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13. ABSTRACT (Maximum 200 words) This reports documents a first draft of projected requirements for an advanced air traffic control concept, named ATALARS (Automated Tactical Aircraft Launch and Recovery System). The ATALARS recognizes the need to interface with other systems within the Battle Management arena. This document attempts to capture the initial concerns facing the system-to-system interoperability issues.				
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ATALARS OPERATIONAL REQUIREMENTS

AUTOMATED TACTICAL AIRCRAFT LAUNCH AND RECOVERY SYSTEM



U.S. Air Force
Electronic
Systems
Division

April 1988



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1. INTRODUCTION

1.1 CONCEPT

The Automated Tactical Aircraft Launch and Recovery System (ATALARS) is a fully automated air traffic management system intended for the military service but is also fully compatible with civil Air Traffic Control (ATC) systems. ATALARS is designed to interface with civil Air Traffic Control (ATC) operations and airspace management systems and to provide interoperability with battle management systems. Specific ATALARS operational functions are:

- o Area airspace management
- o Approach control
- o Landing control
- o Departure control
- o Information advisories

ATALARS provides interoperability with the:

- o ATC of other landing sites within the ATALARS coverage area
- o Tactical airspace management system
- o Tactical airspace defense system
- o Local point air defense system
- o NATO and EUROCONTROL and ICAO Procedures

The entire ATALARS Ground Control Unit (GCU) capability will be contained in a mobile, battlefield protected, remotely located van equipped with sophisticated processors, displays, and ground and space communications links capable of performing automated airspace management, control, launch and recovery functions at multiple landing areas within the ATALARS jurisdiction. The ATALARS concept is illustrated in Figure 1-1.

The ATALARS concept primarily is based on the Automated Dependent Surveillance (ADS) passive surveillance system. The ADS information will be obtained from aircraft-derived position and track reports and will be enhanced

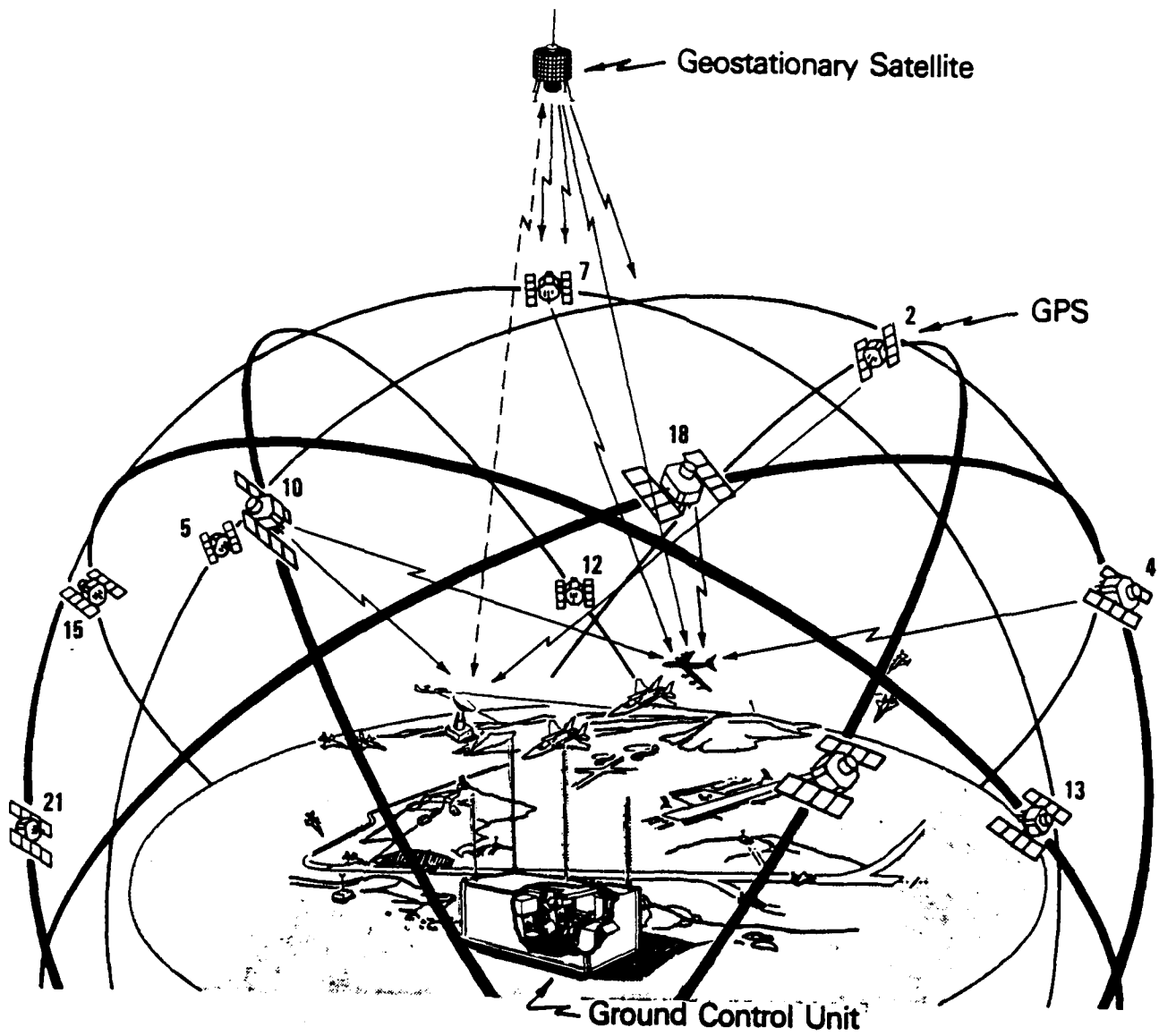


FIGURE 1-1. ATALARS CONCEPT

by the active surveillance obtained through the advanced TACS track reporting network. The ADS reports will be received via secure communications data and voice links directly from the aircraft when in line-of-sight or through a relay chain or satellite communications link when the aircraft is out of line-of-sight.

