?

CALS has a two-phase strategy: Phase 1 focuses on interfacing systems through the mid-1990s, while Phase 2 focuses on integrating systems over the long term. The outlook for TOs in the Air Force is similar. At a high level, the TO process is shown in FIGURE B5-1 as Creation, Management, and Use.

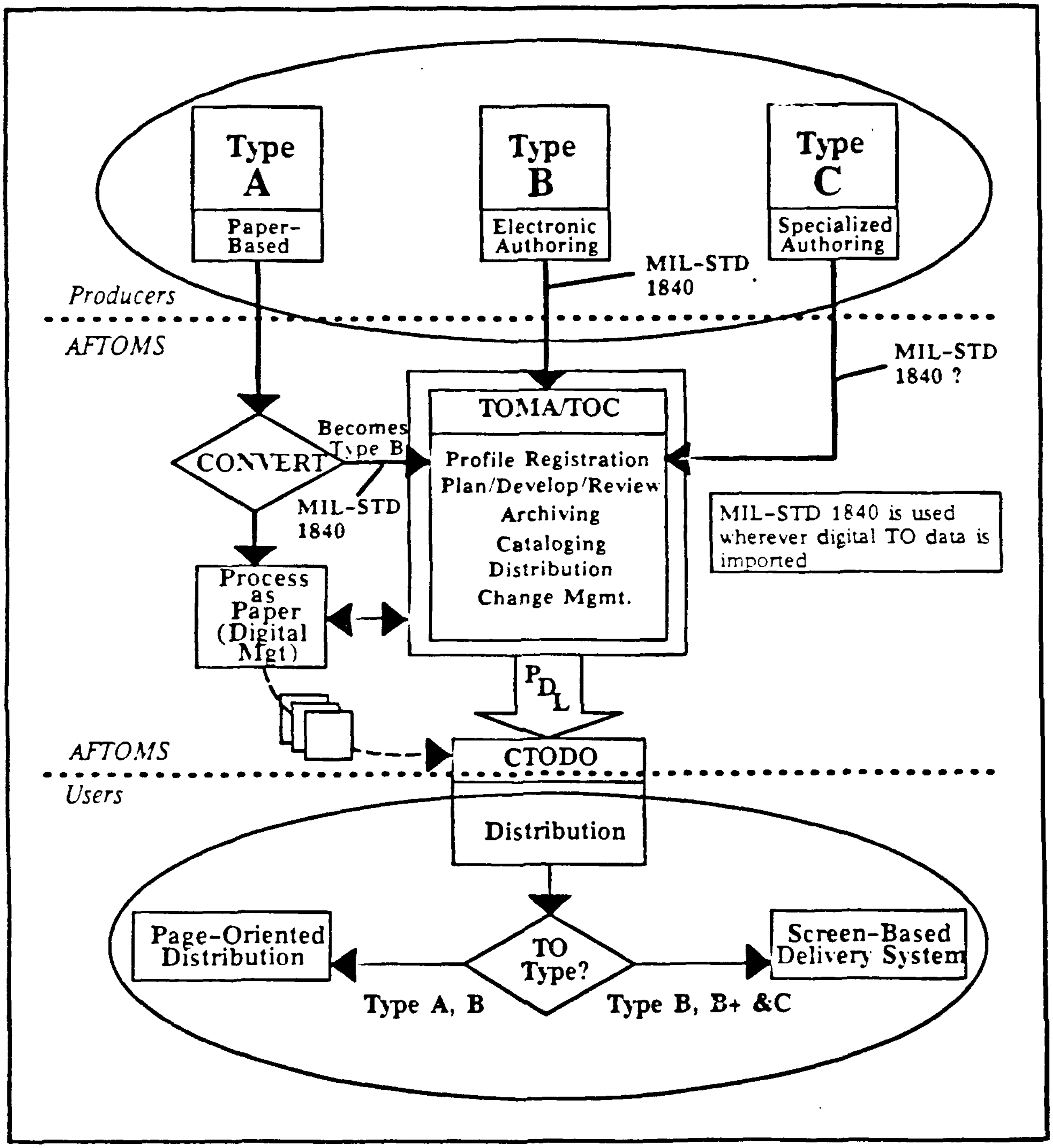


FIGURE B5-1. TECHNICAL ORDER FUNCTIONAL FLOW

The process flows from top to bottom with some feedback loops. The Creation process takes place primarily within the contractor sector by producers. TOs are delivered by contractors to the ALCs where the Management functions occur. Technical orders are delivered by AFTOMS to the users at base level and below where the user functions occur.

The long–term goal of the Air Force and AFTOMS is to have interoperability across all TO functions. This is commonly called *vertical integration*. For initial deployment a realistic strategy for the Air Force is to have vertical interoperability. Since there are many producer systems that could provide input to AFTOMS and many user systems that AFTOMS would deliver to, well–defined standard interfaces are needed at these in–and–out points to achieve interoperability.

B5.2.2 Assumptions

The feasible interoperability approaches are based on the following assumptions:

- In the FY93–FY95 deployment time frame, interfacing will be the main form of interoperability;
- An automated technical order solution is a near–term goal, while an automated technical information solution (comprising TOs, product data, logistics support data, software product data, etc.) is a long–term goal;
- The above goals can be achieved incrementally;
- There will be standardized interfaces on the both the input and output sides of AFTOMS; and
- LMTOS and ATOS will not be a part of the automated TO solution of the late 1990s.

B5.3 PARTICULAR INTEGRATION APPROACHES

B5.3.1 Input to AFTOMS

This subsection describes systems that deliver TOs (and related information) to AFTOMS. In FIGURE B5–1, they are depicted by arrows that enter the AFTOMS TOMA/TOC functional box. There are two types of systems:

- Authoring (producer) systems; and
- Conversion systems.

B5.3.1.1 Authoring Systems

TO authoring takes place primarily in the contractor sector. Many different kinds of systems are used; most of these systems are not under the control of the Air Force. Furthermore, it would be unwieldy to define an interface catering to the details of very different and modifiable producer configurations. To bring some consistency and order to this interchange, the

Air Force (and DoD) recognize the need for a standard interface. This interface should not require any detailed knowledge by AFTOMS of the hardware/software/communications configurations used by contractors in their authoring systems. Also, AFTOMS should not be dependent on the embedded functionality of any authoring system.

Interoperability of AFTOMS with authoring systems will be at the data interchange level. The implementation vehicle to accomplish this interchange is the MIL-STD 1840 and the conformance software packages resident in the authoring systems and in AFTOMS. This MIL-STD 1840-based approach has been widely accepted in the CALS community by the major participants and is the only authorized approach for the near term (CALS Phase 1). In the long term (CALS Phase 2), other more integrated approaches, now under discussion by various committees, could be defined and adopted.

B5.3.1.2 Conversion Systems

The primary role of conversion systems is to convert paper TOs into digital form. There are approximately the same number of conversion systems in existence as there are authoring systems. Compared to authoring systems, technical solutions for conversion systems are not fully developed as operational systems. Conversion could take place organically within the Air Force, at service bureaus, or in the contractor sector. Regardless of where the process takes place, the many-to-one mapping still exists.

Conversion is not a totally automated process. There is still a considerable amount of trained judgment and labor required to clean up and complete the processing. Over the next few years, the average amount of trained labor required per scanned page will be significantly reduced. In the near term the best way to achieve interoperability between conversion systems and AFTOMS is to specify an interface that:

- Is standard at the data interchange level;
- Does not depend on the degree of trained labor in the conversion process; and
- Is similar to the authoring system interface.

If the conversion output interface is equivalent to the authoring system interface, it would be transparent to AFTOMS where the TOs came from; and all subsequent management functions could be performed identically on all imported TOs. This would simplify interoperability on the AFTOMS side. Just as authoring systems need to acquire MIL-STD 1840 support software, so will conversion systems. The combination of conversion functionality, trained labor, and MIL-STD 1840 support on the conversion system side of the interface will produce incoming TO data in the standard acceptable format. AFTOMS will not need to readjust its activity every time there are conversion technology advances. In addition, this same interface could remain in place as long as conversion activity is still required.

B5.3.2 User (Delivery) Systems

As shown in FIGURE B5-1, AFTOMS resides in the middle of the overall TO process. To complete vertical integration of the process, AFTOMS must deliver the technical orders (along with some related management information) to users. In FIGURE B5-1, the point of interoperability is shown as the dotted line separating the Base CTODO (inside the domain of AFTOMS) from the Distribution box, which links user systems at the base level.

One way in which TOs can flow to users is by using AFTOMS demand printing at the Base CTODO and intra-base delivery. This subsection describes the more sophisticated technique of digital delivery to other systems at base level. These other systems will assume the responsibility of delivering the TOs (in paper or display form) to the users. These end-user delivery systems are an integral part of the vertical integration of TOs, but are not part of the current AFTOMS system. If no User System exists below the CTODO, then the paper delivery approach will be used.

B5.3.2.1 Standard Interface

Like the input systems described in Section B5.3.1, many user systems will exist. Currently, there is an initiative to define, acquire, and deploy a standard base-level user system that can be adopted by many weapon system programs. However, this initiative is at a very formative stage and will not become reality before the year 2000. Consequently, when AFTOMS is initially deployed, the one-to-many relationship between AFTOMS and user systems will exist.

Considering all the specific user system configurations and functionalities that AFTOMS might be called on to distribute TOs to or otherwise support, a standard interface is the most appropriate approach for interoperability. However, there is more than a one-way flow of information that must be supported. There are three major information flows:

- Technical Orders (AFTOMS ➧ user system);
- Profile Registration (user system ➧ AFTOMS); and
- Change Requests (user system ➧ AFTOMS)

Two new weapon system programs under development, the B2 and the ATF, are planning to deploy user systems at their operating bases. The B2 will be using the Improved Technical Data System (ITDS) and the ATF is planning to develop a user system based on the Integrated Maintenance Information System (IMIS) concept. While these user systems are currently program-specific, they could be modified to become solutions for other programs. Since these efforts are well underway, a more detailed look at their interfaces with AFTOMS is needed to integrate the operating concepts and system configurations on both sides of the interface.

B5.3.2.2 ITDS

ITDS is a user system, residing at operating bases and depots, which delivers TOs and associated data to maintenance and support users. The ITDS configuration is shown in FIGURE B5-2. A key component in the configuration is the Local Library. A Local Library, one per installation, serves as the data base manager and repository for the TOs at that installation. It is linked to the shops and flight line devices via LAN.

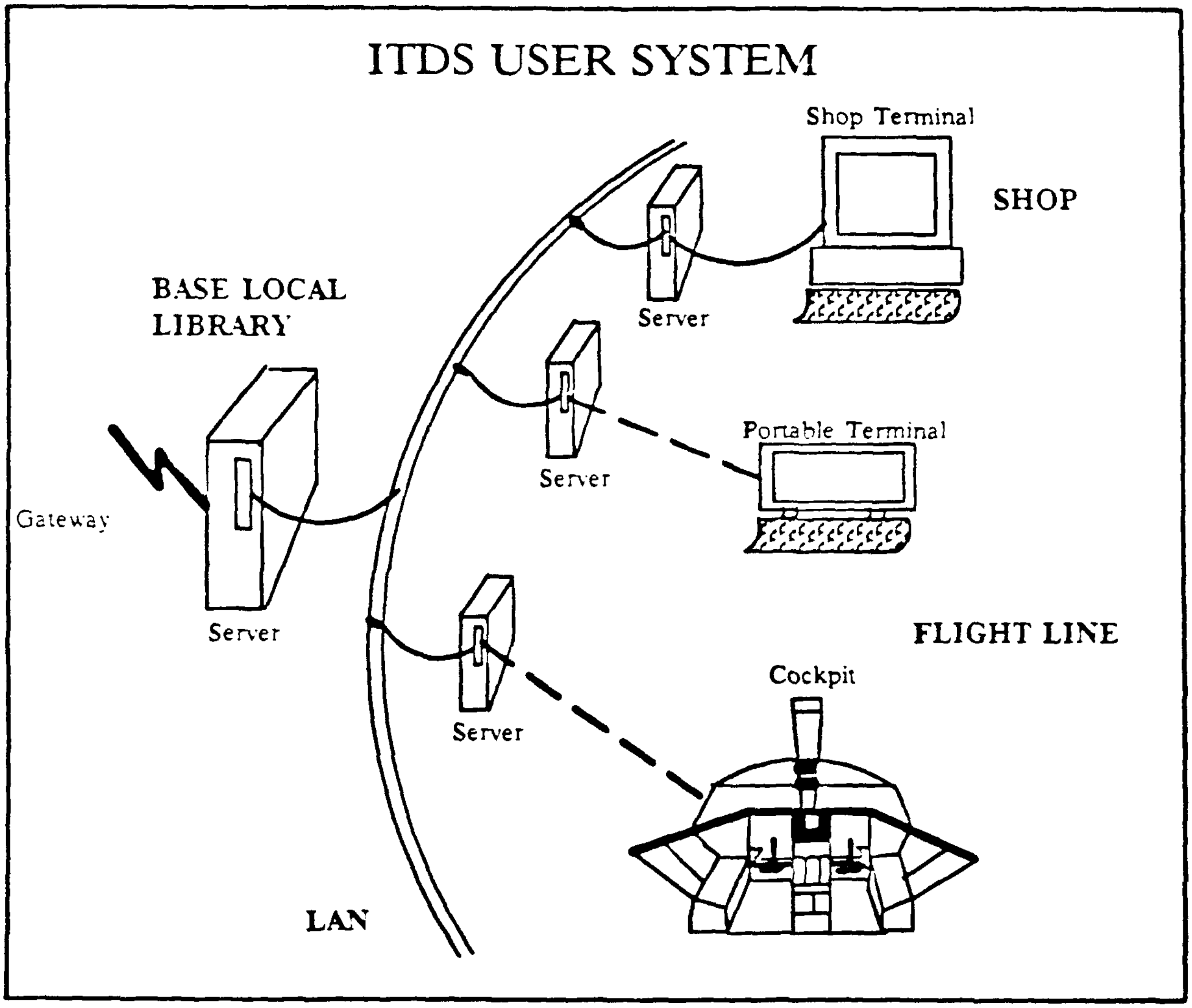


FIGURE B5-2. ITDS CONFIGURATION (CONCEPTUAL VIEW)

The AFTOMS concept provides a CTODO at every base and depot that it services. The AFTOMS CTODO and the ITDS Local Library need to be linked, using logical gateways for their respective systems, as shown in FIGURE B5-3. This interface would support the information flows identified above and would not require either system to deal with the configuration and technical details of the other system. Furthermore, if the configuration of either system was modified, it would probably not affect this interface. Since both systems will be under development during the same time period, this is an important consideration.

