

TECHNICAL REPORT

**Air Traffic Control and Airspace Systems
2010 Air Traffic Control Operational Concept**

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1.0 INTRODUCTION

The Federal Aviation Administration (FAA) is responsible for providing and maintaining the United States' air navigation and air traffic control system. This responsibility was established by the Federal Aviation Act of 1958 and it also stipulated that the FAA shall operate the common system in full consideration of the requirements for national defense. The facilities, equipment, airports, personnel, regulations, and procedures that the FAA uses to control and manage the airspace is called the National Airspace System (NAS). As the national defense requirements have evolved, the Department of Defense (DoD) has become responsible for providing some of the air traffic control (ATC) services. Today DOD ATC facilities controls approximately 20% of the air traffic in the NAS.

The National Airspace System (NAS) Plan was published by the FAA in 1981 and it established the timelines for the system modernization which would take the NAS into the twenty-first century. The NAS Plan did not include the modernization of the DOD ATC systems. As a co-provider of ATC services, military ATC, air navigation, airspace management, and system components must be interoperable and/or compatible with the modernized FAA systems to an extent which assures the user of no derogation of services - in fact, a transparency of ATC services. The September 1989 NAS Plan update recognized DOD's goals, assumptions, and planning efforts for the NAS Plan implementation. The FAA is in the process of implementing the NAS Plan and, except for a few programs, will complete it by the end of the century. On the other hand, the DoD does not have a funding vehicle such as the NAS Plan, they have not generally allocated resources to modernize their ATC systems, and the changing world situation and budget reductions make it unlikely that resources will be available in the near future.



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1.1 Background

In recognition of the potential problems between the FAA and DOD ATC systems, the USAF Electronics Systems Division approved a contract in April 1987 for innovative research into potential post-2000 military ATC and airspace management system concepts. This contract had three distinct tasks, divided into three different time periods:

a. Task 1 assessed the potential problems associated with the lack of interoperability and compatibility between existing military ATC systems, including those currently in procurement, and the civil systems with which they must interface.

b. Task 2 assessed the potential problems associated with the lack of interoperability and compatibility between military ATC systems and the FAA systems with which they must interface in 1999. This time period was chosen because it coincides with the completion of nearly all of the NAS Plan projects.

c. Task 3, which is the subject of this report, requires the development of an operations concept which will specify the expected personnel and equipment interactions associated with the further evolution of the FAA's NAS and military ATC in the year 2010.

1.2 Objectives

The purpose of this report is to present an operations concept which delineates the expected personnel and equipment interactions between DOD ATC facilities and the FAA NAS in the year 2010. In order to portray these interactions, scenarios will be used. Two scenarios were defined - one showing a military aircraft progressing through the NAS and a second showing how a DoD aircraft will transition from the military ATC system into Special Use Airspace (SUA) and back to the military ATC. The intent is to show, in an animated format, the interactions between personnel,

including the required information to be passed, and the hardware/software interfaces necessary to pass the information.

While operating in a predominately peacetime environment, the DoD must still practice for an eventual wartime role. As such, the DoD must have the ATC equipment necessary to perform both roles: to be interoperable within the existing host nation ATC system (e.g., the US/FAA NAS system or Europe's EUROCONTROL system) and to be compatible within the interservice ATC/C3 system. In order to perform both roles, the DoD ATC system will be designed much the same as it is today with fixed ATC facilities interfaced with the host nation's en route system and mobile/tactical systems performing the wartime role.

Certain assumptions were made in the creation of these scenarios. In the current state of avionics, both DoD and commercial air carrier aircraft have avionic capabilities that enable them to be landed via autopilot in all weather conditions while the pilot is "hands-off." Certain DoD tactical aircraft have further capability to be flown from the ground (drone aircraft) by pilots using data link. This technology has further expanded to include directing tactical aircraft from link-up, to the target areas, and recovery back to its base of origin.

Both DoD and commercial aircraft have the ability for coupled approach/auto-land whereby the on-board avionics together with the autopilot can land the aircraft while the pilot is "hands-off" the controls. While civil aircraft use a cockpit-based auto-land system, DOD aircraft employ a mix of cockpit-based and ground-based systems capable of landing the aircraft. Some DoD ATC facilities are capable of recovering aircraft from as far away as 60 nautical miles (NM) by means of auto-lock-on, capable of positioning the aircraft in the approach/arrival traffic pattern, and capable of auto-landing the aircraft off to the precision approach landing system for a hands-off auto-land.