The ATALARS is required to provide automated guidance and control of a large number of aircraft for all phases of flight operations. The time that the aircraft will be under ATALARS control will be of short duration, but will require flight guidance through complex air defense corridors, zones, and safe vectoring to the precision landing gates and precision guidance for zero visibility landings. One ground-based ATALARS GCU will serve multiple landing sites. ATALARS must maintain compatibility with civil ATC systems (EUROCONTROL, FAA and ICAO procedures) by using compatible air navigation communications and avionics equipment in a peacetime environment and assume full air control in case of national emergency or a wartime situation in NATO, NAS and similar coverage areas.

1.2 OBJECTIVES

ATALARS objectives are:

1. Provide a high level of survivability by protecting the ATALARS GCU by means of a suitable shelter and a capability to move it to another location.
2. Increase sortie generation rates through the automation of airspace, flight management and air defense coordination, and close coordination of ATC functions and TACS operations.
3. Provide a flexible basing to include main operating bases, co-located operating bases and by vectoring aircraft to alternative prepared runways, roadways, and emergency fields.
4. Provide automated airspace management, metering, and clearance delivery with an option of computer assisted control-by-exception.
5. Provide an alternative to ADS surveillance by having access to the TACS of netted radar data link.

6. Use a reliable and secure communication link, such as JTIDS, HAVEQUICK and SINCGARS for information exchange among controllers and pilots and provide access to the air defense surveillance networks.
7. Provide system reliability by redundancy of navigation, communication, and landing systems.
8. Provide rapid service reconfiguration capability.
9. Provide full compatibility with NATO, EUROCONTROL, FAA and other operations.
10. Provide full compatibility with ICAO recommended practices (ICAO ANNEX) and ICAO FANS recommendations.

1.3 ATALARS OPERATIONAL ENVIRONMENT

ATALARS operational requirements are based on a future system environment mix between military and civilian equipment of the Communication, Navigation, Surveillance (CNS) services within the 2015 time period. A projected CNS system equipment summary from which selection for the ATALARS concept could be made is listed below.

1.3.1 List of Future CNS System Equipment

SURVEILLANCE EQUIPMENT

Active Surveillance

- o Over-the-horizon radar (OTH-B): AN/FPS 118 (1800 nautical mile range)
- o Long range radars: AN/GPN-20 and AN/GPN-24
- o Tactical Air Defense Radars: AN/TPS-43 and AN/TPS-70
- o Airborne Warning and Control System: E-3A
- o Bistatic radars
- o VORTEX, satellite-based imaging radar
- o Electro-optical, Advanced Tactical Air Reconnaissance System

Passive Surveillance

- o GPS/INS aircraft position, track reports over JTIDS, MODE-S Data Link or L-band satellite data link
- o JTIDS aircraft position, track report
- o CIS-Satellite Independent Surveillance
- o RDSS-Radio Determination Satellite Service

Mobile Surveillance

- o MMLS/MLS
- o AN/MPN-14 - Mobile radar
- o SRV - Surveillance Restoral Vehicle
- o TRV - Tower Restoral Vehicle
- o GPS PL-GPS Pseudolite
- o RPV - Remotely Piloted Vehicle
- o SMR - Surface Movement Radar
- o NMR - New Mobile RAPCON
- o ATARS - Advanced Tactical Air Reconnaissance System

COMMUNICATIONS EQUIPMENT

- o AN/URC-56C Joint Airborne Communications Center - mobile communications post operable on ground or airborne
- o JTIDS communications channel (secure)
- o MIDS communications channel (secure)
- o UHF - HAVEQUICK, anti-jam radio, 225-400 MHz (TADIL C-Link 4) data and (TADIL A-Link 11) voice
- o HF - Medium and long range communications with anti-jam
- o TADIL B-Link 1, Tactical Digital Information Link to TACS, FAA and EUROCONTROL (NATO)

- o VHF - SINCGARS, Single Channel Ground-Air Radio with anti-jam, 30-88 MHz
- o ROBUST/LPC
- o JAMPS
- o TRI-TAC - Digital network
- o SATCOM - L-band data and voice links
- o MILSTAR
- o ACTS, Advanced Technology Satellite in K_U (20 GHz) and K_A (40 GHz) bands
- o C-band MLS frequency band: 5.000-5.200 GHz and 5.150-5.250 GHz
- o MODE-S Data Link
- o RDSS - Radio Distance Surveillance System

NAVIGATION EQUIPMENT

- o GPS/INS: PPS and SPS services
- o JTIDS - Navigation Service Mode
- o MIDS - Navigation Service Mode
- o E-3A - Navigation Service Mode
- o MLS-RNAV (3-D and 4-D)
- o Barometric Altimeter quantization increment, $\Delta H = 25$ feet

A typical ATALARS environment will be as follows:

1. NAVIGATION - operates without primary and probably secondary radars and radio aids to navigation. Probable systems in use will be GPS, JTIDS, MIDS and MMLS/MLS and aircraft position derived either in the aircraft (ADS) or on the ground and then uplinked to the aircraft (RDSS).
2. SURVEILLANCE - down-linked positional and velocity navigation track data using information derived in the aircraft (ADS); or on ground (RDSS); or active surveillance obtained over TADIL A, B, C or Link 11,

4, 1; respectively, or from a Surface Movement Radar or MMLS in the landing area. A bistatic radar may also be used at the ATALARS GCU with compatible receiver capable of interfacing with tactical air defense radars.

