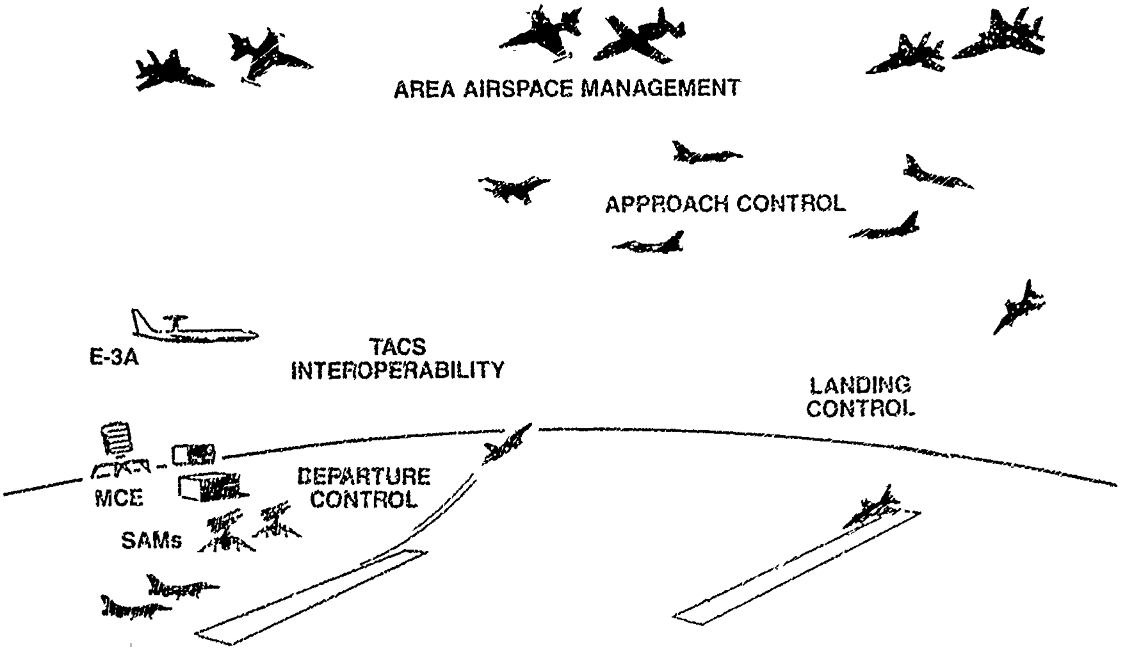
Advanced Air Traffic Control Concept Study

Automated Tactical Aircraft Launch and Recovery System (ATALARS)



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This report documents the results of analyses performed to extend and expand the definition of the Automated Tactical Launch and Recovery System (ATALARS) presented in ESD-TR-86-259, Advanced Air Traffic Control Concept, 19 June 1986. The Electronic Systems Division (ESD) Technical Report (TR) concluded that tactical air traffic control (ATC) has long been deficient in survivability with no firm planning to resolve future needs. It formulated a concept that eliminates the need for complex ATC systems at every airbase, suggesting, instead, an aircraft based system with a single ground control unit, integrated to provide ATC for a large geographical area including multiple launch and recovery areas. This report further develops the concept by presenting the results of a detailed functional analysis and a preliminary functional design effort. It also provides recommendations for further development of the ATALARS concept.

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Technical Report

CONCEPTS, REQUIREMENTS AND DESIGN ANALYSIS

for the
Automated Tactical Aircraft
Launch and Recovery System
(ATALARS)

Prepared For:
Electronic Systems Division
Air Force Systems Command, USAF
Hanscom AFB, Massachusetts 01731-5000
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TABLE OF CONTENTS

PAGE

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This report documents the results of analyses performed to extend and expand the definition of the Automated Tactical Launch and Recovery System (ATALARS) presented in ESD-TR-86-259, Advanced Air Traffic Control Concept, 19 June 1986. The Electronic Systems Division (ESD) Technical Report (TR) concluded that tactical air traffic control (ATC) has long been deficient in survivability with no firm planning to resolve future needs. It formulated a concept that eliminates the need for complex ATC systems at every airbase, suggesting, instead, an aircraft based system with a single ground control unit, integrated to provide ATC for a large geographical area including multiple launch and recovery areas. This report further develops the concept by presenting the results of a detailed functional analysis and a preliminary functional design effort. It also provides recommendations for further development of the ATALARS concept.

The study effort was conducted under the guidance of 1st Lt. Guy C. St. Sauveur, ESD/XRC. Mr. A. Frueauf of ARINC Research Corporation was the Project Leader under the overall management of Mr. P. McCree, the TEMS Manager for HH Aerospace Design Co., Inc. Primary contributors to the report were Messrs. A. Frueauf (ARINC Research Corporation), J. McDermott (ARINC Research Corporation), D. Piligian (ARINC Research Corporation), R. Hubbard (ARINC Research Corporation), P. Quinan (Vanguard Research, Inc.), and K. Creighan (HH Aerospace Design Co., Inc.).

REPORT SUMMARY

The Automated Tactical Aircraft Launch and Recovery System (ATALARS) is an advanced system, in the conceptual stage, for performing military terminal area air traffic control (ATC) in the post-2000 time period. The ATALARS will provide airspace management, approach control, departure control, landing guidance, and other ATC facility functions. Rather than the standard techniques of conventional radar surveillance, voice communications, and centralized ground control, the ATALARS will use new techniques made possible by near term technology. Communications will be by both data link (e.g., Joint Tactical Information Distribution System (JTIDS) or similar systems) and voice (e.g., HAVE QUICK or similar systems). Surveillance will be indirect using position reporting from the aircraft via the data link and data from air surveillance systems also using data link. The required position accuracy will be provided by new navigation systems such as the Global Positioning System (GPS). Traffic control functions will be split between the aircraft (pilot and terminal) and ground system (controller supported by ADP in a mobile vehicle).

ATALARS ground units will be capable of dispersed deployment and netting, and will allow multiple, fixed-base, off-base, and ad hoc base operations with other tactical air operations within the tactical theater as well as interoperability with Air Force and Army air defenses. It will interface with Battle Management resources to be capable of overseeing the operation and area conditions to a given landing area. ATALARS would provide essential feedback to pertinent Battle Management elements (i.e., Remote Surveillance Units and Mobile Control Towers). ATALARS must perform airspace management (i.e., overall management of the traffic in its assigned airspace), approach control (i.e., controlling the traffic intent on landing in the airspace), and airfield traffic management (e.g., landing guidance, takeoff scheduling) to the extent that remaining airbase facilities cannot do so. Each of these three functions involves long term (next operations cycle) planning, short term re-planning, traffic monitoring, situation monitoring (e.g., runway status, weather), and control (e.g., issuing instructions). These functions have been decomposed using the techniques of structured analysis and are described in Section 6.0.

These three basic functions have many elements in common (e.g., aircraft tracking, weather monitoring). Combining these common elements leads to the definition of system functions (e.g., a surveillance function). The system functions have, in turn been decomposed and allocated to subsystems (e.g., the elements of the surveillance function were allocated between the aircraft and the van). Section 7.0 provides a preliminary overview of system design concepts and their allocation to subsystems. For the analysis, ATALARS was defined as consisting of four subsystems:

1. The van subsystem which consists of:
   a. Vehicle(s) and associated support equipment (power, heating, venitilation, air conditioning, etc.)
   b. ADP subsystem
   c. Communications subsystem

2. The aircraft subsystem which consists of:
   a. a modified communications unit
   b. interfaces between the communications units and other aircraft subsystems (e.g., navigation)

3. The airbase subsystem which would include:
   a. a runway monitoring subsystem
   b. a communications subsystem for interfacing with the ATALARS van (ADP subsystem)

4. The external interface subsystem which would include any ATALARS unique communications hardware/software for interfacing with external agencies such as tactical command and control facilities.

The functions to be allocated to these subsystems are defined as:

1. Surveillance which includes establishing and maintaining tracks as well as obtaining and maintaining data relevant to the track.

2. Situation monitoring and assessment which includes identification of generally adverse ATC situations and issuance of appropriate advisories to pilots/controllers.

3. Control of air traffic which aggregates various control and control related functions (handoffs, stack extraction, spacing, sequencing).

4. Control of ground traffic which exercises control over ground traffic (aircraft and ground vehicles) at an airfield.

5. Landing control which includes landing scheduling and provides guidance to aircraft approaching a landing gate.

6. Departure control which schedules aircraft departures and provides the final approval prior to takeoff.

7. Planning which includes overall planning and plan adjustment of airspace management, route selection, and scheduling.

8. Exercise/training which includes support for data collection and simulation.

The actual design is driven by numeric requirements (e.g., the number of aircraft simultaneously in the assigned airspace), operational considerations (e.g., pilot workload), environmental considerations (e.g., variance in aircraft avionics suites), near term technology (e.g., JTIDS, GPS), and other factors. Section 8.0 provides a preliminary identification of these factors and assesses their potential impact on design.

Section 9.0 provides planning information for the continuation of the program. A preliminary schedule is provided for follow-on program tasks. Appendix C contains an initial cost estimate of the program tasks through the completion of a feasibility demonstration of the ATALARS concept.

This study effort concludes that several analyses must be performed to investigate critical design areas to minimize the risk for a full scale development program.

SECTION 1.0
INTRODUCTION

This document contains the results of a US Air Force contracted study effort on the Automated Tactical Aircraft Launch and Recovery System (ATALARS) concept which was formulated in ESD-TR-86-259, Advanced Air Traffic Control Concept, 19 June 1986. The ATALARS is an advanced system for performing tactical military terminal area air traffic control (ATC) in the post-2000 time period. The study was conducted under the guidance of 1st Lt. Guy C. St. Sauveur, ESD/XRC.

1.1 BACKGROUND

Since 1979 the Air Force Systems Command Vanguard process has identified through extensive analysis of the ATC mission area a lack of long range concept developments to address projected mission requirements of the 1990's. Numerous programs have evolved which enhance or replace current equipment being used in ATC. Unfortunately, these programs are not survivability oriented based on the projected threat and sortie requirements. Survivability studies were performed between 1982-1986 under sponsorship of ESD, Hanscom AFB. These studies identified major issues relating to ATC in a tactical wartime environment and edified the need for long range planning with survivability as the major thrust. The ATALARS concept as presented in ESD-TR-86-259 evolved out of these efforts.

1.2 SCOPE

This report builds upon the concept presented in the ESD technical report by performing a functional analysis of terminal ATC services. The resulting functional design is integrated into the expected tactical environment of the post-2000 time period.

1.3 CONTENT

The report is composed of 10 sections with four supporting appendices. Section 2.0 describes the ATC mission requirements. Section 3.0 descirbes ATC user capabilities. Section 4.0 identifies ATC deficiencies. Section 5.0 provides the ATALARS concept of operations. Section 6.0 identifies and provides an analysis of ATALARS mission functions. Section 7.0 combines the ATALARS functions into subsystems. Section 8.0 discusses the design considerations for ATALARS. Section 9.0 provides program and feasibility demonstration planning information for validating the ATALARS concept. Section 10.0 provides conclusions and recommendations of the study effort.

SECTION 2.0
MISSION REQUIREMENTS

Although the concept for performing military terminal area ATC (Figure 2-1) in the post-2000 time period is anticipated to change, the aircraft missions (e.g. reconnaissance, refueling, interdiction) will remain essentially the same. However, enhanced aircraft performance and advanced avionics will provide for more flexible mission profiles and inflight rerouting. The number and variety of aircraft performing the missions will increase. It is expected that more flexible, ad hoc, dispersed aircraft basing will be used. Larger numbers of smaller bases and covert off-base locations will exist. Tactical operations will be changed to include new procedures for entry into base airspace, altitude of approach, and holding patterns. ATC operations will interface with air defense weapon systems and will have to take place despite increased wartime threats that will include significant monitoring, jamming, radiation homing, and destruction capabilities by the enemy.

2.1 AIRCRAFT TYPES

The types of aircraft requiring ATC services in this time period will consist of a wider mix than in the 1980-1995 time period. This mix will consist of versions of the present fleet, with new avionics, extended life versions of the present fleet and advanced aircraft now on the drawing board. Extended life versions of the circa 1986 aircraft will exhibit characteristics different from today's versions, including shorter and faster landing and takeoff capabilities. They will also have improved cockpit suites that will display extensive situation data from on-board sensors and data received via tactical data links.

2.1.1 Advanced Aircraft

The more advanced aircraft will have operating profiles allowing shorter landings and takeoffs. These aircraft will be highly maneuverable and have a variety of landing and takeoff profiles. Aircraft will also be able to operate on unprepared terrain at off-base landing sites. Stealth techniques will be used on some aircraft to deny enemy radar, consequently denying friendly radar detection as well.

2.1.2 Transport and Bomber

Transport and bomber aircraft with precise landing entry windows and minimum holding time will require ATC services. Preplanned coordination and real-time inflight rerouting will be necessary to optimize traffic control of these types of aircraft and to interweave them with conventional aircraft at dynamic landing locations.

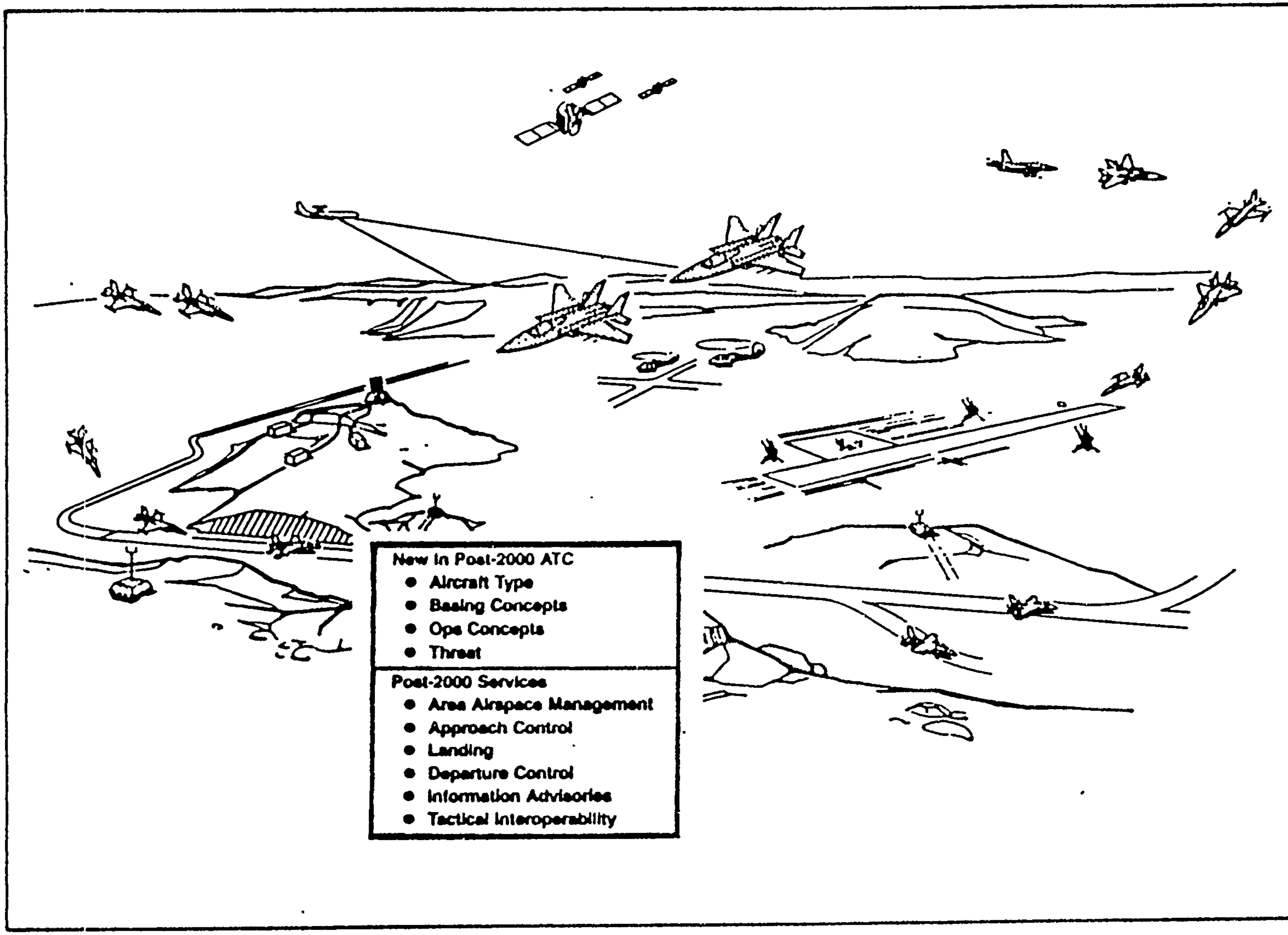

Figure 2-1

Terminal ATC Services

2.1.3 Helicopters

An extensive number of helicopters and hover aircraft will be in the inventory. Aircraft from the Army, Navy, and Marine Corps will interact in the airspace. The aircraft and procedures of these services must be accommodated, as well as those of NATO and other allies.

2.2 OTHER CONSIDERATIONS

ATC operations in the post-2000 time frame will also be influenced by other factors, some of which are addressed in the following paragraphs.

2.2.1 Basing Concepts

The basing concepts in this time period will be driven by the need for survivability and recovery from battle damage. As the range and accuracy of tactical weapons increase, airbases will become more vulnerable to attack and will result in the use of non-fixed base configurations. It is expected that the aircraft types will allow smaller geographic space for airbases. The fixed bases will also contain alternate strip areas, either contingent to the base or nearby. Some clustering of runways in a geographic area will be provided, but they will be dispersed from each other to prevent collateral destruction. Also, dispersed covert small landing fields will be used. Dispersed bases will have minimum resources and, to the degree possible, be kept covert until necessary for use. The runways will be narrower and shorter. The physical makeup of these bases will vary greatly from constructed bases to ad hoc field arrangements using dirt strips and roadways. Clustered and dispersed runways will result in overlapping areas of approach and departure paths. Multiple runways will have to be controlled by a single control facility. Bases will likely change rapidly relative to availability and supportability for the aircraft requiring ATC service.

2.2.2 Operational Concepts

In the post-2000 time period, terminal ATC operations will be required to be more flexible and real-time managed than at present. Preplanned information will be available, but will change to match the operational situation. Aircraft navigation systems will permit more flexible routes to and from airbases, not following fixed structures and entry points. In addition, because of the ad hoc bases, extensive publication of operation procedures will not be available for prestudy by aircraft commanders. Predefined, specific landing procedures will not always be possible. The ad hoc nature of the bases will require that greater real-time flight information be conveyed to aircraft on base locations and configurations. Control operations will have to direct aircraft to appropriate bases within an overall area, perhaps to covert bases or areas previously not used for landings. Takeoff flow control and location of holding positions will be dynamic to account for base battle damage and the need to be unpredictable.

The operational situation will require higher sortie rates. This will be reflected in aircraft flying closer together ^ and from areas smal" r than the current situation.

2.2.3 Environmental Conditions

The environment in which ATC will have to operate will be significantly hostile. Landings and takeoffs must be possible in all weather and light conditions. Blind landings must be possible in this time period for all high priority aircraft, if not all aircraft.

Enemy countermeasures will be present. These will be both direct and collateral attacks by the enemy that will require maintenance of ATC in the presence of electronic countermeasures, electromagnetic pulse, anti-radiation missile, and chemical threats.

The ATC services must have a method of self-healing and restoral, including the ability to rapidly reconstitute itself. The ATC function must be expandable to take over different geographic areas in addition to its originally designated area.

2.3 TERMINAL ATC SERVICES

In the post-2000 time period, it is expected that the terminal ATC services will have to be similar to those services provided today, but with expanded capability and flexibility. The services provided will include area airspace management, approach control, landing control, departure control, information advisories, and interoperation of ATC with other tactical mission areas (Figure 2-2).

2.3.1 Area Airspace Management Service

The area airspace management service should ensure safe aircraft operation and passage within an area airspace, while allowing the various aircraft to carry out their assigned missions. The ATC service should execute control over all aircraft in the airspace by maintaining their safe separation and routing. It should include the surveillance of all friendly aircraft in the airspace to know the position, identity, and plans of all aircraft. The service should order the movement of the aircraft to their desired destination by efficient and safe operations. The airspace to be managed should extend from an individual base up to a wide area containing multiple bases and different base types. Capabilities for managing a hundred or more aircraft simultaneously should be provided.

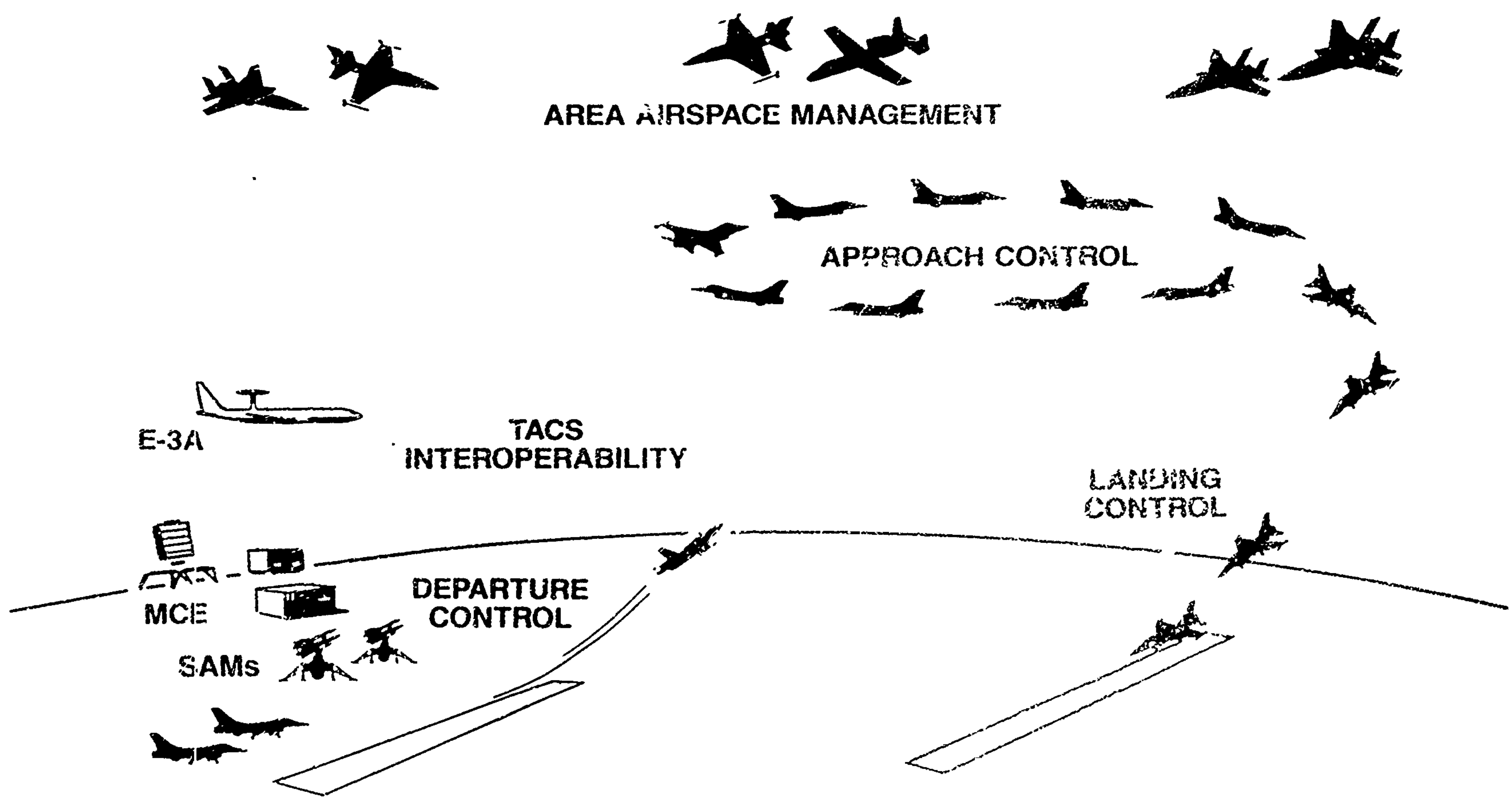

Figure 2-2

ATC Services

2.3.2 Approach Control Service

Approach control service should be provided for aircraft wishing to land or approach an area within the airspace being managed. This service should efficiently and safely bring an aircraft into the area covered by the precision approach service and visual landing point. The approach control service should be provided for up to 10 bases and up to 300 aircraft operations, recognize emergency landing needs, and respond to aircraft requiring this special service by efficient insertion into the landing operations. It should dynamically move and automatically adjust the flight parameters of stacked aircraft without forcing all aircraft to change their approach plans and timing.

2.3.3 Landing Control Service

Landing control service should be provided under all operational conditions: day, night, adverse weather, and damaged runways. The landing service should permit blind landing operations and allow flexible approaches, optimum for the aircraft and operational conditions involved. The service should be integrated between the pilot and the ground control function. This integration would allow for real-time exchange of essential information. The landing service should also provide control instructions and guidance for missed approaches and redirection to an efficient reentry into the landing sequence.

The service should be capable of simultaneous operation with close proximity airfields while limiting the length of time where structured and fixed flight paths are required to be flown. The service should not limit the number of aircraft that can obtain guidance at any one time.

The landing control service should be capable of keeping track of runway status and determining the appropriate runways to use for landing operations. This should include knowledge of support facilities and the landing site's traffic load, both present and predicted.

2.3.4 Departure Control Service

The departure control service should provide efficient spacing and control of takeoff operations, responses to requests for takeoff, and sequencing of takeoffs to effectively use the runway between landings and takeoffs. The service should provide for the management of takeoffs to efficiently reduce ground delay time and exposure to attack. It should provide flow control that will insert the aircraft into the airspace in a safe manner, timed for efficient execution of its mission. This service should also minimize the adjustments to the desired aircraft optimum flight geometry and to the flight paths of other coexistent aircraft. Departure control services should be able to maintain cognizance over all aircraft and their status at multiple bases. It should provide sufficient planning capability to preassign takeoff slots and make dynamic adjustments.

2.3.5 Information Advisories Service

This service should provide in-flight advisory information. Aeronautical information pertinent to aircraft operation should be provided to support landing and takeoff operations. Currently, automatic terminal information service provides this essential information. The proposed system would incorporate additional battle management information such as runway status, enroute weather conditions, expeditious routing, potential hazards, and defense elements. It should provide emergency assistance to lost aircraft or those in distress.

2.3.6 Tactical System Interoperability Service

Interoperability of the ATC operations with tactical defensive and offensive air operations in, and adjacent to, the controlled airspace should be provided. The ATC and tactical operations should be integrated through the netting of sensors and control elements. The ATC control units should be a part of the tactical network to exchange information. The ATC operations should be capable of receiving track information from the tactical surveillance network. It should provide aircraft flight plans and aircraft identification to the tactical elements via the tactical track distribution network.

To provide safe passage of aircraft, direct interoperation with base air defense elements should be provided. The ATC service should supply the air defense elements with position data on approaching aircraft, as well as providing information on dynamic base approach and takeoff corridors.

SECTION 3.0
USER CAPABILITIES

The ATC operations of the late 1980s to early 1990s will be upgraded through programs now planned. This upgr. ing includes new facilities being deployed into the field through the 1990s. The systems/facilities described in the following paragraphs are expected to be in place in the pre-2000 time period.

3.1 MOBILE MICROWAVE LANDING SYSTEM (MMLS)

The Mobile Microwave Landing System, like the fixed base MLS, is a precision approach and landing guidance system providing a landing capability for operations in adverse weather. The MMLS consists of ground-based precision approach equipment that generates microwave guidance signals, thereby enabling MLS-equipped aircraft to continuously display aircraft position relative to a pilot-selected course and glidepath down to a minimum decision height. The system includes azimuth antenna, elevation antenna, and precision distance measuring equipment. A variety of tactical missions can be satisfied by the MMLS such as an initial precision approach and landing capability to a small, hastily established assault zone, restoral at bases that have lost their precision approach control, and a landing capability at newly established airfields.

3.2 MEW MC..ILE RADAR APPROACH CONTROL (RAPCON)

The New Mobile RAPCON (NMR) will provide a rapidly deployable, wartime, ATC RAPCON for restoring terminal area ATC services at fixed bases and establishing RAPCON operations at alternate and bare base airfields. The operations subsystem, the radar subsystem, and the support equipment that comprises the NMR will be used for forward area tactical operations in a hostile environment. During wartime, NMR operations will support tactical wing and squadron level high surge, sortie generation capabilities. The highly mobile operations subsystem provides a radar approach facility that houses four terminal ATC positions and associated communication. The operations subsystem together with the radar subsystem provides RAPCON and area control services, primary and secondary surveillance radar landing service, and alerts/advisories to maintain flight safety.

