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DEFENSE AIRBORNE RECONNAISSANCE OFFICE (DARO)

UNMANNED AERIAL VEHICLES (UAV) PROGRAM PLAN

APRIL 1994

#892

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DEFENSE AIRBORNE RECONNAISSANCE OFFICE (DARO)

APRIL 1994

DEPARTMENT OF DEFENSE

Deputy Under Secretary of Defense
(Advanced Technology)

Washington, D.C. 20301

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EXECUTIVE SUMMARY

The Congressional Authorization Conference in November 1993 sent a message that was clearly received by the Department of Defense (DoD). The report said that, in this new, post-Cold War era, "tactical reconnaissance is relatively more important to national security than at any other time in our history." At the same time, a new approach was requested that would "bring management attention, order, and efficiency" to tactical airborne reconnaissance development and acquisition. On 6 November 1993, in response to Congressional concerns, the Deputy Secretary of Defense (DepSecDef) created the Defense Airborne Reconnaissance Office (DARO), under the Under Secretary of Defense (Acquisition and Technology) (USD(A&T)). The DARO has been charged with unifying existing reconnaissance architectures and enhancing the management and acquisition of all joint Service and Defense-wide manned and unmanned airborne reconnaissance/surveillance capabilities.

DARO is engaged in the task of benchmarking its fundamental responsibilities and resources. It will create the climate necessary for change by concentrating its energies in the following areas: (a) assessment and tradeoff of system level capabilities; (b) analysis of system requirements to ensure interoperability; (c) development of new and improved sensor technologies; (d) pursuit of Advanced Concept Technology Demonstrations; and (e) development of a unifying airborne reconnaissance architecture consistent with other reconnaissance related roadmaps. The architecture will be joint and integrated, address manned and unmanned systems, stress open and digital designs, be adaptable to changing threats and include multi-level secure communications linked into the global network.

In developing an effective unmanned aerial vehicle (UAV) program plan, an evolutionary approach is the most prudent course of action given the existing and forecast budgetary environment. An evolutionary approach to the migration of UAVs into the mainstream of tactical reconnaissance capabilities builds on mature technologies, while permitting a "phased" approach to architectural development, testing, and operational employment. A broad range of alternatives exists, and now is the time to make a commitment to a proper mix of UAVs and manned reconnaissance capabilities. These alternatives will be available as developments warrant and simulations validate the interoperability of UAVs and manned aircraft to meet mission needs. Figure ES-1 identifies the major UAV programs that are the primary focus of the DARO. Other UAV systems discussed in this document for completeness and context are shown in relation to the primary DARO programs in Figure ES-2. This initial UAV program plan embraces lessons learned from past UAV programs and builds on recommendations of the 1993

Defense Science Board (DSB) Summer Study on Global Surveillance and the DoD Deep Target Surveillance/Reconnaissance Study to integrate manned and UAV capabilities. Most importantly, this plan highlights the ultimate goal of any military system or plan — service to the warfighter.

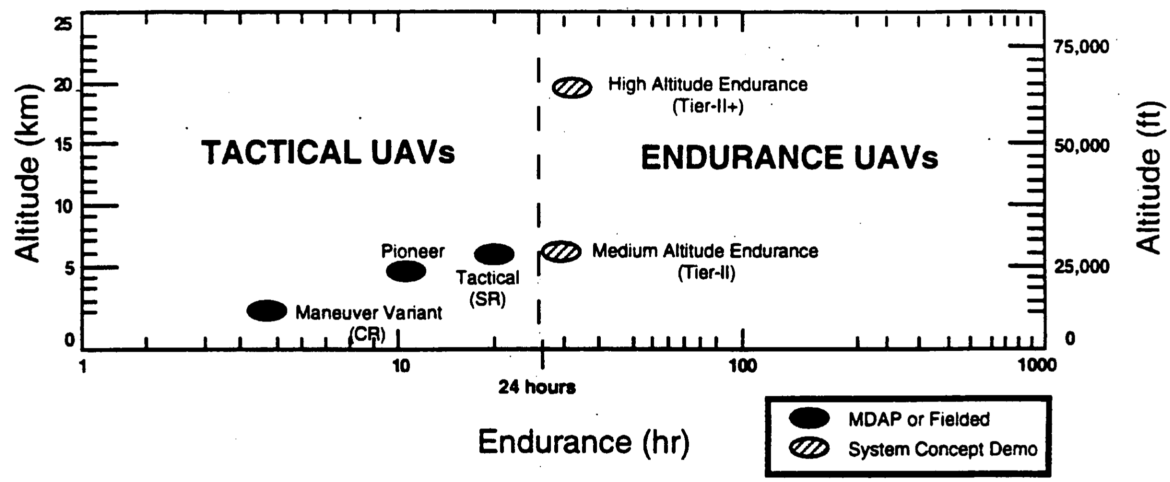

Figure ES-1 Major DARO UAV Programs

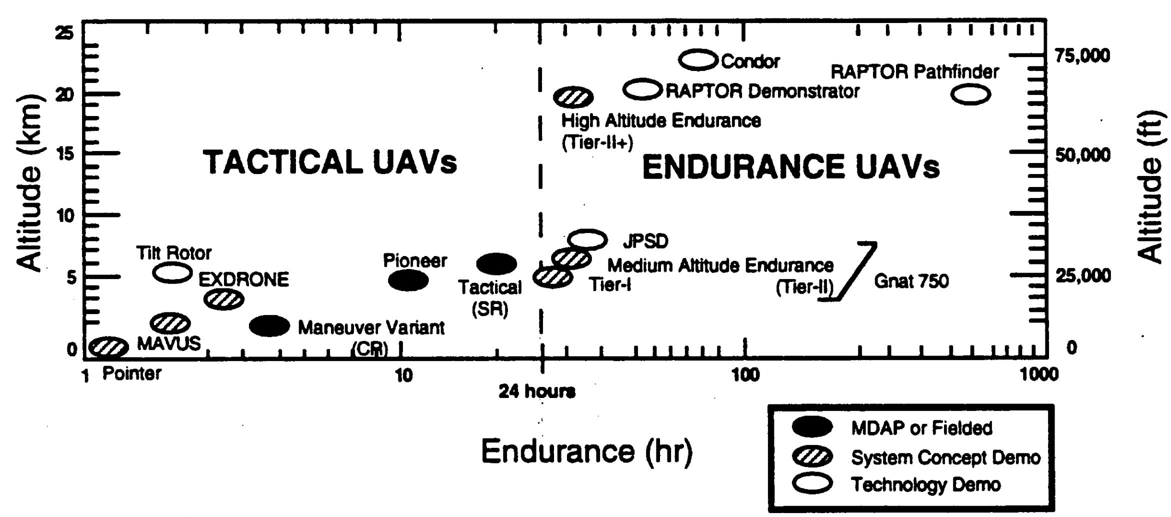

Figure ES-2 UAV Total Landscape

1. DARO OVERVIEW

1.1 INTRODUCTION

The Defense Airborne Reconnaissance Office (DARO)[1] is responsible for the development and acquisition of both manned and unmanned aerial reconnaissance and surveillance capabilities. This is the DARO Program Plan for the management of unmanned aerial vehicles (UAV). This seminal document focuses on the UAV programs under the DARO auspices. Other UAV programs are discussed for completeness and context. The Director, DARO provides insight and oversight for the programs that comprise the Defense Airborne Reconnaissance Program (DARP). DARO oversees designated Service and Defense agency executing agents who are responsible to the Director, DARO for the execution of the technology demonstrations, development and acquisition programs, and projects of the DARP.

The on going DARP UAV acquisition programs are managed by the Unmanned Aerial Vehicles Joint Project Office (UAV JPO). DARO has a relationship with the UAV JPO that is central to the effective management of UAVs. The UAV programs managed for DARO by the UAV JPO are the Joint Tactical UAV Program, previously known as the Short Range UAV Program, a Shipboard Variant, and the Maneuver Variant, previously known as the Close Range UAV Program. The program names were changed to eliminate confusion with the mission need statements and operational requirements documents which have the same original names. These programs were consolidated under a single manager to achieve program cost and schedule savings, reduce government management overhead, and streamline the programs' documentation and review process. The UAV JPO submits a separate annual UAV Master Plan to Congress as directed by the FY1988 Appropriations Act. The 1994 Plan is being prepared and will be forwarded in early April. The UAV JPO Master Plan focuses on recent Congressional concerns regarding program progress, user involvement in programs, accelerated fielding of systems, and UAV commonality and interoperability.

The Endurance UAV Demonstration Programs are the Medium Altitude Endurance (MAE) UAV, which was known as Tier-II, and the High Altitude Endurance (HAE) UAV previously known as Tier-II+. The new names better reflect the operational environment being explored by these demonstrations.

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1 Acronyms are defined when first used in text. Appendix B defines acronyms used more than once in the text and acronyms used in figures.

1.1.1 Background

Current Defense Planning Guidance requires the military to support operations through peace, crisis, and war. A prime mission of tactical reconnaissance is to get targeting-quality attack information directly from sensor to user in an increasingly time-compressed combat environment. However, recent and on going analysis suggests the US has neither the quantitative nor qualitative tactical reconnaissance capability to support projected military operations in two Major Regional Contingencies (MRC).

Specifically, UAV systems have not yet fully realized their high payoff potential to perform reconnaissance missions and other missions for the warfighters that have arisen with the advent of time-critical targets. These targets include (but are not limited to) tactical ballistic missiles and mobile surface-to-air missiles. UAV abilities to meet this time-critical need would make targeting of less time-critical targets, using other reconnaissance assets, significantly more effective in the rapid defeat of an enemy.

Congress recently supported the creation of a tactical reconnaissance office to redress the condition where "management of joint Service and Defense-wide airborne reconnaissance capabilities is fragmented among the Services and Defense Agencies, which precludes trade-offs, produces conflicting architectures, and hinders the acquisition of joint and independent programs." The DepSecDef established the DARO on 6 November 1993 to "manage the development and acquisition of all joint Service and Defense-wide airborne reconnaissance activities." Specifically, the DARO is the single focal point for all DoD joint Service and Defense-wide airborne reconnaissance and surveillance programs, to include both manned and unmanned systems.

1.1.2 Objectives

The Defense Airborne Reconnaissance Program addresses the acquisition of both manned and unmanned joint Service and Defense-wide capabilities. The DARP will comprise an overarching, unified airborne reconnaissance architecture along with development, acquisition, and investment strategies to ensure maximum commonality and interoperability for effective warfighter support. The DARP architecture is being structured in cooperation with the Services, CINCs, and Defense Agencies responsible for the architectures of the various intelligence disciplines. This architecture, coordinated with Services, Agencies and Commands, will be published in the Spring timeframe.

The DARO's Unmanned Aerial Vehicle (UAV) Program Plan explains the unmanned aspects of the DARP. This plan is submitted as the overall baseline for the DoD's UAV capability. It outlines the nonlethal unmanned reconnaissance initiatives. It clarifies the approach for incorporating UAVs in a more significant and balanced way to support aerial reconnaissance missions at the theater operational and tactical echelons and below.

1.2 CHARTER

The DARO is a development and acquisition organization, formed and staffed jointly by the USD(A&T) and the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) (ASD(C3I)), to provide effective and coordinated management of joint Service and Defense-wide airborne reconnaissance programs in response to warfighting needs. The responsibility for improving airborne tactical reconnaissance capability is shared between the acquisition and intelligence communities.

The DARO is responsible for the development and acquisition of joint Service and Defense-wide airborne reconnaissance platforms (manned and unmanned), sensors, data links and data relays, and ground systems. This includes modifications to Service and Agency-unique ground stations to achieve and maintain interoperability with joint Service and Defense-wide airborne reconnaissance and surveillance collectors. DARO, working with the Services and Agencies, will define the development, acquisition, and investment strategies for joint Service and Defense-wide airborne reconnaissance activities; defend the budget before Congress; and monitor budget execution. The Director/DARO (D/DARO) is responsible for assuring that planning for each element of the DARP fits within the context of the overall architecture for airborne reconnaissance/surveillance.

1.2.1 Organization

A DoD directive establishing DARO's responsibilities is in coordination. DARO is a development and acquisition organization under the authority, direction, and control of USD(A&T). The approved DARO organization is shown in Figure 1-1.

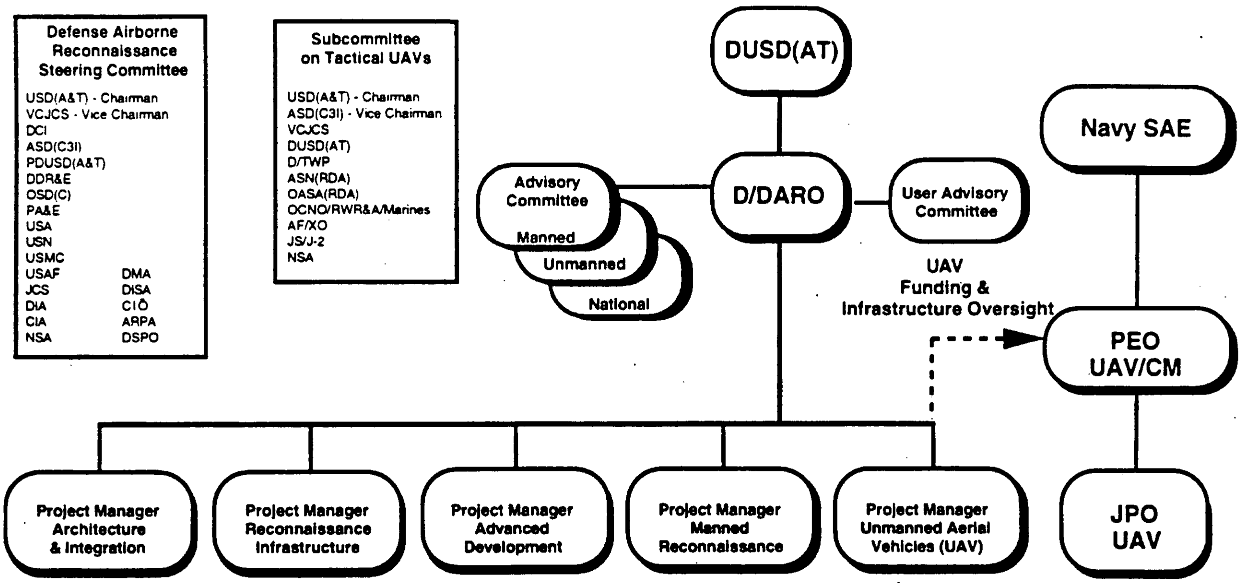

Figure 1-1 DARO Organization

1.2.2 Activity

DARO will support innovative and streamlining strategies for the development and acquisition of advanced airborne reconnaissance capabilities. For example, selected programs are candidates to be pursued as Advanced Concept Technology Demonstrations (ACTD). ACTDs provide a critical step in effectively transitioning technology to military utility by providing users an understanding and evaluation of utility before commitment to acquisition. ACTDs are intended to reduce acquisition risks and uncertainties at relatively low costs. Users can develop concepts of operations (CONOPS), while deferring major investment until demonstration of the value and maturity of the technology. Decision makers are also provided system options as threats evolve. Figure 1-2 is an extract from a typical ACTD proposal. ACTD status is conveyed only when a program has met the requirements established by DUSD(AT). These include a plan submitted according to the guidelines and approved by DUSD(AT).

1.2.3 DARO-Related Committees

The principal committees that interface and support the DARO are: Defense Airborne Reconnaissance Steering Committee (DARSC), Subcommittee on Tactical UAVs, and four Advisory Committees supporting D/DARO (see Figure 1-1). These committees are in the process of formalizing their charters and authorities. The DARSC will focus on maintaining

Operational Capabilities	Demo Concept
• Develop operating and control procedures for endurance UAVs in support of a variety of different forces and scenarios • Forces develop dissemination requirements • Support development of more capable follow-on EUAVs	• Endurance (>24 hours) UAV with EO and SAR sensors providing Near-Real-Time Surveillance support to forces
Proposed Guidance	**Schedule**
• Interact with users to define the principal user interface. In conjunction with that POC, develop detailed demo plans consistent with program for development of the UAVs	• Demo mid FY96

Figure 1-2 Medium Altitude Endurance UAV

oversight, providing overall direction, and approving priorities/key jurisdictional decisions or positions among the Services and Defense Agencies. The Subcommittee on Tactical UAVs will review UAV acquisition-related activities and serve as the senior consulting board supporting the JROC for adjudicating UAV requirements and resources. The Advisory Committees will provide inputs on consolidating and reconciling CONOPS to include deployments; operations with manned, unmanned, and national assets; and associated logistics and sustainment matters.

1.3 KEY DARO RELATIONSHIPS

1.3.1 Assistant Secretary of Defense (C3I)

The DARO maintains a close relationship and coordination with ASD(C3I). Program reviews between ASD(C3I) and USD(A&T) are performed regularly. In addition, the deputy to the Director of the DARO is from the ASD(C3I) staff. Since ASD(C3I) is responsible for the overall DoD C3I architecture, there will be close coordination, integration, and interoperability of the functions/capabilities of the DARO systems with the C3I architecture. The key DARO executive committees, the DARSC and Subcommittee on Tactical UAVs, have ASD(C3I) participation. These committees approve priorities and strategies managed and developed by DARO.

1.3.2 UAV Joint Project Office (JPO)

In 1988, Congress directed DoD to consolidate the management of DoD non-lethal UAVs under the UAV JPO. The UAV JPO is the development and acquisition agent of the DARO for almost all UAVs. Its functional responsibilities include UAV commonality and interoperability, systems engineering, technology exploitation, test and evaluation, integrated logistics support, and international programs. Its program responsibilities include the Tactical UAV, Shipboard Variant, Maneuver Variant, the MAE UAV, and some tactical demonstration programs. (Lethal UAVs are covered in the DoD Stand-off Weapons Master Plan.) On going tactical UAV programs, currently managed by the UAV JPO as DoDD 5000.1 Acquisition Category 1 programs, are the responsibility of the Navy Service Acquisition Executive (SAE). The Advanced Research Projects Agency (ARPA) is the lead development organization for the HAE UAV which is managed outside the UAV JPO and the Navy SAE.

1.3.3 Defense Agencies

The Central Imagery Office (CIO), National Security Agency (NSA), and Central Measurements and Signatures Intelligence (MASINT) Office (CMO) produce functional architectures. The DARO is a participating representative on the various agency architecture committees of these agencies to ensure consistency of the overall architecture and individual system compliance. DARO is defining an "information architecture" for airborne reconnaissance. That architecture will identify the information sources, communication paths, and data formats by which not only imagery but Signals Intelligence (SIGINT), MASINT, and other sources will move more quickly from the sensor, through intermediate processing and exploitation steps, to the user. The DARO information architecture will build on the complementary architecture effort of CIO and NSA.

1.3.4 Intelligence Community

The DARO is working closely with the Director Central Intelligence (DCI) Community Management Staff (CMS) and other members of the Intelligence Community to ensure a coherent and integrated approach to the overall intelligence architecture. The DCI is represented on the DARSC and the CMS will continue to work with the DARO on architecture development.

1.4 FUTURE KEY DARO ACTIVITIES

The DARO is in its first year of operation. During the next year or more, the DARO will:

- Specify the information architecture to address both manned and unmanned airborne reconnaissance capabilities for FY 1994 through 2000 and project an investment strategy through 2010
- Prioritize a technology roadmap to guide investments of key/emerging UAV-related technologies which will be coordinated through JROC (see section 8)
- Review the strategic Industrial Base implications of a smaller, high-technology base for reconnaissance/surveillance assets, as we rely more on commonality and interoperability
- Investigate opportunities to utilize more robust distributed interactive simulations to both evaluate and mature training and readiness and prototypes, and support the acquisition process. Warfighters can and will be better able to visualize enhanced UAV support to contingency operations (see section 8)
- Participate in the ASD(C3I)-led activity called "2 x MRC Study Review"
- In conjunction with the users, plan enhanced joint exercise participation to provide "live data" for future analysis and application of UAV systems and for user acceptance
- Increase emphasis on how UAVs best fit into our evolving information architecture, to include requirements management, exploitation management, and data distribution.

Notwithstanding the challenges of increasing demands and fewer resources, the DARO is aggressively pursuing a strategy to get capability into the field early, optimize an airborne reconnaissance force mix of manned and unmanned platforms, and add new systems that provide better overall capability. This key shift in airborne reconnaissance program emphasis from little reliance on UAVs to a growing, balanced reliance on UAVs will provide an affordable approach to meeting reconnaissance requirements and keeping our technology at the leading edge.

1.5 RELATIONSHIP WITH NATIONAL SYSTEM DATA ARCHITECTURE AND OVERALL C4I ARCHITECTURE

Satisfaction of tactical military operators' information needs requires data from many different collection and processing systems. Those systems range from the national collection systems with their tasking, processing, and dissemination architectures to small hand-launched UAV systems (see section 5.1) with their own nondevelopmental item (NDI) architectures. Use of common collection tasking strategies and data formats for these disparate systems aids the timely and transparent flow of information to the ultimate tactical operator. Well-considered program interfaces to existing collection tasking standards, processing and exploitation systems, and information dissemination systems will all reduce the intelligence footprint on the battlefield and make optimal use of scarce personnel resources.

The evolving command, control, communications, computers, and intelligence (C4I) architecture focuses on "information pull" for satisfaction of the operational forces' information needs. In addition, the embodiment of the C4I architecture within DARO's airborne reconnaissance framework will integrate these manned and unmanned tactical reconnaissance assets into the warfighters' pool of resources. New C4I technologies will be leveraged so commanders and manned platforms can "reach out" through UAVs to "see" deeper and "hear" more clearly. To fully support those objectives, DARO will aggressively manage new programs for compliance and look at the cost/benefit of retrofits to existing programs.

2. UNMANNED AERIAL VEHICLES (UAVS) IN DOD - AN OVERVIEW

Unmanned aerial vehicles[1] can make significant contributions to the warfighting capability of operational forces. In Operation Desert Storm, during which 85 percent of available US airbreathing tactical reconnaissance assets were committed, UAVs emerged as a "must have." They greatly improve the quality and timeliness of battlefield information while reducing the risk of capture or loss of troops, thus allowing more rapid and better informed decision making by battlefield commanders. They are cost effective and versatile systems. While reconnaissance, surveillance, and target acquisition (RSTA) are the premier missions for UAVs, they can also provide substantial capabilities in communications, electronic warfare (EW), electronic support measures (ESM), mine detection, command and control, and special operations mission areas. UAVs can readily perform a multitude of inherently hazardous missions: those in contaminated environments, those with extremely long flight times, and those with unacceptable political risks for manned aircraft. Allotting these "dirty" and dangerous missions to UAVs decreases the risks to manned aircraft and frees pilots to perform missions that require the flexibility of the manned system. UAVs are a viable alternative as the Services wrestle with the many challenges of downsizing the force structure.

2.1 UAVS IN DESERT STORM

UAVs played a significant role in Operation Desert Storm. The success of the Pioneer UAV affirmed the military Services' commitment to integrate UAV systems into their force structures for a number of missions. Operation Desert Storm illustrated that the family of UAV systems concept is valid. UAV systems can be separated based on mission, Service, and echelon of command-supported requirements.

Six Pioneer UAV systems participated in Operation Desert Storm — three with the First Marine Expeditionary Force (I MEF), two with the US Navy (USN) battleships USS MISSOURI and USS WISCONSIN, and one with the US Army (USA) VII Corps. The Pioneer system provided near-real-time RSTA and battle damage assessment (BDA) during both day and night operations.

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[1] This plan addresses only nonlethal UAVs. See Appendix A for definitions of UAV-related terminology.

Each Pioneer system supported multiple units and performed different reconnaissance missions on each flight. Significantly, airborne Pioneers were often tasked to verify radar contacts generated by the Joint Surveillance and Target Attack Radar System (JSTARS) aircraft. JSTARS and Pioneer-coordinated operations worked very well; JSTARS served as a wide-area alerting sensor for high-priority mobile targets, and Pioneer acted as the confirming sensor.

Pioneer also proved to be survivable (given that air superiority had, for the most part, been achieved). While manned aircraft tended to fly mostly at medium altitudes for enhanced survivability, Pioneer flew all missions below 5,000 feet above ground level (AGL) and within the envelope of optically-directed guns and infrared (IR) missiles. In over 300 sorties and over 1000 flight hours, only one Pioneer was lost as a result of enemy action.

Airspace integration and command and control of Pioneer operations were demanding. Each Service chose different ways to handle the flight coordination of Pioneer with manned aircraft. The concerns raised prior to Desert Storm as to the "mixability" of UAVs and manned aircraft were shown to be solvable.

Pioneer does have some limitations, which were also clearly demonstrated in Desert Storm. When operated as a corps-level asset with the USA VII Corps, Pioneer did not have the range and endurance required for all ground operations. The VII Corps clearly needed a UAV system with a radius of action of about 300 km using an airborne data relay, plus a time on station in excess of four hours at maximum range. Pioneer range was generally satisfactory for the USN and US Marine Corps (USMC), but additional endurance, including greater on-station time, would have reduced the operational tempo. At night, mission endurance was further reduced, in some cases, by an inadequate forward-looking infrared (FLIR) cooling system. Additionally, lack of precision navigation and geolocation capabilities prevented Pioneer from providing precise information for the targeting of weapons.

Pioneer's launch and recovery characteristics were also a major limitation. The USA had to construct UAV airfields on short notice to support the ground force scheme of maneuver because they lacked the pneumatic launcher capability of the USMC. This required the diversion of critical engineering resources from combat operations. Aboard ship, use of a net recovery system was manpower intensive, caused air vehicle damage, and restricted the use of deck space on most ships.

Pioneer's use of 100 octane aviation gas was a logistic limitation because it is not in the US military supply system and could only be obtained in Bahrain. The next closest source was Greece.

Although only one Pioneer air vehicle was downed by Iraqi air defenses, 12 others were destroyed in operational accidents. Material/subsystem failures, operator error, and co-site electromagnetic interference (EMI) between Pioneer systems accounted for the majority of losses. Pioneer has only five frequency channels to control air assets.

Finally, imagery dissemination from the Pioneer ground control station (GCS) to using units was not satisfactory. The Pioneer remote receiving system units were deficient in both operating range and data dissemination capability. USMC Pioneer units did construct a nonsecure, ground microwave system to the I MEF Command Post some 15 km away, using commercial equipment borrowed from the US Air Force (USAF). This link was judged highly effective in keeping the I MEF Headquarters informed on a real-time basis.

Overall, many valuable lessons were learned. Despite the problems, the tremendous success of UAV systems in Operation Desert Storm sends a strong message regarding the utility of UAV systems in combat. In an era of budget constraints, doing more with less is mandatory. UAVs have the capability to perform multiple functions and significantly enhance battle management systems, and are excellent force multipliers due to their combat utility, versatility, and cost effectiveness. The lessons documented in "Pioneer in The Gulf War," dated 15 May 1992, have helped reaffirm the course and direction being taken with the Tactical and Endurance UAV programs.

2.2 UAV MISSION NEED STATEMENTS

The Chairman of the Joint Requirements Oversight Council (JROC) has validated mission need statements (MNS) for UAV capabilities in the DoD. These need statements group UAVs into four operational categories: close range, short range, medium range and endurance.

The JROC Close and Short MNS will be satisfied by the Joint Tactical UAV Program. Some of the JROC Endurance and Medium MNS will be satisified by the MAE and HAE programs. Figure 2-1 summarizes the required capabilities of each need statement. Figure 2-2 graphically depicts the operational envelopes in terms of UAV radius of action versus time of flight.

	JOINT TACTICAL PROGRAM*			ENDURANCE PROGRAM*
CATEGORIES / CAPABILITIES	CLOSE	SHORT	MEDIUM	ENDURANCE
Operational Needs	RS, TA, TS, EW, MET, NBC	RS, TA, TS, MET, NBC, C2, EW	Pre-and Post-Strike Reconnaissance, TA	RS, TA, C2, MET NBC, SIGINT, EW, Special Ops
Launch and Recovery	Land/Shipboard	Land/Shipboard	Air/Land	Not Specified
Radius of Action	None stated	150 km beyond forward line of own troops (FLOT)	650 km	TBD
Speed	Not Specified	Dash> 110 Knots Cruise <90 Knots	550 Knots <6.5 km .9 Mach >6.5 km	Not Specified
Endurance	24 hrs Continuous Coverage	8 to 12 hrs	2 hrs	≥24 hrs on Station
Information Timeliness	Near-Real-Time	Near-Real-Time	Near-Real-Time/Recorded	Near-Real-Time
Sensor Type	Day/Night Imaging, EW, NBC	Day/Night Imaging, Data Relay, Comm Relay, Radar, SIGINT, MET, MASINT, TD, EW	Day/Night Imaging*, SIGINT, MET, EW	SIGINT, MET, COMM Relay, Data Relay, NBC, Imaging, MASINT, EW
Air Vehicle Control	None Stated	Pre-Programmed/ Remote	Pre-Programmed	Pre-Programmed/ Remote
Ground Station	Vehicle & Ship	Vehicle & Ship	JSIPS (Processing)	Vehicle & Ship
Data Link	Worldwide Peacetime Usage, Anti-Jam Capability	Worldwide Peacetime Usage, Anti-Jam Capability	JSIPS Interoperable Worldwide Peacetime Usage, Anti-Jam Capability	Worldwide Peacetime Usage, Anti-Jam Capability
Crew Size	Minimum	Minimum	Minimum	Minimum
Service Need/ Requirement	USA, USN, USMC	USA, USN, USMC	USN, USAF, USMC	USA, USN, USMC, USAF

*Note: The broad classifications of UAVs have recently been changed to "Tactical" and "Endurance." The MNS refers to "close" and "short," which are now designated "Tactical."

LEGEND

C2 - Command and Control
EW - Electronic Warfare
JSIPS - Joint Service Imagery Processing System
MASINT - Measurements and Signatures Intelligence
MET - Meteorology
NBC - Nuclear, Biological and Chemical
RS - Reconnaissance and Surveillance
SIGINT - Signals Intelligence
TA - Target Acquisition
TS - Target Spotting
TD - Target Designator

Figure 2-1 Mission Need Statement (MNS) Summary

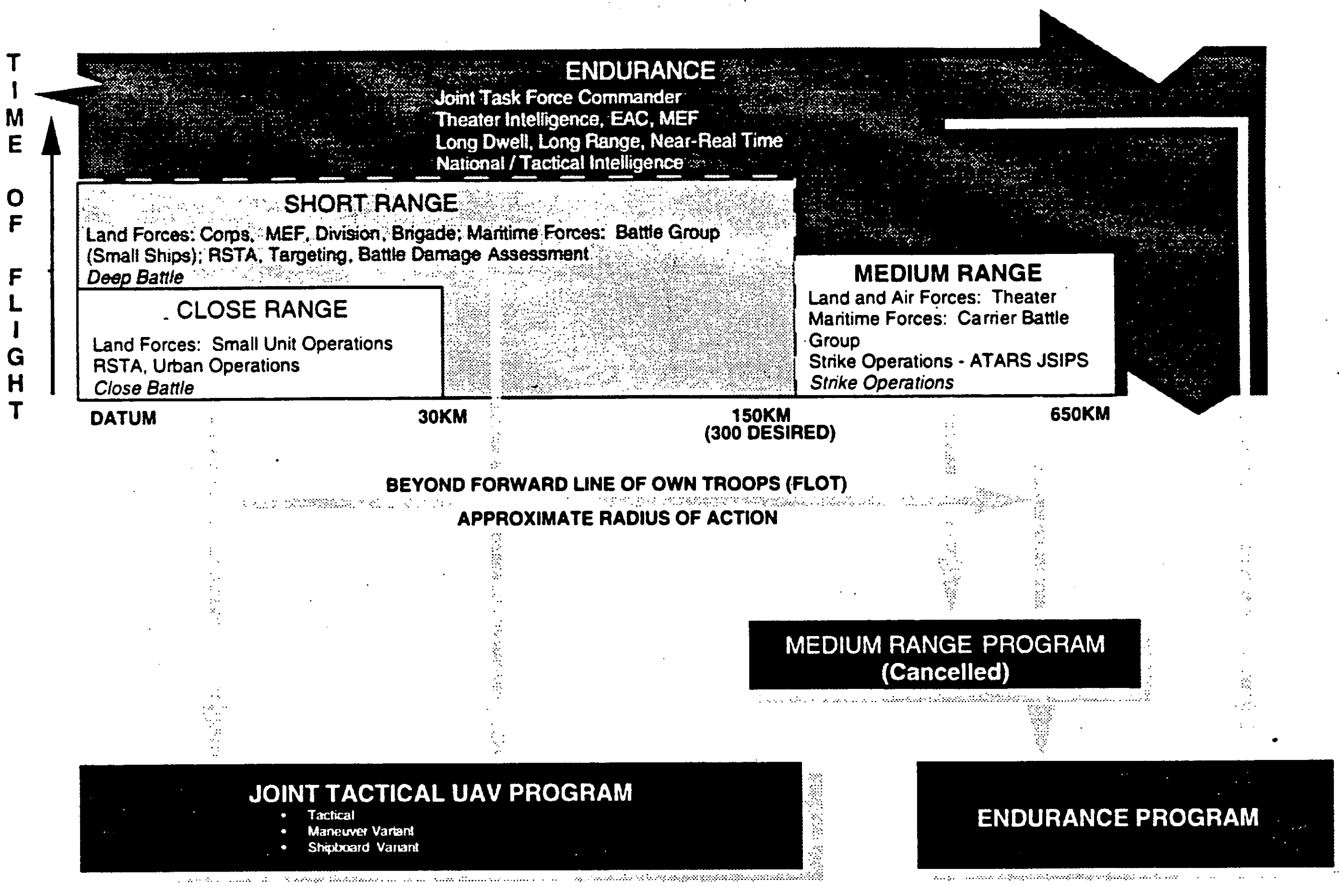


Figure 2-2 Categories of Capabilities

2.3 UAV PROGRAMS

The Joint Tactical UAV Program is discussed in detail in Section 4. The Tactical UAV supports the needs of USA divisions from echelons corps and below and of Marine Air-Ground Task Force (MAGTF) from the MEF and below. The Shipboard Variant of the Tactical UAV supports USN combatant needs. Enemy activities out to a range of 150 kilometers or more beyond the forward line of own troops (FLOT) or datum point (in USN operations) can be exploited for 16 hours of every 24 hours with the Tactical UAV system. A Maneuver Variant of the Tactical UAV addresses the needs of lower-level units, such as USA light divisions/brigades/battalions and USMC regiments/battalions, to target their direct support weapons systems and to conduct RSTA out to approximately 30 kilometers beyond the FLOT.

The Medium Range Need Statement addresses capabilities to provide pre- and post-strike reconnaissance of heavily defended targets and to augment manned reconnaissance platforms or high-altitude UAVs by providing high-quality, near-real-time imagery. The Medium Range UAV Program was established to address the requirements of the medium range need statement.

However, this program was terminated on 29 October 1993 by Under Secretary of Defense (Acquisition) (USD(A)) for reasons of affordability and the conclusion that an endurance UAV offered superior performance at lower cost.

The Endurance Need Statement addresses a wide variety of mission and payload types. Required capabilities include imagery, signals intelligence, communications and data relay, electronic warfare, and others. Endurance UAV systems must have the capability to remain on station for 24 hours or more. Autonomous flight is required and data relay through satellites is greatly desired. The Endurance UAV demonstrations discussed in detail in Section 6 are multi-faceted and contain many elements which started before the creation of DARO and were not under the management umbrella of the UAV JPO. Those endurance UAV elements include a Medium Altitude Endurance (MAE) (Tier-II) endurance capability, a new High Altitude Endurance (HAE) UAV (Tier-II+) and associated ARPA sensor initiatives for more robust capabilities, a recently completed Joint Precision Strike Demonstration (JPSD) of UAV control and imagery transmission through a satellite, and the RAPTOR Pathfinder demonstration platforms of BMDO. DARO has established a cohesiveness among these various UAV elements, placing most under the cognizance of the UAV JPO.

2.4 UAV COMMONALITY AND INTEROPERABILITY

Satisfying UAV requirements in an affordable and timely fashion dictates the need for a disciplined, overarching acquisition strategy. The strategy must guide the development process to result in a family of UAV systems with common subsystems and components, and must achieve transparent interoperability with a myriad of external C4I elements. The development philosophy espoused by the UAV JPO and supported by DARO includes:

- Strong user support and participation
- Harmonizing operational requirements among the Services and Unified Commands
- Developing a UAV system architecture to ensure interoperability among UAV systems and subsystems
- Procuring off-the-shelf technologies for initial UAV systems
- Developing procurement specifications for UAV systems after Services have acquired hands-on operational experience
- Fielding and supporting affordable systems.

Achievement of UAV system commonality and interoperability will be accomplished to the degree it is cost effective from a user perspective. Although commonality is a major driver for reducing life-cycle cost, it may not be achievable across all UAVs. Where commonality cannot be achieved, DARO will focus on interoperability.