3. COMMUNICATIONS - JTIDS, HAVEQUICK, SINCGARS, TADIL, or Mode S Data Link

4. LANDING

- o VASI: Visual Aids
- o Nonprecision: GPS, PTAG
- o Precision: CAT I - GPS; CAT II - Tactical MLS; CAT II, GPS Pseudolite with Dual Frequency and Carrier Phase data; and CAT IIIC - MMLS.

Operational issues to be resolved in the future to establish a proper system mix and operational compatibility between military and civilian CNS systems are listed below.

1.3.2 Interoperability and Design Problems

1. Establish interoperability and compatibility with NATO, EUROCONTROL, ICAO practices for ATC and airspace management systems.
2. Specify required Navigation Performance Capability (RNPC) and Minimum Navigation Performance Specification (MNPS) minimum operational levels.
3. COMMUNICATIONS: Decision required as to which system mix should be adopted - JTIDS Data Link, HAVEQUICK, SINCGARS, COMSEC, Terrestrial L-Band Communications Link, Mode S Data Link, etc.
4. MMLS signals are not protected against jamming.
5. MLS-RNAV: Decision required as to which service level will be adopted including 4-D capability.
6. Barometric Altimeter: The military uses radar altimeter and geodetic (GPS) altitude where civilians intend to use barometric altimeter up to flight level of FL1000 with altimeter quantization increments, ΔH , of 25 feet.

7. CAT IIIc capability: Does not exist to-day, may be achieved by use of MMLS and perhaps with the GPS Pseudolite with dual frequency and carrier phase data.
8. Controller-Pilot direct communication link for data and/or voice requirement. Can the communications link also be used for measuring range to the aircraft?
9. Coordinate reconstruction: For a precise position fix, it is required to use the correct translation algorithm; for example, MLS (ρ, θ, ϕ) translates to Cartesian x, y, z ; GPS earth-referenced systems use latitude and longitude; National Airspace System (NAS) design uses ρ, θ for navigation courses and fixes for man/man and man/machine interfaces.
10. Geodetic reference datum: many references exist; for example, NAD27, WGS72, WGS84 or EU50; ICAO and GPS has adopted WGS84. Which geodetic reference datum will ATALARS adopt?
11. Determine which ground controller and aircraft pilot displays will be used - CRT, plasma displays or others?
12. Adoption of Ada computer language, C language or some Ada modified versions or other higher level languages such as LISP or PROLOG to be used for AI work.

1.4 APPROACH

The Operational Requirements is one of the ATALARS system performance documents required for the system specifications. A logical evolutionary sequence of the development of the performance specification is shown in Figure 1-2. The shaded area in the flow chart represents the present position in the overall sequence and the requirements presented in this document.