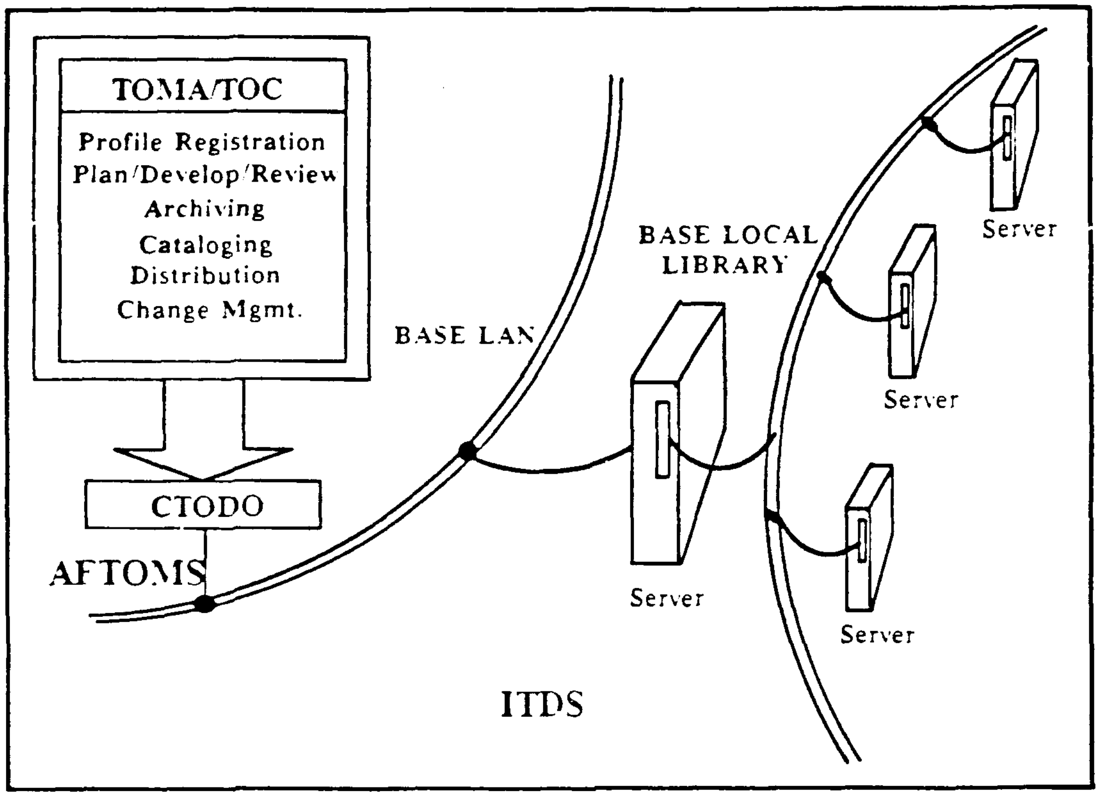


FIGURE B5-3. ITDS INTERFACE

B5.3.2.3 IMIS

When implemented, IMIS will be based on a maintenance information delivery concept that is designed to improve the capabilities of aircraft maintenance organizations. Technicians will be provided with a single information system for intermediate and organizational maintenance. IMIS will reside at base level and will provide the technician with direct access to several maintenance information systems and databases. IMIS will display graphical technical instructions (i.e. Type C TO data), provide intelligent diagnostic advice, provide aircraft battle damage assessment aids, analyze in-flight performance and failure data, analyze aircraft historical data, access and interrogate on-board built-in-test capabilities. It will also provide the technician with easy, efficient methods to receive work orders, report maintenance actions, order parts from supply, and complete computer-aided training lessons and simulations.

The IMIS concept is illustrated in FIGURE B5-4. TOs are one of the key information types that need to be delivered to IMIS. Therefore, the AFTOMS-IMIS interface requirements are very similar to the AFTOMS-ITDS ones. A major difference exists in what IMIS does with various information types prior to its delivery to system maintenance users. First, a significant amount of integration with other data types (diagnostics, training, etc.) needs to occur. Then, the linked information is presented to users in a more integrated manner as described above. AFTOMS needs to provide a TO interface as shown in FIGURE B5-5.

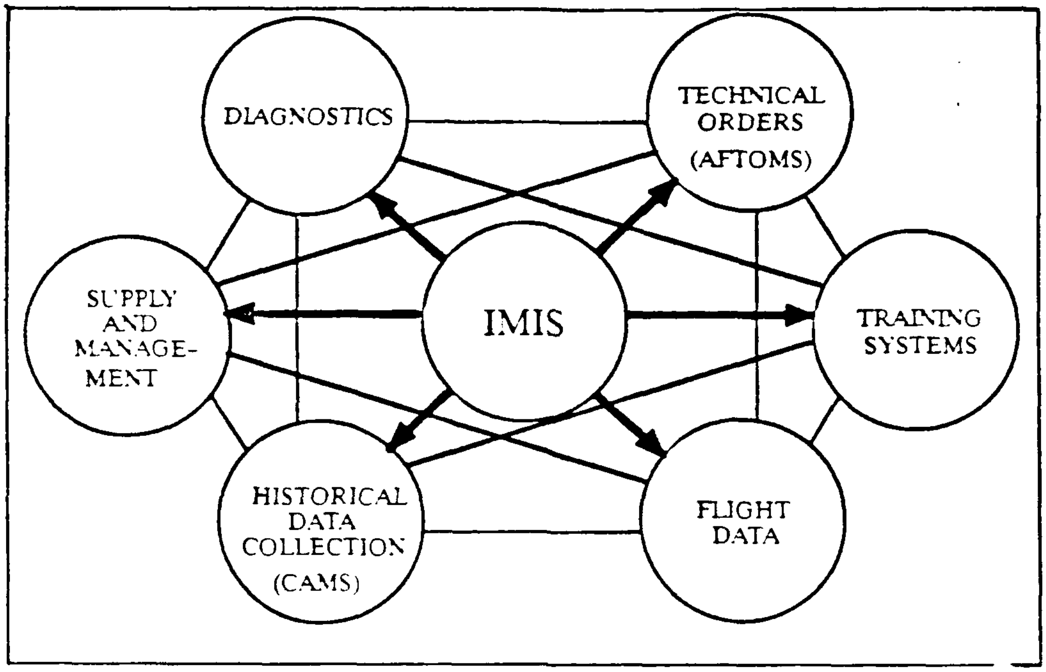


FIGURE B5-4. IMIS INTEGRATION OF DATA

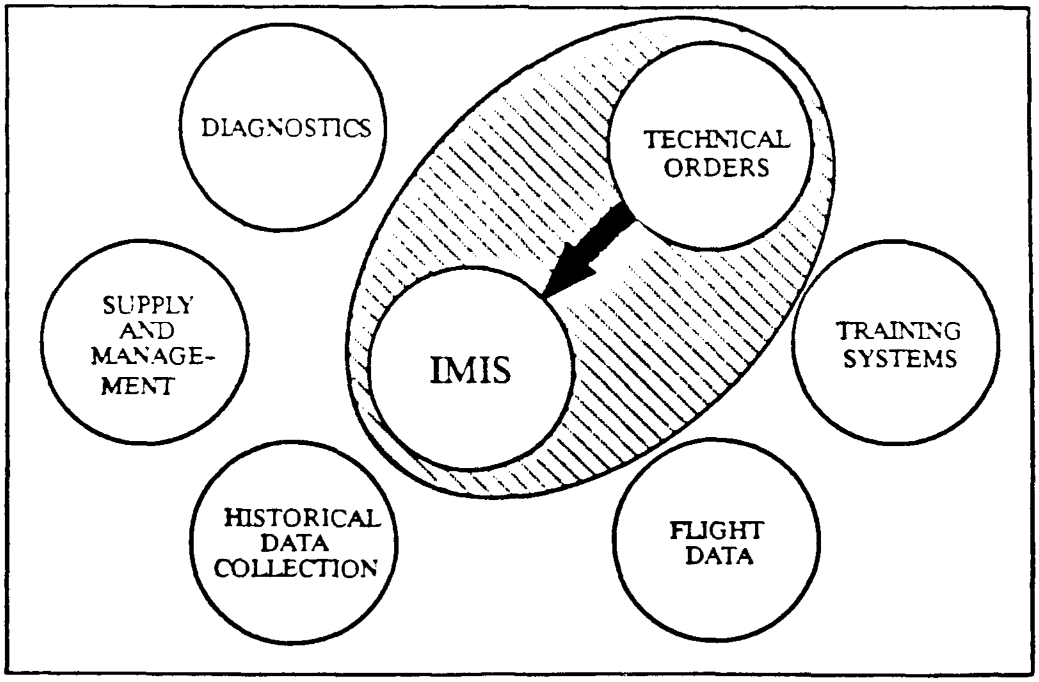


FIGURE B5-5. AFTOMS-IMIS INTERFACE

In fact, all user systems will have different functional capabilities, data types, etc. This illustrates why AFTOMS needs to develop a standard Tier 3-Tier 4 interface and not be too tightly coupled to user systems to which it delivers TOs.

B5.3.2.4 Layered Interface

The interface to user systems such as ITDS and IMIS will have a layered look, as illustrated in FIGURE B5-6. On the AFTOMS side will be the standard portion of the interface. On the user system side, each system will develop a tailored module to complete the link up.

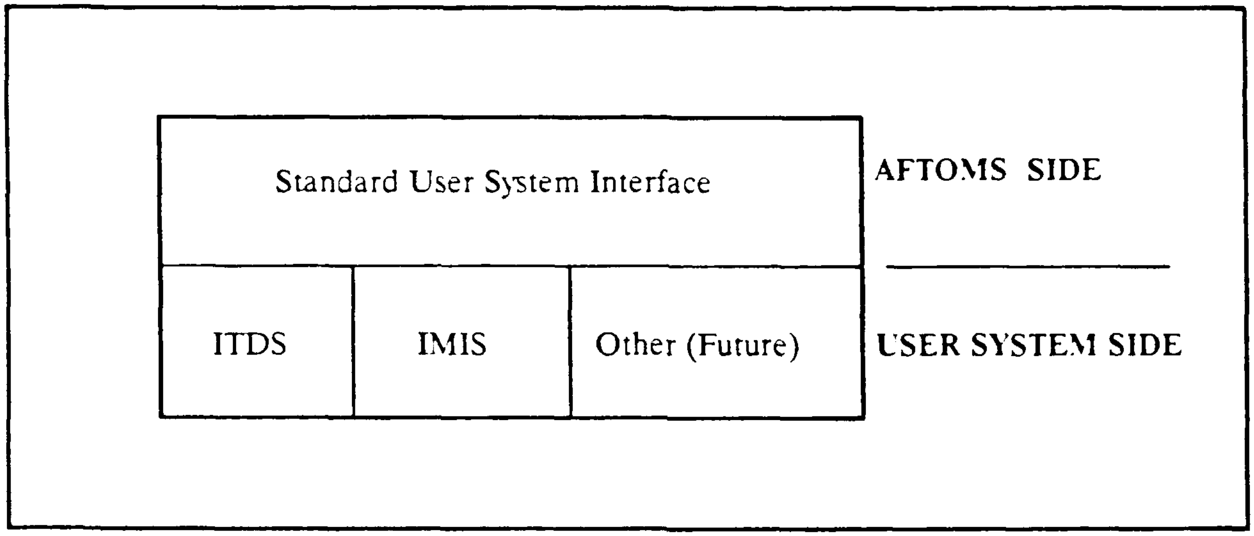


FIGURE B5-6. USER SYSTEM INTERFACE

B5.3.3 Other Systems

The IMIS system introduces the concept of *horizontal integration* to TOs. Horizontal integration is the integration of data, functions, systems, etc. within an organizational boundary (i.e. base-level maintenance). FIGURE B5-4 shows the different types of data that are usually used to perform maintenance activities. Similar situations exist in the engineering design and manufacturing areas. Two systems: Core Automated Maintenance System (CAMS) (deployed) and PDD (concept), fit into this category and warrant a closer look for interoperability with AFTOMS.