Commonality and interoperability concepts that are necessary for successful UAV acquisition include the following:

- UAV systems must have common functions and should share as much common equipment and associated software as is practical to reduce life cycle cost and to simplify logistics support.
- UAV systems must be designed to fit into Service C4I architectures and with other UAV systems to be used effectively in multi-Service and Unified Command operations.
- UAV systems must allow for growth in performance and readily accommodate new component technologies to have long-term utility in the field. Figure 2-3 provides a pictorial of the UAV commonality that will exist among the Tactical and Endurance UAV Programs.

2.5 SUMMARY OF ACTIVE, INACTIVE, AND OTHER UAVs

Table 2-1 provides the characteristics of active DoD UAVs and Table 2-2 provides characteristics of inactive/terminated DoD UAVs for historic reference. Section 7 addresses other relevant non-DoD UAVs. Table 2-1 addresses more than the UAVs of the Joint Tactical UAV Program. It includes the operational Pioneer UAV system, systems that demonstrate vertical take-off and landing (VTOL) (attractive for small maritime combatant or other non-airfield applications), and very low-cost UAVs that could be considered expendable in many applications. UAV systems tend to be characterized by the air vehicle, and the tables are structured accordingly. However, as can be seen in Figure 2-4, the air vehicle is not the system cost driver. Lastly, a map of Government and industrial UAV testing and manufacturing activities in the US is included as Figure 2-5. Descriptive charts for inactive/terminated DoD UAVs, Figures 2-6 through 2-12, are included to provide background and address key lessons learned for future UAV efforts.

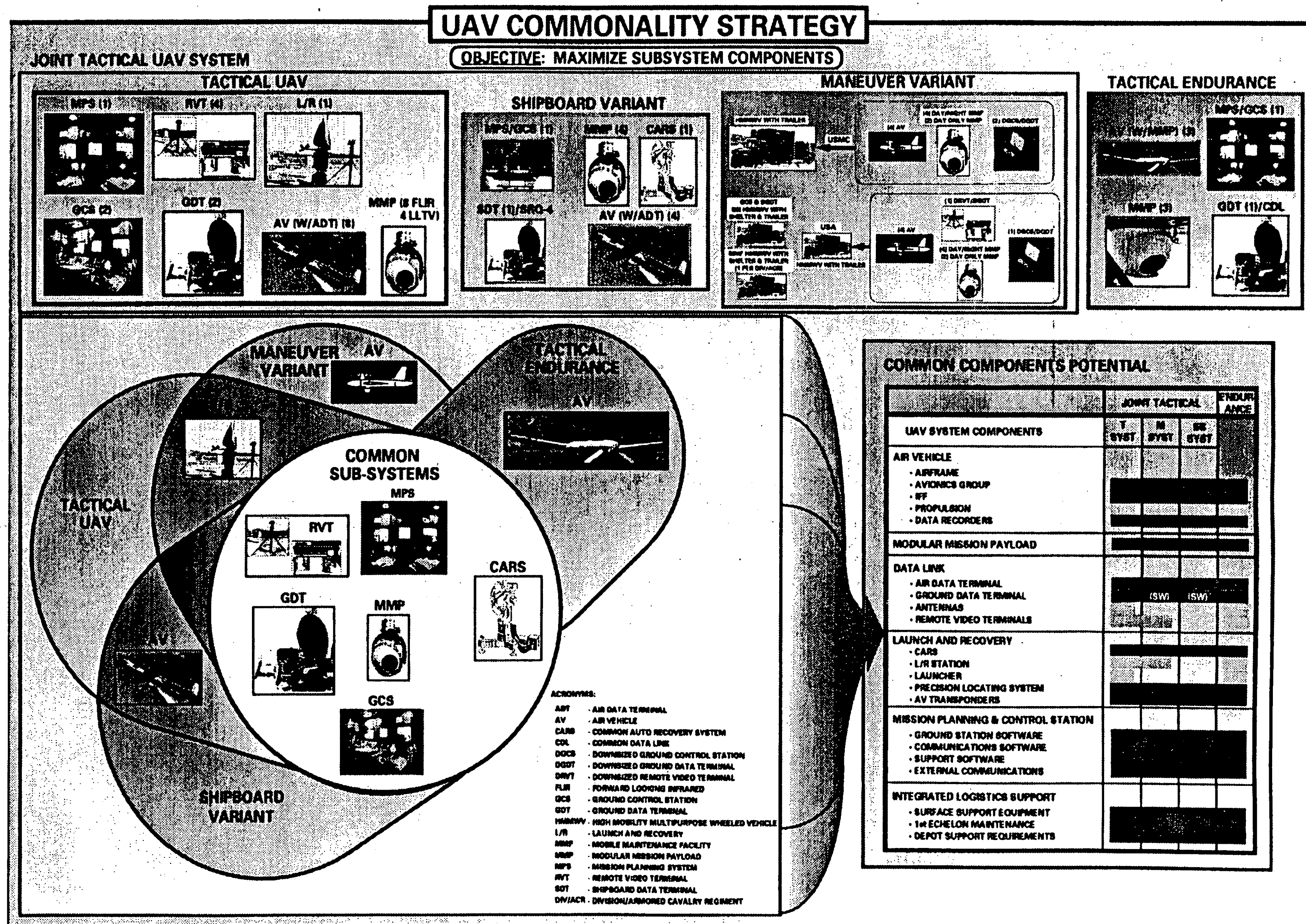


Figure 4-4 UAV COMMONALITY STRATEGY

Table 2-1 Active DoD UAVs

	TECHNOLOGY DEMONSTRATIONS						
System / Characteristic	Tilt Rotor	Vertical Launch/ Recovery	JPSD	RAPTOR	Pathfinder	Condor	Pointer
Altitude km	>6.5km	3.3 km	8.2 km	20 km	20 km	20 km	.32 km
Endurance hr	>2 hrs	5 hrs	24 hrs	>50 hrs	Weeks	48 hrs	1 hr
Radius of Action km	204 km	TBD	925 km	1000 km	Variable	7960 km	10 km
Speed km/hr	>370 km/hr Hover	280 km/hr	240 km/hr	325 km/hr	120 km/hr	460 km/hr	46 km/hr
Propulsion	1 Turboshaft 2 Propellors 420 hp	TBD	1 Recip 80 hp	1 Recip Turbochg 80 hp	8 Solar Electric 11 hp	2 Recip. turbochg. 175 hp	Battery 0.3 kw
Gross Take-off Weight kg	815 kg	TBD	400 kg	900 kg	240 kg	9230 kg	3.8 kg
Payload/Sensor Type	91 kg	91 kg	100 kg EO	80 kg EO/IR	20 kg	600 kg SAR/EO/IR SIGINT	0.35 kg TV
Data Link	C-Band	TBD	JTIDS SatCom	TBD	TBD	X-Band LOS	70-75 MHz 1.7-1.85 Downlir
Data Rate	20 MHz	TBD	TBD	TBD	TBD	274 Mbps	20 MHz
Deployment	N/A	N/A	N/A	N/A	N/A	Ferry	2-person carry
Launch/Recovery	VTOL	VTOL	Runway	Runway	Runway	Runway	Hand Laun Stall to Gro
Operation	PP or RC	PP or RC	PP	PP	PP	Auto	RC

NA = Not Applicable. Demo System
TBD = To be determined

SYSTEM CONCEPT DEMONSTRATION PROGRAMS					MAJOR DEFENSE ACQUISITION PROGRAM (MDAP) OR FIELDED SYSTEMS			
EXDRONE	MAVUS I/II	I-MAE (TIER-I)	MAE (TIER-II)	HAE (TIER-II+)	Tactical (MDAP)	Shipboard Variant (MDAP)	Maneuver Variant (MDAP)	Pioneer (Fielded)
3.05 km	3.3 km	Min - .5 km Max - 8.2 km	7.6 km	20 km	7 km	7 km	3 km	4.9 km
2-3 hrs	2 hrs	24 hrs	>24 hrs	>24 hrs	11.6 hrs	11.6 hrs	3 hrs	5 hrs
40 km LOS	60 km	925 km	930 km	1000-6000 km	275 km	275 km	52 km	185 km
160 km/hr	130 km/hr	240 km/hr	240 km/hr	550-740 km/hr	>165 km/hr	>165 km/hr	140 km/hr	158 km/hr
1 Recip 8 hp	1 Turboshaft	1 Recip. 80 hp	1 Recip. 80 hp	TBD	2 Recip. 60 hp	2 Recip. 60 hp	TBD	1 Recip 28 hp
40 kg	190 kg	400 kg	851 kg	6000-18000 kg	700 kg	700 kg	91 kg	200 kg
11.4 kg TV	45 kg EO/IR	100 kg EO/IR	205 kg SAR EO/IR	450-700 kg SAR/EO/IR	45 kg EO/IR (90 kg capable)	45 kg EO/IR (90 kg capable)	>23 kg EO/IR	45 kg TV, FLIR
485 MHz Uplink 1.7-1.88 GHz Downlink	C-Band	C-Band Relay	UHF/C Ku-band	50 Mbps SatCom + LOS	C-Band + LOS	C-Band + LOS	C-Band + LOS	C-Band
20 MHz	20 MHz	1.5 Mbps	1.5 Mbps	50 Mbps	20 MHz	20 MHz	20 MHz	20 MHz
Single C-130	N/A	Multiple C-130	Multiple C-130	Multiple C-130	Multiple C-130	Multiple C-130	Multiple C-130	4-5 per C-5 Shipboard
Rail/Parachute	VTOL	Runway	Runway	Runway	Unimproved Area/RATO	CV/CVN + LHA/LHD	Unim-proved Area	Runway, RATO/ Net
PP or RC	RC	PP	PP or RC	Auto	PP	PP	PP	PP or RC

PP = Preprogrammed
RC = Radio Controlled
Auto = Automatic

Table 2-2 Inactive DoD UAVs*

System / Characteristics	DEMONSTRATION PROGRAMS			DEVELOPMENT PROGRAMS			
	Raven† (UK)	Sprite† (UK)	SKYEYE (Greywolf)	AMBER	Aquila	Medium Range	Compass Cope
Altitude, km	5.2 km	2.6 km	5.9 km	8.8 km	3.9 km	Min- 2 km Max-14.8 km	18.3 km
Endurance, hrs	4 hrs	2 hrs	10 hrs	38 hrs	3 hrs	2 hrs	36 hrs
Radius of Action, km	35 km	31.5 km	148 km	2222 km	445 km	648 km	8000 km
Speed, km/hr	185 km/hr	130 km/hr	130 km/hr	222 km/hr	200 km/hr	925 km/hr	900 km/hr
Payload/Sensor Type, kg	17 kg EO, IR	6 kg EO, IR	80 kg TV, FLIR	38 kg EO/IR	27 kg TV, FLIR	130 kg EO, IR	318 kg

* Active after 1977, significant funds expended (>$50M)

† Foreign Cooperative Test supporting requirements determination (funding was less than $50M threshold)

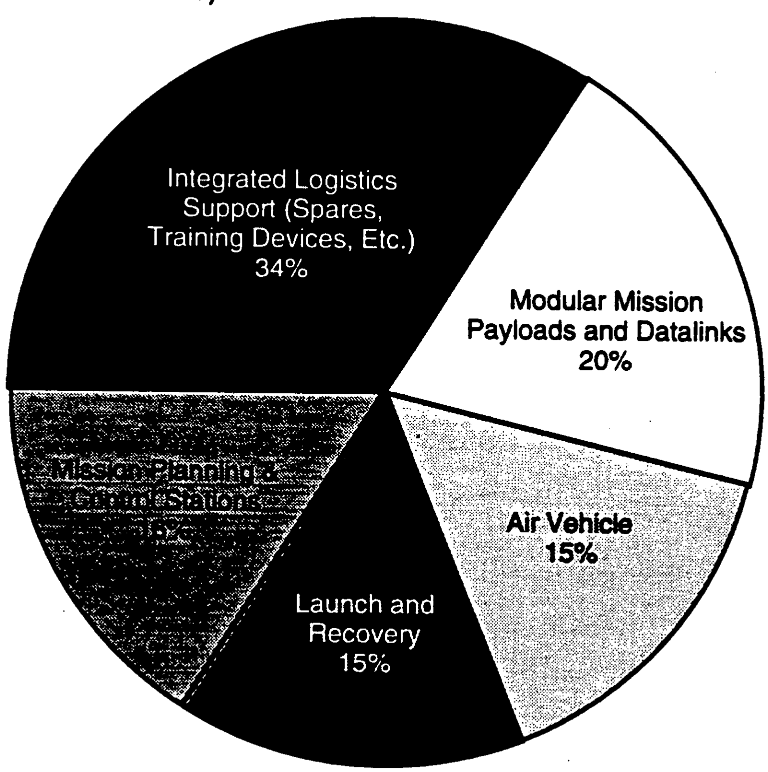


Figure 2-4 UAV Notional Subsystem Cost Breakout

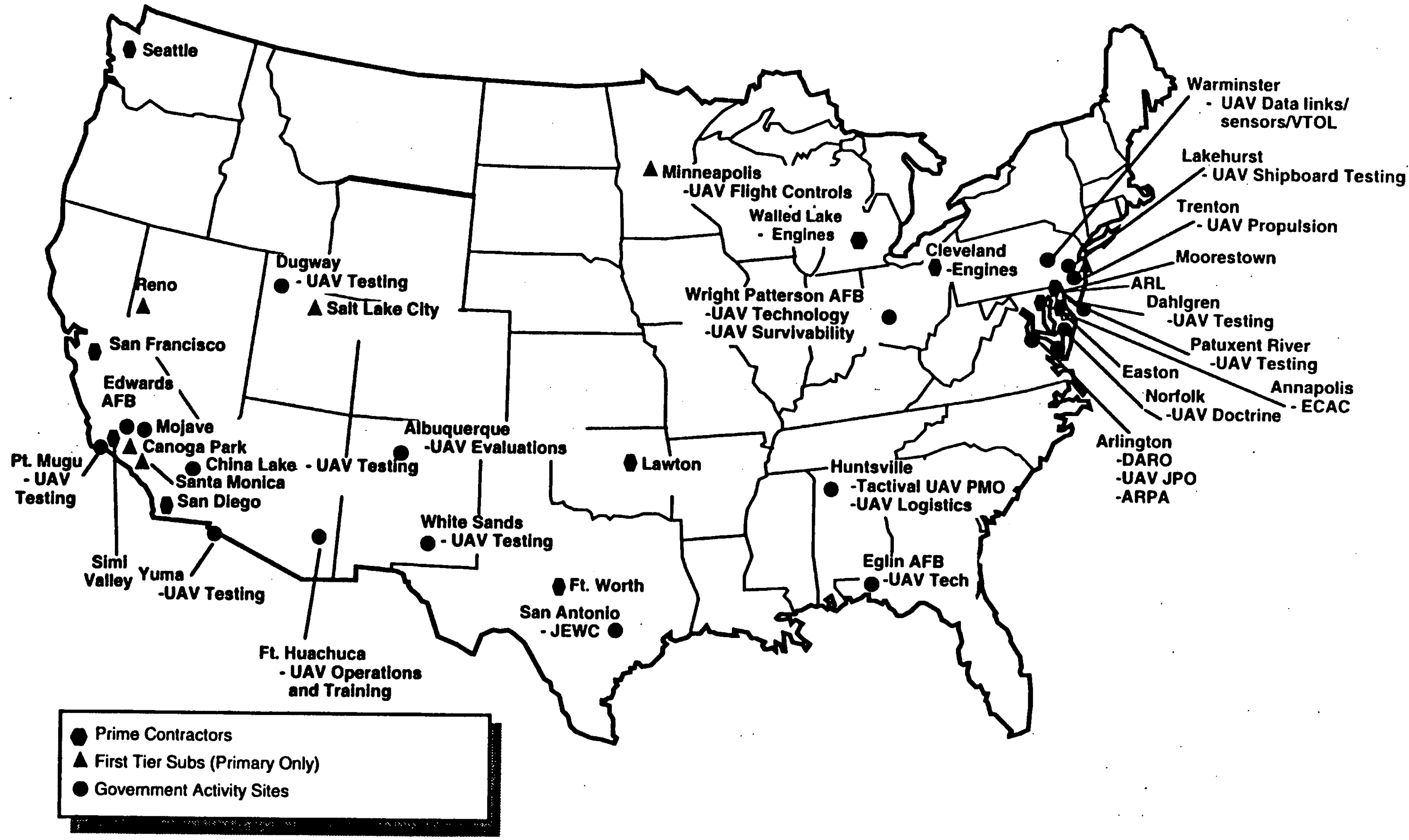
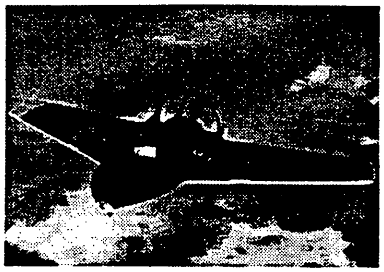


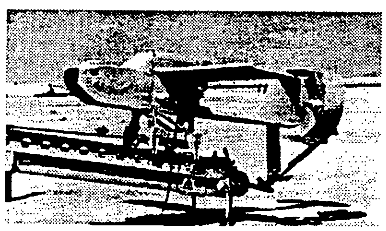
Figure 2-5 UAV Contractors and Government Activity Sites



Performance Parameters	
Altitude	3.7 km
Endurance	3 hours
Radius of Action	445 km
Speed	204 km/hr
Propulsion	2 stroke, recip, 26 hp
Gross T/O Wt.	583 kg
Payload	60 kg
Sensor Type	EO/IR, laser designator
Datalink	Digital, 50 Mbps, E-band
Deployment	1 System
Launch / Recovery	RATO & Rail / Net
Operation	Pilot-controlled and Preprogrammed

Key Lesson Learned: Requirements stability and need to capture user expectations

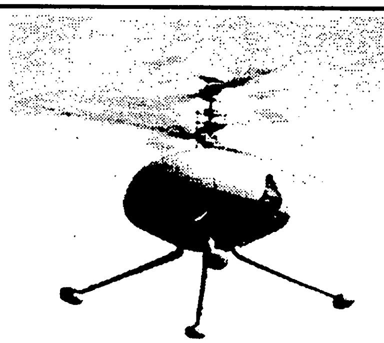
Figure 2-6 Aquila (Battlefield RSTA)



Performance Parameters	
Altitude	4.9 km
Endurance	3.5 hours
Radius of Action	35 km
Speed	182 km/hr
Propulsion	13 hp Sach Dolman piston engine
Gross T/O Wt.	407 kg
Payload	84 kg
Sensor Type	EO/IR
Datalink	
Deployment	Test Only
Launch / Recovery	Rail / Skid, parachute
Operation	Preprogrammed

Key Lesson Learned: Benefits of Off-the-Shelf Technology

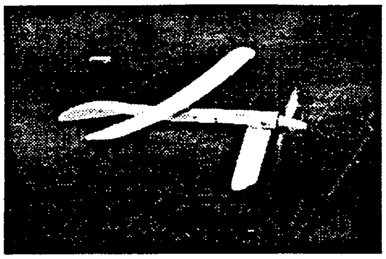
Figure 2-7 Raven (Foreign Comparative Test of Close Range UK System)



Performance Parameters	
Altitude	2.4 km
Endurance	2 hours
Radius of Action	31.5 km
Speed	130 km/hr
Propulsion	2 6 hp piston engines
Gross T/O Wt.	194 kg
Payload	29 kg
Sensor Type	EO/IR
Datalink	
Deployment	Test Only
Launch / Recover	VTOL
Operation	Pilot-Controlled

Key Lesson Learned: Benefits of Off-the-Shelf Technology

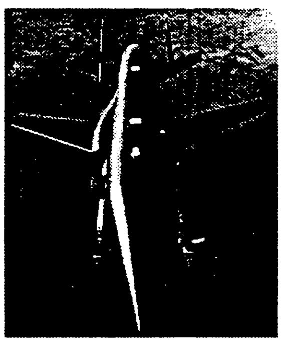
Figure 2-8 Sprite (Foreign Comparative Test of VTOL UK System)



Performance Parameters	
Altitude	8.2 km
Endurance	38 hours
Radius of Action	2222 km
Speed	222 km/hr
Propulsion	
Gross T/O Wt.	1067 kg
Payload	
Sensor Type	EO/IR
Datalink	Digital, 80 mps, X-band
Deployment	
Launch / Recovery	Airfield / Airfield
Operation	Pilot-controlled and Preprogrammed

Key Lesson Learned: Criticality of Systems Integration and Cost Control

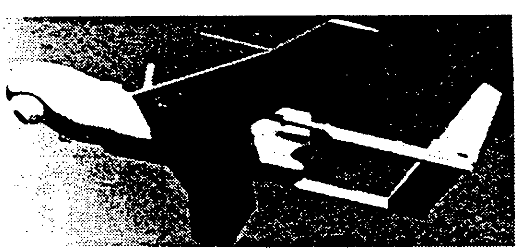
Figure 2-9 Amber (High Altitude, Long Endurance)



Performance Parameters	
Altitude	13.7 km
Endurance	2 hours
Radius of Action	1200 km
Speed	1019 km/hr
Propulsion	Turbojet
Gross T/O Wt.	2420 kg
Payload	638 kg
Sensor Type	EO/IR
Datalink	MIDL/MIST 120-140 Mbps
Deployment	
Launch / Recovery	RATO Air / Airfield
Operation	Preprogrammed

Key Lesson Learned: System Affordability and Issues Associated with Integration of Sensor

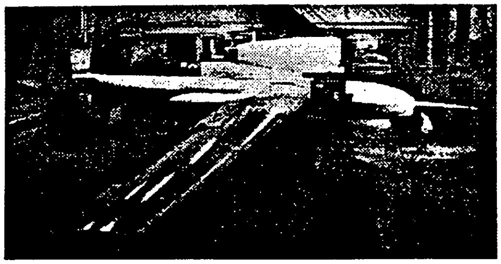
Figure 2-10 Medium Range (Pre- & Post-Strike Reconnaissance and BDA)



Performance Parameters	
Altitude	5.9 km
Endurance	10 hrs
Radius of Action	148 km
Speed	130 km/hr
Propulsion	Internal Combustion, propellor
Gross T/O Wt.	330 kg
Payload	80 kg
Sensor Type	VIDEO/FLIR
Datalink	unk
Deployment	C-130
Launch / Recovery	Catapult
Operation	Remote pilot

Key Lesson Learned: Criticality of Systems Integration / Engineering

Figure 2-11 SKY EYE



Performance Parameters	
Altitude	18 km
Endurance	25 hrs
Radius of Action	unk
Speed	unk
Propulsion	Turbojet
Gross T/O Wt.	6400 kg
Payload	318 kg
Sensor Type	None
Datalink	unk
Deployment	Self
Launch / Recovery	Improved airfield
Operation	Remote pilot

Key Lesson Learned: Software Integration, Cost Control, and Concept of Operations

Figure 2-12 Compass Cope

3. CONCEPT OF OPERATIONS

3.1 HISTORIC BACKGROUND

The UAV provides an additional critical warfighting capability to the field commander. The family of UAVs is uniquely qualified to conduct day/night RSTA, BDA, and battlefield management at all levels and intensities of conflict. Employment of the UAVs in Desert Storm proved the capability of UAV systems in a highly lethal, possibly contaminated combat environment.

> The Vice Chairman JCS, as the JROC Chairman, stated, "The exceptional utility of PIONEER in Operation Desert Storm...reinforces the importance of the requirement for this capability. PIONEER proved that the utility of the unmanned aerial vehicle can be decisive in future battles."

The UAV system provides the commander with an enhanced capability to collect, disseminate, and exploit combat intelligence information in near-real-time in all types of environments.

DARO, in coordination with the Joint Staff and Services, will work with tactical users across the Services to assure that the employment doctrine evolves with the technical capabilities. DARO will likewise ensure that warfighter training reflects the unique contribution of UAVs employed in isolation (e.g., in Special Operations), as well as in concert with other airborne, national, and tactical assets.

Reliable and effective UAVs have proven to be a force multiplier. Over three hundred UAV sorties totaling over 1000 flight hours were flown in Desert Storm with outstanding results. (See Section 2 for further discussion of UAVs in Desert Storm.) UAV class categories can be selected or tailored to achieve maximum flexibility and thus enhance mission success.

3.2 EMPLOYMENT CATEGORIES

This DARO plan addresses broad concepts for both tactical and endurance UAV systems. The Joint Tactical program comes in three variants: Tactical, the Shipboard Variant, and the Maneuver Variant. The endurance program has two variants: Medium Altitude Endurance (MAE) and High Altitude Endurance (HAE). The MAE UAV system will provide a quick response RSTA capability supporting the JTF and below with up to twenty-four hours of on-station capability. The air vehicle will carry electro-optical (EO) and synthetic aperture radar (SAR) imagery sensors and will have satellite relay for beyond line-of-sight missions at nominal collection altitudes of 4900 to 8200 m. The HAE will carry larger, multiple discipline (SIGINT, Imagery Intelligence (IMINT), and satellite and communication relay) payloads and will provide the JTF commander and subordinate tactical units with on-demand reconnaissance collection coverage across all mission areas with an on-station duration in excess of 24 hours at ranges of 5600 km.

As stated in Joint Pub 3-55.1, Joint Tactics, Techniques, and Procedures for Unmanned Aerial Vehicles, the Services have developed and integrated UAV employment techniques to enhance their overall warfighting capabilities. The UAV systems, required support personnel, and ground control stations will normally remain under operational control of their Service component commander. Although the doctrine for endurance UAVs is yet to be developed, it is anticipated that similar practices will apply.

The Joint Force Commander (JFC) has the authority to provide guidance and to direct UAV assets for the overall support of his campaign plan. The JFC may direct the Joint Force Air Component Commander (JFACC) to coordinate UAV operations to support the JFC campaign plan and, where necessary, to support other component plans and objectives which support the overall JFC plan. Such tasking is accomplished consistent with applicable Joint Publications and published along with all other reconnaissance assets in the daily air tasking order (ATO).

DARO recognizes that as UAV systems gain increased capability and high performance UAV systems gain collection responsibility over larger regions, the imagery systems must be integrated into the CIO Imagery System Architecture, including linkage to the Requirements Management System (RMS), where appropriate.

3.3 TACTICAL AND ENDURANCE SPECIFIC CONCEPTS OF OPERATIONS

3.3.1 Tactical

Each Service CONOPS is based on Service force structure and doctrine.

The USA Tactical UAV CONOPS calls for fielding two Tactical UAV systems per Corps. The Tactical UAV will be a prime asset, using its relay capability, to help meet the Corps RSTA and deep targeting requirements out to 300 km beyond the FLOT. The USA will field one Tactical UAV system to each heavy division and heavy armored cavalry regiment (ACR). The

Tactical UAV system will be a prime asset to meet the division-level RSTA and deep targeting needs out to a range of 150 km beyond the FLOT. The Army UAV CONOPS (Figure 3-1) calls for fielding the Maneuver Variant UAV system to help meet the needs of the brigade for close battle targeting and RSTA. The USA need for an endurance UAV to be fielded at the Echelons Above Corps (EAC) is contained in the Endurance MNS. A draft Operational Requirements Document (ORD) is in staffing. The USA plans to field five Maneuver Variant UAV baseline systems to each light division and light ACR, and three Maneuver Variant UAV baseline systems to each heavy division, heavy ACR, airborne and air assault division. In the light division, where the Tactical UAV System support requirements exceed the division's capabilities, the Maneuver Variant UAV will be both the divisional general support (GS) asset and the brigade direct support (DS) asset. In the heavy division and heavy ACRs, the Maneuver Variant UAV will be in direct support of each brigade, provide a prime asset to target the brigade's direct support weapons systems, and provide RSTA out to a range of 30 km beyond the FLOT. The UAV systems provide direct real-time connectivity to their echelon's fire support and intelligence infrastructure, and will have connectivity with Tactical Artillery Fire Control (TACFIRE), Advanced Field Artillery Tactical Data System (AFATDS), All-Source Analysis System (ASAS), and JSTARS Ground Station Modules (GSM). Both the tactical and maneuver UAV baseline systems provide a jump/overlap capability to allow for coverage during movement at each echelon.

USMC Tactical UAV CONOPS (Figure 3-2) calls for the deployment of one system with eight air vehicles per MEF. The system is part of the UAV company within the Surveillance, Reconnaissance and Intelligence Group (SRIG). It will be employed in direct or general support of all levels of MAGTFs. During a 24-hour period, the UAV system will be capable of a maximum of 16 hours of reconnaissance coverage. In the relay mode, with one collecting UAV and one relay UAV aloft, the system will conduct long missions for aviation support out to a range of 300 km beyond the FLOT. The USMC requires five systems total, with two systems on the West coast in support of the I and III MEF and one system on the East coast in support of II MEF. Two systems are war reserves/maintenance float. The systems are designed to have connectivity with the AFATDS, Intelligence Analysis System (IAS), and JSTARS GSMs.

The USMC Maneuver Variant CONOPS (Figure 3-3) calls for the deployment of five UAV systems with the UAV company of the SRIG. The system will be employed in general and direct support of all levels of MAGTFs. Ground control stations must be capable of entering appropriate fire support and intelligence networks to include (but not limited to) the AFATDS,

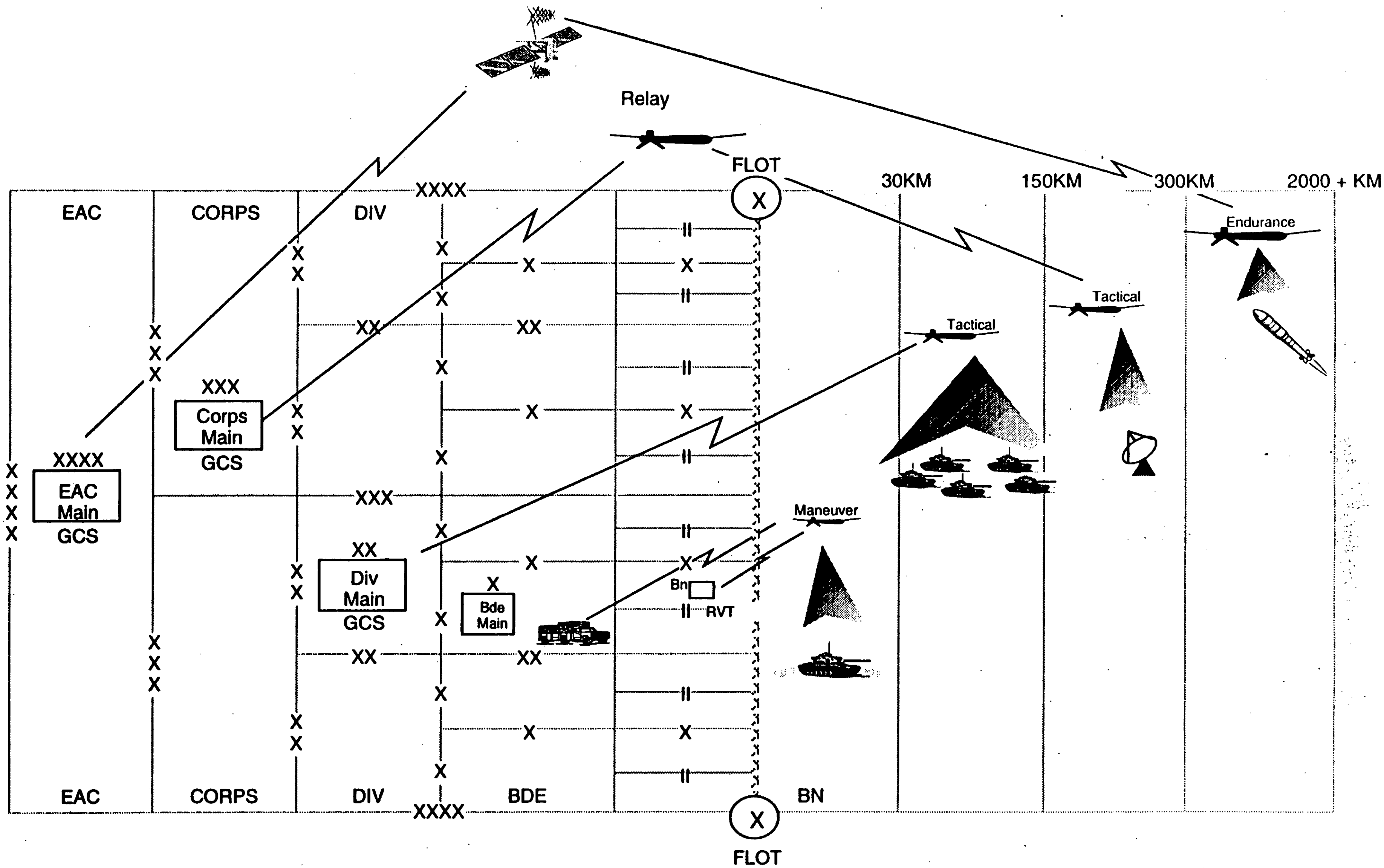


Figure 3-1 Army Maneuver UAV CONOPS

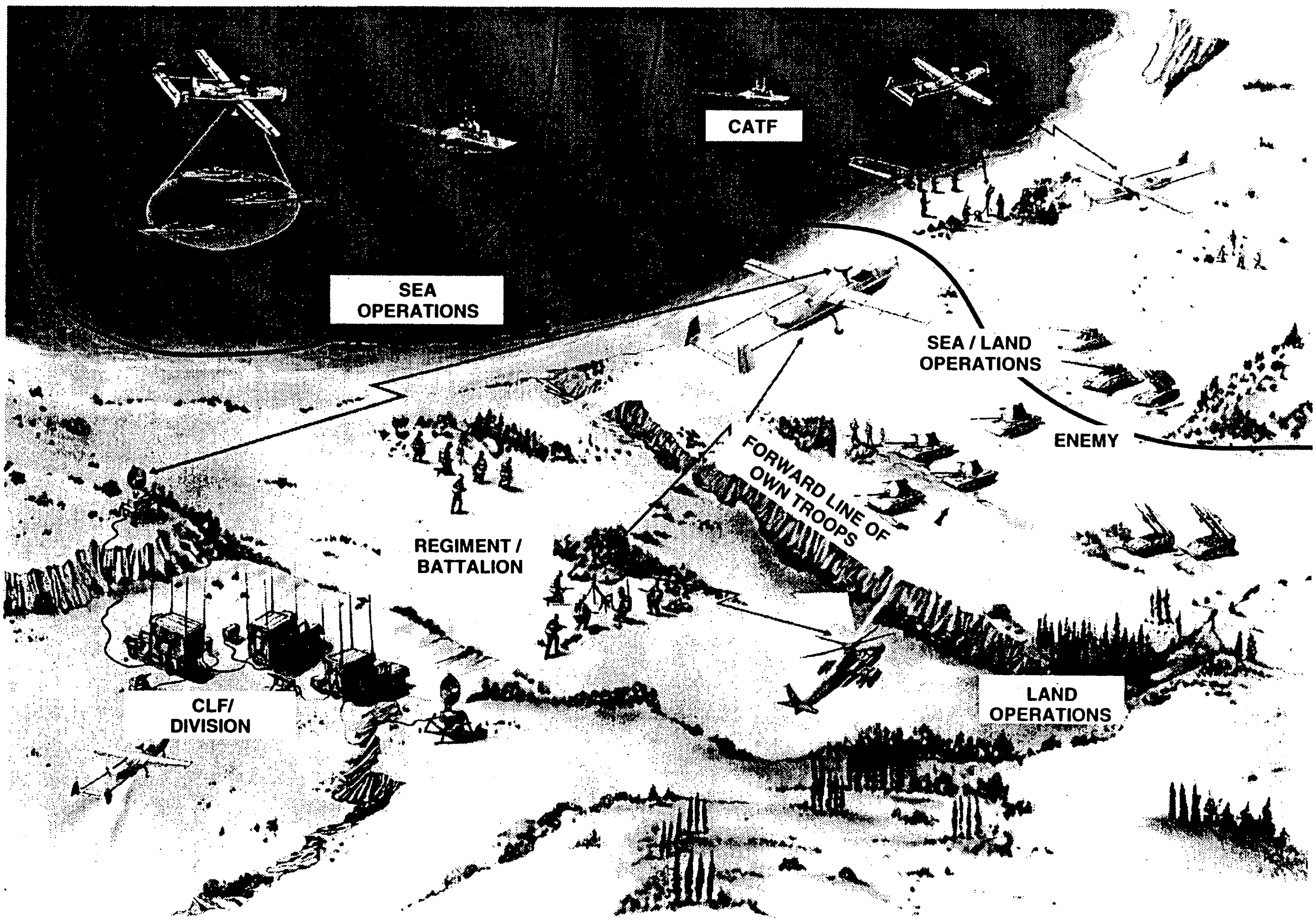


Figure 3-2 USMC TACTICAL UAV CONCEPT OF OPERATIONS

TACFIRE (Version 10), and IAS. The system must have connectivity with the JSTARS GSM. It will support artillery, aviation, light armored infantry, and other operations 30 km beyond the FLOT. The period of coverage provided is 12 out of every 24 hours. The USMC has a requirement for 20 Maneuver Variant UAV systems to provide direct support for each regiment, Marine Expeditionary Unit (MEU), and Maritime Pre-position Squadrons. Initially, five Maneuver Variant systems will be centrally located in each SRIG to optimize training, maintenance, and tasking, with the remaining systems in war reserve/maintenance float.