3.3 TOWER RESTORAL VEHICLE (TRV)

The Tower Restoral Vehicle will provide Air Force ATC units, at designated tactical airbases, the capability to rapidly restore control tower assets. The TRV is an austere, fully self-contained, ATC control tower facility with a limited mission duration of up to 7 days, that is intended to support the survivability of ATC operations under wartime conditions. The system includes ground-to-air and intrabase radio communications, a small shelterized tower mounted on a standard 1-1/4 ton military off-road vehicle, and a towed trailer. The highly mobile, self-propelled TRV will be capable of supporting limited surge launch and recovery operations under visual meteorological conditions. n conjunction with other assets, it will also support pe tions under instrument flight rules.

3.4 SURVEILLANCE RESTORAL VEHICLE (SRV)

The Surveillance Restoral Vehicle will provide Air Force ATC units with a minimal surveillance and approach control capability in the event of loss of fixed surveillance and radar approach control assets, or support to off base and alternate landing strips. The system is housed in a highly mobile, self-propelled vehicle capable of a mission length up to 7 days. It includes a tactical secondary surveillance radar capability, ground-to-air and intrabase voice communications, a small operations shelter mounted on a standard 1-1/4 ton military off-road vehicle, and a towed trailer. The SRV will be capable of supporting limited surge launch and recovery operations under visual meteorological conditions and instrument meteorological conditions.

3.5 HAVE QUICK RADIO

The HAVE QUICK Program provides an air/air and air/ground jam resistant modification to selected airborne and ground-based radios. The design utilizes a frequency hopping capability. Channel or frequency changes are made many times a second in an apparently random manner so that no pattern is evident to a potential hostile jammer. The scheme is implemented by storing within every HAVE QUICK Radio a pattern of frequencies to be used for a given day and utilizing this pattern according to the time of day. HAVE QUICK radios retain the capability to operate in a normal (non-hopping) mode.

3.6 JOINT TACTICAL INFORMATION DISTRIBUTION SYSTEM (JTIDS)

The JTIDS is an advanced radio system which provides information distribution, position location, and identification capabilities in an integrated form for application to tactical military operations. The JTIDS architecture, signal and message structures provide a building block for a wide variety of information distribution techniques that can be configured by the user to match his particular needs. Information distribution is accomplished by the pooling of time slots into participation groups and the assignment of the various net management time slot access modes and relay modes of the group. The JTIDS distributes information at high rates, encrypted in such a way as to provide security and with sufficient jam resistance to yield high reliability in a hostile electromagnetic environment. The system provides a capability to interconnect scattered sources and users of information. It provides surface and airborne elements with both a position location capability within a common position reference grid and an intrinsic identification capability through the dissemination of secure position and identity information. The JTIDS also provides a capability for the transfer of digitized voice data.

3.7 PHYSICAL SURVIVABILITY FACILITIES

Several efforts have been initiated, some of which have been discussed in the preceding paragraphs, to improve ATC performance under various wartime threats. Survivability of ATC systems in a wartime environment is essential. The Air Force is identifying a set of assets that can be rapidly deployed to provide Quick Wartime Restoral of TRACALS Equipment and Services (QWROTES). Current QWROTES concepts envision that these assets will be stored in-theater within semi-hardened facilities that are remote from potential on-base targets. Plans are also in being to semi-harden fixed base RAPCON facilities.

SECTION 4.0
DEFICIENCY ANALYSIS

Although the programs described in Section 3.0 will improve the ATC capabilities, residual deficiencies will still exist. The enemy threat will also have evolved, overcoming some of the defensive mechanisms provided by these systems, and leaving the ATC operations with the following shortfalls.

4.1 VULNERABILITY

The ATC operations will be dependent on active sensor radiation for surveillance of aircraft that can be exploited by the enemy. These radiations can pinpoint the location of runways and concentration points of aircraft. Physical vulnerability remains a key issue. General location of the ATC systems close to runways will continue to subject them to collateral damage when a base is attacked. This could include possible direct attack against ATC facilities during periods of increased sortie activity.

4.2 COVERAGE AND CAPACITY

Capacity limits of existing and planned systems will be exceeded because major activities remain manual and the number of aircraft to be controlled exceed design capacities. Multiple base netting proposals will not diminish the overload factor for control. The required recovery rates of 70-100 aircraft per hour, will not be supported.

4.3 ELECTRONIC COUNTERMEASURES

An electronic countermeasures shortfall will remain, even with the improved voice communications provided by HAVE QUICK radios. Deficiencies will exist because of changing threat situations that may overcome the protection provided by these radios.

The surveillance portion of the ATC operations remains vulnerable because of the use of active radar sensors that will be jammable. The secondary radar (beacon) subsystem remains vulnerable to collateral jamming.

4.4 SECURITY

The planned implementations will not offset the threat of enemy monitoring. The systems do not appreciably increase the degree of security provided to the information transfer required for ATC operation.

4.5 RESTORATION

The planned ATC configuration will remain somewhat short of the required restoral setup times. Sufficient ATC units will not be provided in the inventory to permit all bases/runways to be individually equipped with restoration equipment. Flexibility to rapidly move to new locations with mobile assets will not be adequate.

4.6 INTEROPERABILITY

Increased interoperability with other tactical systems will remain at a low, slow level and will be carried out primarily by voice. Interfaces with local air defense missile units will remain somewhat disconnected and, if available, carried out by voice without an adequate common grid reference between systems.

DoD efforts will continue to achieve interoperability of future tactical systems through standard data interfaces and information exchange formats. Modifications to some systems may be required to meet this standard, or a special interface maybe provided to accommodate other formats which are widely used by tactical systems.

4.7 ACCURACY AND RESPONSIVENESS

Inadequate accuracy and responsiveness will continue to exist. Radar type accuracies will be inadequate for high speed maneuverable aircraft in this time period. The ability to reduce aircraft separation to increase sortie rates is directly dependent upon the accuracies and timelines of the information used for ordering the aircraft into landing and takeoff queues. The planned systems will remain dependent upon radar operations that will be corrupted and disabled by jamming, local clutter, and terrain masking.

SECTION 5.0
CONCEPT OF OPERATIONS

The ATALARS concept is to provide, in a tactical environment, integrated airspace management, approach control, departure control, and landing functions in the post-2000 time period. It is currently not intended as a replacement for existing/planned facilities and systems, but rather as a survivable supplement which can take over ATC related functions as it becomes necessary because of degradation due to enemy action or other factors. Thus, ATALARS must be flexible in terms of increasing or decreasing the number and types of functions it must perform. It must be integrated physically and functionally into the overall airspace management system, given the physical and functional configuration of that system at any given point in time.

The typical European conventional war scenario provides a context for visualizing the role of ATALARS. At the start of the war, the existing airspace management system (Army Airspace Command and Control, Air Force Tactical Air Control System (TACS), ATC facilities at the airbases) provides all of the necessary capability. It is expected that the airfields, being fixed facilities, will be subject to conventional air attack as well as sabotage and unconventional attacks. Assuming a degree of enemy success, airfields and associated control facilities will be in various states of servicability. Contingency plans for using alternate fields and even highways, such as autobahns in West Germany, will be implemented.

These alternates will also have varying degrees of control capability. In addition, damaged airfields and alternates will have different servicing capabilities/rates, forcing replanning of airfield utilization. The situation will be extremely dynamic due to repair activities, continuing enemy attacks and changing mission requirements.

An ATALARS integrated into this environment can be viewed as an air traffic control element servicing one or more distributed airfields (i.e. where an ATC element normally services one airfield with multiple, essentially collocated runways and facilities, ATALARS services one or more "airfields" with geographically separated runways and facilities).

Due to the geographic dispersion, ATALARS may have to deal with a larger volume of airspace than normally attributed to ATC airbase facilities. In geographically constrained areas (e.g., the "Iron Triangle" in West Germany), this may result in aircraft operating in the ATALARS airspace over which an ATC airbase facility would not normally exercise control. At a minimum, ATALARS must maintain an awareness of these aircraft and potentially provide guidance for flight safety purposes.

ATALARS would provide the minimum necessary control to maintain operations in this environment. Similar situations can be constructed for a Korean war, Middle Eastern war or Caribbean conflict where the introduction of substantial air forces could temporarily exceed the capability of the host country and U.S. introduced airspace management systems.

The ATALARS would be deployed and operated at the direction of the HQ Tactical Air Forces (HQTAF) or Tactical Air Control Center (TACC) or analogues such as NATO (e.g., HQ Allied Air Forces Central Europe (AAFCE) or the HQ of an Allied Tactical Air Force (ATAF)) in the various theaters. The airspace and control responsibilities within that airspace would be defined and assigned to ATALARS as part of the normal planning process for each operations cycle. Adjustments would be made as required.

Given its assignment, ATALARS would establish interfaces and coordinate interface procedures with control systems responsible for abutting airspace, air defense entities operating within the ATALARS airspace, and command and control facilities, if any, at the airfields/airbases in the ATALARS airspace. These interfaces would provide for exchange of tracking and identification data, handoff to other control systems, and notifications of (impending) activity.

The expected activity within this airspace would be provided to ATALARS via normally developed Air Task Orders (ATOs) and flight plans as well as adjustments thereto. Constraints on that activity (air defense free fire zones, safe corridors, etc.) would also be provided to ATALARS as part of the normal dissemination of such data within the TACS.

ATALARS would monitor the air activity, exercising control as necessary to cope with accidental deviations from flight plans, necessary deviations from plans due to changes in airbase status or other factors, and the routine sequencing and spacing problems associated with landing and takeoff operations.

The unique feature of ATALARS operations would be the employment of an interface between the aircraft and the ground control facility which allows for allocation of the control function among the aircraft commander, ground controller, and automated support. As an example, an aircraft returning as planned from a mission, can automatically be provided information regarding other aircraft in the air corridor to allow the aircraft commander to maintain appropriate spacing. Alternatively, presence of enemy aircraft in the airspace may require intervention of the ground controller.

5.1 AIRCRAFT ACTIVITY

The following subsections discuss ATALARS operations in the context of various types of aircraft activity in the assigned airspace. The primary responsibilities of ATALARS comprise departing, returning, and landing aircraft. However, ATALARS must be capable of dealing with other activity in its airspace as well.

5.1.1 Transiting Aircraft

Since ATALARS performs primarily as an ATC airbase facility, there should be few aircraft transiting the assigned airspace. The possibility could exist primarily because of the multiple airbase responsibility of ATALARS. In general, ATALARS would accept handoff on entry, flight-follow, and then handoff on exit. Control would be exercised if flight following showed a deviation from flight plan or a situation developed requiring a deviation from flight plan.

5.1.2 Aircraft Performing Missions

It is improbable, but conceivable that aircraft would be performing missions (e.g., tankers providing refueling, combat air patrol operations, orbiting reconnaissance platforms) in ATALARS assigned airspace. ATALARS would monitor but not support the activity. The airspace involved would be designated for that use and ATALARS would exercise control only if the activity began to drift outside the assigned airspace. On completion of the mission, the aircraft would be treated as a transiting or landing aircraft.

Other types of missions (e.g., air defense intercept, ground attack) which might take place in ATALARS assigned airspace would be monitored with the intent of rerouting traffic away from the activity if necessary.

5.1.3 Aircraft Returning to Base

Aircraft returning as planned to a fully operational base are treated much like transiting aircraft. ATALARS would accept the handoff, flight follow, and handoff to the airbase ATC facilities. ATALARS could adjust the sequencing/spacing of aircraft arriving at the handoff transition point.

In a severely degraded environment, ATALARS would assist the returning aircraft by identifying a suitable landing strip and routing the aircraft to the area as well as assuring the sequencing/spacing of aircraft arriving in the area of the strip.

5.1.4 Landing Aircraft

In the event of landing delays, ATALARS would establish an actual (or virtual) stack, inserting and extracting aircraft as appropriate. If necessary, ATALARS would provide guidance from stack extraction to the landing gate defined by the landing systems usable by the aircraft.

5.1.5 Departing Aircraft

After takeoff, a departing aircraft is treated like a transiting aircraft. If necessary, ATALARS would schedule runway utilization (takeoffs and landings) to accommodate planned operations and emergencies.

5.1.6 Taxiing Aircraft

Ground traffic, whether at an airbase or autobahn strip, will not generally be the responsibility of ATALARS. However, in degraded conditions where ground traffic congestion affects landing/takeoff scheduling, ATALARS must maintain an awareness of the situation and may be required to assist in alleviating the congestion or controlling the impact.

5.2 CONTROL MODES

ATALARS will operate in three different modes:

1. Automated Guidance (e.g., collision avoidance, sequencing/ separation, landing)
2. Pilot Control Support (e.g., stack insertion, collision avoidance)
3. Ground Controller Support (e.g., landing scheduling)

5.2.1 Automated Guidance

Under relatively routine conditions, ATALARS Automated Data Processing (ADP) (ground based and on board the aircraft) will generate guidance information for the aircraft commander and provide sufficient supporting data to allow aircraft commander assessment of the guidance. The specific requirements of the aircraft (e.g., transit of the ATALARS airspace via a particular corridor, return to a particular airbase) would be defined for the ATALARS directly or by reference to planning data. ATALARS would flight follow the aircraft (based on aircraft reporting), providing direction as required to assure safe separation, provide appropriate sequencing/spacing, avoid accidental course or altitude deviations, and assure proper positioning (e.g., approaching a landing gate). As appropriate, ATALARS would provide traffic and other information relevant to the activity of the aircraft.

5.2.2 Pilot Control Support

In this mode, ATALARS acts as a decision aid for the aircraft commander with respect to ATC related actions. As an example, ATALARS could present the returning aircraft commander with alternative airstrips, routing to the selected airstrip, open landing slots/stack positions, etc. In effect, ATALARS identifies alternatives and provides information relevant to the aircraft commander's selection of the alternative. As the decision is made, ATALARS provides guidance and/or presents ensuing alternatives.

5.2.3 Ground Controller Support

Ground controllers exercise control by exception (e.g., emergencies), in response to changing situations (e.g., weather), and in terms of managing the utilization of the airspace (e.g., defining corridors). The ATALARS ADP system will support these activities by identifying the need for controller action, aiding the controller decision making, and assisting in setting up the mechanisms to allow control to revert to the other modes.

5.3 OTHER CONSIDERATIONS

The ATALARS concept has been developed on the basis of a comparatively "clean" operational environment. Aircraft are assumed to be equipped with capabilities such as the JTIDS, HAVE QUICK radios, GPS, and Microwave Landing System (MLS). Landing areas are MLS equipped. Surveillance data is available via digital data link from other sources. An actual tactical environment may vary substantially from this ideal. Host country and allied air forces may have substantially different avionics suites. Civil aircraft may be a factor. Older surveillance systems may be in use or communications interoperability problems may exist. Airfields may use different landing guidance systems. These factors contribute to questioning the operational, as opposed to the technical, feasibility of the ATALARS concept. It was not the intent of this study to address the issues raised by these factors in detail. Their resolution will be based on a combination of operational procedures, system design, and possibly even complementary acquisitions as ATALARS moves along the acquisition life cycle. Thus, in general, the following sections assume a comparatively "clean" operational environment.

SECTION 6.0
MISSION FUNCTIONS

Any system can be considered a functional entity composed of personnel, facilities, hardware, software, databases, and all other components of the system. This entity, independent of actual design, must perform certain functions in order to meet the required operational capability described in documents such as Statements of Need, Concepts of Operations, etc. This section describes the functions of ATALARS in a hierarchical context as derived from a top down structured analysis. The methodology used is described in Appendix A. Subsequent design efforts will re-aggregate and allocate lower level functions into functional subsystems. For example, all functions involving weather monitoring may be combined into one function, and the elements thereof allocated first between man and machine and then further allocated to the physical subsystems of the machine, e.g., communications processors, data processor, database, display, database management system (DBMS), etc. Thus, the descriptions presented in this section merely address the requirements of the functional entity, ATALARS. Subsequent efforts will resolve design issues such as whether the database requirements must be satisfied with a fully automated database or a mixture of hard copy and automation, or whether manual intervention is required prior to issuing certain traffic control instructions.

As described in Section 5.0, ATALARS is responsible for managing/controlling air traffic in a defined airspace (ATALARS Control Zone) to the extent necessitated by absence or degradation of facilities and systems normally responsible. From a functional standpoint, ATALARS must be capable of all airspace management and air traffic control functions in its assigned airspace and, at the same time, it must interface with those existing/remaining facilities and systems performing functions that ATALARS could perform. Thus, provisions are made for both performing a function or for handoffs to/from ATALARS from/to other systems performing that function.

The following subsections describe ATALARS in terms of four primary functions: airspace management, approach control, airfield traffic control, and exercise/training. Figure 6-1 illustrates the definition of the first three in terms of the type of aircraft activity that the function addresses. Airspace management addresses all aircraft activity except that associated with landing and ground activity at the airfield. Approach control deals with aircraft intending to land within the airspace. Airfield traffic control addresses runway and taxiway activity as well as aircraft on final approach.

Each of these functions generically decompose into a set of planning, situation monitoring, traffic monitoring, and traffic

ATALARS FUNCTION	AIRCRAFT ACTIVITY*
AIRSPACE MANAGEMENT	- TRANSITING - ENTERING THE AIRSPACE - EXITING THE AIRSPACE - PERFORMING MISSIONS - ORBITERS (e.g., Reconaissance Platforms) - REFUELING - OTHER
APPROACH CONTROL	- RETURNING TO BASE - APPROACHING A LANDING GATE - PRIOR TO LANDING - TRANSITION TO AIRFIELD OR HOLDING AREA
AIRFIELD TRAFFIC CONTROL	- LANDING - DEPARTING - TAXIING

*IN A GIVEN TACTICAL SITUATION ATALARS MAY BE RESPONSBILE FOR ANY SUBSET OF THESE ACTIVITIES.

FIGURE 6-1

CORRELATION OF ATALARS FUNCTIONS AND AIRCRAFT ACTIVITY control functions. Planning may be comparatively long term (e.g., for the next operations cycle) or short term (e.g., in response to the effects of an enemy attack on an airbase). Situation monitoring involves monitoring the combined traffic activity (e.g., corridor utilization) and factors potentially affecting that activity (e.g., weather). Traffic monitoring consists of maintaining status and tracks on aircraft. Traffic control is generally exercised in response to required deviations from plans (e.g., an airfield can no longer be used or aircraft with an emergency), to prevent unintentional and potentially dangerous deviations from plans (e.g., aircraft drifting out of corridor), and to resolve actual/potential problems (e.g., sequencing and spacing of aircraft for landing or aircraft closing on a collision course).

The following subsections describe this decomposition to a level of detail consistent with avoiding premature design decisions. Appendix B provides a listing of the total hierarchical structure. It is recommended that the reader review the Appendix prior to continuing with this section and periodically reference it in order to provide a contextual overview for the following discussions.

6.1 AIRSPACE MANAGEMENT

This section describes the functional requirements for planning/coordination, environment monitoring, air traffic monitoring, and air traffic control for the airspace management function. (See Figure 6-2)

6.1. Planning/Coordination

When assigned a mission from HQ TAF/TACC, an ATALARS would be activated at a given location (latitude and longitude) providing the bases or airfields within designated boundaries with an ATALARS capability. Abutting or overlapping control authorities such as a Control and Reporting Center (CRC) would be identified along with any functional limitations or extensions relative to ATALARS functions. The ATALARS database would be initialized given the assigned boundaries and limitations. Appropriate ATALARS functions would be enabled and this information coordinated with all external interfaces including other elements of the TACS (e.g., the Airborne Warning and Control System (AWACS)), Army and Airbase Air Defense Systems and any remaining Base/Airfield ATC systems.

ATALARS will establish coordination procedures with the external interfaces and define the functions to be exercised by ATALARS within the given boundary locations. This process allows ATALARS to physically and functionally integrate itself with existing ATC facilities/capabilities and allows for a smooth and efficient coordination with these systems and their functions. The primary purpose is to ensure that all functions are sufficiently addressed, but not duplicated. ATALARS will update its databases and activate/inhibit appropriate functions upon system initialization, a

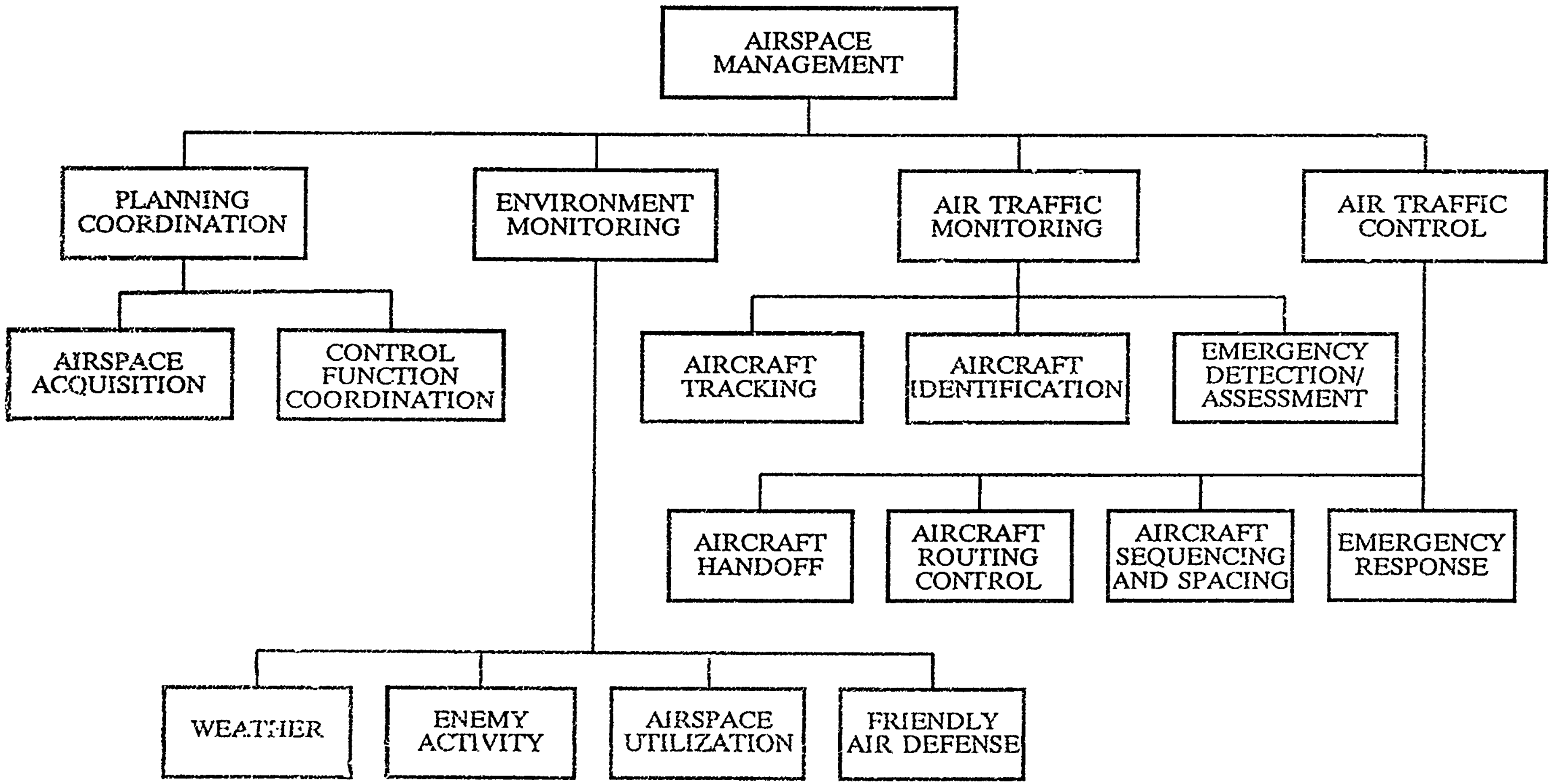

FIGURE 6-2
AIRSPACE MANAGEMENT

change in status (operation) of any existing ATC function, or a change in functional mission requirements. Redundant ATALARS functions will ensure a survivable system providing full ATC services.

6.1.2 Environment Monitoring

In order to provide adequate and accurate ATC support, the ATALARS is required to monitor the environment in which the system is operating. Changes in the environment will affect the functions that ATALARS must perform as well as the degree to which flight plans can be followed.

6.1.2.1 Weather

Weather reporting, predicting, and forecasting are performed at airbase or other local Air Weather Service (AWS) services. Reports from aircraft provide additional data. ATALARS will receive and review AWS and pilot reports to establish and maintain a weather database. This database will be continually updated to provide the most recent weather conditions to pilots and controllers when requested. Any ATALARS function affected by weather can access weather information through the database. In addition, weather advisories can be issued on a general basis to aircraft and controllers to ensure that affected parties are aware of critical weather conditions.

6.1.2.2 Enemy Activity

Enemy activity within ATALARS airspace is monitored through a database which contains the identification and location of all threats. Information concerning threats in the area is obtained through either pilot reports or air defense systems notifications. The database is updated as new threats are identified or as known threats change. Unidentified aircraft are treated initially as threats by the ATALARS automation system. Threat advisories are issued to ensure the widest possible dissemination of warnings to appropriate systems (aircraft or air defense). Routing functions use the data to route friendly traffic around enemy activity.

6.1.2.3 Airspace Utilization

Definition of restricted airspaces, corridors, and other controlled airspaces are maintained by the ATALARS database to enable theater operations and ATALARS functions to be performed on a non-interference basis. The airspace utilization function acts to monitor the aircraft activity in these areas to identify potential problems (e.g., overcrowding).

6.1.2.4 Friendly Air Defense

Conflicts between friendly aircraft and friendly air defenses (e.g., flying into free fire zones) are avoided by monitoring air defense activities. Current information on air defense activities and rules of engagement (ROE) are provided to and maintained by ATALARS with advisories sent to affected aircraft. ATALARS must be notified of changes in deployment and ROE. Conversely, routing functions that route aircraft into defended airspace must notify the appropriate air defense system.

6.1.3 Air Traffic Monitoring

Air traffic monitoring includes the requirements for aircraft tracking, aircraft identification, and emergency detection/ assessment.

6.1.3.1 Aircraft Tracking

In order to maintain control of an aircraft, it is necessary to track that aircraft. Establishing and maintaining a track on all aircraft within ATALARS airspace allows ATALARS to maintain control of the entire airspace. A track on each aircraft is established and maintained from a variety of sources. GPS and relative navigation information from the aircraft, position information from an external source such as the air defense system or AWACS, an interfacing authority handoff, as well as takeoff and touchdown notification, all provide track information pertinent to the ATALARS database. Note that track information from multiple sources requires ATALARS to correlate track data and select the best (most accurate) source.

The tracking process then consists of checking the new information for validity, consistency, and error tolerances and updating the database to reflect the new information. This track information is shared with the air defense system in keeping with the air defense coordination mentioned in 6.1.2.4. There is also internal ATALARS coordination to ensure that a positive track is established on an identified aircraft and that all tracked aircraft can be identified. Finally, the tracking function flags the database for aircraft exiting ATALARS airspace so that ATALARS functions do not proceed out of scope.

6.1.3.2 Aircraft Identification

In parallel with the tracking function, ATALARS is required to positively identify the aircraft. The identification function is triggered when an initial transmission is made by an aircraft or when an aircraft is passed to ATALARS control by an interfacing authority. In other cases identification is provided by the aircraft itself or by the outside source. Depending on the amount of information received from external sources and its relative completeness, the identification function will attempt to interrogate the aircraft and match or verify the information with the database including the ATO, flight plan, Identification Friend or Foe (IFF) code, and any unique characteristics of the aircraft. The validity of the interfacing authority will also be verified, if applicable. Aircraft identification information is shared with the air defense system to maintain coordination between ATALARS and air defense functions. An internal coordination with the ATALARS tracking function ensures all tracked aircraft are identified and all identified aircraft are tracked. Note that ATALARS requires more detailed identification than just "friendly". In order to provide appropriate guidance, ATALARS must know the flight plan. Thus, it must be able to correlate aircraft identification and flight plan.