B5.3.3.1 CAMS

CAMS is a standard base-level system for maintenance data collection and maintenance management information and control. It is a transaction processing system that supports base-level maintenance for aircraft, ground-launched cruise missiles, engines, trainers, support equipment, test equipment, missiles, munitions, and communications electronics. CAMS also inputs job data and outputs information to personnel at remote locations in the maintenance complex.

Systems like ITDS and IMIS will exist at base level. CAMS currently exists at many bases and performs maintenance functions. How should AFTOMS interoperate with CAMS?

In FIGURE B5-4 TOs (AFTOMS) are linked with IMIS and Historical Data Collection (CAMS) is linked with IMIS. In the presence of an integrating system at base level such as IMIS, AFTOMS would not need to link directly with CAMS. CAMS is not a system that plays a direct role in the vertical integration of TOs; thereby, the linkage is indirect. However, if there is not an integrating system at base level and there is a need for TO data to be delivered directly to CAMS, the standard interface approach can be implemented for CAMS as well.

B5.3.3.2 Product Definition Data (PDD) System Concept

The PDD concept is depicted in FIGURE B5-7.

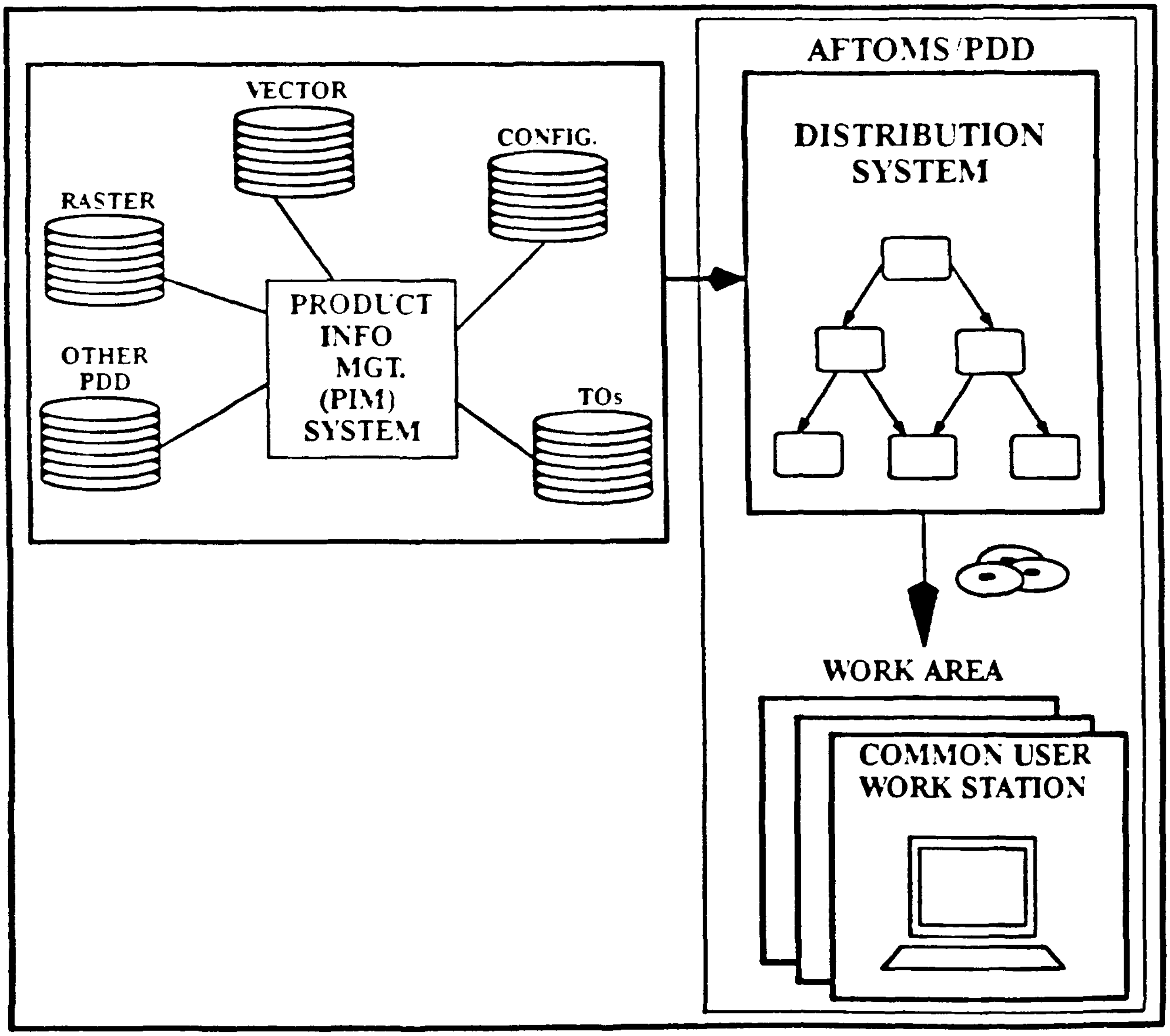


FIGURE B5-7. AFTOMS/PDD INTERFACE

The PDD concept has two major components: a Product Information Management (PIM) system, and the distribution system (that maps to the AFTOMS distribution system). PIM provides accurate and consistent data to the users of PDD by managing the access, storage, and change of the diverse types of PDD data (raster, vector, manufacturing data, specifications, etc.). PIM has three primary functions:

- **Data Management** – This function assigns descriptors that give each PDD component identifying information for later retrieval and cross-referencing with all other related PDD components. The Data Management system will access the PDD data in an integrated fashion.

- **Configuration Change Management** – This function makes use of this integrated PIM database during implementation of a change to an existing configuration item. All other affected data types that need to be changed are found via cross-referencing information and are updated to reflect the item change. One of these inter-dependent data types is TOs.

- **Data Usage** – This function records PDD data creation and use. This information will be used to focus future PDD data acquisitions and provide a monitoring of the operational capability.

PDD is currently a concept and the major use of the AFTOMS-PDD interface would be for support of the ALC sustaining engineering functions (modifications, repair, etc.). Because of the close relationship between engineering design changes and corresponding updates in TOs, it is important to link these data bases via another standard CALS interface.

B5.4 RISK ASSESSMENT

AFTOMS is a system that will be deployed in the F93–FY95 time frame. Systems such as ITDS, IMIS, and PDD have acquisition and deployment plans that overlap this time frame. Currently, these systems are all at the conceptual level and are more or less moving targets. Often, good ideas at the conceptual level are not that easy to implement and do not solidify until a workable detail design is produced. The timing is such that these programs will not reach a detail design level for several years. The risk that these systems will not interoperate remains high until more details are worked out in defining the standard interfaces.

CALS is an initiative that stresses interoperability. There is always a tendency in large efforts to try to acquire as much capability as soon as possible. Since AFTOMS is the first of the CALS initiatives, an inherent risk exists that the Air Force or DoD will try to turn AFTOMS into CALS. CALS goals need to be realized incrementally. AFTOMS, as currently scoped, is a first and very significant step for CALS. **To avoid adding risk, the Air Force must stabilize and maintain the scope of AFTOMS, and clearly identify the standard interfaces to other CALS systems.**

B5.5 RISK ABATEMENT

To reduce risk for timely deployment of AFTOMS and its interoperability with other CALS systems when they are deployed, the following activities should take place in the FY90-FY91 time frame:

- Work with all participating organizations to solidify the MIL-STD 1840 interface for acceptance of technical order data into AFTOMS;
- Develop a standard interface specification for user systems as soon as possible;
- Form a team, consisting of AFTOMS and ITDS personnel, to define in detail the AFTOMS-ITDS interface; and
- Form a team, consisting of AFTOMS and IMIS personnel, to define in detail the AFTOMS-IMIS interface.

SECTION B6:
System Buildability

B6.1 SCOPE AND RELEVANCE

The success of AFTOMS is predicated both on building a high quality system that conforms to the Request For Proposal (RFP) and then embedding it operationally into the AFLC organizational structure and culture so that it properly services the Air Force Using Commands. A poor quality system will not survive operationally, or will limp along at a substandard level of productivity, and certainly will not provide a solid technical order component for future CALS integration projects. On the other hand, a system that is not operationally accepted by either AFLC or the using commands -no matter how good its technical and other merits-must also be considered a failure.

The organizational issues (which essentially map AFTOMS functionality and responsibility to existing or new organizational elements, or which develop RFP requirements to prevent any such conflicts from arising) were considered to be outside the scope of the AFTOMS POC effort and are being addressed by the AFTOMS SPO. However, the POC team recognized that proper design and training approaches could help mitigate the organizational acceptance risk almost independently of the actual organizational mapping. Beyond that, the risks related to organizational issues will not be considered further in this section, which will now focus on system buildability issues.

System buildability addresses the integration of individual dimensions and technologies to the task of building a high-quality system that fully realizes the RFP. Since the RFP is not yet available, the To-Be Model was used as a partial surrogate for it. Aspects of system quality are discussed in Section B8 (Operational Utility) so they will not be addressed directly in this section; however, **the evaluation of buildability risk indirectly presumes high, but not excessively high, quality goals for AFTOMS.**

Within the foregoing context, system buildability can be assessed by developing a framework for modeling the project risk, evaluating the overall risk, identifying the risk contributors, and finding opportunities for risk reduction. **To facilitate AFTOMS system buildability, it is critical that the project risk be kept low overall, maybe medium in few carefully-managed areas where it can't or shouldn't be reduced further, and never above medium in any area; the latter would jeopardize the project.** The choice of actual technologies or methods of integration used is constrained by the other needs of AFTOMS (e.g., functionality, standards conformance, contribution to system quality, etc.), but within those constraints each choice may be traded off to reduce project risk.

B6.2 STATE OF INTEGRATION FEASIBILITY

To assess the feasibility of building AFTOMS, a framework for quantitatively modeling project risk must be developed. One useful and not overly complex analytical approach is to decompose the total project risk into a set of contributing risk factors, assess and weight both the importance and risk contribution of each such factor, and finally consolidate all these weighted contributions into an integrated whole. Using this model to provide a baseline reference, the project risk can be evaluated first as if no POC work had been done. Then, it can be reevaluated using the findings from the POC. The resulting changes in total project risk and the individual risk contributors highlight areas of significant post-POC residual risk, areas where risk reductions were attained readily or with difficulty, and thereby disclose opportunities for further risk reduction work if needed.

B6.2.1 Risk Decomposition

A hierarchical decomposition of total AFTOMS buildability risk is shown in FIGURE B6-1. Hierarchical decomposition is used because it provides a simple, familiar structure for methodically decomposing risk into components, then recursively decomposing each of those risk components, etc., as detailed and deep as needed; it offers two other major advantages: the level of detail in the decomposition can vary in different parts of the structure depending on what makes sense for a risk component; and nearby risk factors at the same level within a risk component can be traded off against their neighbors or modified to reduce the total local risk contribution of their parent component without significantly increasing the risk of more remote components. A small practical disadvantage of this structured decoupling is that weighting factors have to be developed for each risk contributor so that they all can be recombined into the whole project buildability risk.

Following this risk decomposition approach, the total **AFTOMS Buildability Risk** is decomposed at the first level into the following four component risks:

- **Task Risk:** Captures the risks associated with WHAT is being built;
- **Technologies and Tools Risk:** Captures the risks associated with HOW it will be built;
- **Project Resources Risk:** Captures the risks associated with the real-world CONSTRAINTS within which it has to be built; and
- **Team Risk:** Captures the risks associated with the various TEAMS involved in the building process.

Continuing with the FIGURE B6-1 risk decomposition to the next lower level, column-by-column, first consider the **Task Risk**.

B6.2.1.1 Task Risk Decomposition

The **Task Risk** is composed of the following two component risks:

- **System Complexity Risk:** Captures the risks associated with the INHERENT complexity of WHAT is to be built; and
- **Requirements Specification Risk:** Captures the risks associated with the QUALITY of the DESCRIPTION of WHAT is to be built.

