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Technical Report

**Preliminary Approach for
Developing an ATALARS
Proof of Concept Model**

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Small Business Innovative Research
(SBIR)
Topic AF 89-031**

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prepared for

**Electronic Systems Division
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13. ABSTRACT (Maximum 200 words) <p>This report documents the results of a study conducted for the purpose of developing a preliminary implementation approach, utilizing planned or existing systems, for a proof-of-concept demonstration of the Automated Tactical Aircraft Launch and Recovery System (ATALARS). The basis for the ATALARS concept was derived from the system presented in ESD-TR-86-259, and from the system configuration described in the Final Report by Airspace Technology Corp. under SBIR Contract F19628-87-C-0195. This report reviews the basic ATALARS system concept and the technologies applicable to a full capability system configuration. The full-up system configuration was evaluated to determine which elements, considered critical to the basic ATALARS system concept, could be implemented in a proof-of-concept (POC) model. Based on the study, it was determined that the POC model should address: 1) the Processing and Display (P&D) and 2) Network Control Functions (NCF). The study describes the basic features of the P&D and NCF to be incorporated into the POC model and preliminary definition of the system configuration.</p>				
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TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
1.0	INTRODUCTION	1
1.1	BACKGROUND	1
1.2	PRELIMINARY TASK EFFORTS	2
1.3	BASELINE SYSTEM CONFIGURATION	3
1.3.1	PROCESSING AND DISPLAY SUBSYSTEM	6
1.3.1.1	PLASMA DISPLAYS	6
1.3.2	COMMUNICATIONS SUBSYSTEM	8
1.3.3	COMMUNICATIONS NETWORK CONTROL	9
1.3.4	AIRCRAFT POSITIONING SUBSYSTEM	10
1.3.5	COCKPIT DATA SUBSYSTEM	10
1.3.6	VEHICLE SUBSYSTEM	11
2.0	PROOF OF CONCEPT MODEL	12
2.1	POC MODEL LABORATORY CONFIGURATION	12
2.1.1	PROCESSING AND DISPLAY FUNCTION	14
2.1.2	NETWORK CONTROL PROCESSOR	14
2.1.3	DISPLAY TERMINALS	19
2.1.4	AIRCRAFT SIMULATOR	22
2.2	POC MODEL FIELD TEST CONFIGURATION	23
2.2.1	CD-91 TRV/SRV SYSTEM	23
2.2.2	SRV/ATALARS SYSTEM CONFIGURATION	24
3.0	POC EVALUATION	26
4.0	PROGRAM SCHEDULE	28
4.1	SYSTEM ENGINEERING	28
4.2	POC DEVELOPMENT TASKS	30
5.0	CONCLUSIONS	34



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LIST OF FIGURES

<u>Figure No.</u>		<u>Page</u>
1.0	ATALARS Functional Block Diagram	4
1.1	ATALARS Preliminary System Level Block Diagram	5
1.3.1	ATALARS Processing and Display Subsystem	7
2.1	Simplified Block Diagram, ATALARS Proof-of-Concept Model	13
2.1.3	Preliminary Layout, ATALARS Proof-of-Concept Controller Display	20
2.2.2	Simplified Block Diagram, ATALARS POC/SRV System Configuration	25
4.0	Preliminary System Engineering Phases, ATALARS Development Cycle	29
4.2	POC Development Tasks (2 sheets)	31

FOREWORD

This report documents the results of a study conducted for the purpose of developing a preliminary implementation approach for an Automated Tactical Aircraft Launch and Recovery System (ATALARS) Proof-of-Concept (POC) model. The study was conditional on the premise of using existing or planned systems in evolving the POC model.

The approach taken was based on the ATALARS system concept as presented in ESD-TR-86-259. This basic ATALARS system concept was further refined under an SBIR study report performed by Airspace Technology Corporation under Contract F19628-87-C-0195. The POC model described herein follows the operational and performance characteristics described in those two documents.

The POC model will address two major elements in the baseline ATALARS concept/configuration: the Data Link and the Processing and Display functions. The plan is to implement the model using a combination of commercial and developmental equipment. Certain elements and features will be based on the Surveillance Restoral Vehicle (SRV) which is presently in Full Scale Development.

This study effort was performed under the guidance of Lt. Melissa Greer, ESD/XR. The Project Leader was Mr. D. B. Whitney with Mr. T. M. Katanik as the primary contributor.

SECTION 1

INTRODUCTION

This report contains the results of a USAF contracted study for a preliminary implementation approach to produce a proof of concept demonstration of the Automated Tactical Aircraft Launch and Recovery System (ATALARS). This study effort is Phase I of Small Business Innovative Research (SBIR) Topic AF89-31 and was performed under Contract F19628-89-C-0080.

The study is a continuation and expansion of the plan described in the Airspace Technology Corporation (Air Tech) Proposal 9173, Transition Plan for Development of the Automated Tactical Aircraft Launch and Recovery System.

Our approach for developing a Proof of Concept (POC) model will make extensive use of efforts to date in developing the SRV and our proposed approach for the NMR. We have structured the plan to include efforts which could be performed under a Phase II SBIR. We propose to develop a laboratory POC model to demonstrate and evaluate certain basic system capabilities. We further propose the possibility of using an SRV for limited field testing. We would use the system presently planned as the CD-91 option to the Full Scale Development Contract. This portion of the plan is described in Section 2.2.

This report consists of five main sections. Section 1, Introduction, contains a brief overview of Air Tech's ATALARS system configuration and discussions relative to the major subsystems elements, including current status of various systems and technologies. Section 2 describes Air Tech's proposed Proof of Concept (POC) model and the equipment and technologies to be included in a laboratory version of ATALARS and the SRV test bed. Section 3 discusses the planned evaluation tasks and Section 4 presents the planned schedule and an overview of the task efforts required to develop the POC model. Conclusions are presented in Section 5.

1.1 BACKGROUND

Under a previous SBIR contract (F19628-87-C-0195), Air Tech performed an in-depth analysis and evaluation of the operational and performance requirements which could be expected for the next generation USAF tactical air traffic control system.

The outcome of this study was a systems concept for a highly mobile, tactical/survivable ATC system. This Advanced Air Traffic Control System (AATCS) was intended to be one approach toward meeting the requirements for ATALARS.

The AATCS concept and the ATALARS system, as described in ESD-TR-86-259 and other subsequent studies, are similar in basic function and operational capabilities. The AATCS system, conceived under Air Tech's previous SBIR contract, was defined to a level whereby specific equipment and technologies were identified for the various subsystems and functional areas.

Under this present study effort, Air Tech proposed to develop a transition plan for a hardware and software suite which could perform a proof of concept demonstration for ATALARS using our AATCS configuration as the strawman system. The transition plan would describe one approach for continuing the development of ATALARS, initially in the laboratory, and eventually as a demonstration brassboard.

1.2 PRELIMINARY TASK EFFORTS

The ATALARS system will be complex in terms of subsystems elements and technologies. The system as presently envisioned does not break any new ground in terms of component or basic system technologies; it does, however, expand on existing technologies and on hardware and equipment in advanced development.

Preliminary task efforts addressed two main areas: review and update of the status of the various systems and equipment which made up the strawman system configuration, and an initial determination of the critical elements of ATALARS which would be required in a proof-of-concept model.

It has always been Air Tech's intention to build ATALARS around existing technologies and equipment to the degree feasible. This dictates that a substantial amount of effort will be required in the area of requirements allocation, equipment interface, interoperability, and control. The preliminary tasks have therefore included prioritizing of subsystem definition in terms of criticality in producing a POC model.

In the course of this study effort, Air Tech reviewed our original system configuration and the hardware and equipment originally identified for the requirement. Key elements of the system, those deemed necessary for a POC model, were evaluated as to current status and recent developments. Not all subsystem elements incorporated into a basic ATALARS would be required for a POC equipment suite.