6.1.3.3 Emergency Detection/Assessment

Emergency detection is a monitoring function which searches the various ATALARS databases for problems. In particular, it compares the environmental data to the track data to anticipate problems. (Potential collisions are treated in Section 6.1.4.4) Since monitoring is an ongoing process, the only triggers required for the situation detection function are clock inputs. Severe environmental changes may also trigger this function. However, provisions are also made to have the aircraft monitor its own situation as well as have ATALARS monitoring the situation for the aircraft. Thus, a pilot initiated distress call also serves as a trigger. Within the ATALARS database, information such as current aircraft locations, aircraft routing, airspace allocations (restricted or controlled), threat, and weather conditions are addressed concurrently. The database is searched for threatening or dangerous conditions resulting from the interaction of all the available data, and any conditions found are highlighted for correction or reaction. Route deviations or other exceptions which may affect the mission or safety of aircraft within ATALARS airspace are also highlighted. Highlighted conditions are then assessed at a severity level to establish appropriate priorities. Based on these assessed priorities, the condition is passed to either the traffic control function (routine course corrections) or the emergency response function as well as alerting the aircraft commander to the nature of the detected condition.

6.1.4 Air Traffic Control

Air traffic control within the airspace management function includes aircraft handoff, aircraft routing, aircraft sequencing and spacing, and emergency response.

6.1.4.1 Aircraft Handoff

Acceptance of a handoff from an external source acts to initialize the implementation of ATALARS functions for the aircraft. Handoff to an external source stops the performance of ATALARS functions. Once an aircraft is identified, and the identification is correlated with a track, a record is established in the ATALARS database. This record is used to access any further information on that aircraft by the functions which follow. If necessary, the aircraft is provided with information to establish communications with ATALARS. As long as the record is appropriately flagged, the system will process the appropriate control information. When the tracking function determines the aircraft to be exiting ATALARS airspace, this function will be provided with details of the boundary through which the aircraft will pass. The aircraft will then be removed from under ATALARS control, and handed-off to the appropriate interfacing authority.

Internal handoffs will occur from the airspace management function to approach control and from airfield traffic control (on takeoff) to airspace management.

6.1.4.2 Aircraft Routing Control

Once ATALARS has acquired the aircraft it is necessary to establish a safe, efficient route within ATALARS airspace. The aircraft routing function determines this route based on the aircraft's flight plan, other aircraft in the airspace, the status of the aircraft, approach control requirements (sequencing and spacing), status of the base or airfield, weather, threat location, and restricted or controlled airspace locations. The determined route (including speed) is used to update the database containing all routes within ATALARS airspace. The appropriate guidance is provided to the aircraft in order to maintain the planned route until control is transferred. At any time, a route interrupt may be received from an emergency detection function (e.g., increasing weather severity), indicating that the current route cannot be completed in a safe and efficient manner. This route interrupt will cause a new route to be developed given the new conditions and a subsequent update to the ATALARS database.

6.1.4.3 Aircraft Sequencing and Spacing

If, during the progress of the aircraft, there is a degradation of route safety or a change in approach control or mission requirements, there may be need to temporarily deviate from the planned route (or speed) while maintaining the overall route mission. The sequencing and spacing function attempts to maintain the sequencing and spacing established by the routing function. Like the routing function, sequencing and spacing considers factors such as the aircraft's flight plan, approach control requirements, etc., to determine the actual route deviations required. Based on the relative success of this analysis in responding to the changes required, this function will finalize and issue instructions that will temporarily alter the current route or instigate a route interrupt and pass the function back to aircraft routing.

6.1.4.4 Emergency Response

When an emergency is detected (e.g., potential mid-air collision), information concerning identification and positioning of the threat or condition is passed to the emergency response function. The emergency response function is activated not so much by specific conditions or threats as it is by time critical situations. Its purpose is to determine reactions required to avoid immediate or imminent dangers including an enemy attack or a mid-air collision. Because it must deal with any situation requiring immediate reaction, this function must access every database which holds information concerning the airspace and activities within the airspace as well as system capabilities and status. After determining the reactions required, the emergency response function will issue avoidance and recovery instructions to the aircraft. Once the threat or dangerous condition is diminished, recovery instructions may prove out of scope for this function. If this occurs, the function will pass to the sequencing and spacing function or the appropriate approach control function for a more comprehensive recovery sequence.

If the aircraft commander reacts prior to instructions from ATALARS or in a different manner, the routing control function (or emergency detection function) will note the deviation and institute a recovery sequence.

6.2 APPROACH CONTROL

The approach control function controls the timing of the arrival of aircraft for final approach. It consists of two categories: those necessary to establish the route parameters for the aircraft (Figure 6-3) and those necessary to cope with traffic congestion beyond that which can be handled with minor sequencing and spacing adjustment. This includes virtual or actual stacking of aircraft awaiting landing. (Virtual stacking as used here covers adjusting aircraft flight profiles to assure appropriate arrival time. Actual stacking would involve making provisions for aircraft to hold in a particular area.) Approach control may involve apportioning returning aircraft between airbases and landing strips in the event airfield servicability has been detrimentally affected. This involves selecting airbases and defining routes (or corridors) for returning aircraft to approach the airbases. The function must also accommodate aircraft with emergency conditions (emergency fuel, battle damage), and provide airbase selection, routing, and scheduling support.

In a comparatively benign environment where operations are progressing smoothly as planned, this function is virtually inactive. The function merely verifies that return to base can proceed as planned. The airspace management function (sequencing and spacing) will provide any minor adjustments required prior to final approach. Handoff will be made to the airfield traffic control function for final approach. In the less benign environment, the approach control function may be extensively exercised.

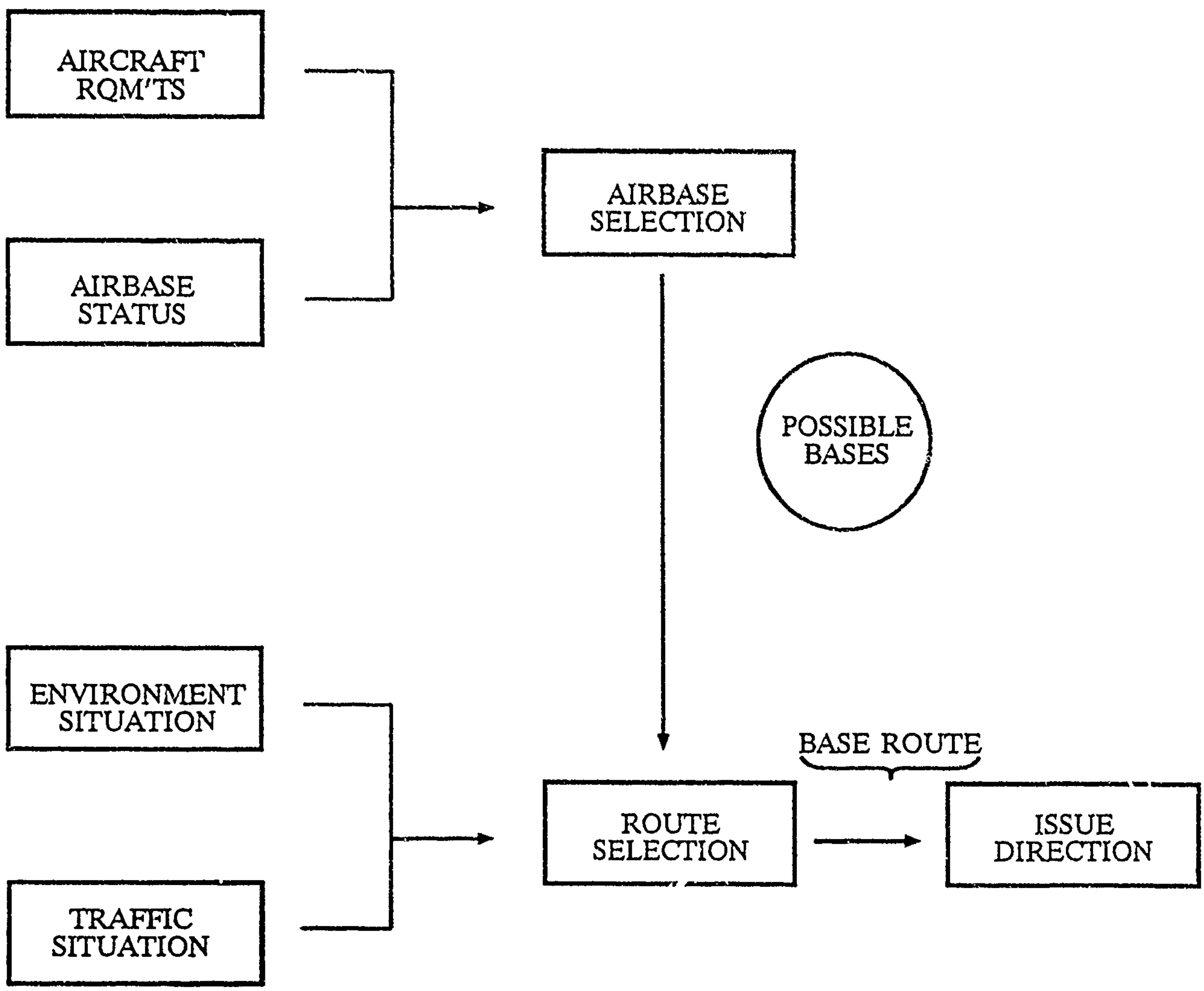

FIGURE 6-3
FUNCTIONAL FLOW FOR ROUTE SELECTION

The approach control function consists of four major sub-functions:

1) Aircraft Route Selection - Reviews current mission plans and airbase status to support the airbase selection process. Also reviews current air traffic situation and other factors (weather) to support route selection.

2) Approach Environment Monitoring - Monitors and provides status of changing conditions in weather, enemy activity, friendly air defenses, and interfacing control systems. Identifies emergency conditions.

3) Stack Operations Monitoring - Upon receipt of handoff from airspace management, stack operations monitoring will continue to track the aircraft through handoff to the airfield traffic control function. Also identifies emergency (or out-of-parameter) conditions.

4) Stack Operations Control - Upon handoff from the airspace management, the stack operations control function will provide guidance and direction as required to the aircraft. It will maintain control until handoff to the airfield traffic control function.

6.2.1 Aircraft Route Selection

When an aircraft enters the ATALARS control zone with the intent to land, the aircraft route selection function assesses the aircraft requirements and primary base status to determine whether problems currently exist that would prohibit the aircraft or group of aircraft from landing. Once this has been accomplished, the ATALARS has either verified that the flight plan can be followed or determined that a change is required. If the aircraft situation was critical, another base nearer may be sought to allow the aircraft to land. If the primary base was either under minimum weather conditions or enemy attack, alternative bases may be requested. The product of this analysis is a matching of aircraft requirements to available airbases. (See Figure 6-4)

Following airbase selection, the current situation with respect to routing would be analyzed. The first function to be exercised would be the airspace environment analysis. Changes to friendly air defenses, controlled corridors, weather conditions between the aircraft and the base, and enemy activity relative to the transit corridor, aircraft, and base would be analyzed for potential impact on route selection.

Following the analysis of the environment, the air traffic situation would be reviewed. This analysis would take inputs from the various traffic monitoring functions and analyze the data relative to potential routes for the aircraft that has entered the

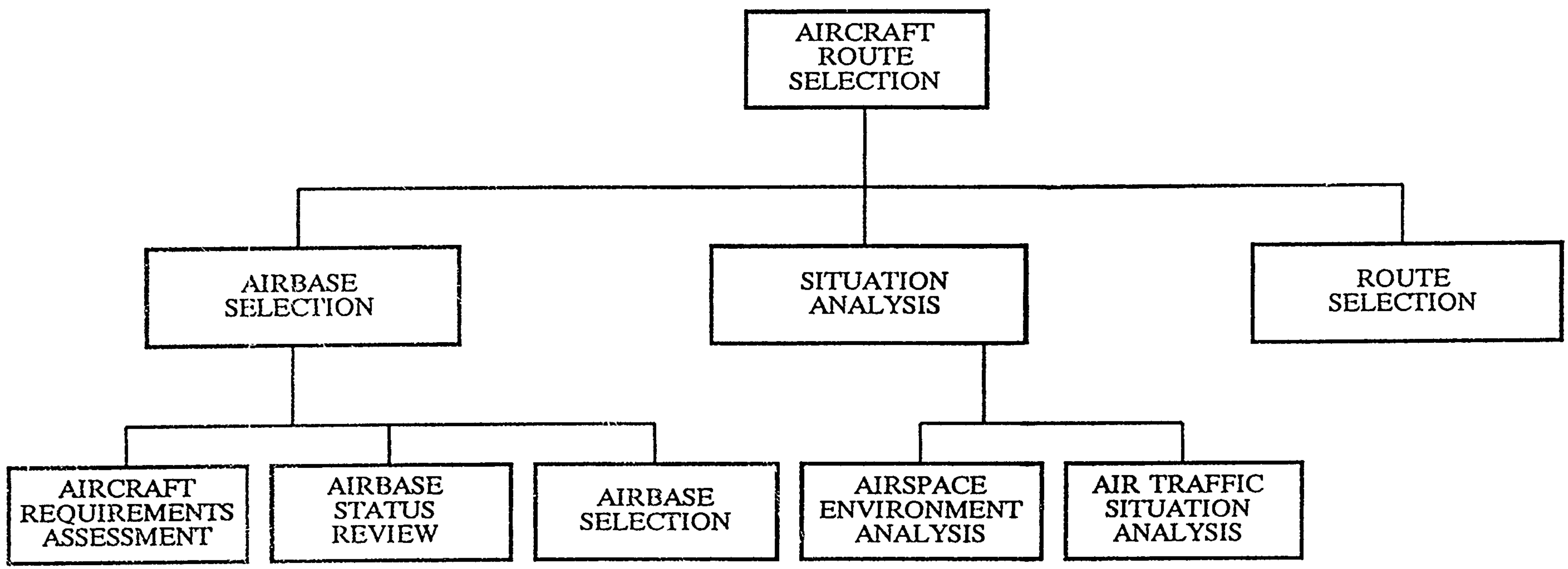

FIGURE 6-4
AIRCRAFT ROUTE SELECTION

ATALARS control zone. From this data, the route selection function can either verify the flight plan or provide recommendations for correcting the route that should be followed to return to the selected base. Once this function has completed the analysis, all the main parameters have been determined and coordinated as a plan.

Data provided by this function will allow the airspace management function to time sequence the aircraft to properly enter and follow its approved transit corridor to the handoff window of the stack controller.

6.2.1.1 Airbase Selection

The airbase selection function assesses two factors in its analysis. They are: the aircraft's capability to follow the flight plan to its intended landing base, and whether the conditions at the planned base will permit the aircraft to land.

Responses are provided by the aircraft requirements assessment and the airbase status review functions. When the analysis has been completed by these functions, the exact status of the aircraft is known and, if necessary, an alternate base is chosen. If there is no change to the flight plan, ATALARS will just perform a verification that the flight plan is viable.

The airbase selection function consists of sub-functions for aircraft requirements assessment, airbase status review, and finally the airbase selection.

6.2.1.1.1 Aircraft Requirements Assessment

Upon notification that an aircraft is entering the ATALARS control zone with a request to land, the aircraft requirements assessment function would request the status of the aircraft. Information provided by the aircraft would be position data, fuel status, and flying status of the aircraft. If there are either aircraft commander or crew injuries, it would require verbal communication between someone aboard the aircraft and the controller who is located at the ATALARS van. (This information would be manually entered by the controller into the ATALARS).

Where the airspace management function has identified the aircraft and correlated it to its flight plan, the aircraft requirements assessment function will calculate the estimated time of arrival (ETA) per the flight plan, estimate the fuel required and compare it to what fuel is available on the aircraft. The approach control function will monitor the fuel status from the time the aircraft enters the control zone until the handoff to the landing gate. Since aircraft returning from missions will be low on fuel, the situation may become critical at any point in time due to equipment malfunctions or just due to the delays caused by their location in the stack. If fuel or any other factor presents a problem, a need to find alternate landing facilities is established.

6.2.1.1.2 Airbase Status Review

If the aircraft can follow the flight plan, the airbase status review function will query the primary base (mission defined base) for anything that would prohibit the aircraft from landing. Data required for this analysis is provided by the approach environment monitoring function. The types of data include weather conditions at the base, enemy activity at or near the base, changes in friendly air defenses, and emergencies at or near the base. If there are no problems noted, the acceptability of the base would be verified.

If the primary base cannot be used or the aircraft cannot follow the flight plan due to low fuel or malfunctions, the status of potential alternates is reviewed for suitability.

6.2.1.1.3 Airbase Selection

The airbase selection function is triggered for one of two reasons. Either the aircraft which entered the airspace has an emergency situation or the primary base has a condition that will not permit the aircraft to land. Based on the aircraft's requirements and the status of suitable alternates, a list of candidate alternates is selected.

6.2.1.2 Situation Analysis

This function is composed of an airspace environment analysis and an air traffic situation analysis. The airspace environment analysis reviews potential aircraft routes for conditions that may prohibit the return of the aircraft. Parameters that this function would review include: weather conditions, enemy activity, and emergency situations. The air traffic situation analysis function will determine if there are any traffic congestion problems.

6.2.1.2.1 Airspace Environment Analysis

The airspace environment analysis function reviews the airspace for changes in weather conditions, encroaching enemy activity, and for changes in friendly air defenses. The purpose of this function is to establish the corridors that returning aircraft may transit with the least difficulty. In other words, the function sets up the guidelines where aircraft can and cannot fly. Changes in the airspace environment that are identified when this function is exercised will be flagged to the information dissemination function (6.2.5) for the purpose of identifying and notifying those aircraft and ground systems concerned. This would include aircraft that are deviating from their approved course.

6.2.1.2.2 Air Traffic Situation Analysis

This function reviews potential routes for congestion that may adversely impact the capability of the aircraft to reach the landing area.

6.2.1.3 Route Selection

This function will first consider the flight plan as the preferred route. If an alternate route is required because of changes to aircraft status or base conditions, this function will use the results of the above analyses (candidate alternates and potential routing problems) to establish candidate route/landing area pairs. These would be prioritized as a function of time required.

After the analysis has been completed, the route selection function would provide recommendations to the aircraft commander or ATALARS controller for a decision.

6.2.2 Approach Environment Monitoring

The approach environment monitoring function monitors the ATALARS control zone for conditions that would interrupt or interfere with an aircraft in a stack or approaching the landing area. It also issues advisories of these conditions and identifies emergency situations.

The type of conditions monitored are:

Weather - Fog, wind, wind shears, rain, snow, icing, or anything that may prohibit an aircraft from approaching a given base.

Enemy Activity -Unidentified and enemy aircraft entering the ATALARS control zone engaged in battle or enroute for attack. The ATALARS control zone would view those areas as restricted to returning aircraft.

Friendly Air Defenses - Changes in coverage or rules of engagement would be identified and processed by the ATALARS for the purposes of re-routing aircraft.

Interfacing Control Systems - Monitors other necessary control functions for their operational status (e.g., MLS would be monitored for landing control at a given base, etc.). This function lets ATALARS accommodate itself to the degradation of any interfacing control system (ATC, MLS, RSU, RAPCON, etc.).

6.2.2.1 Weather

The purpose of this sub-function is to monitor the weather conditions in the ATALARS control zone and at each of the bases. The weather updates will be checked at specific time intervals to identify major problems caused by local weather conditions. The information would be provided to the other ATALARS functions for the purpose of redirecting air traffic in approach corridors or stacks.

Outputs from this function will be utilized in either confirming flight plan routing or in determining alternates. These outputs will be the inputs to other functions such as base selection, stack control, and information dissemination.

6.2.2.2 Enemy Activity

This function monitors all enemy activity in and around the perimeter of the ATALARS control zone. Inputs are provided by external sources such as AWACS. The output of this function is the exact location of any unfriendly forces and any other relevant information available. This information will be an input to the route selection decision process. The data would be updated frequently to permit corrections as the situation requires. It would also be used to respond to threats to aircraft in approach corridors or stacks.

6.2.2.3 Friendly Air Defenses

This function monitors friendly air defenses and their coverage zones. In addition, the rules of engagement are defined prior to the mission and updated as required. This function will provide inputs to the route selection process for the purpose of verifying that the flight plan was correct or for the decision process required in revising the flight plan. It also assesses potential problems with approach corridors and stacks.

6.2.2.4 Interfacing Control Systems

The purpose of the interfacing control systems function is to monitor the status of each of the control and landing systems with data provided from the airfield status monitoring function (6.3.2). As the capabilities of these interfacing system degrade either due to equipment failure or due to enemy action, this function would phase in the ATALARS control as required. The database must include the control capability at each base within the ATALARS control zone.

6.2.2.5 Emergency Identification/Notification

The purpose of this function is to monitor the ATALARS control zone for any emergency situation, and identify the type of emergency that exists with its appropriate location. The types of emergencies that would be identified include: wind shear problems, aircraft being vectored too close to each other, enemy advances into the ATALARS control zone, unplanned changes in the friendly air defenses, loss of communication with the friendly air defenses, loss of the air traffic control capability, and loss of an automated landing systems like the MLS.

6.2.2.6 Issue Advisories

After formal identification of aircraft entering the ATALARS control zone, the first query to the approach control function for

Outputs from this function will be utilized in either confirming flight plan routing or in determining alternates. These outputs will be the inputs to other functions such as base selection, stack control, and information dissemination.

6.2.2.2 Enemy Activity

This function monitors all enemy activity in and around the perimeter of the ATALARS control zone. Inputs are provided by external sources such as AWACS. The output of this function is the exact location of any unfriendly forces and any other relevant information available. This information will be an input to the route selection decision process. The data would be updated frequently to permit corrections as the situation requires. It would also be used to respond to threats to aircraft in approach corridors or stacks.

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6.2.2.6 Issue Advisories

After formal identification of aircraft entering the ATALARS control zone, the first query to the approach control function for base and route selection will be followed by a timed and dated message. The message will update the pilot on the environment. While this information is being presented to the pilot, the ATALARS approach environment monitoring functions will be simultaneously updating the information to the current conditions.

Updates to these advisories will be made each time significant changes occur.

6.2.3 Stack Operations Monitoring

The stack operations monitoring function monitors all aircraft within the ATALARS control zone in their various entry and holding locations.

6.2.3.1 Aircraft Tracking

The primary purpose of this function is to continue tracking the aircraft through the holding stack to final approach at which time the airfield traffic control function would take over.

Outputs from this function would be utilized in time sequencing aircraft that have just entered the ATALARS control zone requesting landing information. In addition, this information would be used to coordinate between the airfield traffic control function and the approach control function for time sequencing the aircraft that are being extracted from the stack for landing.

6.2.3.2 Emergency Detection/Assessment

This function monitors the stacks for any emergency situations. Once detected, it defines the type of emergency and assesses the criticality.

Following the assessment of the emergency, this function will trigger those functions necessary to provide assistance to the aircraft involved. Additionally, a flag will be sent to the information dissemination function to assure alerting all concerned parties.

6.2.4 Stack Operation Control

The stack operations control function maintains control by guiding the aircraft into virtual and actual stacks and handoffs to the ATALARS landing function. This control function is comprised of six sub-functions:

1) Aircraft Handoff - This function is where the control of the aircraft in the ATALARS control zone is either handed to the stack operation control or handed to the airfield traffic control function.

2) Stack Insertion - This function calculates the time sequence, aircraft velocity, etc. for aircraft to be inserted into the stack. Additionally, it notes the spacing required in order to maintain the proper flow of air traffic taking off and landing.

3) Stack Traffic Control - This function maintains control of the air traffic within the stack, and makes changes that are necessary to keep a safe separation among the aircraft.

4) Stack Extraction - This function provides the sequencing and spacing for aircraft to land at a given base

5) Runway Monitoring - This function monitors the runway and provides the data required to time sequence/space the aircraft being extracted from the stack.

6) Emergency Response - This function takes over the control of vectoring aircraft out and around emergency situations.

6.2.4.1 Aircraft Handoff

Within the approach control function, the aircraft handoff is being accomplished from one ATALARS function to another. Once the airspace management function has completed its process, the control of the aircraft would be handed over to the approach control function. The second time the handoff of control takes place is when the aircraft has been extracted from either the virtual or the actual stack. Then the airspace control would be handed to the ATALARS landing control function.

6.2.4.2 Stack Insertion

The stack insertion function has three states of operation; virtual stack insertion, actual stack insertion, and no action required. Virtual stack insertion is the process of time sequencing and vectoring the aircraft to the landing base location. In times of light aircraft activity, the virtual stack may be the only timing and spacing required to get the aircraft to the landing gate. Insertion of aircraft into an actual stack or holding area would be a continuation of the virtual stack process. Instead of handing-off to airfield traffic control, the stack control function would assume control. This process would be necessary at times when the volume of air traffic is in excess of what the landing base(s) can handle during a given period. No action would be required when the aircraft is performing according to the intended flight plan and no air traffic or environmental problems exist.

6.2.4.3 Stack Traffic Control

When either virtual or actual stack operations are required, the stack traffic control function will be in operation. The main purpose of this function is to provide the direction necessary to orchestrate the stack operation. It directs changes in the altitude or position to eventually bring the aircraft to its planned extraction point. The control of the aircraft in an emergency would be handed directly to the emergency response function for immediate action.

An aircraft that starts to drift out of the assigned pattern, provided that it is not in an emergency situation, will be directed by the stack traffic control function to return to its approved holding or transit corridor.

6.2.4.4 Stack Extraction

In both the virtual stack and actual stack operations, the stack extraction function would be utilized to properly time sequence and space the aircraft landing at a given airbase. For this function to operate, it must query the aircraft tracking function and the runway monitoring function for real time status. Once the status has been assessed, the stack extraction function will direct the aircraft to the appropriate window to its final landing gate. Simultaneously, the stack extraction routine would trigger the information dissemination function to notify the ATC function about the landing aircraft.

6.2.4.5 Runway Monitoring

The runway monitoring function is mainly controlled by the airfield traffic control function. Data from this function which contains traffic traversing the runway will be utilized by the stack insertion and extraction functions. This function will provide the status of runway usability, (i.e., runway battle damage, crashed aircraft, ground vehicles blocking the runway, or barrier/cable status).

6.2.4.6 Emergency Response

The primary purpose of this function is to provide direction to the aircraft with the emergency and, if necessary, expedite the landing of the aircraft. Typical types of emergencies that would require a reaction are: quick changes in the environment (i.e., weather, wind shear problems, etc), aircraft with damage to critical systems and collision avoidance.

6.2.5 Information Dissemination

This function disseminates information to those agencies or aircraft necessary to safely complete the mission. For example, in the case where direction has been given to an aircraft or groups of aircraft, this function would be triggered to send out notification of the aircraft entering the control zones to the air traffic controllers, friendly air defenses, and any other agency required.

Triggering of this function may be accomplished by any of the ATALARS functions.

6.2.5.1 Aircraft Notification

This function will notify the pilot of major changes to the mission plan, such as recent changes in the friendly air defense corridors, location of existing emergencies, and critical changes in weather.

6.2.5.2 Controller Notification

This function will alert the controller at the primary landing base that there is an aircraft that has entered the control zone with an intent to land and the route the aircraft is expected to follow. Additionally, the status of the aircraft is provided, if it is in an emergency situation.

6.2.5.3 Air Defense Notification

This function notifies the friendly air defenses of friendly aircraft about to enter their coverage zones.

6.3 AIRFIELD TRAFFIC CONTROL

This section describes the requirements for the process of scheduling and controlling air and ground traffic at airfields in an ATALARS control zone. (See Figure 6-5)

6.3.1 Traffic Scheduling

Traffic scheduling is the processing of landing and takeoff requirements (Figure 6-6) and results in the assignment of a time slot for each aircraft requesting takeoff/landing.

6.3.1.1 Landing Requirements Assessment

Traffic landing requirements are derived from an assessment of current aircraft movements in the control zone as well as the planning for future takeoffs and landings at airfields, Up to 300 aircraft are to be accommodated, distributed over 10 airbases. While the sub-functions are described in terms of ATALARS performing all of the scheduling, most probably it will be a cooperative effort between ATALARS and the airfields.