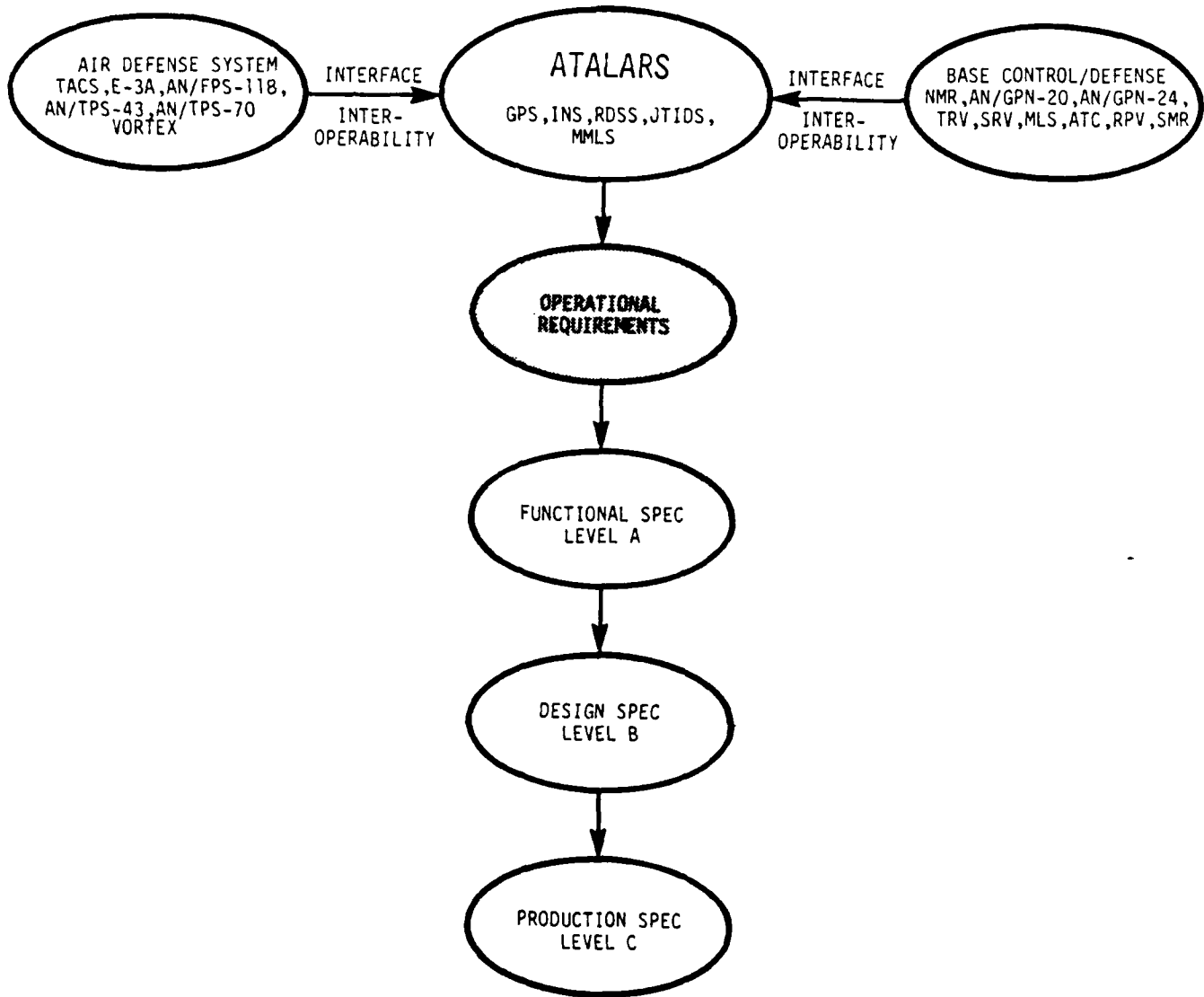


FIGURE 1-2. ATALARS PERFORMANCE SPECIFICATION DEVELOPMENT FLOW CHART

2. ATALARS REQUIREMENTS

The basic ATALARS operational requirements in qualitative and quantitative terms are developed to provide a safe, coordinated, efficient, automated, and secure airspace management service within its designated area of responsibility. This multi-airport management and control service is to be achieved through internetting with a remote, mobile ground control units and TACS and shared with an airborne control system, such as E-3A, or a properly equipped airborne vehicle. The air traffic management requirements include: air traffic control and air traffic flow management and coordination with TACS, approach control, departure control, landing guidance, and other tactical ATC functions. ATALARS is required to be compatible with NATO operations and with the civil aviation user population, EUROCONTROL and ICAO procedures and perform equally in wartime and a peacetime environment.

The ATALARS operational requirements are presented as follows: first, general overall system operational requirements; followed by requirements related to environment and phase of operation; and finally, specific system operational requirements.

2.1 GENERAL SYSTEM OPERATIONAL REQUIREMENTS

2.1.1 Area of Control

The required areas of an ATALARS GCU control jurisdiction for controlling flight arrivals, departures and inflight routes is an area within a nominal radius of 60 nautical miles. This area typically corresponds to a RAPCON coverage area. In addition, the ATALARS GCU is required to support airspace management of up to 300 nautical miles range and for a peak load of 600 aircraft for the purpose of operational margins and for future growth capacity. The altitude coverage is specified from 0 to 100,000 feet within the entire coverage area.

2.1.2 Airspace Structure

The ATALARS is required to be compatible with peacetime and wartime air route structures. Peacetime air route structures are based upon charted high- and low-altitude airways used by both civil and military pilots. Future air route structures will depend on free routes used with dynamic allocation of flight profiles and sectorization as a function of traffic density and configuration. The reserved air routes will be much more adaptive to mission requirements.

A wartime environment requires a highly structured, closely controlled airspace. Procedures based upon protected air defense corridors and zones will be established by TACS and base defense controls and made available to ATALARS through a defense network.

The three types of flights to be accommodated are: IFR under ATALARS control services; VFR (a non-cooperating flight, therefore not receiving ATALARS service); and CVFR (requesting control services at or prior to entering ATALARS airspace).

2.1.3 Flight Trajectories

The following flight trajectories are required:

- o High structured safe corridors and danger zones.
- o Most economical routes determined by a pilot prior to or during the flight.
- o 3-D (position) and 4-D (position plus time) flight trajectories
- o Straight-in emergency routes
- o For trajectory calculations and flight control, it is required that the 4-D flight predictions are made at 5, 10 and 15 minute intervals of individual trajectories.

2.1.4 Modes of Operation

There are three modes of operation specified for the ATALARS system.

2.1.4.1 Automatic Mode - where computers will control the flow of traffic into and out of runways and flight routes. The ATC controller will monitor system performance and will react to the system via a data link. Additional monitoring information to be provided will be computer-controlled traffic buildup along route segments, corridor entry/exit, and runway landing gates. When changes become necessary, controllers will be required to enter metering/spacing and flow rate parameters that affect the computer process. When capacity is reached, controllers will enter the adjustment criteria for each situation: changes in capacity or spacing parameters, or changes in flight routing.

2.1.4.2 Semi-Automatic Mode - Route assignments and clearances will be made by controllers with computer assistance and delivered via an air-ground data link. Computer generated flight clearances or control commands are verified prior to transmission to the aircraft.

2.1.4.3 Manual Mode - Emergency conditions or unequipped (VFR) or damaged aircraft accepted by the system for manual control via voice instructions.

2.1.5 Control Concept

Full automation, by means of control-by-exception, is a requirement for the ATALARS system operation. However, system control can be accommodated at three distinct levels:

- Fully automated - control commands automatically displayed in the aircraft,
- Semi-automated - control commands displayed first to the controller and then transmitted to the aircraft,
- Manual - voice control of the aircraft.

The ATALARS control is divided between airborne and ground control. A pilot will see his flight situation on his cockpit display similar to the ground control unit's display except that it is less sophisticated with more limited onboard traffic control capability. Pilots will be able to monitor their own positions relative to nearby aircraft as well as relate their trajectory on their situation displays. In an emergency, an aircraft may be assigned to

assume limited control of the ATALARS airspace. However, in normal situations, airspace control will be delegated to the Airborne Warning and Control System, E-3A, or TACS element being supported by a JTIDS type of data link.

2.1.6 Time Under Control

The projected average time span under ATALARS control in an automated mode is from 5 to 30 minutes for anticipated aircraft speeds from 100 knots to Mach 3. Some emergency flights will require voice control procedures. In these situations, observation time under voice control will be significantly longer.