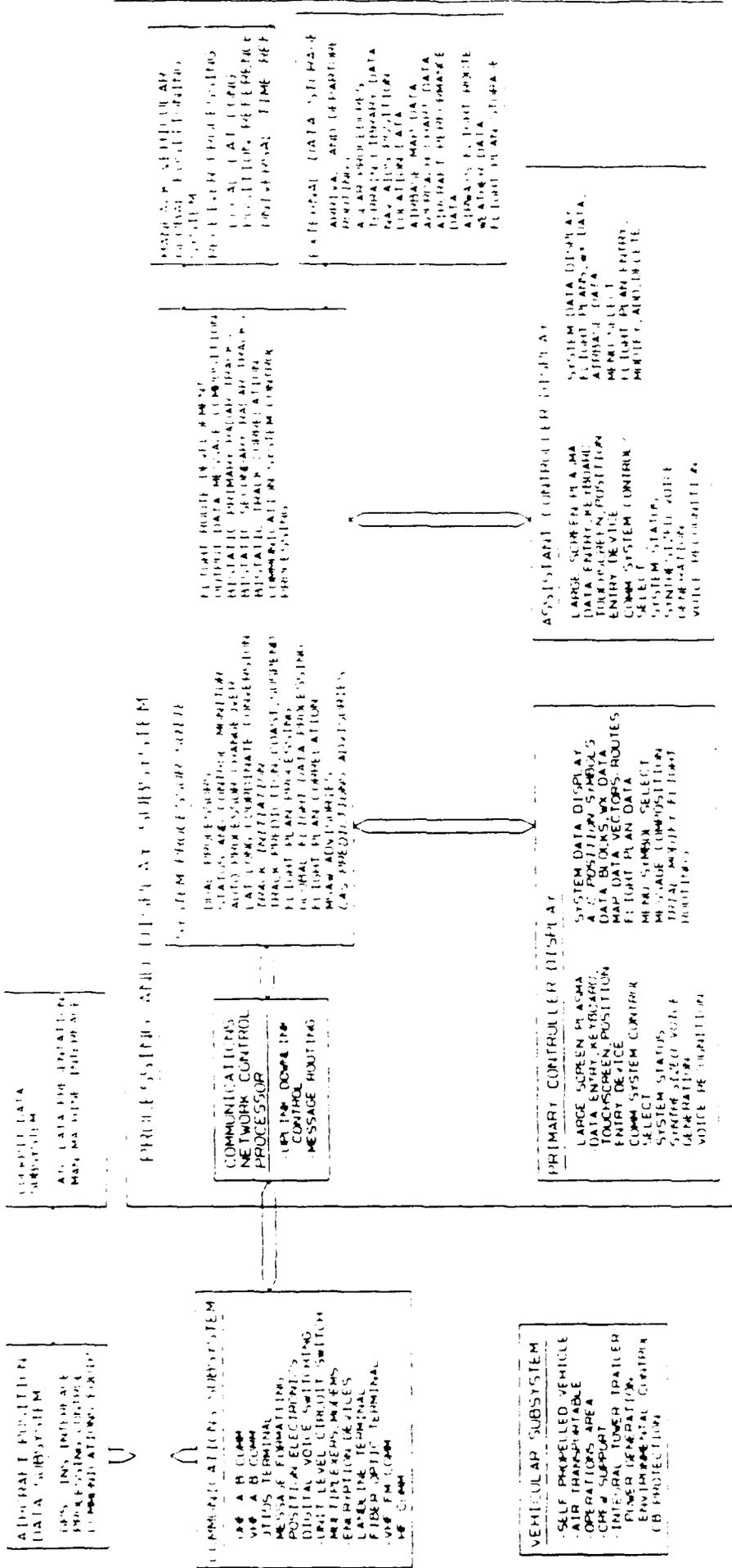
1.3 BASELINE SYSTEM CONFIGURATION

The system configuration of a full-up ATALARS is shown, functionally, in Figure 1.0 and in the system level block diagram provided as Figure 1.1. This configuration, or one slightly reduced in performance/operational capability, would be suitable for a field deployable, development test version. A scaled down version, suitable for a POC model, is described in Section 2.0.

In order to develop a program or transition plan, it is necessary that the system be broken down into subsystem or technical elements. This allocates specific functional requirements into equipment groups which can be designed, developed, and tested independently. The individual subsystem elements would then be incrementally integrated during system integration and test to produce the complete system.

For planning purposes, we have assumed a system configuration of six major subsystem elements:

- Processing and Display, the main system processors, ancillary and peripheral equipment, the controller displays and associated workstation hardware, and the system software.
- Communications Subsystem, the air-ground and land mobile radios, JTIDS terminal, landline comm (TRI-TAC) including wireline and fiber optics, antennas and any associated encryption equipment.
- Communications Network Control, the processor/formatter function for sequencing, routing, timing, and control of uplinked and downlinked ATALARS voice and data.
- Aircraft Positioning Subsystem, the airborne segment which will provide the interface to the A/C GPS/INS and the airborne comm equipment, and perform the processing and control of uplinked/downlinked voice and data.
- Cockpit Data Subsystem, the man/machine interface to the pilot.
- The Vehicle Subsystem, the C-130 transportable vehicle outfitted with operations/controller workspace, support facilities, and including environmental and power equipment.



ADAPTABLE FUNCTIONAL DATA SUBSYSTEM

- GPS, INS, INERTIAL PROCESSING, ORBITAL CORRECTIONS, ETC.

COMMUNICATED DATA SUBSYSTEM

- AT&T DATA FOR OPERATING MAN MANIPULATED PROGRAM

COMMUNICATIONS SUBSYSTEM

- VIA A B COMM
- VIA A B COMM
- MESSAGE FORMATIONS
- POSITION ELECTRONICS
- DIGITAL VOICE SWITCHING
- CIRCUIT LEVEL CIRCUIT SWITCH
- MULTIPLXERS, MUXES
- EMERGENCY DEVICES
- LASER LINE TERMINAL
- FIBER OPTIC TERMINAL
- VIA FM COMM
- VIA GMM

SYSTEM PROCESSOR

- PLAN PROCESSING
- STATUS AND CONTROL MONITOR
- ADDITIONAL CORRECTION DATA
- LAT LONG COORDINATE CORRECTIONS
- TRACK INTERPOLATION
- TRACK POSITION ERROR CORRECTION
- FLIGHT PLAN PROCESSING
- CENTRAL FLIGHT DATA PROCESSING
- FLIGHT PLAN CORRELATION
- MAN ADVISORY
- CALL PROCEEDINGS ADVISORIES

VEHICULAR SUBSYSTEM

- SELF PROPELLED VEHICLE
- AIR TRANSPORTABLE
- OPERATIONS AREA
- OPER SUPPORT
- CENTRAL TOWER TRAILER
- POWER GENERATION
- ENVIRONMENTAL CONTROL
- CB PROTECTION

PRIME SYSTEMS AND DUTY SUBSYSTEM

OPERATOR SEQUENTIAL CONTROL

- OPERATOR SEQUENTIAL CONTROL
- LOCAL DATA DISPLAY
- OPERATOR SEQUENTIAL CONTROL
- OPERATOR SEQUENTIAL CONTROL

OPERATIONAL DATA SUBSYSTEM

- ANALOG, ANALOG, ANALOG

PRIMARY CONTROLLER DISPLAY

- LARGE SCREEN PLASMA
- DATA ENTRY KEYBOARD
- TOUCH SCREEN POSITION
- ENTRY DEVICE
- COMM SYSTEM CONTROL
- SELECT
- SYSTEM STATUS
- SYSTEM STATUS
- GENERATION
- VOICE RECOGNITION

ASSISTANT CONTROLLER DISPLAY

- LARGE SCREEN PLASMA
- DATA ENTRY KEYBOARD
- TOUCH SCREEN POSITION
- ENTRY DEVICE
- COMM SYSTEM CONTROL
- SELECT
- SYSTEM STATUS
- SYSTEM STATUS
- GENERATION
- VOICE RECOGNITION