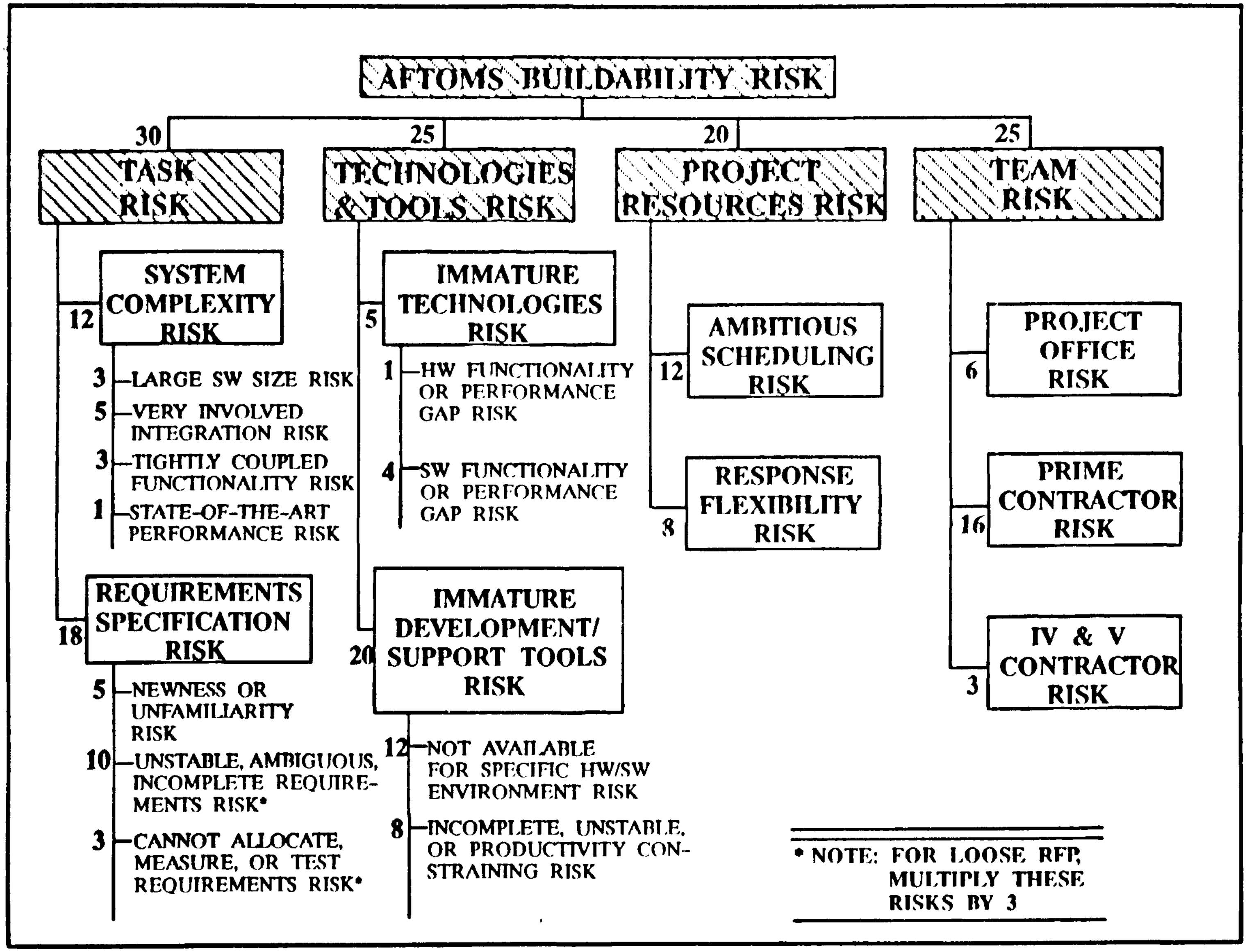


FIGURE B6-1. WEIGHTED RISK BREAKDOWN STRUCTURE

Continuing to the next level, each of the above two risk components is decomposed as follows. The **System Complexity Risk** is composed of the following four risk factors:

- **Large Software Size Risk:** Increases as the amount of functionality and the size of the software to be developed increases, but decreases (as in AFTOMS) if chunks of that functionality can be provided by integrating off–the–shelf commercial software products;

- **Very Involved Integration Risk:** Increases as the amount of functionality, number of commercial software products, variety of hardware platforms/operating systems/development languages/etc., and interfaces to other systems have to be used or integrated in a networked, distributed environment to build AFTOMS;

- **Tightly Coupled Functionality Risk:** Increases the problems associated with making local changes in functionality or correcting errors during testing if (through the design) effects of such changes are not or cannot be kept local, but interact (in perhaps intricate and subtle ways) with many logically remote parts of the system; the AFTOMS concept does not require much tight coupling of functionality; a

- **State–of–the–Art Performance Risk:** Increases when the system must break through the existing performance envelope and do things no other system has done before, and where every design tradeoff favors increased performance at the expense of other desirable characteristics; **AFTOMS makes no such extraordinary performance demands.**

Similarly, the **Requirements Specification Risk** is composed of the following three risk factors:

- **Newness or Unfamiliarity Risk:** Increases if requirements are being developed for functionality, hardware platforms, etc., outside the past experience of the RFP team so in effect the team is learning and specifying this system or type of system for the first time (AFTOMS' case);

- **Unstable, Ambiguous, Incomplete Requirements Risk:** Increases when the technical portion of the RFP is loosely stated so that significant requirements changes are required during development to clarify, elaborate, correct, integrate, or tradeoff initial RFP requirements (representing a potential problem in AFTOMS); and

- **Cannot Allocate, Measure, or Test Requirements Risk:** Increases when the RFP requirements are stated in such vague or general terms that they don't discriminate (in the hundreds of operationally important particulars) between a quality AFTOMS system and a poor one; and they don't provide the validation baseline needed for acceptance testing of the delivered system (representing another potential problem in AFTOMS).

B6.2.1.2 Technologies and Tools Risk Decomposition

Continuing to the **Technologies and Tools Risk** column of FIGURE B6-1, this risk component can be decomposed into the following two major risk subcomponents:

- **Immature Technologies Risk:** Captures the risks associated with the hardware and software technologies and products that will be integrated into AFTOMS and have to perform operationally during AFTOMS use; and

- **Immature Development/Support Tools Risk:** Captures the risks associated with the hardware and software tools used to build AFTOMS, and perhaps maintain it, but that will not become part of the operational system.

Continuing to the next level, each of the above two risk components is decomposed as follows. The **Immature Technologies Risk** is composed of the following two risk factors:

- **HW Functionality or Performance Gap Risk:** Increases if needed standards-compliant hardware platforms, peripherals, communications, or other devices cannot provide adequate support to AFTOMS functionality, or adequate levels of performance, throughput, and reliability; and

- **SW Functionality or Performance Gap Risk:** Increases if needed standards-compliant software technologies and products cannot provide needed AFTOMS functionality, adequate levels of performance, or require significant design changes or workarounds.

Similarly, the **Immature Development/Support Tools Risk** is also composed of the following two risk factors:

- **Not Available for Specific HW/SW Environment Risk:** Increases if hardware devices or software technology development/or tool products needed to build AFTOMS do not either exist, support required standards, or integrate/interoperate well with other system elements in the HW/SW development environment; and

- **Incomplete, Unstable, or Productivity-constraining Risk:** Increases if the development/support tools provide incomplete functionality, are not well-tested, or are operationally difficult to use.

B6.2.1.3 Project Resources Risk Decomposition

Continuing to the **Project Resources Risk** column of FIGURE B6-1, this risk component can be decomposed into the following two major risk subcomponents:

- **Ambitious Scheduling Risk:** Captures the risks associated with building and fielding AFTOMS in a compressed time frame, thereby requiring technical integration of many dynamically changing parallel activities; and
- **Response Flexibility Risk:** Captures the risks associated with quickly evaluating and resolving unforeseen technical problems or taking advantage of technical opportunities while maintaining forward project momentum to keep to the schedule.

These two risk components were not decomposed further because such details were beyond the scope of this POC study, and it was unnecessary to do so for judging and quantitatively estimating their risk contributions.

B6.2.1.4 Team Risk Decomposition

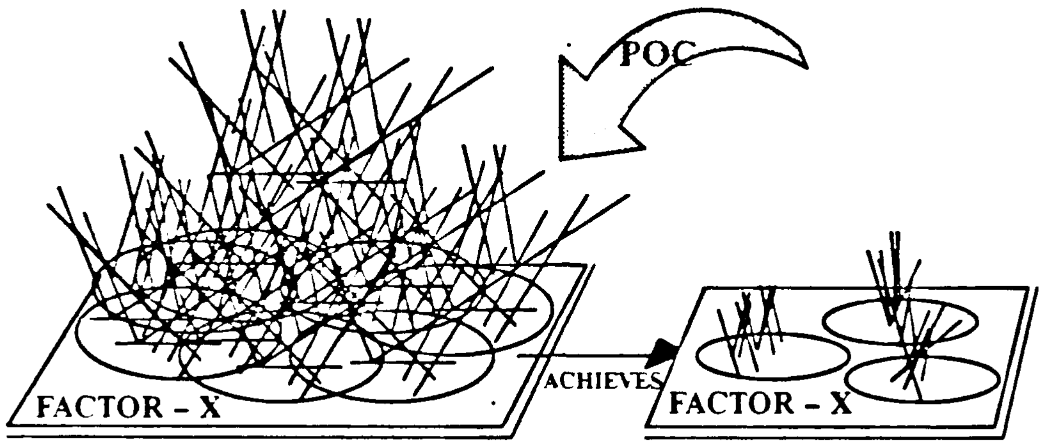
Continuing to the **Team Risk** column of FIGURE B6-1, this risk component can be decomposed into the following three major risk subcomponents:

- **Project Office Risk:** Captures the risks associated with managing a large, complex, technologically advanced project under conditions of an ambitious schedule, many suppliers of technology products and services, and with a team (SPO, Prime Contractor, and IV & V Contractor) that has not worked together before on a similar project;
- **Prime Contractor Risk:** Captures the risks associated with defining, architecting, designing, implementing, integrating, testing, documenting, installing, and managing a large-scale, technologically advanced and complex hardware/software integration project such as AFTOMS that involves numerous hardware and software product suppliers and subcontractors: and
- **IV & V Contractor Risk:** Captures the risks associated with reviewing and evaluating the prime contractor's interim and final technical products (i.e., requirements clarification, architecture, high-level and detail-level designs, implementation code, testing results, documentation, etc.), validating the system against the approved requirements, performing special studies for the SPO, and doing all this in a timely fashion so as not to jeopardize the schedule and ensure system quality.

These three risk components were not decomposed further because such details were beyond the scope of this POC study, and it was unnecessary to do so for judging and quantitatively estimating their risk contributions.

B6.2.2 Risk Contribution Modeling

Given the foregoing **AFTOMS Buildability Risk** decomposition, the resulting component elements (or risk factors of the decomposition) must be weighted and their relative risk contributions estimated. A simple model for doing this for any risk factor–X is shown in FIGURE B6–2.



PRE - POC

- **WEIGHTING (W):**

  A JUDGMENTAL MEASURE OF THE CUMULATIVE NUMBER AND SIZE OF THIS FACTOR'S RISK AREA/HOT SPOTS (i.e., the extent of the unknown areas, their integration complexities, and overall importance of this factor to the total system.

- **RISK (R):**

  A JUDGMENTAL MEASURE OF THE AVERAGE INTENSITY OF THE RISK WITHIN THAT FACTOR.

- **RISK CONTRIBUTION (C):**

  THE PRODUCT: W x R

POST - POC

- **SEE A NET REDUCTION FOR THAT RISK FACTOR IN:**

  THE NUMBER AND EXTENT OF HOT SPOTS; AND

  THEIR AVERAGE RESIDUAL INTENSITY OR RISK

FIGURE B6–2. RISK JUDGMENT AND WEIGHTING

Consider first the pre-POC perception of the risk contribution of factor-X. Intuitively, this risk contribution can be estimated as a product of two judgmental measures: how widespread or how much of the AFTOMS system does it potentially affect (captured as the weighting, W); and how much perceived risk does that factor potentially have (captured as the risk, R). Thus, with this model it is possible to have: a low-risk factor that is widespread which accumulates to a moderate risk contribution; or a high-risk factor that is localized which results in a moderate risk contribution at most; or a high-risk factor that is widespread which produces a very high risk contribution; or a low-risk factor that is localized which contributes little risk; or finally, various shadings of W and R which result in risk contributions ranging from low to high.

The POC activity (whether solely hands-on, solely hands-off, or some combination of the two) thinks through and evaluates either directly or indirectly that factor's role and effect on AFTOMS; and if its risk contribution is significant, it suggests appropriate risk abatement strategies. In this dual risk assessment/abatement process some pre-POC risk perceptions turn out to be non-existent or insignificant; whereas, others turn out to be significant, but can be avoided, neutralized, or managed with some change in strategy or design approach; while a few may turn out to be unabatable or even more severe than anticipated. Thus, the POC activity generally produces a reduction in W or R, or both, and results in a smaller risk contribution for factor-X.

For example, user interface technology is very important to AFTOMS. Pre-POC, its risk contribution was perceived to be very high because of the large number of interfaces to be built and their importance to system usability (combining for a high weighting W), and the emerging, still problematic state of technologies (X-Windows, graphic user interface development tool kits, etc.) for developing distributed, hardware-independent interfaces (producing a high R value). The POC activity reduced this risk contribution significantly by lowering W (since it demonstrated that any AFTOMS user interface could be developed as a minor variation on a few basic types), and by lowering R (since working with the technology products disclosed problem areas and showed that they could be resolved satisfactorily). Thus, aside from the issue of distributed performance, the post-POC risk contribution of user interface technology is low to moderate since the POC team has confidence that any user interface likely to be specified for AFTOMS can be built.

B6.2.3 Risk Estimating

The following quantitative estimates of weighting (W) and risk (R) were developed for the baseline pre-POC case.

Based on applying extensive experience (gained in developing military systems) to high-level requirements information specific to AFTOMS (gained doing pre-POC and POC work), the pre-POC weightings (W) of 30, 25, 20, and 25, respectively, were assigned to the four first-level risks; they are shown in FIGURE B6-1 next to each risk. These initial four weightings add up to 100, the total buildability risk. Continuing in this fashion downward through FIGURE B6-1, while comparing various risks to each other and consolidated weightings to their constituents, all the W-values were estimated, adjusted, and used in this analysis. These baseline W-estimates are also listed in the first numerical column of TABLE B6-1.

The R-value for each risk factor was judged as High (H), Medium (M), or Low (L), where high represents a 50% greater risk than medium and low is 50% less risky than medium. For a system in which performance is paramount in importance (e.g., Apollo or Star Wars) the spread between high, medium, and low would be set much greater, but for AFTOMS the narrower spread is suitable. The resulting R-estimates are listed in the second numerical column of TABLE B6-1.