6.3.1.1.1 Schedule Planning

The planning for traffic landing requirements assesses the expected future aircraft activity in the control zone and its capability to handle the traffic load. The process is initiated by a periodic review of flight plan data. The pertinent data is provided by interfaces to the TACS (TACC and WOCs) as well as data

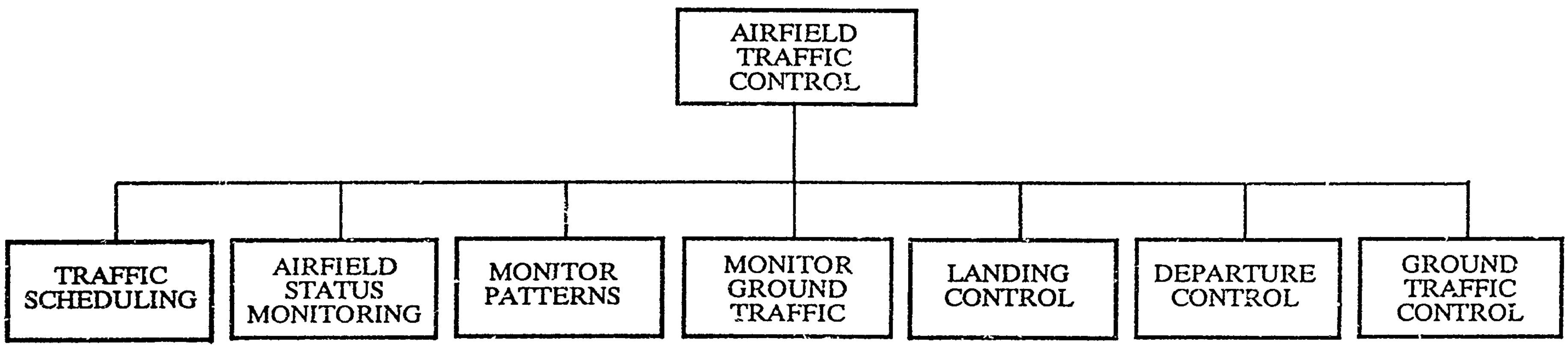


FIGURE 6-5
AIRFIELD TRAFFIC CONTROL

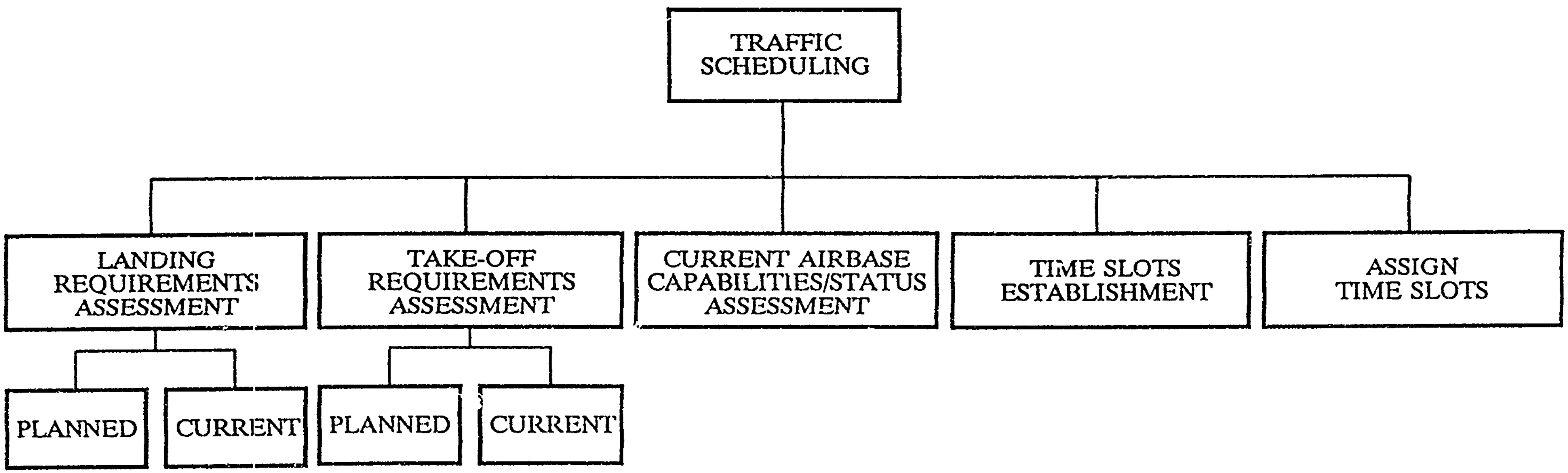


FIGURE 6-6
TRAFFIC SCHEDULING

from the airfields. The data is keyed to the ID to be given by the aircraft on entering ATALARS airspace, and includes routing information, length of flight, destination, mission number and priority. The ATALARS must be capable of handling the frequency of changes occurring in the control zone and the expected volume of air traffic. The system database requirements include aircraft characteristics, basing requirements (i.e., primary and alternate bases), and weather forecasts. Outputs are used for projecting landing requirements (number of aircraft, runway assignment, and arrival times) at airfields within the control zone.

6.3.1.1.2 Current Scheduling

Current scheduling relates to the real time air traffic situation in the control zone. The process starts with a request from the airbase selection function in approach control. This may be a routine request for a landing time slot, a result of overload in the number of aircraft in the stack, or an immediate request for landing due to aircraft damage or crew injury. The input to the control system will be from aircraft automated digital data or a voice communications request from the pilot. The input contains the aircraft position (latitude, longitude, altitude), vector, type of aircraft, fuel remaining, and any damage report. The ATALARS must be capable of processing immediate requests for landing emergencies and handle the expected air traffic density of 70-100 aircraft per hour. Pertinent database information is derived from other system functions and includes current weather conditions and airfield status. The output will be used to assign time slots for each aircraft by arrival time and runway assignment.

6.3.1.2 Takeoff Requirements Assessment

Assessment of takeoff traffic requirements involves current aircraft awaiting takeoff and aircraft filing flight plans at airfields in the control zone. Up to 10 bases may be included in various ATALARS control areas. As with scheduling landings, takeoff scheduling will probably be a cooperative effort between ATALARS and the airfields.

6.3.1.2.1 Schedule Planning

The planning for aircraft takeoffs includes an assessment of future air activity in the control zone and its capability to handle the expected additional air traffic as a result of takeoffs. The process is initiated by a review of flight plan database information. The flight plan will include the requested departure time, routing information, priority, and type of aircraft. The flight plan is assigned a specific identity which is passed to the airspace management function. The database requirements include minimum runway length for aircraft type, aircraft spacing for takeoffs, weather forecasts, enemy activity, and the air defense situation. The ATALARS must be capable of handling the volume of planned takeoff traffic data. Outputs are used to establish time slots for departing aircraft and runway assignments.

6.3.1.2.2 Current Scheduling

Current scheduling requires an assessment of the real time air traffic situation in the control zone. The process is initiated by a request for takeoff instructions from ground traffic control. The ATALARS will review the flight plans for current scheduled takeoffs within a specified time period. By reviewing the departure times, runway assignment/requirement, type of aircraft, priority, current weather conditions, and air defense environment, the function assigns a time slot and runway for the requesting aircraft.

6.3.1.3 Current Airbase Capabilities and Status Assessment

This function assesses the current condition of up to 10 airbases with respect to their capacity for aircraft landings and takeoffs as a function of time. The assessment is based on airfield status data provided by the airfield status monitoring function and standard operating procedures given the conditions (e.g., runway width, weather). The output consists of defining landing and takeoff intervals.

6.3.1.4 Time Slots Establishment

This function establishes the order of landings and takeoffs at airbases in an ATALARS control zone. The process is used for planning air traffic activity or is initiated by a situation change requiring establishment of more time slots or different time assignments. Inputs come from other functions such as landing requirements assessment, takeoff requirements assessment, and current airbase capabilities/status assessment. Database requirements must include fuel consumption rates per aircraft type, separation distance between aircraft, and weather conditions. The process results in establishing landing/takeoff slots to be used in the landing control and departure control functions. This function initially produces a plan (schedule of time periods for landings, takeoffs or both) for the next operations cycle and then adjusts the plan as required.

6.3.1.5 Assign Time Slots

This function assigns specific time slots for aircraft awaiting landing or takeoff instructions at airfields in the ATALARS control zone. The function is initiated by a landing request, airbase selection, or takeoff request. Inputs for this function are the available time slots for each request. Database requirements include separation distance between aircraft, weather conditions, and runway conditions. Outputs go to notify the controller for stack extraction and aircraft takeoff through the landing control and departure control functions.

6.3.2 Airfield Status Monitoring

This function determines and maintains the status of airfields within the control zone. It is used in planning traffic scheduling and air traffic control. (See Figure 6-7)

6.3.2.1 Control Systems

This process monitors the operational status of various airfield systems (landing system, ATC tower, air/ground communications, air defenses, etc.). The process is initiated by a notification of change in status for one or more of the systems. Inputs include periodic reports which identify the system and its operational status; exception reports which identify the system, reason it is not operational, and projected outage time; and return to operation reports which identify the system and the restoral time. ATALARS must accommodate a relatively small volume of data and expected frequency of changes. The database will identify each control system and its current operational status including predicted restoral times for any non-operational systems. Outputs from this function are used to assess current airbase capabilities/status and issue advisories to local air traffic and the airspace management function.

6.3.2.2 Runways

This function monitors the operational status of all runways (i.e., weather, barriers, cables, etc.) at airfields within the control zone. The process is initiated by a notification of change in operational status. Inputs include periodic reports which identify the airfield/runway and its status; exception reports which identify non-operational airfields/runways, the reason (aircraft accident, enemy action), and the projected out of service time; and return to service reports which identify the airfield runway and time returned to service. The information is provided from automated digital data or manual inputs. The function must accommodate a relatively small volume of data and expected frequency of changes. The database requirements include the identity of runways/autobahns and their status or forecasted status changes. Outputs, changes in runway status, are provided to the traffic scheduling, airbase selection, and landing control functions. This function must operate in real-time to react to runway outages (e.g., crash, sabotage) as aircraft are approaching.

6.3.2.3 Taxiways

This function monitors the operational status of taxiways at airfields in the control zone. It is initiated by a change in status notification. Three types of input reports will be accommodated: periodic, exception, and return to service. All reports will identify the taxiway. The exception report will provide the reason it is not operational (i.e., enemy action, congestion) and its projected out of service time. The return to

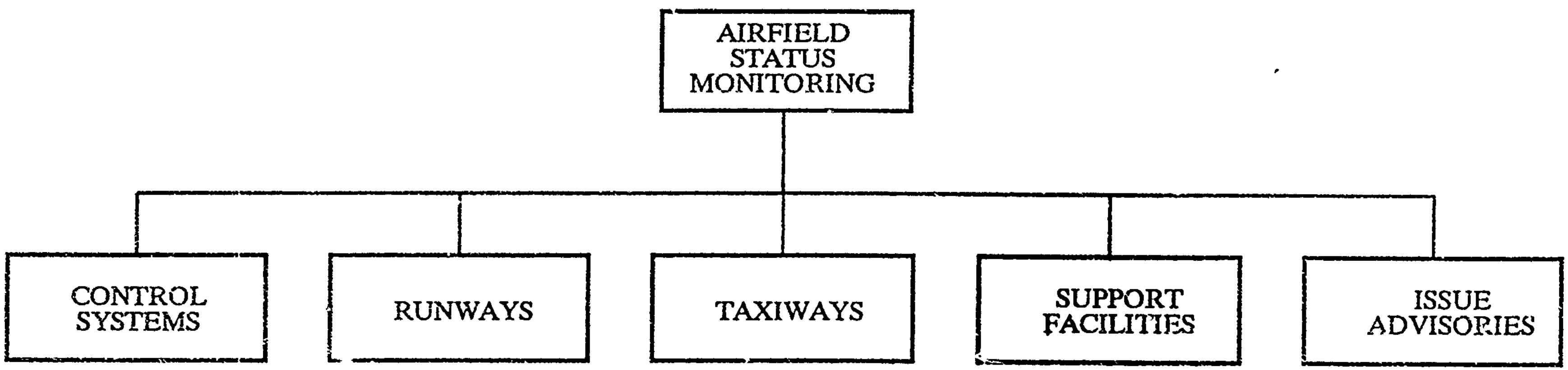


FIGURE 6-7
AIRFIELD STATUS MONITORING

service report will also provide the restored service time. The system must handle a relatively small volume of data and expected frequency of changes. The database requirements include an identification of taxiways and their status or forecasted status change. Outputs are used to issue notifications to the traffic scheduling, departure traffic control, and ground traffic control functions.

6.3.2.4 Support Facilities

This process monitors the status of airfield support facilities (fuel, ordnance, maintenance and fire control equipment). It is initiated by a notification of change in status or by a periodic review of support capabilities. The inputs include fuel availability, maintenance capabilities for aircraft type, types of ordnance available, and status of emergency equipment. The function must have the storage capacity of data for 10 airbases, as well as handle the expected frequency of changes. The database requirements include the current and predicted changes to fuel and ordnance availability, and maintenance capabilities (i.e., lack of spare parts, personnel). Outputs are used to support the airbase selection function through notification of changes.

6.3.2.5 Issue Advisories

This function issues advisories to aircraft and other ATALARS functions on the current status or changes to airfield capabilities in the control zone. It is started by a change in status from the monitoring of control systems, runways, taxiways, and support facilities. Outputs are a periodic notification of airfield status to aircraft and to the traffic scheduling and airbase selection functions. This information will be transmitted when requested by another function or action.

6.3.3 Monitor Patterns

This function monitors aircraft after takeoff or after stack extraction until handoff to airspace management or landing control.

6.3.3.1 Aircraft Tracking

This function establishes and maintains track of 70-100 aircraft per hour leaving stack operations control or entering the airspace management system from departure control. The process is started by notification from the stack extraction or departure control functions. Inputs include track identification, speed, vector, and runway selection for landing aircraft and the flight plan for departing aircraft. The database .ust include track information on all aircraft in the control zone and updated flight plan data for departing aircraft. Outputs provide the current aircraft location to the approach control and airspace management functions.

6.3.3.2 Emergency Detection/Assessment

This function detects air traffic which are not following directed routings in the area of stacks and airfields, and provides an assessment of their impact on airspace management in the control zone. The process is initiated by detection of a deviation from aircraft tracking and assesses changes required to avert collision with other aircraft. Inputs include a detection of aircraft following too close, incorrect altitude, aircraft in the wrong corridor, aircraft crash on takeoff or landing which blocks the runway, and unidentified aircraft in the monitor pattern area. The database includes track information for inbound aircraft and flight profiles for takeoffs. Outputs will alert the controller and pilot, as applicable, of the emergency or deviation.

6.3.4 Monitor Ground Traffic

This function establishes and maintains the locations of all ground aircraft and vehicles on runways and taxiways.

6.3.4.1 Runways

This function monitors the location of all aircraft and ground vehicles on runways. Periodic reviews are made of vehicle/aircraft locations and any requests to cross runways. The process includes vehicle/aircraft identification and location. Runway identifications, ground vehicle (fuel or crash truck), and taxiing aircraft identifications are required for the database. Outputs are used to notify the landing control, departure control, and ground traffic control functions.

6.3.4.2 Taxiways

This function monitors the location of all aircraft and ground vehicles on taxiways. Periodic reviews are made of vehicle/aircraft locations. The process includes the identification of taxiing aircraft and ground vehicles (fuel, maintenance) using the taxiways. Taxiway identifications, ground vehicle identification, and taxiing aircraft identification are required for the database. Outputs are used to notify ground traffic control.

6.3.5 Landing Control

This function contains requirements for controlling aircraft handoff, landing sequencing, aircraft guidance, and emergency response.

6.3.5.1 Aircraft Handoff

When an aircraft enters the final landing approach window, the landing handoff function will confirm aircraft intentions/capabilities along with airbase activity and runway status. The aircraft is then put into a landing queue which includes all aircraft in final approach. If more than one aircraft is found to be within the final approach window, the landing sequencing function is flagged, otherwise the process is passed to the runway control function.

6.3.5.2 Landing Sequencing and Spacing

The landing sequencing function will prioritize the landing queue for any aircraft with conflicting approaches. This prioritization will be based on the aircraft's status and location. The process is then passed to runway control for coordination. It also fine-tunes the spacing of approaching aircraft.

6.3.5.3 Aircraft Guidance

The landing guidance function initially provides the aircraft with the final approach clearance. It then provides guidance to the landing gate defined by the landing system in use (e.g., MLS). (Note that the landing gate could be visual acquisition of the runway or airstrip by the pilot.) The landing guidance precision must be in accordance with the landing gate requirements. Thus, ATALARS must meet the most stringent requirements imposed by the absence of any landing guidance system at the airfield itself. The limitation on this requirement will be the precision with which the aircraft can determine its own position, altitude, and velocity.

6.3.5.4 Emergency Response

Emergencies occurring during final approach will require responses as stated in 6.2.4.6. Aircraft which are unable to land will be re-entered into the landing procedure through the stack operations control function.

6.3.6 Departure Control

An aircraft requesting departure clearance will have that request passed to the departure control function. This function confirms aircraft capabilities, runway status, and assigned takeoff slot. Then it is entered into the departure queue which contains all aircraft requesting departure clearance. If more than one aircraft requests departure clearance at the same time, the departure sequencing function is activated; otherwise, the process is passed to the runway control function which will issue takeoff clearance.

The departure sequencing function will prioritize the departure queue for all aircraft awaiting departure clearance. This prioritization will be based on the time the clearance was requested, the aircraft's status, and assigned time slot. Assignment or reassignment of time slots may be required. The process is then passed to runway control for coordination which will issue takeoff clearances.

After takeoff guidance may be provided to ensure a safe transition into ATALARS airspace. Information such as the aircraft's capabilities, status and flight plan in addition to current local air activity are taken into account in determining the pattern to be followed by the departing aircraft. Control is then passed to the aircraft routing function of airspace management to provide for the aircraft's control through the remaining ATALARS airspace.

6.3.7 Ground Traffic Control

This function includes control of aircraft and ground vehicle movements on runways, taxiways, and emergency response.

6.3.7.1 Runway Control

Runway activity must be controlled at a central point due to the requirement to service landing as well as departing aircraft. This function follows the landing or departure handoff after any sequencing required to keep the associated landing or departing queue updated. Once engaged, the runway control function will allocate runway time according to assigned time slots. This function will also consider the runway status, current weather conditions, and the status of the aircraft in determining the amount of runway time required for each landing or departure activity. Consequently, the runway control function will provide information on the allotted runway availability. The runway control function will then issue a landing or takeoff clearance to the landing or departure guidance function to safely land the aircraft or allow the aircraft to depart.

6.3.7.2 Taxi Control

This function controls the traffic flow for both aircraft and ground vehicles. It allows flights to enter and depart the runway area in an efficient manner and provides the appropriate control instruction. For landing aircraft, the taxi control function allocates room to allow the aircraft to reach its docking position once it has landed and ATALARS control is no longer necessary. This function also monitors the status of the aircraft and servicing capabilities of the base or airfield to provide effective coordination between the two. For departing aircraft, once the aircraft has requested departure clearance, this function must coordinate with runway control to establish the runway and time slot allocated to that aircraft. The aircraft is then entered into the traffic flow and monitored up to entry into the appropriate runway area where control is passed to the runway control function to await takeoff clearance.

6.3.7.3 Emergency Response

Emergencies occurring during ground traffic control will require responses as stated in 6.2.4.6.

6.4 EXERCISE/TRAINING

The ATALARS concept is a deviation from the current methods of providing ATC. Further, while more automation is to be expected in the future for both civilian and military ATC, the ATALARS will most probably remain a variation from the peacetime norm with fully operational ATC systems. Thus, fairly extensive training of operators will be required. To a more limited extent training exercises involving pilots, airbase personnel, and operators of interfacing control systems are also necessary. Thus, like all tactical systems, the ATALARS will be deployed and exercised.

The ATALARS is, however, a wartime system, primarily intended to provide the minimum necessary degree of control. This concept may not be compatible with peacetime requirements for control. Thus, peacetime operations may require the ATALARS to perform additional functions and will potentially require significant differences in its external interfaces to civilian ATC and range control systems as compared to wartime external interfaces.

Substantial analysis of this aspect of the ATALARS is not a requirement of this study. A cursory examination of this issue suggests that there will be a planning function similar to that described in Section 6.1.1, but with some differences due to more rigid peacetime exercise planning requirements and flight safety consideration. There will be a requirement for interfacing with range control in addition to tactical systems. This interface will involve flight safety coordination, possibly more extensive exchange of track data, and probably a more formalized and complex handoff process. Similarly, there may be more stringent requirements placed on interfacing with a civilian ATC (e.g., the civil corridor over the Eglin AFB range), although range control may be able to perform this function rather than having the ATALARS do so. This interface would involve handoff of military aircraft entering the exercise area and possible exchange of planning data as well as track data.

Some comparatively standard functions that might also be included in the ADP system to support exercise/training are data collection and simulation. Data could be automatically collected, stored, and processed to provide for post exercise evaluation and event reconstruction. Simulations could be used for operator training, to supplement exercise activity (e.g., increase traffic density), and to modify the exercise environment (e.g., weather).

SECTION 7.0
SYSTEM DESIGN CONCEPTS

The previous section discussed the ATALARS in terms of operational system functions, i.e. in terms of what the combination of personnel, communications, and ADP must do. Very limited consideration was given to allocation of tasks between man and machine. The subsystems were not yet defined except perhaps implicitly, and interface requirements were not aggregated. This section begins the process of defining the ATALARS as a system, rather than an operational entity.

Section 4 of ESD-TR-86-259 provided an overview of the ATALARS concept in terms of six subsystems: indirect surveillance, automated ground management and control, automated control data and information transfer, landing guidance, aircraft on board ATC, and interface with tactical systems. This particular decomposition of the ATALARS combines the definition of system functions with subsystem allocations, e.g., the control function (developing and issuing direction to aircraft) is split between automated ground management and control and aircraft on board ATC. For the purpose of establishing and maintaining a structured approach to the design of the ATALARS, the operational functions have been aggregated and allocated to a series of design functions which can in turn be further decomposed and allocated to the various subsystems.

The ATALARS definitely consists of at least two subsystems: an ATALARS van and an aircraft subsystem. Less definitely, there may be an airbase subsystem (involving, for example, some means of monitoring runways) and possibly an external interface subsystem (for example a communications terminal to be deployed to the local airbase air defense system). These latter two subsystems will remain comparatively ill-defined until detailed design trade-offs are conducted and acquisition strategies are developed which take into consideration related on-going programs (e.g., would a GPS terminal required for relative navigations be considered part of the ATALARS?).

The following subsections discuss the ATALARS van subsystem, the aircraft subsystem, the airbase subsystem, and other interfaces. Section 8 presents design considerations (e.g., mobility, survivability, security, capacity, and ADP).

7.1 VAN SUBSYSTEM

The ATALARS van subsystem will mainly consist of an automation element with interfaces to external subsystems and the controller. The automation element will provide the database, information processing, and appropriate decision making support to conduct the ATC mission. To meet this requirement it is necessary to ensure maximum benefit from both hardware and software relative to system performance as well as system functions. The automation element will automate the ATALARS surveillance, situation monitoring and assessment, air traffic control, ground traffic control, landing control, departure control, and planning functions.

7.1.1 Automation Element

Hardware is the key to the systems' ultimate abilities. It is therefore important to choose components whose architecture portrays the same attributes that the automation element must possess. Use of multitasking will reduce idle time in the central processing unit and more effectively mimic human processing by concurrently working several tasks (in small increments). Input and output devices must act not only to translate information between man and machine, but they must do so in consonance with the capabilities of the ATALARS controller. The emphasis here lies solely with the ability to display this information to the controller (or pilot), allowing the human to make the decisions. Providing data that can be interpreted accurately and quickly is essential, including the ability to allow data to be presented in various formats, but always differentiating between the types of data. The ability to simultaneously display a combiniation of different information clearly on one display/monitor will allow one controller to perform/monitor many functions. One method of handling the large volume of information would be to present only initial data and controls unless additional information is requested. Control support of recommended options can queue the controller to reduce reaction time and increase confidence in the actions that need to be taken.

7.1.1.1 Software

As hardware dictates the ultimate abilities of the system, the software determines how well the system works. Concurrent programming (having several programs in execution at a given time) is the first concept employed to make the construction of an ATALARS automation system feasible. By moving the various activities of an operating system into asychronous processes, only the mechanisms for interprocess communication and time sharing are allocated to a fundamental operating system kernel. The kernel gives each process the appearance of having control of all processing capabilities which can be accessed through that kernel. These virtual processing units allow many programs to be executed at a single instant. These systems are called open systems when they deal with large quantities of diverse information within massive concurrency.

Another characteristic of open systems is asynchrony. Since the system cannot predict the behavior of its environment, new information can enter the system at any time requiring it to operate asynchronously with that environment. Due to their physical distance, components of the system would have to be slowed to the lowest common denominator in order to maintain synchronization, so these too must operate asynchronously to achieve real-time performance. Decentralized control is required to keep decisions close to where they are needed in order to avoid confusion created by an inability to maintain a current status on the entire system. This is due to the asynchronous behavior of the communications and the inherent unreliability and bottleneck characteristics of using a single controlling devices. The components of an open system may have their internal operation, organization or current state unavailable to other components because of security reasons or communications outages. Information should be transferred between components via explicit communications to maintain security, conserve energy, and ensure the integrity of each component. These explicit communications allow each component to track its own state and interfaces and allows detection and identification of downed systems. The failure of any component must be accomodated by other operating components to allow the system to operate continuously.

7.1.1.2 Database

The data requirements of an ATALARS system will be very large, and the architecture on which this database is structured should enhance an ability to access the data quickly. Such an architecture might be based on a relational model, that is, data is stored and accessed by means of a two-dimensional table where data can be traced by its relation to other data in the table. Network or tree-based structures can also be used but these may prove to be too limited for an ATALARS implementation. Measures to ensure the validity of the data such as making use of a replicated database should be employed to support fault-tolerance within the processing system.

7.1.1.3 Operational Code

The operational software should be approached by ensuring a strict adherence to standards, employing a top down, traceable design, and allowing functional partitioning. Attributes to be gained by use of a functionally distributed design include improved performance (in reduced response times), increased flexibilty, maintainability, reliability, and an adaptability for incremental enhancements. The top down design should address a hierarchical decomposition of activities to subactivities, to specific tasks, in order to support a system response based on event clustering, efficiently determining machine aiding requirements, and allowing establishment of effective decomposition tools.

The nature of air traffic control requires expert knowledge on the part of the controller to quickly interpret vast amounts of data and immediately apply them in a real-time, real world environment. As the amount and types of information available to the controller increases, it becomes extremely critical what tasks are allocated to maximize the controller's effectiveness. In designing the automation system to perform those tasks, concepts of expert system technology are applied to the performance of highly specialized tasks normally considered to require human expertise. By providing the system with highly detailed knowledge of the rules of air traffic control, the system can apply that knowledge without the consult of a human operator.

7.1.2 Surveillance

From Section 6.0 it is clear that the ATALARS must establish and maintain a track on aircraft in the assigned airspace. While precision requirements vary between the operational functions (e.g., flight following an aircraft in a transit corridor as opposed to providing landing guidance), other requirements are fundamentally the same (i.e., the need for position, altitude, velocity, identification, and associated flight plan data). Thus, the ATALARS surveillance function may be considered the aggregate of the tracking functions. Also included is the initial appending of flight plan data and the maintainance of any changes to that data as introduced by other ATALARS functions or other controlling authorities.

Since the surveillance function is a passive activity which monitors and correlates positional data received from external sources, much of this activity will consist of managing that database.

7.1.2.1 Track Data

In the ATALARS concept, there are two sources of track related data: reports from the aircraft and reports from external surveillance systems (air defense radars, AWACS, TACS radars). In both cases the interface will consist of a data link and voice communications.

To provide the basic track data (position, altitude, and velocity) the aircraft subsystem (See Section 7.2) must periodically and automatically transmit its knowledge, derived from on-board systems, to the ATALARS van. Thus, the aircraft subsystem must provide readouts from the appropriate avionics (e.g., GPS, MLS, INS, altimeter) in a format suitable for automatic transmission (e.g., via JTIDS).

The van subsystem must be able to accept and automatically process data from both sources, correlate as required, and produce a displayable, geographic track database for use by either man or machine in performing functions requiring track data. Tracks (position, velocity) must be updated periodically with frequency of update based either on the most stringent requirement (landing guidance) or the requirement imposed by the activity of the aircraft. A track prediction algorithm may be required to compensate for terrain masking.

The aircraft ID must be associated with the track. Position data provided by the aircraft subsystem will include ID; however, external sources will have "U/I" (unidentified) and "enemy" designations as well as friendly ID. Most probably, the tracking function will, on updating the tracks, also check for course and velocity deviations as well as potential collisions.

The tracking function must also handle tracks outside the ATALARS airspace, since automatic transmissions will be received by the van even if the aircraft is outside the airspace. Similarly, data from external sources may include both irrelevant and relevant (impending handoff) tracks outside the airspace.