Given the pace of advancements in computer miniaturization and the limited space in military aircraft, it is inevitable that the auto-land systems will incorporate datalink in a combined system

capable of receiving both automatic precision landing guidance and message/ATC instructions. This information will be presented on a Multi-Mode Display (MMD) along with other flight information such as weather, navigational guidance, terminal collision avoidance, and general ATC information.

Another recent advancement in commercial aviation is the advent of datalink for both general messages and eventually ATC messages within the NAS. By using datalink, frequency congestion within a typical NAS ATC sector can be reduced by 50% by standardizing routine transmissions such as frequency changes at pre-determined locations along federal airways/jet routes. Additionally, military systems will evolve to a datalink interface with the civil en route and terminal ATC systems as well as the military ATC/information systems for which they were designed. Furthermore, conformal antennas and smart skin fuselages will enable pilots to establish pilot/air traffic controller and pilot/weapons controller links in addition to datalinks for the transfer of data communications with ground stations.

En route navigation within the NAS will be primarily based upon a combination of a US Global Positioning System (GPS), the USSR's Global Navigation Satellite System (GLONASS) and an on-board GPS/INS (Inertial Navigation System) hybrid avionics systems. Civil and military aircraft will fly reasonably direct routes between arrival and departure route waypoints utilizing grid navigation within the NAS system.

On the battlefield, systems such as the USAF's Automated Tactical Aircraft Launch and Recovery System (ATALARS) or the Army's Air Traffic Navigation, Integration and Coordination System (ATNAVICS) will perform a combination of both command, control, communications (C3) and ATC functions. Specifically, these systems will be mobile, capable of battlefield protection to operate within an Electronic Counter-Counter Measure (ECCM) environment, and will have combat net radio and secure voice, data, imaging, positioning, and command and control networks to provide a real-time air traffic picture. The surveillance capability will include both surveillance and precision

modes, utilizing satellite assisted navigation (GPS) for position determination (automatic dependent surveillance) with full auto-land capability. Both systems are envisioned to be highly mobile and yet still be able to fully integrate with host nation ATC systems.

It is within this environment that the following scenarios will take place. While no attempt was made to name specific manufacturers or systems, there are references to specific NAS programs that are on-going and future concepts that are assumed to be operational by the year 2010.

1.3 Scope

This report assesses the inter-service and intra-agency interactions from the stand point of a 2010 military aircraft progressing through the 2010 civil NAS. The progress will be depicted by describing each step of two different, but typical military flights from the filing of the flight plan to the completion of the mission. Future ATC and aircraft systems are described based on the projection of current and planned systems, technology trends, and other studies that have investigated the future of aircraft and ATC systems. All of the information presented in this report is unclassified and was freely provided by military, federal, and commercial sources.

1.4 Document Organization

The remainder of this document is organized in the following manner. Section 2 consists of the technical report, which is divided into two sub-sections. The first sub-section provides the scenario of a DoD aircraft flying through the 2010 ATC system. The second describes a DoD aircraft operating within the DoD ATC system. Section 3 presents the findings and results of the analysis.

2.0 PEACETIME ATC SCENARIO

The pilot of a military aircraft (BOLAR 12) at March AFB, California, files a flight plan with March Base Operations. The pilot files for the DAGGETT THREE Standard Instrument Departure to DAGET Intersection and hence, direct to the geographic coordinates of the TRIXY Intersection - the entry point for the OCEAN FIVE Arrival to NAS Oceana, Virginia - at Flight Level 41,000 feet (FL 410). The flight plan is input at Base Operations and fed via the NAS Interfacility Communication System (NICS) through the Ontario Automated Flight Service Station (AFSS) to the Flight Service Data Processing System (FSDPS) at the Los Angeles Area Control Facility (ACF), where it will be stored until activated and forwarded to the Los Angeles Metroplex Control Facility (MCF) serving the major airports within the LA area. After reviewing the computer flight plan, then checking the weather, NOTAMS, and terminal/en route advisories on the March Automatic Weather Distribution System terminal, the flight crew prepares the aircraft for flight.