Finally, for the baseline pre-POC case the risk contribution (C = W times R) for each lowest-level risk factor is shown in numerical column 3; for computability, it is based on setting medium risk at a level of 2. Risk contributions for the composite risk components are obtained by adding up their constituent risk contributions; and the total baseline pre-POC buildability risk for AFTOMS in FY91-FY93 under the expected scheduling conditions with a good, quality RFP is estimated at 2.67, which is one-third below a High rating.

The remaining columns of TABLE B6-1 show the estimated risk reduction results of the FY89-FY90 POC work. Separate risk reduction estimates were made for the hands-off, hands-on, and integrated total POC contributions. For each lower-level risk factor, its W and R values were judgmentally re-estimated in the light of the POC findings, and the computed risk contributions and consolidations were done as described above. The results are discussed below in Section B6.3.

Although all the weighting and risk estimates in this AFTOMS Buildability Model are judgmental (and therefore difficult to substantiate individually with documentation) they are reasonable as an overall pattern; and the number of risk components is large enough so that the total **AFTOMS Buildability Risk** is not that sensitive to small differences in the estimated values.

TABLE 6-1. KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK

KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK	BASELINE (NO POC)			RISK REDUCTION CONTRIBUTION FROM								
				TECHNOLOGY I&A REPORT ONLY			DEMO SYSTEM PROTOTYPING ONLY			COMPLETE POC (REPORT + DEMO)		
	W	R	C	W	R	C	W	R	C	W	R	C
● THE TASK:	.30		.86	.25		.61	.21		.44	.19		.32
1. COMPLEXITY OF SYSTEM INCREASES AS:	.12		.35	.11		.29	.10		.22	.08		.18
a. Software size is large	.03	H	.09	.03	H	.09	.02	H	.06	.02	H	.06
b. Integration is very involved: (# of I/Fs, functionalities, and variety of HW platforms, distributed sites, etc., being concurrently developed)	.05	H	.15	.04	H	.12	.04	M	.08	.03	M	.06
c. Requirements are interdependent and tightly coupled	.03	H	.09	.03	M	.06	.03	M	.06	.02	M	.04
d. Requirements stress some limits (e.g., extreme accuracy, precision, performance, etc.)	.01	M	.02	.01	M	.02	.01	M	.02	.01	M	.02
2. QUALITY OF REQUIREMENTS ADDS RISK IF:	.18		.51	.14		.32	.11		.22	.11		.14
a. Significantly different from previous implementations	.05	H	.15	.04	H	.12	.03	M	.06	.03	M	.06
b. Unstable, ambiguous, not clearly defined, or incomplete	.10	H	.30	.08	M	.16	.06	M	.12	.06	L	.06
c. Cannot readily allocate, measure, or test them	.03	M	.06	.02	M	.04	.02	M	.04	.02	L	.02

LEGEND:
W – Fractional Weighting (0.0 – 1.00)
R – Risk Assessment (H=3, M=2, L=1)
C – Risk Contribution (W x R)

TABLE 6-1. KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK (cont'd)

KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK	BASELINE (NO POC)			RISK REDUCTION CONTRIBUTION FROM: TECHNOLOGY I&A REPORT ONLY			DEMO SYSTEM PROTOTYPING ONLY			COMPLETE POC (REPORT+DEMO)		
	W	R	C	W	R	C	W	R	C	W	R	C
● THE TECHNOLOGIES/ TOOLS	.25		.73	.18		.35	.13		.13	.12		.12
1. TECHNOLOGIES ARE NOT MATURE	.05		.13	.03		.05	.03		.03	.03		.03
a. HW functionality or performance inadequate	.01	L	.01	.01	L	.01	.01	L	.01	.01	L	.01
b. SW functionality or performance inadequate	.04	H	.12	.02	M	.04	.02	L	.02	.02	L	.02
2. DEVELOPMENT OR SUPPORT TOOLS ARE NOT MATURE:	.20		.60	.15		.30	.10		.10	.09		.09
a. Not available for needed HW/SW environment	.12	H	.36	.08	M	.16	.05	L	.05	.04	L	.04
b. Incomplete, unstable, or productivity constraining	.08	H	.24	.07	M	.14	.05	L	.05	.05	L	.05
● THE PROJECT RESOURCES:	.20		.50	.16		.40	.16		.32	.14		.28
1. SCHEDULE IS AMBITIOUS: (Tight with a lot of parallelism)	.10	M	.20	.08	M	.16	.08	M	.16	.07	M	.14
2. RESPONSE FLEXIBILITY IS LIMITED: (Tight budget, lots of interacting parties, & serious time lags in making changes)	.10	H	.30	.08	H	.24	.08	M	.16	.07	M	.14

TABLE 6-1. KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK (cont'd)

KEY FACTORS CONTRIBUTING TO FY91-FY93 PROJECT RISK	BASELINE (NO POC)			RISK REDUCTION CONTRIBUTION FROM: TECHNOLOGY I&A REPORT ONLY			DEMO SYSTEM PROTOTYPING ONLY			COMPLETE POC (REPORT + DEMO)		
	W	R	C	W	P	C	W	R	C	W	R	C
● THE TEAM	.25		.58	.20		.38	.15		.28	.13		.25
1. SPO HAS LITTLE EXPERIENCE IN LARGE-SCALE HW/SW PROJECTS	.09	M	.18	.07	M	.14	.06	M	.12	.06	M	.12
2 CONTRACTORS HAVE MINIMAL EXPERIENCE IN:	.16		.40	.13		.24	.09		.16	.07		.13
a. User problem area	.03	M	.06	.02	L	.02	.02	L	.02	.01	L	.01
b. Building, integrating large-scale HW/SW systems	.05	M	.10	.04	M	.08	.03	M	.06	.03	M	.06
c. The relevant technologies and tools	.08	H	.24	.07	M	.14	.04	M	.08	.03	M	.06
● THE OVERALL NET WEIGHTED RISK:	1.00		2.67	0.79		1.74	0.65		1.17	0.58		.97
● PERCENT REDUCTION IN NET-WEIGHTED RISK:			0			34 8			56.2			63.7

B6.3 PARTICULAR INTEGRATION APPROACHES USED

AFTOMS buildability risk can be reduced by integrating POC findings into the remaining phases of the AFTOMS project: RFP development, proposal selection criteria development, architecture and design evaluation, IV & V oversight of development products, specific problem and alternative solution evaluation for the SPO, etc.

The TABLE B6-1 POC risk reduction results are summarized graphically in FIGURE B6-3. These results are taken relative to the baseline total **AFTOMS Buildability Risk** of High-minus (or 2.67) corresponding to a "Tight" RFP (about 350 pages of good quality technical requirements) and No POC.

For each POC activity scenario (R: Report Only POC, D: Demo System Only POC, and R + D: combined Report and Demo System POC), the upper half of FIGURE B6-3 depicts the estimated minimum and maximum buildability risk reductions for that activity under Tight RFP conditions. The minimum risk reduction estimate represents the case where the POC results are only integrated into the RFP and proposal selection criteria development products prior to contract award, and thereafter ignored; whereas, the maximum risk reduction estimate case presumes full integration of POC findings into the entire AFTOMS development and installation life cycle.

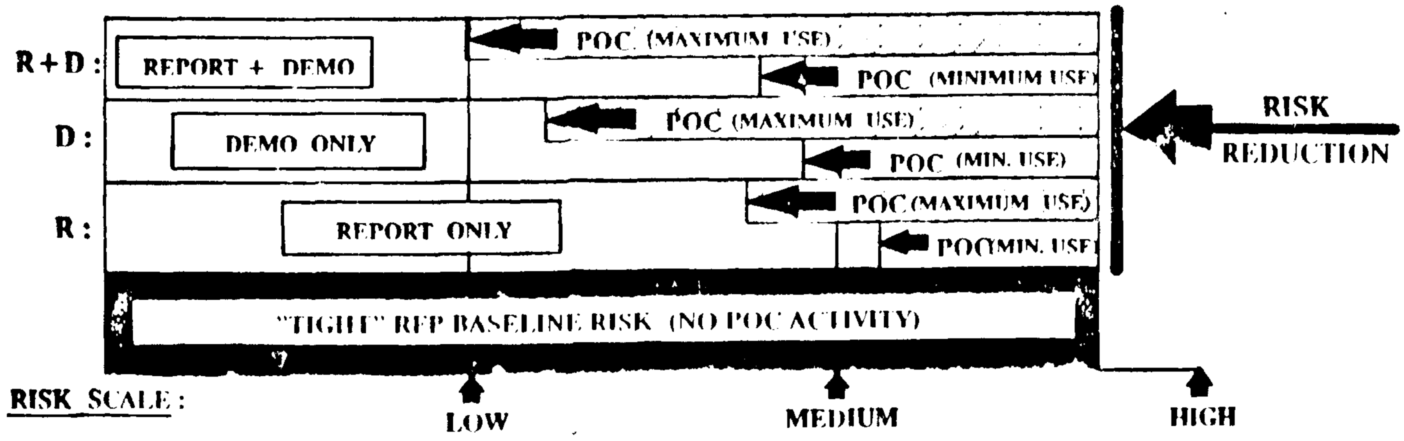
The bottom half of FIGURE B6-3 summarizes the maximum risk reduction contributions of the major risk components identified in FIGURE B6-1 for each of the three POC activity scenarios.

B6.3.1 In Demo System

The Demo System Only scenario shows the contribution of this POC activity to total buildability risk reduction: the baseline 2.67 risk is reduced to 1.92 (minimum reduction) or 1.17 (maximum reduction).

The risk reduction impact of the Demo System is greatest in:

- Improving requirements quality (57%) by providing a functioning table-top model that demonstrates key requirements (including user interfaces) and the interactions between elements of the AFTOMS concept;
- Reducing technology (77%) and development and support tool (83%) risks by working hands-on with leading representative products to build actual AFTOMS functionality rather than just doing generalized evaluations; and
- Reducing IV & V contractor (60%) and prime contractor (60%) team risks, and the response flexibility (47%) risk by providing a dynamic functioning table-top model of AFTOMS that can be kept current which is a useful framework for evaluating designs, problems, and potential solutions.



EFFECTS OF RISK REDUCTION ON THE KEY RISK CONTRIBUTORS :

- **TASK:**
  - -SYSTEM COMPLEXITY
    - R / D: -17% / -37%
    - R+D: -49%
  - -REQUIREMENTS QUALITY:
    - R / D: -37% / -57%
    - R+D: -73%
- **TECHNOLOGIES/TOOLS:**
  - -MATURITY OF TECHNOLOGIES:
    - R / D: -62% / -77%
    - R + D: -79%
  - -MATURITY OF DEVELOPMENT & SUPPORT TOOLS:
    - R / D: -50% / -83%
    - R + D: -85%
- **PROJECT RESOURCES:**
  - -AMBITIOUS SCHEDULING:
    - R / D: -20% / -20%
    - R + D: -30%
  - -RESPONSE FLEXIBILITY:
    - R / D: -20% / -47%
    - R + D: -53%
- **TEAM:**
  - -PROJECT OFFICE:
    - R / D: -22% / -31%
    - R + D: -33%
  - -IV&V CONTRACTOR:
    - R / D: -40% / -60%
    - R + D: -67%
  - -PRIME CONTRACTOR
    - R / D: -40% / -60%
    - R + D: -67%

FIGURE B6-3. POC FINDINGS SIGNIFICANTLY REDUCE AFTOMS BUILDABILITY RISK

B6.3.2 In Other Hands–on Technology Evaluations

Many technology products were evaluated individually before they were either selected or rejected for use in the Demo System. Experience with the selected ones is described in the Supplement to this report and is incorporated in Section B6.3.1; whereas, hands–on experience with the rejected ones is incorporated in Section B6.3.3. FY89 rejection of technology products for use in the Demo System **should not bias or preclude their reconsideration for the full–scale AFTOMS.**

B6.3.3 Other Assessments for FY91–FY93

The Report Only scenario shows the contribution of this POC activity to total AFTOMS Buildability Risk reduction: the baseline 2.67 risk is reduced to 2.20 (minimum reduction) or 1.74 (maximum reduction).

The risk reduction impact of the AFTOMS hands–off analytical activity, as supported by relevant independent product evaluations, is greatest in:

- Improving requirements quality (37%) by thinking through the AFTOMS concept and the functional and technology requirements needed to realize it;
- Reducing technology (62%) and development tool (50%) risks by investigating which technologies/tools could be used and how they should be used to build AFTOMS and avoid integration/performance problems; and
- Reducing IV & V contractor (40%) and prime contractor (40%) team risks by providing a useful framework for evaluating designs, problems, and solutions during development.

Comparing the Demo Only and Report Only risk reductions shows an interesting result: the Demo Only risk reductions are greater. This is because some Report Only thinking is still required in a Demo Only POC activity in order to be able to understand selected AFTOMS requirements and design a Demo System. Then the Demo Only adds to that the risk reduction findings from the hands–on aspects of working with technology products and development tools as well as integrating requirements to obtain working AFTOMS functionality. Taken singly, the Demo Only is more valuable for risk reduction than Report Only, but both together are even more valuable reducing the total risk to: 1.82 (minimum reduction) or 0.97 (maximum reduction). **This risk reduction synergy results from the fact that although there is some common ground covered by each type of POC activity separately, there are also many issues that are better explored using one approach or the other.** See Section 1.2.3 to understand the strengths and weaknesses of the hands–on versus hands–off risk assessment/abatement approaches.