Also, it is conceivable that there may be aircraft in the ATALARS airspace for which the ATALARS should not provide any guidance (e.g., interceptors). These tracks must be flagged to avoid providing any automated guidance.

7.1.2.2 Ancillary Data

In order to allow automation of some of the more routine ATC functions, the ATALARS must be aware of the intent of the aircraft (i.e., the flight plan). Thus, as a track is established and maintained, the system must also establish and maintain the associated ancillary data: intended course, speed, altitude, and destination. The surveillance function must append this data to the track data as a track is established. As changes are made due to pilot decisions, ATALARS guidance or other factors of this data must be updated.

7.1.3 Situation Monitoring And Assessemnt

The three primary mission functions all require varying degrees of status/situation monitoring to assess the impact on air operations. The environment to be monitored includes weather, enemy activity, friendly air defenses, interfacing systems, airbases, and air traffic related factors (e.g., density, delays). This system function would aggregate the requirements of all three functions, maintaining the distinction between these requirements; for example, weather data for airspace management as opposed to airfield traffic control.

The function must produce and update a displayable, geographic situation database. Access to the database (either direct or in terms of a display) must allow separation or aggregation of the various environmental factors as well as varying levels of detail (e.g., the airfield traffic control function must consider wind shear situations on runway approaches, while the airspace management function only requires a generalized weather situation).

The function must identify generally adverse situations (e.g., thunderstorm, enemy activity) and issue appropriate advisories as well as identifying more specific and immediate emergency situations (e.g., a crash on a runway when other aircraft are approaching or loss of a landing control system).

In view of the need to minimize the manual workload within the van, much of the data to be processed by this function to establish and maintain the database must be provided via data link. Similarly, the system must be capable of automatically generating and disseminating advisory information.

7.1.4 Control of Air Traffic

This system function aggregates the various control and control related mission functions: internal and external handoffs, general (e.g., corridor utilization) and specific (e.g., stack extraction, spacing, sequencing) guidance, and emergency response. The ATALARS concept calls for three versions of control: automated issuance of guidance information using knowledge-based techniques, pilot decisions based on information provided by the ATALARS, and ground controller guidance. Further, each of the three primary operational functions requires a different degree of control in terms of precision. In addition, the ATALARS concept fundamentally calls for control by exception. Guidance is provided only to the extent necessitated by deviation from plans or emergency situations.

7.1.4.1 Handoffs

To a certain degree handoffs can be implicit and automated. As an example, as an aircraft enters the ATALARS airspace, the system can automatically flag the track for ATALARS control and issue a message, to be acknowledged by the aircraft, establishing the ATALARS as the control authority. The process would be reversed on exiting the airspace. Similarly internal handoffs to establish a different or more precise mode of control can also be handled automatically by modifying the track flag. Thus, a transmitting aircraft following a pre-established corridor or flight plan may never interact with the ATALARS van except for the "handshake" on entry, exit, takeoff, or landing.

7.1.4.2 Emergency Response

Emergency control requirements can be differentiated from normal control requirements in terms of available (required) response time (e.g., seconds for collision avoidance versus longer time frames for providing instructions to assure proper sequencing and spacing for landing). Due to the expected degree of automation involved in the control function, the ground controller may not be "in the loop" as an emergency situation requiring immediate reaction arises. To provide him data, allow him to assess the situation, and issue instructions may take too long. Thus, the system must provide for automated generation of instructions to the pilot (e.g., veer left) while simultaneously notifying the ground controller. Less time sensitive emergencies (e.g., fuel shortage) would be brought to the attention of the ground controller, if the system could not automatically provide one or more recommended courses of action to the pilot.

7.1.4.3 Normal Control

Normal control will be a combination of pilot/controller interaction and knowledge based automated/semi-automated support. Aircraft which are not following a pre-planned route or cannot do so will most probably require controller support using voice communications to establish the situation, select a course of action, and define an appropriate flight path. To a limited extent, the system could be designed to allow the pilot to digitally query the ADP system in the van and receive appropriate guidance or optional courses of action (e.g., nearest usable landing strip). The bulk of the comparatively routine control requirements can be met by a knowledge-based system presenting information to the pilot.

The knowledge-based system must be capable of differentiation between mandatory control instructions (e.g., on landing approach), discretionary instructions (e.g., entry into a landing pattern in low density traffic under VFR conditions), and generalized instructions (e.g., corridor utilization rules). Further, it must allow for pilot or controller override with appropriate follow-up.

7.1.5 Control of Ground Traffic

The extent to which the ATALARS must exercise control over ground traffic (aircraft and ground vehicles) at an airfield is, at this point, a fuzzy area. Clearly, if the ATALARS is to take over all ATC tower functions in the event of the destruction of the tower and/or RSU, control of ground traffic is included. However, since ground vehicles will not likely have digital communications and manpower in the van will be limited, control for multiple airfields from the van may not be feasible. Most probably, this function would have to be apportioned between the van and alternative/back-up systems at the airfield which may or may not be part of the ATALARS. Procedural "work-arounds" may also be employed.

7.1.6 Landing Control

Conceptually, the landing function is simple: it schedules landing and provides guidance to the aircraft to a landing gate determined by aircraft and airfield capabilities (e.g., MLS, visual acquisition of the runway). Actual implementation is somewhat more complex.

The system must determine the landing gate for the particular aircraft/airfield combination based on the data provided by the situation monitoring functions. Scheduling is also affected by various environmental factors, aircraft status, and runway utilization (e.g., takeoff schedules). Provisions must also be made for missed approaches and emergency situations (e.g., wheels up). Thus, automation of this function will require a combination of techniques and access to a substantial database with both static (e.g., MLS characteristics) and dynamic (e.g., weather) components.

7.1.7 Departure Control

Departure control is potentially the simplest system function in that much of the "control" is pre-planned (e.g., departure flight path). Departure control is fundamentally a scheduling function with transmission of a "go" signal after an environmental status check (e.g., is the runway clear?) just prior to the scheduled takeoff. Two "hand-shakes" are required: readiness for takeoff and takeoff.

The scheduling itself would be at three levels. The first (performed by the planning function) would provide takeoff slots. The second, performed by this function, would assign slots on request by the airbase shortly before the aircraft are ready. The final would be the assignment/reassignment as the aircraft indicates readiness. To minimize the manual workload in the van, communications with the airbase and with the aircraft would require data links.

7.1.8 Planning

Potentially the most manpower intensive function is the aggregation of the planning functions: the overall planning and plan adjustment of the airspace management function, route selection from the approach control function, and scheduling from the airfield traffic control function. While a large amount of automation and automated support can be provided (particularly to routing and scheduling), much of the data may not be available in machine processable form. Current and planned efforts to automate, at least partially, some aspects of air operations planning (e.g., the use of a Computer Automated Force Management Systems (CAFMS) for ATO generation) will alleviate the situation (while probably aggravating interoperability issues).

7.1.9 Exercise/Training

See Section 6.4.

7.2 AIRCRAFT SUBSYSTEM

The ATALARS will interface with airborne aircraft and aircraft preparing for takeoff. While on the ground, the interface will be used for pilot/controller communications and to automatically identify the aircraft and its location on a runway/taxiway. While airborne, the interface will be used for pilot/ATALARS communications in passing control instructions, providing position information, advising the pilot of current airfield conditions, and notifying the controller of critical aircraft conditions (i.e., emergency fuel level, aircraft damage, crew injury). Prior to takeoff or entry into an ATALARS control zone, some basic information (flight plans, fuel consumption rate and fuel capacity by aircraft type) will have been entered into the database.

The JTIDS or similar system will be used as the primary method of data transfer through this interface. While the aircraft is on the ground the controller may also use manual data inputs. Air/ground voice radio communications will be used as an alternate method for information transfer.

The aircraft interface has a two fold purpose: first to provide aircraft data to the ATALARS van/controller, and secondly to provide communications between the van/controller and the aircraft/pilot. The first can be considered the downlink interface and is used to provide aircraft position and status information as well as pilot entered data to the ATALARS van/controller. The second can be considered the uplink interface and is to be used by the van/controller for providing instructions/information to the pilot or for requesting specific information from the ATALARS aircraft terminal.

Figures 7-1 and 7-2 depict two functional configuration designs for the aircraft interface. Both of these designs assume a JTIDS or compatible terminal in the aircraft. The first uses the JTIDS terminal interface with the aircraft data bus to provide all required aircraft status information to the ATALARS terminal. This will also require aircraft status information to be provided to the ATALARS terminal. This will require some modification to the JTIDS terminal for the transfer of aircraft status data to the ATALARS interface. Data will transverse this interface for communications between the ATALARS aircraft terminal and the ATALARS van. The second design requires the direct connection of the ATALARS terminal to the aircraft data bus. The second design will result in a simpler interface between the JTIDS and ATALARS aircraft terminals by requiring less of a modification to the JTIDS terminal.

As a minimum, the ATALARS aircraft terminal will consist of a Digital Data Processor (DDP), Pilot Data Input Device, Display Monitor, and a JTIDS Interface. The DDP will accomplish the automated collection of aircraft status information (either through the JTIDS interface or a direct data bus interface), do the necessary data processing for dissemination to the downlink interface, process/disseminate data received from the uplink interface, process data entered by the pilot, and display appropriate information on the pilot's monitor. Data messages will be coded for transmission through the JTIDS terminal and may include aircraft track number, aircraft identification code, aircraft system status, and position information. The pilot's monitor which could include a heads-up display will provide weather, controller instructions, advisories, and emergency information. The DDP software design should include a pilot acknowledgement routine for critical instructions/advisories. After initial "hand-shaking" between the ATALARS van and aircraft terminal, the aircraft terminal will automatically provide periodic updates on its position through the use of the GPS. Prior to takeoff, the flight plan will be entered in the DDP for reference and will be updated as necessary. The design of the ATALARS aircraft terminal must carefully consider the limited space available in the aircraft. Of particular concern will be the size of the display monitor.

The ATALARS will rely on the JTIDS voice capability for voice communications between the pilot and controller. The HAVE QUICK radio will be used as secondary mode for voice communications.

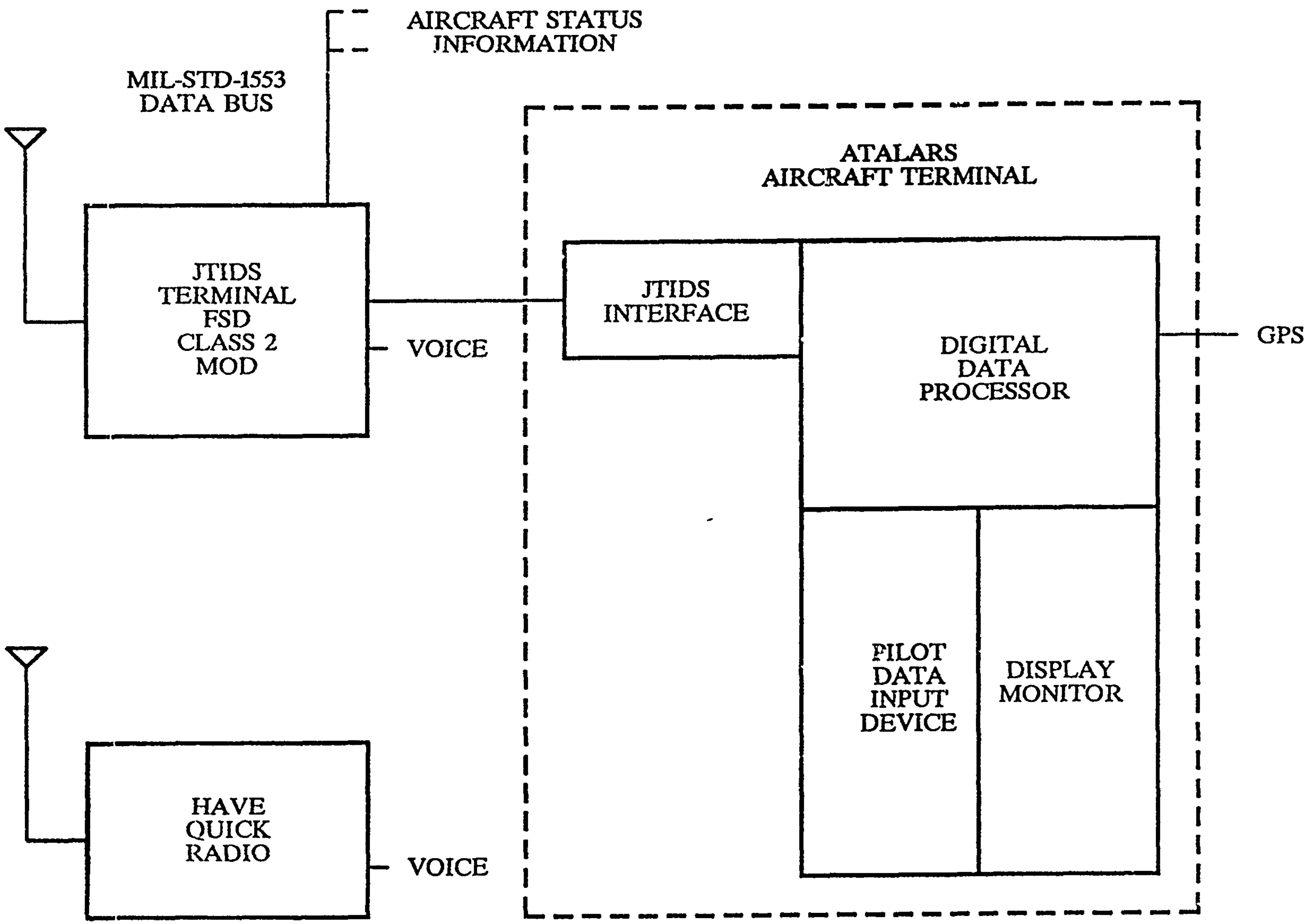


FIGURE 7-1
AIRCRAFT FUNCTIONAL CONFIGURATION 1

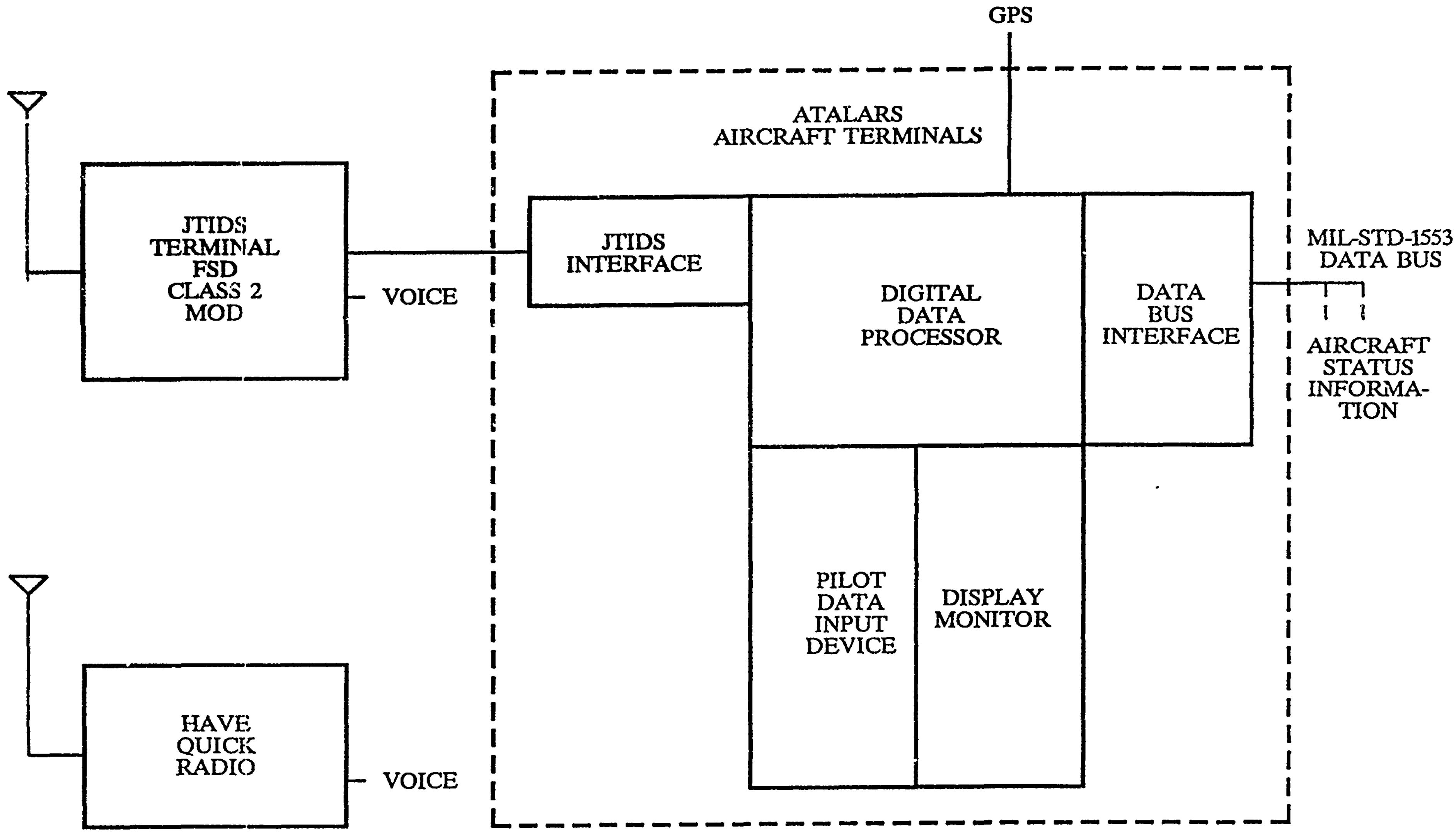


FIGURE 7-2
AIRCRAFT FUNCTIONAL CONFIGURATION 2

7.3 AIRBASE SUBSYSTEM

Exclusive of communications interfaces with the airbase, the ATALARS may be required to provide (deploy) equipment to each airfield it will support to assist in the performance of two functions: accurate positioning of the aircraft relative to the runway and monitoring of runway/taxiway conditions.

7.3.1 Aircraft Positioning

In the absence of a landing system such as MLS, the ATALARS must provide accurate landing guidance to aircraft. MLS normally provides ICAO Category II capability (100 feet decision height) and can provide (for specially configured aircraft) ICAO Category III capability (no decision height minimum). The GPS precise positioning service (PPS) is expected to provide 15 meter spherical error probability (SEP) accuracy . Thus, if the runway location is known to the same accuracy (using a portable GPS receiver), MLS-type capability cannot be provided.

GPS can also be used in a differential mode (relative to a GPS receiver at a known ground reference point) to provide submeter accuracies. Achieving these accuracies in a real-time mode requires RF transmission from the receiver site. Thus a transceiver would have to be deployed to a known position relative to the runway to achieve the positioning accuracy necessary to provide adverse weather landing guidance.

7.3.2 Runway/Taxiway Monitoring

From a functional perspective, the requirements for runway and taxiway monitoring are simple. The design of a readily deployable, reliable sensing system capable of virtually all-weather operation is, however, less readily definable. Functionally, the sensing system must provide ceiling, visibility, surface condition, and usage status. Manual observation and reporting of the first three combined with accurate positioning data for aircraft on the ground (using the GPS differential navigation mode) is one possible solution. More sophisticated sensing systems for usage data which would cover ground vehicles as well as aircraft are probably required for adverse weather operations. (See Section 8.0)

7.4 COMMUNICATIONS INTERFACES

7.4.1 Tactical Air Control System (TACS)

The ATALARS management unit will interface with TACS elements (e.g., CRC,AWACS) under which the ATC function is subordinate and/or has mutual airspace coverage responsibility. The interface will be accomplished through the TACS air and ground data communications networks. The TACS provides planning, direction, and control of tactical air operations. The ground TACS that will be fielded prior to the year 2000 is known as the Modular Control Element (MCE). The MCE may be deployed to form a complete system or deployed incrementally (CRC, Control and Reporting Post, Forward Air Control Post) to augment an existing fixed or mobile control system. The basic system module of the MCE is the AN/TYQ-23 Operations Module (OM) which provides overall airspace management from a ground based system. It may operate independently or in conjunction with other related systems such as the AWACS, HQ TAF, TACC, and an Army/Air Force air defense system. The OM is expected to be fielded using the TADIL-A and TADIL-B message formats through a JTIDS equipment interface for data transfer with the airborne TACS elements such as AWACS and for airbase defense systems. The AWACS will use the new TADIL-J message format when communicating within the TACS nets or with JTIDS equipped aircraft. Like the OM, the ATALARS van will communicate with these systems to obtain aircraft tracking information. To minimize the extent of ATALARS software design, a single message exchange format should be specified. It is expected that in the post-2000 time period the standard message format will be TADIL-J; with all operational systems using this format. Therefore, ATALARS should be designed using the TADIL-J format for message exchange (or another format which is being widely used by tactical systems in the ATALARS fielded time frames). Modifications to other systems may be required to meet this standard message format or a special interface provided in the ATALARS to accommodate other message formats.

After initial deployment of an ATALARS and communications connectivity has been established, the TACS interface with ground systems such as the OM or the AWACS must be sized to accommodate the volume of message transfer. This may become of particular concern when an ATALARS has ATC responsibility for several airfields with heavy traffic volume. The minimum data rate for this interface should be 16Kb/s.

7.4.2 Air Defense Systems

ATALARS will interface with Air Force and Army air defense elements protecting the runways at airfields/airbases in the combat area. The ATALARS van operation with these air defense systems will be similar to that of other TACS elements. ATALARS will provide flight planning information and the air defense systems will provide tracking information as well as identify friendly air corridors for ATC operations. This interface will be established using a dedicated radio link or cable connection when the systems are colocated. Current interfaces with air defense systems operate at 600/1200/2400 bps and use the TADIL-B message format. Although no new programs to replace or change the air defense system have been identified, it is expected that this will occur and will allow the use of the standard JTIDS data message format (TADIL-J) in the post-2000 time period. As with the TACS interface, some special accommodations may be required for systems which have not converted to the TADIL-J format. A heavy volume of information transfer should be expected through this interface to provide current updates to the databases of both the ATALARS and air defense systems. Data rates of 16Kb/s or more should be expected for this interface.

7.4.3 Airbase

The ATALARS van will have direct data connections to up to 10 nearby airbases for ATC coordination and planning. A single interface may be provided for each airbase to provide connectivity to the ATC tower, base/wing command center, and local weather information. The on-base connections will be made through the existing base communications network or tactical communications elements.

The volume of data provided by the airbase will change as conditions of the airfield are affected by weather, control systems status, takeoffs/landings, and runway availability. Several dedicated radio links (including relays) will be required to provide the data connectivity for multiple airbases. Cable interfaces will also be necessary to allow connection of colocated facilities. It may be possible to minimize the additional communications facilities by direct connection to the closest TRI-TAC communications network interface. A low data rate (4800 bps or less) is expected for each airbase connection. Interfaces at the airbase need to be specified including the message formats. Terminal devices may be required at the base/wing command centers and ATC towers to enter information or receive requests from the ATALARS van/controller. Sensors could be connected to either terminals for data transfer of weather information and control system status. Figure 7-3 depicts a typical deployment of an ATALARS van with multi-airfield responsibility. Distances between relay points would be 10-15 miles allowing the use of millimeter wave radios. The number of sensors would vary by location depending on other data available at the base command center. Voice communications would be used as an alternate means of providing data to the ATALARS controllers.

7.4.4 Weather Service

In addition to the airbase interface, weather forecasts and local conditions will be provided through an interface with the Tactical Automated Weather Distribution System at nearby airfields/airbases. The weather information will be provided through a dedicated digital data link. A capability for manual inputs via the airbase interface will provide an alternate method of entering local weather conditions/observations.

7.4.5 Inter-ATALARS

An interface will be provided to permit the exchange of ATC information among adjacent ATALARS. Figure 7-3 includes a depiction of two ATALARS serving several airbases. Connection of the systems would be via one or more millimeter wave radio links. Each ATALARS van database would store appropriate information on several airbases

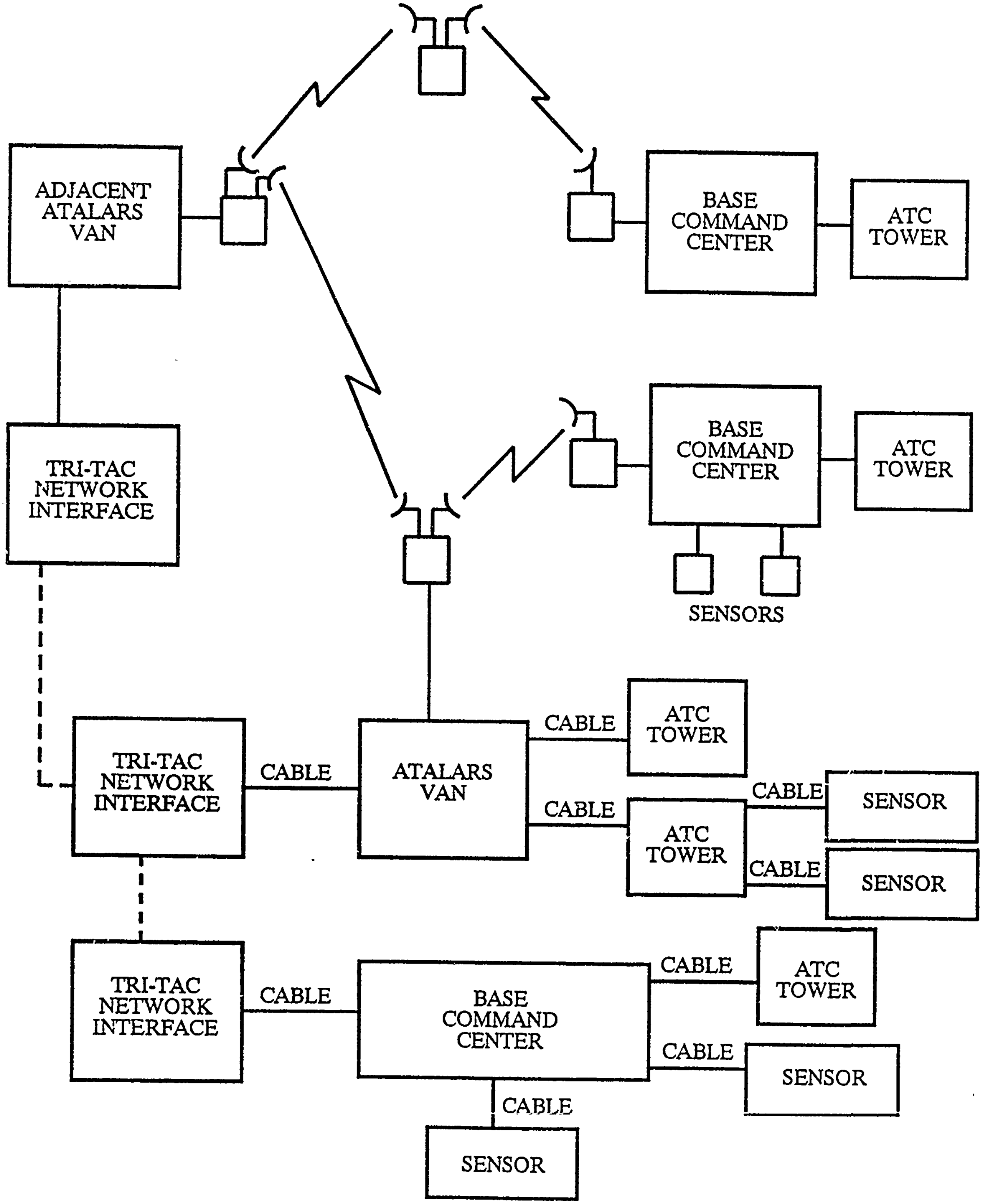


FIGURE 7-3
TYPICAL ATALARS DEPLOYMENT

to allow transfer of control in case of equipment failure and/or other emergencies at one of the monitored locations. Millimeter wave radio links would also be used for connection of the adjacent ATALARS units and a maximum data rate of 64Kb/s should be expected.

SECTION 8.0
DESIGN CONSIDERATIONS

The previous two sections defined what an ATALARS must be capable of doing and what must be designed. This section discusses considerations in developing that design. The ATALARS design will be driven by numeric requirements (e.g., the number of aircraft simultaneously in the assigned airspace), operational considerations (e.g., pilot workload), environmental considerations (e.g., variance in aircraft avionics suites), near term technology (e.g., JTIDS, GPS, or similar systems), and other factors.