The proposed flight plan enters the Los Angeles ACF Traffic Management Processor (TMP) flight plan database. Once in the database, the route of flight is processed to resolve traffic conflicts, amended accordingly, and formatted to a clearance message. The TMP sends the amended clearance message back to the March Military Control Tower (MCT), via the NICS, for relay to the pilot. The pilot programs the navigation computers to accept "CIV/ATC" in order to receive civil ATC datalink messages along with voice on his UHF radio. The pilot switches to the Clearance Delivery frequency and requests the ATC clearance by datalink. The departure and amended en route clearance is then transmitted to the aircraft receiver and displayed in the cockpit on the multi-mode display. When alerted by an aural beep, the pilot selects "MSG" position and receives the clearance. The clearance is reviewed and acknowledged by the pilot by activating the "MSG ACCEPT" reply on the display. The pilot then sets the appropriate code of 2412 into the transponder and sets in the current altimeter setting.

When ready to taxi, the pilot contacts March Ground Control for taxi instructions via VHF/UHF radio. When ready for takeoff, the pilot contacts the Local Controller and obtains a takeoff clearance to maintain runway heading and to climb to and maintain 15,000 feet. Upon rotation, a departure message is automatically sent to the Area Control Computer Complex (ACCC) within the LA ACF. This activates BOLAR 12's flight plan and alerts the LA MCF that BOLAR 12 is active. Once airborne, BOLAR 12's transponder reply is acquired by the secondary surveillance radar (SSR) serving the March AFB area, and the radar data is forwarded to the LA MCF. The Mode S SSR interrogator reads the reply as 2412 transponder code and sends the digitized beacon data directly to the ACCC at the LA MCF. Once airborne and other traffic is no longer a factor, the local controller advises the pilot of BOLAR 12 to contact the Los Angeles MCF departure controller on VHF/UHF radio. The pilot contacts the departure controller at the LA MCF, who acknowledges BOLAR 12's call and verifies the climb to 15,000 feet.

BOLAR 12's automatic datalink Departure Message (DM) activated the flight plan which alerts the Los Angeles ACCC to track the 2412 transponder code. Once the aircraft climbs above 500 feet above ground level (AGL), the transponder code appears adjacent to the primary target and the ACCC automatically initiates a datablock for the radar target on the controller's display.

The departure controller sees the datablock and receives the pilot's initial contact radio call via voice. The controller tells the pilot to "verify (that the aircraft is) passing through 1500 feet," which allows the controller to validate that the pilot has entered the right altimeter setting and that what the controller sees in the datablock is in fact the altitude the aircraft is passing through. Once validated entering the NAS, this procedure will not have to be performed again. The pilot acknowledges the altitude that the aircraft is passing through. The controller also notes the blinking center of the target to verify the identification (IDENT) and that the target with that datablock was, in fact, BOLAR 12.

The LA MCF monitors the climb of BOLAR 12 as it continues on its route. Once the aircraft leaves 8,000 feet, the ACCC automatically hands BOLAR 12 off to the LA ACF. The datablock appears on the low altitude sector responsible for the airspace above the LA MCF and accepts the hand-off on BOLAR 12. The MCF controller initiates the standard datalink message for BOLAR 12 to contact the LA ACF controller on UHF/VHF radio.

It is envisioned that all initial calls within the 2010 NAS are made by voice to alert the controller that the pilot has established the communications check thereby reminding the controller of the aircraft's presence. Once initial contact has been made, all further routine communications can be conducted using Mode S data link. In the event of a situation needing immediate response or an emergency, voice communication will take precedence.

BOLAR 12 checks in on VHF radio and advises the LA ACF controller that BOLAR 12 is on frequency. At the same time, the ACF TMP again reviews BOLAR 12's route of flight for potential conflicts. In this scenario, ACF TMP determines (through Automated En Route ATC - AERA 3) that two potential conflicts exist with other traffic. Since both potential conflicts can be resolved by limiting BOLAR 12's climb, the ACCC alerts the controller to the situation while simultaneously resolving it by issuing a datalink message to BOLAR 12. The message will request the pilot restrict the climb to 10,000 feet, so the aircraft may pass underneath the (lower) conflicting traffic flying at 11,000 and 12,000 feet mean sea level (MSL) respectively. A message is sent simultaneously to the departure controller to monitor BOLAR 12's altitude until it is clear of the conflicting traffic. The controller soon observes that BOLAR 12 is clear of, and safely separated from, both aircraft. He then issues a datalink clearance to the pilot of BOLAR 12 to continue the climb to 15,000 feet and proceed via own (aircraft) navigation on the cleared route of flight. The pilot is again alerted by the aural tone, selects "MSG," and reads and accepts the clearance.