B6.4 RISK ASSESSMENT

The system buildability risks for FY91–FY93 and beyond are:

- **Organizational Issues Risk:** This incorrectly or inappropriately maps AFTOMS functionality and responsibility to existing or new organizational elements which can affect the acceptance and implementation success of AFTOMS;

- **Misuse or Non-use of POC Results Risk:** This fails to take full advantage of the FY89–FY90 POC work (as described in Sections 2, 3, and 4) in order to maximize the potential for total buildability risk reduction (e.g., limiting POC use to pre-award activities and SPO products would only reduce the total risk from High-minus to Medium-minus rather than all the way down to Low, as is possible); and

- **"Loose" RFP Risk:** This awards the contract on the basis of a brief (about 50-page) technical specification that does not discriminate well between proposed solutions and relies on the contractor to develop the full set of detailed specifications required to build, test, and validate AFTOMS. Because of the tight project scheduling constraint, this would present developers with a moving requirements target, increase parallelism of activities to keep to schedules, add to integration risks, continually pose configuration control problems, increase the number of problems to solve, and probably result in a lower-quality system that will require Engineering Change Proposals (ECPs) to make acceptable. Using the buildability model to quantify this, **a "loose" RFP would result in a final total AFTOMS Buildability Risk of Medium, even if full advantage is taken of the POC findings, rather than the Low risk that's possible with a Tight RFP**; otherwise, the risk would remain High if POC is only used for pre-award activities.

B6.5 RISK ABATEMENT

The system buildability risks can be abated as follows:

- **Organizational Issues Risk:** This risk was beyond the scope of the FY89 -FY90 POC study, but the risk should be assessed by the AFTOMS SPO since it can impact RFP requirements, training requirements, and the strategy for installing AFTOMS.

- **Misuse or Non-use of POC Results Risk:** Reduce this risk by fully integrating the FY89–FY90 POC work into both pre-and post contract award activities to maximize the potential for total AFTOMS Buildability Risk reduction.

- **"Loose" RFP Risk:** Reduces this risk by using the POC findings to focus resources in the time available on particularly problematic or risky specification areas, thereby selectively tightening up the RFP in those areas offering the largest risk reduction payoff. Also, a more intensive FY90 and post-award Demo System enhancement activity could increase the downstream POC payoff (e.g., **Type C functionality could first be evaluated and integrated into the Demo System to determine the best approach for its integration into the full-scale** AFTOMS); similarly, other important issues could be investigated in parallel with the main AFTOMS activity without risking its progress.

SECTION B7:
Reliance on Conformance to Standards

B7.1 SCOPE AND RELEVANCE

Since certain standards are mandated by the U.S. Government there is no question that AFTOMS will have to conform to standards. Conformance to mandated standards must be total and direct (explicit) while conformance to other optional standards may be none, partial or total, and direct or indirect (implicit). Indirect conformance occurs when an integrated commercial technology product itself conforms to certain standards.

Applicable standards include data interchange standards as well as de facto and de jure computer industry standards. Each standard has its particular unique mix of advantages and disadvantages (relative to the needs of AFTOMS) which can impact AFTOMS development, performance, operational usefulness, and life-cycle costs. These costs arise from post-IOC maintenance, enhancement, modification, and upgrading efforts. Most standards are themselves constantly evolving to keep up with changes in technology, market factors, and the needs of users of standards. Integrating several commercial technology products, each supporting or non-supporting particular standards partially or completely, can prove troublesome because of the potential conflicts and resulting incompatibilities.

Therefore, risks exist for AFTOMS in relying on conformance to standards both individually and as an integrated group; and such risks cannot be totally avoided. The objective of this section is to explore the nature of these risks and propose key elements of a strategy for abating them.

B7.2 STATE OF INTEGRATION FEASIBILITY

The state of integration feasibility is assessed by first reviewing general considerations about standards, then defining a framework for viewing the integration of standards, and finally evaluating the problems and feasibility of integrating standards to facilitate building, using, maintaining and modifying AFTOMS.

B7.2.1 General Considerations

Standards, used properly, offer several significant advantages in developing large-scale software systems; these are:

- Ability to replace numerous detailed variants with a single standard option (or smaller number of options) that are easier to build and maintain, thereby reducing the quantity of customized integration required;
- Opportunity to buy and integrate Commercial Off-The-Shelf (COTS), standardized, sophisticated functionality rather than have to build it customized, thereby saving development time and cost, and leveraging available expertise;
- Benefit from the higher reliability inherent in standardized functionality as it has undergone heavier testing and usage in more varied circumstances, thereby assuring higher quality; and

- Benefit from the controlled flexibility afforded by standards to upgrade standardized functionality, add new functionality, port to other hardware platforms, and support new integration objectives, whether in functionality or standards.

Standards also have several potential disadvantages; these are:

- Tendency to freeze the state of the technology used below the constantly emerging state of the art, thereby sacrificing potential performance or functionality gains;
- Necessity to accept excess functionality needed to fully support a standard that is irrelevant to the task at hand, thereby adding to software overhead;
- Compromise to use a standard which does not do the required job because the standard itself is either incomplete, too restrictive, or a partial mismatch, thereby requiring additional customized support;
- Gross instability or obsolescence if the standard is not part of a predictably evolving technology, or is outgrown by hardware advances, or lacks the stability of substantial de facto usage, or is not widely supported by vendors or the government; and
- Unpredictable or negative interaction effects of combining and integrating multiple standards, some of which may be conflicting.

Essentially, the open system architecture viewpoint argues that reliance on conformance to standards is a sensible system development strategy. It acknowledges that the traditional goals of using the latest technology, maximizing performance, minimizing resource utilization, and customizing functionality to support cosmetic variants –while still important to some degree– are now outweighed by the long–term goals of usage and maintenance productivities. Therefore, the best system development strategy for a large–scale, long–lived, heterogeneous, operational system like AFTOMS is to take advantage of the benefits of particular standards while neutralizing or managing their problems; and if that is not possible, then balancing their benefits and their associated problems. This requires the successful integration of many standards. The following presents a framework for defining and evaluating such an integration.

B7.2.2 Framework for Standards Integration

Individual applicable standards are categorized, listed, and characterized in TABLE B7–1 by compliance status, benefits, and comment (if applicable).

Compliance status is either: **Gov't Req'd**, which marks those standards that are mandated by the government and apply to AFTOMS; **AFTOMS Req'd**, which identifies those standards that are essential to the success of AFTOMS; or **AFTOMS Opt'l**, which identifies those optional standards that may be useful to AFTOMS given a particular design approach.

Benefits are split into two major categories, each with two subcategories, as follows:

- The first major category identifies those standards that simplify either using the system (**Use**) or building it (**Build**), thereby reflecting near-term benefits; and
- The second major category identifies those standards that provide long-payoff benefits by facilitating either maintainability (**Maint.**) or future integration (**Integ.**) with other technical order and CALS systems.

An asterisk preceding the standard's name indicates hands-on use of that standard in the AFTOMS Demo System. Superceding or related standards or other plans are noted in the comment column of the table.

It is assumed that AFTOMS is not subject to any overriding standards (such as safety for a nuclear facility or survivability for a critical weapon system) which would take precedence over the standards listed in TABLE B7-1. Therefore, only integration of the listed standards need be considered for risks.

Using this framework, the integration risk assessment proceeds in decreasing priority order: from left-to-right by column (first the **Gov't Req'd** group, then the **AFTOMS Req'd** group, and finally, the **AFTOMS Opt'l** group), and top-to-bottom by each standard within that column. For each standard within a column, its integration risk is assessed against all the standards already integrated in the preceding, higher-priority columns and against the higher-listed standards in its own column. Using the data gathered in the POC activity, this risk assessment identifies the:

- Standards gaps;
- Conflicting incompatibilities;
- Unusual current or future instabilities;
- Constraining inflexibilities;
- Performance degradation; and the
- Status of the standard (de facto or de jure, substantially defined or not, accepted or controversial, and is it in competition with another standard).

TABLE B7-1. AFTOMS STANDARDS FRAMEWORK

STANDARD	COMPLIANCE			SIMPLIFIES AFTOMS IN		LONG-PAYOFF BENEFITS IN		COMMENT
	Gov't Req'd	AFTOMS Req'd	AFTOMS Opt'l	Use	Build	Maint.	Integ.	
Data Encoding Interchange:								
MIL-STD 1840	X	X		X	X	X	X	Needs DTD/OS
*ASCII	X	X		X	X	X	X	
IGES	X		X					CGM & PDES
CGM	X	X		X	X	X	X	CGM Extension
CCITT/Group 4	X	X		X	X			
*SGML	X	X		X	X	X	X	Interactive SGML
PDES			X				X	For CALS
Data Storage Access:								
*ANSI SQL		X		X	X	X	X	
*Optical (general use)		X		X	X			Need Stds.
Archival optical			X	X	X			Not Acceptable
Digital User Interfacing:								
*X-Windows		X		X	X	X	X	
*WYSIWYG			X	X				
Digital Communication:								
OSI	X	X			X		X	AFTOMS Goal
GOSIP	X	X			X		X	Support OSI
*Ethernet	X	X		X	X		X	Per GOSIP
*Token Ring	X		X				X	Per GOSIP
X.25	X	X		X	X		X	Per GOSIP
*TCP/IP			X	X	X			Support TP4/IP
X.400	X					X	X	Per GOSIP
*NFS			X	X	X			Support TP4/IP
Platforms Hardware:								
*SCSI		X		X	X		X	To SCSI-2
Scanning		X		X			X	Conversion

Legend:

*Indicates Hands-on POC Usage

FIGURE B7-1. AFTOMS STANDARDS FRAMEWORK (CONT'D)

STANDARD	COMPLIANCE			SIMPLIFIES AFTOMS IN		LONG-PAYOFF BENEFITS IN		COMMENT
	Gov't Req'd	AFTOMS Req'd	AFTOMS Opt'l	Use	Build	Maint.	Integ.	
Software Development:								
*UNIX	X	X			X	X	X	
POSIX	X	X			X	X	X	To UNIX
*ANSI C		X			X	X	X	
C++			X		X	X	X	Use With C
Ada	X		X		X	X	X	Use in Design
CASE		X			X	X	X	For Design Quality
Document Structure, Tagging & B+ Enhancement, and Display:								
ODA/ODIF			X	X			X	Future
*PDL		X		X	X	X	X	To SPDL
Training:								
*Hypertext		X		X	X	X	X	For Linking

B7.2.3 Integration Feasibility and Problems

B7.2.3.1 Government Required Standards

Data Encoding and Interchange Standards

The Data Encoding and Interchange standards are fairly well integrated except for some overlap between Initial Graphics Exchange Standard (IGES) and Computer Graphics Metafile (CGM). Since IGES currently has operational problems, it will be supplanted in the mid-to-late 1990's for sophisticated technical applications by an approved Product Data Exchange Standard (PDES). IGES is inferior to CGM for simple, AFTOMS-style 2-D technical illustrations. CGM or raster Consultative Committee for International Telephone and Telegraph (CCITT)/Group 4 should take precedence in AFTOMS. However, if the development and operational usefulness of CGM is delayed beyond FY91, then IGES support may have to be provided in AFTOMS to accept vectorized TOs from contractors. The other standards in this group are complementary. **The biggest risks in this group arise from the slow development of validated DTD and OSs to support MIL–STD 1840.**

Digital Communications Standards

The Digital Communication standards are also fairly well integrated since they support various elements of the master OSI architecture for interconnection. Only the Ethernet and Token Ring standards overlap because they provide competing, alternative architectures for LANs. Either one can be used in AFTOMS. But given that DoD's Unified Local Area Network Architecture (ULANA) program is installing Ethernet earlier than Token Ring LANs, and that most of AFTOMS-relevant technology products provide extensive support for the Ethernet protocol, AFTOMS should favor Ethernet except where a particular technology product requires the Token Ring protocol or where the deterministically predictable performance of token passing is required.

Software Development Standards

The Software Development standards are currently partially integrated, but should be further integrated by FY91. There are several different versions of UNIX (AT&T V.3, Berkeley 4.3 Berkeley Systems Development (BSD), Open Software Foundation (OSF) 1.0, etc.), which do not yet support the Portable Operating System Interface (POSIX) standard. AT&T's V.5 version reportedly will be POSIX-compliant. POSIX itself is evolving and being completed. For example, POSIX now only defines an interface between programs written in the C language and the UNIX operating system; work is currently underway to define an Ada language adaptation for POSIX and a language-independent version of POSIX. POSIX work is also being performed in networking and security issues.

There are no significant integration problems between standards listed in the different groups within the **Gov't Req'd** column.

B7.2.3.2 AFTOMS Required Standards

The Data Encoding and Interchange standards and the Digital Communication standards in this column are completely consistent with the same standards in the preceding column, including the critical need for validated DTD and OS specifications to support MIL–STD 1840.

The standards listed in the Data Storage & Access group, Digital User Interfacing group, Platforms & Hardware group, Document Structure, etc., group, and the Training group focus on additional functionalities which do not conflict with any of the preceding standards discussed and, therefore, should pose no significant integration risks. Over the next few years, official support for some of these standards will develop and become incorporated into the Gov't Req'd column.

In the Software Development group, American National Standard Institute (ANSI) C and Computer-Aided Support Environment (CASE) are additions to the preceding discussion.

Both are complementary. POSIX, which supports C, will also support ANSI C; and POSIX will support portions of a UNIX-based CASE environment for development and maintenance. Ada (a programming language per MIL-STD 1815), which could be used on AFTOMS to develop the design, is supported by a standard CASE environment called the Ada Programming Support Environment (APSE). Non-Ada CASE environments are not likely to become standardized soon.

There are no significant integration problems between standards listed in the different groups within the **AFTOMS Req'd** column.