8.1 GENERAL CONSIDERATIONS

Like all tactical systems, ATALARS must be designed to be survivable in a high intensity, conventional conflict where extensive use of electronic combat is involved. Thus, the basic concept discribed in ESD-TR-86-259 calls for mobility, indirect (no radar emissions) surveillance, and secure anti-jam (AJ) communications.

8.1.1 Mobility

Despite the use of indirect surveillance and frequency hopping communications, the ATALARS van will emanate sufficient radiation in the frequency bands to be readily detectable and locatable. Thus, for survivability reasons alone the van must be mobile. (Note that since it will not be near the FEBA/FLOT, it will not be as readily targetable) Unless a "leap-frog" concept is employed with one van in operation while a second is being redeployed, the ATALARS must remain in operation while in motion.

In addition, since JTIDS and HAVE QUICK (or similar systems) are line-of-sight systems, deployment locations must be based on terrain masking considerations. Thus, the van must be capable of rough cross-country travel to assure its deployment at a suitable location and operation while in motion.

In effect, the requirement is for a self-propelled, self-contained vehicle. This places a premium on weight, space, and power. It also implies a degree of redundancy, if, as suggested in ESD-TR-86-259, remote communications vehicles are employed.

Clearly, cost benefit analyses must be conducted to evaluate single versus multi-vehicle designs and "leap-frogging" versus in-motion operation.

8.1.2 Security

In general, the interface options discussed later in this section provide adequate security (encryption, low probability of intercept (LPI)). Since ATALARS is not the primary or only user of either the data (e.g., ATO) or communications media (e.g., JTIDS), ATALARS requirements will not be a driver with respect to the security issue. In effect, the security of aircraft or TACS communications will be upgraded, if necessary, and ATALARS will be forced to be compatible.

If, as suggested in ESD-TR-86-259, remote communications vehicles are used by ATALARS, LPI and encryption considerations become a factor in intra-ATALARS communications. The use of millimeter wave radios (highly directional antennas) and fiber-optics cables (both suggested in ESD-TR-86-259) may be precluded by the mobility requirement. They are absolutely precluded if operation while in motion is required. If, as expected, the TACS elements become more mobile as well as physically and functionally dispersed, data and voice communications used by the TACS should be suitable for use by ATALARS.

8.1.3 Survivability

Both of the above discussions relate to survivability as well. One of the bases for the mobility requirement is survivability. LPI communications reduce vulnerability to SIGINT locating systems. Electromagnetic pulse (EMP) hardening and Chemical Biological, Radiological (CBR) protection are standard requirements and must be incorporated. (Note that these latter requirements are often waived in order to use off-the-shelf (OTS) or Commercial OTS (COTS) equipment. However, ATALARS is expected to operate in an environment which is being severely degraded due to conventional and other types of attacks. Thus, these requirements cannot be waived.) Hardening against conventional ordnance (e.g., kevlar blankets) may be an option which consumes too much space and/or adds too much weight.

Survivability against jamming is provided by A-J features of systems such as JTIDS and HAVE QUICK. However, as with security, whatever communications systems are used by the TACS will also be used by the ATALARS. Thus, the TACS requirements and the resulting design will drive ATALARS communications.

To a certain extent, the above statement applies to the ATALARS interfaces with the airbases as well However, some aspects of the interface (e.g., for runway monitoring) may be unique to ATALARS. Since the multi-base nature of ATALARS and the mobility requirement preclude the use of cables and probably highly directional systems, other means of achieving LPI/A-J are required.

8.1.4 Coverage and Capacity

Coverage and capacity are interrelated. In theory, coverage provided by ATALARS can be expanded (using relays), until the capacity limits are reached. In practice, coverage limits for

ATALARS are based on two operational factors: geographic dispersion of the airfield to be serviced, and the related volume of airspace which ATALARS must control to assure safe and efficient operations.

At a minimum, it would seem that ATALARS would require two to three minutes of coverage of returning aircraft in order to provide any room at all for sequencing and spacing aircraft. This suggests a 20 to 30 nautical mile radius zone surrounding the airfield. If spacing between airfields is considered, the zone may be expanded an additional 20 to 30 nautical miles. (This assumes that ATALARS serves a geographically concentrated set of landing strips, airfields, and airbases, not widely separated ones.) Thus ATALARS coverage zones would be on the order of 50 to 100 nautical miles maximum dimension. (Note that this begins to present line of sight problems with respect to low flying aircraft and possibly with ATALARS/airbase communications).

This area of coverage, in a scenario such as the NATO Central Region, can involve large numbers of aircraft, possibly in excess of the 300 aircraft specified in ESD-TR-86-259. However, as ATC facilities are reduced by enemy attacks, thus requiring the use of ATALARS, the number of aircraft is also reduced due to attrition.

Again considering the European scenario and the propensity of tactical air operations to be concentrated at particular hours, the combined launch or recovery rates for several airfields could be substantial over a short time period. Aircraft from four or five squadrons returning to bases from air interdiction missions within an hour is reasonable. Adding some air defense activity, a continuous stream of close air support missions, and a few miscellaneous missions, ATALARS could be required to support up to 200 takeoffs and landings in an hour (approximately two flights of four aircraft each, every two minutes).

Considering the ready availability of memory and rapid processing capability of today's ADP technology, these numbers are not constraining. Even one second track updates are well within the capability of an IBM PC. The most probable constraining factor will be the degree of manual involvement in the takeoff and landing processes and the number of simultaneous (i.e., within one or two minutes) activities involved. One emergency and several flights of aircraft should, however, be well within the capacity of three or four ADP supported controllers.

8.2 ADP SYSTEM

The ADP system is intended to automate many controller functions as well as to decrease controller workload for the remaining functions by providing automated support. In effect, the software will be an expert system performing certain functions and decision-aiding others. Thus, there are two types of design considerations: maintaining continuity of the controller functions, and to a lesser extent maintaining manual review and override capability

In addition, the ATALARS concept requires it to assume functions of other systems as these systems are destroyed by enemy action or become unusable for other reasons. Thus, ATALARS must be designed with a modularity that corresponds to the functional modularity of the systems whose functions it will assume.

8.2.1 Continuity of Functions

Both the ADP hardware and software must have a fail-safe capability. More specifically, both must incorporate self-diagnostic and self-healing features that prevent abrupt termination of guidance functions and provide for notifying both controller and pilot of degradation or cessation of capabilities. This notification must include a description of self-healing action, recommended action, and/or imposed limitations on operations that ensue from the failure.

8.2.2 Manual Review and Override

As with all expert systems, it is doubtful that the ATALARS software can be designed to accommodate all contingencies. Thus, ATALARS must provide for a review and override by two persons: the pilot and the controller. In the event of override by one, it must notify the other, possibly with recommendations for subsequent action by the controller if the pilot overrides.

Another significant requirement is the necessity for the controller(s) to review software decisions in the aggregate, rather than individually. Review of each guidance instruction developed by the software would not significantly reduce controller workload. Thus, the software must provide an overview (e.g., of corridor activity) in a manner which allows assessment of overall viability of software directed activity.

A final significant difference between the ATALARS and current systems is its real-time nature. Most current systems speed the decision making process to the point where operator review of software output takes less time than manual decision making. For ATALARS this may not be true under certain conditions (e.g., collision avoidance, landing guidance). Thus, extreme care must be taken in the design to avoid elemental review processes and to provide rapidly assimilatable presentation of data for decision review.

8.2.3 Functional Modularity

It is clear that the ATALARS cannot be allowed to operate in a manner where its functions overlap other system functions (e.g., providing landing guidance when MLS is in use). Thus, each function must be carefully bounded and tailored to correspond to the functions of external systems so that enabling/disabling of these functions maintains a non-overlapping ATC environment.

This enabling/disabling feature of ATALARS functions must also accommodate variability in the environment (e.g., allowing the use of MLS at one airfield while providing landing guidance at another). Further, in some cases, the design must provide for disabling only the output dissemination (e.g., issuing, guidance) portion of the function because ATALARS cannot assume the function or perform other functions if continuity is not maintained (e.g., MLS provides landing guidance, but ATALARS must monitor and control runway usage).

8.2.4 Applicability of Off-the-Shelf Hardware

Current 16-bit Very Large Scale Integrated (VLSI) circuit technology can support the multitasking environment and may prove adequate for the ATALARS application, although proven 32-bit technology could very well meet a post-2000 implementation.

Timing will be more critical than ever before in the post-2000 real-time environmnent. The width of the databus will affect the speed with which the processor can "crunch" numbers and evaluate decisions. Currently, 32-bit VLSI circuit technology is providing this state-of-the-art performance; however, it will be important to evaluate the microcode support available to insure the ATALARS processor is being used efficiently, taking maximum benefit of the processing speed/performance.

Data storage is a vital element of the ADP, since ATALARS will receive large quantities of data from various sources. Immediate accessability precludes the use of secondary storage devices for much of this data. Dedicated Read-Only-Memory (ROM) along with high speed Random-Access-Memory (RAM) will obviously be used. For example, Dynamic RAM (DRAM) has shown its usefulness in error detection when used for a fault-tolerant check resulting from a Hamming code or voting scheme to ensure the accuracy of the data.

The use of color displays enhances the controllers' discretion in identifying and manipulating data. Although the number of colors used will be determined from a human engineering standpoint, the availability of colors will be a function of the display technology. Cathode Ray Tube (CRT) technology provides high resolution, full-spectrum color; however, its space requirements may prove undesirable. New plasma and LCD technology have a distinct advantage in that they may be applied to slim profile, flat panel displays. Currently, color applications in these two new technologies are limited; however, further development may bring color as well as a proven track record to allow ATALARS to take advantage of the flickerless, distortionless viewing; small size; low weight and power; low maintenance; and high reliability of these technologies.

The type of input device should be flexible for maximum use by the controller. Whether it is an interactive touch screen, a digitizing tablet, a light pen, a trackball, a pushbutton, or a mouse, the automatic system should not hinder the controllers actions. Some alphanumeric input from the keyboard will probably be required; however, research into automated voice recognition inputs could prove invaluable i 'upport of real-time updates to the ATALARS database. The use f non-volative magnetic bubble memory may also provide the high c ity storage. Its ruggedness, small size, light weight, and limited power dissipation could prove advantageous to the ATALARS design.

8.2.5 Applicability of Off-the-Shelf Software

By the time ATALARS is under full scale engineering development, it is highly probable that some of the ATALARS functions will have been automated for other systems. The FAA has an automated collision avoidance program in progress. The MCE program (See 7.4.1) is automating certain ATC (CRC, CRP, FACP) functions such as surveillance, track correlation, track/ATO correlation, and identification. Higher order languages such as C or Ada are currently being used in real-time operating environments. Further, current DOD regulations require Ada to be used as the higher order language for all software procurements. Thus, it is highly probable that the ATALARS development will be able to use off-the-shelf software as a basis for many of its functions making use of Ada implementations.

The software language utilized is mostly a function of maintainability to be discussed in light of projected capabilities. The operating requirements of ATALARS are not expected to exceed these types of environments. The use of specialized languages for data manipulation or symbolic computation should be accessed for their flexibility in working with the chosen general-purpose language as well as providing more or better capabilities. Current implementation such as the use of LISP in a C-based environment shows potential for future developments to take advantage of specific capabilities/features in multiple languages.

8.3 EXTERNAL INTERFACES

As with the planning for any new system, interoperability must be considered early in the program to allow an orderly implementation and fielding of the system. Some items that must be considered include: the time period for system fielding (both the initial system and the length of phase-in time), identification of interfacing systems/equipment that will be operational during the fielding period, other interfacing systems/equipment that will be implemented shortly after system fielding, modifications required to other systems/equipment that will be operational during the fielding period (to include minimum operational quantities to satisfy mission requirements), and the number of proposed systems that will be fielded. External interfaces were discussed briefly in 7.4 and will be included in design considerations of this section. Because of the limited quantity of expected production systems, the fielding of a system such as ATALARS should not require extensive modifications to other interfacing systems or disrupt the capability of other systems to satisfy their primary mission requirements. Careful consideration should be given to operation with interfacing systems.

8.3.1 Airbase Interface

The airbase interface actually involves several subsystems and interfaces. These are: the tower interface (if operational), the ground traffic monitoring subsystem and interface, the weather monitoring interface, the Weapons Operations Center interface, and the landing system interface

8.3.1.1 Tower Interface

If the tower (including RAPCON and RSU) is fully or even partially operational, the interchange of data between the ATALARS van and the tower is minimal. Further, the workload within the van is minimal with respect to operations at that airbase. Thus, secure voice communications could suffice for handoffs and the occasional exchange of situation and status data.

However, there are benefits to be gained from a digital interface for track data and machine processable messages. The handoff process is surer with less chance of miscorrelating tracks. Congestion at the airfield or weather changes that could affect automated ATALARS sequencing and spacing functions could be directly input without manual intervention in the ATALARS van. Further, if tower functions are only partially degraded, data from ATALARS may be used to minimize the number of tower functions lost. Voice communications would still be required for non-formatted messages, emergencies, and unique situations.

In effect, there are options for the interface with the tower. In terms of increasing complexity and cost these are: secure voice only, secure voice and a data entry terminal for direct input of data from the tower to ATALARS, secure voice and a terminal for data entry and display of ATALARS tracks, and secure voice and a fully integrated ATC airbase facility subsystem to provide for exchange of data between the tower and ATALARS.

The last option is incompatible with the basic premise of ATALARS (e.g., if there is damage to the tower to the point where ATALARS must take over some function, the ATALARS interface would probably also be damaged). The other three options should be the subject of a cost-benefit trade study.

8.3.1.2 Ground Traffic Monitoring Subsystem and Interface

If tower functions (including an RSU) are sufficiently degraded to the point where ATALARS must monitor runway and taxiway traffic, ATALARS requires a sensing subsystem, a means, preferably automated, of transmitting the information to the van, and communications for exercising some degree of control over the traffic. Traffic control could be performed by airbase personnel and relevant information transmitted to the van via voice. However, this kind of inter.ace would require the full attention of one controller in the van, making it impractical to service up to ten airfields.

There are a number of sensor options which require investigation. Rudimentary pattern recognition technology could be employed with imaging sensors. Magnetometers, motion sensors, heat sensors, and others are also possibilities. Issues relating to the use of sensors include numbers, cost, reliability, false alarm rate, deployability, and data transmission options. In addition, consideration needs to be given to the nature of the reporting: absence of anything to be sensed, positive data indicating arrival or departure from the runway or taxiway, or both. The technology, including automated processing, has been available since the late 1960s. Extensive cost reduction efforts were undertaken in the early 1970s; however, current state of the art and associated costs require more extensive investigation then is possible under the current study effort.

8.3.1.3 Weather Monitoring Interface

Weather, as it relates to landings and takeoffs (ceiling, visibility, wind-shear), requires continuous monitoring only in rapidly changing conditions (e.g., thickening fog, approaching thunderstorm). Voice communications would seem to be acceptable under almost all conditions except where all bases serviced by ATALARS are geographically close and affected by the same rapidly changing weather pattern. Even under these conditions, since the probability that all bases are simultaneously very active is low, voice communications should not overload van personnel. Thus, maintaining voice communications with an observer should suffice.

8.3.1.4 Weapons Operations Center (WOC) Interface

Planning within the TACS and its overseas analogues is becoming increasingly automated. ATALARS will require a direct digital interface with whatever system is in use at the WOC to develop and maintain the more detailed flight plans produced in response to the ATO. The same interface could be used to exchange additional information; however, this would probably require a software modification to the system used by the WOC. Such an interface would allow direct data entry from the WOC as well as providing the WOC with situation data from the ATALARS.

8.3.1.5 Landing Systems Interface

The ATALARS concept presumes operations involving a landing system (MLS or similar system) or, in its absence, the use of a GPS

8.3.2.2 Surveillance and Control Interfaces

It is currently planned to replace the CRC, Control and Reporting Post (CRP), FACP, and MPC, with the MCE. The AWACS and surface-to-air defenses such as the HAWK are to be interfaced with the MCE. Thus, in theory, a TADIL-B interface to an MCE would provide the necessary external surveillance data through the MCE surveillance function. This interface may even obviate the necessity for track correlation within the ATALARS.

Alternatively, the ATALARS may require separate interfaces for surveillance data as follows:

1. AWACS (JTIDS, TADIL-A). This would also provide compatibility with the Navy Air Tactical Data System (ATDS) and the Naval Tactical Data System (NTDS).

2. CRC, CRP, FACP, and MPC or the MCE equivalent (TADIL-B) This would also provide compatibility with Army Air Defense Command Posts (AADCPs) and the Marine Tactical Air Operations Center (TAOC).

Coordination to establish the specifics of procedures for aircraft transiting airspace boundaries or operating in overlapping control zones requires voice communications between ATALARS and the other control authority (e.g., CRC). Although some data relevant to those procedures may require entry into the ATALARS database, it is doubtful that all required communications could be accomplished via rigidly formatted messages.

8.3.2.3 Air Defenses

The ATALARS will require interfaces with long range surface-to-air defenses (e.g., HAWK), short range defenses (e.g., at the airbase itself), and possibly other types of defenses such as jammers. Currently, TADIL-B is used by the AADCP and the Army Tactical Data Link (ATDL-1) by HAWK fire units. These are both automatic, secure, full-duplex, point-to-point, dedicated links. The first would provide the means for notifying ATALARS of changes in deployment, corridors, ROEs, etc. The second would be used by ATALARS to notify HAWK fire units of approaching friendly aircraft, if necessary. Voice or data link could be used for coordination with local (airbase) air defenses, since they would not normally operate in free fire modes unless the airbase is under attack.

8.3.3 Weather

Weather information (other than the detailed runway related data) is available indirectly through the necessary TACS interfaces (HQ TAF, TACC, WOC) discussed above. Thus, while the desirability of direct interfaces with AWS systems (e.g., the Tactical Automated Weather Distribution System) is unquestionable, the necessity is not unquestionable. Specific cost-benefit analyses which need to be performed are associated with: automated direct input of AWS data to the ATALARS database, off-line AWS input to a separate terminal and display, and relay of data via TACS elements.

8.3.4 Inter-ATALARS

The requirements for an inter-ATALARS interface are fundamentally the same as for other surveillance and control interfaces. Thus, whatever interface is used for exchange of track data with the TACS (e.g., TADIL-B) can also be used to do the same between ATALARS vans. Voice communications will be required to coordinate responsibilities and procedures at airspace boundaries.

SECTION 9.0
PROGRAM AND FEASIBILITY DEMONSTRATION PLANNING

9.1 INTRODUCTION

Section 6.0 described ATALARS in terms of its primary system functions (airspace management, approach control, airfield traffic control, and the exercise/training approach). Figure 6-1 illustrated the definition of the first three in terms of the type of aircraft activity. This section describes recommended programmatic events for the completion of the conceptual phase and provides the basis for an initial field demonstration and subsequent procurement activity for the ATALARS program. For purposes of discussion within this section, various program phases are identified in Figure 9-1 and further expanded in the following paragraphs. Preliminary cost estimates for Phase I and II are described in Appendix C. Phase I costs are estimated at approximately $1M and Phase II at $10.7M to 11.5M.

Phase O is currently being accomplished under a Technical Engineering Management Support (TEMS) contract through HH Aerospace Design, Inc. with ARINC Research Corporation and Vanguard Research Inc. as team members. The Phase I effort will include a further analysis directed toward the Man-Machine Interface (MMI) for both the aircraft and ground applications leading to a feasibility demonstration in the field, Phase II. Currently, the feasibility demonstration is anticipated to include three contractors for the purpose of obtaining different designs. Following the field demonstration, a contract will be awarded for Full Scale Engineering Development (FSED), Phase III. This will be followed by an expanded field test, Phase IV, which would be used to check out the algorithms developed in Phase III. After a certain confidence level has been reached (e.g., safety of flight, MMI), the Full Scale Production (FSP), Phase V, contract would be awarded. This section covers the milestones and requirements leading to, but not including, the FSED effort.

A proposed program schedule depicting major milestones through the award of the FSED contract is presented in Figure 9-2. (Note: This schedule was generated using the assumption that program funding is available for each program phase at the time that it is required.)

9.2 PHASE I CONTRACTOR TASKING AND PRODUCTS

This phase includes follow-on analyses and an initial demonstration of the ATALARS concept. he .asks and associated cost to generate the Request for Proposal (RFP) documentation (except for the functional specification) for the Phase II feasibility demonstration are not included in this effort.

PHASE	DESCRIPTION
0	FUNCTIONAL ANALYSIS & REQUIREMENTS REVIEW
I	FOLLOW-ON ANALYSES & INITIAL DEMONSTRATION
II	ADDITIONAL ANALYSES & FEASIBILITY DEMONSTRATION
III	FULL SCALE ENGINEERING DEVELOPMENT
IV	EXPANDED FIELD TESTING
V	FULL SCALE PRODUCTION

FIGURE 9-1 ATALARS PROGRAM PHASE DEFINITION

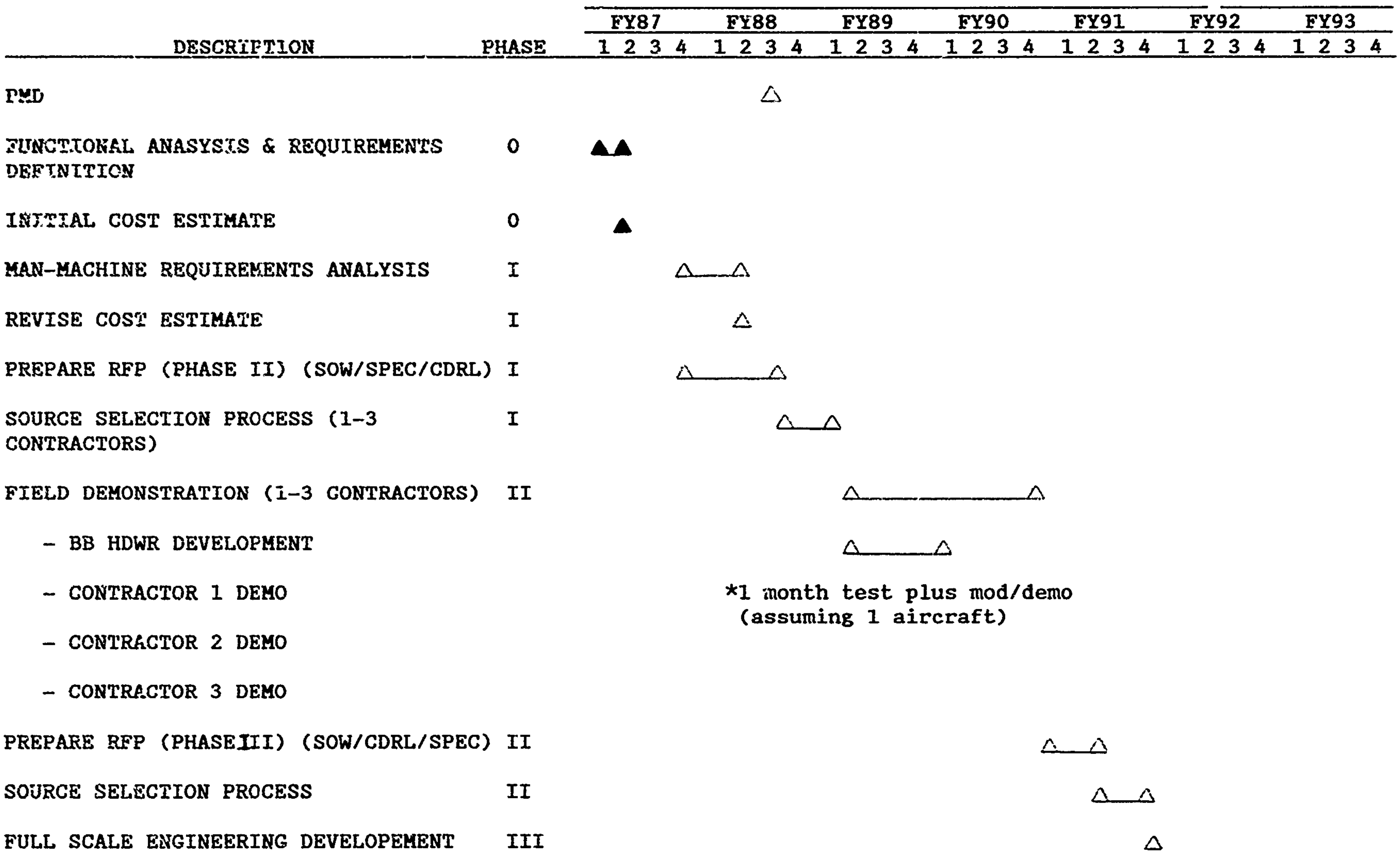


FIGURE 9-2 ATALARS - PROGRAM SCHEDULE

One of the most critical ATALARS design issues is the MMI between the controller and the ADP system and between the pilot and the aircraft communications terminal. There are some fundamental qualitative requirements such as the need for the controller or the pilot to "immediately" grasp the importance of the information being presented, and the need to present an "overview" to the controller in a manner which allows him to focus on those singular events that require immediate attention. It is clearly feasible to meet the data requirements delineated in Section 6.0. However, it is not immediately obvious that the above, and even more subtle, qualitative requirements can be met. Thus, a further exploration of the ATALARS MMI should be accomplished. This exploration should be performed prior to a more extensive effort to develop a feasibility demonstration model because the data generated will provide a more definitized base for the technology trade-offs that are necessary for the development of a working feasibility demonstration model.

9.2.1 Man-Machine Interface Requirements Analysis

This task requires the contractor to complete an analysis of the ATALARS MMI requirements. This will be an initial cut at optimizing the controller's and pilot's interaction with ATALARS. The key element of this analysis is not just to display the data, but rather how to display the information in easily usable form by the controller and pilot. The contractor will be required to interface with experienced ATC personnel to acquire their operational perspective.

9.2.2 Technology Review

This task requires the contractor to review the current technology for evaluating some initial design considerations discussed in Section 8.0 (voice actuated operator inputs, sensors for runway and ground traffic monitoring). The contractor will be required to recommend the applicability/feasibility of using this technology in the system design during the follow-on program phases.

9.2.3 Demonstration

The principal contractor task for this phase is to acquire and assemble the hardware components and associated software for the man-machine interface requirements demonstration. Selection of typical pilot and controller displays (see Table 9-1) will be used to demonstrate the ATALARS capabilities to interested Air Force users. The display demonstration could be accomplished through the use of two personal computers (one each for controller and pilot displays) with a graphics software capability. (See Appendix D for demonstration hardware/software considerations.) The real problem for the contractor is to display the aggregated data so that it becomes information that is readily understood by the controller/ pilot and an immediate response (i.e., action/no action) can be initiated. One action could be for the controller to interact with

TABLE 9-1

ATALARS SYSTEM DEMONSTRATION

ATALARS VAN DISPLAY TO CONTROLLER	AIRCRAFT DISPLAY TO PILOT
- SYSTEM STATUS: MLS, GPS, RAPCON	NONE
- DISPLAY HANDSHAKE INFORMATION OBTAINED FROM THE AIRCRAFT -- CODE - VERIFICATION -F16 -FLIGHT PLAN A -AIRBASE X -AIRCRAFT SYSTEMS STATUS	- DISPLAY HANDSHAKING INFORMATION TO THE PILOT (ALERTING PILOT THAT THE AIRCRAFT HAS ENTERED THE ATALARS CONTROL ZONE.)
- DISPLAY FLIGHT FOLLOWING WITH NO ATALARS ACTION (TRACKING 4 AIRCRAFT	- NONE
- DISPLAY COLLISION AVOIDANCE	- DISPLAY ATALARS DIRECTION TO PILOT (EITHER CLIMB TO 5000 FT AND HOLD OR DIVE...)
- DISPLAY WEATHER PROBLEM - WITH CORRECTIVE ACTION (WIND SHEAR)	- DISPLAY ATALARS DIRECTION TO PILOT...
- DISPLAY SEQUENCING & SPACING PROCESS (INCL. TAKEOFF & LANDING)	- DISPLAY ATALARS DIRECTION TO PILOT.
- DISPLAY THE STACKING PROCESS	- DISPLAY ATALARS DIRECTION TO PILOT.

ATALARS to obtain an additional level of detail regarding a specific aircraft. Several menu driven displays would be presented to simulate the ATALARS automation capability by providing information/instructions for use by the controller and pilot. Additionally, examples of controller/pilot actions, as required, are described for each display. The following displays provide some critical conditions which may be encountered by controllers/pilots and are recommended for use in the demonstration.