2.1.7 Control Response Time

The average equipment control response time will be about 2 to 3 seconds plus 6 seconds for pilot response. The system integrity requirement is specified between 7 to 10 seconds for the system to indicate that there is a malfunction and readings are not correct. Therefore, the total response time will be up to 15 seconds for manual operation. However, response time for precision approaches will be 0.5 seconds. Using computer generated commands and assigning a proper priority level, control response time will be reduced to 1 to 3 seconds.

Alerting facilities will be provided to issue 2 minute warnings in case of aircraft proximity to reserved airspace or deviations from the flight path. Alert messages may be generated automatically by the TCAS in the automatic mode.

2.1.7.1 Service Interoperability - ATALARS is required to be compatible with civil ATC and capable of providing joint civil and military airspace management and control in an emergency.

2.1.7.2 Flight Speed Range - The flight speed range is from 100 knots to Mach 3. Subsonic speeds are anticipated for a mix of arrivals and departures with some supersonic speeds for overflights.

2.2 SYSTEM OPERATIONAL REQUIREMENTS RELATED TO ENVIRONMENT AND PHASE OF OPERATIONS

2.2.1 Precision Landings

- o Approach Control Sites: A single ATALARS GCU system is required to control up to 10 landing sites within a 60 nautical mile nominal coverage area (one landing site per primary airbase).
- o Runways: A specific site will have one primary and up to two secondary runways per landing area. The total number of runways under one ground control unit can be up to 30 runways with some runways as short as 2500 feet and runway surfaces of rough fields or gravel road beds.
- o Capacity per Landing Area: One airport landing site is required to accept up to 100 aircraft. Roadways and emergency fields are not included in this requirement.
- o Aircraft Surge Landing Rates: A landing rate during surge periods shall be one aircraft per 30 seconds per runway.

2.2.2 Precision Landing Accuracy Requirements

Flexible precision approach and landing, and missed approach service will be provided by the Microwave Landing System, GPS Pseudolite, and satellite-compatible L-band terrestrial systems.

Accuracy based on CAT IIIC requirements are:

Azimuth at 8 feet altitude:	13.4 feet (95 percent)
Elevation at 8 feet altitude:	1.3 feet (95 percent)
Range:	+100 feet
Approach Coverage Arc:	360 degrees, 120 degrees minimum
Vertical Coverage:	20 degrees up to 20,000 feet altitude
Range of Coverage:	20 nautical miles
Aircraft Separation; in approach/ landing path:	1.5 nautical miles
Aircraft fix rate:	4 to 39 fixes/second
Time to Alert:	0.5 seconds during landing.

2.2.3 Navigation

Navigation will be based largely on a high-integrity and high-accuracy global satellite-based navigation system. Three-dimensional information will be available, along with a standard system time service. This system will as a minimum provide at least "non-precision approach" capability. Operation within a given area of controlled airspace will require navigation equipment compatible with RNP categories predicated on applied Air Traffic Management (ATM) systems parameters (including in particular, aircraft density separation standard and ATC procedures).

ATALARS navigation parameters are aircraft position, velocity, and track data derived by onboard equipment. Two levels of position accuracy may be available based on the services provided by GPS: the P-code (Precision Position Service (PPS)) and the C/A-code (Standard Precision Service (SPS)) for fast acquisition. Both codes may have denial of accuracy or Selective Availability (SA) and in addition the P-code is encrypted. Projected position and time accuracies using these codes are listed in Table 2-1.

TABLE 2-1. GPS SERVICE PARAMETER ACCURACIES

<u>PARAMETER</u>	<u>PPS P-CODE without SA</u>	<u>SPS C/A-CODE with SA</u>
Position	18m (95%)	100m (95%)
Altitude	28m (95%)	157m (95%)
Velocity	0.1 to 0.5 m/s	0.5 m/s
Time	180 nanosec (95%)	385 nanosec (95%)

Based on the premise that either GPS or a similar satellite system will be available for navigation services, the requirements for civil navigation has been developed and are shown in Table 2-2.

A use of GPS geodetic altitude in the aircraft is also specified for the purpose of comparing barometric elevation readings with the GPS values for

calibration, for cross referencing and for monitoring variations in these differences along the flight path.

Enroute automatic navigation is used in the highly structured routes and/or for flying along restricted zones. In the battle zones, separation of aircraft will be based on the PPS service accuracy flying a typical route structure as discussed in a reference* designed to suit a particular military operation.

TABLE 2-2. OPERATIONAL REQUIREMENTS FOR USE BY CIVIL AVIATION

<u>ATS Environment</u>	<u>Accuracy</u>		<u>Fix Rate</u>	<u>Time to Alert</u>	<u>Avail-ability</u>	<u>Reli-ability</u>
	<u>Horizontal</u>	<u>Vertical</u>				
High Density Continental En Route	1000m	100m	continuous	10 sec	99%	99%
High Density Terminal and Holding Areas	500m	100m	continuous	10 sec	99%	99%
Non Precision IFR Approach	100m	100m	continuous	10 sec	99%	99%
Precision IFR Approach CAT IIIC	13.4 feet at 8 feet altitude	1.3 feet	continuous	1/2 sec	99%	99%

In approach and terminal areas, an alternative to JTIDS exist. An aircraft equipped with an airborne computer and an automatic flight control system could be coupled with the MLS airborne receiver to provide Microwave Landing System Area Navigation (MLS RNAV) capability. The most distinctive features of RNAV are three levels of route construction capability: one segment approaches, two segment approaches and full curved approaches in both horizontal and vertical dimensions.

*COMAAFCE SUP 35001M "Airspace Control Plan", HQ AAFCE, Ramstein AB, Germany, July 1981, NATO (Secret).