As BOLAR 12 approaches the sector boundary, the ACCC initiates an automatic hand-off to the next en route low-altitude sector. Within the ACF, the datablock on the departure controller's scope

flashes the hand-off message as the datablock for the aircraft appears in the en route low-altitude sector's airspace, which shows the same information to the en route controller. The en route low sector controller automatically accepts the hand-off. This stops the flashing of the hand-off portion of the datablock, indicating to the departure controller that the hand-off has been accepted. The departure controller then advises the pilot of BOLAR 12 via Mode S data link to contact the next Los Angeles ACF controller via VHF/UHF voice.

The pilot of BOLAR 12 contacts the en route low-sector controller via VHF voice and states that BOLAR 12 is climbing to 15,000 feet and requests higher. The Controller acknowledges the pilot's call and instructs him to continue the climb to FL 410.

As BOLAR 12 approaches the boundary of this sector, the ACCC again activates the hand-off message to the en route high-altitude sector position. This again causes the datablock on the radar console to flash, informing the low-sector controller of the impending hand-off. Once the hand-off is accepted by the high-sector controller, the low-sector controller advises the pilot of BOLAR 12 via datalink (using the nearest Mode S sensor) to contact the next controller via VHF/UHF voice. The pilot reviews the frequency/control change on the multi-mode display and acknowledges the instructions to contact the next sector on UHF through the ACCEPT function. The sending controller sees the datablock change which indicates the military pilot has accepted the communications transfer instruction.

After initial radio contact with BOLAR 12 is made, the en route high-altitude controller is alerted by the ACCC to a potential conflict between the climbing BOLAR 12 and a flight of four military training aircraft practicing formation flight maneuvers in an overhead Air Traffic Control Assigned Airspace (ATCAA) area beginning at FL 290. The flight has spilled out of the assigned altitude and is on a converging course with BOLAR 12. The controller advises the pilot of BOLAR 12 to restrict his climb to FL 280 to remain clear of the other aircraft. The controller issues this clearance via UHF voice due to the urgency of the situation. The pilot acknowledges the clearance verbally and

levels off and reports at FL 280 via datalink. Once BOLAR 12 is clear of the traffic, the controller initiates a datalink message to the pilot advising him to continue the climb to FL 410. The pilot of BOLAR 12 acknowledges verbally and reports departing FL 280. BOLAR 12 subsequently levels off at FL 410.

During the en route portion of the flight, BOLAR 12 navigates using GPS with INS as its backup; its position updates are automatically fed through automatic dependent surveillance (ADS) to each control center on the ground along its route of flight via satellite. The procedure of handing BOLAR 12 off from sector to sector within each ACF--as well as ACF to ACF--continues the same way. Each time BOLAR 12 is within 15 minutes of a particular sector the truncated flight plan (only the portion applicable to the particular sector) is passed to the sector by the serving ACCC. The flight plan is presented on an arrival list until the datablock is handed off. The electronic strip is presented in the data bay with the other flight plans and is continuously updated as to crossing times at specific fixes, altitude, routing changes, or any other change that might affect the flight.

While en route, BOLAR 12 receives a message on its Joint Tactical Informational Data System (JTIDS) terminal via the MILSTAR satellite from 21st Air Force that additional cargo will have to be loaded at NAS Oceana, which necessitates a change in destination for the third leg of their trip. The flight crew will file an amended flight plan upon arrival with the NAS Oceana Flight Operations. Since the new destination will be outside of the continental U.S., the flight plan will be forwarded through International Civil Aviation Organization (ICAO) via the NICS and will be coordinated with Air Defense.

As BOLAR 12 continues to NAS Oceana, the hand-off procedure is repeated sector to sector across country until BOLAR 12 approaches within 100 NM of the destination airfield. At that time, the pilot requests and receives weather and terminal information via datalink from the NAS Weather Communications Processor in the servicing ACF. Complete weather and terminal information is

graphically presented to the pilot describing the latest weather reports, forecast, notices to airmen (NOTAMs), runway in use, and the type of auto-approach to expect.