9.2.3.1 Controller Displays

9.2.3.1.1 Control System Status. This display presents the current status of the airbase/airfield control systems (e.g., MLS, ATC tower, RSU, RAPCON) to include date/time of latest update. The display should highlight any non-operational control systems and trigger an appropriate action by a controller to activate an ATALARS function.

9.2.3.1.2 Aircraft Handshaking. This display identifies aircraft entering the ATALARS control zone, provides aircraft status, correlated flight plan data to the van subsystem, and requires an action by the controller (i.e., aircraft emergency).

9.2.3.1.3 Flight Following. This display presents the tracking of several aircraft within the control zone. The display should highlight any aircraft deviating from its flight plan, and therefore, require controller intervention.

9.2.3.1.4 Sequencing & Spacing. This display presents sequencing and spacing of aircraft preparing for takeoff and landing. The displayed information would allow the controller to identify any improper sequencing/spacing.

9.2.3.1.5 Aircraft Stacking Process. This display shows the stack environment within the control zone due to traffic congestion. Aircraft are also displayed entering and leaving the stack. The display should alert the controller of any aircraft requiring immediate landing (e.g., emergency fuel, aircraft damage).

9.2.3.1.6 Emergency Condition. The displayed emergency condition would be two aircraft on a collision course and system instructions to either/or both aircraft. The displays would alert the controller of this condition and the system instructions being given. The controller would monitor the condition and intervene if appropriate action was not taken to avoid the collision.

9.2.3.1.7 Severe Weather Alert. This displays a severe weather condition (e.g., wind shear) in the vicinity of an airfield and corrective action instructions given to aircraft approaching the landing gates.

9.2.3.2 Pilot Displays

9.2.3.2.1 System Handshaking. This display alerts the pilot that the aircraft has entered an ATALARS control zone and confirms that the on-board subsystem has provided the required data to the ATALARS van subsystem.

9.2.3.2.2 Sequencing & Spacing. This displays the instructions received from the ATALARS van depicting the order of landing and takeoffs. It also displays flight clearance instructions.

9.2.3.2.3 Aircraft Stacking Process. This displays instructions from the ATALARS van for aircraft entering a holding pattern (stack). The relative position of other aircraft in the stack will also be displayed.

9.2.3.2.4 Collision Avoidance. This displays instructions from the ATALARS van for avoiding a collision course. Highlighting of data would be required to alert the pilot to acknowledge ATALARS direction.

9.2.3.2.5 Severe Weather Alert. This identifies a severe weather condition to the pilot and including system instructions. Highlighting of data would be required to alert the pilot.

9.2.4 Functional Specification

The final task is to prepare an ATALARS functional specification. The ATALARS functions described in Section 6.0 will form the basis for the specification. This continues the process of establishing ATALARS performance requirements for follow-on program phases. The functional specification is a preliminary document that will be further refined during the feasibility demonstration phase.

9.3 PHASE II CONTRACTOR TASKING AND PRODUCTS

This phase is intended to demonstrate the feasibility of the ATALARS concept. In general, the ATALARS concept does not establish requirements that are beyond the realm of current or near-term state-of-the-art hardware or software. In the more specific sense, the composite of the requirements needs an integration of near-term technologies; e.g., display hardware, expert system software, information display techniques, data entry techniques, and others. This combination of technologies must operate in an environment where failure to meet quantitative requirements (e.g., response time) and qualitative requirements (e.g., situation recognition) can have substantial negative impacts. Thus, it is recommended that a feasibility demonstration effort be undertaken prior to embarking on full scale development and risking the discovery that another year or two of technology development is necessary. This demonstration would assure that not only is the blending of the technologies feasible, but also that the MMI can be developed to meet the requirements derivable by analysis as well as those requirements which will surface only during field demonstration.

It is assumed that multiple contracts will be awarded. Once again, the task and associated cost to generate RFP documentation for a follow-on phase, (i.e., FSED) are not considered part of the contractors' effort.

9.3.1 Trade-off Analyses

Prior to conducting the feasibility demonstration the contractors will perform trade-off analyses. These analyses should address man-machine requirement issues such as the possibility of employing artificial intelligence to aid or replace air traffic controller expertise. The results of the technology review conducted in Phase I would be used to determine the necessity for voice actuation in ATALARS. The other design considerations discussed in Section 8.0 should also be included in a trade-off analysis (e.g., single versus multi-vehicle design and "leap-frogging" versus in-motion operation). The contractors should also make use of the analyses performed in the Phase I effort.

These analyses will influence each contractor's breadboard design and should be used in the program office down select evaluation process.

9.3.2 Interoperability Analyses

The criticality of ATALARS interoperability requires the early completion of these analyses. Potential interfaces with airbase systems (e.g., ATC facilities, weather monitoring, weapons operation center), current and future tactical systems, weather systems, and inter-ATALARS should be considered. These analyses will provide inputs to the ATALARS family of specifications and are precursors to the interface control drawings.

9.3.3 Class II Modification Package

All group "B kit" contractors and their associated "A kit" contractor will be required to prepare a Class II modification package for the selected aircraft. The package will, as a minimum, describe the group "B kit" and group "A kit" requirements, and include aircraft modification/demodification procedures.

9.3.4 Conduct Feasibility Demonstration

The contractors will be required to acquire and assemble the components necessary to demonstrate a breadboard model of an ATALARS system through the interaction of hardware, software, displays, and operators. Both the ground and aircraft segments of the system will be included. The automation concept of air traffic control would be demonstrated through a preliminary design using hardware, higher order language software, and communications interoperability of the ATALARS van and aircraft subsystem. The demonstration would include a selection of critical system functions described in Section 6.0 (airspace management, approach control, and airfield traffic control). As a minimum, those functions associated with the controller and pilot displays discussed in 9.2.3.1 and 9.2.3.2 should be included in this demonstration plan. Figure 9-3 illustrates a proposed pilot display depicting air traffic activity in the vicinity of the aircraft and local airfields.

9.3.5 System Specification

Following the down select process, the contractor will prepare a "Type A" Specification for ATALARS. This will form the system functional baseline for ATALARS during the FSED phase.

9.3.6 Aquisition Considerations

The Phase I effort will include the generation of the system specification that will be the basis for Phase II. The plan for Phase II would be to award three contracts. The effort would be to generate breadboard hardware which will be utilized in the field to demonstrate the feasibility of automating the air traffic control functions in the ATALARS van and the aircraft cockpit. Air traffic controllers and pilots should be involved in the early stages of the breadboard design and test effort. The breadboard design would entail the development or modification of two data communication systems, one being an airborne system and the second being a ground system. It is envisioned that enough JTIDS Class I and II terminals (either prototypes or production assets) could be borrowed to support the three contractors in their design process.

To support the field testing effort, 1 to 3 aircraft would be required. These aircraft (either T-37 or T-39s) may be available from the 4950th Test Wing located at Wright-Patterson Air Force Base. The proposed schedule, Figure 9-2, illustrates the worst case of having only one aircraft available for the Class II modification. The time frame illustrated shows 1 month for the modification, 1 month for the field test, and 1 month for the restoration of the aircraft. The field demonstration test time could be shortened, if more aircraft are available.

In order to make the modifications to the aircraft, the contractors must be teamed with an approved aircraft modification contractor or ESD must fund ASD to obtain the proper aircraft modification team. For this effort it is recommended that each contractor be teamed with an "A kit" contractor. This will expedite the modification process.

Although not a firm requirement, use of flight simulators prior to field testing should be investigated. This would give pilots an opportunity to gain experience with ATALARS before actual flight operations. However, this would delay the field test period and further complicate the Phase II effort.

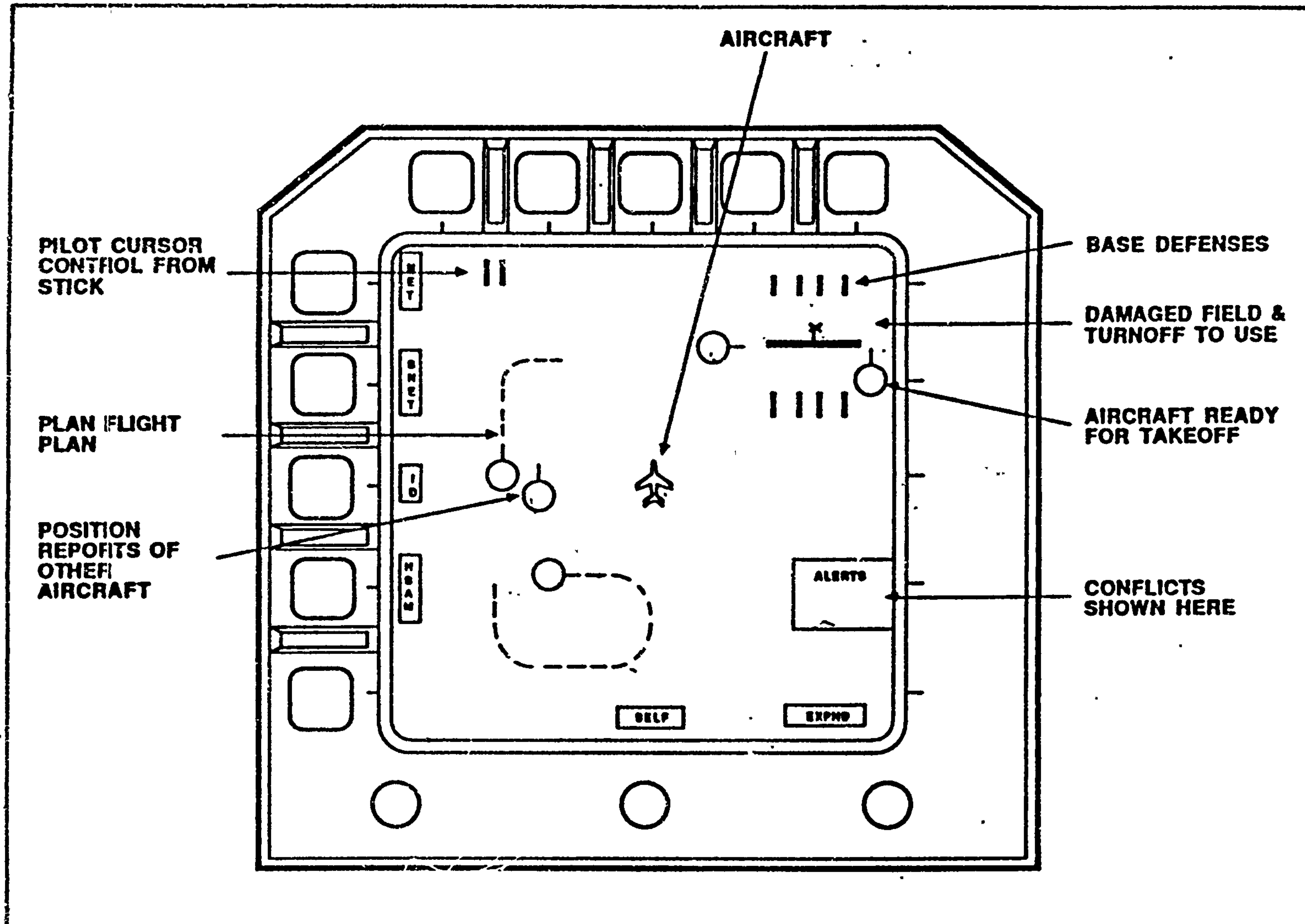


Figure 9-3

ATALARS Aircraft Display

The multiple contractor approach should be strongly considered for the feasibility demonstration phase. This would provide a variety of ATALARS approaches to evaluate, which is highly desirable given that ATALARS represents a new concept for ATC operations. With the multiple contractor approach, there would be a down select decision after the feasibility demonstration test. It is important to identify early the ATALARS functions to be demonstrated and the criteria to be used to select the winning design approach.

SECTION 10.0
CONCLUSIONS AND RECOMMENDATIONS

The analyses which provide the basis for this report suggest that ATALARS is technically feasible using current state-of-the-art technology. It is, however, also clear that ATALARS is on the leading edge of that technology and an immediate development effort without further analyses would present a high risk. The critical design and technology issues are discussed below.

The analyses did not address operational viability/feasibility or programmatic issues in detail. However, several were identified and are discussed in this section.

The recommendations presented in Section 9.0 are also summarized in this section.

10.1 CRITICAL DESIGN AREAS

The following are considered critical ATALARS design areas in the sense that they are key to effective functioning of ATALARS and may present difficulties in a development effort.

10.1.1 Man-Machine Interface - Controller

There are four critical aspects of this interface between the controller and the ADP system:

1. The display of information to the controller, not as is currently done in ATC systems on an aircraft by aircraft basis, but in the aggregate so that the controller understands the overall situation and can identify situations requiring attention to individual aircraft.

2. The display of information to the controller in such a manner that it is immediately intelligible in time critical situations.

3. The rapid manipulation of displays by controllers in time critical situations.

4. Minimization of the time and effort involved in data entry into the system when such information is not directly input via data link.

10.1.2 Man-Machine Interface - Pilot

There are two critical aspects of the interface between the pilot and the ADP system:

1. Presentation of instructions and information to the pilot in a manner which allows immediate reaction in emergencies and allows informed decision making on the part of the pilot when options or limited guidance is provided.

2. Minimization of time and effort in providing the data to the ATALARS system.

10.1.3 Stand-by Operations

In the highly volatile tactical environment ATALARS must be capable of assuming functions within minutes or seconds of the time that the need arises. This implies the need for a stand-by operation and a triggering mechanism based on monitoring the performance of ATC functions of other facilities.

10.1.4 Remote Status Monitoring

Current ATC systems rely on visual and other local status monitoring systems (e.g., for runway monitoring). ATALARS must have equally reliable, but remote and automated means of status monitoring.

10.1.5 Precision Guidance

The criticality of ATALARS being able to provide comparatively precise guidance is clear; however, given a precise navigation such as GPS, development of that capability should be fairly straightforward. Less obvious from a design standpoint is the development of the mechanisms and methodologies for compensating for variations in navigation accuracies and variations in cabilities of systems (e.g., MLS) with which ATALARS must interface or interoperate.

10.1.6 Artificial Intelligence

ATALARS is to be designed as an expert system which performs a substantial portion of the ATC functions currently performed by a human. The determination of which functions (and to what extent) the expert system will perform (them) is highly critical to the effectiveness of ATALARS. The development of an appropriate knowledge base is well within the state-of-the-art; however, the time criticality of the environment, the necessity for the man-in-the-loop checks and balances, and the need for establishing and maintaining "trust" in the expert system require capability beyond that of current expert systems.

10.2 TECHNOLOGY ISSUES

Technology issues associated with ATALARS are derivative of critical design areas where alternative technologies are applicable or the current state-of-the-art is marginal. These include:

1. The MMI is the area of physical interaction with the system for display manipulation and data entry (e.g., via voice)

2. The sensor portion of the runway monitoring subsystem

3. The communications processing subsystems of the ATALARS which must have the flexibility to maintain interoperability with evolving communications units of organizations with which ATALARS must interface.

10.3 OPERATIONAL ISSUES

Two operational issues were identified in the analysis:

1. The ATALARS fundamentally depends on appropriately equipped aircraft to perform its functions. Provisions can be incorporated to allow ATALARS to provide ATC for aircraft not appropriately equipped, but such service may be manpower intensive and involve degraded capabilities. It is probable that not all U.S. and allied aircraft operating in a tactical environment will be appropriately and similarly equipped. Operational workarounds may be required to avoid swamping ATALARS controllers with servicing inadequately or inappropriately equipped aircraft.

2. As described in this report, ATALARS is fundamentally for use in situations where "regular" ATC services are available. Thus, functions become operational as "regular" ATC services are degraded. ATALARS would function substantially different from future ones. Pilot (and controller) training must address these differences and accommodate that transition to ATALARS control will take place in a degrading environment, often in emergency situations.

10.4 PROGRAMMATIC ISSUES

ATALARS must interface or interoperate with other systems which will be developed or will evolve comparatively independently of ATALARS (e.g., aircraft data link communications, aircraft navigation systems, TACS Communications and other ATC systems). As with all systems, a degree of schedule and technical integration is required to assure operational capability when the system is fielded. (If ATALARS were to be developed today consideration would have to be given to the JTIDS and GPS programs to assure that these systems were operational and appropriately interfaced when ATALARS was fielded) The nature of the ATALARS suggests that is will not be the driver, but rather that it will be driven, with respect to external interfaces and complementing systems. Further, some of the design and technology issues are being addressed by other DOD and FAA programs, suggesting OTS availability for components of ATALARS in the future. The specific issues identified are:

1. New systems for exchanging data necessary to ATALARS within the TACS and external to the TACS are being considered, but not yet under development. Thus assuring ATALARS interoperability with the current TACS is inappropriate. The ATALARS program must be structured to accomodate the evolution of TACS communications as it takes place to assure interoperability when ATALARS is fielded and when TACS communications are upgraded thereafter.

2. Similarly, aircraft communications are evolving. To avoid a requirement for an ATALARS terminal to be installed (retro-fitted) into aircraft, the same approach must be taken to this interface as to the TACS interface.

3. There are current FAA programs to automate ATC functions and to provide runway data. If these are nearing fruition as ATALARS reaches the development stage, consideration should be given to integrating aspects of these programs with the ATALARS development.

10.5 RECOMMENDATIONS

Prior to proceeding with the development of ATALARS we feel that additional analysis of technical capabilities are required which would proceed a demonstration of the ATALARS concept. This effort includes:

1. The necessity to verify that the system is feasible from a human factors standpoint, i.e., that state-of-the-art MMI technology can be applied to develop an ATALARS.

2. The review of current technology for critical design areas; i.e., display manipulation, data entry, and sensor use for runway monitoring.

3. Trade-off analyses for use of artificial intelligence to aid or replace controller expertise, van subsystem design, and interoperability with interfacing systems.

4. Verification that the system is operationally acceptable to controllers and pilots and can indeed provide a safe, efficient and effective ATC environment.

To address the first two items, we recommend a short study contract to address the MMI problem and investigate technology issues. To address the last two items, we recommend a contract to conduct trade-off analyses and develop a minimally capable breadboard system which is integradable with current ATC simulators and demonstrable on flight test ranges.

APPENDIX A
FUNCTIONAL ANALYSIS METHODOLOGY

This appendix describes the methodology used in the ATALARS functional analysis. A top-down structured approach was used to identify and define the required ATALARS operational functions. This technique treated ATALARS as a black box of unspecified design which performs certain operational functions (e.g., flight following). These functions were further decomposed into subfunctions, activities, subactivities, tasks, subtasks, etc., to a level of detail consistent with maintaining independence of design. More specifically, if further decomposition required a design decision such as allocation between man and machine, the decomposition process was complete.

The output of the decomposition process is a functional hierarchy such as depicted in Figure A-1. Section 6.0 presents and discusses the functional hierarchy developed for ATALARS. In this report, the term "function" was used generically and applied to all levels of the functional hierarchy.

The results of this functional decomposition were merged with a subsequent decomposition of ATALARS into functional subsystems (e.g., database management, display) as depicted in Figure A-2. The merging took the form of allocating the lowest level of operational functional elements to the appropriate functional subsystem. This then provides a system functional baseline for further design efforts.

The decomposition process is applicable not only to the development of a functional hierarchy, but also to functional flow diagrams, N^2 diagrams, and input/output (interface) requirements as depicted in Figure A-3. These aspects of the decomposition combined with allocation of numerical requirements provide the basis for the eventual functional specification for the system. These alternative depictions also provide checks on consistency and completeness of the functional hierarchy and associated data. The N^2 diagrams assure that each input for a functional element has a source. The functional flow assured that each functional element belonged in a sequence and that all elements needed for a sequence are defined.

The body of data developed for each functional element is pictorially shown in Figure A-4. Figure A-5 presents a sample of the data sheets used to maintain the information on each functional element. These data sheets have been developed for each functional element described in Section 6.0 and were completed as necessary during the aggregation/allocation process.

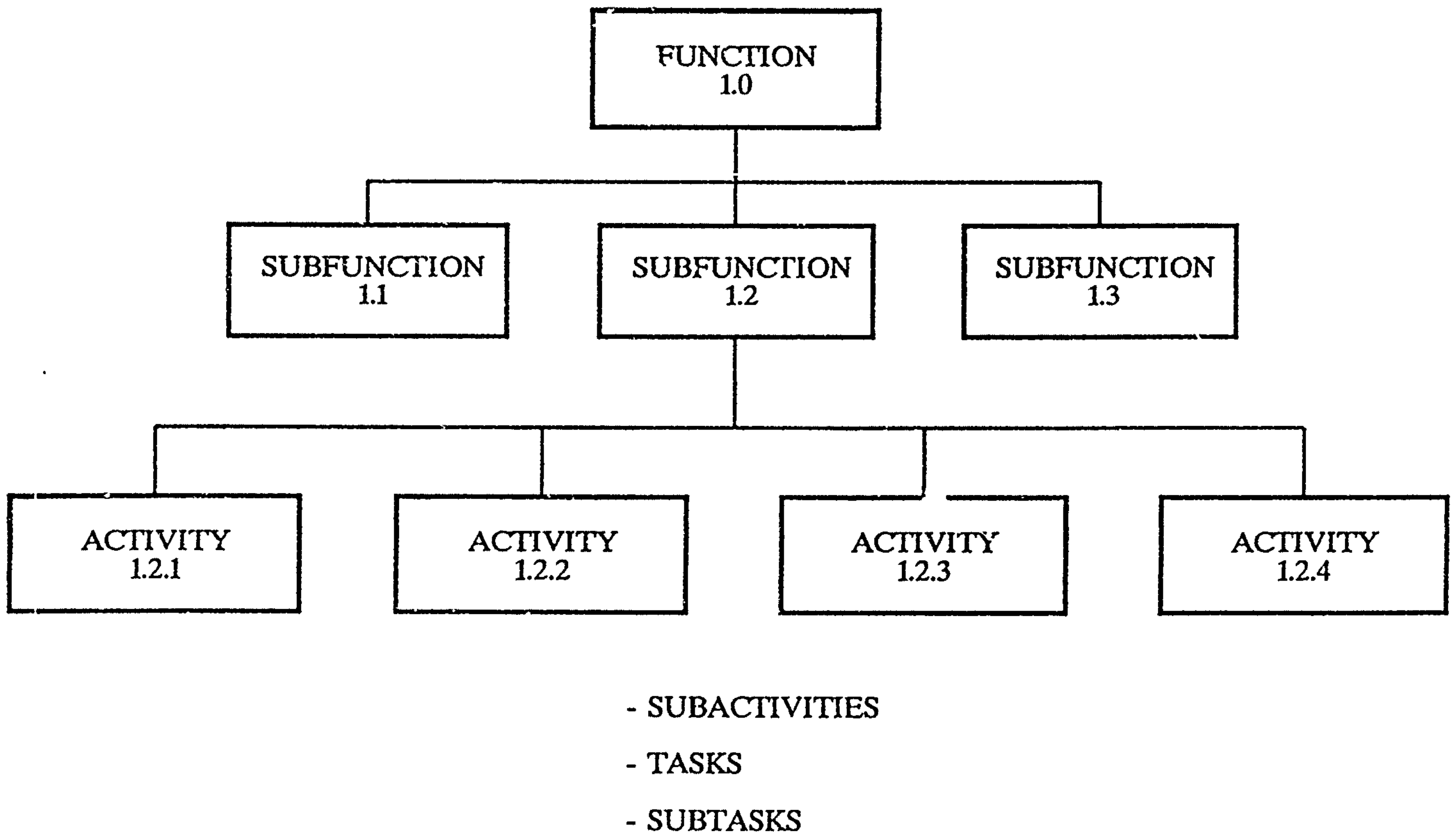


FIGURE A-1
FUNCTIONAL HIERARCHY

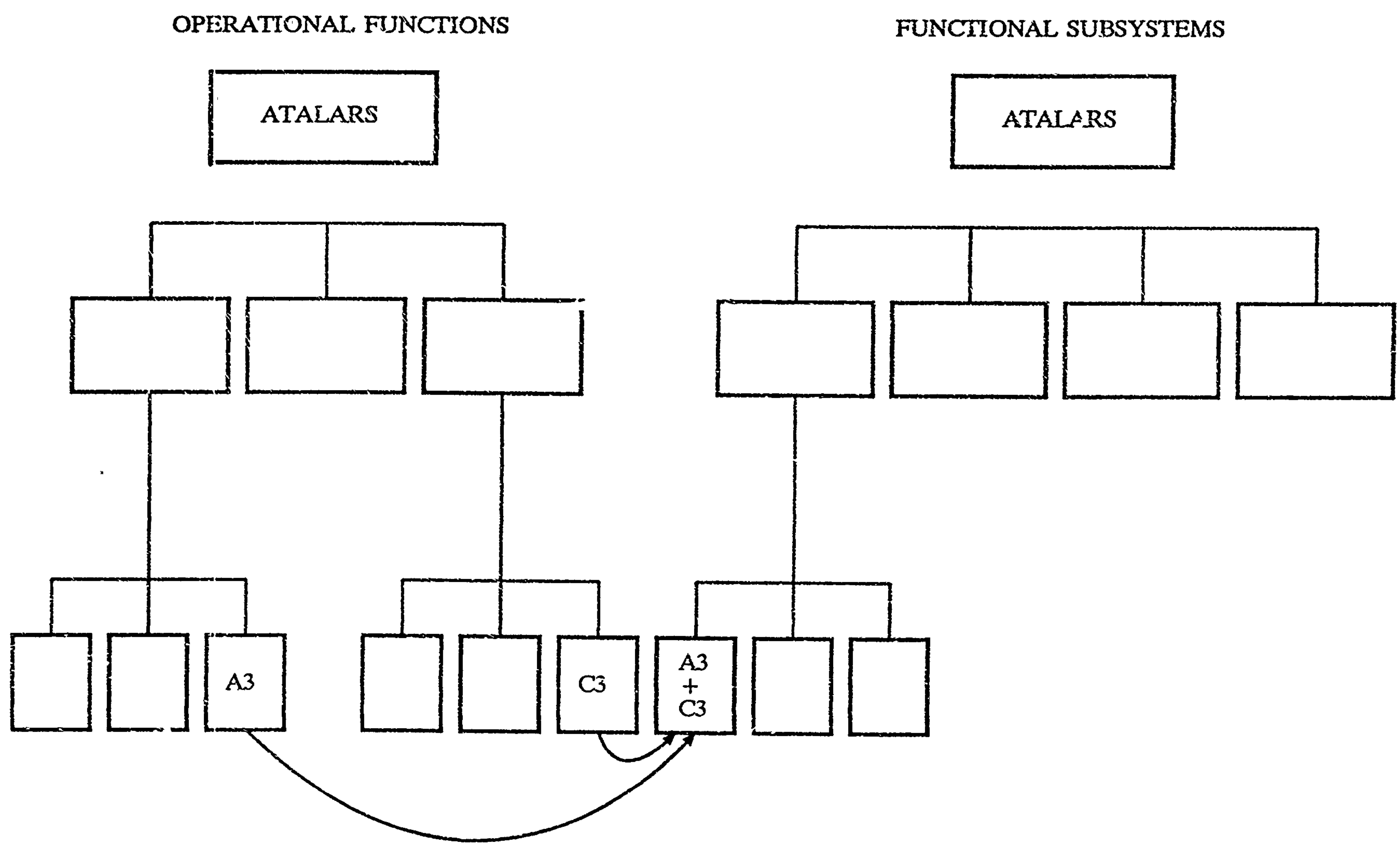
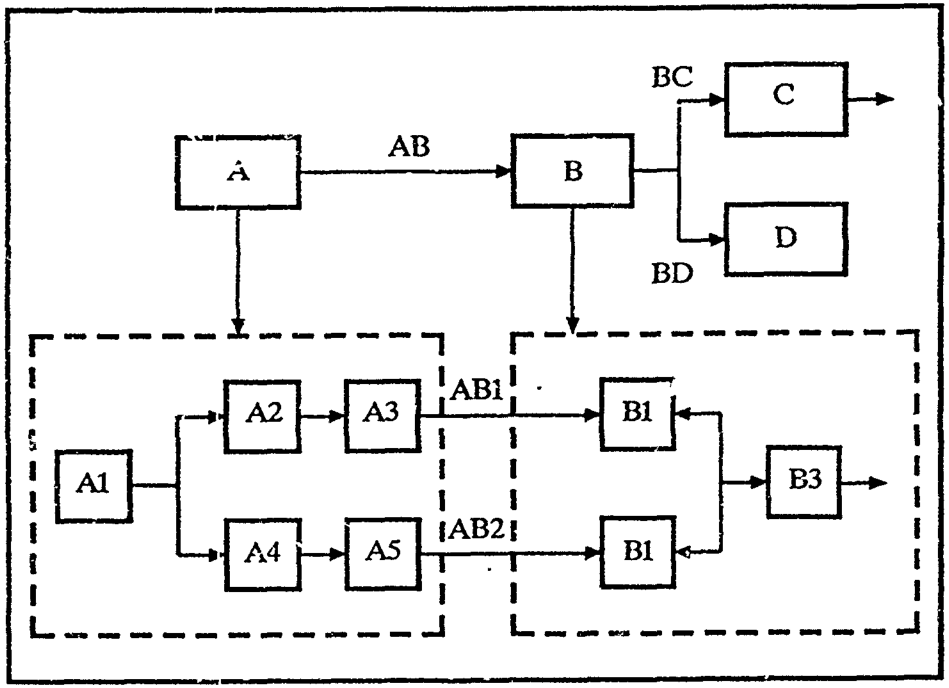