Fig. 1.0 AT&T Apollo Functional Block Diagram

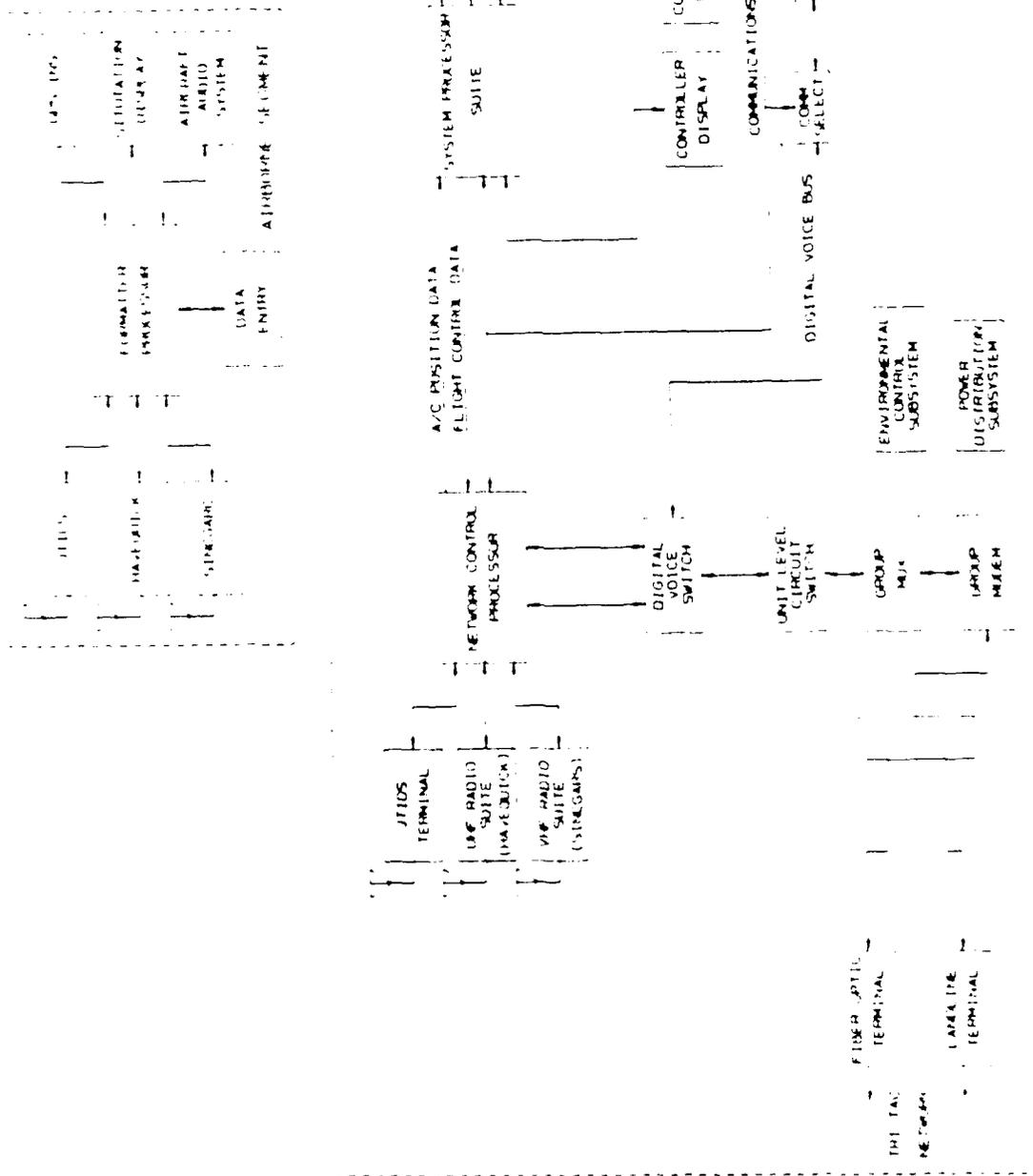


FIG. 1-1 ATALAM'S PRELIMINARY SYSTEM LEVEL BLOCK DIAGRAM

In Air Tech's original AATCS configuration, we identified specific equipment/technologies applicable to the ATALARS requirement. A number of specific equipments and technologies are still prime candidates for incorporation into ATALARS and in fact are still evolving and improving. Others have been overtaken by events and may no longer be a prime consideration.

During the course of this study effort, Air Tech reassessed certain of these equipments/technologies to determine the present status and future outlook.

1.3.1 Processing and Display Subsystem (PDS)

As shown in Figure 1.3.1, the PDS is comprised of a number of subsystem elements. The heart of the subsystem is the System Processing Suite (SPS).

In Air Tech's original system configuration, the SPS was planned around a VMEbus architecture supporting multiple 32 bit processors and intelligent I/O devices. Recent developments in MULTIbus II and FUTUREbus technologies have made these bus structures highly suitable candidates for the ATALARS application.

Adoption by the Navy of FUTUREbus as a standard architecture makes it attractive due to its high performance, multi-processor support and the prospect of broad vendor support for NDI components.

1.3.1.1 Plasma Displays

The AC Gas Plasma Display terminals are still a highly viable technology for ATALARS and continue to be improved. Recent developments include large screen (14 x 24 inch) displays for NMR and an improved 80386 based applications processor for SRV. Texas Instruments has developed a next generation Graphics Processor, the TMS 34020. This advanced 32 bit processor, expected to be available in a MIL qualified version in approximately 24 months, could be applicable to SRV, NMR, and ATALARS.

Much effort is being expended in the areas of active matrix Liquid Crystal Displays (LCD) and Thin-Film Electroluminescent (TFEL) technologies. Extending these technologies to large screen displays suitable for military applications and environments is a formidable task. Plasma technologies are still dominant, and currently available, in fully militarized designs.

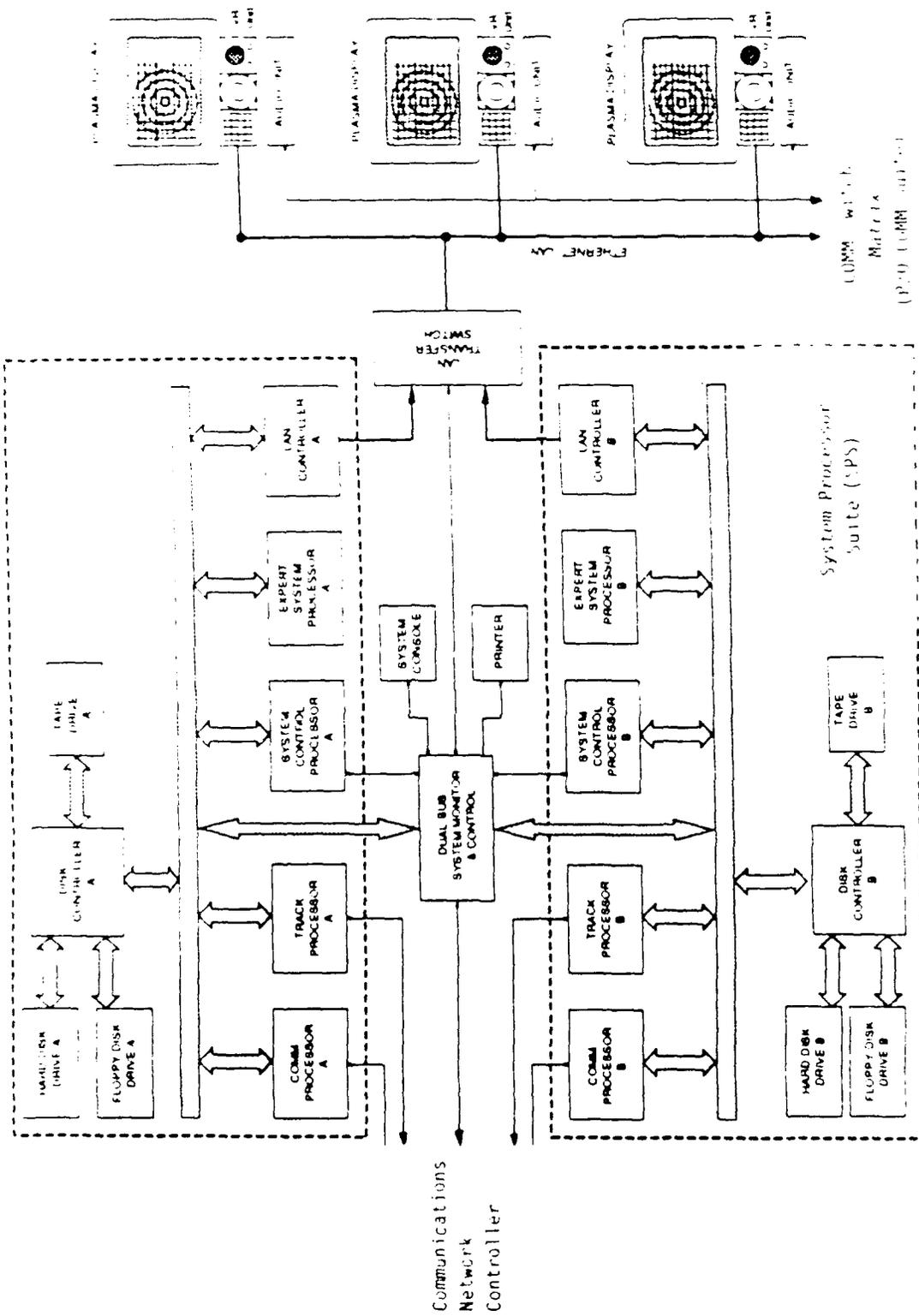


Fig 1.3.1 ATALAPS Processing and Display Subsystem

There are on-going efforts toward development of high resolution color plasma displays under a NASA Phase II SBIR and a HDTV development contract from DARPA.