As BOLAR 12 approaches a pre-planned descent point, the pilot is issued a descent clearance to FL 230 (the lowest altitude in the high-altitude controller's sector). Once handed off to the Washington ACF controller, BOLAR 12 is issued a clearance to cross a point 70 NM west of Oceana at 17,000 feet and proceed with the OCEAN FIVE arrival to NAS Oceana via datalink. The pilot again acknowledges through the "ACCEPT" function on the multi-mode display and initiates the descent.

The Washington low-sector controller hands the aircraft off to Oceana Approach Control, the destination Military Radar Approach Control Facility (MRACF). Oceana accepts the hand-off, thereby automatically alerting the Washington controller to descend BOLAR 12 to 10,000 feet, as required by local procedures. The Washington low-sector controller advises the pilot of BOLAR 12, via Mode S datalink, to continue the descent to 10,000 feet and contact Oceana Approach on UHF. The pilot of BOLAR 12 acknowledges this message via datalink.

The pilot contacts the Oceana arrival controller on UHF, states the passing altitude, and the clearance to descend to 10,000 feet. The Oceana controller acknowledges the radio call, issues a further descent to 5,000 feet, and instructs the pilot to program the avionics to auto-lock onto the microwave landing system (MLS) approach to runway 23L. The Oceana controller initiates the automatic sequencing of BOLAR 12 into the flow of arriving traffic; the aircraft auto-pilot establishes contact with the Microwave Landing System (MLS). The pilot selects the auto-landing programs on the cockpit instruments and flight control computer, identifies the MLS signal, and monitors the approach to runway 23L while configuring the aircraft to land. After landing and taxiing clear of the runway, the pilot contacts the ground controller and taxis to the appropriate ramp.

2.1 Tactical/Wartime Scenario

In this tactical/wartime exercise scenario, the military pilot of ZORRO 50 prepares for a low-level high-speed flight into special use airspace delivering ordnance into an predetermined target area within an established range. As part of the mission briefing, the pilot is warned to encounter electronic countermeasures (ECM) and that there will be surface-to-air missiles (SAMs) (simulated) surrounding the target area.

After receiving the mission briefing from squadron operations, the pilot files a flight plan with the military base operations from the base of origin, as follows: fly direct to a point in space (a geographical reference point west of the airfield using GPS), descend to 500 feet AGL, proceed direct to the entry point of the exercise area, delay for one hour, and return via the exit point of the exercise area direct to a geographical reference point west of the field for recovery into the airport via autolink.

After the flight plan is filed, it is passed directly to the Military Control Tower (MCT) and military radar facility (MRACF) via a local area network (LAN) that ties base operations with the MCT and the MRACF. The flight plan is passed to the Clearance Delivery controller's inactive display list in the MCT. The mission preparers have already programmed the avionics (black boxes) into the aircraft with preset information such as the tail number of the aircraft, pilot's name, mission data, and preselected target identifications for the automated target acquisition system.

Once in the aircraft, as part of the pre-flight checklist, the pilot sets the Mode S datalink comm switch to MIL/ATC for operation within the military ATC environment. On the Multi-Mode Display (MMD), the navigation data (route) will appear, along with other information, such as the Terminal Collision Avoidance System, weather, ATC messages, target acquisition display, weapons status, and target identification data. All the information on the MMD may appear on a Heads Up Display (HUD) or on the pilot optical system on the pilot's visor.

The pilot switches to the clearance delivery frequency to request clearance via Mode S datalink. The use of Mode S datalink enhances the mission profile by allowing for "silent departure" procedures. The pilot reviews the clearance, which is exactly as it was filed, on the MMD and accepts it by pressing the ACCEPT button. The pilot then receives taxi instructions from the hanger to the active runway via Mode S datalink. When adjacent to the departure runway the pilot switches to the local control channel and is issued a "silent" take-off clearance again via datalink.

The pilot takes the runway, departs, then contacts the departure controller in the MRACF via datalink. The departure controller issues approval to climb to 3,000 feet. After the pilot has departed, the flight data controller activates a departure message and the electronic strip is transferred from the inactive list to the active list on the departure controller's display down in the MRACF. After checking his airspace for conflicting traffic, the controller clears the military pilot on his route. Once out of the radar traffic pattern for the base, and upon reaching the designated point in space, the pilot of ZORRO 50 switches the transponder to 1200 (VFR code), descends to 500 feet AGL, and proceeds direct to the range.