B7.2.3.3 AFTOMS Optional Standards

The IGES, PDES, and Token Ring standards appearing in this **AFTOMS Opt'l** column have already been discussed; they are not central to the success of the AFTOMS concept, but may have to be supported because of specific considerations for MIL-STD 1840 contractor compliance, future integration with the Product Definition Data (PDD) system concept, and commercial application constraints.

The Data Storage & Access group lists optical disk for archiving as optional because standards are essentially non existent and the government does not yet recognize optical media as officially trustworthy media for permanent storage.

The WYSIWYG standard in the Digital User Interfacing group is a useful optional standard for Tier 2 processing. It is being integrated with the PDL standard, and poses no significant integration problems with other standards listed.

In the Digital Communication group, Transmission Control Protocol/Internet Protocol (TCP/IP) and Network File System (NFS) are existing standards that will be superceded by Government Open System Interconnect Protocols (GOSIP) requirements to go to TP4/IP, but will still be supported in practice as a subset or variant. Since GOSIP does not cover workstation-based environments, AFTOMS may have some flexibility in choosing which standards to support if such a choice provides significant advantages.

In the Software Development group, C+ + and Ada are listed as **AFTOMS Opt'l**. C+ + is listed because it is object-oriented, preferable to C for developing certain types of software, compatible with C and the preceding standards, as well as the base language for UNIX V.5 and a growing list of sophisticated UNIX-based application technologies. Whereas, Ada is listed because it may only be suitable for the design, but not the implementation of AFTOMS; the reason being that X-Windows, which is critical to AFTOMS, is not yet supported in an Ada environment.

Finally, the Office Document Architecture/Office Document Interchange Format (ODA/ODIF) standard is listed as a future AFTOMS possibility for supplementing SGML to control and interchange formatted documents like office memos. At best, it is an incomplete standard which is not yet required for CALS, but may become incorporated into a future version of GOSIP. Future integration with PDD may require support for the Electronic Data Interchange (EDI) standard within AFTOMS which will be a part of MIL-STD 1840. There are no significant integration problems between standards listed in the different groups within the **AFTOMS Opt'l** column.

B7.2.3.4 Implicit Standards

Implicit standards are important because AFTOMS-integrated application technology products could embody some standards which may pose integration risks with any of the foregoing standards. This is less-troublesome for UNIX-based products which are less proprietary-oriented in general, and therefore, are more likely to provide incomplete support of standards rather than present incompatibilities. Most likely, AFTOMS, will integrate the following four critical application technologies: DMS, RDBMS, UIMS, and ODS.

DMS products are not now standardized; they use proprietary file structures which make the AFTOMS TO databases less portable and offer significantly different functional capabilities. Therefore, they are less compatible. Newer DMS products are showing a trend toward using a RDBMS or an object-oriented database technology for document storage and management. However, the lack of DMS standards is likely to continue for several years and adds risk to future life-cycle maintainability.

RDBMS products all support ANSI SQL which provides a standard for guaranteeing schema and data portability across products so they add minimal risk to standards integrations.

UIMS products are relatively new and most are based on the X-Windows standard to obtain network capabilities and device independence. However, they do use competing incompatible toolkits to construct the aesthetic user interface environment. In a few years, these toolkits will mature and evolve into one or two de facto standards (i.e, Open Look from UNIX Int., Motif from OSF, etc.).

ODS products are just emerging; in general, they support a Program Design Language (PDL) version for screen output, usually display PostScript. In the future, they will likely support Standard PDL (SPDL), a standard PDL being defined by International Standards/Services Organization (ISO). ODS products have to link into a DMS product to obtain the displayable content which can pose an integration problem with some DMS systems.

B7.3 PARTICULAR INTEGRATION APPROACHES

One of the most important goals of the Demo System effort was to employ as many computer-based standards as possible. The POC activity has identified standards as one of the critical success factors for AFTOMS. In selecting the component modules, the Demo System team had two main criteria:

- Demonstrate the major functional activities identified in the AFTOMS system concept: and

- Develop a heterogeneous system by adhering to as many government and industry standards as possible.

The computer industry has had a major change in its approach to building systems over the past few years. The Seybold Report on Publishing Systems refers to the modern systems as Fourth Generation Systems. The fundamental concept is that systems are built and integrated from hardware and software components readily available in the marketplace from many diverse suppliers. Integration is the main task and adherence to standards make this approach viable. Most major suppliers in the computer industry adhere to this concept and are building components and system products in this manner.

The AFTOMS Demo System team wanted to employ the same strategy. However, this revolution in the computer industry began only recently and most of these type of products are recent offerings or pre-release (Beta) versions. The Demo System activity was scheduled for development in FY89 and completion in early FY90. The above-stated conditions forced another set of decision filters in regard to the selection of components adhering to standards:

- Decisions had to be based on adhering to the schedule;
- Products selected (even, if pre-releases) needed to have some level of support from the vendor; and
- Products selected needed to be integratable with the other selected components.

Despite all those factors in the decision process, a significant number of products supporting industry standards were employed. They include:

- UNIX;
- Ethernet;
- Token Ring;
- TCP/IP;
- NFS;
- X-Windows;
- SQL;
- C;
- PostScript; and
- SGML.

The use of X-Windows proved to be a big success story. A major concern of Air Force management was the protection, portability, and coexistence of the software with other CALS software. X-Windows has been created and advertised as the solution to these key issues. The experience in the Demo System activity bears this promise out. The user interface software for AFTOMS was developed on one manufacturer's workstation with their X product (window system and toolkit) and subsequently ported and executed on two different workstations in their X-Window environments. The user interface looks the same to the users (except for minor details). This software could coexist with other CALS applications in any X-Window environment which addresses the problem of proliferation of workstations and terminals for multi-applications users in the CALS world. Also, this solution allows the application to be totally independent of the hardware and operating system.

Another standard that was employed with a successful outcome was NFS. CALS, and certainly AFTOMS, will consist of many computer systems with their proprietary underlying file systems. These systems need to interact with each other to access and transfer information stored in these file systems. NFS is designed to solve this problem. The Demo System successfully used NFS to allow the proprietary file systems to interact because they all support the NFS standard.

Within AFTOMS, the data management activity will make heavy use of an RDBMS. The basic components of AFTOMS are the user interface and the database. The user interface repeatedly and consistently fields user requests requiring an access (ie. query or update) to the database. In the relational database model, SQL functionality provides this access capability; many vendors support this SQL interface. The Demo System user interface software uses embedded SQL calls mixed with C language code to interface to its database. This SQL interface will allow a change to a different RDBMS product without having to modify the Demo System user interface software.

B7.4 RISK ASSESSMENT

The following risks, which complicate AFTOMS integration, were identified:

- **Standards Gap Risk**: DMS technology products lack standards which could increase AFTOMS life-cycle costs; and optical media are not acceptable as a standard yet for archiving permanent data within a government environment, which could force interim use of paper or microfilm for archival storage. Development of validated DTDs and OSs is a slow process: these support MIL-STD 1840.

- **Standards Interaction Risk**: As an implementation language, Ada does not yet support POSIX or X-Windows and would complicate AFTOMS development and integration.

- **Standards Instability Risk**: Affecting the evolving POSIX-standardized flavor of UNIX to a small degree; and the maturing, settling down of emerging technologies: Optical media and devices, CASE environments, UIMS, and ODS.

- **Standards Obsolescence Risk**: This is a minor risk as the IGES, TCP/IP, and NFS standards are being superceded by other standards; these sets of standards may need to be supported based on the details of the AFTOMS design.

B7.5 RISK ABATEMENT

Risk abatement strategies for the four classes of identified risk follow:

- **Standards Gap Risk**: If a DMS functionality–versus–standards tradeoff must still be made in FY91, then select that DMS technology product which supports the complex technical publishing and document configuration control requirements, yet is on a development path that will make the DMS product less proprietary over time. To handle the archiving problem, perhaps optical media could be used for semi–permanent archiving (e.g. 10–15 years) until the media standards become solidified and optical media become accepted by government as trustworthy for permanent storage. In the meantime, archival integrity could be sampled periodically, and technical order data rewritten automatically to resolve any quality deterioration. Development and validation of standardized DTDs and OSs should remain a high priority program issue.

- **Standards Interaction Risk**: Ada should not be used at all or used only as a design language to gain design portability; then use C or C++ to implement the portable design description.

- **Standards Instability Risk**: Minimize dependence on unstable or unpredictable standards (which is not easily possible in AFTOMS), and design in flexibility using interfaces, logical objects, or software layering to absorb changes in these standards; **avoid tight integration**.

- **Standards Obsolescence Risk**: Localized effects of conflicts or overlaps between standards can be minimized through design by constraining standards to independent functional areas, separating standards by system element location, layering standards, and by controlling standards through networked system administration.

SECTION B8:
Operational Utility

B8.1 SCOPE AND RELEVANCE

In general, each dimension of integration in this report focuses on a particular view into AFTOMS which evaluates aspects of many functionalities, technologies, and related issues to explore the risks and implications associated with that viewpoint. In fact, the same area of functionality, technology, or issue may be represented in more than one dimension of integration, which cannot be avoided in a complex interactive system such as AFTOMS; but the resulting exploration is not the same since the integrating focus of each dimension is different. The resulting exploration of any complex topic from multifocused viewpoints provides a more thorough, understanding of that topic. Therefore, several topics already partially covered in other sections are revisited in this section from the viewpoint of operational utility.

The focus of operational utility is actual use of AFTOMS after it is built; that is, what are the important considerations and risks in making AFTOMS:

- Realize its projected benefits as quickly as possible after Initial Operational Capability (IOC);
- More productive in day-to-day use; and
- Support future enhancements and integration with other technical order or technical data systems which emerge from the CALS initiative.

The viewpoint and scope of this section are designed to identify the critical alternatives and tradeoffs in functionality, technologies, methods of using the technologies, procedures, etc., that can be incorporated into the Full Scale Engineering Development (FSED) phase of AFTOMS development which will then leverage the operational utility of the system. Actions taken after IOC will have less leverage, be mostly corrective in nature, and are not considered explicitly.

B8.2 STATE OF INTEGRATION FEASIBILITY

Discussion of relevant, operational utility enhancing issues is facilitated by grouping these issues into three categories to:

- Accelerate startup;
- Promote productive daily use after installation; and
- Support long-term productive viability.

B8.2.1 Rapid Startup

Although AFTOMS is capable of managing both a paper and digital technical order environment, it is primarily designed for (and operates most optimally in) a fully digital environment; therefore, any measures that can accelerate the transition and progress toward a full-digital environment will both simplify technical order management and distribution, and increase the benefits from AFTOMS. Such measures include:

- Intelligent packaging and rapid installation;
- Weapon System (WS) selection and digital technical order acquisition or scanning conversion; and
- Adequate staffing and quick user training.

B8.2.1.1 Intelligent Packaging and Rapid Installation of AFTOMS

Intelligent packaging includes a weapon system configuration tool, good quality system and operational documentation, together with automated, and mostly, standardized installation procedures.

The WS configuration tool would define an AFTOMS configuration and time-based database loading plan appropriate to the particular characteristics of a TOMA's weapon system. The configuration tool would specify required resources (i.e., workstation platforms, printers, database sizing, archival sizing, optical disk devices, LAN & WAN communications, software functionality distribution, interfaces to ATOS I and G022, handling contingencies and survivability problems, etc.) to handle the weapon system; and adapt the configuration to account for ULANA and DDN scheduling. The data loading plan would specify, the numbers of paper and digital WS and commodity TOs, the numbers of outstanding change requests, the paper-to-digital conversion progress, and the numbers of Tier 2 operators needed for cataloging/indexing, B+ tagging, change processing, etc.

B8.2.1.2 Digital Database Development

This measure addresses the size and quality of the digital TO database supporting a WS TOMA. The size, as represented by the percentage of the total WS inventory of TOs in digital form, is important to maximize the AFTOMS benefits to the TOMA managing that WS suite of TOs. Therefore, effective acquisition planning/management tools for timely acquisition of new digital TOs or contractor-implemented changes to existing TOs, and an aggressive but economical program of scanning conversion of paper TOs into digital form are critical to maximizing the digital database size. In fact, the scanning conversion should be performed in anticipation of AFTOMS installation at a WS TOMA.

Once a TO is in digital form, its quality determines its usefulness for change processing at Tier 2 and on-line display at Tier 4. Thus, Type B– is adequate for digital distribution, but Type B is needed to facilitate change processing, whereas Type B+ provides superior information tailoring and control to individual Tier 4 users. Depending on the original Type A TO quality and format peculiarities, scanning conversion may only allow a B– form; additional Tier 2 manual-assisted work would be required to convert it to MIL-STD 1840 compliant Type B form. Type B+ requires additional Tier 2 manual-assisted work to tag the TO contents for customized delivery; the degree of B+ tagging can be controlled incrementally and increased over time (as experience is gained) to provide recurrently useful capabilities to Tier 4 at the one-time cost of additional processing at Tier 2. New digital TOs acquired from contractors should be at least Type B and perhaps already tagged to a specified level of Type B+. Not all the TOs in an AFTOMS database have to be at the same level of tagging quality; but if they are not, then some of the above benefits are sacrificed for those at lower quality levels, and certain automatic referencing capabilities may only be one-sided (i.e., from B+ to B TOs, but not vice versa). However, for older TOs and those that are relatively inactive in terms of change management, a lesser quality would be an acceptable economic tradeoff.