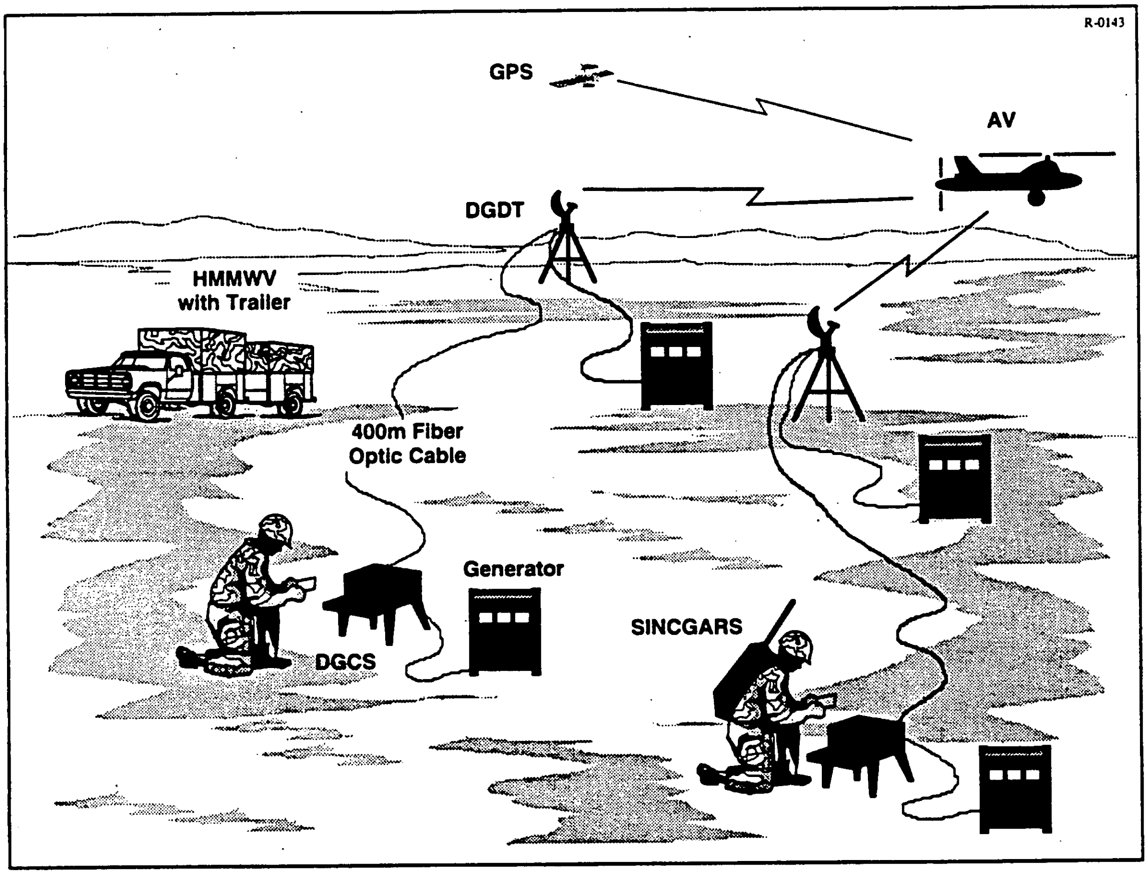


Figure 3-3 Maneuver UAV Concept of Operations (USMC)

The USN notional UAV CONOPS (Figure 3-4) calls for the employment of the Shipboard Variant of the Tactical UAV System. Each Shipboard Variant system will include eight air vehicles. The system will be supported by 15 VC-6 detachments. The system will be capable of providing up to 24 hours tactical coverage and will be deployable at all times aboard as many as 23 CV/CVN and LHA/LHD ships. The notional CONOPS calls for 18 systems distributed in the following scheme: fourteen systems to support East and West coasts, two systems for Western Pacific Command (WESTPAC), and two systems for training. Information will flow into the Combat Information Center or Joint Intelligence Center (JIC), if applicable. The Tactical GCS will be integrated into or on existing ship spaces. With a relay-configured UAV airborne, the system will be capable of receiving RSTA data in excess of 200 km.

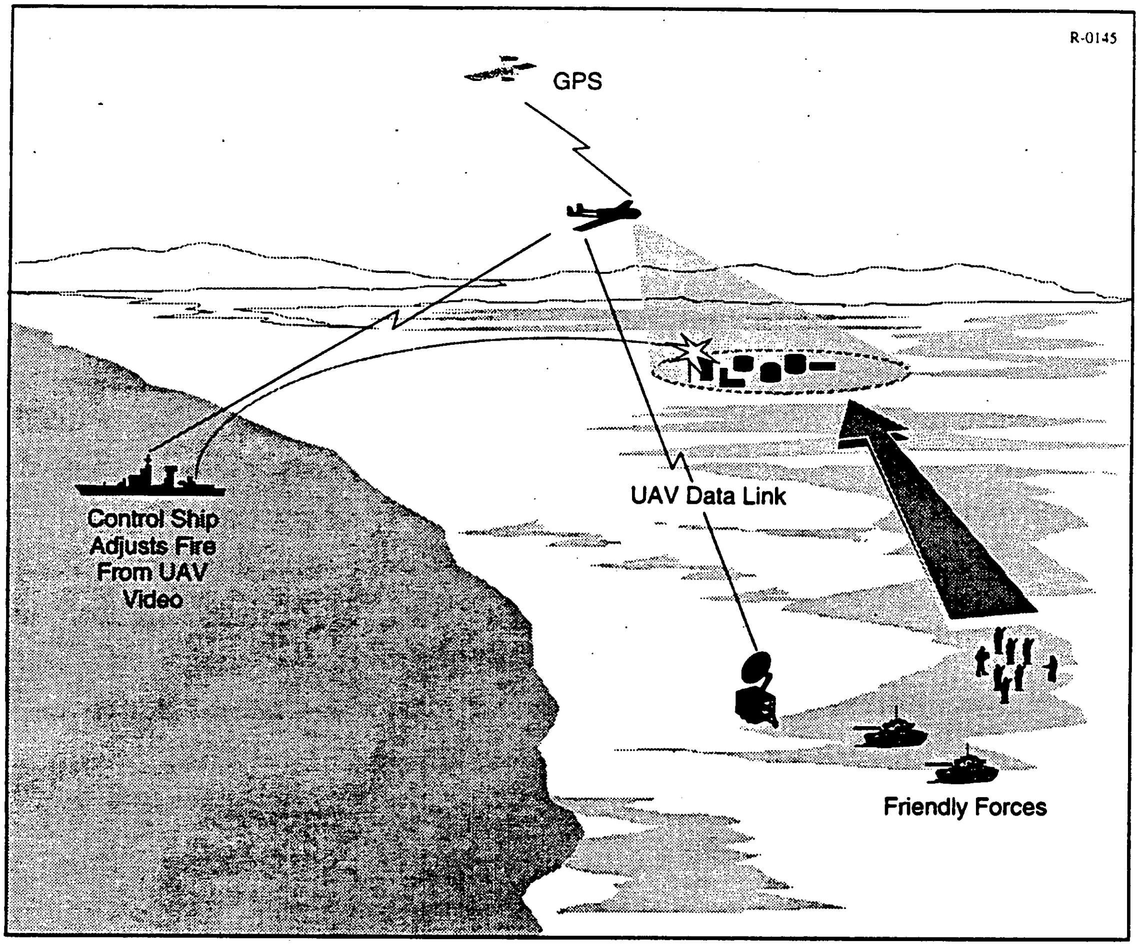


Figure 3-4 Shipboard Variant Concept of Operations

3.3.2 Endurance

The following describes the interface relationships that endurance UAV systems have with external systems and provides identification of information-users, up to and including the national levels. There are two endurance UAV concepts. The Medium Altitude Endurance UAV provides a rapid response capability to the user. This system concept demonstration has as its objective the development of a concept of operations for tasking, control, airspace management, etc. The High Altitude Endurance UAV is a long-term demonstration with greater payload, altitude, and range capability than MAE, and will provide capabilities far in excess of those formerly provided by penetrating reconnaissance platforms.

The MAE UAV system operating at low-to-medium altitudes will possess the capability to disseminate releasable, high resolution imagery (visible, IR and SAR) to warfighting tactical users, the JFC, JIC/Joint Analysis Center (JAC), and the National Military Joint Intelligence Center (NMJIC). The MAE UAV will make an immediate contribution to the warfighting capability of operational forces. The specific MAE CONOPS is in coordination and will address operations and users of information. The MAE will greatly improve the quality and timeliness of battlefield information while reducing the risk of capture or loss of aircrews and allow more rapid and better informed decisions by the JFC and his supported forces.

While reconnaissance, surveillance, and target acquisition are the primary missions for MAE, this system could also be employed to demonstrate additional capabilities in electronic warfare, battle damage assessment, Signals Intelligence (SIGINT), mine detection, command and control, meteorological collection, communications relay, environmental sampling, and special operations mission support. The MAE UAV provides long-dwell surveillance capabilities that are particularly valuable when cued by existing national, theater, and tactical collection systems. It can readily perform hazardous missions for extended periods of time: those in contaminated environments; those with extremely long flight times; and those with unacceptable political risks for manned aircraft. Allotting these dangerous or tedious missions to the MAE UAV increases the survivability of manned aircraft and frees aircrews for missions requiring the flexibility of a manned system.

The imagery products from MAE UAV will include: freeze frame/video clips via the Joint Defense Intelligence Support System (JDISS); motion video via the Joint Worldwide Intelligence Communications System (JWICS); verbal reports directly to tactical forces; and full video tapes via courier. Inherent in this connectivity is the utilization of TROJAN SPIRIT II which provides C, X, and Ku band; UHF (line-of-sight and satellite); and VHF communications. See Figure 3-5.

The HAE UAV system will alleviate the lack of broad area coverage, point target reconnaissance, and sustained point surveillance identified as a key deficiency during Desert Storm and in the Deep Target Surveillance/Reconnaissance Study as well as the Defense Science Board (DSB) Global Surveillance Study. The primary sensor will be a SAR that is capable of down-linking directly, or via satellite, to the Joint Force Commander and components. The initial requirement is to search over 136,000 km^2 per day and provide 1900 point targets per day for

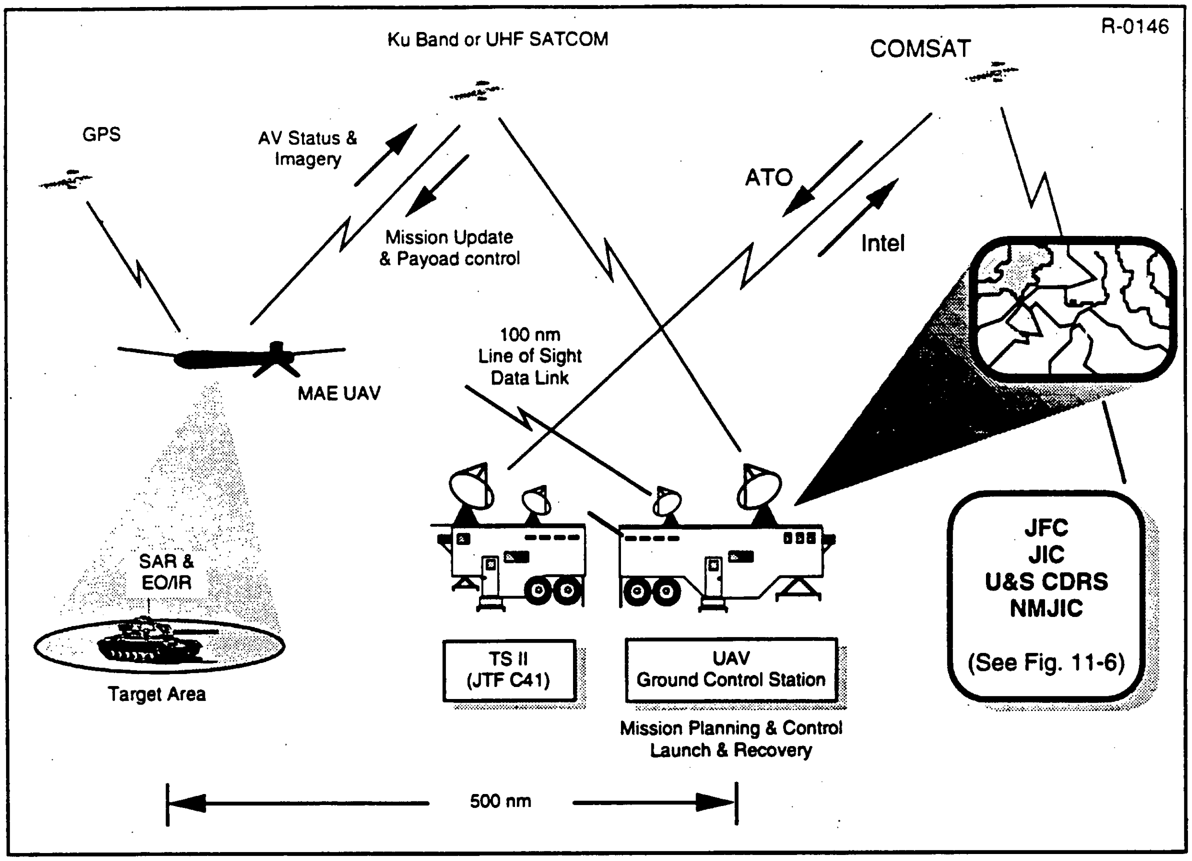


Figure 3-5 Medium Altitude Endurance (MAE) UAV Concept of Operations

pre and post strike reconnaissance. Since this system has a minimum on-station duration of 24 hours at a distance of 5600 km, it will provide the critical targeting necessary to support a task force commander during a major regional conflict. The specific HAE formal CONOPS is in coordination and will address operations and users of information. The main users will be the theater and tactical elements, but simultaneous availability to national users will also be accommodated. See Figure 3-6.

3.4 AIRSPACE CONTROL

As previously stated, the Pioneer UAV had some shortfalls in Desert Storm. Some of the shortfalls included airspace control and EMI. Airspace control is provided to prevent mutual interference from all users of the airspace, facilitate air defense identification, and accommodate and expedite the flow of all air traffic safely. The JFACC is responsible for airspace control plans

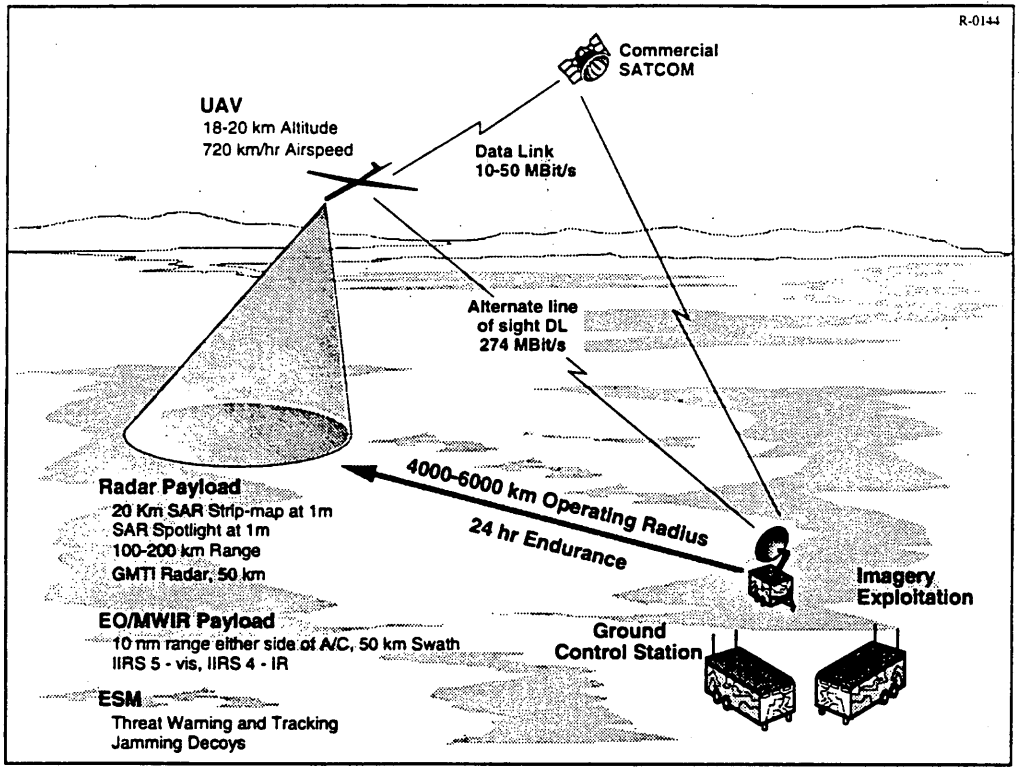


Figure 3-6 High Altitude Endurance (HAE) UAV Notional Concept of Operations

and procedures through use of an airspace control plan (ACP) following the guidance contained in Joint Pub 3-52. Over-flight permission prior to outbreak of hostilities must be fully orchestrated with the host nation supporting the UAV operations.

DARO is working with the UAV users to provide UAV systems with the capability and flexibility to preclude operational losses due to mutual radio/radar interference, EMI, and supporting integrated operator training with forces. Command, Control, and Communication (C3), along with launch and recovery procedures and operations must be established prior to UAV employment in a crisis or war.

4. TACTICAL UAV PROGRAMS

4.1 JOINT TACTICAL UAV PROGRAM — A MAJOR DOD PROGRAM

4.1.1 Background

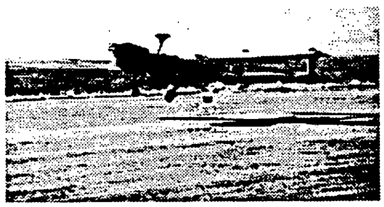
All tactical UAV programs are managed by the UAV JPO. The UAV JPO provides acquisition and full life cycle support, and works closely with the Service users to develop integrated operational employment concepts. The Joint Tactical UAV Program is the baseline for the family of UAVs. Along with its Shipboard and Maneuver Variants, it will answer the warfighting Commander in Chief's (CINC) continuing need for an unmanned means of conducting:

- Day and night aerial reconnaissance
- Intelligence collection
- Surveillance, and target acquisition
- Communications/data relay
- Electronic warfare
- Collection of weather data to support combat operations
- Minefield detection
- Nuclear, biological, and chemical sensing day and night, and in limited adverse weather.

The requirements for tactical UAVs exist during peacetime as well as at all levels of conflict for employment in both land- and sea-based environments. They are critical in situations where immediate information feedback is needed and manned aircraft are unavailable, or when excessive risk or other conditions render such use impractical or imprudent.

The Joint Tactical UAV Program consists of three systems:

- The Tactical UAV for use by USA division to EAC levels, and all levels of MAGTFs (Figure 4-1)
- The Shipboard Variant of the Tactical UAV for use by Naval Expeditionary Warfare Commanders on big deck amphibious assault ships (LHA/LHD class) and aircraft carriers (CV/CVN) (Figure 4-2)
- The Maneuver Variant for use by lower level units such as USA brigades/battalions and USMC regiments/battalions/companies (Figure 4-3).



Performance Parameters

Altitude	7 km
Endurance	11.6 hours
Radius of Action	275 km
Speed	> 165 km/hr
Propulsion	2 engines, 2 cylinder, 4 stroke 60 hp
Gross T/O Wt.	700 kg
Payload	45 kg
Sensor Type	EO/IR
Datalink	C Band Analog, BW 20 MHz
Deployment	Multiple C-130s
Launch / Recovery	Unimproved Area 200 m x75 m
Operation	Preprogrammed Flight

Key Information

Program status: Development
- Early Fielding
- IOT&E
- MS III

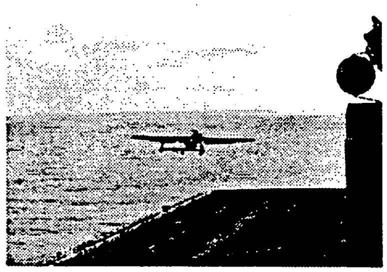
User USA, USMC, USN

Contr Agency UAV JPO
Prog Manager Col P.K. Tanguay
(205) 895-4449

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
IPR	Δ					
Early Fielding	Δ					
IOT&E		Δ				
MS III			Δ			
IOC			Δ			

Figure 4-1 Tactical UAV



Performance Parameters

Altitude	7 km
Endurance	11.6 hours
Radius of Action	275 km
Speed	> 165 km/hr
Propulsion	2 engines, 2 cylinders, 4 stroke, 60 hp
Gross T/O Wt.	700 kg
Payload	45 kg
Sensor Type	EO/IR
Datalink	C Band Analog, BW 20 MHz
Deployment	Shipboard
Launch / Recovery	CV/CVN and LHA/LHD
Operation	Preprogrammed Flight

Key Information

Program status: Development
- Maritime R&D
- IOT&E
- Automated Recovery System

User USN, USMC

Contr Agency UAV JPO
Prog Manager Col P.K. Tanguay
(205) 895-4449

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Contract Award (CARS)	Δ	Δ				
DT (CARS)		Δ				
Del 1st USN Sys			Δ			
USN Log Demo			Δ	Δ		
IOC					Δ	

Figure 4-2 Shipboard Variant of Tactical UAV

Cost and Operational Effectiveness Analysis (COEA) in progress	Performance Parameters

Performance Parameters

Altitude	2 km
Endurance	3 hours
Radius of Action	52 km
Speed	140 km/hr
Propulsion	TBD
Gross T/O Wt.	91 kg
Payload	23 kg
Sensor Type	EO/IR
Datalink	C Band Analog, BW 20 MHz
Deployment	1 C-130
Launch / Recovery	Unimproved Area (30 x 75)
Operation	Preprogrammed flight

Key Information

Program status: Development
- Contract awards for downsized equipment
- Contract award for common GCS

User USA, USN, USMC

Contr Agency UAV JPO
Prog Manager Col P.K. Tanguay
(205) 895-4449

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
IPR	Δ					
Downsize Equip DT		Δ				
System CDR			Δ			
DT/OT			Δ	Δ		
Full Production					Δ	—

Figure 4-3 Maneuver Variant of Tactical UAV

4.1.2 Status

The Tactical UAV received Defense Acquisition Board (DAB) approval for low-rate production (LRP) of seven systems[1] on 19 January 1993. Delivery of the seven LRP systems will occur from May 1994 through April 1995. Early fielding of the first LRP system is expected to occur in late FY94. The operating tempo (OPTEMPO) demonstration will occur in early FY95, followed by the first article test. The initial operational test and evaluation (IOT&E) will occur in July 1995. Seven systems will be sought in early FY95 to maintain production capability and to provide sufficient hardware to support all training, test, and fielding activities.

The currently planned Shipboard Variant program will focus on integrating the system into the host ships. This approach uses existing Tactical UAV hardware, software, and equipment; however, some of the equipment (such as the GCS) will be removed from their shelters and placed in shipboard spaces. Other required efforts include installation of a launch

[1] A system is defined as eight air vehicles and necessary support equpment.

and recovery system (to include auto recovery), full marinization of the air vehicle, and establishment of intermediate level maintenance aboard ship.

Research and development (R&D) tasks for the Shipboard Variant program have been identified and can begin as early as FY94. With a FY94 start, estimated completion of the R&D phase and initial operational capability (IOC) is expected in early FY98.

The Maneuver Variant will continue to pursue acquisition of common Tactical UAV GCS hardware, which is part of the USA system. Contract award for the common Tactical hardware will occur in February 1994. The downsized Tactical GCS, ground data terminal (GDT), and remote video terminal (RVT) contract award is scheduled for April 1994. This equipment will be integrated with an air vehicle, modular mission payload, air data terminal, launch and recovery equipment, and the common Tactical systems equipment.

4.2 FIELDED SYSTEMS — PIONEER - THE INTERIM OPERATIONAL TACTICAL UAV SYSTEM

4.2.1 Background

Operations in the early 1980s in Grenada, Lebanon, and Libya identified a need for an on-call, inexpensive, unmanned, over the horizon targeting, reconnaissance and BDA capability for local commanders. As a result, in July 1985, the Secretary of the Navy (SECNAV) directed the expeditious acquisition of remotely piloted vehicle (RPV) systems for fleet operations using non-developmental technology. Two Pioneer systems were procured by the USN for an accelerated testing program in 1986. In September 1987, routine deployment of the Pioneer system on board battleships commenced. During 1987, three systems were delivered to the USMC, and within the next seven months they were deployed to Morocco in support of an Allied amphibious assault training operation, and to the USMC base at Camp Pendleton, CA for Exercise Kernel Blitz. In 1990, a system was delivered to the USA. Between 1986 and 1992, over 7,500 Pioneer flight hours were logged. The USN has deployed Pioneer on four battleships supporting worldwide operations in Africa, northern Europe, the North Atlantic, Korea, the Mediterranean, and contingency operations in the Persian Gulf. The USMC has integrated Pioneer support with Weapons and Tactics Instructor (WTI) courses, a wide variety of exercises, and the US Customs Service in drug interdiction missions. The USA has used Pioneer in support of numerous exercises including those at the National Training Center and in the Republic of Korea. During Operations Desert Shield/Desert Storm, the six operational USA, USN, and

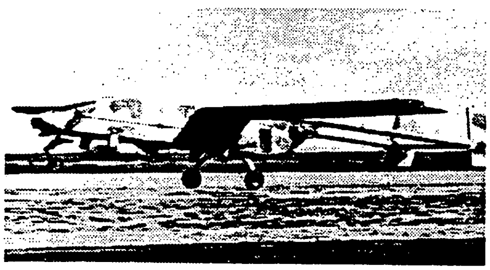
USMC units flew over 300 missions. USN assets were used for battleship target selection, spotting naval gunfire, and BDA. The USMC used Pioneer to direct air strikes and provide near-real-time reconnaissance for special operations, and the USA used Pioneer to accomplish BDA, area searches, route reconnaissance, and target location.

As the Tactical UAV transitions into USA and USMC units, additional land-based Pioneer systems will be provided to the USN; some will be "marinized" and installed aboard amphibious ships, and others will be used as spares to support ship deployments. Current estimates reflect Pioneer ground units transitioning to the Tactical UAV in FY97 or beyond. Pioneer is presently deployed in three USMC UAV companies, one USA company (assigned to the 304th Military Intelligence Batallion at Ft. Huachuca, AZ), and two USN detachments aboard LPD-4 class ships, with additional systems assigned to the DoD UAV Training Center at Ft. Huachuca, AZ, the Fleet Assistance Support Team (FAST) at Pt. Mugu, CA, and the USN's detachment at Patuxent River, MD. There is no Allied cost sharing in the Pioneer program.

4.2.2 Status

Pioneer is fielded in the USA, USN, and USMC with life cycle support provided by the UAV JPO. Present JPO Pioneer efforts are focused on two primary tasks (see Figure 4-4). The first is to improve the system's operational readiness. An aggressive program, albeit with limited funding, is underway to accomplish this. Readiness requirements are being addressed to identify more accurately the equipment, parts and supplies, and training needed to keep Pioneer units operating effectively until the Tactical UAV is available.

Pioneer system improvements are being evaluated for implementation as well as improved safety programs and standardized operations and maintenance practices. In addition, plans for transitioning of Pioneer systems to the USN for installation aboard amphibious-class ships have been developed and will be implemented with the phasing-in of the Tactical UAV for USA and USMC units. A major element of this plan is the outfitting of an additional six amphibious ships with the equipment required to conduct Pioneer operations at sea.



Performance Parameters

Altitude	4.9 km
Endurance	5 hours
Radius of Action	185 km
Speed	158 km/hr
Propulsion	Gasoline, 2 stroke, reciprocating engine 26.8 hp
Gross T/O Wt.	200 kg
Payload	45 kg
Sensor Type	TV, FLIR
Datalink	C Band Analog, BW 20 MHz
Deployment	4 systems (C-5)
Launch / Recovery	Rato, airfield / net
Operation	Piloted

Key Information

Program status: Fielded

- Provide an RSTA, BDA and battle field management UAV capability for the operating forces

User USA, USMC, USN

Contr Agency UAV JPO
Prog Manager CAPT A. Hutchins
(703) 692-4313

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Basic Shipalt Installations	▲		△			
• LPD13	△					
• LPD15	△					
• LDP8		△				
Detachment Standup	▲		△			
• Det H	△					
• Det I		△				
• Det J		△				

Figure 4-4 Pioneer (Interim Tactical UAV System)

5. TACTICAL UAV DEMONSTRATIONS

Tactical UAV operational and technology demonstrations have been conducted by the UAV JPO to:

- Allow users to acquire hands-on experience with UAV systems
- Provide assessments of emerging technologies that can improve performance, reduce cost, and provide different capabilities.

Demonstrations in the tactical UAV arena have been used to explore the viability of very low cost UAVs (less than $30,000 per air vehicle) and the maturity of VTOL air vehicles. Very low cost UAVs are an inexpensive way for user communities to become familiar with UAV operations and employment concepts. In their own right, they may have a role as "throw away" or expendable UAVs. VTOL air vehicles are very attractive for small ship application and wherever launch and recovery space is at a premium.

5.1 POINTER HAND-LAUNCHED UAV

5.1.1 Program Description

Ten Pointer hand-launched (HL) UAV systems were procured via a non-developmental item (NDI) acquisition in 1990 as a demonstration capability for the UAV JPO. Since that time, these systems have been demonstrated and/or evaluated by five USA divisions, four USMC units, and numerous other activities inside and outside the DoD, including the Drug Enforcement Administration (DEA), the USA Corps of Engineers, and the Bureau of Land Management. The primary purpose has been to establish familiarity with UAVs, develop user needs, and identify system/concept requirements and shortcomings.

User involvement has been the central focus of the HL UAV demonstration program. On 15 June 1992, the USA III Corps forwarded an Operational Needs Statement (ONS) for 30 HL UAV systems to support the maneuver battalion commander with a "see over the next hill" capability. Following Phase I of a two-part Concept Evaluation Program (CEP), the USA responded that there was no requirement, but that USA III Corps could continue operational experimentation. Phase II is currently in progress to develop and refine operational concepts and doctrine for the USA Mounted Warfighting Battle Space Laboratory. Pointer also participated in an evaluation by the USA Dismounted Warfighting Battle Space Lab of selected emerging technologies in Operations Other Than War (OOTW). During this evaluation, Pointer was employed by the 82nd Airborne Division during the exercise at the Joint Regional Training Center in November 1993.

The dual use potential of the HL UAV is rapidly emerging. The National Guard Bureau has been using a Pointer system to evaluate the effectiveness of UAVs in support of law enforcement activities. To date, at least 12 "operational" reconnaissance and surveillance missions have been flown in Oregon and Washington, primarily in support of counter-drug operations and once for the Washington State Gambling Commission. Throughout FY93 and FY94, demonstrations have been conducted and evaluations are planned for non-DoD customers such as the National Park Service, the United States Department of Agriculture (USDA) Forest Service, the Bureau of Land Management, and the Federal Bureau of Investigation (FBI). These agencies have a variety of missions from law enforcement to environmental and cultural resource management. The USA Corps of Engineers Construction Engineering Research Laboratory is evaluating a Pointer system as an environmental research and analysis tool. They are also conducting lightweight, multispectral IR sensor development using the Pointer platform. There is no Allied cost sharing in the Pointer HL UAV program.

5.1.2 Status

The HL UAV program, illustrated at Figure 5-1, has been at the forefront of UAV demonstrations in terms of user involvement. Although the project started as a low-cost means of getting a UAV into the users' hands, it has developed into a program in its own right with demonstrated capability. In the last year there have been four successful deployments of the Pointer to the National Training Center, Ft. Irwin, CA; completion of a Phase I CEP resulting in an ONS from USA III Corps; initiation of a Phase II CEP; successful deployment with the Oregon National Guard; and a successful technical experiment on interoperability with an unmanned ground vehicle. While maintaining the capability to conduct demonstrations to new potential UAV users, the focus throughout FY94 will be on exploring concept definition for an HL UAV through a Phase II CEP and follow-on evaluation of the requirement development in OOTW. This focus will require the continued development of technical upgrades, including a Global Positioning System (GPS)/auto navigation capability, pan-and-tilt camera, night vision capability, and data links that operate in the military frequency band.

Performance Parameters

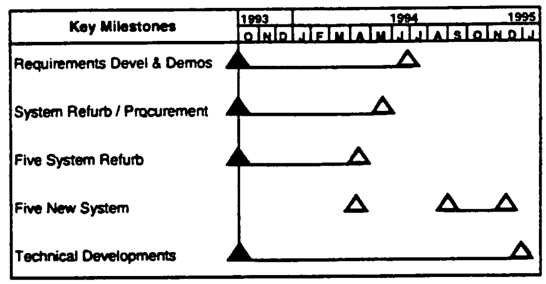
Altitude	.3 km
Endurance	1 hour
Radius of Action	10 km
Speed	46 km/hr
Propulsion	Battery-0.3 kw
Gross T/O Wt.	3.8 kg
Payload	0.35 kg
Sensor Type	Daytime TV
Datalink	72 MHz uplink; 1.6 GHz downlink
Deployment	2-Person Carry
Launch / Recovery	Hand-launched / Deep stall to ground
Operation	Piloted

Key Information

Program status: Demonstration
- Hands-on user UAV experience
- Capability for scout troop
- Potential paramilitary and civilian uses

Contr Agency UAV JPO
Prog Manager LtCol T. Lindsay
(703)746-0342

Programmatics



Air Vehicle Unit Cost approximately $20K

Figure 5-1 Pointer (Demonstration of Very Low Cost UAV Concept)

5.2 EXDRONE

5.2.1 Background

The EXDRONE system is a low-cost reconnaissance UAV designed to support maneuver regiments and brigades. Each system consists of 10 air vehicles, 2 GCSs, 1 pneumatic launcher, and 5 recovery/safety parachutes. The system is transported in two High Mobility Multipurpose Wheeled Vehicles (HMMWV). The air vehicle is a delta platform flying wing with a symmetrical airfoil. The power plant is a small one-cylinder, two-cycle, air-cooled engine with a two-blade propeller. The flight control system consists of a UHF uplink receiver (with a 40 km range) linked to a GPS-based autopilot. The autopilot is a 16-bit microprocessor controlled system which provides up to 5 pre-programmable waypoints and is gyro stabilized. The autopilot can be operated in two modes: manual override and full autonomous. The air vehicle payload is a fixed, down-looking zoom color camera. Image intensifiers and FLIRs have been successfully tested. The air vehicle uses a forward-looking camera to provide the pilot a horizon. The 10-watt video transmitter has a 40 km range. The GCS is suitcase sized and includes a 30-watt uplink transmitter, video receiver, color monitor, GPS telemetry decoder, and RS-170 output. The GCS is compatible with off-the-shelf TV monitors and the USMC IAS.

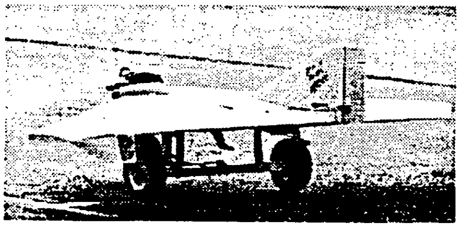
The operational scenario for the system is to pneumatically launch the air vehicle from the regimental/brigade tactical operations center (TOC). The air vehicle is manually flown to mission altitude and the autopilot is engaged. The air vehicle then dashes to the mission area. It loiters over the mission area for up to 2 hours. Imagery is fed to a TV in a USA brigade TOC or to an IAS suite in a USMC command operational center (COC). The IAS grabs pertinent frames, enhances and annotates the imagery, and digitally disseminates to higher and lower echelons. At the end of the mission, the air vehicle is recovered by parachute.

The baseline vehicle was developed by the John Hopkins Applied Physics Laboratory in the early 1980s. The production vehicle incorporates modifications developed by the Naval Air Warfare Center-Aircraft Division (NAWC-AD), Patuxent River, MD, and the National Aeronautics & Space Administration (NASA), Langley Research Center, Hampton, VA. In November 1991, a contract for 100 vehicles was awarded, and deliveries were completed in September 1992. These vehicles were used to conduct an operational demonstration. The system was used by the 101st Air Assault Division, 24th Infantry Division, 1st Cavalry and 2nd Marine Division. The 101st Air Assault Division and 1st Cavalry Division continue to operate the system.