2.2.4 Surveillance

Passive surveillance is required for the ATALARS coverage area. Aircraft navigation systems, along with automatic altitude-reporting capability, will be of sufficient integrity to serve as the source for automatic dependent surveillance (ADS) in airspace within and beyond the coverage of conventional ATC surveillance facilities. The navigation systems currently in wide use, predominantly inertial navigation systems over the ocean, initially will support an excellent ADS service. Eventually, as the global satellite navigation system comes into being, ADS service will be improved by the high accuracy and integrity achievable from such a system, and by the significant benefits to be achieved by the use of a common position determination standard. In summary, for surveillance, a combination of ADS (using GNSS) along with satellite communications-derived cooperative independent surveillance for certain airspace would be used. Compatible L-band terrestrial cooperative independent surveillance may be required for selected terminals. Surface movement radar (SMR) is likely to continue to be required, adding satellite-compatible L-band terrestrial systems for airport surface surveillance guidance and control.

The required navigation message reporting rate will be one message within 2-5 seconds. With the required processing time, these two parameters will establish absolute and relative error limits of the system. Position accuracies of 50-200 feet (95%) are required along the enroute tracks. Air interface with the tactical surveillance network is also required for airspace management and system calibration, and for system backup. The TDM coding is used for polling aircraft position reports and the polling time is synchronized to UTC via GPS satellite. The ADS message rate during aircraft landing will be much greater than enroute message rates. The ATALARS GCU will require four messages per second for landing monitoring.

2.2.5 Communications

It is required that ATALARS communications will use digital data-link techniques to permit high efficiency information flow. Data-link communications are an essential ingredient in ATC automation. A voice capability will be required for enroute areas; more voice communications are likely to be needed in

terminal areas. Communications services (data and some voice) between aircraft and the ground system will use satellite relays over ocean and remote land areas, at low altitudes in both low-density and high-density enroute areas to support ADS and for other services. In high-density terminal areas, terrestrial and direct air-ground communications will be preferable to a satellite-based communications system. In summary, communications would be a combination of satellite data and voice, and satellite-compatible L-band terrestrial data and voice elements to permit one space/terrestrial communications avionics unit in the aircraft. VFH/UHF (SINCGARS/HAVEQUICK) voice may be retained, as may be the Mode S data-link.

The estimated peak message rate is 140 messages/second. The estimated back-up voice channel requirement is six channels.

2.2.6 ATALARS Ground Control Unit

2.2.6.1 Ground Control Center - The ATALARS airspace management and control is to be conducted from a control center located in the mobile van. However, airspace management and control operational functions can be divided between airborne and ground-based controls. The major operational functions of the management and control requirements are automation of the various functions as listed below:

- o Air Traffic Management of 300 aircraft with multiple base capability and netting with other ground management units and tactical air control units and maintenance of 300 active tracks.
- o An Approach Control Service for up to 10 bases and 300 aircraft with consideration for critical aircraft parameters.
- o A Landing Service providing a blind landing capability at a rate of one aircraft per 30 seconds and runway status/management.
- o A Departure Control Service providing proper takeoff spacing and minimum attack exposure.
- o An Information Advisory Service providing weather, temperature profile, runway status, hazard identification, routing information, and emergency assistance to lost or distressed aircraft.

- o A Tactical Interoperability Service providing coordination with local tactical defenses and sharing of tracking data with defense surveillance units.

Additional management and control functions are as follows:

Flow management	Flight clearance
Flight control	Flight following
Flight information distribution	Mission coordination
Air defense coordination automated processing	Flow Planning/Adjustment
Passive tracking	Runway/Route Selection/Maintenance
Metering Sequencing	Path conformance monitoring
Command Guidance	Proximity warnings
Minimum Safe Altitude Warning	Performance Monitoring
Data Link Management	Aviation Data Collection

2.2.6.2 Ground Control Display - A composite 3-D color display of the coverage area is an ATALARS requirement by fusing all surveillance sensor data, stored digital map, known position and threat data, and tracks related to actual coordinates during approach and landing.

Additional display requirements:

- o Position-time, infringements, automatic updating of flight plans, control system status, aircraft handshaking, aircraft sequencing and spacing, and emergency conditions.
- o Wind and temperature profiles, meteorological updating from the control station and from pilot reports.
- o Flight path predictions using Artificial Intelligence (AI), 4-D predictions for control of individual trajectories.
- o Capability to display, zoom, plan, rotate projections and display surfaces from 1 to 4,000 square miles and color elevation contours in 10 foot increments.

2.2.6.3 Computer Requirements - Estimated computer requirements for the ground control unit are as follows:

- o VHSIC-based computer structure
- o Speed - 20 MIPS
- o Physical memory - 32 Mbits with 256 Mbits virtual memory in distributed architecture

2.2.7 Pilot Display

Use of glass cockpits and CRT with Heads-Up displays are anticipated. The pilot flight management unit display will resemble ground display. The display surfaces will be shared with other aviation functions such as JTIDs, MLS and tactical air control functions. The flight path guidance information will be presented on a Heads-Up display to allow the pilot to have full visibility during the critical approach and landing phases of flight. Split-second life-or-death decision algorithms using smart systems with AI are displayed together with radar maps, stored digital map for all weather and 4-D Flight Management System (FMS) capability. Wind and temperature profile data and graphical weather presentations from the central processor over a data link are required. Additional requirements are system handshaking, aircraft sequencing and spacing, and collision avoidance information data.

2.2.8 Runway Management

A fixed or mobile tower at each landing site is intended to manage the close-in runway activity, coordinate and assist launch and recovery validation with the ATALARS GCU, and report runway status and activity as required.

2.2.9 Meteorology

Meteorological data is required to be exchanged between a control center and the aircraft in two ways. Weather reports are regularly obtained from the centralized source at a fixed site as well as dynamic weather reports from pilots during flight. These data are processed and sent to pilots at regular intervals or sent instantly if a dangerous situation develops.