All of these efforts will continue to improve the basic plasma display technology and all are applicable to the ATALARS display terminal.

1.3.2 Communications Subsystem

ATALARS will require communication capability covering the air traffic control, tactical air control, and command coordination functions. The equipment which would provide the required operating capability would for the most part be inventory items.

The key element, the air-ground/ATC function, has been planned around JTIDS, HAVEQUICK, and SINGARS equipment. Air Tech believes that the UHF, VHF approach using HAVEQUICK and SINGARS as the up/down voice and data link warrants strong consideration. This emphasis is driven by the planned widespread use of these AJ equipments for both airborne and ground transceivers. The factors which will impact the suitability of this approach, and which would need to be addressed in a POC model are discussed in Section 2.0.

Development of the HAVEQUICK equipments is on-going. The program has proceeded to HAVEQUICK II and IIA, with version II being an improvement to the original equipment concept. The IIA version will provide additional improvements including a faster frequency hopping and finer frequency airborne unit, new ground radios (GRC-XXX) and new vehicular radios (VRC-XXX). ESD has recently awarded contracts to Rockwell-Collins and Motorola to continue work on IIA versions.

The SINGARS ground equipment, being manufactured for the U.S. Army by ITT-Aerospace Optical, are presently in production. ITT is also developing a next generation Integrated Secure Communications (ICOM) version of the radio. A second source award for SINGARS ground radios has also been made to General Dynamics Electronics/Tadiran Industries. The AF contract for an airborne SINGARS, HAVESYNC (ARC-205), with Cincinnati Electronics, has been terminated. A new solicitation is expected to be issued by ESD in the December 1989 time frame. Termination of the original contract will certainly delay deployment of interoperable tactical VHF AJ ground-air equipment.

JTIDS has been a strong candidate for the ATALARS data link function. The basic system capabilities include a number of data reporting items needed for ATC functions. This includes the Relative Navigation (RNAV) and Precise Participant Location and Identification (PPLI) reporting features which would provide the A/C identification and location data needed by the ATALARS processor. JTIDS, as originally conceived, was not intended to support ATC operations. Consequently, some problems remain to be resolved if the system is to be a viable part of an ATALARS concept. Certain of these relate to message set content and format as described in the analysis/demonstration report prepared by Analysis and Computer Systems (ACS) under contract F19628-87-C-0254.

An additional consideration is the basic JTIDS network cycle of 12 seconds. There will be situations, such as close-in (60 miles or less) ATC operations which would require position update rates of 3 to 5 seconds. The possible degradation of the ATALARS position data rate due to the JTIDS network structure may be unacceptable for the ATC function.

A very fundamental factor in planning the ATALARS communications suite is the planned deployment of airborne JTIDS terminals. At the present time, a limited number of platforms are scheduled to receive JTIDS. This leaves a large number of fixed wing and rotary wing aircraft types which still must be accommodated by ATALARS.

1.3.3 Communications Network Control

A critical element in the ATALARS system will be the digital communications link between the ground facility and the aircraft. The link will handle aircraft generated position, identity and status information transmitted to ATALARS, and advisories, commands and information requests transmitted from ATALARS to the aircraft.

The link must support a data rate as will be required for the real time target tracking and decision making functions in the Processing and Display System, while at the same time maintaining a secure, anti-jam communications channel.

A network control and synchronization function will be required to permit an orderly and non-interfering exchange of data. This function is resident in JTIDS, which provides the necessary levels of security, network synchronization, and capacity.

The use of the HAVEQUICK and SINCGARS radios will implement anti-jam and data encryption capabilities at data rates up to 16KB/S, but will require some means of user-unique time slot assignment and synchronization, i.e. network control.

The network control function will be processor based, either as a stand-alone device or as part of the System Processor. Network control is a substantial part of the ATALARS concept and will be one of the critical elements to be developed for the POC model. There is presently no identifiable stand-alone system element which performs this function.

1.3.4 Aircraft Positioning Subsystem

ATALARS will be unique in comparison to conventional radar based ATC systems through the concept of Aircraft Derived Position Data. The eventual deployment of a full constellation of GPS satellites will provide almost complete worldwide position location capabilities for all GPS equipped aircraft. By downloading the GPS derived data, alone or in concert with data from the aircraft's on-board Inertial Navigation System (INS), via a suitable communications scheme, precise aircraft location data can be provided to ATALARS.

GPS is a dynamic technology with continuing development in both ground and airborne equipment. Although the Aircraft Positioning Subsystem will be a vital element in a field deployable demonstration ATALARS, its function would be simulated in a POC model.

1.3.5 Cockpit Data Subsystem

This element of ATALARS is an area requiring substantial study and analysis. The functions required to enable an efficient flow of information between the ground controller/system and the pilot will involve voice/data and a cockpit display capability.

Voice communications will be retained through current radio techniques, either in the clear (conventional) or secure (anti-jam or encrypted). Presenting digitally derived/transmitted data to the pilot poses some complex problems in man/machine interface, human factors, and cockpit work load considerations.

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Initial consideration, only at a very elementary level so far, have included heads-up-displays (HUD) and synthesized voice techniques. HUD systems are presently used for navigation/flight control and tactical weapons systems. They may be adaptable to support the ATALARS ATC function. Substantial evaluation remains to be done to determine the feasibility of implementing ATALARS with these existing systems.

The synthesized voice technologies are expanding very rapidly, both in basic component technology, speech recognition and syntax techniques, and speech processing workstations. Significant efforts in adapting voice recognition techniques to ATC simulation systems appears to be at the forefront of synthesized voice for ATC applications.

The development of the cockpit subsystem requirement for ATALARS will most probably be one of the later tasks in the system development. At the present time, AFSC-ASD is continuing to work on the Advanced Cockpit Program (ACP). Some of the features to be investigated for the ACP include voice recognition and voice presentation. At the point in time where the ATALARS cockpit man-machine interface and human factors are better defined, it should be presented to the ACP project group for consideration in the development of the advanced cockpit operational capabilities.

A type of cockpit workstation will need to be developed for a field deployable ATALARS test bed. A graphic display simulation would be implemented for the POC model.

1.3.6 Vehicle Subsystem

This element of ATALARS is the lowest priority in the system evaluation. The basic requirements: C-130 transportability, high mobility, high survivability, fully self contained operation, etc., can be met using today's technologies in vehicles and support systems.

Air Tech does not propose to do any development work on the vehicle subsystem for the POC phase of the program. However, transportability/mobility guidelines would be followed during any conceptual/developmental efforts to insure that the final system configuration would meet the deployment requirements.

SECTION 2

PROOF OF CONCEPT MODEL

The concept of an automated passive air traffic control system raises a number of questions and apprehensions regarding the feasibility and outright practicality of such a scheme.

It would be generally agreed that a system such as ATALARS, configured with the equipment and technologies as described herein could perform the functions envisioned. It then becomes necessary to take the system concept from the paper stage to a point in the system development cycle where key technological questions can be addressed. In Air Tech's ATALARS concept, we rely heavily on hardware and equipment in inventory or in advanced stages of development. This emphasis on existing equipment reduces the overall unit level development effort, but retains the necessity for a very strong system level engineering effort.

In arriving at a POC system configuration, Air Tech evaluated those elements of ATALARS which we felt were critical to the basic operating premise and which could be designed and evaluated in a Phase II effort. We identified two key subsystem elements which must be evaluated in order to establish the feasibility of our ATALARS approach. These two subsystems, (1) Processing and Display and (2) Network Control are both considered critical and can be configured as a POC model using developmental hardware and software and simulation devices.

The objective of the POC effort would be the development, test, and evaluation of the critical elements of ATALARS as a laboratory test bed. Following the laboratory testing, we would adapt the demonstration system configuration, consisting of both ground-based and airborne elements to further refine the baseline system concept. We would propose to investigate the use of the CD-91 SRV as the test bed for this limited field test.

2.1 POC MODEL LABORATORY CONFIGURATION

As shown in Figure 2.1, the POC model would consist of three main elements: the system Processor and Display suite, the Comm Link Simulator, and up to N Aircraft Simulators. The software and firmware required for each element would be a combination of modified and newly developed code.