5.2.2 Status

In July 1993, the Commanding General (CG) USMC Combat Development Command requested four improved EXDRONE systems to further develop Maneuver Variant UAV concepts and provide an interim capability. In November 1993, a contract was awarded for 60 air vehicles with the following improvements: UTM-GPS, down-look zoom payload, UHF control frequency upshift, and pan/tilt zoom payload. The USMC 1st RPV Company will receive two systems in May 1994. Two follow-on systems are planned to be equipped with the pan/tilt zoom payload and fielded in FY95.

Currently, there is no Allied cost sharing in the EXDRONE program.



Performance Parameters

Altitude	3 km
Endurance	2-3 hours
Radius of Action	40 km
Speed	160 km/hr
Propulsion	Gasoline engine, 8 hp
Gross T/O Wt.	40 kg
Payload	11.4 kg
Sensor Type	Daytime TV
Datalink	485 MHz uplink; 1.7-1.85 GHz downlink
Deployment	Single C-130
Launch / Recovery	Rail / Parachute
Operation	Piloted or Preprogrammed

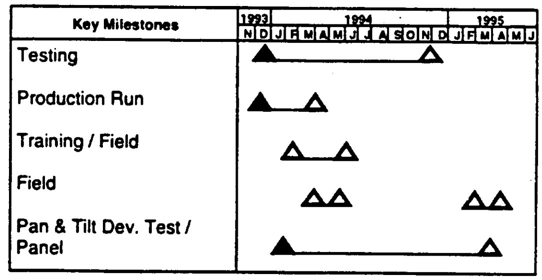
Key Information

Program status: Demonstration

- Hands-on user UAV experience
- Potential interim capability for lower echelon users

User	USMC (potential)
Major Subs	None
Contr Agency	UAV JPO
Prog Manager	LtCol J. Yencha (703) 640-2581

Programmatics



Air Vehicle Unit Cost approximately $25K

Figure 5-2 EXDRONE (BQM-147A) (Demonstration of Very Low Cost UAV Concept)

5.3 MAVUS I/II (MARITIMIZED VERTICAL TAKE-OFF AND LANDING UAV SYSTEM)

5.3.1 Background

The USN and the Canadian Department of Industry, Science, and Technology (CDIST) established a project agreement for development, test, and evaluation of a maritimized VTOL UAV system as a Defense Development Sharing Project (DDSP). The air vehicle used was the CL-227 Sentinel. The overall purpose of the project was to develop, test, and evaluate a VTOL UAV system for use on board small USN combatants. The UAV system was used to: evaluate operational utility; define the cost and benefits of employment of VTOL UAV systems in an operational environment; assess operational compatibility of VTOL UAV systems with embarked helicopter systems; assist in definition and development of VTOL UAV mission roles and tactics in support of surface combatants; evaluate easy-on and easy-off system employment concepts; and evaluate the ability of existing ship's crew to operate VTOL UAV systems as an integral part of the ship's combat system.

The primary objectives of the project were to use the operational employment lessons learned with the maritimized VTOL UAV system to develop system performance specifications while concurrently conducting the operational demonstration in conjunction with the activities of a North Atlantic Treaty Organization (NATO) Project Group. As an additional objective, the project initiated design efforts to define a standardized and interoperable maritime UAV system that could be used by naval forces of the participant nations in the common defense of the US and Canada. To achieve this additional objective, the Canadian Navy participated in, and supported, the operational demonstration of the maritimized UAV system.

Following MAVUS I, the USN and Industry Science and Technology Canada (ISTC) agreed to extend their participation in the MAVUS program. The MAVUS II project will provide further risk reduction of VTOL UAV concepts.

The primary objectives of the demonstration program are to:

- Demonstrate the automated launch and recovery capability of MAVUS II on board small naval combatants
- Develop and evaluate operational concepts
- Collect data on VTOL UAV system operations and performance.

The MAVUS II project is being conducted in three phases. Phase I was the laboratory development/integration and testing of an automated launch and recovery system (common automated recovery system (CARS)); hardware and software changes that were a result of lessons learned during MAVUS I; and technical improvements to the overall system to assist in operator interface. This phase was conducted at the prime and subcontractors' facilities. Phase II is the land-based testing of the modified MAVUS I system with CARS at Ft. Sill, OK. Phase III is the integration of the system aboard USS VANDEGRIFT (FFG-48) which will then conduct a six week at-sea early operational assessment of the system.

5.3.2 Status

The MAVUS I operational demonstration accomplished a total of 68 flights with a total flight time of 73.7 flight hours. This included: initial ground testing at Yuma Proving Grounds to test navigation capabilities and to expand the flight envelope; System Integration and Test at NAWC-AD, Patuxent River, MD to carry out certification of the system prior to ship deployment; operational demonstration aboard USS DOYLE (FFG-39); and subsequent automatic recovery land-based testing at Ft. Sill, OK.

During a six week period, USS DOYLE spent 24 full days at sea, eight of which were dominated by severe weather conditions. Seven missions were carried out using day TV and FLIR mission payloads to ranges of up to 20 km. Communications relay and EW payloads originally scheduled for the demonstrations were not flown during the at-sea period.

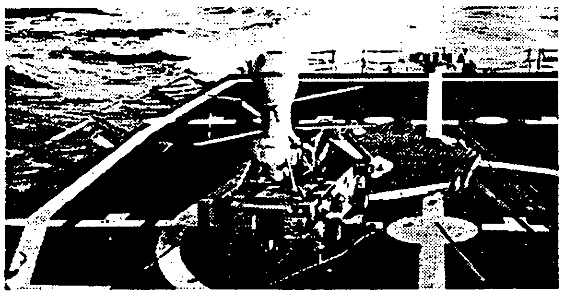
The operational demonstration aboard USS DOYLE during the Standing Naval Forces, Atlantic (STANAVFORLANT) cruise proved that VTOL UAV could accomplish the following:

- Operate from small naval combatants with 5 degrees of pitch, 10 degrees of roll, 1.5 m/s heave and 20 knots of wind across the deck
- Provide covert high resolution coastal surveillance in support of amphibious operations and NATO tasking
- Provide passive visual identification of ships, without exposing or risking friendly surface ships or helicopters
- Operate with U.S. and NATO helicopters
- Provide over-the-horizon surveillance and target classification.

In addition, the fully automatic land based recovery demonstration in FY93, following USS DOYLE deployment, was a success. The capability to recover the air vehicle within inches of the center of the selected touchdown point without operator intervention was demonstrated. This paved the way for the next phase of automated recovery testing aboard a small surface combatant.

MAVUS II will commence operational flights aboard FFG-48 on 28 February 1994. It recently completed ground-based testing at Ft. Sill, OK, and successfully demonstrated the ability of CARS to consistently guide the MAVUS air vehicle to a very accurate approach and landing. The ship installation process was completed by the Superintendent of Shipbuilding, San Diego and Long Beach Naval Shipyards in February 1994. The Navy's Operational Test and Evaluation Force (OPTEVFOR) will have personnel aboard the ship and will provide an Early Operational Assessment (EOA). The US Coast Guard and United Kingdom's Royal Navy have shown an interest in MAVUS and will have observers aboard FFG-48 during a portion of the demonstration.

The results of MAVUS II/I provide a solid database of VTOL UAV system information that is applicable to both land- and sea-based operations. It will be used to support requirements and CONOPS development for a VTOL UAV system and provide a departure point for program development and risk assessments.



Performance Parameters

Altitude	3.3 km
Endurance	2 hours
Radius of Action	60 km
Speed	130 km/hr
Propulsion	Turbo Shaft, Jet
Gross T/O Wt.	190 kg
Payload	45 kg
Sensor Type	EO/IR
Datalink	Analog C band, 20 MHz
Deployment	Not Applicable
Launch / Recovery	VTOL
Operation	Piloted

Key Information

Program status: Demonstration
- Demonstrate operation aboard small USN combatant
- Demonstrate automated recovery
- Determine suitability in shipboard environment

User None, demonstrator only

Contr Agency UAV JPO
Prog Manager CAPT A. Hutchins
(703) 692-4313

Programmatics

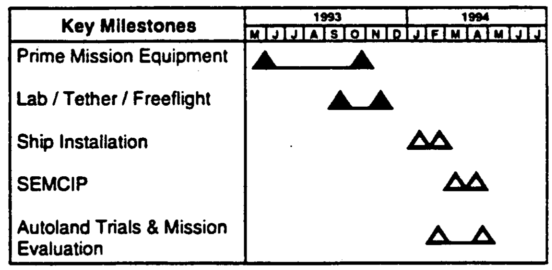


Figure 5-3 MAVUS I/II

5.4 TILT ROTOR UAV

5.4.1 Background

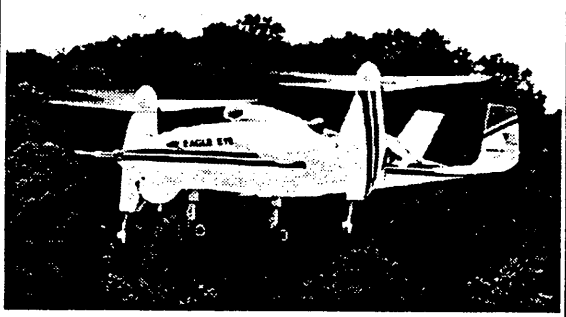
The Tilt Wing/Rotor UAV System (TRUS) Demonstration is a two-phased program for the evaluation of tilt wing/rotor UAV technology for a wide variety of missions. The objectives are to: (1) assess the state of tilt wing/rotor UAV technology; (2) provide data to assist in requirements definition of a maritime UAV; and (3) accomplish risk reduction of VTOL UAV technology. The TRUS air vehicle offers an attractive combination of rotary and fixed wing technologies. It provides VTOL and hover capability, along with low speed characteristics superior to those of fixed-wing aircraft. In addition, its cruise and dash speed characteristics exceed those of rotary-wing aircraft.

Phase I, completed in June 1992, was a four-month study effort that addressed the preliminary design of a VTOL UAV for small USN combatants. The results provided a departure point for future VTOL UAV system definition. Products from the Phase I study were: a flying quality and performance (FQ&P) study, a launch and recovery envelope study, a weight and balance study, a propulsion system study, an avionics system study, an antenna pattern study, a reliability and maintainability study, a structures and materials study, an electrical analysis study, a shock and vibration analysis study, a payloads study, a mechanical requirements study, a support equipment study, and logistics support analysis (LSA).

Phase II is a flying qualities demonstration. It was awarded as a contract option in July 1992 to fabricate two air vehicles and conduct testing at Yuma Proving Grounds, AZ. The objectives of the demonstration are: 10 hours of cumulative flight, hover capability, transition to forward flight, and achievement of forward flight speed of 150 knots or greater. There is no Allied cost sharing in the TRUS program.

5.4.2 Status

The contractor has fabricated two air vehicles, illustrated in Figure 5-4, and successfully completed factory flight testing in November 1993. A more extensive FQ&P demonstration at Yuma Proving Grounds, AZ, was recently completed. TRUS successfully transitioned from the hover mode to the full airplane mode and flew at speeds in excess of 150 knots. This



Performance Parameters

Altitude	3.3 km
Endurance	>2 hours
Radius of Action	TBD
Speed	280 km/hr
Propulsion	Turbo Shaft, Jet 420 hp
Gross T/O Wt.	815 kg
Payload	91 kg
Sensor Type	TBD
Datalink	C band
Deployment	Not Applicable
Launch / Recovery	VTOL
Operation	Piloted or Preprogrammed

Key Information

Program status: Technology Demonstration
- Demonstrate operation aboard small USN combatant
- Demonstrate automated recovery
- Determine suitability in shipboard environment

User None, demonstrator only

Contr Agency UAV JPO
Prog Manager R. Glomb
(703) 746-0342

Programmatics

Not applicable. Demonstration completed February 1994

Figure 5-4 Tilt Rotor UAV

demonstration was precedent setting in that it was the first time tilt rotor air vehicle technology was successfully demonstrated in an unmanned aerial vehicle. The Government now has a database of information that will be extremely useful in the future to develop technical requirements and plan follow-on programs (which are presently unfunded).

5.5 VERTICAL LAUNCH AND RECOVERY

5.5.1 Background

The objectives of the Vertical Launch and Recovery (VLAR) program, shown in Figure 5-5, are to conduct air vehicle technology demonstrations beyond tilt wing/rotor and to evaluate and establish a baseline for emerging VTOL UAV system technologies. These different air vehicle technologies include: ducted fan, jet lift, vertical attitude, stopped rotor, and conventional helicopter, as well as tilt wing and tilt rotor. There is no Allied cost sharing in the VLAR program.

No Photo Available

Performance Parameters

Altitude	3.3 km
Endurance	5 hours
Radius of Action	TBD
Speed	280 km/hr
Propulsion	TBD
Gross T/O Wt.	2000 kg
Payload	91 kg
Sensor Type	TBD
Datalink	TBD
Deployment	Not Applicable
Launch / Recovery	VTOL
Operation	Radio Controlled or Preprogrammed

Key Information

Program status: Demonstration
- Demonstrate flying qualities and performance of a variety of VTOL UAV concepts

User None, demonstrator only

Contr Agency UAV JPO
Prog Manager R Glomb
(703) 746-0342

Programmatics

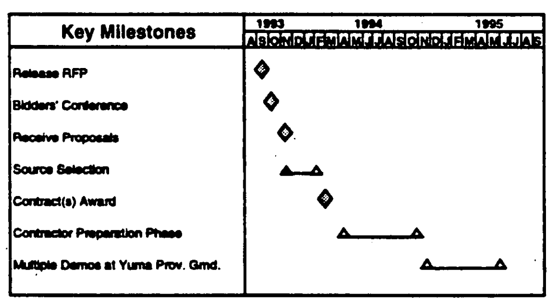


Figure 5-5 Vertical Launch and Recovery

5.5.2 Status

A request for information (RFI) was issued in September 1992 to solicit comments and information from industry on VLAR air vehicles. A request for proposal (RFP) and statement of work (SOW) were developed during the 4th quarter of FY93 for a competitive nine-month activity for air vehicle preparation, studies, and test preparation, followed by a three week flying qualities demonstration at Yuma Proving Ground, AZ. Funding was released by OSD(C) in August 1993. Source selection of contractor(s) is now underway.

6. ENDURANCE UAV PROGRAMS

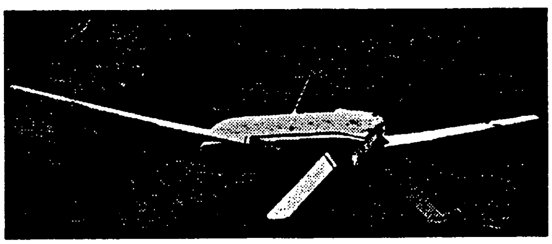
Endurance UAV programs have historically been managed by ARPA or the Advanced Reconnaissance Support Program (ARSP). Endurance UAVs are a critical element of DoD's UAV program. Currently, there are two Endurance UAV demonstrations receiving significant DARO management attention and funding. These are the MAE and HAE demonstrations. Both demonstrations are geared to provide a quick capability to support a major regional conflict, such as Desert Storm, contingencies, such as Bosnia, or counternarcotics/counterproliferation operations. Warfighters will gain valuable insight about integrating UAVs with other tracking, control, dissemination and exploitation procedures and reconnaissance assets. The MAE demonstration provides initial flight vehicles and EO/IR sensors to support limited operations in 12 months, and a capability to support military operations with EO/IR and SAR within 30 months of contract award (January 1994). The HAE will operate at a significantly higher altitude and with a larger payload, carrying sensors of greater capability. The HAE demonstration expects its first flight in 36 months after contract award.

All other Endurance UAV programs resulted from earlier experimental efforts and are single vehicle or limited number technology/system demonstrators. They are described in Chapter 7. These other Endurance UAV programs helped to further a number of high altitude endurance UAV technologies in areas such as vehicle design, propulsion, and survivability. System test failures served the purpose of identifying and eliminating ineffective technologies and concepts during these programs.

During the last decade of the Cold War, the large payload capacity planned for the high-altitude long-endurance regime allowed systems with significant operational potential to satisfy requirements from many disciplines. However, this flexible and robust capability is currently unaffordable. The new threat profile requires not only new strategies but also different system capabilities at significantly reduced costs. In addition to the technical benefits from earlier endurance programs, the DARO's evolutionary development approach reflects the programmatic lessons learned.

6.1 MEDIUM ALTITUDE ENDURANCE (MAE)

The MAE UAV is a 30 month activity responding to a JCS initiative to bring near-real-time imagery to the Joint Task Force (JTF) Commander (see Figure 6-1). It provides the JTF Commanders a long dwell, tactical UAV system with continuous, near all-weather surveillance and target acquisition over defended foreign areas. Through a multi-sensor air vehicle, the demonstration will be used to support RSTA missions as directed by the JTF Commander. The UAV will remain on station at extended ranges (>930 km) for periods exceeding 24 hours carrying high resolution sensors to identify and track small, mobile targets (e.g. artillery). The MAE demonstration is compatible with other reconnaissance systems and will provide a releasable product to foreign military and national entities. Through a CONOPS document, component planners will detail the implementation and functions supporting a JTF operation.



Performance Parameters

Altitude	7.6 km
Endurance	24 hr
Radius of Action	930 km
Speed	240 km/hr
Propulsion	Single recip.
Gross T/O Wt.	851 kg
Payload	205 kg
Sensor Type	SAR/EO/IR
Datalink	UHF/C/Ku Band, 1.5 Mbps SatCom
Deployment	C-141 Transportable
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Immediate field use
- Residual military operational capability
- Investigation of CONOPS & military utility
- Initial buy of 10 air vehicles and 3 ground stations

User	USA/USAF/USMC/USN
Contr Agency	UAV JPO and US Army CECOM
Prog Manager	CAPT A. Rutherford, USN 703-692-3423

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Project Start	△					
Contract Awards	△					
Critical Design Reviews	△					
Demo A/V, UHF, D/L, EO/IR	△					
Demo A/V, WB D/L, SAR		△				

Figure 6-1 Medium Altitude Endurance (MAE) UAV

The MAE system carries an EO/IR payload with a ground sampled distance (GSD) of eight inches, a one foot IPR SAR, and a Satellite Communication (SATCOM) data link capable of UHF and/or Ku band communications. These requirements, approved by the JROC, are delineated in USD(A) memorandum of 12 July 1993 and DUSD(AT) memorandum of 17 November 1993. In FY96, following flight and field demonstrations of the MAE UAV, an advanced SIGINT sensor may be considered. The joint CONOPS for employment of the UAV is being developed by a working group chaired by USACOM with membership from CINCs, the Joint Staff, the UAV JPO, and the training and doctrine commands from each of the Services.

Source selection for the MAE UAV air vehicle and data link was completed in January 1994. A common data link (CDL) contractor was also chosen. A competition for the SAR will be completed by March 1994.

FY94 activities focus on ground/lab test of the EO/IR and UHF satellite communications. By the end of FY94, three air vehicles and one GCS will be delivered and flight demonstrations will begin. Field demonstration of the EO/IR and UHF communications and ground testing of the SAR and wideband satellite communications link will be conducted by the third quarter of FY95. By the third quarter of FY96, field demonstration of the entire MAE UAV system — with ten air vehicles and three GCSs — will be completed. No Allied cost sharing is planned for MAE UAV demonstration.

6.2 HIGH ALTITUDE ENDURANCE (HAE)

As mentioned previously, the HAE is a long-term demonstration to satisfy broad area coverage and deep target surveillance/reconnaissance (see Figure 6-2). The HAE demonstration will be significantly more capable than MAE, including a much larger radius of action (5550 km), greater operating altitude (20 km), greater payload capacity (with more capable sensors), and higher bandwidth satellite data links (50 Mbps). The program has an aggressive $10M goal for air vehicle unit flyaway recurring costs. Although low observability is being considered for survivability, it is not a driving requirement. Initial sensor payloads will include EO, IR, and SAR systems with broad area coverage. ARPA is the lead development organization with Service support. After the initial flight tests, these roles will be reversed. ARPA is working with the users to prepare a tentative concept of operations during the second quarter of FY94. Issues that need to be resolved during CONOPS development concern: remote vs. forward basing, ferry vs. transport, operations during early crisis phase, contractor operations and maintenance, communications capacity and location, automatic target detection and cueing aids, survivability approaches, tie to the global information grid, interface with national systems and ground exploitation, data formats, volume of data to be handled, and interface to theater and tactical exploitation systems (see Section 3).

System Objectives

- Low cost, attritable system
- Wide-area reconnaissance/surveillance
- Continuous, all weather day/night coverage
- Overt support to military operations

Performance Parameters

Altitude	20 km
Endurance	> 24 hr
Radius of Action	6000 km
Speed	550-740 km/hr
Propulsion	Dual; Type TBD
Gross T/O Wt.	6,000-18,000 kg
Payload	450-700 kg
Sensor Type	SAR / EO / IR
Datalink	50 Mbps SatCom
Deployment	Multiple C-130
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Immediate field use
- Residual military operational capability
- Investigation of CONOPS & military utility
- Initial buy of 10 aircraft

User	USA/USAF/USN
Contr Agency	ARPA
Prog Manager	Mr. J. Entzminger 703-696-2295

Programmatics

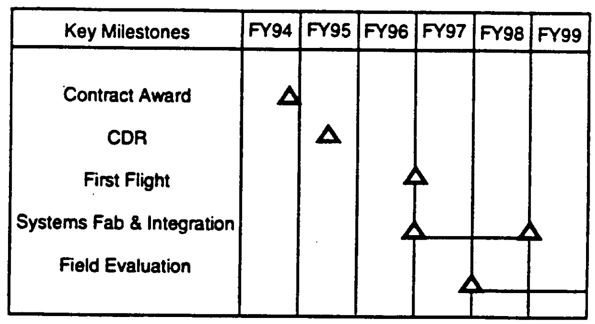


Figure 6-2 High Altitude Endurance (HAE) UAV

and ground exploitation, data formats, volume of data to be handled, and interface to theater and tactical exploitation systems (see Section 3).

The initial concept is to build two UAV engineering test systems with sensors and communications. Up to eight UAV demonstration systems with two GCS and communication systems will be procured after initial test flights. Initial efforts will require spares and support to enable two years of operational testing and evaluation. Provisions to procure additional systems will be predicated on performance, affordability and risk reduction effort.

The business strategy is evolving as the concept matures. The emphasis will be on streamlined acquisition rules. Possible use of the new ARPA "Other Agreements Authority" is being investigated. The key is to have a small, capable program office with streamlined reporting. Various contract approaches are now under review.

7. OTHER UAV PROGRAMS

Although there are many potential non-DoD users of UAV technology, including civilian, scientific, and commercial, there is only one significant US government development program underway outside the DoD: the NASA Environmental Research Aircraft & Sensor Technology (ERAST) program. The Department of Energy's (DOE) Atmospheric Radiation Measurement (ARM) program is poised to take advantage of UAV developments in the commercial sector, but is not currently sponsoring any UAV development. This section will discuss the baseline requirements of the ERAST program and platforms that are being utilized for early demonstrations. In addition, a commercial development project underway to support the DOE ARM program will be presented.

The Ballistic Missile Defense Organization (BMDO) and DARO have agreed to transfer the RAPTOR Demonstration air vehicle programs to DARO under UAV JPO responsibility. The FY94 program will continue as previously defined by BMDO to support their test and evaluation requirements. Pending the test results and OSD/BMDO decisions on lethal UAVs in Theater Ballistic Missile (TBM) defense, BMDO will identify vehicle requirements for the RAPTOR vehicle programs to DARO.

Condor will continue to be a single vehicle program under the auspices of Lawrence Livermore National Laboratory (LLNL). DARO will evaluate any requirements for an Endurance UAV that emerge from the LLNL Condor efforts against MAE and HAE capabilities to avoid unnecessary additional vehicle development.

7.1 HISTORY, BACKGROUND AND RELEVANCY

The development of the first high-altitude unmanned aircraft was sponsored by the DoD in response to the downing of manned U-2 and RB-47 aircraft by the Soviets in 1960. These incidents resulted in intensive design studies, leading to the development of several aircraft that are discussed in this section.

In the quarter century beginning in the mid-sixties, the trends in high altitude unmanned aircraft were toward higher altitude, heavier payload, and longer endurance (see Table 7-1). The evolution to higher altitudes was driven by improvements in anti-aircraft technology, while the requirements for heavier payloads and longer endurance were driven by users of the information collected by these aircraft. Figure 7-1 illustrates these trends using the data in Table 7-1.

Table 7-1 Characteristics of High-Altitude Unmanned Aircraft

AIRCRAFT	GROSS WEIGHT (KG)	WING AREA (M^2)	LOITER ALTITUDE (KM)	ENDURANCE (HOURS)
AQM-91A Compass Arrow	2400	23	26	2+
XQM-93A Compass Dwell	2400	17	14	21
Model 845A Compass Dwell	1600	16	14	24
YQM-94A Compass Cope	5900	45	17	17
YQM-98A Compass Cope	6500	32	17	24
Condor	9200	101	20	58

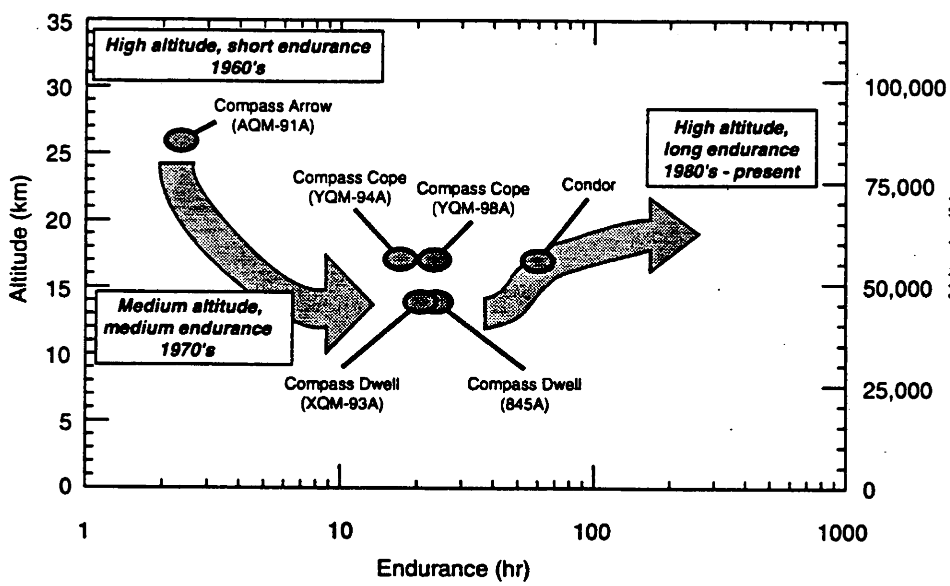


Figure 7-1 History of High Altitude, Long Endurance UAVs Illustrated by Their Performance Characteristics and General Trends In Development

All three trends stressed aircraft technology, in particular propulsion systems, airframe materials, and avionics. Propulsion systems had to operate at higher altitude and at greater efficiency, while the airframe had to be made larger and lighter. Avionics systems had to be able to navigate over very long distances and execute contingencies during flights lasting days. In addition, system failure rates had to be reduced to achieve an acceptable probability of mission success.

Two of today's Endurance UAV demonstrations, the MAE and HAE, are capitalizing on and improving aircraft technology advancements that have *demonstrated* autonomous flight at altitudes of seven to 20.4 km and flight duration of one to three days, respectively, both with payloads near 450 kg. Section 8 in this program plan describes some of the UAV enabling technologies. A brief description of past Endurance UAV demonstrations follows to illustrate the trends described above.

Compass Arrow — The first attempt to develop a high-altitude, subsonic, UAV began in 1966 as a military program to replace (or supplement) the U-2. This program was called Compass Arrow with a military designation AQM-91A, also known as the Model 154 (see Figure 7-2). Published reports describe the Compass Arrow as having a 2400 kg gross weight and a 14 m wing span. Powered by a single J97-GE-13 turbojet, unconfirmed performance estimates suggest the air vehicle had an endurance of over five hours at an altitude of approximately 25 km.

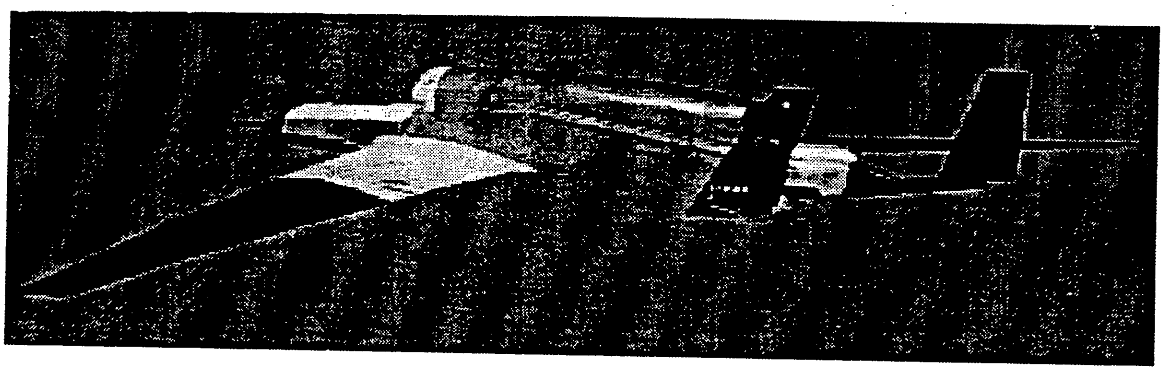


Figure 7-2 Compass Arrow (AQM-91A)

From an operational standpoint, the AQM-91A offered a unique capability. It flew at an altitude comparable to the SR-71, which was much higher than the U-2, and thus provided exceptional survivability against anti-aircraft threats. The SR-71 flew at supersonic speeds (Mach > 2.5), while the AQM-91A flew at high subsonic speeds (Mach ~ 0.8), closer to that of the U-2. This allowed the AQM-91A to carry payloads that could not function in a supersonic environment while providing the survivability resulting from flying at 25 km. Like many of the

UAVs of the 1960s, the AQM-91A was launched from a DC-130 aircraft and recovered by a helicopter, which snagged it while descending by parachute. It was operated in this manner until 1973, when all AQM-91A aircraft were retired. Although altitude was considered important to maintain survivability, the DoD pressed requirements for longer endurance, even if gains in endurance were obtained at lower altitude.

Compass Dwell — The Compass Dwell program was started in the late 1960s as a competitive effort to address the endurance issue.

One air vehicle was the L450F, with a military designation XQM-93A (see Figure 7-3). The L450F was a converted SGS 2-32 sailplane powered by a 35 kw PT6A-34 turboprop. It was designed to carry a 450 kg payload to a 14 km altitude for about 21 hours. Designed as an optionally-piloted vehicle, the L450F first flew with a pilot in 1970. Unmanned flights began after aircraft flight worthiness was demonstrated. Such flights culminated in a 21-hour flight in January of 1972. In its unmanned configuration, the air vehicle had a gross weight of 2400 kg with a 17 m wing span.

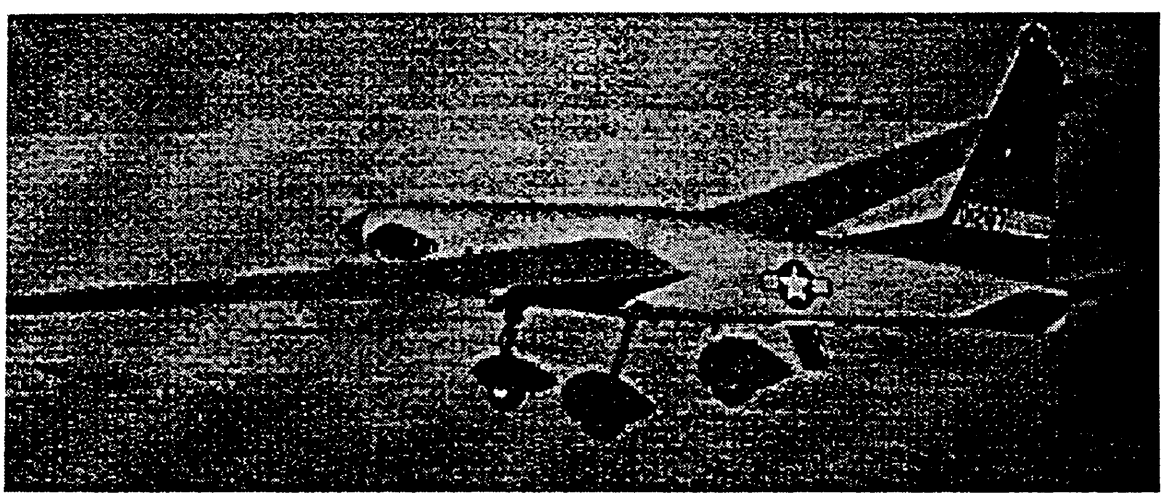


Figure 7-3 Compass Dwell (XQM-93A)

The competing UAV was the Model 845A, somewhat smaller than the L450F, based on a converted SGS 1-34 airframe (see Figure 7-4). The Model 845A first flew in April 1972. It was powered by a single turbocharged TIO-360 reciprocating engine rated at 200 hp. With a gross weight of approximately 1600 kg and a wing span of 18 m, the Model 845A could carry a 136 kg payload to an altitude of approximately 14 km for about 24 hours. Endurance of 28 hours was demonstrated in July 1972 with a lighter payload.

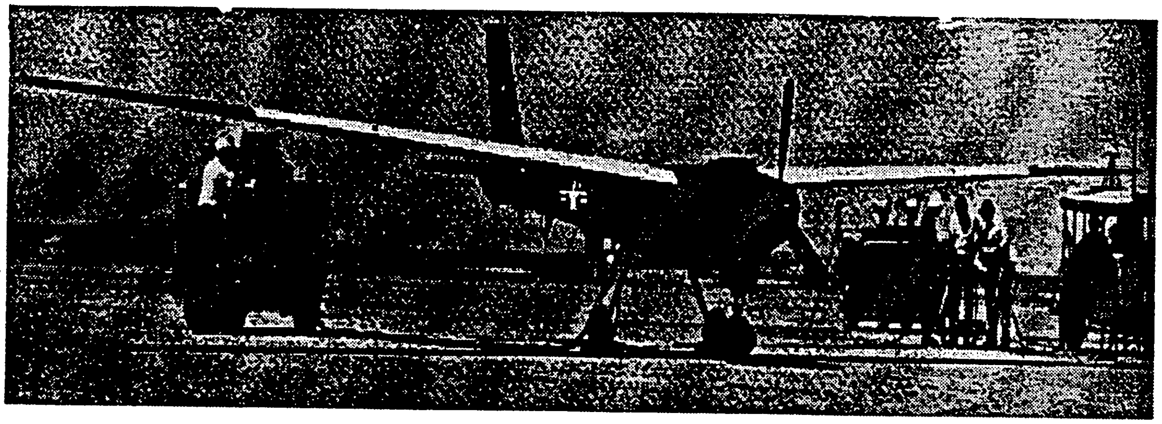


Figure 7-4 Compass Dwell (845A)

While the L450F and Model 845A were in flight test, the DoD determined that neither aircraft truly met requirements for high-altitude, long-endurance (HALE) unmanned aircraft. At that time, 24-hour endurance was adequate to meet most mission requirements. However, anti-aircraft threats drove altitude requirements higher so that neither Compass Dwell aircraft was selected for production. Nonetheless, Compass Dwell demonstrated two key capabilities: (1) high altitude UAVs were capable of safe operation for periods in excess of one day, a major technical accomplishment; and (2) both turbocharged-reciprocating and turboprop engines were shown to be practical propulsion systems for high-altitude, long-duration flight.

Compass Cope — In conjunction with the Compass Dwell program, the USAF started a more ambitious competitive HALE UAV program in 1970. Compass Cope requirements were to carry a 320 kg payload to an 18 km altitude for up to 30 hours.

The YQM-98A first flew in August 1974 (see Figure 7-5). It had a 6500 kg gross weight with a 24 m wing span. In November 1974, the air vehicle flew for 24 hours at over 17 km altitude. It was powered by an Air ATF-3.

The competing air vehicle, designated YQM-94A, had a 5900 kg gross weight with a 27m wing span. It was powered by a J97-GE-100 non-afterburning turbofan. The first YQM-94A flew in July 1973; it crashed on approach during its second flight. The second prototype flew in November 1974 and demonstrated an endurance of 17 hours at altitudes above 17 km.