The flight data on ZORRO 50 is passed via microwave link from the MRACF directly to the Tactical Ground Control Unit (TGCU) in the field. This information is retrieved and stored in the flight database and listed on the inbound aircraft list. As the pilot approaches the range in Special Use Airspace (SUA), an automated hand-off is effected with the TGCU unit controlling ZORRO 50 in the exercise area.

The TGCU controller maintains surveillance over the aircraft through the use of GPS and ADS and down-linked positional and velocity navigation track data using information derived from the aircraft avionics. The TGCU controller performs an authentication using the datalink avionics special code loaded by mission planners; the code was forwarded to the TGCU via secure microwave link. Once the automatic hand-off is complete, the departure controller advises the military pilot to contact

POGO Control (the TGPU controller) via datalink. The pilot then switches his Mode switch to MIL/C3 and establishes contact with POGO Control using datalink.

The TGPU controller, having authenticated ZORRO 50 as a "friendly," then takes track control and directs the aircraft to the battle area through an established air defense corridor set up as an additional measure against fratricide. The TGPU controller now has complete control over the aircraft through datalink avionics link to the aircraft's autopilot functions.

This automatic mode provides flexibility to the TGPU controller for multi-tasks during the height of the air battle. At any time the controller can allow control commands to be automatically delivered to the aircraft via datalink and displayed directly in the cockpit on the MMD. During non-battles, the controller can automatically establish metering/spacing into tactical air bases (TAB) to ensure the most efficient flow rate to recover tactical aircraft. The TGPU can also switch to a semi-automatic mode to screen computer-generated clearances or control commands and manually transmit these messages to the aircraft via datalink.

The controllers of POGO Control have operational control over all the exercise aircraft for the White (friendly) Air Force. Another TGPU control unit controls the opposing aircraft; a third element unit oversees the entire exercise as an evaluation unit. During emergency conditions, the TGPU control unit also provides controllers with voice communications in the event of battle damage or emergency aircraft conditions.

POGO Control directs ZORRO 50, as well as five other attack aircraft, to the target area. Once within range of the targets, ZORRO 50's on-board target acquisition computer locks onto the target and, together with the autopilot, maneuvers the aircraft around simulated radar emitting missile sites. Once over the target, the practice laser bomb is dropped and the aircraft maneuvers again around other simulated missile sites and egresses the area.

In the event of a situation involving battle damage, the TGPU performs a system integrity check through datalink to verify the system status of the various avionics and primary control components. In the event that a system or component is damaged, the system integrity check will alert the TGPU controller and a redundant system can take over to enable the recovery of the aircraft. After mission completion, the TGPU Controller performs another authentication procedure and guides ZORRO 50 to the exit point through another existing air defense corridor prior to handing the aircraft off to the MRACF.

Prior to the hand-off, the TGPU control unit forwards the abbreviated flight plan back to the MRACF via secure microwave link. The flight plan is received, processed, and forwarded to the appropriate controllers' inbound list.

Once the authentication procedure is performed and validated, the automatic handoff is accomplished. After the hand-off is accepted, the TGPU Controller advises the pilot to contact the MRACF via datalink. The pilot switches back to MIL/ATC and contacts the radar facility via datalink. The MRACF locks onto the aircraft through the datalink avionics and advises the pilot that ZORRO 50 is going to be sequenced into the radar pattern with the other aircraft.

Once other traffic is clear of ZORRO 50, its track is locked onto by the ground-based processor which guides the aircraft down a precision approach path. After the aircraft has been auto-landed, the pilot resumes control of the aircraft and taxis off the runway back to the hanger.

3.0 SUMMARY

Although the precepts of the civil/military air traffic control structure and interface is not expected to change by the year 2010, a tidal wave of advancement in methodology has begun. The 2010 environment will certainly feature automation, secure communications, integrated hardware/software and facilities for realistic readiness training and simultaneous civil ATC application, in addition to new cockpit procedures and automated capabilities. The system will be largely space-based and aircraft-embedded for communications and navigation, while remaining dependent upon ground-based support for command and control, and surveillance functions. The combination of ground-based and space-based systems, reliant upon satellite transmission, will form a technically complex interaction which will be contradictorily simple in operation. Human factors engineering and reductant/alternate path, decentralized communication will form a more reliable network.