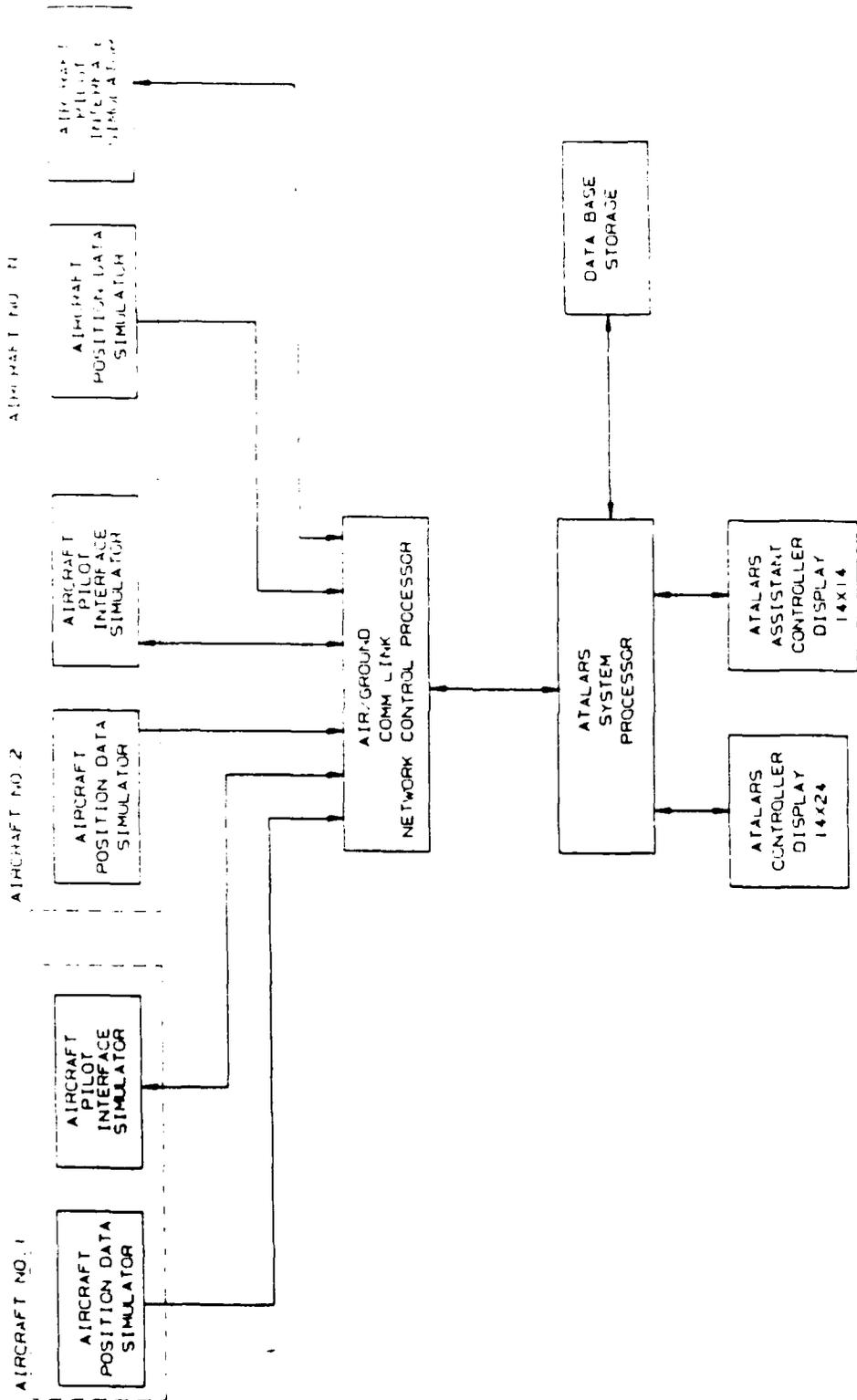


FIG 2.1 SIMPLIFIED BLOCK DIAGRAM
ATALARS PROOF OF CONCEPT MODEL

2.1.1 Processing and Display Function

The technology required to process and display aircraft track and plot data is highly matured and widely used in all major ATC systems. The full capability ATALARS will expand on this basic capability through the addition of collision avoidance and terrain avoidance algorithms, also widely used in ATC systems, and flight planning and routing functions presently not common to terminal control systems.

In the POC system, the processor would perform the aircraft positioning function based on the position data from the A/C simulators. The system processor will interface with the network processor, peripheral storage devices, and the controller displays. Functionally, it will perform data and input/output management, algorithm processing and message generation. The man-machine interface and a significant amount of the application and graphics processing will be performed in the controller display terminals. The displays proposed for the POC model are based on Air Tech's Model 1024 Plasma Display. The graphics capabilities incorporated in these displays will relieve the system processor of much of the detailed graphics manipulations.

2.1.2 Network Control Processor

The Network Control Processor will simulate the digital communications link which would transmit aircraft position, identity, and status information from the aircraft to the ground based elements and advisories, commands and information requests from the ground station to the aircraft. Network control and synchronization are required in order to permit an orderly and non-interfering exchange of data.

In the POC model, the processor will be the interface between the aircraft Simulators and the POC System Processor. It will be configured with one communications channel for each simulator and will perform the following functions:

- Link control and conversion
- Uplink and downlink time synchronization
- Downlink time slot assignments
- Message data buffering, formatting, and code conversion
- Local time reference processing

Airspace Technology

Data update rates will be addressed independently for uplink and downlink operations. Worst case will be the downlink requirement, since each aircraft must routinely report its position on a regular basis to permit accurate ground-based tracking and real-time display to be performed. The uplink will be used only when specific advisories or requests for information must be transmitted to an aircraft. Current ATC systems require a three to five second update rate for terminal area traffic (less than 60 nmi from the airfield) and ten to fifteen second update rates for long range, enroute aircraft (60-300 nmi).

In the POC model, we would propose minimum position reporting intervals of 3 seconds for targets less than 60 nmi, 6 seconds for targets between 60 and 120 nmi, and 12 seconds for targets between 120 and 300 nmi.

Since the type of data and transmission rate are quite different for the uplink versus the downlink, they will be considered separately. Additionally, the downlink message rate will be relatively constant for a given number of aircraft, whereas the uplink rate will vary considerably depending on the amount of advisory and control information required to be sent to specific aircraft.

The primary information to be transmitted on the downlink consists of aircraft position (latitude, longitude, and altitude), unique aircraft identity code, and status codes and service request/acknowledge codes. Information such as speed and heading could be derived by the POC system processor similar to the method used in today's radar based systems.

The status code and service request/acknowledge code fields are intended to provide a shorthand method of transmitting common status information such as low fuel, weapons status, damage status, etc., and service request/acknowledgement such as alternate routing, weather, airfield status, message confirmation, etc. Special service-request codes could even be used to request more network time be allocated to a particular aircraft to allow transmission of longer text messages on a non-routine basis.

A basic downlink message structure could contain the following:

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COMMUNICATIONS

<u>Information</u>	<u>Digits</u>	<u>Bits</u>	<u>Data Capacity</u>
Latitude	7 (BCD)	28	Deg., Min., Sec.
Longitude	7 (BCD)	28	Deg., Min., Sec.
Altitude	3 (BCD)	12	0-99,000 ft (100's)
Aircraft ID	4 (OCT)	2	4096 codes
Net ID	2 (HEX)	8	256 nets
Status	2 (HEX)	8	256 codes
Service Req/Ackn	2 (HEX)	8	256 codes
Total Info Bits		104	
Checksum/Error Detection		8	
Synchronization		10	
Total Bits/Message		122	

The uplink messages will vary depending on the number of aircraft, frequency of update, and nature of the message traffic. A basic uplink message structure could contain the following:

<u>Information</u>	<u>Length</u>	<u>Bits</u>	<u>Data Capacity</u>
Net ID	1 (byte)	8	256 nets
Message Type Code	1 (byte)	8	256 message types
Aircraft ID	4 (OCT)	12	4096 codes
Length Code	1 (byte)	8	Up to 256 data bytes
Data Fields	variable	88	Typical 10-byte message
Total Info Bits		116	
Checksum/Error Detection		8	
Synchronization		10	
Total Bits/Message		134	

In the POC model, the data link scheme will include features deemed critical in evaluating the overall Air Tech ATALARS concept. The network control structure must be synchronized such that Aircraft Position Reports do not overlap in either the airborne or ground station environment and the capability should be provided for the ground station to discretely address individual aircraft as well as broadcast information of interest to all aircraft. In addition, the capability should be provided for aircraft to randomly enter the system without benefit of pre-assigned identity codes or time slots.

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Based on these system requirements, Air Tech would propose the Multiple Update Rate, Self-Synchronized Data Link (MSDL) for the POC model. This approach establishes a full uplink/downlink cycle of 12 seconds, subdivided into four sub-cycles of three seconds each, i.e., SCA, SCB, SCC, and SCD. Each three second sub-cycle consists of 300 slots of 10 milliseconds each for a total of 1200 slots/cycle. Each slot includes data, synchronization, checksum, jitter, and propagation guard bands.