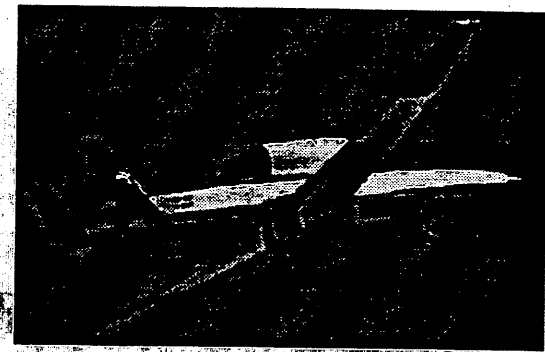


Figure 7-5 Compass Cope (YQM-98A)

The YQM-94A (see Figure 7-6), was selected as the Compass Cope winner in 1976. Redesignated the YQM-94B the production version was designed to have a gross weight of 6500 kg with a wing area of 45 m^2. Increased power was to be provided by a derated TF34-GE-100 turbofan. This heavier air vehicle was to carry a 545 kg payload to altitudes above 17 km for up to 24 hours.

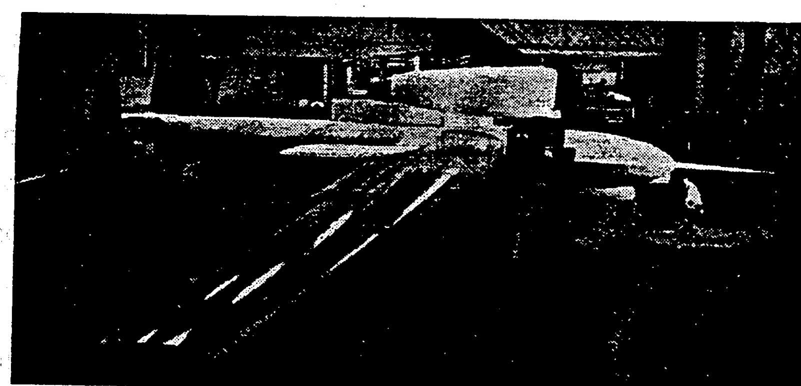


Figure 7-6 Compass Cope (YQM-94A)

As with many programs, the Compass Cope payload continued to grow in size and weight, so the baseline production design was not able to meet its altitude-endurance performance requirements. Also, due to expected improvements in anti-aircraft weapons, the production Compass Cope was less survivable than originally expected. These factors led to program termination in July 1977.

Condor — Interest in more advanced air-breathing piston engines culminated in development of the Condor (see Figure 7-7). This UAV was designed to overcome perceived performance deficiencies in the Compass Dwell and Compass Cope programs. Consequently, Condor has a payload capacity of 230 - 600 kg (up to 1200 kg with optional pods) and can loiter in excess of 50 hours at altitudes up to 20 km. To achieve this performance, the Condor has a gross weight of 9200 kg and uses two 131 kw liquid-cooled piston engines for propulsion. To achieve loiter altitudes of 20 km, Condor engines have two stages of turbocharging. A lengthy development program resulted in a specific fuel consumption less than 0.4 lb/bhp-hr at loiter conditions. Moreover, the propulsion systems have sufficient reliability for multi-day missions.

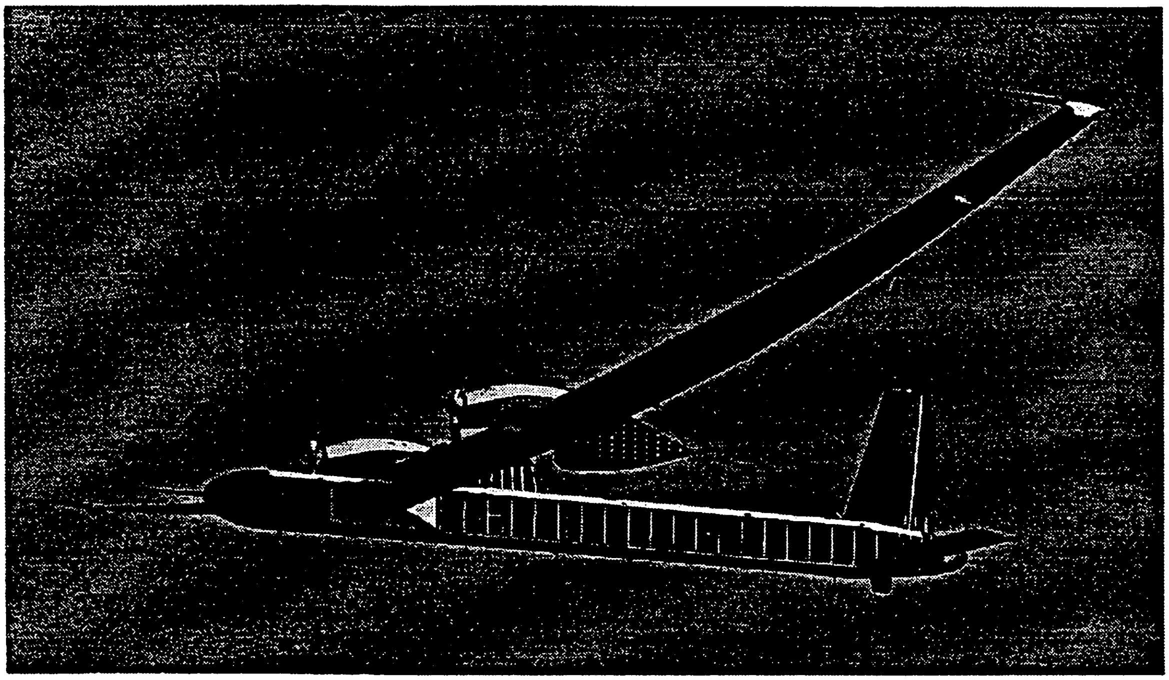


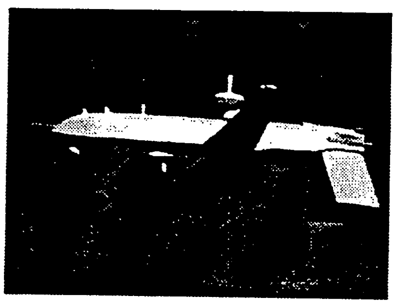
Figure 7-7 Condor

The Condor airframe is much larger than its predecessors. Constructed from modern composite materials, it has a 60 m wing span with an aspect ratio of 37. In addition, Condor has a redundant flight control system that allows fully autonomous flight, including automated takeoffs and landings.

The Condor first flew in 1988. During an eight flight test program, a new altitude record for propeller-driven aircraft was established at 20.4 km. One flight had an endurance of over 58 hours. The program was canceled in 1990. The Condor system and production tooling was recently transferred to LLNL, where plans have been developed to reconstitute and fly the aircraft to carry scientific and military-demonstration payloads.

7.2 I-MAE

The Interim MAE (I-MAE) is a US government program to field a quick-response, endurance UAV capable of providing optical imagery in crisis situations (see Figure 7-8). The Gnat 750 was selected as the aircraft platform. Two aircraft with sensors are being tested and fielded during FY94. The I-MAE project will provide technical and operational lessons learned to follow-on endurance UAV programs.



Performance Parameters

Altitude	0.5 - 8.2 km
Endurance	24 hr
Radius of Action	925 km
Speed	240 km/hr
Propulsion	Single recip. (80 hp)
Gross T/O Wt.	400 kg
Payload	100 kg
Sensor Type	EO/IR
Datalink	C-Band Relay
Deployment	Multiple C-130
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Immediate field use
- Crisis response
- Initial buy of 2 aircraft

User

Contr Agency
Prog Manager

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
First Flight	△					
Complete Fleet (7 systems)		△				
Ops Support	△ ——	——	——	— —	— —	— —

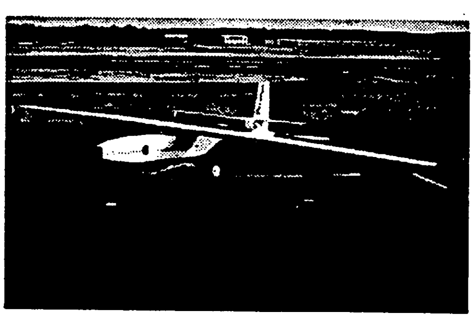
Figure 7-8 Interim Medium Altitude Endurance (I-MAE) UAV

7.3 ERAST PROGRAM AND PERSEUS A

UAVs have the potential to serve as an ideal complement to existing platforms in providing answers to key questions regarding earth and atmospheric science. In spite of the successes of NASA's manned aircraft campaigns, there is a need for subsonic aircraft with still higher ceiling, longer range, greater endurance, and other advanced characteristics to fulfill data collection requirements identified by various scientific communities. In response to this growing scientific need, the NASA Office of Aeronautics has undertaken the responsibility to develop technologies that will enable US industry to develop fully mission-capable UAVs. This new initiative, the ERAST program, began in FY94, and is scheduled to last for seven years with flight demonstrations of vehicle technology and payload capability throughout the program. Major flight demonstrations will occur by the mid-term of the program, affording an assessment of technology development. By the end of the program, a final demonstration of scientific mission capabilities will be accomplished. There is potential synergy with DARO, since DoD needs are pushing UAV technology in similar directions, though for different reasons.

ERAST program management is also aggressively pursuing joint agreements with other agencies, including DOE, the UAV JPO and BMDO, aimed at leveraging both needs and developments outside NASA. A similar agreement with DARO is currently in the discussion phase. Since the requirements of the ERAST high-altitude, long-endurance mission are very similar to those of the HAE UAV, close coordination and cooperation could afford mutual benefit.

Under the aegis of the High Speed Research Program, NASA has contracted to provide a UAV, Perseus A, capable of attaining 25 km altitude with a 65 kg payload to collect in-situ data for the investigation of the effects of high-speed aircraft on the atmosphere. Although the Perseus A aircraft (see Figure 7-9) is an important step toward meeting scientific needs, there is an urgent need for UAV technology development leading to increased operational capabilities while maintaining or lowering operational costs.



Performance Parameters

Altitude	> 25 km
Endurance	1 hr (on station)
Speed	185 km/hr
Propulsion	Piston Engine (Gasoline and LOX)
Gross T/O Wt.	780 kg
Payload	65 kg
Empty Weight	521 kg
Wingspan	18.6 m
Propeller diameter	
High-altitude	4.4 m
Low-altitude	2.64 m
Pro max altitude	>25 km

Figure 7-9 Perseus A

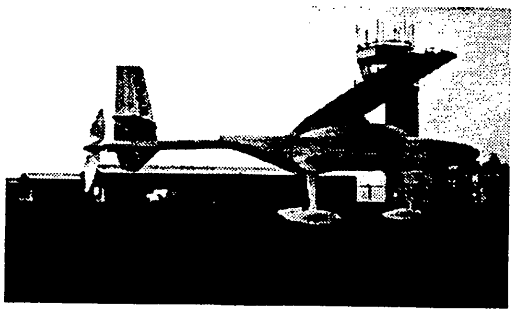
Table 7-2 presents the ERAST and Perseus characteristics of advanced capability UAVs. They illustrate that an emerging generation of UAVs offers great promise for meeting scientific needs if they can do so in a cost-effective manner while alleviating the constraints typical of manned flight vehicles such as mission duration, altitude limits, and flight over inhospitable terrain.

Table 7-2 Other UAVs (Non-DoD)

System / Characteristics	Perseus A (NASA)	Perseus B (DOE)	ERAST (NASA)	ERAST (NASA)
Altitude, km	25 km	18 km	25-30 km	16-24 km
Endurance, hrs (on station)	1 hr	24 hrs	4-50 hrs	12-96 hrs
Radius of Action, km	100 km	5000 km	1-20k, km	5-20k, km
Speed, km/hr	200 km/hr	250 km/hr	TBD	TBD
Payload/Sensor Weight, kg	65 kg	200 kg	100-1400 kg	50-1600 kg

7.4 THE DOE ARM PROGRAM AND PERSEUS B

The DOE, in cooperation with the DoD's Strategic Environmental Research and Development Program (SERDP), has begun a project to explore the usefulness of UAVs for climate-relevant measurements in the ARM program. Major goals of the ARM UAV project include developing miniaturized climate research instruments for use in a small inexpensive UAV, developing payloads to demonstrate those instruments in flight, and obtaining valuable scientific data. There is no support for the development of environmental research UAVs at this time. However, plans are underway for the utilization of existing or near-term UAVs for instrument test flights. The Gnat 750 is currently being used to carry visible and infrared radiometers. The Perseus B (see Figure 7-10), will be used for additional ARM experiments once it has demonstrated flight capabilities during an internal DOE commercial development project.



Performance Parameters	
Altitude	18 km
Endurance	24 hrs
Speed	185 km/hr
Propulsion	Piston Engine (Turbocharged)
Gross T/O Wt.	1000 kg
Payload	200 kg
Wingspan	17.9 m
Wing area	16 m^2
Take-off weight	1,000 km
Payload weight	200 kg
Altitude capability	20 km

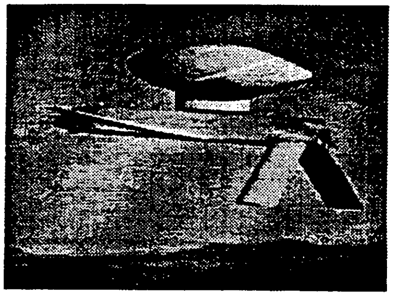
Figure 7-10 Perseus B

7.5 JOINT PRECISION STRIKE DEMONSTRATION (JPSD)

The JPSD has demonstrated command and control of a UAV and its payload sensor via satellite link using Joint Tactical Information Distribution System (JTIDS) algorithms (see Figure 7-11). During the flights, the UAV relayed sensor video data and telemetry to the GCS at El Mirage, CA, and to the Topographic Engineering Center (TEC) at Ft. Belvoir, VA. The demonstration was managed by the JPSD program office in coordination with the UAV JPO and the Army's Communications-Electronics Command (CECOM) Intelligence and Electronic Warfare Directorate (IEWD) with additional support from the Army Research Laboratory. This demonstration illustrated technology solutions to deficiencies within the functional areas of surveillance and target acquisition. The final report was due from JPSD by 31 January 1994. It will contain the lessons learned in JPSD and requirements for a UAV platform to carry specific sensors supporting precision strikes. DARO will evaluate the requirements against ongoing UAV programs to determine which vehicle(s) in the Tactical and Endurance classes are capable of satisfying the needs. There was no Allied cost sharing in JPSD.

7.6 RAPTOR DEMONSTRATIONS

In the aftermath of Desert Storm, the Ballistic Missile Defense Organization (BMDO) undertook a fast-paced Advanced Technology Demonstration (ATD) program to demonstrate lethal kill capability of a SCUD-like TBM with an air-based missile defense concept called Responsive Aircraft Program for Theater Operations/Theater Application Launch on Notice (RAPTOR/TALON). BMDO determined that one of several concepts for boost-phase intercept



Performance Parameters

Altitude	8.2 km
Endurance	24 hrs
Radius of Action	925 km
Speed	240 km/hr
Propulsion	Single recip.(80 hp)
Gross T/O Wt.	400 kg
Payload	100 kg
Sensor Type	EO
Datalink	JTIDS SatCom
Deployment	N/A
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Control of both aircraft and sensor
- Video transmission at 1 frame every 3 seconds
- Relay to both El Mirage and Ft. Belvoir

User	None, Demonstrator Only
Contr Agency	JPSD Program Office
Prog Manager	Col Fricas

Programmatics

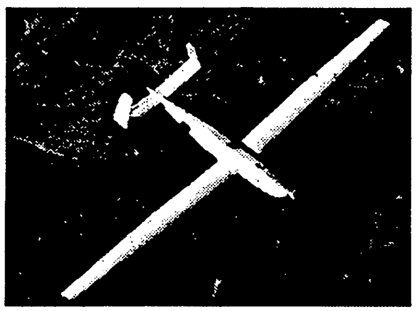
Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Flights	▲					
Final Report Due	△					

Figure 7-11 JPSD—Joint Precision Strike Demonstration (Demonstration of Command and Control via Satellite Link Using JTIDS)

(BPI) of TBMs could be performed from a small HALE UAV carrying new sophisticated hypersonic weaponry. As part of this ATD goal, BMDO has developed two HALE UAVs for integrated concept testing. The first, termed the RAPTOR Demonstrator, is a reciprocating engine, composite UAV. The second, termed the RAPTOR Pathfinder (originally designed for other purposes), is a solar-electric powered UAV which could provide extremely long endurance flight capability for small payloads (20-30 kg). These air vehicles will be transferred administratively to the UAV JPO to support the BMDO and other users.

7.6.1 RAPTOR Demonstrator

The RAPTOR Demonstrator program, managed by the BMDO, is developing two low-cost HALE UAVs (see Figure 7-12); one for testing and one for risk reduction. The Demonstrator aircraft, with a 20 m wing span and 90 kg payload capacity, will be tested at altitudes up to 20 km. It is propeller-driven by a single, 60 kw, dual-stage-turbocharged gasoline engine—a modified Rotax 912. RAPTOR Demonstrator airframes are of composite (graphite epoxy) construction with gross weight less than 900 kg. The first RAPTOR Demonstrator began low-altitude flight testing in April 1993. High-altitude, long-endurance testing began in early 1994. Flight testing of the risk reduction air vehicle should begin in late 1994. No allied cost sharing is planned for RAPTOR Demonstrator.



Performance Parameters

Altitude	20 km
Endurance	> 50 hr
Radius of Action	1000 km
Speed	325 km/hr
Propulsion	Single recip.(80hp)
Gross T/O Wt.	900 kg
Payload	90 kg
Sensor Type	EO / IR
Datalink	TBD
Deployment	N/A
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Surveillance capability
- TMD launch detection demonstration
- Initial buy of 2 aircraft

User	BMDO, Demonstrator Only
Contr Agency	BMDO
Prog Manager	LtCol D. Tietz 703-693-1568

Programmatics

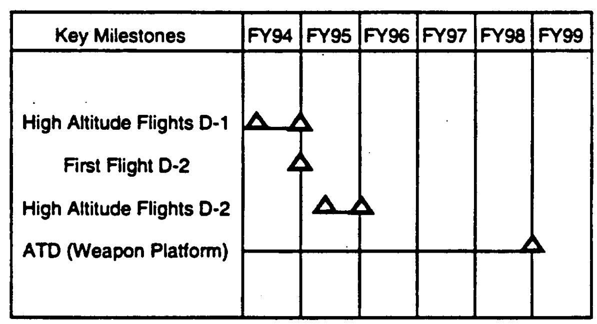


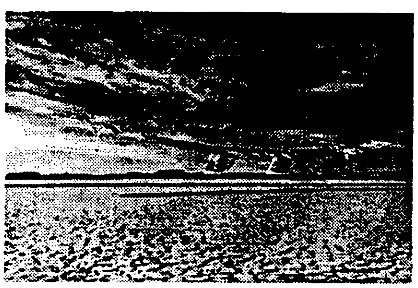
Figure 7-12 RAPTOR Demonstrator (High-Altitude, Endurance, Surveillance UAV)

Requirements for a UAV-based lethal TBM defense capability are under review in OSD and BMDO. DARO will address any platform requirements that materialize from these reviews by evaluating ongoing RAPTOR Demonstrator and other Endurance-class UAV programs for capability to satisfy the needs. DARO does not anticipate any new platform development.

7.6.2 RAPTOR Pathfinder

The RAPTOR Pathfinder (formerly called HALSOL: High-Altitude SOLAR) was fabricated in 1983 to explore solar-electric propulsion technologies for HALE flight. The 30 m span-loaded, flying-wing configuration was chosen to minimize mass and required propulsive power. It employed solar cells to power electric motors during daylight, and planned to store excess solar energy in batteries for propulsion at night. In 1983, solar-cell technology efficient enough to accomplish HALE flight was prohibitively expensive, so flight tests were conducted with battery power only. HALSOL was put into storage shortly after initial flight tests.

In FY92, BMDO determined that the HALSOL could have application for theater missile defense and sponsored upgrades including high-efficiency, light-weight solar cells, new materials having greater strength and ultra-violet (UV) resistance, and new and more efficient electric motors and propellers. In early FY94, Pathfinder completed several low-altitude (< 90m) flights at Edwards AFB, CA. A round of improvements currently in progress should provide performance needed to reach 20 km in flight tests to be conducted during summer of 1994 (see Figure 7-13). The program is on the path toward achieving the BMDO goals of extremely long duration flight at high altitudes. The ultimate goal of the program is to produce a 63 m spanloaded wing capable of extremely long endurance above a 20 km altitude carrying a 20 kg payload in day/night flight at mid-latitudes. No Allied cost sharing is planned for RAPTOR Pathfinder.



Performance Parameters

Altitude	20 km
Endurance	Weeks
Radius of Action	Variable
Speed	120 km/hr.
Propulsion	Solar elec. motor (11 hp)
Gross T/O Wt.	240 kg
Payload	TBD
Sensor Type	TBD
Datalink	TBD
Deployment	NA
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Solar electric energy collection
- Regenerative fuel cell energy storage
- TMD launch surveillance
- Initial buy of 2 aircraft

User	BMDO, Demonstrator Only
Contr Agency	BMDO / DARO
Prog Manager	LtCol D. Tietz 703-693-1568

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Low Altitude Flight	▲					
High Altitude Flight (Planned)	△					

Figure 7-13 RAPTOR Pathfinder (High-Altitude, Long-Endurance, Solar Electric UAV)

7.7 CONDOR

The basic capabilities of the Boeing Condor were described earlier in this section. After three years of dormancy, Condor was transferred by the previous DoD sponsor to the LLNL, under the auspices of an LLNL project in radar ocean-imaging sponsored by OSD(C3I) (see Figure 7-14). LLNL has been tasked to examine several possibilities: (1) alternative uses of the Condor, including missions of potential interest to NASA, National Science Foundation (NSF), National Oceanographic and Atmospheric Agency (NOAA), DOE, DEA, and commercial users, (2) inexpensive ways to reconstitute the aircraft for potential use in these new applications, and (3) alternative uses within the DoD, including radar ocean-imaging, special operations support, ballistic missile defense roles (such as the proposed Defender system) and other uses.

Several organizations are funding, or expressing an intention to fund, further studies of Condor's applicability to scientific and defense missions during FY94 and FY95. No Allied cost sharing has been identified for Condor.

Performance Parameters

Altitude	20 km
Endurance	48 hr
Radius of Action	7960 km
Speed	460 km/hr
Propulsion	2 turbo-chrg recip. (175 hp)
Gross T/O Wt.	9230 kg
Payload	600 kg
Sensor Type	SAR / EO / IR / SLAR / LIDAR
Datalink	X-Band
Deployment	Ferry
Launch / Recovery	Runway
Operation	Preprogrammed

Key Information

Program Status: Demonstration
- Successful flight series in 1988 and 1989
- Aircraft transferred to LLNL in 1993
- Multi-agency applications under study
- Probable aircraft reconstitution in 1995

User	DoD/DOE/NASA/NOAA/NSF
Contr Agency	OSD (C^3I)
Prog Manager	Dr. T. Lawrence 510-422-5322

Programmatics (Preliminary)

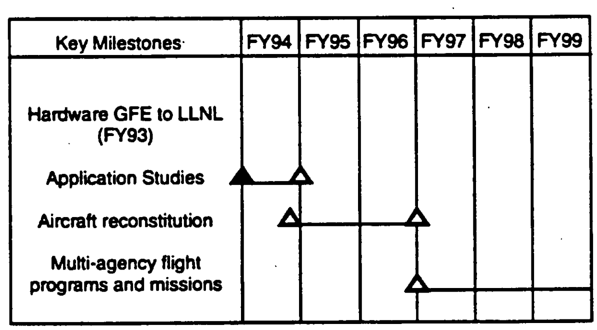


Figure 7-14 Condor High-Altitude, Endurance UAV (Potential Joint Program with Both Defense and Scientific Missions)

8. UAV ENABLING TECHNOLOGY

This section introduces the enabling technologies that support DARO UAV programs. It is not all-inclusive and not all efforts identified are funded, nor has an exhaustive search of all applicable technology been conducted. Research and development are on-going both under DARO auspices by UAV JPO and by other DoD laboratories and agencies. In the future, DARO will review these activities and refine its own technology program to ensure that it is prioritized and complete. The technologies are briefly introduced and discussed in the following subsections. A UAV enabling technology matrix (see Table 8-1) relates each technology to current UAV programs.

8.1 PROPULSION

8.1.1 Small Heavy-Fuel Engines

Heavy fuels (JP5, JP8) are requirements for the Tactical, Maneuver Variant, Shipboard Variant, and Endurance UAVs for both safety and logistic support reasons. In 1989, the UAV JPO initiated a technology demonstration program to develop small, lightweight, heavy-fuel engine (HFE) technology for UAVs, since no off-the-shelf HFEs met Tactical UAV requirements. Contracts were awarded to determine the feasibility of small HFEs for UAV application. Most of the program goals were met; however, significant development remains before production can begin. A contract has been awarded for the competitive selection, integration, demonstration, and evaluation of an HFE for the Tactical UAV. In addition, the UAV JPO has begun to investigate recuperative turbine engine development, which not only has the potential of providing a more efficient common HFE power plant but also offers the high reliability and maintainability of turbine engines. Moreover, this recuperative engine technology may have application in the Endurance-class UAVs. Consequently in FY94/95, the UAV JPO will conduct laboratory altitude testing of a recuperative engine prototype.

8.1.2 High-Altitude Turbo-Fan Jet

Research is needed in modifications to commercial production high-pressure-ratio turbo-fan jet engines to adapt them to HAE UAV systems.

Table 8-1 UAV Enabling Technology Matrix

MAJOR CATEGORY	SPECIFIC TECHNOLOGY	TACTICAL SYSTEMS			ENDURANCE SYSTEMS	
		MANEUVER	TACTICAL	SHIPBOARD	MAE	HAE
I. Propulsion	A. Heavy-Fuel Engines	X	X	X	X	X
	B. High-Alt Turbo-Fan Jet	N/A	N/A	N/A	N/A	X
II. VehicleControl/ Management	A. Auto Lndg/Recov Techniques	O	O	O	O	O
	B. Adv Flgt Con/Nav/ Flgt Mgmt	O	O	O	O	O
III. Airframe	A. Lgt Wgt Composites	X	X	X	X	X
	B. Ice Det & Removal	X	X	X	X	X
IV. Communication	A. UHF/VHF Comm Relay	X	X	X	X	X
	B. Anti-jam/LPI	X	X	X	O	X
	C. Satcom	N/A	N/A	N/A	X	X
V. Mission Payloads	A. IMINT					
	1. EO/IR	X	X	X	X	X
	2. Multispectral	O	O	O	O	X
	3. SAR	N/A	O	O	X	X
	4. LIDAR	O	O	O	O	N/A
	B. GMTI Radar	N/A	O	O	O	X
	C. SIGINT	O	O	O	O	O
	D. MASINT					
	1. Acoustic	O	O	O	O	O
	2. Non Imaging IR	O	O	O	O	O
	3. Laser Detection	O	O	O	O	O
	4. NBC Detection	O	O	O	O	O
	5. Mine Detection	N/A	O	O	O	O
	E. Laser Designator	O	O	O	N/A	N/A
	F. Atmospheric Sensing					
	1. In-Situ	O	O	O	O	O
	2. Remote	O	O	O	O	O
VI. Data Exploitation	Auto Tgt Det/Cue/Recog	O	O	O	O	X
VII. VTOL		O	N/A	N/A	N/A	N/A
VIII. Air Transport-able		X	X	X	X	O
IX. Survivability	A. ESM	O	O	O	O	X
	B. ECM	O	O	O	O	X
	C. Decoys	N/A	O	O	O	X
	D. Low Observables	N/A	N/A	N/A	O	O
X. Integration & Test	A. Systems Integ Lab	X	X	X	X	X
	B. Test Facilities	X	X	X	X	X
	C. Modeling & Simul	X	X	X	X	X
XI. Computers and S/W	A. Flight Control	X	X	X	X	X
	B. Mission Planning	X	X	X	X	X
	C. Ground Control	X	X	X	X	X

Legend: X — Key Performance Requirement
O — Mission Need Objective

8.2 VEHICLE CONTROL/MANAGEMENT

8.2.1 Automated Landing/Recovery Techniques

Tactical/Maneuver Systems — Automated recovery is a critical need for the Tactical, Shipboard, and Maneuver Variant UAVs to reduce attrition due to pilot error on recovery, particularly during maritime and inclement weather operations; to reduce training costs; and to enhance safety of operations. Portable millimeter-wave tracking radar technology, which has the potential to meet the common automated recovery system requirements, was successfully demonstrated in 1992. Additional automated recoveries in shipboard and inclement weather operational environments are required to reduce technical risks.

Differential GPS — Civilian and commercial development of differential GPS for precision landing needs to be adapted to UAV systems. It offers potential of highly affordable worldwide category 3 take-off and landing capability in a truly portable and easily set-up system at forward tactical bases.

Deep Stall Recovery — ARPA and NASA studies in the 1980s identified the ability for precision recovery of UAVs with deep stall coupled with automatic small rocket deceleration in final phase. Further analysis is required to determine applicability to existing systems.

8.2.2 Advanced Flight Control/Navigation/Flight Management

Further development is required for a compact, lightweight, integrated inertial/GPS; identification friend or foe (IFF); and pre-programmable flight management system. A UAV JPO/USAF Wright Laboratory program to develop a modular integrated avionics group (MIAG) will be demonstrated in FY95, dependent upon funding. A critical need exists for this technology in the UAV Tactical and Endurance classes for improved target acquisition and fault tolerance.

8.3 AIRFRAME

8.3.1 Lightweight Composite Structures

There is need for inexpensive manufacturing technology for large composite aeronautical structures. This is particularly true for high-temperature-cure graphite composite structures, which are currently very expensive.

8.3.2 Ice Detection and Removal

There is a critical need for a system to sense and remove wing ice and thus, expand the flight environment of UAV systems. A current ARPA program in capacitive sensing and advanced-explosive actuator ice removal has shown some promise and will be continued.

8.4 COMMUNICATIONS

8.4.1 Multichannel UHF/VHF Communication Relay

This effort addresses a UAV communication relay capability for the family of UAVs. The relay system would provide range extension of communications and overcome horizon limitations. It would enhance command and control of forces operating over a wide geographical area. The USA desires a UHF/VHF relay capability for Tactical and Maneuver Variant UAVs. Moreover, the USMC has a requirement for a five channel VHF relay supporting the Single Channel Ground and Airborne Radio System (SINCGARS). Furthermore, there is a validated Service need for small lightweight hardware for a battlefield communications relay. This effort is currently being pursued by the UAV JPO with a technology demonstration in FY95 on the Tactical UAV. However, further development will be required before production.

8.4.2 Anti-Jam/LPI

The DARO/USAF Wright Lab Airborne Imagery Transmission (ABIT) CDL program for the U-2 requirement is underway and will be restructured to also support the HAE UAV demonstration.

8.4.3 Satcom

Commercial Satellites — Use of commercial Intelsat/Panamsat communication satellites offer attractive and affordable communications capability for endurance UAV reconnaissance systems. Initial studies indicate that approximately 50 Mbps are possible from airborne systems worldwide. R&D is required to develop lightweight affordable airborne systems with reasonable power and antenna size. Significant R&D underway for the U-2 Extended Tether Program is applicable and will be integrated into the Endurance programs.

8.5 MISSION SENSOR PAYLOADS

Background — Multi-mission payloads provide UAV systems with the capability to perform their assigned functions, such as RSTA, EW, and communication relay. As the UAV project progresses and technology advances, the Services will call on the UAV family of systems to perform these functions in support of their missions through employment of various mission payloads. The Services' needs will determine payload priorities for development and integration into UAVs.

The following provides discussions of a number of UAV payload-related technology activities that are resourced by a variety of Service and other agency sponsors. The UAV JPO is monitoring and coordinating these efforts for potential future UAV applications. The UAV JPO capitalizes on the investment of others in the development of payloads by expending its limited resources for the evaluation of existing payloads and, when selected, their integration into the family of UAVs. Commonality and interoperability are stressed across all UAVs for any payload type selected. Test results will be analyzed to assist in UAV mission payload definition and to develop specifications for potential transition into the UAV family of systems.

8.5.1 Imagery Intelligence (IMINT)

Visible/IR — There is a requirement for affordable, compact, high-resolution imaging systems for both Tactical and Endurance UAVs. The use of both low-light-level charge-coupled detector (CCD) electro-optical and IR focal plane arrays will be investigated.

Lightweight Common FLIR — A FLIR is the primary imaging sensor for the Joint Tactical and Maneuver UAVs in performing RSTA functions. Recent advances in FLIR technology allow better sensitivity, greater resolution, reduced weight, and better stability, resulting in improved performance. The UAV JPO will demonstrate a lightweight FLIR/CCD TV camera with an on-board autotracker as part of the Tactical UAV Block II improvement. This payload is planned for demonstration on the Tactical UAV in FY95.

8.5.2 Multispectral (MS)

Multispectral Imaging Sensor — A joint Office of Naval Research and UAV JPO program to develop a 82 kg sensor will be demonstrated in a Tactical UAV in 1997. The Naval Research Laboratory (NRL) led HYDICE research program is scheduled to conduct manned aircraft flight tests for data collection and analysis and this will provide fundamental information for design of future UAV multispectral payloads. R&D on exploitation tools needs to be continued. Other MS sensors may also be adapted for use on Endurance UAVs.

8.5.3 Synthetic Aperture Radar (SAR)

On-Board Image Formation Processing — SAR processing requires about 1000 operations/pixel and the HAE UAV will collect 10 to 50 million pixels/second, resulting in a requirement for 10-50 GFlops (10^9 floating point operations per second) of on-board signal processing. Current technology is available to support this, but cost and power needed are high. Continued R&D is required.

Antennas — Affordable lightweight phased-array antenna technology is required.

RF Power Generation — High-efficiency, lightweight RF modules are needed to provide up to 12 kw peak power and 2 kw average power at X band.

Foliage Penetration — The need exists to be able to detect targets in foliage. This requires high-resolution low-frequency radar. A current ARPA/USAF Wright Laboratory program is underway, but suffered cuts in the FY94 Congressional Appropriation.

3-D Interferometry — The HAE UAV could provide significant 3-D terrain-mapping capability with interferometric SAR. Current ARPA/USA Engineering Topographic Center/USAF Wright Lab work is underway and will be closely followed and applied as available.

8.6 GMTI RADAR

Moving Target Indicator (MTI) Radar — A 45 kg-class ground moving target indicator (GMTI) radar payload is needed for the Joint Tactical UAV. Recent experiences in the Persian Gulf War proved the operational utility of the JSTARS, which can provide a large surveillance picture to the theater and corps/division commanders in support of interdiction and precision strike missions. A UAV MTI radar could complement the JSTARS by providing surveillance over the blind spot due to shadowing or by concentrating on regions of immediate concern to the lower-echelon commanders. The UAV MTI radar should be able to detect and automatically track many moving targets and classify moving vehicles. In addition, it is desirable to incorporate a spotlight mode SAR/inverse synthetic aperture radar (ISAR) on the MTI to detect stationary targets by highlighting one small selected area at a time. Finally, the UAV MTI radar could be used for surface search over sea, to track ships, while the ISAR mode could be used to highlight individual ships for target identification. The USA UAV Training and Doctrine Command (TRADOC) System Manager (TSM) at Ft. Huachuca, AZ, had evaluated a prototype NDI MTI radar mounted on a helicopter to further refine TRADOC's requirement for a UAV MTI radar payload.

GMTI radar drives the power and antenna aperture required to detect moving ground targets at realistic ranges. The HAE UAV with GMTI could provide a significant capability to complement JSTARS, but requires an affordable power amplifier and conformal array antenna.

8.7 SIGNALS INTELLIGENCE (SIGINT)

SIGINT (COMINT, ELINT, FISINT) — A UAV communications intelligence (COMINT) system would be capable of intercepting and locating enemy communications in support of US forces on land or at sea and would also provide non-obtrusive monitoring of potential adversaries in peacetime. A UAV Electronics Intelligence (ELINT) system capable of intercepting and locating enemy radars could provide information concerning the enemy's electronic order of battle. A family of common hardware and software modules could be developed and a UAV COMINT/ELINT mission payload could be configured for each category of UAV based on mission needs. The UAV JPO is conducting proof-of-concept demonstrations for a limited capability COMINT payload and a separate EW/Jammer payload. These proof-of-concept demonstrations will be conducted on board the Pioneer air vehicle during late FY94 or early FY95. The EW/Jammer payload was developed by the Joint Electronic Warfare Center (JEWC) to meet USA needs. NSA is involved as a technical and operational advisor to the UAV JPO for both of these demonstrations.

An UAV Foreign Instrumentation Signals Intelligence (FISINT) system capable of intercepting and measuring targeted signals could provide detailed technical information (e.g., telemetry) concerning the enemy's advanced weapons systems, especially in the realm of ballistic missiles. This information could then be used to exploit and possibly, electronically interfere with the enemy's employment of tactical and strategic ballistic missiles. Using a common module to complement the COMINT and ELINT sensor modules, a FISINT payload could be reconfigured for each category of UAV based on specific mission need.