FIGURE A-2
AGGREGATION AND ALLOCATION

FUNCTIONAL FLOW



REQUIREMENTS ALLOCATION

T_A = ALLOWABLE TIME FOR FUNCTION A

$T_{A1} + T_{A2} + T_{A3}$

or $= T_A$

$T_{A1} + T_{A4} + T_{A5}$

N^2 DIAGRAM

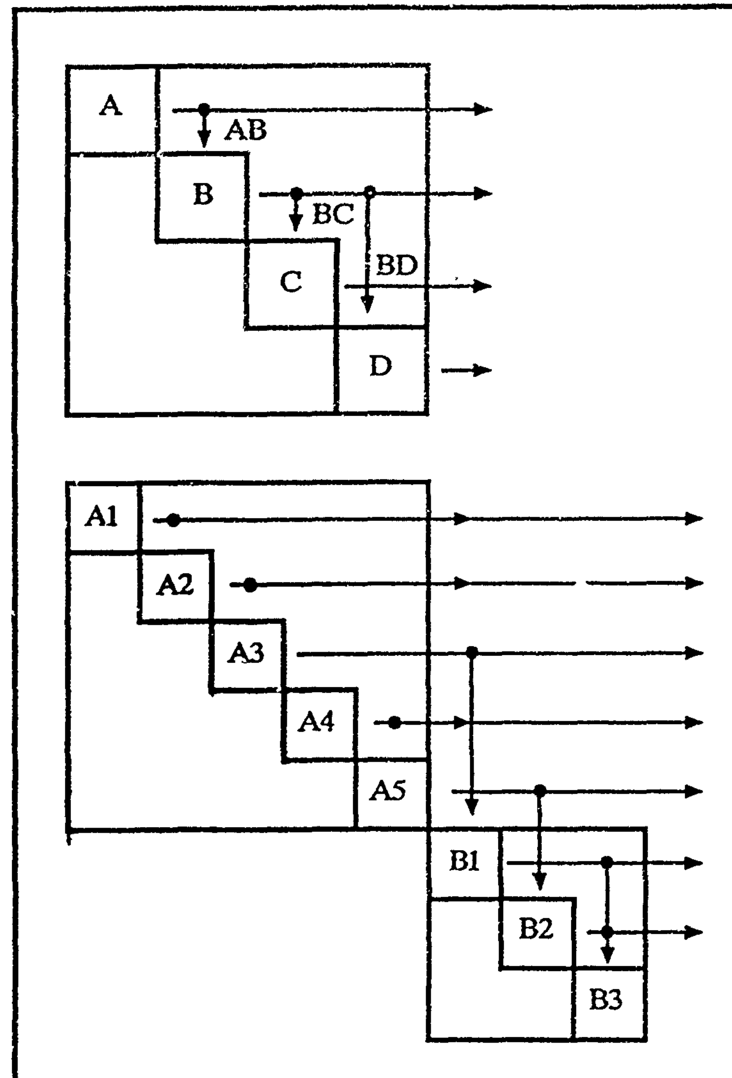
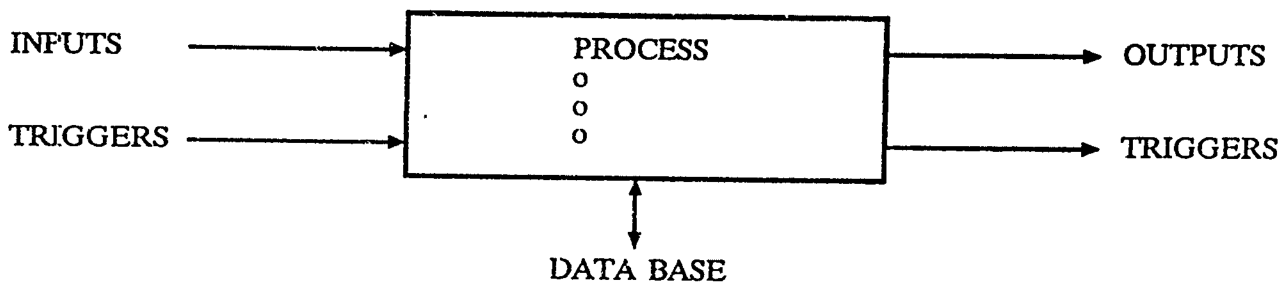


FIGURE A-3
OTHER APPLICATION OF DECOMPOSITION



REQUIREMENTS:

INPUTS/OUTPUTS	TRIGGER	DATA BASE	PROCESS
- DATA CONTENT	- FREQUENCY	- DATA CONTENT	- INPUT/OUTPUT PROCESSING
- FREQUENCY	- NATURE	- VOLUME	- DB INTERACTION
- VOLU…		- SOURCE	- OUTPUT/TRIGGER PRODUCTION
- SOURCE		- OTHER	- FUNCTION DECOMPOSITION
- OTHER			

FIGURE A-4
FUNCTION DESCRIPTION

FUNCTIONAL AREA: Airspace Management
FUNCTIONAL PROCESS NO. 6.1.1 Planning/Coordination
TITLE: Airspace Acquisition

DESCRIPTION: Define airspace for which ATALARS has control responsibility

	SOURCE	CONTENT	FORMAT
TRIGGERS			
Establishment of need (inc. new operations cycle)	HQTAF, Clock	Requirements (mission) boundary locations (latitude, longitude) Bases/airfields being supported	
INPUTS			
External Interfaces (inc. Control Authority(s))	TACC etc.	Interface ID (name, method of control: IFR, VFR)	
Boundary Locations	TACC etc.	length, width, height (sections)	
Special Instructions	HQTAF, TACC	limitations or extended functions	
PROCESS			
Initialize system, Initialize databases			
DATABASE:			
Airspace Boundary Definition Interface Definition			
OUTPUTS			
Coordination with all external interfaces	CRC, AWACS etc. also Army/ Airbase Air Defense and Base/Airfield ATC tower	ATALARS ID hand-shake (scope of control: boundary, priority, limitations)	
PASS PROCESS TO			
Control Coordination	internal link		

FIGURE A-5
DATA SHEET

APPENDIX B
ATALARS FUNCTIONAL HIERARCHY

Tables B-1 through B-4 present the ATALARS functional hierarchy using a numbering scheme which corresponds to that used in Section 6.0 of this report.

Table B-1
6.1 AIRSPACE MANAGEMENT

6.1.1 Planning/Coordination	(Next Ops Period)
6.1.1.1	Airspace Acquisition
6.1.1.1.1	Airspace Boundary Definition
6.1.1.1.2	Airspace Interface Coordination
6.1.1.1.3	Airspace Acquisition
6.1.1.2	Control Function Coordination
6.1.1.2.1	Control Function Allocation
6.1.1.2.2	Control Interface Definition
6.1.1.2.3	Control Establishment
6.1.1.2.4	Adjustments
6.1.2 Environment Monitoring	
6.1.2.1	Weather
6.1.2.2	Enemy Activity
6.1.2.3	Airspace Utilization
6.1.2.4	Friendly Air Defense
6.1.3 Air Traffic Monitoring	
6.1.3.1	Aircraft Tracking
6.1.3.2	Aircraft Identification
6.1.3.3	Emergency Detection/Assessment
6.1.4 Air Traffic Control	
6.1.4.1	Aircraft Handoff
6.1.4.2	Aircraft Routing
6.1.4.3	Aircraft Sequencing and Spacing
6.1.4.4	Emergency Response

Table B-2
6.2 APPROACH CONTROL

6.2.1 Aircraft Route Selection	
6.2.1.1	Airbase Selection
6.2.1.1.1	Aircraft Requirements Assessment
6.2.1.1.2	Airbase Status Review
6.2.1.1.3	Airbase Selection
6.2.1.2	Situation Analysis
6.2.1.2.1	Airspace Environment Analysis
6.2.1.2.2	Air Traffic Situation Analysis
6.2.1.3	Route Selection
6.2.2 Approach Environment Monitoring	
6.2.2.1	Weather
6.2.2.2	Enemy Activity
6.2.2.3	Friendly Air Defenses
6.2.2.4	Interfacing Control Systems
6.2.2.5	Emergency Identification/Notification
6.2.2.6	Issue Advisories
6.2.3 Stack Operations Monitoring	
6.2.3.1	Aircraft Tracking
6.2.3.2	Emergency Detection/Assessment
6.2.4 Stack Operations Control	
6.2.4.1	Aircraft Handoff
6.2.4.2	Stack Insertion
6.2.4.3	Stack Traffic Control
6.2.4.4	Stack Extraction
6.2.4.5	Runway Monitoring
6.2.4.6	Emergency Response
6.2.5 Information Dissemination	
6.2.5.1	Aircraft Notification
6.2.5.2	Controller Notification
6.2.5.3	Air Defense Notification

Table B-3
6.3 AIRFIELD TRAFFIC CONTROL

6.3.1 Traffic Scheduling	
6.3.1.1	Assessment Landing Requirements
6.3.1.1.1	Scheduled Planning
6.3.1.1.2	Current Scheduling
6.3.1.2	Assessment Takeoff Requirements
6.3.1.2.1	Schedule Planning
6.3.1.2.2	Current Scheduling
6.3.1.3	Current Airbase Capabilities/Status Assessment
6.3.1.4	Time Slots Establishment
6.3.2 Airfield Status Monitoring	
6.3.2.1	Control Systems
6.3.2.2	Runways
6.3.2.3	Taxiways
6.3.2.4	Support Facilities
6.3.2.5	Issue Advisories
6.3.3 Monitor Patterns	
6.3.3.1	Aircraft Tracking
6.3.3.2	Emergency Detection/Assessment
6.3.4 Monitor Ground Traffic	
6.3.4.1	Runways
6.3.4.2	Taxiways
6.3.5 Landing Control	
6.3.5.1	Aircraft Handoff
6.3.5.2	Landing Sequencing and Spacing
6.3.5.3	Aircraft Guidance
6.3.5.4	Emergency Response (inc. missed approach)
6.3.6 Departure Control	
6.3.7 Ground Traffic Control	
6.3.7.1	Runway Control
6.3.7.2	Taxi Control
6.3.7.3	Emergency Response

Table B-4
6.4 EXERCISE/TRAINING

6.4.1 Planning

(Same as 6.1.1, but inputs different)

6.4.2 Range Control Interface

6.4.2.1	Flight Safety Coordination
6.4.2.2	Track Data Exhange
6.4.2.3	Handoff

6.4.3 Civilian ATC Interface

6.4.3.1	Near Term Planning Data Exhange
6.4.3.2	Track Data Exchange
6.4.3.3	Military Aircraft Handoff

6.4.4 Data Collection

6.4.4.1	Post Exercise Evaluation
6.4.4.2	Situation Reconstruction

6.4.5 Simulation

6.4.5.1	Exercise Support
6.4.5.2	Training

APPENDIX C
PHASE I & II COST ESTIMATES

1.0 INTRODUCTION

This Appenidx contains the initial cost estimates to accomplish the ATALARS program and demonstration planning efforts described in Section 9.0 of this report. Included are all tasks associated with the Phase I Initial Demonstration and the Phase II Feasibility Demonstration. Phase I consists of the four tasks as described in Sections 9.2.1 through 9.2.4, respectively. Phase II consists of three tasks: (1) Analyses as described by Sections 9.3.1 & 9.3.2; (2) Feasibility Demonstration as described in Sections 9.3.3 & 9.3.4; and, (3) System Specification as described by Section 9.3.5. Each phase also includes considerations for Other Government Costs such as Government Furnished Equipment (GFE), and Engineering & Management support.

The estimating approach relied upon the technical description and program schedule contained in Section 9.0, as well as expanded information obtained through direct conversation with authors of the report. The primary estimating methodology is manloading based upon engineering assessments with all man months costed at $10K in FY87 dollars. Major exceptions to this are the Phase II software, GFE, and material estimates. Relevant groundrules, assumptions, and details will be introduced within the respective sections to which they apply.

The estimates were performed in BY87 dollars. All escalation used the Revised OSD(C) Inflation Factors dated 11 December 86. The entire effort has been assumed to fall within the Research & Development (3600) Appropriation. A summary of the estimates phased in constant BY87$ and TY$ is shown below. Note: A key assumption that Phase II has three additive estimates, each representing one of three assumed contractors.

Phase I & II Summary Estimates

FY87$ in Millions (3600)

	FY87	FY88	FY89	FY90	TOTAL
Phase I	.08	.91	.05		1.04
Phase II (1)	-	-	8.45	3.02	11.47
Phase II (2)	-	-	8.35	2.37	10.72
Phase II (3)	-	-	8.35	2.37	10.72
TOTAL	.08	.91	25.20	7.76	33.95

Inflation Indices (BY87/3600/11DEC86)

	FY87	FY88	FY89	FY90
	1.024	1.060	1.095	1.128

TY$ in Millions

	FY87	FY88	FY89	FY90	TOTAL
Phase I	0.1	1.0	0.1	-	1.2
Phase II (1)	-	-	9.3	3.4	12.7
Phase II (2)	-	-	9.1	2.7	11.8
Phase II (3)	-	-	9.1	2.7	11.8
TOTAL	0.1	1.0	27.6	8.8	37.5

2.0 PHASE I

Described are the Labor & Material costs of four tasks associated with the contractual effort, as well as other government costs for Engineering & Management support. A summary by task is shown below. Costing details are included in the following paragraphs; technical descriptions of each task are in Sections 9.2.1 through 9.2.4.

Phase I
FY87$ in Thousands

Task 1		180
Task 2		90
Task 3		490
Task 4		180
	Contract	940
	Eng. Spt.	45
	Mgt. Spt.	55
		1040

2.1 TASK 1: MAN-MACHINE REQUIREMENTS ANALYSIS

The effort is entirely labor, estimated by manloading and based upon an engineering assessment. The task will be an initial cut at optimizing the controller's and pilot's interaction with ATALARS.

2.2 TASK 2: TECHNOLOGY REVIEW

The effort is entirely labor, estimated by manloading and based upon an engineering assessment. The task will include a review of current technology to evaluate initial design considerations, i.e., voice actuated operator inputs, sensors for runway and ground traffic monitoring.

2.3 TASK 3: DEMONSTRATION

Labor costs account for $480K with the remaining $10K required for hardware. The three categories of labor are Systems Engineering/ Program Management (SE/PM) ($180K), ATC/Pilot Expertise ($60K), and Software Development ($240K). The SE/PM effort requires a lead Engineer/Manager to coordinate system level design and provide ongoing analysis of the detailed design. An additional individual will be required during the last six months to assist with analysis. Expertise of operational specialists is required to insure a satisfactory requirements analysis and preliminary design. Software Development will be accomplished by a small team consisting primarily of analysts. Their product will be software to generate graphics displays. All the above manloadings are based on engineering assessments. The software assessment is based on an analogy to a similar development of a graphics display designed to simulate the tracking function.

The hardware consists of two desktop computers, two small displays, and minor peripherals. The IBM AT and Kodak Data Show (See Appendix D) are used as points of comparison for cost.

2.4 TASK 4: FUNCTIONAL SPECIFICATION

The effort is entirely labor, estimated by manloading and based upon an engineering assessment. The task will provide a preliminiary functional specification for ATALARS.

2.5 ENGINEERING SUPPORT

Assumes a manmonth prior to contract award to prepare Request for Proposal (RFP) documentation and 3.5 manmonths after completion for follow-on Government analysis.

2.6 MANAGEMENT SUPPORT

Assumes a manmonth prior to contract award and 4.5 manmonths after completion. Each effort is associated with preparation of RFP documentation.

3.0 PHASE II

Described are the Labor & Material costs of the three tasks associated with the contractual effort, as well as Other Government Costs such as GFE and Engineering & Management support. A summary by task for each of three contractors is shown below. Costing details are included in the following paragraphs; technical descriptions of each task is contained in Section 9.3 as specified in paragraph 1.0 of this Appendix.

Phase II
FY87$ in Thousands

	(1)	(2)	(3)	TOTAL
Task 1	900	900	900	2700
Task 2	7480	7210	7210	21900
Task 3	240	-	-	240
Contract	8620	8110	8110	24840
GFE	2500	2500	2500	7500
Eng. Spt.	110	110	110	330
Mgt. Spt.	240	-	-	240
	11470	10720	10720	32910

3.1 TASK 1: ANALYSES

Approximately ten trade-off and five interoperability studies are anticipated. An engineering assessment of 6 manmonths per study was used to manload this requirement.

3.2 TASK 2: FEASIBILITY DEMONSTRATION

Included are all contractor efforts necessary to design, manufacture, test and demonstrate the breadboard system. Major cost elements include Group B, Group A/Install, Flight Test, SE/PM, Data, and Engineering Change Order (ECO).

3.2.1 Group B

Components include hardware, software and integration. Hardware and labor estimates consider design & manufacture of unique items as well as modifications to GFE items. Unique items include an air conditioned, fully powered van and the necessary processing & display equipment. Modifications to the data terminals and ATC emulator/simulator will be required. Estimates of $350K for design, $300K for manufacture, and $300K for material are engineering assessments.

Software estimates consider the requireme s analysis, design, code/unit test, integration and hardware/software integration. The effort results in software which permits demonstration of the functions associated with controller & pilot displays as described in Sections 9.2.3.1 & 9.2.3.2. Being prototype by nature and targeted for a breadboard system, it is assumed that strict compliance with military standards for testing, reliability, documentation, etc., will not be required. Also, while demanding a certain amount of real-time, interactive capability, it is assumed that the specification will be somewhat flexible, allowing work-arounds and/or simulations. As such, the COCOMO definition of the semidetached mode of development is considered appropriate. Each of the 12 displays is sized at an average of 5000 Lines of Code (LOC) of nominal complexity. Multiplied by 12 for total development, the effort rounds to 200 manmonths. Requirements analysis & hardware/software integration are estimated as 10% & 30%, respectively. This equates to 10 LOC/day (60KLOC/280 MMTH) for the fully integrated software.

3.2.2 Group A/Install

Contained is a nominal 6 manmonth effort by the prime contractor to generate an interface package and a subcontract to an integration contractor amounting to $1.0M to accomplish the Class II modification. The subcontract amount is based on an analogy to a $9M Class V modification program with five Line Replaceable Units (LRUs). The $1.0M is considered appropriate given a breadboard model of a single LRU.

3.2.3 Flight Test

Contained is a nominal 6 manmonth effort by the prime contractor at the test facility.

3.2.4 Systems Engineering/Program Management

Manloaded estimates of 83 & 55 manmonths are based upon engineering assessments of the requirement. This equates to 19% of Prime Mission Equipment (PME) (Group B, Group A/Install, GFE).

3.2.5 Data

A manloaded estimate of 58 manmonths equating to 8% of PME is assessed.

3.2.6 ECO

Estimated as approximately 10% of PME.

3.3 TASK 3: SYSTEM SPECIFICATION

This task will be performed by the contractor selected for Phase III. A manloading of 24 manmonths is assessed as reasonable. While not directly attributable to the A Specification preparation, this task will require a low level presence within SE/PM & Data Cost Elements. This amounts to $270K during the final 6 months of performance.

3.4 GOVERNMENT FURNISHED EQUIPMENT (GFE)

Required are two data terminals and an ATC Emulation/Simulation capability. It is assumed that two JTIDS Class 2 terminals priced at $1.2M each and requiring minimal modification, as well as an AN/GPN-T4 priced at $0.1M will be available for each contractor in FY89.

3.5 ENGINEERING SUPPORT

Included is a $75K requirement for the test facility and 3.5 manmonths for a follow-on analysis.

3.6 MANAGEMENT SUPPORT

Included is a manmonth for contract monitoring during each of the 14 months of the contract. Month 30 includes ten manmonths for the downselect process. This effort is not impacted by multiple contracts.

4.0 CONFIDENCE LEVEL ASSESSMENT

The overall confidence level of these estimates is very much dependent upon the technical descriptions available. Since it is a conceptual phase, Phase I is primarily a Level of Effort (LOE) study intended to refine the definition of Phase II. As such, cost & schedule uncertainty of Phase I is relatively low. The cost & schedule estimates of Phase II, however, being very much dependent upon the results of Phase I requirements analysis, technology review and functional specification, have more inherent uncertainty. Subsequent estimates with these results should be performed.

The general estimating methodologies present another factor which impacts the overall confidence level. Two-thirds of the estimate is labor. Manloadings based upon engineering assessments are responsible for 42% of the $11.47M for the first Phase II contractor. Another 25% is derived by COCOMO for the software effort. Finally, 33% is derived by engineering assessments of material requirements.

APPENDIX D
PHASE I DEMONSTRATION HARDWARE/SOFTWARE CONSIDERATIONS

This appendix contains a review of current state-of-the-art hardware and software capabilities for consideration in the Phase I demonstration.

1.0 INTRODUCTION

The man-machine interface may require highly specialized capabilities for demonstrating the automation of the system. For example, enhanced graphics and color are basic necessities in a pilot's heads-up display or a controller's display. The processing speed is also a critical requirement to simulate real-time system functionality. As each requirement becomes an option in the demonstration, cost and complexity become the key to determining the system's quality and accuracy in simulating an ATALARS environment. This results in a series of trade-offs which identify limitations using various off-the-shelf systems. The following paragraphs present the capabilities of various hardware/software which can be the basis for these trade-offs.

1.1 HARDWARE

An IBM PC/XT/AT or compatible system has the most flexibility and is generally the most expensive. It is less portable than other systems available (a laptop system). Color and enhanced graphics are available on most models (again except for the laptop) but both high resolution color monitors and enhanced graphics adapter cards are specialized options. Due to the processing speed needed (8 MHz will probably be the minimum required), the higher priced, more elaborate XT or AT models are more appropriate.

For enhanced graphics, the industry continues to emulate the Apple Macintosh. The major drawback is its lack of color (all shading is done in grey scale). However, the system comes complete allowing full use of its graphics capabilities. The system is also portable, since the monitor is built in.

Display technology is one aspect of an ATALARS implementation that could be demonstrated. The high resolution and color that is currently available using CRTs will enhance the man-machine interface; however, LCD or plasma technology may be more appropriate in a mobile/tactical ATALARS environment. On a more practical level, LCD or plasma displays are more portable, as evidenced by their use in laptop personal computers. This portability could be very desirable when taking the demonstration to Air Force users. The obvious drawbacks of LCD and plasma technology, including lack of color and limited graphics, would be expected to decrease as these technologies evolve.

A PC-based graphics system should provide the most complete, user-friendly environment to support the ATALARS man-machnie demonstration. A dedicated graphics workstation would be roughly four times as expensive, less user-friendly, and would probably not provide as many options. The graphics capabilities gained from a dedicated workstation would also far exceed any design requirements generated for ATALARS at this point of development.

1.2 SOFTWARE

There are many software graphics packages available in the micro-computer industry. Packages such a Lotus' Freelance and Microsoft's Micrographics Windows Draw provide very extensive graphics capabilities; however, features such as animation may still be difficult to duplicate. These graphics packages, having been designed for freehand static presentations, may actually make displaying objects in an ATALARS format more difficult. The majority of graphics packages will make the most of a system's capabilities and provide elaborate graphics; however, they may also require specific system enhancements.

Languages such as Microsoft's BASIC Version 2.0 do allow for graphics The strength of a general purpose language is that the graphic symbol library consists of essential primitives such as lines and arcs. In simulating an ATALARS environment, these primitives allow the programmer to design the display formats without being constrained to the formats available in the graphics package. This method, while only providing simple representations, allows more flexibility when attempting to animate the various scenarios. To allow a language such as BASIC to provide quality graphics and animation will require very high processing speeds (8-16 MHz) such as those found in the 80286-based IBM PC/ATs or the 80386-based Compaq Deskpros.

1.3 VISUAL ENHANCEMENTS

Because of the need to demonstrate this system to a sizeable audience at many locations, visual enhancement systems need to be addressed. These systems may also serve to enhance the man-machine interface by simulating some ATALARS characteristics. The most promising of these systems is the Kodak Data Show. The Data Show employs LCD technology by taking the RGB output from the PC and displaying the information on a liquid crystal screen overlayed on an overhead projector. The drawbacks would be the limitation of the LCD technology and compatibility requirements with systems other than an IBM PC.

Slide systems such as the Polaroid Pallette or Celtic Technologies VFR-2000 Screen Camera provide strong graphics and color enhancements even making color slides from monochrome displays. In addition to systems providing in-house capabilities, there are also graphics services available from outside vendors. However, since slides are obviously a static medium, their use would not support animation or an on-line demonstration. To make slides work in an automated environment, a system called Video Show can be used. This system provides the ability to save graphic images generated on a PC and present them with various transitional sequences to allow a graphic flow from image to image. Again, the transitions are not conducive to animation. The Video Show does provide extended graphics and color capabilities and is highly portable. All of these visual support systems are based on the use of static graphics and text, so their use in an animated demonstration would be considered non-standard at best.

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GLOSSARY

AADCP	Army Air Defense Command Posts
AAFCE	Allied Air Forces Central Europe
ADP	Automated Data Processing
AJ	Anti-Jam
ATAF	Allied Tactical Air Force
ATALARS	Automated Tactical Aircraft Launch and Recovery System
ATC	Air Traffic Control
ATDL	Army Tactical Data Link
ATDS	Air Tactical Data System
ATO	Air Task Order
AWACS	Airborne Warning and Control System
AWS	Air Weather Service
C^2	Command and Control
CAFMS	Computer Automated Force Management System
CBR	Chemical Biological Radiological
COTS	Commercial Off-the-Shelf
CRC	Control and Reporting Center
CRP	Control and Reporting Post
CRT	Cathode Ray Tube
DBMS	Data Base Management System
DDP	Digital Data Processor
DOD	Department of Defense
DRAM	Dynamic Radom Access Memory
ECO	Engineering Change Order
EMP	Electromagnetic Pulse
ESD	Electronic Systems Division
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FACP	Forward Air Control Post
FEBA	Forward Edge of Battle Area
FLOT	Forward Location of Troops
FSP	Full Scale Production
FSED	Full Scale Engineering Development
GFE	Government Furnished Equipment
GPS	Global Positioning System
HQ TAF	Headquarters Tactical Air Forces
ICAO	International Civil Aviation Organization
ID	Identification
IFF	Identification Friend or Foe
INS	Inertial Navigation System
JTIDS	Joint Tactical Information Disbribution System
LCD	Liquid Crystal Display
LOC	Lines of Code
LPI	Low Probability of Intercept
LRU	Line Replaceable Unit
MCE	Modular Control element
MLS	Microwave Landing System
MMI	Man-Machine Interface
MMLS	Mobile Microwave Landing System
MPC	Message Processing Center

GLOSSARY (cont.)

NATO	North Atlantic Treaty Organization
NMR	New Mobile RAPCON
NTDS	Naval Tactical Data System
OM	Operations Module
OTS	Off-the-Shelf
PME	Prime Mission Equipment
PPS	Precise Positioning Service
QWROTES	Quick Wartime Restoral of TRACALS Equipment and Services
RAM	Random-Access-Memory
RAPCON	Radar Approach Control
RFP	Request for Proposal
ROE	Rules of Engagement
ROM	Read-Only-Memory
RSU	Remote Surveillance Unit
SEP	Spherical Error Probability
SE/PM	Systems Engineer/Program Management
SRV	Surveillance Resotral Vehicle
TACC	Tactical Air Control Center
TACS	Tactical Air Control System
TADIL	Tactical Digital Information Link
TEMS	Technical Engineering Management Support
TR	Technical Report
TAOC	Tactical Air Operations Center
TRV	Tower Restoral Vehicle
U/I	Unidentified
VFR	Visual Flight Rules
VLSI	Very Large Scale Integrated
WOC	Weapons Operations Center