2.3 SPECIFIC OPERATIONAL REQUIREMENTS

2.3.1 Coordinate Transformation

Coordinate transformation will require a common language for the automated and high precision operation. Long range navigation systems, such as GPS, use earth-referenced systems with latitude and longitude as their base language. MLS system converts ρ, θ, ϕ to Cartesian x, y, z . These algorithms are referred to as MLS reconstruction algorithms. According to FAA requirements, they are not acceptable as a man/man or man/machine interface in a safe and effective navigation system. The NAS design uses $\rho-\theta$ for navigation courses and fixes.

It is also required that common geodetic datum be used for reference. GPS and civil aviation have adopted WGS 84 geodetic datum. In many areas, other references are used, such as NAD 27, WGS 72 and European EU 50.

2.3.2 Technology

Design of advanced CNS systems will require new technologies: use of Artificial Intelligence in prediction algorithms, sophisticated modulation techniques, fiber optics to eliminate electromagnetic interference, as well as low power radiating systems.

2.3.3 ATALARS GCU Survivability and Vulnerability

It is required that some level of ATALARS GCU survivability efforts be made to combat chemical/biological agents by use of filters, coatings and positive internal pressures. Chemical and biological resistant paints must be used on all exterior surfaces. Personnel are required to operate the equipments using available equipment (CB clothing and masks). The host base will provide bunkered or protected standby facilities for which ground control unit is to be deployed. The modules themselves will not provide any survival protection other than the capability to move to other locations.

Signals in space are required to be protected from non-intentional interference by using spectrum suppression, fiber optics for data communications, and advanced modulation techniques.

2.3.4 Threat

A threat condition of possible equipment destruction or incapacitation of operations in a wartime or in a national emergency may exist at an operating site when the built-in survivability threshold for the site is exceeded. To reduce an imminent threat, movement of the equipment and quick set-up in safe surroundings is required. The allocated time for the ATALARS equipment set-up at a new site and system calibration is 15 minutes. The time to move the equipment to a new site is 30 minutes over land and 90 minutes over water up to distances of 20 nautical miles.

2.3.5 Compatibility and Interoperability

Compatibility and interoperability are defined as follows:

Compatibility: The ability of the ATALARS airspace management and control system to operate without interference with NATO and other systems, such as, EUROCONTROL, and ICAO operational procedures.

Interoperability: The ability of the ATALARS airspace management and control system to operate together with NATO and other systems, such as, EUROCONTROL, ICAO, and NAS facilities.

The definitions stated above indicate that if the compatibility and/or interoperability exists there are advantages in terms of reliability, integrity, and continuity of service, if the ATC systems use compatible air navigation, communications and avionics equipment and utilize information from as many sources as possible. In order to effect such a possibility, avionics manufacturers will be required to incorporate the capability of processing all ATC and airspace management and control system data as required for safe operation of the system. Compatibility with NATO and civil ATC systems such as EUROCONTROL, ICAO and NAS operations are required in peacetime, but full interoperability and control is required in wartime.

2.3.6 Accuracy

2.3.6.1 Horizontal Accuracy - The primary accuracy requirements are keyed to a 95 percent containment level; that is, for 95 percent of the flying time of all aircraft using the system within the area of coverage, the aircraft will be within the stated accuracy limits during the time that the system is operational. Concern about navigation performance for the remaining 5 percent of the time may necessitate a further specification of accuracy. Secondary figures may therefore need to be provided as well, perhaps keyed to a 99.9 percent containment level. In general terms the 95 percent containment values are of help to navigation system designers, but the higher values may be required for the planning of air traffic systems safety to enable separation criteria, route spacings, etc., to be established.

2.3.6.2 Vertical Accuracy - Barometric altimeter accuracy requirements have traditionally been specified as a 3-sigma level. For normally distributed errors, which appears to adequately describe current altimeter designs, this is equivalent to a 99.74 percent containment level.

2.3.7 Reliability

The reliability requirement of an ATALARS system is 99 percent. It is a function of the frequency with which failures occur within the system. It is the probability that a system will perform its function within defined 99 percent performance limits for a specified period of time under given operating conditions. Reliability is a time dependent parameter.

2.3.8 Integrity

Integrity is defined as the ability of a system to detect and indicate malfunctions in its operation to ensure the user is aware that the system is not operating within its specified performance limits. The navigation system should therefore, either be intrinsically able, or be enabled by exterior means, to notify the operator when the system is operating outside its defined performance limits. The system should then either overcome the fault (e.g., by redundancy) or indicate at its output that the computed position may not have the specified

accuracy. If redundancy is reduced, this should be indicated to the user. The integrity requirement for non-precision approach is 10 seconds (ICAO FANS Recommendation, Section 6.1.2, Ref. 8N4/055 (ANNEX 12) Draft) for the system to detect and indicate a fault. For the landing phase, the integrity requirement is 1 second or less.

2.3.9 Time to Alert

Time to alert is the maximum allowable time interval between a receiver commencing to utilize information erroneously transmitted from a satellite and the warning to the user that the navigation system has a malfunction likely to be significant to a specified mode of operation. In the terminal area, the maximum time to alert is 15 seconds. It will be necessary for alerting systems to provide a range of alerts relating to various operational areas, flight situations and levels of degradation.

2.3.10 Availability

The availability requirement for the ATALAR system is specified to be 99 percent. It is the percentage of time that the services of the system are unable to meet the specified performance standards. Availability is also an indication of the ability of the system to provide usable service within the specified coverage area. It is a function of both the physical characteristics of the operating environment and the technical capabilities of the ATALARS system. Availability is a time independent parameter in contrast to reliability which is a time dependent parameter.