Network synchronization is provided by a special message code from the system processor which transmits the ground station coordinates, net identity, as well as a cycle start time reference mark.

Each aircraft simulator would synchronize an internal clock to the uplinked cycle start mark at the beginning of each cycle, and counts through all 1200 slots. This timer is used as a reference by the aircraft simulator to determine when its assigned slot time starts.

The first slot(s) of each sub-cycle would be allocated to uplink traffic, with the remainder for downlink traffic. The first four downlink slots are reserved for aircraft simulators entering the net which would randomly transmit a position report in one of these four slots during one of the four sub-cycles (i.e., one of 16 possible slots every 12 seconds). The systems processor will log the aircraft ident into the database and assign it a discrete time slot on the next uplink message slot open. Subsequent reports from the aircraft simulator would be transmitted in its assigned slot.

In order to provide multiple position update rates, aircraft simulators would be assigned sub-cycle patterns, as well as specific slots. Aircraft at close ranges would be assigned an ABCD pattern resulting in a report every three seconds (once per sub-cycle). Intermediate range aircraft would be assigned an AC or BD pattern resulting in a report every six seconds (every other sub-cycle). Long range aircraft would be assigned a single sub-cycle pattern, i.e., A, B, C, or D resulting in a report every 12 seconds (once per cycle).

If we assume a distribution of uplink messages for a full capability ATALARS system as shown below, the resulting average uplink rate is 260 messages per minute, or about 52 messages per 12 second cycle.

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COMMUNICATIONS

<u>Range (nmi)</u>	<u>Message Interval</u>	<u>No of Aircraft</u>	<u>Total Msg Rate</u>
<40	30 seconds	100	200 msgs/min
40-100	2 minutes	200	100 msgs/min
100-300	5 minutes	300	60 msgs/min
Total		600	260 msgs/min

This will require that the first 13 slots of each sub-cycle be reserved for uplink traffic. Adding three slots for synchronization data and broadcast messages, the first 16 slots of the 300 slot sub-cycle would be reserved for uplink traffic. This leaves 284 downlink slots per sub-cycle, or 1136 slots per 12 second full cycle (approximately 95 slots/second). Various distributions of short, long, and medium range aircraft can be accommodated by dynamically assigning either a 3, 6, or 12 second reporting interval to aircraft based on criteria such as range, mission criticality, emergency status, etc. A typical scenario is shown below.

<u>Range (nmi)</u>	<u>No. of A/C</u>	<u>Reports/cycle</u>	<u>Time Used</u>	<u>Report Interval</u>
<40	100	4	4.2 sec	3 sec
40-100	200	2	4.2 sec	6 sec
100-300	300	1	3.2 sec	12 sec
Total	600		11.6 sec (out of 12 sec)	

The ratio of uplink to downlink slots in a full-up ATALARS could be increased or decreased dynamically as well, depending on the data load by reassigning discrete aircraft reporting slots to make more or less slots available to the uplink traffic. If additional uplink time is required without compromising traffic capacity, target update rates can be reduced, or a second uplink channel could be added to permit full duplex operation.

The POC model network control function would be intended to simulate the data link control, synchronization, and formatting operations. In ATALARS, this would be performed using the ATALARS system processor, JTIDS, HAVEQUICK, and SINGARS radio equipment and the ATALARS equipment suite in the aircraft.

2.1.3 Display Terminals

The displays to be used for the POC model will be 14 x 24 inch AC Gas Plasmas. The addressable resolution will be approximately 73 pixels per inch (horizontal and vertical) providing a total matrix size of 1024 x 1760 pixels. The units are the same size as are presently used in the NMR Demonstration Operations Center. They will use the same high speed drive electronics as are used in Air Tech's 14 x 14" SRV display extended to a wider matrix size in the x-direction. Each display unit will consist of the Plasma Display head and associated drive electronics, an Applications Processor, and a Graphics Processor. A separate power supply is located external to the display. The proposed combination of NMR and SRV technology was selected to reduce non-recurring costs during the development of the POC model.

The display will incorporate operational features and performance normally associated with an ATC indicator, i.e. selectable ranges, range marks, off-set, centered operation, etc. Features resident in the basic SRV display will be retained although some will be adapted for the POC.

Combining the features of the SRV display with the larger NMR type display will provide both an air situation presentation (PPI) and a tabular/data list presentation, as shown in Figure 2.1.3. The PPI area, approximately 13 inches in diameter, will display all non-filtered aircraft tracks with data blocks and will allow the operator to select geographic/navigational symbols, control lists, and maps. The tabular/functional area of approximately 10 x 14 inches can be used to display flight plan data, control lists, filter data, free text, prompts, etc.

Man-machine interface to the system will be via soft switches located on the display screen, a track ball controlled cursor, a touch screen overlay, and a keyboard. Functions most frequently used are operator selected directly from the area where the current status is displayed. For functions less frequently used, a pop-up menu system is employed.

A touch entry panel will use a matrix of IR emitters and detectors located along the edge of the display panel. Resolution is 0.125 inch anywhere on the display surface. Touch entry would be used primarily for operator selection of menu/action soft switches. Other functions requiring a closer tolerance data entry or similar action, i.e. target designation, map preparation, etc., would use the trackball

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and cursor combination. The keyboard would be used for message composition, flight plan entry, and other plain text type data.

Geographic data required for normal operation and for processor based routing functions, i.e. maps, minimum safe altitude warning (MSAW) profiles, hazard areas, etc., are created in an off-line utility accessed via a menu entry. To create a map, the operator would input points on the situation display using the trackball/cursor, the touch screen, or by keyboard entry of X-Y coordinates. Using the menu, the operator would specify the type of line/object/symbol to be drawn at that location. Lines between locations are drawn after entering the end points, or in the case of a spline curve entering points along the desired curve.

Selection of maps is done by placing the trackball cursor over the desired map number and selecting. Up to five maps can be displayed simultaneously (overlaid). Maps are stored in non-volatile EEPROM.

Once a selection has been made from the map preparation menu for creating a new map or editing an existing map, that sub-menu remains on-screen until the operator is ready to save, abandon, or use without saving that map. Up to 32 pre-defined map symbols will be provided based on standard aviation map symbology. Maps can be rotated and translated relative to the center of the display. The map drawing system uses a simple "point-and-shoot" concept for placing lines and symbols.

The menu system is used for less-used functions and is accessed by selecting the menu block, or via the menu key. A Menu Window pops up on the screen and is only visible when called up and disappears after the selection is made. All routine quick-access functions do not display the menu. Menus are functionally grouped, providing an operator with limited training a logical presentation and access via only two levels. An exception is creation and editing of maps which adds a third level. Menu options are selected by keypad entry of item number or by selecting a menu using the trackball. All operations, except numeric data entry, can be done with the trackball.

Short quick action entry sequences are provided for the most common controller operations. Most quick-access operations are performed by a single action and all can be completed in no more than two (exclusive of numeric data entry). All functional areas are accessed and modified, as applicable, by using the trackball to place the cursor over the area and

pressing the trackball select key. Selection and/or action functions are indicated by a reverse video block. For data entry, legal entry limits are displayed in the Preview/Response area and the entries echoed back. Operations requiring specific target designation use the trackball to place the cursor over the target and press the trackball select button.

To select the display range and range marks, the controller uses the trackball, range and/or range mark select on-screen display and select key. Display offset is done by selecting "set" under the offset on-screen display, positioning the cursor to the desired radar origin location, and pressing locate. To return to center, select center on the screen. Return to the previously "set" origin is accomplished by selecting "set" and then pressing locate without moving the trackball cursor.

A readout of the cursor range and azimuth relative to the display center is displayed continuously in the upper-right section of the screen. Relative range and bearing between any two points can be measured by relocating the cursor origin reference to a point of interest and pressing the "locate" button. All subsequent movement of the cursor will show range and bearing relative to the new reference point.

The tabular display area will be used for procedural data, i.e., simulation of operational information - weather and NOTAMS and dynamic ATC control data - arrival/departure lists, flight strips, and processor/control information.

2.1.4 Aircraft Simulator

In the POC model, we will need to simulate the functions which will eventually be performed by an ATALARS airborne equipment suite. The very basic capabilities would be the generation/control/transmission of aircraft position data and a simulated pilot interface/display function.