The Endurance UAV demonstrations could provide significant capability for SIGINT if lightweight modular systems were developed. The advanced SIGINT architecture program in

DARO is developing modular open system hardware for application to existing DoD platforms and it is intended to apply that hardware and architecture as much as possible to the Endurance UAV demonstrations.

8.8 MEASUREMENTS AND SIGNATURES INTELLIGENCE (MASINT)

Acoustic — Airborne acoustic sensors capable of working at UAV airspeeds while detecting acoustic energy from moving vehicles are needed. It may be feasible to adapt the US Army BAT acoustic sensor to this task, but engine noise must be canceled out.

Non Imaging IR Detection — The ability for UAV systems to remotely detect artillery firing, missile launches, and other hot sources of energy is needed.

Detection Of Lasers And Laser Energy — Remote detection of lasers and laser energy is a future capability to support UAVs in monitoring the battlefield.

Nuclear, Biological, and Chemical (NBC) Detection — The capability is needed for remote and in-situ detection and recognition of nuclear, biological, and chemical weapons. New sensors must be developed which are lightweight and fairly low cost to operate on UAVs.

Nuclear/Radioactivity Detection — Service mission needs solicit development of a nuclear weapon and radiation fallout detection payload for the family of UAVs. The USA CECOM Laboratory has modified the ground-portable Radio Activity Detection, Indication and Computation (RADIAC) sensor (AV/VDR-12) for airborne application. A prototype was demonstrated on an OH-58 Kiowa Warrior helicopter in FY91. The UAV JPO plans to evaluate this payload on the Pioneer in FY94 for future application in the UAV family.

Chemical Agent Detection — Various Service needs cite a UAV chemical agent detection payload. Current efforts use an interferometric IR sensor to analyze chemical agent clouds to provide a standoff capability in alerting military forces to chemical munitions events. The USA Chemical Research, Development and Engineering Center has been pursuing a chemical agents detection technology demonstration program since FY91. The UAV JPO plans to evaluate their payload on the Pioneer in FY94 for future inclusion into the Tactical and Maneuver Variant UAVs.

Mine Countermeasures (MCM) — Two MCM payloads are being developed by the USA and USN, respectively: a land mine countermeasure payload that can detect/map individual land mines or patterned minefields, and an amphibious mine countermeasure payload that can detect/localize the mines in the surf zone/shallow water. Both technologies were demonstrated at Ft. Hunter Ligget, CA, in 1991. The USN's UAV mine countermeasure payload advanced technology demonstration program will start in FY95, and integration of the land mine payload Airborne Standoff Minefield Detection System (ASTAMIDS) into the Joint Tactical UAV is planned to begin in FY96.

8.9 LASER DESIGNATOR

Laser Designator — A laser designator boresighted to a FLIR performs accurate ranging and target designation for precision guided munitions. A nondevelopmental item (NDI) derivative of the Aquila's FLIR/laser designator (Night Eagle) was installed on the UH-1N helicopter and performed successfully during Desert Storm. In FY95, the UAV JPO plans to demonstrate the Night Eagle payload on the Pioneer in preparation for a Tactical UAV performance, evaluation, test, and interface verification.

8.10 ATMOSPHERIC SENSING

8.10.1 In-Situ

Meteorological (MET) Sensor — Service mission needs exist for a lightweight UAV MET payload for the family of UAVs. The MET payload would measure temperature, humidity, atmospheric pressure, and wind velocity using the UAV's navigation data. The UAV MET payload would provide data for a wide range of applications, to include delivery and use of battlefield obscurants, artillery fire adjustment, smart munitions performance prediction, and weather forecasting to aid aviation flight safety and support operational planning. The USA Atmospheric Sciences Laboratory (ASL) developed and demonstrated a small, lightweight MET sensor in FY88. The UAV JPO plans to evaluate MET sensor performance on Pioneer in FY94 to refine requirements for the Tactical, Maneuver Variant, and Endurance UAVs.

Atmospheric sensing systems could be payloads on the HAE UAV for dual use military/civilian application. Both LLNL and NASA have funded research in this area; and the DARO has opened dialogue with both on the possibility for joint activities.

8.10.2 Remote

The need exists in civilian environmental sciences for inexpensive high-altitude and long-endurance sensors such as passive radiometry and active laser techniques to provide remote characterization of atmospheric aerosols, water vapor, and key chemical species.

8.11 DATA EXPLOITATION

Automatic Target Detection, Cueing, and Recognition — Image data exploitation is man-intensive and the situation becomes critical when wide-area collection produces upwards of 137,000 sq km/day. The need exists for automatic target cueing to cue the image analyst to potential targets and eventually to automatically recognize target type and identity. Significant R&D has been pursued by ARPA, USAF, USN and USA laboratories. Automatic target detection and cueing is now feasible to a significant level of performance and R&D needs to continue to improve this technology.

8.12 VERTICAL TAKE-OFF AND LANDING (VTOL)

Evaluation of technologies, such as tilt rotor, tilt wing, ducted fan, jet lift, and conventional helicopter, may lead to a common UAV platform for the Tactical, Shipboard Variant and Maneuver Variant UAVs. The need for access to take-off and landing strips would be eliminated. A common platform and elimination of the need for prepared spaces for take-off and landing are both key elements in the UAV JPO program plan.

8.13 MOBILITY & TRANSPORTABILITY

Significant system and life cycle cost will be avoided if UAV systems are easy to transport. New techniques in modular assembly and folded structures are required.

8.14 SURVIVABILITY

Continued research and development are needed in improved survivability for UAVs, including application of very low observables to low-cost UAVs. This should include both radar cross-section and infrared emissions reduction, and exploration of aircraft shaping and radar absorbent materials.

The HAE UAV demonstration will be an overt vehicle that is required to penetrate into potentially hostile areas and must have a moderate degree of survivability. This could take the form of a combination of both on-board and off-board threat warning and avoidance techniques using electronic support measures, electronic countermeasures (ECM) employing active jamming, and towed decoys to protect against both the tracking radars and missiles. These active ECM and decoy techniques become easier as the observables of the UAV are decreased and thus, low-observable techniques may also be employed.

8.15 INTEGRATION & TEST

8.15.1 Systems Integration Laboratory

The UAV Systems Integration Laboratory (SIL) was established by the UAV JPO at MICOM as the Center of Technical Excellence for the joint family of UAVs. The SIL provides a test bed for technology assessment, insertion, demonstration, and transfer, as well as a central database for UAV test results and "lessons learned." Analysis, simulation, and testing (bench test, captive flight, etc.) conducted in the SIL at the direction of program managers (PM) will result in substantial risk reduction, cost savings and improved performance in field testing. The SIL test bed is a mechanism for UAV participation in CINC Battle Lab, and other technical and operational demonstrations and exercises, through the WARBREAKER and Defense Simulation Internet (DSI). In addition to facilitating resolution of interoperability procedures, interfaces, and tactics, use of the resources of the SIL early in the program will ensure each PM a smooth transition to post-deployment support.

8.15.2 Modeling and Simulation

Advanced distributed simulation and modeling techniques are being investigated by a number of DoD laboratories and there is significant work in progress at ARPA. Distributed simulation and modeling are critical throughout the entire development and acquisition process. Priorities outlined in the Director, Defense Research and Engineering (DDR&E) letter of 21 January 1994 will be followed. They include such things as (1) interoperability of live, virtual, constructive simulations to support operational readiness, (2) developing authoritative representations such as terrain, wilderness, and smoke, (3) supporting various advanced distributed simulation demonstrations and experiments, and (4) extending modeling and simulation beyond training applications.

8.16 COMPUTERS AND SOFTWARE

UAV systems are by nature computer hardware- and software-intensive and rely on R&D being accomplished in government laboratories as well as by commercial industry. This includes both on-board flight control, data processing, signal processing and mission planning as well as ground control systems. Software engineering tools, fault-tolerant software, reusable code techniques, open systems, and compatible languages are examples of critical areas for R&D.

8.17 OTHER

Micro-miniaturization and low-power technology are needed to increase UAV endurance and reliability.

9. TEST AND EVALUATION

9.1 OVERVIEW

The UAV JPO is the focal point and interface for UAV developmental test and evaluation (DT&E) among the program management offices and supporting multiservice field test activities that comprise the UAV Joint Test Force. The UAV JPO provides liaison to individual Service headquarters and OSD (Director, Test and Evaluation; Director, Operational Test and Evaluation) with regard to both developmental and operational test and evaluation (OT&E) of UAV systems. Additionally, the UAV JPO provides liaison to the individual Service OT&E agencies for the planning and support of UAV operational testing. The UAV JPO maintains the status of capabilities, limitations, policies, and procedures associated with national and international facilities, as well as environments that are suitable for UAV test and evaluation activities. The respective test and evaluation master plans (TEMPs) for each of the UAV programs readily serve as a source for the scope, objectives, structure, and resources of developmental and operational test programs.

The coordinated relationship of a disciplined methodology and appropriate test resources produces information necessary to decisionmakers at each stage of the system acquisition cycle for the purposes of risk reduction. This information is based on: identification of user requirements in response to a fully described and validated threat; development and maintenance of standard Modeling and Simulation (M&S) for pre- and post-test analysis; thorough use of these M&S tools to predict, update, and correlate equipment test results throughout contractor, developmental, and operational testing and evaluation; and maintenance and full utilization of credible testing resources. The final objective of system testing, employed throughout all phases of UAV system development and modification, is to produce effective and suitable systems that satisfy user needs.

9.2 DEVELOPMENTAL TESTING AND EVALUATION

UAV Program Managers conduct joint DT&E throughout the system acquisition process and life cycle to ensure that the DoD gets an effective and suitable system. Decisionmakers will use DT&E results to help decide whether the system is ready for dedicated OT&E. DT&E is conducted on components and subsystems at all levels, as well as on whole systems, and covers:

- Preplanned product improvements testing
- Hardware and software integration testing

- Modification testing
- Qualification testing
- Initial production acceptance tests.

To accomplish UAV DT&E requirements, it is necessary to resource and schedule DT&E activities using the multiservice test facilities while minimizing significant investment in improvements to the various facilities. For example, coordination between the UAV JPO and the Naval Air Warfare Center (NAWC) is underway to develop a land-based ship motion simulator through modifications of existing simulator hardware to meet shipboard UAV objectives.

9.3 OPERATIONAL TESTING AND EVALUATION

The planning and execution of OT&E for UAVs are conducted by the Multiservice Operational Test and Evaluation Force, with the USN as the Executive Service. At this time, the US Navy has designated the US Army Operational Evaluation Command as the principal Operational Test Agency (OTA) for conduct of the Tactical UAV operational testing. A matrix depicting current developmental test/operational test (DT/OT) test sites for UAV systems covered in this plan is at Table 9-1.

Adequate OT&E entails portraying operational test realism. This requires test sites that possess representative topographical and climatic environments of areas where the UAV system may be deployed, the integration of interfacing and supporting units, and complex target arrays simulating threat forces. Accordingly, formal operational testing for UAV systems requires strong user involvement to ensure the system is operationally effective and suitable. This may require substantial resources, personnel, materiel, and test sites. Participating in training exercises, combined arms exercises (CAXs), and field training exercises (FTXs) may help reduce these expenditures if test controls can be maintained.

Integrated logistics support (ILS) for UAV systems is evolving and will require definition and maturity to support formal OT&E. Respective ILS plans for each of the UAV systems are an integral part of both developmental and operational test planning and execution, and will be employed to ensure early identification and optimization of critical logistical elements. Logistics support for a UAV system may not mature during testing but must be sufficiently developed to allow operational personnel to perform organizational-level maintenance during OT&E.

Table 9-1 DT/OT Test Sites

UAV/Site	1	2	3	4	5	6	7	8	9	10	11	12
Maneuver Variant					AV/Sensor demo before RFP release							
Tactical		Survivability				FQ&P and sensor, LUT + OA	Sensor captive carry & SIL	Environ-mental & Trans-portability				Propulsion
Shipboard Variant			LHD land based test									
Medium Range	Mini-carrier suitability			FQ&P and sensor								Propulsion
Medium Altitude Endurance					FQ&P and sensor	FQ&P and sensor						
Pioneer			FQ&P			Op/mainte-nance training						
DEMONSTRATIONS												
EXDRONE	FQ&P and payload development/integration			GPS/auto-nav develop								
Pointer		Accept test, GPS/auto-nav develop					UGV demo		Payload development			
MAVUS I/II										FQ&P and autoland develop-ment	Data link	
TRUS					FQ&P							
VLAR					FQ&P							

1. NAWC-AD, Patuxent River, MD
2. NAWC-WD, China Lake, CA
3. NAWC-WD, Point Mugu, CA
4. Hill AFB, Dugway, UT
5. Yuma Proving Ground, AZ
6. Fort Huachuca, AZ
7. Redstone Arsenal, AL
8. White Sands Missile Range, NM
9. Defense Evaluation Support Activity, NM
10. Fort Sill, OK
11. NSWC Dahlgren, VA
12. NAWC-AD, Trenton, NJ

FQ&P = Flying Qualities and Performance
LUT = Limited User Test
OA = Operational Assessment

UGV = Unmanned Ground Vehicle

NAWC-AD = Naval Air Warfare Center - Aircraft Div
NAWC-WD = Naval Air Warfare Center - Weapons Div
NSWC = Naval Surface Warfare Center

The predicted survivability of a UAV system in a combat environment is a critical factor that must be quantified in cost-effective terms to a reasonable level of confidence. The use of destructive field tests involving a panoply of air defense weapons integrated into a realistic combat scenario and firing live ammunition is extremely expensive. However, by use of nondestructive field tests, vulnerability and survivability can be determined to a reasonable level of confidence using computer simulations incorporating force-on-force models. Operational training exercises also hold potential for determining UAV survivability at reasonable cost.

To accurately predict UAV system survivability in an operational environment, representative user personnel must be employed to obtain tactical expertise and specific training. Such personnel will perform mission planning to determine the best solution for both mission accomplishment and system survivability. To assure that only certified computer models are employed in the analysis of operational UAV survivability, the services of the Survivability/Vulnerability Information Analysis Center (SURVIAC), a DoD technical center with acknowledged expertise in aircraft survivability, will be used.

9.4 DEFENSE EVALUATION SUPPORT ACTIVITY UAV EFFORTS

The UAV JPO has established a Memorandum of Understanding with the Defense Evaluation Support Activity (DESA), Kirtland AFB, NM, to conduct joint UAV operations and systems evaluation efforts. The DESA, an OSD activity reporting to the Director, Test and Evaluation (T&E), is chartered to provide a broad spectrum of T&E support to both DoD and non-DoD agencies. Primary objectives and goals concerning the DESA support to the UAV JPO include:

- Developing an operations and technical maintenance capability to support UAV systems demonstrations and evaluations
- Developing a T&E strategy and use of DESA's T&E capability and association with multiple government agencies (both DoD and non-DoD) to conduct timely evaluations of UAV systems and associated sensors for DoD and non-DoD mission applications
- Providing a cost-effective UAV support capability geared toward rapid evaluation of UAV systems and associated equipment.

The DESA has provided or supported operational demonstrations of UAV capabilities using the Pointer UAV system for various government and nongovernment activities. In particular, a UAV evaluation effort has been established with the National Guard Bureau to evaluate UAV applications in both federal and state National Guard mission areas. Initial evaluation efforts are on-going with the Pointer UAV in support of the Oregon National Guard. National Guard support is provided to many civilian agencies and this effort provides an excellent opportunity to identify and assess civilian applications of UAVs and to establish baseline data on the UAV JPO's hand-launched UAV concept. Additionally, the DESA is working with local, regional and national Federal Aviation Administration (FAA) elements to address airspace management and safety certification processes for UAV operations in both military and civilian applications.

10. INTEGRATED LOGISTICS SUPPORT

The UAV Joint Logistics Steering Panel (JLSP), chartered by the UAV JPO and consisting of the Defense Logistics Agency (DLA) and each UAV program Integrated Logistics Support (ILS) manager (lead and participating), was established in January 1992. The JLSP provides consolidated and coordinated ILS guidance for the UAV ILS community, including UAV initiatives with organizations and systems such as:

- Joint Logistics Center of Excellence (JL-COE)
- Joint Logistics Management Information System (JLMIS)
- Joint Logistics Assessment (JLA)
- Joint Logistics Assessment Review Group (JLARG)
- UAV Computer-Aided Acquisition and Logistics Support (CALS) System.

Efforts continue to refine joint logistics operating policy, plans, and procedures compatible with OSD and UAV JPO guidance for the family of UAVs. New ILS opportunities for improving UAV operational readiness with economy will be identified and nurtured to fruition.

The following are the logistics initiatives completed in 1993. The UAV JPO:

- Finalized the UAV Family Configuration Management Plan and established the UAV Family Configuration Control Board
- Developed and implemented joint standardized nomenclature and a mission design series numbering system for nonlethal UAVs to provide a common identification that accurately describes the current and future UAV programs
- Surveyed and identified existing common and peculiar support equipment and automatic test equipment which may be applicable to UAV systems to minimize cost and reduce inventory redundancy
- Reviewed UAV systems' acquisition program documentation to ensure that supportability characteristics are accorded consideration equal to performance, cost, and schedule
- Developed and published a Capstone UAV ILS Planning Guide for use by program personnel
- Established logistics constraints for maximum weight and volume of organizational level support equipment. This provides the most

efficient and effective support with the optimum amount of personnel and equipment

- Analyzed individual UAV organizational support equipment requirements.

10.1 JOINT LOGISTICS CENTER OF EXCELLENCE

In September 1991, the Joint Logistics Commanders (JLC) approved a UAV JL-COE concept of designating an existing logistics organization to enhance and coordinate support for the logistics elements of UAV programs. In August 1991, the UAV JL-COE was assigned to the Integrated Material Management Center (IMMC) at Huntsville, AL. The following are major functions of the JL-COE:

- Identify and support an ILS infrastructure utilizing the IMMC and other Services' cognizant field activities
- Host management meetings with all UAV logistics personnel
- Encourage all UAV system program/logistics managers to implement MOAs with the JL-COE to obtain common core ILS support and benefits of lessons learned
- Interface with the Joint Depot Maintenance Analysis Group (JDMAG) for selection of common UAV depot level maintenance support initiatives. At the field level, this will include ensuring that when UAV systems are fielded, all elements of logistics support are fully available and that the support system is mature.

The JL-COE continues to address logistics supportability of organizational level support equipment to ensure consistency of standards/policies across the UAV family. A logistics support equipment commonality and integration strategy approach continues to be refined, and the UAV Capstone ILS Guide which addresses equipment supportability initiatives is being reviewed by UAV program personnel.

10.2 JOINT LOGISTICS MANAGEMENT INFORMATION SYSTEM

The JLMIS is a UAV JPO initiative started in 1991 to provide UAV program offices with access to UAV-related logistics data. The JLMIS will reflect DoD CALS and Corporate Information Management (CIM) requirements. This system will provide the capability to connect UAV logistics activities with UAV-related data bases (Integrated Weapon System Database (IWSDB), Contractor Integrated Technical Information Service (CITIS), and Government

Integrated Technical Information Service (GITIS)) for rapid and integrated analyses to enhance logistics support and assessments. System planning will allow this capability to support the program offices with information required to help determine system specifications, readiness levels and supportability requirements. A phased implementation allows the system to grow with the increase in UAV systems. Maximum use of existing modified/standardized software programs within the Services' logistics community will be required whenever such programs can meet the joint requirements. This capability will be available to all UAV activities to encourage commonality within the joint support arena. JLMIS-related objectives achieved in 1993 include:

- Development of a JLMIS Phase II concept document, requirements statement and user guide
- Development of software modules for JLA assessment that will interface future software logistics modules with IWSDB
- Introduction of a prototype module that will access disparate data sources and demonstrate the utility of the JLMIS workstation
- Continued dialog with the CALS logistics program to share logistics analysis enhancement experience and workstation development knowledge.

10.3 JOINT LOGISTICS ASSESSMENT

JLA is a joint logistics evaluation of the adequacy of the planning, management, budgeting, and execution of ILS for UAV programs. The intent of the multiservice logistics assessment is to eliminate redundancy in Service logistics assessments while ensuring that all Services' legitimate logistics requirements are covered. The JLA draft report will be presented to the JLARG, which comprises flag-level representation from all Services and is chaired by the UAV JPO. The final JLA report will recommend whether the UAV JPO should certify the adequacy of the logistics support program for the impending milestone/program review.

10.4 COMPUTER-AIDED ACQUISITION AND LOGISTICS SUPPORT

The UAV CALS strategy will be compatible with OSD, USN, CALS, and JLSC requirements and will define the methodology for developing UAV CALS-related documentation, a concept of operations, and an acquisition strategy. Implementation of a UAV CALS strategy will enable more effective generation, exchange, and use of data for UAV systems and equipment to include management, design/engineering, manufacturing, logistics support, and operations data. UAV CALS requirements will be included in the development of and installed on the UAV JLMIS.

10.5 HUMAN SYSTEMS INTEGRATION

As required by DoD Directive 5000.1 and DoD Instruction 5000.2, each UAV program will prepare a Human Systems Integration (HSI) Plan and a Training Development Plan. Both plans will address trade-offs between cost and performance and, in addition, will address HSI impacts upon design and schedule. UAV programs will follow USN and UAV JPO policy and guidance for development of these plans. Each UAV program will identify an individual responsible for HSI.

The HSI initiatives begun in the UAV programs are being continued and will be expanded. These initiatives will influence design throughout the acquisition cycle by identification of manpower, personnel, and training trade-offs in connection with emerging LSA information. Other trade-offs with HSI include cost, schedule, performance, and risk. Existing skills will be stressed to minimize unique requirements in the force structure. Requirements for additional manpower are being minimized. Training and training device requirements will be continually evaluated to streamline and minimize time and material resources, training aids, and facilities; and to incorporate modularity, embedded training, and on-the-job training. Human factors, safety, and health hazard issues will also receive similar analysis for optimization of the entire HSI program throughout the UAV program. Manpower Estimate Reports completed and planned will be applied to ensure that force structure is not unduly impacted.

The UAV JPO will monitor these plans to ensure they are consistent with joint UAV family HSI objectives. The 1993 HSI objectives that were completed include:

- Development of the Joint UAV Family HSI Plan
- Monitoring of the HSI Plan generated by each UAV system
- Monitoring of UAV technical development plans (TDP) and concepts generated by each UAV system.

10.6 TRAINING AND PERSONNEL

Training for UAVs will reflect congressional guidance to minimize personnel and training costs. Centralized formal UAV training for common core modules and standardized common core training materials will be the focus. Common core training may be conducted at one or more training sites. The Ft. Huachuca UAV Joint Service Training Center (JSTC) is designated as the UAV JPO training agent for the Tactical and Maneuver Variant UAVs. In February 1993, a ground-breaking ceremony was held at Ft. Huachuca to initiate the construction of the UAV JSTC facility. Completed 1993 objectives include:

- Continued coordination of the development and use of "common core" training materials in support of the Joint Tactical UAV Program training requirements

- Provision of guidance to UAV system managers to assist in satisfying UAV system-peculiar training requirements

- Concept exploration of an external pilot training simulator program to integrate existing government-owned hardware and software and use government training device experts from the Naval Training Systems Center, the USA's Simulation, Training and Instrumentation Command, and the USAF's Simulation Systems Program Office

- Initiation of an operator trainer combined with a UAV payload operator trainer, utilizing computer-based training materials, interface courseware, and embedded training techniques.

The personnel required to support UAVs will be directly related to the specific UAV system that is to be fielded. Each Service will assess the individual skills required to operate a system and determine if an existing, Air Force specialty code (AFSC), Army military occupational specialty (MOS), or USN enlisted classification (NEC) can be used to accommodate the UAV operation and maintenance requirements. If, after analyzing the personnel needs, a Service determines that a new AFSC, MOS or NEC is required, it will identify the knowledge, skills, and experience levels required for the UAV tasks.

11. OVERVIEW OF RELATED PROGRAMS

UAV programs have different levels of interface with other programs. Some require or depend on interfaces with other tactical military systems to provide optimal support to the user. Examples of those external systems are the Contingency Airborne Reconnaissance System (CARS), the Enhanced Tactical Radar Correlator (ETRAC), and the Joint Service Image Processing System (JSIPS). UAV programs are also dependent on other program developments for advancement of technology or delivery of systems for integration with a specific UAV program. Examples of these other programs are the advanced SIGINT sensor development, the Joint Deployable Intelligence Support System (JDISS), the Joint Worldwide Intelligence Communication System (JWICS), and the TROJAN SPIRIT II communications system.

These external interrelationships can be grouped into three categories. The first category includes programs that provide the capability to exploit information or fuse information with other sources. The next category includes programs that are advancing sensor technology, and the last category includes programs that are developing or fielding communications devices and systems.

11.1 SYSTEMS FOR INFORMATION EXCHANGE AND EXPLOITATION

Tactical and Endurance UAV systems satisfy the information needs of the supported USA corps, divisions and brigades, and USMC forces by providing timely information needed for detection, identification, and targeting at the corps and MAGTF levels and below. Required system interfaces for Tactical UAV systems include the AFATDS, ASAS, IAS, and JSTARS GSM. Control and funding for AFATDS, ASAS, IAS, and JSTARS GSM are vested with the individual Services.

The interface between the tactical UAV GCS and the JSTARS GSM that supports targeting and BDA (illustrated in Figure 11-1) deserves special mention. JSTARS GSM migration to the Common Ground Station with input from tactical UAVs will provide the capability to combine off-board information with JSTARS-derived MTI information. That tip-off can cue the imaging sensor on a UAV to verify target identification, provide target location for attack, and provide immediate BDA following the attack. Figure 11-2 shows the E-8C JSTARS Program.

Planned Endurance UAV demonstrations will address information needs of the supported commander by providing timely information needed for detection, classification, identification and targeting for EAC, including the theater or JTF Commander. Because those

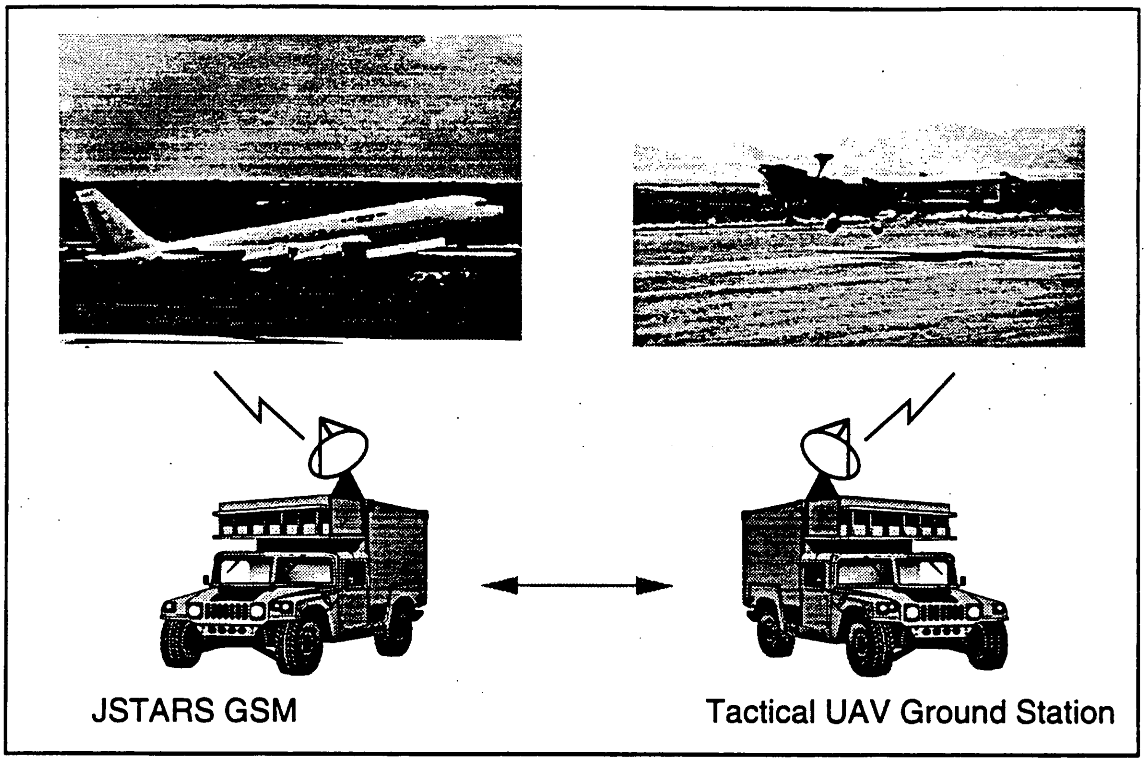
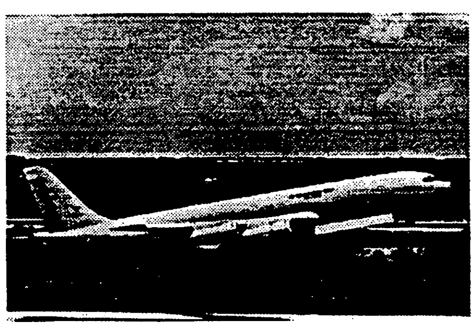


Figure 11-1 JSTARS Tactical UAV Interface



Performance Parameters

Altitude	10.6 km
Endurance	7+ hours
Radius of Action	(unk)
Speed	810 km/hr
Propulsion	4 Turbo-fan
Gross T/O Wt.	153,000 kg
Sensor Type	MTI and FTI radar
Datalink	Surveillance & Control Datalink (SCDL)
Deployment	Self
Launch / Recovery	Improved Runway
Operation	Manned

Key Information

Program status: Development

- The airborne wide-area ground surveillance multi-mode radar system has the ability to detect, locate, classify, and track both moving and fixed objects in all weather conditions. This radar is placed in a Boeing 707. The system supports battle management, force allocation, and damage assessment.

User USAF, USA

Contr Agency USAF
Prog Manager Col Bruce Mills
(617) 377-5725

Programmatics

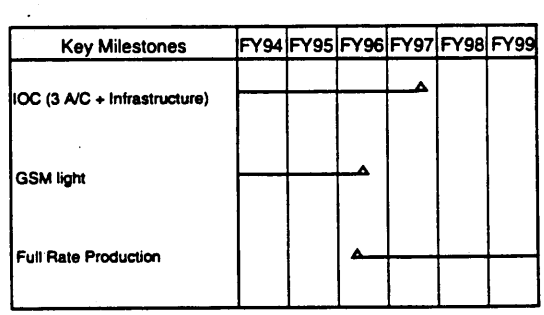
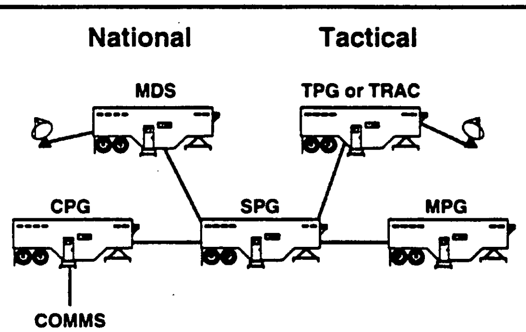


Figure 11-2 E-8C JSTARS

commanders are supported by larger and more capable imagery processing systems, required information interfaces for the Endurance UAV demonstrations include the Common Ground Station, JSIPS (see Figure 11-3), Modernized Integrated Exploitation System (MIES) which exploits the radar imagery processed by ETRAC, JDISS/JWICS, the Contingency Airborne Reconnaissance System (CARS), Remote/Temporary Remote Operating Facility Airborne (ROFA/TROFA) for SIGINT sensors. Control and funding for the CARS, JSIPS, MIES, and ETRAC programs are within the DARO. Currently the JSIPS program is being restructured to incorporate commercial off-the-shelf (COTS) hardware and software; convert to an open system architecture; use best commercial practices; and implement contractor logistics support (JSIPS II). The USA will maintain two MIES systems and convert the Engineering Development Model (EDM)/JSIPS into a MIES for National and Theater Imagery Exploitation. The USA will be directed to address the transition from MIES to JSIPS II in its FY96 POM submission. The USMC will receive one JSIPS EDM, one JSIPS II. Likewise, the USMC EDM will be swapped out to a JSIPS II in the outyears. Other programs described in this section are controlled and funded by the individual sponsoring Services or Agencies.



Performance Parameters

Mobility:	Tailorable deployment by C-5, C-141 or C-130 Type 4 (unimproved roads)
Sensor Input:	MDS (National), ASARS II, ATARS (Tactical)
Product:	Reports and Imagery
Comms:	AUTODIN, PSTN, TRI-TAC, MSC-63A UHF SATCOM, DISNET-1, DSNET-3
Interoperability:	MDS, TRAC, ATARS, EPDS, ETUT, CIS, IAS, IPA, CDL, NITF, CATIS

Key Information

Program Status:	Operational, Low Rate Production (LRIP)
User	USA, USN, USAF, USMC
Contr Agency	JSIPS PMO (ESC/ICI)
Prog Manager	Mr. Rich Bleau (617) 217-6048

Programmatics

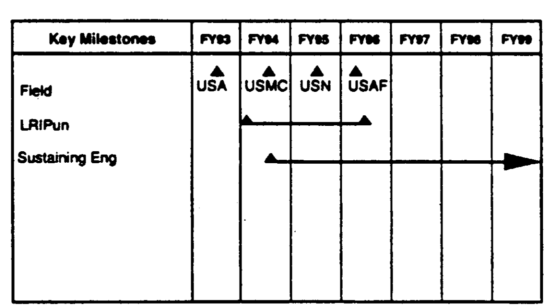


Figure 11-3 Joint Service Imagery Processing System

The CARS (see Figure 11-4) will provide day/night, all-weather, near real time processing, exploitation, and dissemination of multi-intelligence sensor data collected by airborne reconnaissance platforms. It supports theater commanders worldwide with critical intelligence required for battlefield management and execution across the spectrum of conflict. During contingency operations or periods of hostilities, CARS will become an asset of the appropriate designated Theater CINC or Joint Force Commander and be responsive to the needs of all theater components. The USAF, as the executive agent for CARS, will deploy and operate the system.

(See Figure 11-4A)	**Performance Parameters** **Mobility:** Tailorable deployment capability single/multiple C-5s **Sensors:** All U-2 Sensors and data links **Interoperability:** U-2, Rivet Joint, AWACS, ABCCC, Senior Scout **Comms:** Theater Tactical Nets, DDN, SATCOM
Key Information **Program Status:** Integration and Test **Operator/User:** ACC/Joint Force Commander **Supporting Agency:** Det 8, 645 MATS, Robins AFB	**Programmatics** **First System Delivery:** Apr 1994, Langley AFB **Second System Delivery:** Sep 1995, Base TBD

Figure 11-4 Contingency Airborne Reconnaissance System

CARS' primary mission is processing, exploiting, and disseminating U-2 intelligence. The objective of CARS is to provide multi-intelligence, multi-sensor, and multi-platform fused intelligence to the warfighter in near real time.

CARS, JSIPS, ETRAC, and MIES are systems primarily intended to support the Service components of a JTF. They may be tasked to support a JTF Commander in the absence of connectivity or support from the Theater JIC/JAC. MAE UAV interfaces to JSIPS and MIES may occur through the Defense Intelligence System Network (DISNET) interfaces with JDISS/JWICS. The HAE UAV CONOPS has not defined interfaces to JSIPS, CARS, ETRAC, and/or MIES.

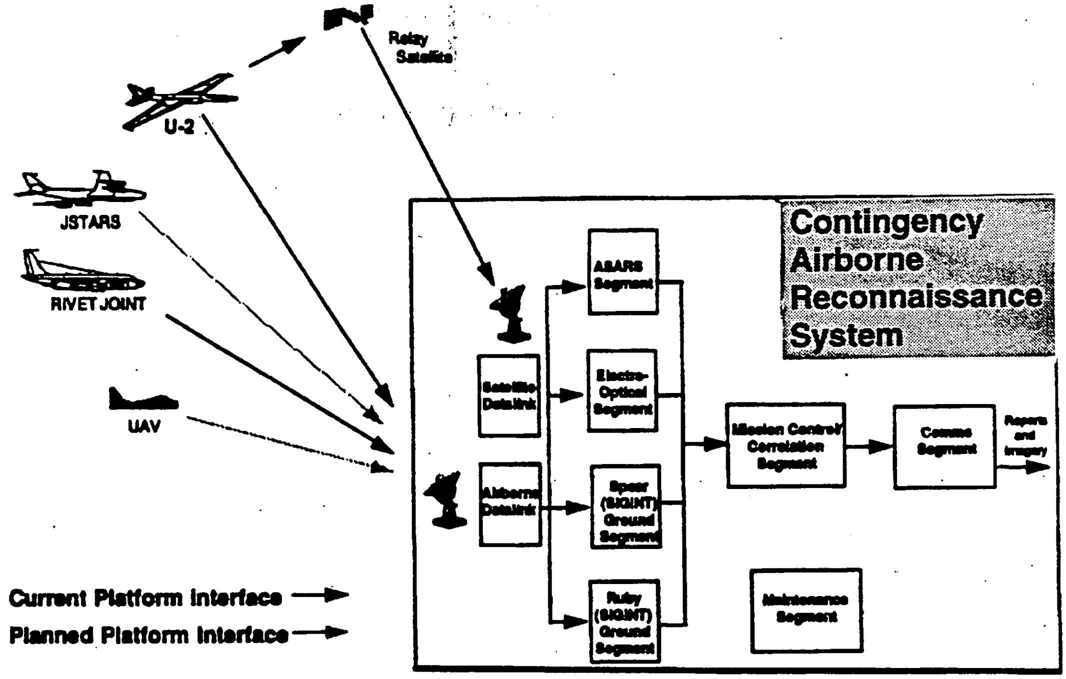


Figure 11-4A CARS Data Flow

MIES (see Figure 11-5) is part of the Army Tactical Exploitation of National Capabilities (TENCAP) Architecture. Its primary products are intelligence reports, annotated imagery, and target data. The MIES system interfaces with National Systems and with the ETRAC system which receives the radar phase history data from the ASARS-2 sensor on the U-2R and processes it into imagery format. It could perform a similar function for any HAE UAV SAR sensors that downlink radar phase history data.