It is within this framework that the scenarios operated. The first took place in the integrated civil/military NAS and other remained exclusively within a military controlled portion of the NAS in the year 2010. By the use of these scenarios, interactions between personnel and ATC equipment was shown. The assumption was made at the beginning of the task that the military had modernized their systems to make them compatible and interoperable with the FAA systems. These FAA systems were based on the NAS at the completion of the NAS Plan in the early 2000's plus some additional evolution, such as the use of Automatic Dependent Surveillance (ADS) for surveillance of en route air traffic. In addition, it was assumed that several DoD programs that are currently in developmental stages and other current technology trends had produced operational systems that were in use by the military aircraft.

These scenarios should provide the reader with an idea of how the DoD and the FAA ATC systems are interfaced, how flight information is passed between facilities, and how the system will look through the eyes of a pilot. Assumptions were based upon current DoD ATC systems planning, FAA

NAS Plan/Capital Improvement Plan, work being performed by the Department of Transportations' Transportation System Center, and DoD Command, Control, and Communications (C³) programs.

APPENDIX A
BIBLIOGRAPHY

Department of Defense and Department of Transportation, 1988 Federal Radionavigation Plan, (DoD-4650.4/DOT-TSC-RSPA-88-4), Washington, DC, 1989.

Department of the Navy "Air Traffic Control Current Configuration Report," Naval Air Systems Command, Arlington, Virginia, October 10, 1988.

Department of the Navy "Air Traffic Control Programs Descriptions," Naval Air Systems Command, Arlington, Virginia, January 1989.

Federal Aviation Administration, Air Traffic Control, FAAH 7110.65E, Current edition, Washington, DC.

Federal Aviation Administration, National Airspace System Level I Design Document, NAS-DD-1000D (includes SCN-1 through SCN-17), Washington, DC, June 1989.

Federal Aviation Administration, National Airspace System Plan, Facilities, Equipment and Associated Development, and Other Capitol Needs, Washington, DC, September 1989.

Federal Aviation Administration, National Airspace System - System Requirements Specification, NAS-SR-1000 (includes SCN-1 through SCN-5), Washington, DC, October 1986.

Federal Aviation Administration, National Airspace System - System Specification, NAS-SS-1000, Washington, DC, December 1986.

U.S. Air Force Air Traffic Control Facility Listing, Air Force Communications Command, Scott Air Force Base, Illinois, March 1988.

U.S. Air Force "ATALARS Operational Requirements," Department of Transportation, Transportation Systems Center, Cambridge, Massachusetts, April 1988.

U.S. Air Force Traffic Control and Landing Systems (TRACALS) Plan (DRAFT), Air Force Communications Command, Scott Air Force Base, Illinois, January 1988.

U.S. Army Air Traffic Control Equipment Handbook, Headquarters, U.S. Army Air Traffic Control Activity, Fort Huachuca, Arizona, January 1983.

U.S. Army Airspace Management and Army Air Traffic in a Combat Zone, Field Manual No. 1-103, Headquarters, Department of the Army, Washington, DC, December 1981.

U.S. Army ATC Master Plan (DRAFT), U.S. Army Aviation Center, Fort Rucker, Alabama, October 1988.

U.S. Army "ATC Reference List," U.S. Army Aviation Center, Fort Rucker, Alabama, May 29, 1987.

U.S. Navy Strategic Initiatives for Air Traffic Control (ATC) and Landing Systems (LS), Naval Air Systems Command, Arlington, Virginia, October 1987.

U.S. Marine Corps Operational Logistics Support Summary (OLSS) for Fleet Marine Force and Traffic Control Systems and Equipment, SPAWAR P4110.566A, Commander, Space and Naval Warfare Systems Command, Arlington, Virginia, October 1987.

APPENDIX B

GLOSSARY

ADVANCED AUTOMATION FUNCTIONS - The ACCC shall receive from other ACCCs trail plans, trajectory update information, and messages containing inputs to and/or outputs from advanced automation functions such as Flight Plan Conflict Probe. The messages shall include flight plan conflict and airspace conflict alerts and displays.

AIRCRAFT - Device/s that are used or intended to be used for flight in the air; when used in air traffic control terminology may include the flight crew.

AUTOMATIC ALTITUDE REPORTING - That function of a transponder which responds to interrogations by transmitting the aircraft's altitude in 100-foot increments.

EN ROUTE - One of three phases of flight services (terminal, en route, oceanic). En route service is provided outside of terminal airspace and is exclusive of oceanic control.