Air Tech proposes to use PC type terminals for each simulator station. The units would be programmed to provide simulated flight routings - start point, routings via waypoints, to an end point. Enroute altitudes, ground speed, and A/C ident would be established in the A/C flight plan. The simulation program will be similar to the routines written by Air Tech to exercise the SRV display terminals, but with increased capabilities as required for the POC model. Simulations would include the capability to emulate specific A/C performance parameters, i.e., speed, altitude, turn rate, etc. A pseudopilot at each simulator would input to the terminal all flight specific data and select A/C performance data from a menu.

The simulator would output an A/C data message - ident, latitude, longitude, altitude, plus any special mission data - via the network control processor, synchronized with the up/down data link scheme.

The PC display terminal and keyboard would be the pseudopilot's interface to the POC system. The display would show three types of tabular data - the A/C position message as downlinked, ATC advisory data/messages, uplinked, and a preview/message composition area. Control and data entry into the simulator would be via the keyboard.

2.2 POC MODEL FIELD TEST CONFIGURATION

The TRV/SRV full scale development program is approximately three months into its scheduled 24 month duration. Although it is too early in the program to determine the feasibility of the idea, we would propose to perform a limited field test of the ATALARS POC laboratory model using an SRV as the basic ATC facility. This approach would allow limited testing of the basic ATALARS system concept without a major expenditure of funds and within a reasonable time frame. The ATALARS/SRV approach, described below, will require coordination with the various participants in the TRV/SRV program, i.e., AFCC and ESD/TVCN/PKTP, in order to utilize the SRV for the ATALARS application. At the completion of the ATALARS testing, the SRV would be brought back to its original configuration.

2.2.1 CD-91 TRV/SRV System

The present TRV/SRV Full Scale Development (FSD) contract includes an option for one each TRV and SRV to support the Constant Demo-91 exercises in Europe. The intent is to develop the CD-91 units in parallel with the FSD units. They will be functionally the same, but without the full testing required under FSD.

The CD-91 schedule calls for system delivery early in 1991, with the European exercises conducted in the May-June time frame of that year. The CD-91 units would be expected to be returned to Air Tech in the August-September time frame for refurbishment and updating. At that point, the ATALARS POC development effort would be expected to be well into the laboratory system development and evaluation phase.

We would propose to adapt the SRV to incorporate the ATALARS Processing and Network Control functions, using the SRV Plasma Displays and on-board HAVEQUICK radios. We would retain the SSR capability which would provide a cross-check against the ATALARS detection and tracking functions.

We would need to develop a Processor-Formatting device to be installed in a GFE aircraft which would interface with the aircraft GPS/INS system and airborne HAVEQUICK radio to provide very rudimentary A/C position data. The airborne package would be a compact unit designed to readily interface with the aircraft equipment without modifications or changes to the aircraft.

2.2.2 SRV/ATALARS System Configuration

The configuration of the POC model interfaced with the SRV is shown in Figure 2.2.2. The network control processor hardware could be readily installed in the SRV shelter and interfaced to one of the AN/VRC-83 radios. The system processor interface to the SRV 14" x 14" plasma displays would be through one of the spare RS-232 I/O parts which are available.

The interface to the SRV system elements are straightforward and can be done without any major changes or modifications to the SRV.

The objective of the limited field test would be to exercise the air-ground comm scheme and evaluate the effectiveness of both the comm and processing techniques.

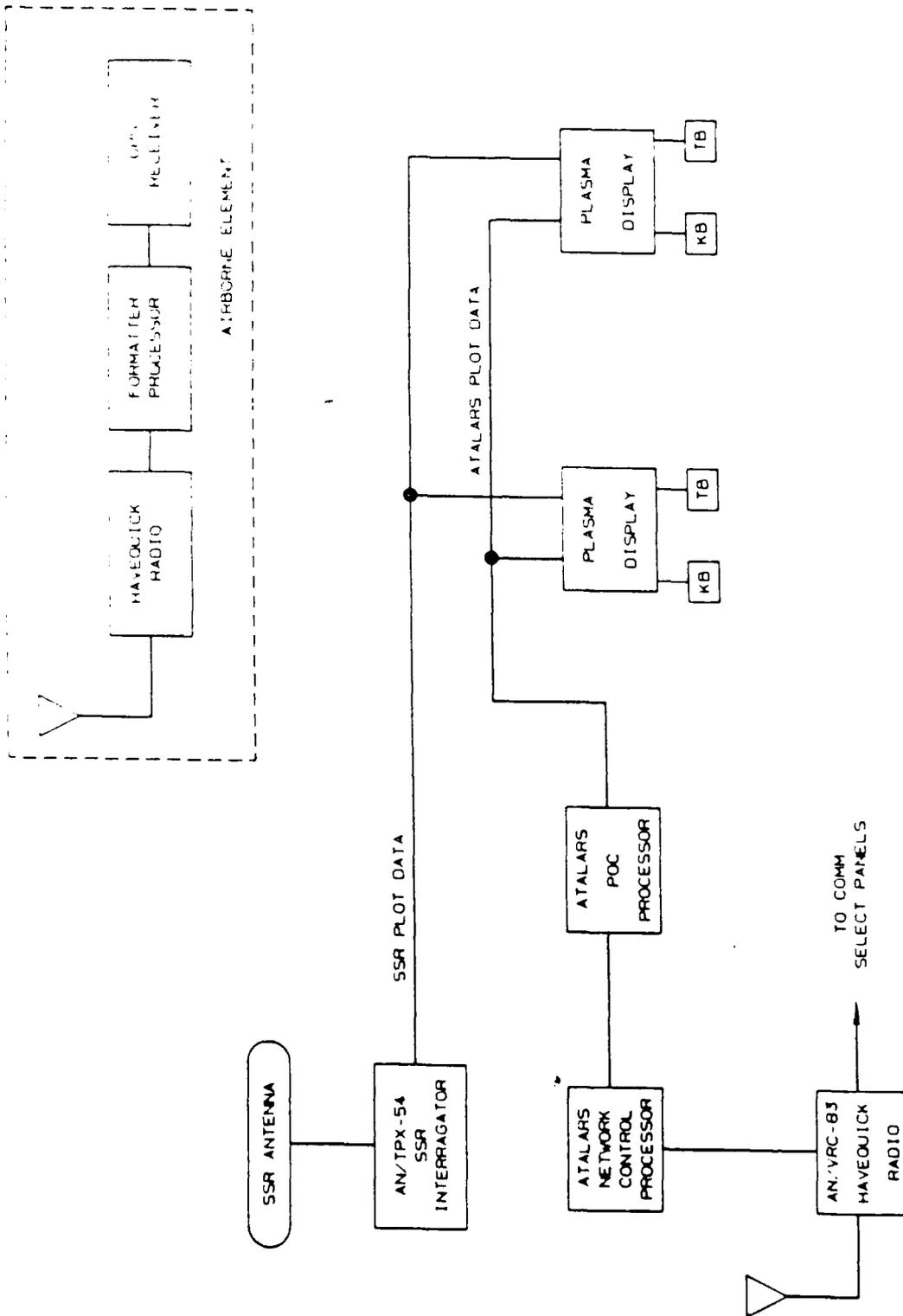


FIG 2.2.2 SIMPLIFIED BLOCK DIAGRAM
 ATALARS POC/SRV SYSTEM
 CONFIGURATION

SECTION 3

POC EVALUATION

The objective of this SBIR effort is to develop a preliminary implementation approach, utilizing planned or existing systems, for an ATALARS POC model.

We based our fundamental ATALARS system concept on the system we had derived in our previous SBIR study. We then evaluated that system concept to determine what elements could be initially implemented in a POC model, taking into consideration on-going developments in technology and the constraints imposed for an SBIR Phase Two contract.

The system configuration for the POC model, as described in 2.0, is intended to form the basis for evaluating what are considered major technical elements in the basic ATALARS concept, i.e., Processing and Display and Network Control.

The processor and its associated software and the plasma display terminals and their firmware would address two basic functions. The first would be the generation and execution of algorithms to process simulator generated aircraft position data and to display and update aircraft positions based on that data and on information resident in the static and dynamic data base. The system processing capabilities would be evaluated to determine the feasibility and effectiveness of the processing routines and the ability of the software to determine rudimentary flight routings and to select recommended control procedures for subsequent transmittal to the aircraft.

The second Processing and Display system function to be evaluated would be the Man-Machine Interface (MMI) to the system. The basic SRV MMI features, and certain of Air Tech's proposed NMR MMI features would be evaluated along with the preliminary ATALARS features which would be added.

The evaluation of the Network Control function will address the suitability of the proposed uplink/downlink scheme for the ATALARS data exchange. Two basic considerations will need to be addressed. First will be the networking and data formatting scheme, we will need to assess the uplink and downlink message structure and update times and the overall networking control and sequencing methodology.