Type C TOs will be stored separately from the Type B class database since Type C TOs utilize an incompatible data model and will be delivered separately to Tier 3. Contractors will presumably deliver them in a Type C compliant format which is yet to be defined.

B8.2.1.3 Staffing and User Training

Adequate staffing is needed initially, particularly at Tier 2, to perform the cataloging, indexing, and tagging of a new digital database to prepare it for distribution by AFTOMS; then, for working and reducing the backlog of outstanding change requests to improve the accuracy of the digital database.

Good user training is needed to make effective use of the AFTOMS capabilities. AFTOMS design itself, in terms of simplified consistent interfaces and interactive help and training facilities, should reduce the training burden overall. But the residual burden requires training support which will vary by function: Tier 4 needs will be minimal, whereas Tier 2 publishing technicians will need the most training support. Type C capabilities will require additional training complexity and time at Tiers 2 and 3. However, in no case should it require more than a few days of training at the outset to begin performing productive work.

B8.2.2 Productive Daily Use

Once AFTOMS is past its transient startup phase at a TOMA, it will be ready for productive daily operational use. AFTOMS productivity can be measured at the TOMA and AFTOMA levels by how well the system:

- Distributes TOs;
- Reduces the change request backlog and correction turnaround time;
- Increases the accuracy level of distributed TOs;
- Improves verification accuracy and timeliness;
- Improves TO usefulness;
- Reduces Cause Code 1 mishaps at Tier 4; and

- Allows for TO cost control separate from weapon system cost.

AFTOMS daily use can be made increasingly more productive by attention to the following issues:

- Practical functionality;
- Database capacity and quality;
- Performance adequacy;
- Reliability and maintainability; and
- User competency enhancement.

B8.2.2.1 Practical Functionality

AFTOMS functionality must be designed and implemented with operational simplicity as a key consideration and error recovery a straightforward matter. This is supported by good design and consistent implementation of simple user interfaces, and careful allocation of functions to the different classes of users.

B8.2.2.2 Database Capacity and Quality

Digital database capacity sizing must account for the number of TOs in a TOMA's inventory (e.g., a B1-B Bomber adds a million pages of new TOs to some base of commodity TOs), up to 30 Kbytes of storage per average TO page, and the added storage required to support AFT022s, cataloging/indexing/B+ tagging information. Additional work spaces must be provided to support productive processing at the various tiers. The database must also be distributed to support the workers while reducing loading and delays on communication lines. The higher the database quality in terms of number of B+ tags per average TO page, the more storage space required. Database servers can be readily added to a network as needed so capacity can be added incrementally and balanced for improved network performance.

B8.2.2.3 Performance Adequacy

Access and processing performance at the various tiers are important to reduce user frustration and errors, and to build user confidence in AFTOMS. Performance should match the perceived complexity of the operator commanded action. For example, local actions should take no more than a few seconds because almost immediate feedback may be required for the operator to base the next action on; whereas, database searches may take minutes. Predictability of outcomes upon which users can build expectations and adapt their work rhythms is more important than a specific response time in any situation. Perhaps for extended tasks, the system can reply with some indication either beforehand or during the operation roughly how extended the operation might be, and whether the operation is progressing satisfactorily so no further user action is needed or initiated in a state of frustrated uncertainty.

B8.2.2.4 Reliability and Maintainability

AFTOMS must operate reliably: that is, users should know what to expect, and the system should produce it each time the action is repeated in similar circumstances; breakdowns or errors should be fairly rare in occurrence, and most rare for frequently invoked actions so that their incidence per human time (a day, week, or month) is no greater than for complex or infrequently performed actions; otherwise, the system will be perceived to be problematic and unreliable; and recovery from errors could be either automatic or user-initiated, but should be relatively quick and straightforward thereby building confidence that the user is in control.

Relying on effective object-oriented design techniques, adhering to standards, and using the mainline well-tested functionality of production grade commercial systems should provide a highly reliable system; and good user interface design can address the perceptual issues discussed above.

This approach will also make AFTOMS more maintainable as problems within the integrated commercial technology products will be corrected by the vendors and the Air Force need only maintain the integrating "glue" software. If the commercial repair turnaround is not soon enough, a temporary workaround is advised since making permanent customized quick fixes to sophisticated technology products is difficult and potentially troublesome.

Reliability should also be extended to include AFTOMS recovery from contingencies. Contingencies include abnormal events such as power outages, fires, communication interruptions, Electromagnetic Pulse (EMP) damage to computers, etc. Impacts on AFTOMS operations will differ depending on tier, function, and the contingency scenario. Since TO availability is most time-critical at Tier 4, paper copies of digital TOs can be maintained locally (e.g., at CTODO or in WAs) for backup. Otherwise, contingency plans should be developed and implemented based on a set of contingency threat scenarios. These scenarios should include the most probable single-event contingencies and a representative set of less probable multiple-event contingencies.

Then an integrated contingency recovery plan can be developed (and distributed as a TO) to include both a common part which is applicable to all contingencies and specific parts each of which is applicable to a specific contingency scenario. This plan should address, but not be limited to, the following issues:

- Data recovery from archived sets;
- Workload shifting to alternate sites;

- Special equipment (e.g., uninterruptable power sources); and
- Special procedures (e.g., rapidly deployable reserve equipment).

This plan should be balanced and tailored to reflect the different cost-benefit considerations; and its implementation should be scalable to the scope of the AFTOMA, each TOMA, and each CTODO. The configuration tool mentioned in Section B8.2.1.1 would incorporate relevant aspects of this plan.

B8.2.2.5 User Competency Enhancement

User training should not end during the initial installation phase. Once the user develops an experience base and is prepared for the next level of training, occasional short training sessions are useful to reinforce good work habits, and teach new or more advanced and productive "power" techniques. This approach periodically enhances average user competency to make full use of the capabilities built into AFTOMS and paid for by the Air Force.

B8.2.3 Long-Term Viability

For long-term viability a system must support change. It cannot be rigid and fragile; difficult or costly to change; and cannot become technologically obsolete. In effect, it must possess adequate upgradeability, flexibility, and extensibility.

B8.2.3.1 Upgradeability

Application systems tend to have long lifecycles. For commercial systems, the average useful life is approximately 15 years; whereas, for military logistics systems such as AFTOMS, the useful life must stretch to 20-to-30 years. However, the underlying commercial technologies in a complex, state-of-the-art, integrated system such as AFTOMS tend to have average generation durations of about 3 years, with the more dynamic emerging technologies showing significant advances every 1-to-2 years until product maturity.

For any technology, each next generation of products:

- Corrects some outstanding problems;
- Offers new functional capabilities, as well as capacity, interfacing and performance improvements;
- Better supports relevant government and industry standards;
- Reduces the differences in important user benefits from the leading products as each provides equivalent (though not identical) coverage; and
- Generally improves price-performance.

An important consideration in AFTOMS is that technical support may be discontinued for prior generation commercial products as vendor resources are shifted gradually to support the current generation products.

Therefore, to avoid technological obsolescence, take advantage of performance improvements, and rely on vendors for maintenance of these sophisticated technology products, it is essential that AFTOMS be readily upgradeable. For example, marginal or inadequate response time can be easily improved by a next-generation workstation platform which (for the same or lower cost) typically will be 3-to-5 times faster in processing speed, and offer more internal memory to reduce the need for frequent slow interaction with a peripheral disk device; or, a future generation of a DMS will undoubtedly incorporate both a fully-integrated relational or object-oriented database and a fully-integrated ODS, both of which may be easier to use and higher performing than those already in AFTOMS. It may make sense to replace three older technology products from different vendors with a single, fully-integrated, higher-performing product from a single supplier.

Upgradeability of AFTOMS is facilitated by using an open architecture that maximizes adherence to important standards (e.g., POSIX, X-Windows, GOSIP, ANSI SQL, etc.) and selecting products that both support these standards and are designed for hardware independence and software portability, even at the expense of current performance or functional capability (if not critical). **Current performance gaps and other deficiencies can be closed or corrected with next generation products in an upgradeable configuration, whereas a non-upgradeable configuration locks in the current performance and problems until a new system is developed.**

Moreover, development of the customized user interfaces and integrating software that "glues" the commercial products together and makes *the configuration* appear as a single system should not compromise upgradeability. Again, standards adherence and good device-independent, object-oriented design is the key.

B8.2.3.2 Flexibility and Extensibility

Over time, new Tier 4 technical order delivery systems such as IMIS, ITDS, and even more advanced future concepts probably will be integrated with AFTOMS; and AFTOMS will need to be integrated with other CALS systems (e.g. PDD) to support a more globally integrated technical data environment. Thus, AFTOMS needs to be both flexible to adapt to new unforseen and loosely defined requirements, and extensible to fully support them.

For flexibility and extensibility, AFTOMS must have an architecture and design infrastructure that supports new interfaces both into and out of AFTOMS and processes the digital data intelligently in between these interfaces. Again, performance should be sacrificed initially (if necessary) to build in needed flexibility and extensibility.

Reliance on adherence to MIL-STD 1840 and its successors for technical order input should make AFTOMS processing independent of contractor's TO authoring and change processing systems.

Reliance on standards (e.g., ANSI SQL, POSIX, GOSIP, object-oriented design, etc.) for all processing within AFTOMS will keep data from becoming tightly coupled to particular AF-

TOMS implementation details which may be changed sometime in the future; and will facilitate automated data conversion from one digital form to another if it becomes required. In addition, such standardized data are easier to access by future technical order or CALS systems.

Definition of a standard AFTOMS Tiers 3/4 interface is needed to anchor the distribution function at Tier 3. Then, new Tier 4 ODS systems can develop their own unique interfaces to the AFTOMS standard interface; this interface layering approach will isolate technological developments in advanced ODS systems from mainline AFTOMS functionality, except for possible enhancements required at Tier 2 for tagging, verification, and change processing.

B8.3 PARTICULAR INTEGRATION APPROACHES

Use of the Demo System during its debug, system integration, and final testing stages (prior to delivery to the AFTOMS SPO) provided an insight into some of the key issues of operational utility. The first issue concerned how to realize the benefits of AFTOMS as soon as possible after IOC. User interface quality plays the biggest part in realizing this objective.

Most computer systems are judged by users on how good the user interface is since that is their primary interaction with the system. There are two keys to a quality user interface:

- Consistency of user interface; and
- Simplicity of user interface.

When team members who did not design or develop the user interface began to learn how to use the Demo System, they had little difficulty. The conventions for choosing functions, system responses and acknowledgments, graphical aids and a minimum of typing, etc. maintained a level of consistency within this system and made it similar to many of the newer generation systems in the computing world. This consistency is the result of using standard windowing systems' toolkits. Simplicity comes from the use of a graphics or picture-oriented interface which eliminates a lot of text input for the user.

The second issue of more productive day-to-day use can only be extrapolated from the limited use by POC team members. Two features, fundamental to the Demo System, which should help in this area are the graphical user interface (GUI), which minimizes the need to memorize commands, and the built-in Help function. In the GUI design approach, the user is led through the system by icons (pictures) and menus related to what the user is doing. Rather than typing in memorized commands, the user simply chooses valid options and from one or more layers of menus. This greatly aids the casual user.

The Help function is built-in and available while the user is working on the system. Some limited experience with the Help function showed that this is a more productive way to assist users than hardcopy reference manuals and quick-view reference cards. The GUI, with multiple windows and direct manipulation features, provides the mechanisms to build in sufficient help aids to enhance productivity.

The third issue of importance concerns future enhancements. In the Demo System debug and testing phases, there was much interaction and feedback regarding changes, modifications, and improvements to the functionality and user interface. In many cases this feedback served to produce a better product. It is envisioned that once AFTOMS is deployed, there will be much feedback of a productive nature recommending improvements. The POC's limited experience of easy implementation of changes with these types of design and support tools was extremely encouraging. Many changes can take place without major redesign by using this design approach. Changes that formerly took man-months to implement can be done in man-days or man-weeks. Changes that were not even possible because of time constraints can be made. The Demo System team was very encouraged by how flexible and comprehensive the options in these toolkits are.

B8.4 RISK ASSESSMENT

From the viewpoint of operational utility the AFTOMS residual risks include:

- Slow buildup of the digital TO database due to scanning conversion or DTD problems;
- Development of a configuration tool for planning the AFTOMS support, conversion, and data loading requirements for each WS;
- Unavailability of adequate communications support due to ULANA I or II and DDN *installation scheduling;*
- Premature implementation of Type C capability before its unique AFTOMS infrastructure support (in authoring, change management, verification, and distribution) is clearly understood and delineated;
- Difficulty in defining a standard Tiers 3/4 interface to support IMIS, ITDS, and other future delivery systems; and
- Capacity or performance problems associated with full-scale operations that were not visible in a limited POC environment.

B8.5 RISK ABATEMENT:

In general, risk abatement reduces to three principles:

- Learn from specific experience to develop sound plans and approaches for:
  - Scanning conversion;
  - Configuration planning;
  - Capacity sizing;
  - Performance balancing;

- Degree of B+ enhancement tagging; and
- Type C integration support.

- Base AFTOMS architecture and design on commercially available technology products that are production grade, adhere to important standards, integrate well, and sacrifice performance (if necessary) to maintain these qualities.

- In developing the integrating "glue" software to bring these commercial products together, use:
  - Object-oriented design techniques;
  - Standard languages (such as ANSI SQL, ANSI C, etc.); and
  - Adhere to standards to maintain system upgradeability, flexibility, extensibility, quality, ease of use, maintainability, etc.