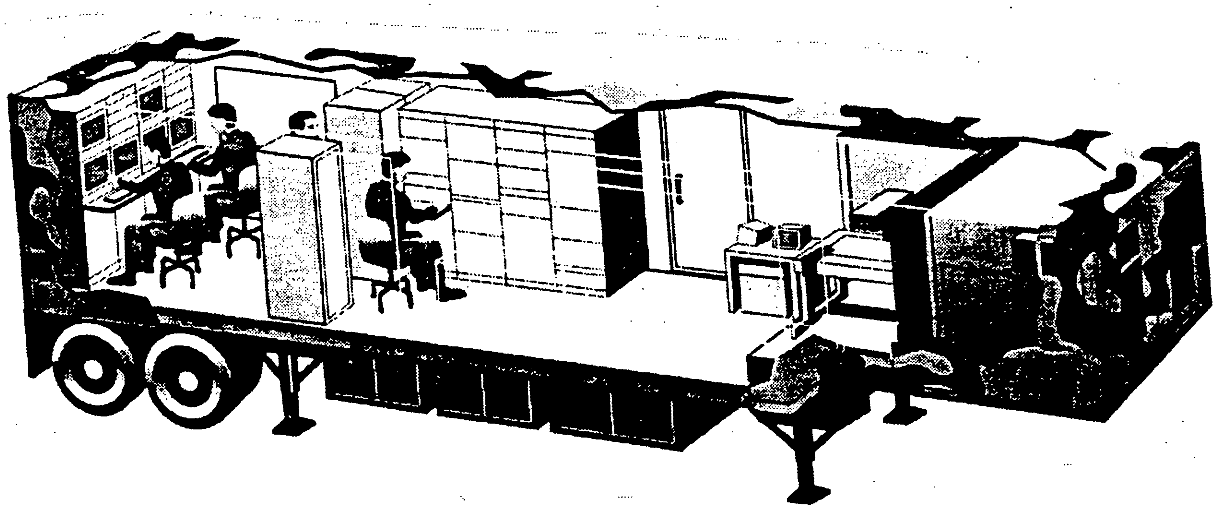


Figure 11-5 Modernized Imagery Exploitation System (MIES)

JDISS/JWICS is a C4I system primarily intended to support the information needs of the theater and JTF Commander with connectivity to the NMJIC and selected extensions to Service theater components. MAE UAV demonstrations will provide information to support the JTF, tactical, theater, and national users (see Figure 11-6).

The NSA Regional SIGINT Operational Center (RSOC) architecture provides for a distributed processing of SIGINT targets to regional centers hosted and operated by the military service cryptologic elements. The NSA portion of U-2 SIGINT processing will be performed at the various RSOCs and is only one of the SIGINT sources used in the RSOC. The RSOC architecture uses a distributed information network to process and exploit SIGINT information separate from the physical location of U-2 ground station processing equipment. Any SIGINT payloads on Endurance UAV demonstrations will be designed with open systems architecture and developed or coordinated with NSA to ensure interfaces with that approved architecture.

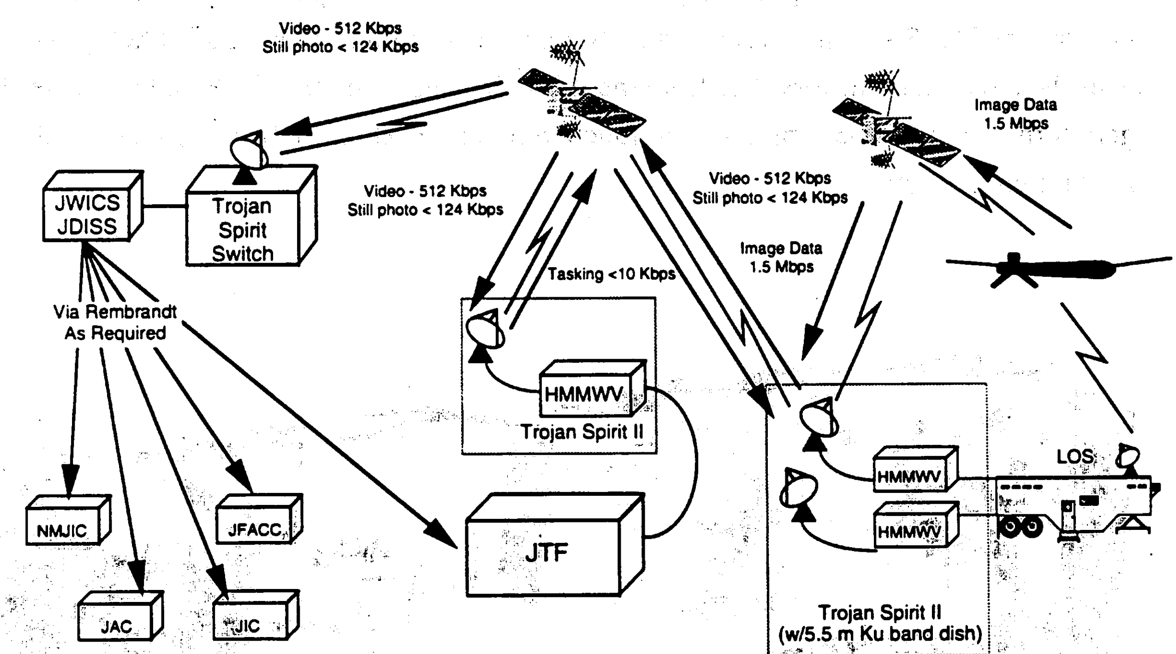


Figure 11-6 MAE End-to-End System Imagery Data Flow

11.2 SENSOR PROGRAMS AND PAYLOADS

Sensors (IMINT, SIGINT, and MASINT) on UAVs are a combination of integration of a previously developed sensor into a program and additional development to meet a specific requirement. Visible EO/IR sensors used in UAVs are generally nondevelopmental items. Integration problems or technical challenges (size, weight, vibration, power, isolation, etc.) that derive from the vehicle require resolution by that UAV program.

The SAR payload for the MAE UAV is under development. The SAR sensor payload planned for the HAE UAV is not currently available and may also require a specific development to meet the requirement.

Any SIGINT sensor on the HAE UAV will be strongly influenced by the open systems architecture Advanced SIGINT sensor technology efforts being pursued by the DARO for manned platforms (U-2, GUARDRAIL Common Sensor (GRCS), and probably EP-3E and RC-135V/W Rivet Joint). These manned platforms are either within the DARO (U-2, EP-3E, and RC-135V/W Rivet Joint) or use technology development from within the DARO (USA GRCS). Interface with that Advanced SIGINT program office is significantly enhanced because the program is controlled and funded within the DARO.

MASINT sensors, though not specifically designated, will be carried as appropriate.

11.3 COMMUNICATION PROGRAMS

All UAV programs require communications for movement of information from the platform through a ground processing station for exploitation and dissemination for use by the tactical operator. There are many interface requirements for standard protocols and equipment, but four programs which are integral to the Endurance UAV programs require special discussion. They are: Common Data Link (CDL), Airborne Imagery Transmission (ABIT), TROJAN SPIRIT II, and wide-band data relay.

The CDL standard (274 Mbps) is mandated by ASD(C3I) for all wide-band data links. This program, managed by the DARO, is currently fielded and provides a data interoperability standard used by the Navy's ES-3/Common High Band Data Link (CHBDL), the Army's GRCS, and the Air Force's U-2 with its Extended Tether Program and Senior Span program. It is the designated standard for the MAE UAV platform-to-ground station data link.

The ABIT program objectives provide a path for meeting the HAE technical requirements for wide-band communications with reduced detectability and a means to provide air-to-air communications. The ABIT program is controlled and funded within the DARO.

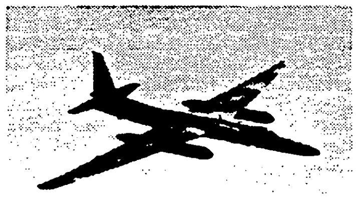
Endurance UAV requirements for dissemination of information to the theater and JTF Commander (as well as the NMJIC) place a heavy burden on communications systems from the UAV ground station to the end-user. TROJAN SPIRIT II is proposed to satisfy those information dissemination needs for the MAE UAV, as illustrated in Figure 11-6. TROJAN SPIRIT II is a Joint Service program that provides access to a number of communication satellite systems as well as other tactical voice communications. It meets the mobility, availability, cost, and airlift requirements of MAE. Program control for TROJAN SPIRIT II is in the USA program office, but funding for units required by MAE or dedicated in support of any other UAV program will be provided though the DARO.

Endurance UAVs, especially HAE, are required to operate beyond ground station line-of-sight and provide data in real time. That requirement can be met only with some form of wide-band data relay. Relay platforms considered for this mission include commercial and military communication satellites and other dedicated UAVs. Availability of satellite transponders capable of wide-band relay is limited. Most assets are already fully subscribed or do not provide world-wide availability. DARO is working with the Joint Staff/J-6 and Defense Information Systems Agency (DISA) to reserve transponder service on commercial satellites to provide the wide-band communications relay services required by HAE.

11.4 MANNED AIRBORNE RECONNAISSANCE PROGRAMS

Non-UAV programs in DARO that provide intelligence data to be used independently or fused with UAV Imagery/SIGINT data are the U-2 (see Figure 11-7), EP-3E (see Figure 11-8), and RC-135V/W Rivet Joint (see Figure 11-9). These manned airborne platforms are normally operated as stand-off collectors. The EP-3E and the RC-135V/W are primarily configured as SIGINT collection/processing/reporting platforms, while the U-2 can be configured for Imagery, SIGINT, or both.

The proposed UAVs in this plan would not be capable of producing the type or amount of SIGINT that these manned airborne platforms are capable of producing and reporting. However, UAVs equipped with Imagery and/or certain SIGINT sensors would provide longer on-station collection times and close-up access to signal and visual environments which are currently difficult to access from stand-off or very high altitude collection systems. UAVs would therefore complement other collectors in the performance of Imagery/SIGINT collection/processing reporting.



Performance Parameters

Altitude	20 km
Endurance	11 hours
Radius of Action	(unk)
Speed	760 km/hr
Propulsion	1 Turbofan
Gross T/O Wt.	20,000 kg
Payload	7700 kg
Sensor Type	SIGINT, IMINT
Datalink	CDL, IDL, CTT, TIBS
Deployment	Self
Launch / Recovery	Improved Runway
Operation	Manned

Key Information

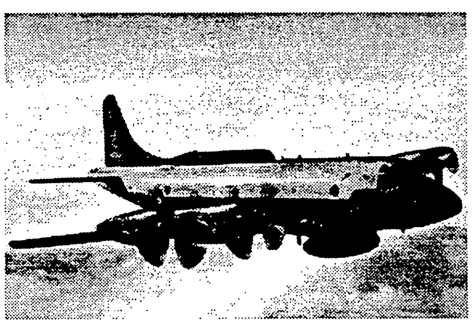
Program status: Fielded
- Multiple sensor collection in support of theater CINC and JTF

Operator	USAF
User	USAF, USN, USMC, USA
Contr Agency	USAF
Prog Manager	Maj Nelson (703) 227-9282

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Reengine	—	—	—	△		
ADV SIGINT DEV	—	—	—	—	—	△

Figure 11-7 U-2



Performance Parameters

Altitude	8.5 km
Endurance	12 hours
Radius of Action	(unk)
Speed	600 km/hr
Propulsion	4 Turboprop
Gross T/O Wt.	64,000 kg
Payload	(unk)
Sensor Type	SIGINT
Datalink	TADIL A, TIBS, CTT, OTCIXS
Deployment	Self
Launch / Recovery	Improved Runway
Operation	Manned

Key Information

Program status: Fielded
- Intelligence, targeting and BDA beyond range of Carrier Assets

Operator	USN
User	USN, USAF, USA, USMC
Contr Agency	USN
Prog Manager	CAPT Leonard (703) 614-2504

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
CILOP	—	—	△			
Storyteller		△	—	—	△	

Figure 11-8 EP-3E

Performance Parameters	
Altitude	10.6 km
Endurance	30 hours refueled
Radius of Action	(unk)
Speed	810 km/hr
Propulsion	4 Turbofan
Gross T/O Wt.	135,000 kg in flight
Payload	(unk)
Sensor Type	SIGINT
Datalink	TIBS, TADIL A, CTT
Deployment	Self
Launch / Recovery	Improved Runway
Operation	Manned

Key Information

Program status: Fielded
- Worldwide tactical SIGINT support to theater users
- Strategic Reconnaissance, I&W, Treaty Monitoring

Operator	USAF
User	USAF, USN, USA, USMC
Contr Agency	HQAF
Prog Manager	Maj. Taylor (703) 697-2795

Programmatics

- Block VI upgrade is in progress
- Recently approved TADIL J upgrades

Figure 11-9 RC-135V/W

An operational benefit for UAVs equipped with imagery sensors is the ability of most SIGINT systems to provide cueing of targets and/or indications of hostile/adverse actions by the opposing forces. Visual confirmation of actual targets vs decoys and maintaining accurate locations of mobile targets is a high priority requirement for tactical commanders. This information is used by the tactical commanders to prepare battle plans for initial attack to determine priorities and assess battle damage to accurately determine the locations of all friendly forces, and to limit damage/destruction of certain military and/or civilian areas.

UAVs with tethered SIGINT sensors would extend the range of SIGINT collection beyond the FLOT and with appropriate planning would utilize existing SIGINT processing and reporting systems.

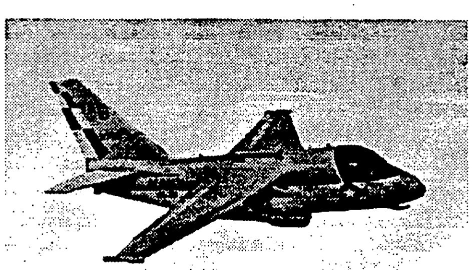
Not every UAV vehicle needs a full SIGINT sensor capability. Consideration will be given to fielding sets of specialized SIGINT hardware to be available as required to meet the operational needs of the tactical commanders.

Additional missions beyond normal intercept of hostile signals to be considered for UAV SIGINT sensors are: relay of data from remote, leave-behind, and/or covert sensors; as a limited capability friendly-forces-receive-only communications/data relay; communications and information security (COMSEC/INFOSEC) monitoring of friendly forces; determining locations of friendly forces (both in front of and behind the FLOT [to include Search and Rescue]); and determining locations of non-threat/non-hostile entities.

During the pre-attack phase, Desert Shield SIGINT resources were able to map the battlefield for the Allies. This pre-attack collection provided the Allies with valuable information used to plan and execute the successful suppression and destruction of most high interest targets within the first days of the war. This mapping of the battlefield continues today as Southern Watch.

More detailed discussion of the interrelationship between manned and unmanned platforms and their role in the overall DoD reconnaissance force mix is contained in the DARO Architecture. That effort has been discussed in section 1 of this program plan.

The criteria for manned systems moving under the DARO were predicated on their joint Service Defense-wide application at numbered AF, Corps, or Fleet level and above. Specific Service programs such as ES-3A (see Figure 11-10), Airborne Reconnaissance Low (ARL), and GRCS (See Figure 11-11), as well as other programs such as ATARS and RF-4 EO/Long-Range Oblique Photographic Sensor (LOROPS) were not included in the DARO's area of responsibility.



Performance Parameters

Altitude	10.6 km
Endurance	6 hours
Radius of Action	(unk)
Speed	810 km/hr
Propulsion	2 Turbofan
Gross T/O Wt.	(unk)
Payload	(unk)
Sensor Type	SIGINT
Datalink	CDL
Deployment	Self
Launch / Recovery	Carrier & Improved Runway
Operation	Manned

Key Information

Program status: Fielded

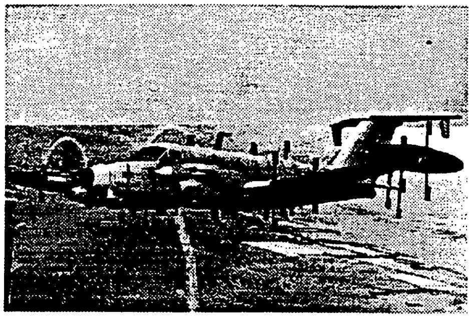
- Provide ongoing SIGINT to carrier battle groups

Operator	USN
User	USN, USMC
Contr Agency	USN
Prog Manager	CAPT Leonard (703) 614-2504

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
BGPHES-Surface Terminal FOC				Δ		

Figure 11-10 ES-3A



Performance Parameters

Altitude	9.5 km
Endurance	5.5 hours
Radius of Action	(unk)
Speed	235 km/hr
Propulsion	2 Turboprop
Gross T/O Wt.	7,300 kg
Payload	(unk)
Sensor Type	SIGINT
Datalink	CDL, CTT
Deployment	Self
Launch / Recovery	Improved Runway
Operation	Manned

Key Information

Program status: Fielded

- Provide target location to Artillery
- COMINT Intercept & DF for Intel or targeting.

Operator	USA
User	USA
Contr Agency	USA
Prog Manager	Maj Sambrowski (703) 697-6525

Programmatics

Key Milestones	FY94	FY95	FY96	FY97	FY98	FY99
Common Sensor II	△					

Figure 11-11 RC-12 GUARDRAIL

APPENDIX A
GLOSSARY OF TERMS

<u>Altitude</u> — Height above mean sea level.

<u>Direct Support</u> — A mission requiring a force to support another force and authorizing it to answer directly the supported force's request for assistance. (Joint Pub 1-01)

<u>Endurance UAV</u> — This UAV category will provide high and medium-altitude, heavy payload and multimission performance capabilities, and on-demand support across all mission areas, with flight duration in excess of 24 hours.

<u>General Support</u> — That support which is given to the supported force as a whole and not to any particular subdivision thereof. (Joint Pub 1-02)

<u>Interface</u> — A boundary or point common to two or more similar or dissimilar command and control systems, subsystems, or other entities across which or at which necessary information flow takes place.

<u>Interoperability</u> — The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together. Interoperability is an operational requirement.

<u>Joint Force Commander</u> — A general term applied to a commander authorized to exercise combatant command (command authority) or operational control over a joint force. Also called JFC. (Joint Pub 1-02)

<u>Maneuver Variant</u> — Satisfies the requirement of the Close Range Mission Need Statement. This UAV will have a range capability of 30 km beyond the FLOT.

<u>Medium Range UAV</u> — The medium range UAV was designed to fly for two hours at subsonic speeds, spending relatively small amounts of time over target areas.

<u>Near-Real-Time</u> — Delay caused by automated processing and display between the occurrence of an event and reception of the data at some other location. (Joint Pub 1-02)

<u>Propulsion</u> — The subsystem that provides thrust to the vehicle (normally an engine).

<u>Remotely Piloted Vehicle (RPV)</u> — An unmanned vehicle capable of being controlled from a distant location through a communication link. It is normally designed to be recoverable. A nonautonomous unmanned vehicle.

<u>Subsystems</u> — The major elements of a UAV system, including: air vehicle, Mission Planning and Control Station (MPCS), mission payload, data link, launch and recovery equipment, and test requirement and diagnostic equipment.

TACFIRE — The current generation U.S. Army tactical artillery fire command and control system. It will be replaced by the Advanced Field Artillery Target Data System (AFATDS).

Tactical UAV — Satisfies requirement of Short Range Mission Need Statement. This UAV will have a range capability of between 150-300 km beyond the FLOT.

Unmanned Aerial Vehicle (UAV) — A powered aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload. Ballistic or semi-ballistic vehicles and artillery projectiles are not considered UAVs.

APPENDIX B
ACRONYMS

A

ABIT	Airborne Imagery Transmission
ACR	Armored Cavalry Regiment
ACTD	Advanced Concept Technology Demonstration
AF	Air Force
AFATDS	Advanced Field Artillery Tactical Data System
ARM	Atmospheric Radiation Measurement
ARPA	Advanced Research Projects Agency
ARSP	Advanced Reconnaissance Support Program
ASARS	Advanced Synthetic Aperture Radar System
ASAS	All-Source Analysis System
ASD	Assistant Secretary of Defense
ASD(C3I)	Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)
ASN(RDA)	Assistant Secretary of the Navy (Research, Development and Acquisition)
ATARS	Advanced Tactical Aerial Reconnaissance System
AV	Air Vehicle
AVGAS	Aviation Gasoline

B

BDA	Battle Damage Assessment
BDE	Brigade
BMDO	Ballistic Missile Defense Organization
BN	Battalion
BW	Bandwidth

C

C2	Command and Control
C3	Command, Control, and Communication
C3I	Command, Control, Communications and Intelligence
C4I	Command, Control, Communication, Computers and Intelligence
CALS	Computer Aided Acquisition and Logistics Support
CARS	Common Automated Recovery System
CARS	Contingency Airborne Reconnaissance System
CATF	Commander, Amphibious Task Force
CDIST	Canadian Department of Industry, Science, and Technology
CDL	Common Data Link
CDR	Critical Design Review
CECOM	Communications-Electronics Command

CEP	Concept Evaluation Program
CG	Commanding General
CIA	Central Intelligence Agency
CIO	Central Imagery Office
CM	Countermeasures
CMS	Community Management Staff
COEA	Cost and Operational Effectiveness Analysis
COMINT	Communications Intelligence
COMM	Communications
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
CR	Close Range
CY	Calendar Year

D

DAB	Defense Acquisition Board
DAES	Defense Acquisition Executive Summary
DARO	Defense Airborne Reconnaissance Office
DARP	Defense Airborne Reconnaissance Program
DARSC	Defense Airborne Reconnaissance Steering Committee
DCI	Director, Central Intelligence
D/DARO	Director/DARO
DDR&E	Director, Defense Research and Engineering
DDSP	Defense Development Sharing Project
DEA	Drug Enforcement Agency
DepSecDef	Deputy Secretary of Defense
DESA	Defense Evaluation Support Activity
DGCS	Downsized Ground Control Station
DGDT	Downsized Ground Data Terminal
DIA	Defense Intelligence Agency
DISA	Defense Information Systems Agency
DIV	Division
DMA	Defense Mapping Agency
DoD	Department of Defense
DOE	Department of Energy
DR&E	Defense Research and Engineering
DS	Direct Support
DSB	Defense Science Board
DSPO	Defense Support Project Office
DT	Developmental Test

DT&E	Developmental Test and Evaluation
D/TWP	Director/Tactical Warfare Programs
DUSD(AT)	Deputy Under Secretary of Defense (Advanced Technology)

E

E&MD	Engineering and Manufacturing Development
EAC	Echelons Above Corps
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMCON	Emissions Control
EMI	Electromagnetic Interference
EO	Electro-Optical
EOA	Early Operational Assessment
ERAST	Environmental Research Aircraft and Sensor Technology
ESM	Electronic Support Measures
ETRAC	Enhanced Tactical Radar Correlator
EW	Electronic Warfare

F

FCT	Foreign Comparative Test
FLIR	Forward Looking Infrared
FLOT	Forward Line of Own Troops
FQ&P	Flying Qualities and Performance
FY	Fiscal Year

G

GCS	Ground Control Station
GDIP	General Defense Intelligence Program
GDT	Ground Data Terminal
GMTI	Ground Moving Target Indicator
GPS	Global Positioning System
GRCS	GUARDRAIL Common Sensor
GS	General Support
GSM	Ground Station Module (JSTARS)

H

HAE	High Altitude Endurance UAV (formerly Tier II+)
HALE	High-Altitude, Long-Endurance
HFE	Heavy-Fuel Engine
HL	Hand-Launched
HMMWV	High Mobility Multipurpose Wheeled Vehicle

hr	Hour
HSI	Human Systems Integration
HW/SW	Hardware/Software

I

IAS	Intelligence Analysis System
IEWD	Intelligence and Electronic Warfare Directorate
IIRS	Imagery Interpretability Rating Scale
ILS	Integrated Logistics Support
I-MAE	Interim Medium Altitude Endurance UAV (formerly Tier I)
IMINT	Imagery Intelligence
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IR	Infrared
ISAR	Inverse Synthetic Aperture Radar
IWSDB	Integrated Weapon System Data Base

J

JAC	Joint Analysis Center
JCS	Joint Chiefs of Staff
JDF	Joint Development Facility
JDISS	Joint Deployable Intelligence Support System
JDMAG	Joint Depot Maintenance Analysis Group
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
JIC	Joint Intelligence Center
JLA	Joint Logistics Assessment
JLARG	Joint Logistics Assessment Review Group
JL-COE	Joint Logistics Center of Excellence
JLMIS	Joint Logistics Management Information System
JLSP	Joint Logistics Steering Panel
JPO	Joint Project Office
JPSD	Joint Precision Strike Demonstration
JROC	Joint Requirements Oversight Council
JS	Joint Staff
JSIPS	Joint Service Imagery Processing System
JSTARS	Joint Surveillance and Target Attack Radar System (also Joint STARS)
JTC	Joint Technology Center
JTC/SIL	Joint Technology Center/Systems Integration Laboratory

JTIDS	Joint Tactical Information Distribution System
JTSC	Joint Technology Steering Committee
JWICS	Joint Worldwide Intelligence Communications System

K

kg	Kilogram
km	Kilometer

L

L/R	Launch and Recovery
lb	Pound
LLLTV	Low Light Level Television
LLNL	Lawrence Livermore National Laboratory
LO	Low Observables
LOROPS	Long-Range Oblique Photographic Sensor
LOS	Line-of-Sight
LRP	Low Rate Production
LSA	Logistics Support Analysis

M

MAE	Medium Altitude Endurance UAV (formerly Tier II)
MAGTF	Marine Air-Ground Task Force
MASINT	Measurements and Signatures Intelligence
MAVUS	Maritime Vertical Takeoff and Landing Unmanned Aerial Vehicle System
Mbps	Megabits per second (10^6 bits/sec)
MDAP	Major Defense Acquisition Program
MEF	Marine Expeditionary Force
MET	Meteorology
MEU	Marine Expeditionary Unit
MIDL	Miniature Interoperable Data Link
MIES	Modernized Integrated Exploitation System
MIST	Modular Interoperable Support Terminal
MNS	Mission Need Statement
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MR	Medium Range
MRC	Major Regional Contingencies
MS	Multispectral
MTI	Moving Target Indicator

N

NASA	National Aeronautics and Space Administration
NAWC-AD	Naval Air Warfare Center-Aircraft Division
NBC	Nuclear, Biological and Chemical
NDI	Nondevelopmental Item
NMJIC	National Military Joint Intelligence Center
NSA	National Security Agency

O

O&M	Operations and Maintenance
OASA(RDA)	Office of the Assistant Secretary of the Army (Research, Development and Acquisition)
OASD	Office of the Assistant Secretary of Defense
OASD(C3I)	OASD (Command, Control, Communications, and Intelligence)
OCNO	Office of the Chief of Naval Operations
ONS	Operational Needs Statement
OOTW	Operations Other Than War
ORD	Operational Requirements Document
OSD	Office of the Secretary of Defense
OSD(C)	OSD (Comptroller)
OT	Operational Test
OT&E	Operational Test and Evaluation

P

PA&E	Program Analysis and Evaluation
PDUSD(A&T)	Principal Deputy Under Secretary of Defense (Acquisition & Technology)
PEO	Program Executive Officer
PP	Preprogrammed

R

RADIAC	Radio Activity Detection, Indication and Computation
RAPTOR	Responsive Aircraft Program for Theater Operations
RATO	Rocket-Assisted Takeoff
RC	Radio Controlled
RCS	Radar Cross Section
R&D	Research and Development
RDT&E	Research, Development, Test and Evaluation
Recce	Reconnaissance
RF	Radio Frequency
ROFA	Remote Operating Facility, Airborne (NSA)
RPV	Remotely Piloted Vehicle

RS	Reconnaissance/Surveillance
RSOC	Regional SIGINT Operations Center
RSTA	Reconnaissance, Surveillance and Target Acquisition
RVT	Remote Video Terminal

S

SAE	Service Acquisition Executive
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communication
SIGINT	Signals Intelligence
SIL	Systems Integration Laboratory
SINCGARS	Single Channel Ground and Airborne Radio System
SR	Short Range
SRIG	Surveillance, Reconnaissance and Intelligence Group

T

T&E	Test and Evaluation
TA	Target Acquisition
TACFIRE	Tactical Artillery Fire Control
TALON	Theater Application — Launch on Notice
TENCAP	Tactical Exploitation of National Capabilities
TBD	To Be Determined
TBM	Theater Ballistic Missile
TD	Target Designator
TEMP	Test and Evaluation Master Plan
T/O	Take Off
TRADOC	Training and Doctrine Command (USA)
TROFA	Temporary Remote Operating Facility, Airborne (NSA)
TRUS	Tilt Wing/Rotor UAV System
TS	Target Spotting
TV	Television

U

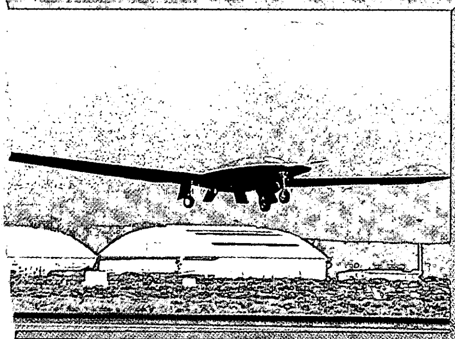
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
USA	United States Army
USAF	United States Air Force
USD(A&T)	Under Secretary of Defense (Acquisition & Technology)
USMC	United States Marine Corps
USN	United States Navy

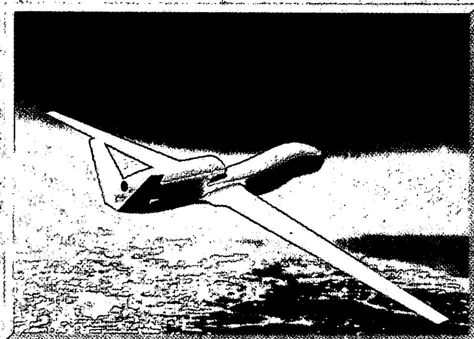
V

VCJCS	Vice Chairman, Joint Chiefs of Staff
VHF	Very High Frequency
VLAR	Vertical Launch and Recovery
VTOL	Vertical Takeoff and Landing

DEFENSE AIRBORNE RECONNAISSANCE OFFICE

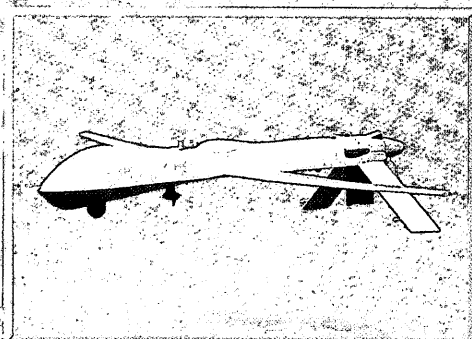
UAV Annual Report
FY 1996
6 November 1996

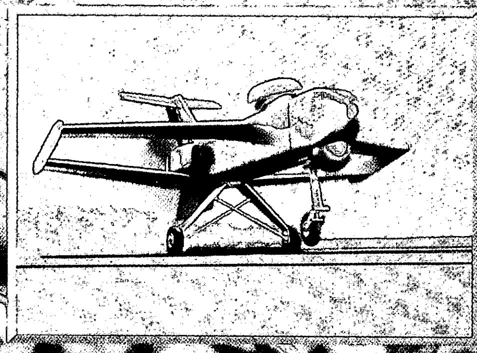


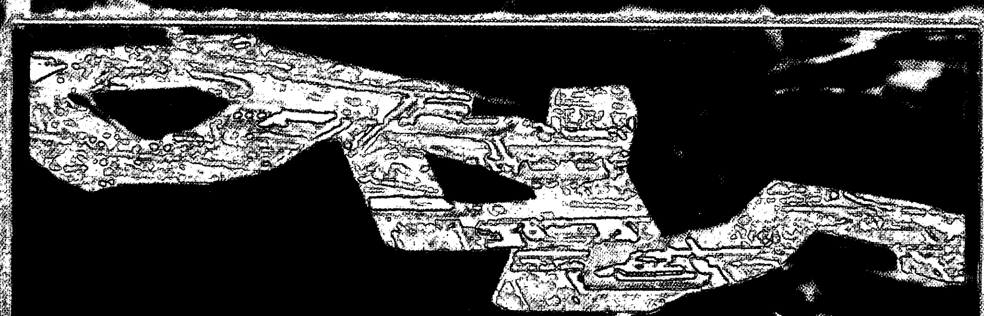


Endurance

Tactical







OUR SECOND UNMANNED AERIAL VEHICLE (UAV) ANNUAL REPORT provides an overview of the Defense Department's UAV program activities for fiscal year (FY) 1996. The Defense Airborne Reconnaissance Office (DARO) is chartered to manage the Defense Airborne Reconnaissance Program (DARP), which includes both tactical and endurance UAVs among its component program elements.

DURING THE PAST YEAR, UAVs have seen major programmatic changes, have continued to demonstrate unique capabilities, and have experienced increasing acceptance by operational users. This report highlights their recent achievements, describes their acquisition plans and issues, and projects the DARO's UAV vision for the future. Key accomplishments, together with a DoD-wide perspective, are summarized below.

I've seen the cities of men and understand their thoughts.

Homer, c. 900 B.C.

As indicated by Homer's insightful statement, THE CONCEPT OF INFORMATION DOMINANCE *has a long history. What is so vastly different today is that technological capability, system performance and operational infrastructure support have converged to allow us to exploit new opportunities in ways never before imagined. For years warfighters have articulated the needs for* situational awareness, target identification, dominant battlefield awareness, dominant battlespace knowledge, *and* information superiority. *Now we have the ability to move from words to deeds.*

The DARO's first responsibility is to develop and maintain the DoD's integrated airborne reconnaissance architecture as a framework for the development and acquisition of improved airborne reconnaissance capabilities. Today, we have an abundance of exciting and important collection, processing, exploitation and dissemination opportunities and the problem is to make choices among them and integrate them into the architectural structure. For our manned platforms, we have a game plan to selectively improve sensors. For our UAVs, we are now ushering in new capabilities in both platforms and sensors to constitute our family of tactical and endurance UAVs. As our architecture migration pictorial shows (page 3), we are concentrating on the best "mix" of manned and unmanned systems to meet warfighting needs well into the next century.

Last year we published our first UAV Annual Report. This is our second edition, and its purpose is to provide updates from 1995 and highlight the significant accomplishments that UAVs have achieved this past year, FY 1996. Simply stated, UAVs are moving from words to deeds. They are being recognized in out-year "vision" documents as providing both a cost-effective solution to our goal of extended reconnaissance and bases for other high-value military and civil applications. There are many Services and agencies involved in the rapid improvements and fielding of UAVs, and on their behalf we are pleased to publish this second edition.