Air Tech Technical Report

Although the plan is to utilize a limited number of Aircraft Simulators, we will need to simulate a larger number of aircraft messages in order to evaluate a higher rate of uplink and downlink message traffic. We would specifically address any potential for problems relative to time slot allocations, initial entry into the net, propagation/jitter problems, and optimum message lengths.

The analysis and measurements to be performed on the suitability of the HAVEQUICK and SINGARS radios to handle data linked message traffic will address two areas: capability to support the data rates and the impact of data transmission and reception on voice transmission/reception.

The outcome of the POC development and test effort will be a determination as to the suitability of Air Tech's basic ATALARS concept as a next generation ATC system. We will have addressed, albeit to a limited degree, two of the major areas which we feel are critical to the premise of aircraft derived position data and the processing and control functions.

If it becomes possible to use the SRV as a test bed in conjunction with the airborne message processor-formatter in a Government aircraft, we will be able to exercise the data link function and the display and tracking function in an operational environment.

The report which will be generated at the conclusion of the effort will include a detailed description of the system, including hardware and software elements. The report will include copies of the test procedures and results and evaluation and analysis of those results. The report would cover both the laboratory efforts and the SRV/ATALARS test results.

SECTION 4

PROGRAM SCHEDULE

The ATALARS Transition Plan needs to address two phases in the overall system evaluation: the POC model development and the longer range Prototype, Engineering Development, and Production phases.

In this section, we will address the overall system engineering approach, incorporating the POC phase and based on an estimated sequence of events and time periods (Figure 4.0). We will also provide a PERT chart for the POC effort.

4.1 SYSTEM ENGINEERING

The System Engineering functions shown in Figure 4.0 are intended to show the types of efforts to be required in evolving the ATALARS system. The sequence of events, albeit quite simplified, will serve to identify and define the functional characteristics of the ATALARS system hardware, software, and support structure through the process of analysis and design. The process would ensure an effective analysis of the mission requirements which would in turn become the system design requirements.

The Feasibility and Concept Formulation stage have been at least partially performed through efforts to date. To our knowledge, the preliminary Life Cycle Cost assessment has not been performed. The next phase, the Concept Exploration, is what we are addressing in this effort. The outcome of this SBIR can possibly go a long way toward setting the ground rules and developing the system specifications for the Engineering Development Phase.

Refinements which come out of Engineering Development as operational, performance, or technical issues are analyzed and evaluated in the Demonstration Validation Phase and would be incorporated in the revisions to the system specifications. At this stage, the System Engineering Management Plan, including the supporting, control, and program management functions, are evolved into a Full Scale Development system solicitation package.

The FSD phase will produce systems which incorporate all of the System Engineering disciplines in addition to hardware, software, firmware, and facilities requirements and specifications. Successful completion of DT&E and IOT&E during the FSD phase will establish the confidence levels in performance, operability, and fulfillment of mission requirements, all under deployed conditions. This in turn would normally lead to a decision to proceed to a production run of ATALARS systems.

In Figure 4.0, we included time references/spans for the various phases. These are intended to be representative only and should not be considered as firm milestones in the program.

4.2 POC DEVELOPMENT TASKS

Three task areas are planned for the POC development as shown in Figure 4.2. The Processing and Display subsystem will be based on the SRV display technology. We will initially translate the operational and performance features described in this report into a series of tasks associated with hardware, software, and firmware elements. This will include modification to the SRV display Applications and Graphics processor designs to operate with the 14" x 24" plasma display panel, adaptation of existing software and firmware, and generation of new software.

The POC processor development will include both hardware and software. The preliminary plan is to use board level assemblies to configure the processor.

The Network Control Processor function will be developed as an additional processing element in a multiple processor hardware configuration of single board computers. Two main tasks are involved, an in-depth analysis of the proposed communication equipments (HAVEQUICK, SINGARS, and JTIDS) and development of the link simulation technique and associated hardware and software.

The equipment analysis will address the capabilities of the various transmitting and receiving equipment to handle the proposed data link message formats and the impact of data transmission on the simultaneous use of the radios for voice transmissions.

Refinement of the data link scheme and development of the link simulation hardware and software will address the basic data link technique in terms of message content and format, and data rate. We will also address the applicable hardware technology and associated software required for implementation. The initial plan to use a board level processor will reduce the hardware design effort, the major tasks being selection of applicable off-the-shelf hardware. The software development will include

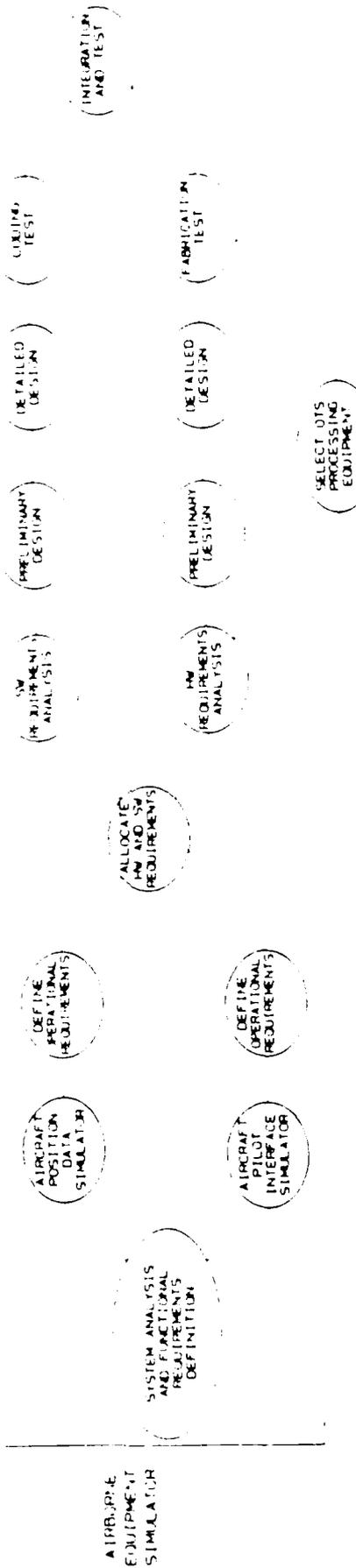


Fig 4.2 POC DEVELOPMENT PHASES

(Sheet 2 of 2)

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EQUIPMENT
SIMULATOR

requirements analysis, coding and module testing to the point where hardware integration occurs. At this stage, the Network Control function would be tested at the subsystem level.

Aircraft simulators are planned to be PC's with monitors and keyboards. The software requirements will establish the functional performance in terms of aircraft flight parameters and man-machine interface. The aircraft position data and flight routings will be based to a degree on routines developed for the simulator used to demonstrate the SRV display. For the POC application, these routines will be dynamic and can be modified by keyboard entry to change flight parameters.

The man-machine interface will be via a tabular data display and the keyboard. Upon completion of subsystem development efforts, the three subsystems will be fully integrated and tested as a POC model.

SECTION 5

CONCLUSIONS

The requirement for a next generation tactical Air Traffic Control system remains as a valid element in the evolution of worldwide ATC facilities. On-going efforts, including deploying the MPN-14K, developing and producing the TRV/SRV, NMR, and FAA Advanced Automation System, and continuing projects to upgrade and modernize existing fixed and mobile ATC assets have as a common denominator reliance on active sensors and radar emitters.

We will shortly enter a new era in the technologies and operational concepts to be used for the ATC functions. We will eventually see almost total reliance on satellite based systems - surveillance, communications, and navigation - for civil and military ATC. Although a high level of interoperability will be required between the military and civil systems, a continuing need will exist for a military system which can operate independently from a fully satellite based surveillance and control system.

The basic ATALARS system premise: aircraft derived position data, conventional air-ground up/down data link, and the extensive use of processor-based control/decision elements is suitable for a purely military application. It could eventually be configured as an ATC system which will operate in conjunction with, or as an alternate to, a communications satellite as the data link element.

The ATALARS concept is one means of providing this military-oriented capability and is a first step in the use of satellite technology - GPS - for ATC. In evolving the proof-of-concept model configuration, we have proposed a bridge between today's technology and our perception of tomorrow's military operational requirements. Within the constraints of an SBIR program, we have proposed an elementary system configuration which employs SRV and NMR subsystem technologies to demonstrate critical operating features in the ATALARS system concept.

Our approach is intended to further the ATALARS concept and is aimed at the eventual development of a system with the capabilities to monitor and control a high number of aircraft movements, over a large area, under peacetime and wartime operating conditions, anywhere in the world.