EN ROUTE AIR TRAFFIC CONTROL SERVICES - Air traffic control service provided aircraft on IFR flight plans, generally by ARTCCs (ACF), when these aircraft are operating between departure and destination terminal areas. When equipment capabilities and controller workload permit, certain advisory/assistance services may be provided to VFR aircraft.

FLIGHT PLAN - Specified information relating to the intended flight of an aircraft that is filed orally or in writing with an ATC facility.

FLIGHT SERVICE STATION/FSS - Air traffic facilities which provide pilot briefing, en route communications, and VFR search and rescue services; assist lost aircraft and aircraft in emergency situations; relay ATC clearances; originate Notices to Airmen; broadcast aviation weather and NAS information; receive and process IFR flight plans; and monitor NAVAIDS. In addition, at selected locations FSSs provide En Route Flight Advisor Service (Flight Watch), take weather observations, issue airport advisories, and advise Customs and Immigration of transborder flights.

HAND-OFF - An action taken to transfer the control of an aircraft from one controller to another if the aircraft will enter the receiving controller's airspace and radio communications with the aircraft will be transferred.

IFR AIRCRAFT/IFR FLIGHT - An aircraft conducting flight in accordance with instrument flight rules.

INSTRUMENT FLIGHT RULES/IFR - Rules governing the procedures for conducting instrument flight. Also a term used by pilots and controllers to indicate type of flight plan.

NATIONAL AIRSPACE SYSTEM/NAS - The NAS includes U.S. airspace; air navigation facilities, equipment and services; aeronautical charts, information and services; aviation rules, regulations, and procedures; technical information; and the labor and material used to control and/or manage flight activities in airspace under the jurisdiction of the U.S.

ROUTE - A defined path, consisting of one or more courses in a horizontal plane, which aircraft traverse over the surface of the earth.

SPECIAL USE AIRSPACE - Airspace of defined dimensions wherein aerial activities must be contained because of their nature, and/or wherein air traffic control limitations may be imposed upon aircraft operations that are not part of the contained activities. Special use airspace includes prohibited areas, restricted areas, warning areas, military operations areas, controlled firing areas, and alert areas.

SURVEILLANCE - The detection, location, and tracking of aircraft within NAS airspace for the purposes of control, separation, and identification. Surveillance systems are electronic in nature; visual methods are purposely excluded. In the case of dependent surveillance, the aircraft provides all flight information. Surveillance systems are differentiated as independent, independent cooperative, and dependent:

1. Independent Surveillance - A system which requires no airborne compatible equipment
2. Independent Cooperative Surveillance - A system which requires airborne compatible equipment (e.g., ATCRBS, Mode S)
3. Dependent Surveillance - A system which requires input from navigation equipment aboard the aircraft either via a data link (e.g., LOFF) or via voice transmission (pilot reports)

TERMINAL AREA - A general term used to describe airspace in which approach control service or airport traffic control service is provided.

TERMINAL AREA FACILITY - A facility providing air traffic control service for arriving and departing IFR, VFR, Special VFR, Special IFR aircraft and, on occasion, en route aircraft.

TOWER/AIRPORT TRAFFIC CONTROL TOWER - A terminal facility that uses air-ground radio communications, visual signaling, and other devices to provide ATC services to aircraft operating in the vicinity of an airport or on the movement area. Authorizes aircraft to land or takeoff at the airport controlled by the tower or to transit the airport traffic area regardless of flight plan or weather conditions (IFR or VFR). A tower may also provide approach control services.

APPENDIX C
ACRONYMS/ABBREVIATIONS

<u>ACRONYM</u>	<u>MEANING</u>
AAS	Advanced Automation System
ACCC	Area Control Computer Complex
ACF	Area Control Facility
ADS	Automatic Dependent Surveillance
AERA	Automated En Route Air Traffic Control
ATC	Air Traffic Control
ATNAVICS	Air Traffic Navigation, Integration and Coordination System
CONUS	Continental, Contiguous, or Conterminous United States
DoD	Department of Defense
FAA	Federal Aviation Administration
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
MHz	Megahertz
MLS	Microwave Landing System
MMLS	Military Microwave Landing System
Mode C	Altitude Reporting Mode of Secondary Radar
Mode S	Discrete addressable Secondary Radar System with Data Link
NAS	National Airspace System
TCAS	Traffic Alert and Collision Avoidance System
UHF	Ultra High Frequency
VFR	Visual Flight Rules
VHF	Very High Frequency