2.3.11 Redundancy

Multiple CNS system mixes have inherited redundancy in the system. However, processors of signals and messages will require a dual system operation.

2.3.12 Security

All messages and signals are required to be protected for at least the length of an operational mission as a minimum.

GLOSSARY

- Ada - Computer Language used by DOD and being adopted by DOT
- ADS - Automated Dependent Surveillance
- AI - Artificial Intelligence
- AJ - Anti-Jam
- ATALARS - Automated Tactical Aircraft Launch and Recovery System
- ATC - Air Traffic Control
- ATM - Air Traffic Management
- Availability - The availability of a navigation system is the percentage of time that the services of the system are usable. Availability is also an indication of the ability of the system to provide usable service within the specified coverage area. It is a function of both the physical characteristics of the operating environment and the technical capabilities of the navigation system.
- Bistatic Radar - Detection of the primary radar signals at an ATALARS GCU site with tactical air defense transmitters located at a remote location.
- CAT IIIC - Zero-Zero Landing Conditions
- CIS - Satellite Cooperative Independent Surveillance
- CNS - Communications, Navigation, Surveillance
- CRT - Cathod Ray Tube
- CVFR - VFR Controlled by Voice
- EUROCONTROL - European counterpart to FAA
- E-3A - (AWACS) Airborne Warning and Control System
- Fix Rate - The fix rate is defined as the minimum number of independent position fixes or data points to be provided by the system per unit time to support a specified operational application.

- GEO/HEO - ESA Hybrid Satellite Navigation System combination of 6 equally spaced geostationary satellites and 12 highly elliptical orbit (HEO) satellites with 12 hour orbits to provide global coverage with some degradation around the equator. Satellite position may be determined in two ways - using a GRANAS (a German alternative to GPS) approach satellite would determine its own position by means of two-way ranging to a number of ground stations. About 16 would be required for global coverage. Using NAVSAT (European alternative to GPS) approach, satellite position coordinates may be derived on ground and uploaded to the satellite. This technique requires 6 regional/control centers and 10 monitoring centers. In either case, four satellites are required for the user's 3-D position determination.
- GEOSTAR - Two satellites for minimum operation, three satellites to cover North America and six satellites to provide world-wide coverage; a "cooperative/dependent" two-way ranging technique; aircraft transmissions are automatically triggered by ground interrogation via one satellite. Aircraft position is determined on the ground by processing aircraft relayed replies with altitude reports. User position, computed at the ground station, is uplinked to the aircraft.
- Global Coverage - The entire earth's surface including polar regions.
- GNSS - Global Navigation Satellite System
- GPS - Global Positioning System - 18 satellite constellation plus 3 operational spares in 12 hour orbits (26,000 km) provides "passive/broadcast" one-way ranging for global coverage. User receiver performs on-board position determination based on information broadcast by a number of satellites. For 3-D position determination, four satellites are required as a minimum. The system supports an unlimited number of users, therefore it cannot be saturated.
- HAVEQUICK - Anti-Jam radio at UHF
- ICAO - International Civil Aviation Organization
- IFR - Instrument Flight Rules
- Integrity - Integrity is defined as the ability of a system to detect and indicate malfunctions in its operation to ensure the user is aware that the system is not operating within its specified performance limits. The navigation system should therefore either be intrinsically able, or be enabled by external means, to identify when part of the system is

operating outside its defined performance limits. The system should then either overcome the fault (e.g., by redundancy) or indicate at its output that the computed position may not have the specified accuracy. If redundancy is reduced, this should be indicated to the user.

- JTIDS - Joint Tactical Information Distribution System
- LPC - Linear Predictive Coding
- MIDS - Multifunctional Information Distribution System (British) counterpart to JTIDS (US)
- MIPs - Million instructions per second
- MLS - Microwave Landing System
- MLS RNAV - Microwave Landing System Area Navigation
- MMLS - Mobile Microwave Landing System
- NAD - North American Datum
- NATO - North Atlantic Treaty Organization
- OTH-B - Over-the-Horizon Radar
- PPS - Precision Position Service
- PTAG - Portable Tactical Approach Guidance System
- RAPCON - Radar Approach Control
- RDSS - Radio Determination Satellite Service
- RNPC/MNPS - Required Navigation Performance Capability/Minimum Navigation Performance Specification
- Reliability - The reliability of a navigation system is a function of the frequency with which failures occur within the system. It is the probability that a system will perform its function within defined performance limits for a specified period of time under given operating conditions.
- RPV - Remote Piloted Vehicle
- SDL - Secure ATC Radio Data Link
- SMR - Surface Movement Radar

- SINCGARS - Single Channel Ground Air Radio
- SPS - Standard Precision Service
- SRV - Surveillance Restoral Vehicle
- TACS - Tactical Air Control System
- TADIL - Tactical Digital Information Link to TACS
- TRACALS - Traffic Control and Landing System
- TRV - Tower Restoral Vehicle
- Time to Alert - The maximum allowable time interval between a receiver commencing to utilize erroneous information received from a satellite and the annunciation to the user of a warning that the navigation system has a malfunction likely to be significant to a specified mode of operation. This time interval should not exceed 10 seconds.
- Vertical Accuracy - 3 sigma (99.74%)
- VFR - Visual Flight Rules
- VHSIC - Very High Speed Integrated Circuit
- Virtual Memory - Additional memory stored
- VORTEX - Satellite-Based Imaging Radar
- WGS - World Geodetic System
- World-Wide Coverage - Coverage not provided above 70 degree North and South latitudes
- 3-D - Three-dimensional; x, y, z
- 4-D - Four-dimensional; x, y, z plus time.