OVER THE PAST TWELVE MONTHS, our expanding UAV community has tackled new doctrinal, operational concept, requirements and interoperability issues. It was a year of "firsts" on many fronts and each achievement is the product of a great deal of dedicated effort and DoD-contractor teamwork.

a. <u>Analysis and Architecture</u>. The overarching efforts that went into refining our integrated airborne reconnaissance strategy as well as laying the groundwork for a joint, interoperable mix of UAVs

The video mosaics on the covers were provided by the National Information Display Laboratory (NIDL).

in an architectural framework deserve much praise. We need to continually improve the analytic base on which decisions are made. The analysis must reach to an assessment of the contribution of intelligence systems to military outcomes in scenarios that are judged to be consequential. Several efforts to quantify the airborne reconnaissance force mix, such as the Reconnaissance Study Group, Joint Warfare Capability Assessments, the SIGINT Mix Study, the C4ISR[1] *Mission Assessment, DARO analysis, the National Reconnaissance Office imagery mix study and others, have proven most helpful. Thus, we see our reconnaissance architecture as embedded in a larger information system roadmap. The value of any architecture is in helping to shape investment decisions for the future, and we have started this process.*

b. Acquisition Initiatives. Integrating acquisition reform initiatives into our UAV programs has helped lead the way for other DoD Advanced Concept Technology Demonstration (ACTD) programs. For example, the Predator *ACTD was the first successful ACTD to transition to a production program and its experiences will be applied to other DoD efforts. Four of our five active UAV programs are (or were) ACTDs —* Outrider, Predator, DarkStar, *and* Global Hawk; Pioneer *is a fielded system — and are progressing well. In addition, integrated product teams (IPTs) are helping to develop requirements and concepts of operations (CONOPS) for the Tactical Control System (TCS), a new development to assure interoperability between our UAVs and their intelligence products for joint operational users. IPTs have also helped to determine tactical synthetic aperture radar (SAR) and data link options. Another key area of IPT support is identification of commercial processes, products and services to support our open architecture.*

c. Funding Support and Program Prioritization. The Congress has been very supportive of the Department's UAV programs and, for the third year in a row, has added funds to our UAV efforts. In addition, the Joint Requirements Oversight Council (JROC) prioritized UAV programs and provided stability in the joint requirements process that supports warfighter needs. The new JROC Review Board (JRB) has also helped us by framing UAV issues, evaluating operations, and proposing recommendations for JROC consideration. The number one priority for UAVs remains the tactical UAVs (Outrider *and* Pioneer), *with* Predator *and the High Altitude Endurance (HAE) UAVs as numbers two and three, respectively.*

d. Achievements. During the last year, we have accomplished the following UAV program-specific actions:

- *On 2 May 1996, the Tactical UAV, or* Outrider, *ACTD contract was awarded for a 24-month period of performance. First flight will occur six months after contract award and a low-rate initial production (LRIP) option for six systems may be exercised before the ACTD ends, i.e., late in FY 1998. The current requirement is for 62 systems (at four air vehicles [AVs] per system), plus attrition spares.*

- Predator *has been the most operationally active UAV program this year. During FY 1996,* Predators *have flown more than 530 missions for nearly 2,500 flight hours — 159 missions and 1,169 flight hours supporting Bosnia operations alone.* Predator *flew the first UAV SAR and Ku-band satellite link mission this year. Dissemination of imagery via the quickly constructed Joint Broadcast System provided a long-sought-for "common picture of the battlefield" to multiple receiving sites both in-theater and back in the U.S. It also operated under control of, and sent information to, a submerged submarine during one demonstration exercise, and supported a carrier battle group during another.* Predator's *marinization feasibility study has been completed and its report will be available in early FY 1997. The JROC identified near-term configuration upgrades that include UHF voice radio, IFF, and wing de-icing. The SecDef approved system and program management agreements for its follow-on acquisition and operational support. The current operational requirement is for 16 systems (at four AVs per system), plus attrition spares.*

[1] *Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance.*

- Pioneer *also deployed to Bosnia and supported the 1st Armored Division; additional* Pioneers *support fleet operations offshore. The Congress provided funding to improve both engine performance and the avionics.* Pioneer *has experienced an unusual rate of mishaps this year, but the improvements cited will help the situation. Thus,* Pioneer *has helped us gain experience to improve reliability for all UAVs. We are planning to extend its operational life from FY 2000 to 2003, when* Outrider *is expected to be available in quantity. The revised requirement is for nine systems through FY 1999 (at five AVs per system), with a gradual phase-out.*

- DarkStar *experienced both its first flight and its first mishap within 24 days of each other. The first successful fully autonomous UAV flight with a low-observable design took place in March 1996. The mishap took place in April and resulted in a year's delay and an approximately $22 million impact to the program. To correct the problem, three configuration design changes are being considered: "hiking" the nose gear, moving the main gear, and sweeping the wings. The next flight is planned for May 1997.* DarkStar's *eventual force size is being determined.*

- Global Hawk *is proceeding well. The wing and body were mated without a problem. Static and integration tests are on schedule. First flight is scheduled for 1997. This will be the first UAV to use a common processor for both electro-optical/infrared (EO/IR) and SAR imagery.* Global Hawk's *eventual force size is being determined.*

- *The TCS development is now underway. The JROC fully supports a common, modular and scalable ground station for tactical UAVs. The TCS will be compliant with the Joint Technical Architecture (JTA), Airborne Reconnaissance Information Technical Architecture and the Joint Interoperability Interfaces, thereby assuring UAV and product interoperability and utility among multiple operational users.*

- *Finally,* Hunter *has enjoyed considerable success during the past several months. Although the DoD decided to cease production after the LRIP buy of seven systems,* Hunter *has performed flawlessly on several exercises and demonstrations to refine UAV employment concepts, and, like* Pioneer, *continues to be used for payload development.*

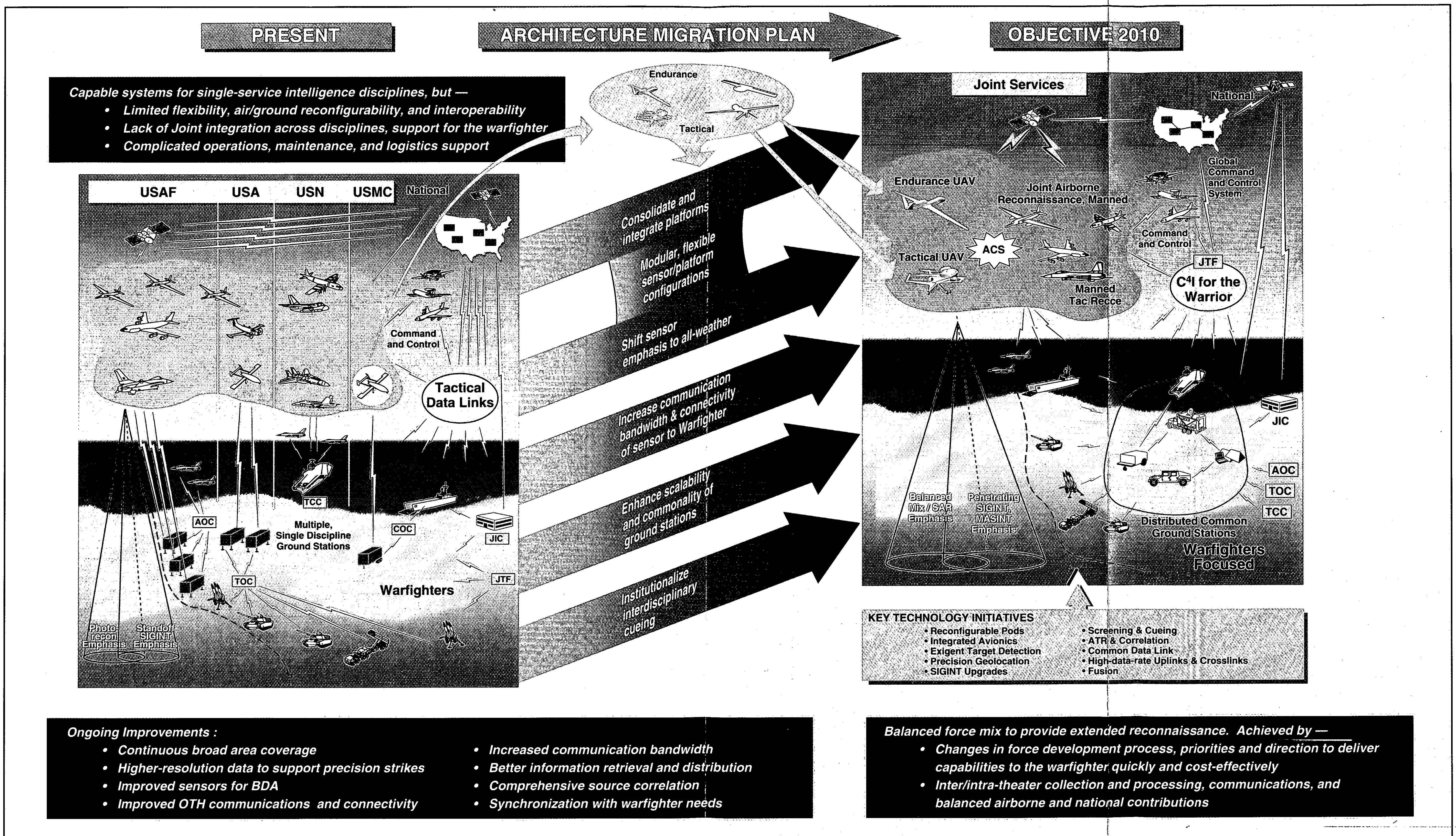
FROM A DoD-WIDE PERSPECTIVE, Joint Vision (JV) 2010, *published in July 1996, represents the vision of the Chairman, Joint Chiefs of Staff (CJCS), for joint warfighting in the 21st century. Its C4I "building codes" are contained in the JTA. Our Integrated Airborne Reconnaissance Strategy and its implementing Airborne Reconnaissance Information Technical Architecture remain in full agreement with JV 2010's provisions for the employment of information to support its key operational concepts —* dominant maneuver, precision engagement, full-dimension protection, *and* focused logistics. *We are continuing to study how UAVs can support joint warfighting concepts as the Defense Department prepares for the Quadrennial Review of Roles and Missions during FY 1997.*

Finally, in the post-Cold War era we can expect our forces to be deployed for a variety of purposes in many parts of the world. The rule, rather than the exception, will be deployment with coalition partners, notably NATO members. We will need to be interoperable — not only with our own forces but also with NATO forces and those of our coalition partners.

All in all this has been a good year for UAVs and we expect an even better year, next year. Thank you for your continued support.

Kenneth R. Israel

MajGen Kenneth R. Israel, USAF
Director, Defense Airborne Reconnaissance Office



ACS Advanced Common Sensor AOC Air Operations Center ATR Automatic Target Recognition C4I Command, Control, Communications, Computers, and Intelligence COC Combat Operations Center JIC Joint Intelligence Center
JTF Joint Task Force MASINT Measurements and Signatures Intelligence SAR Synthetic Aperture Radar SIGINT Signals Intelligence TCC Tactical Control Center TOC Tactical Operations Center

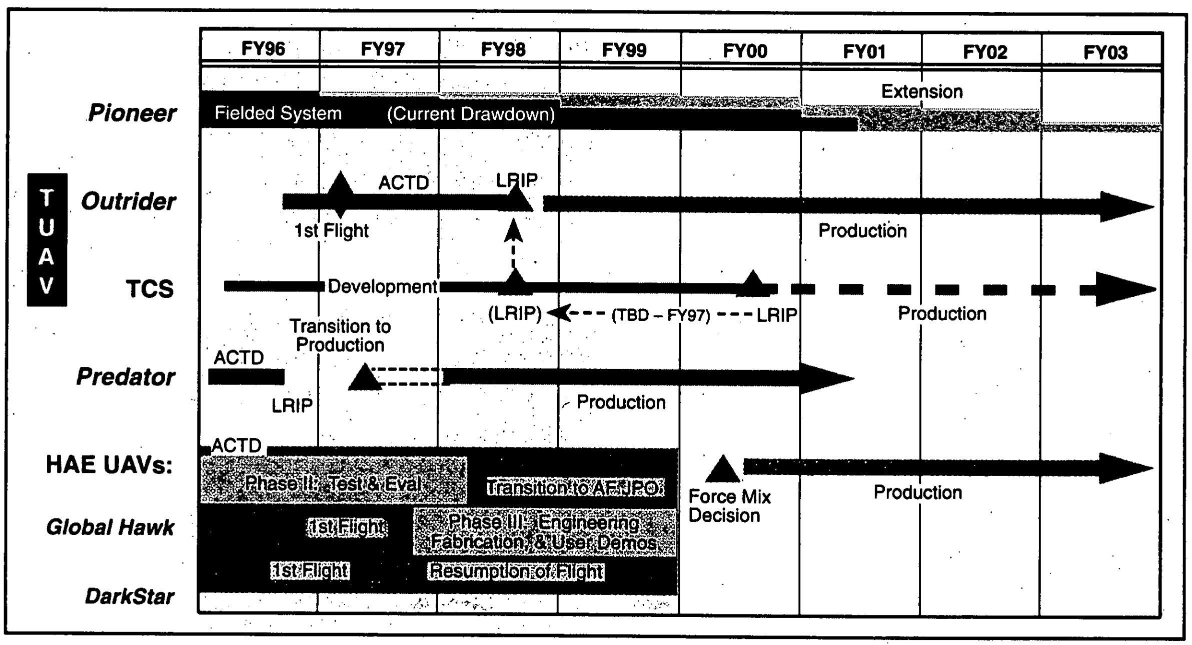
The UAV Migration Process

Migration to the airborne reconnaissance Objective Architecture for 2010 is envisioned as a 15-year process, during which architectural, programmatic and technological activities will proceed in an incremental, but coordinated process. Adjustments, however, will be necessary to meet emerging operational needs. The DoD's planning and programming processes project out-year budgets only about half that far. Accordingly, the information presented below and to the left provide planning "snapshots" of our investment strategy for UAVs as part of the evolving DARP.

UAV Summary Schedule

An integrated schedule of key UAV program milestones and interactions is depicted below. Of note, some out-year projections represent objectives for which resource allocations must still be resolved. This process is actively being addressed in both Joint Staff and acquisition community forums, as operational priorities are matched against available resources and system maturity in the planning, programming and budgeting system.

Integrated UAV Program Schedule



Resource Allocations

Basic financial projections to support the airborne reconnaissance goal of a balanced manned-unmanned force mix that is both interoperable and affordable are illustrated in the graphics to the left.

The funding "pies" indicate UAV investments will constitute over one-quarter of the DARP's $6 billion out-year budget, while manned system investments will continue to exceed UAV levels.

A breakout of the UAV segment of each pie illustrates the relative investment funding projected for tactical UAVs (*Pioneer* and *Outrider*), *Predator*, and the HAE UAVs (*Global Hawk*, *DarkStar*, and their Common Ground Segment), respectively. Pending resolution of *Predator* and HAE UAV acquisition issues through FY 2000, the lion's share of out-year investment is projected for tactical UAVs.

Future decisions may adjust these shares over time, depending primarily on the outcome of the *Outrider* and HAE UAV ACTDs. These decisions will be supported by JROC recommendations and priorities.

Congressional Actions

The Congress continued to be very supportive of our UAV programs during its deliberations on FY 1997 budget requests. Major funding increases for *Pioneer*, *Predator* and *DarkStar*, plus sustained funding for our support programs, will enable the Department to accelerate production and maintain investment levels to complete our UAV ACTDs.

Program	Increase	Congressional Guidance	Effect
Pioneer	$15M	Procurement of: • Spare and repair parts for the 9 systems • Replacement AVs and higher-reliability engines Integration of MIAG and U-CARS	Maintenance of *Pioneer's* readiness at current levels while *Outrider* is in development Avionics upgrade to improve system performance and reduce support costs
Predator	$50M	Procurement of: • 11 AVs, allocated as two systems (at 4 AVs per system, plus 3 AVs to back-fill the ACTD systems to 4 AVs per system) • 2 GCSs, and 2 Trojan Spirit II communications systems	This will greatly assist *Predator's* transition to a production program. The JROC's objective is to field 16 systems and the Congress has declared full support for this requirement
DarkStar	$28.5M	Recovery from the crash of AV #1 Purchase of long-lead components for AV #5 (to replace AV #1) Integration of EO framing technology into the aircraft and ground equipment	Timely recovery from the first AV's April 1996 mishap. Design and software corrections will be integrated into AV #2 prior to resumption of flight testing (Spring 1997)
Hunter	$12M	Removal of three systems from storage to further develop UAV concepts of operation	Expands potential for additional CONOPS development and exercise support
U-CARS	$8M	Installation of U-CARS in *Predator* and *Outrider* systems as soon as practicable	Improvement of operational performance during recovery and landing
VTOL UAV	$15M	Flight test of the *Puma* VTOL UAV	Further evaluation of VTOL technology

ACTD Advanced Concept Technology Demonstration AV Air Vehicle EO Electro-Optical GCS Ground Control Station
MIAG Modular Integrated Avionics Group U-CARS UAV Common Automatic Recovery System VTOL Vertical Takeoff and Landing

Other Congressional Issues

Tactical UAVs. Congress has consistently supported the development of a UAV that can be placed directly in the hands of tactical warfighters. *Outrider* is such a system, and will be delivered for evaluation within a year of contract award.

***Predator* Marinization.** The Navy has completed the requested feasibility study on marinizing *Predator*, and the report will be delivered to Congress by early 1997. This preliminary study found that:

- *Predator* operations can be integrated with Naval air doctrine
- Full shipboard operation could be relatively costly and require significant AV modifications (to include development of a heavy-fuel engine)
- Shipboard control of (shore-based) AV and payload could support joint littoral warfare at reasonable cost, although at some reduction in responsiveness.

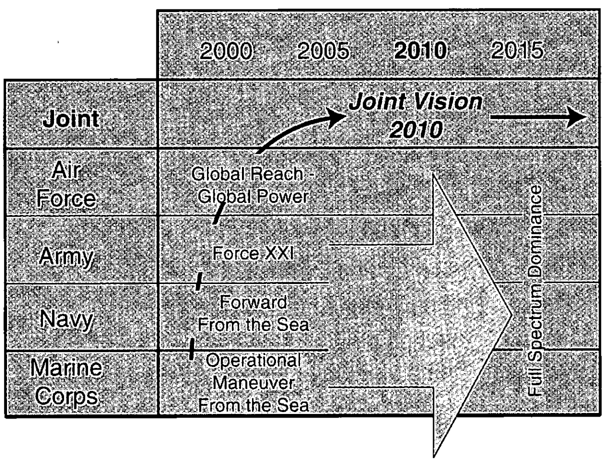
HAE UAVs. The Department examined the merits of combining *Global Hawk* and *DarkStar* as a single system, and found that the most cost-effective approach was a balanced mix of the two complementary HAE UAV systems: a highly capable, moderately survivable *Global Hawk* and a moderately capable, highly survivable *DarkStar*.

Expanding Roles for UAVs

The post-Cold War "revolution in military affairs" led to end-to-end reviews of capabilities needed for future warfare. Missions and functions cross a peace-contingency-war spectrum and the types and levels needed must be acquired in a resource-constrained environment. This new environment requires reexamination of roles and missions, resources available to support both modernization and sustainment of forces, and streamlined acquisition techniques to acquire more effective capabilities at lower cost.

Visions for Joint Warfighting

The Department's vision that will shape warfighting operational concepts for the next century has been documented in the July 1996 publication of the Chairman's *Joint Vision (JV) 2010.* With emphasis on joint warfighting, JV 2010 is the prescription for new levels of effectiveness by leveraging forces and technologies.

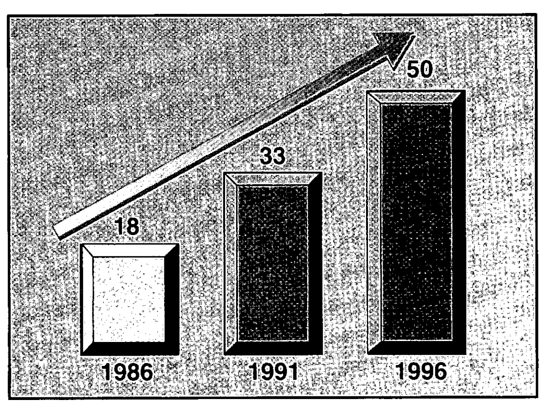


The JROC's Joint Warfighting Capability Assessment (JWCA) area that includes airborne reconnaissance is Intelligence, Surveillance and Reconnaissance (ISR).[1] JV 2010 argues that intelligence provided to our joint military commanders to support accurate delivery of precision munitions will be a principal requirement for continued military superiority. This key capability derives from an information-dependent operating environment.

In 1994, and in conjunction with the emergence of joint warfighting visions and the JWCA process, the DARO published its own vision, the *Integrated Airborne Reconnaissance Strategy,* which projected the Objective Architecture for 2010. DARO's programs are being managed to achieve this architecture, which will also conform to the Defense Information Infrastructure (DII) Common Operating Environment (COE) and the Global Command and Control System (GCCS). System technical interfaces will also comply with DARO's Airborne Reconnaissance Information Technical Architecture (ARITA) and the Joint Technical Architecture (JTA), which establish the technical interoperability "codes" for joint systems.

UAVs in Other Nations

Many of our allies and other nations have also recognized the utility of UAVs and are moving rapidly to develop their own capabilities. This offers us an opportunity and a challenge. The opportunity will come from our ability to develop and field a family of UAVs that will set the standard for performance in their class while remaining affordable. The challenge is that our UAV systems will need to interoperate with those of our allies and coalition partners to be effective in future contingency operations.



Nations with UAVs

[1] The JWCA is an eight-area functional analysis process that employs a joint, cross-Service programmatic focus to strengthen the JCS's ability to identify the best affordable joint warfighting capabilities for U.S. military forces. The ISR JWCA interacts with the other seven areas.

UAVs Over Bosnia

UAV deployments to Bosnia, in support of joint and combined operations, are the major UAV "success story" of FY 1996. They include both operational triumphs and acquisition lessons learned. Principally, they illustrate how UAVs can contribute vital information to enhance tactical operations and strategic decision-making.

Predator Deployment #1 (1995) Gjader, Albania

The first deployment, from July through November 1995, involved three *Predators* in essentially a "come-as-you-are" ACTD demo configuration, which included an electro-optical/ infrared (EO/IR) sensor, and C-band line-of-sight (LOS) and UHF SATCOM beyond-line-of-sight (BLOS) data links. Despite two early losses,[1] the *Predator* system and its operators showed steady improvements in operational practices, supportability in the field, liaison with other in-theater agencies, and the military utility of imagery products. Ad hoc taskings sometimes produced better mission results than planned "point target" taskings, and several additional steps assured better image quality.

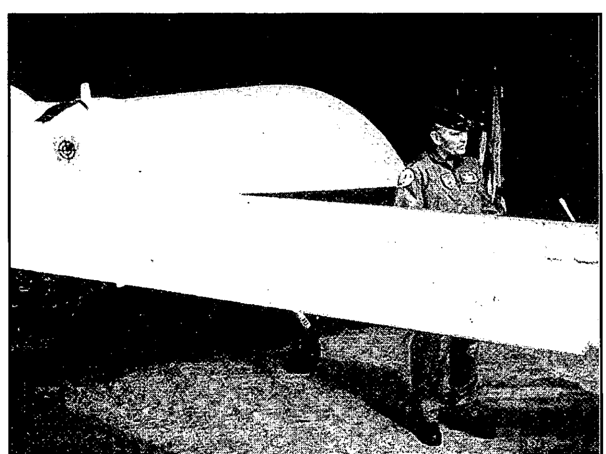
Despite its early limitations for all-weather operation, *Predator* helped determine the course of the Bosnia conflict. During September 1995, after several diplomatic and operational initiatives to relieve shelling and intimidation of civilian enclaves, especially in Bosnia's Sarajevo-Gorazde area, NATO forces resorted to active bombing to bring the warring factions to the negotiating table. Many previous agreements to remove field weapons from the area had been broken, but NATO forces could not hold the violators responsible without confirmation. With *Predator*, however, weapons movements became subject to long-dwell video surveillance, and continuous coverage of area roads showed no evidence of weaponry being withdrawn. This single ISR resource thus gave NATO commanders the key piece of intelligence that underlay their decision to resume the bombing campaign that, in turn, led to the Dayton peace accord signed in December 1995.

The needs for (1) an all-weather sensor, and (2) an all-weather flight capability, were clearly demonstrated. Other needs included a more robust communication link throughput, improved data dissemination to better exploit the near-real-time imagery products, the ability for UAV pilots to talk directly to air traffic control agencies, and a full IFF capability for the UAVs.

Predator Deployment #2 (1996) Taszar, Hungary

When another three *Predators* deployed on 1 March 1996, they were in a final ACTD configuration, which included:

- A synthetic aperture radar (SAR) sensor, as well as the basic EO/IR payload;
- A Ku-band SATCOM BLOS link, as well as the original C-band and UHF SATCOM links;
- Ice-mitigation features to reduce the risks of flying in poor weather;[2] and
- A progressively expanding information dissemination infrastructure, to provide theater-wide and international access to imagery products.



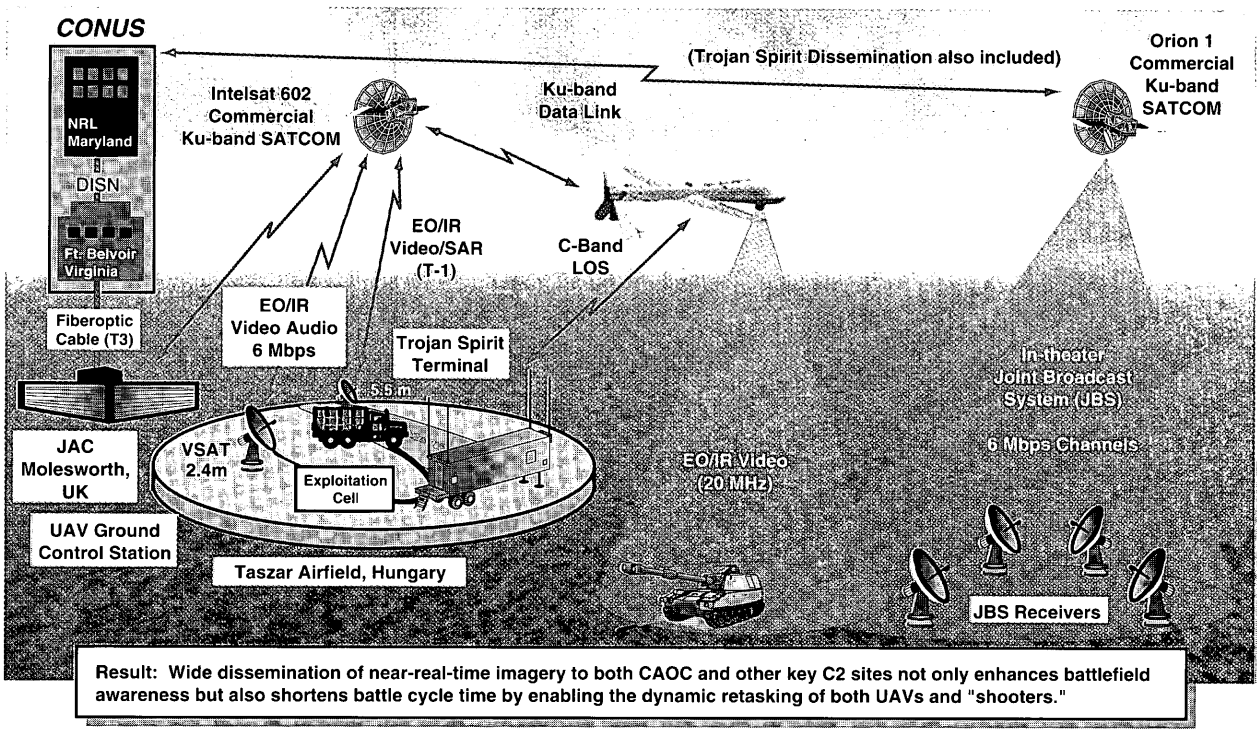
LtGen Bethurem, Commander, AIRSOUTH, presides over *Predator* transition ceremony at Taszar, Hungary, 2 Sep 96

[1] One *Predator* was lost from hostile fire, the other from engine failure.

[2] Active de-icing capabilities were installed in late-1996, and will be part of the production baseline.

Continuing Support for Joint- and Combined-Force Contingencies

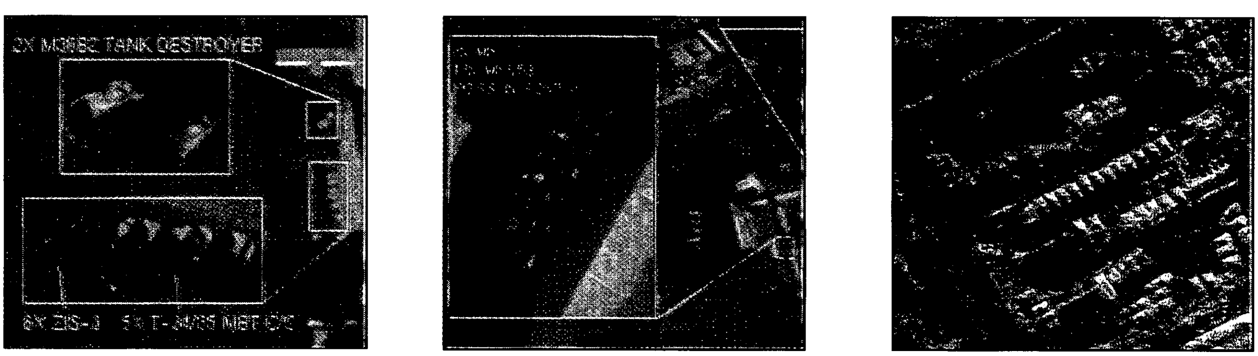
Even more significant than the *Predator* performance "firsts" is the wide use made of its imagery, amplified by the increased network of receiving stations — both in-theater and back in CONUS. The development of this dissemination capability is shown below. It first used VSATs at selected receiving sites, and then the SATCOM-based Joint Broadcast System (JBS).[3]



CAOC Combat Air Operations Center DISN Defense Information System Network JAC Joint Analysis Center NRL Naval Research Laboratory VSAT Very Small Aperture Terminal

The Predator-JBS network represents the first time for the simultaneous broadcast of live UAV video to more than 15 users. This provided a common picture of the "battlefield." Video imagery can be viewed either as full motion video or (as the cover shows) via a "mosaicking" technique at the ground station. Examples of single-frame *Predator* imagery are shown below.

Bosnia Imagery



EO **IR** **SAR**

[3] The JBS is a combined effort by the DARO, National Reconnaissance Office (NRO), Defense Information Systems Agency (DISA), and other DoD agencies.

UAVs Over Bosnia (Cont'd)

Pioneer Deployments (1995 – 96)

During their ten-year history of supporting contingency operations world-wide, *Pioneers* have deployed three times in support of Bosnia, twice afloat and once on land.

Navy VC-6 Pioneer systems have supported Sixth Fleet operations in the Mediterranean and Adriatic Seas since 1994. Most recently, one system deployed aboard USS Shreveport (August 1995 – February 1996) and flew three missions over Bosnia in January. Another deployed aboard USS Austin in July 1996 in support of fleet operations, and is available for contingencies ashore as needed.

On 12 June 1996, the 1st Marine UAV Squadron (VMU-1) deployed one *Pioneer* system to Tuzla, Bosnia, to support peacekeeping operations. They flew more than 30 missions before returning to the U.S. in October 1996.

Today, *Pioneer* is the Department's only marinized UAV for the near term to support contingencies.

Key *Predator* Accomplishments

- **Jul 95**: Deployed to Gjader, Albania, to support UN operations, monitor hostilities
- Aided search for downed pilots
- Imagery proved Serbs had not withdrawn forces threatening Sarajevo and Gorazde
- Imagery helped NATO target resulting air strikes, provided real-time BDAs
- **Nov 95**: Returned to U.S.

- **Mar 96**: Deployed to Taszar, Hungary, to support NATO peacekeeping operations and monitor belligerents
- Routine flight in congested airspace, across two national boundaries; control by AWACS in operations area
- Passed video imagery to Joint STARS ground station module in Hungary – first UAV-Joint STARS interoperation. (Live cross-cueing operations planned, but weather & Joint STARS' departure from theater intervened)
- During late Summer/early Fall of 1996, monitored mass grave sites near Sarajevo, which provided evidence of 1995 massacres
- **Sep 96**: Monitored the Bosnia election activities
- Quick-response observations to preclude confrontations between Bosnia factions or with NATO units
- **Oct 96**: Covering and monitoring of deploying forces

Key *Pioneer* Accomplishments

- **Aug 95**: VC-6 deployed aboard USS Shreveport to support fleet operations
- **Jan 96**: Flew three sorties over Bosnia in support of Implementation Force (IFOR) and Marine Expeditionary Unit (MEU) requirements
- Successfully demonstrated video retransmission to the command ship (USS Wasp) to support amphibious task force and landing force commanders (CATF/CLF)
- **Feb 96**: Returned to U.S.

- **Jun 96**: VMU-1 deployed to Tuzla, Bosnia, to support Task Force Eagle commander
- Real-time imagery provided via *Pioneer's* Remote Receiving Station (RRS) directly to IFOR units
- Task Force Eagle demonstrated dynamic retasking, using *Pioneer*
- Surveillance of population centers, suspected terrorist training areas, and route reconnaissance
- **Oct 96**: Returned to U.S.

- **Jul 96**: VC-6 deployed aboard USS Austin to support fleet operations, be available for contingencies

On 2 September 1996, at Taszar, Hungary, the 11th Reconnaissance Squadron of the Air Force's Air Combat Command (ACC) assumed operational control of Predator assets.

... We received an inkling of what combat will look like in the 21st century during Desert Storm and more recently in our support of NATO action in Bosnia. In both cases, unmanned aerial vehicles have demonstrated the ability to provide continuous real-time battlefield surveillance.

Dr. Paul G. Kaminski, USD(A&T)
Statement before the House Permanent Select Committee on Intelligence on Enabling Intelligence Technologies for the 21st Century, 18 October 1995

UAV Program Overview

Outrider

The most significant programmatic action of FY 1996 was the restructuring of the Joint Tactical UAV Program to the Tactical UAV Program. The award of the *Outrider* ACTD program contract in May 1996 clearly demonstrated the Defense Department's commitment to fielding a tactical UAV to support brigade/regimental and potentially maritime operational needs. The first flight will occur within six months of contract award, first system delivery within a year, and low-rate initial production (LRIP) is planned to begin 24 months after award, i.e., immediately following the end of the ACTD program. We plan to fund 62 systems by FY 2004.

Predator

Second, the transition of *Predator* from an ACTD to a production program occurred during this time frame. The Air Force committed Operations and Maintenance (O&M) funds and manpower billets to fully support the *Predator* system, as directed by the JROC. At a 13 June 1996 meeting at Langley AFB, Air Combat Command (ACC) outlined sustainment needs for the *Predator* program. Its program costs per system were baselined to include four AVs, one ground control station (GCS), one Trojan Spirit II dissemination system, and spares. The SecDef designated the Air Force as lead Service, U.S. Atlantic Command (USACOM) as Combatant Command, and the Navy as the acquisition agent.*

Pioneer

Third, with the restructuring of the Joint Tactical UAV Program, it became evident that *Pioneer's* phase-out needed to be extended from FY 2000 to FY 2003. More resources are now required to sustain *Pioneer* at its current level of readiness for nine systems through FY 1999, with phased decreases thereafter.

HAE UAVs

Fourth, within the HAE UAV ACTD, managed by DARPA, both UAVs are making progress. *DarkStar* is recovering from the loss of its first AV (which will be replaced by AV #2 in the flight test program), and *Global Hawk* has completed fabrication of AV #1 and is proceeding with ground tests and checkout in preparation for a planned first flight in 3Q/FY 1997. Additionally, the program is on track to produce a fully integrated Common Ground Segment capability for the HAE UAV system in 1Q/FY 1998.

Program	FY95 Status	FY96 Programmatic Action:
Pioneer	Fielded system	• Service life to be extended
Hunter	LRIP	• Contract allowed to expire; some assets operating, the rest stored
Maneuver UAV	RFP in preparation	• Reconstituted as the Tactical UAV (TUAV) ACTD, or *Outrider*
Predator	ACTD program	• ACTD completed; transitioning to LRIP program
Global Hawk	In HAE UAV ACTD	• ACTD continuing
DarkStar	In HAE UAV ACTD	• ACTD continuing

**The Air Force is designated as the lead Service for operating and maintaining the Predator UAV at the conclusion of the Advanced Concept Technology Demonstration, as recommended in JROC Memo 151-95. United States Atlantic Command will be the Combatant Command and the Navy Service Acquisition Executive will have responsibility for system development and procurement.*

Dr. William J. Perry, SecDef
Memorandum for Secretaries of the Military Departments (et al.)
on Assignment of Service Lead for Operation of the Predator UAV, 9 April 1996

UAV Management

DARO has responsibility for overseeing the management of UAV funding and acquisition. By charter, it is the DoD's focal point for airborne reconnaissance acquisition matters, to include architectures, budget, finances, fiscal plans, system-level trade-offs, and commonality and inter-operability issues. As an Office of the Secretary of Defense (OSD) organization, DARO forwards key issues and recommendations to the Defense Airborne Reconnaissance Steering Committee (DARSC), which is a DoD-wide corporate body co-chaired by the USD(A&T) and the Vice Chairman of the JCS (VCJCS). USD(A&T) is the decision authority for airborne reconnaissance acquisition.

For operational matters, the JCS is responsible for validating UAV operational requirements through the JROC UAV Special Study Group (SSG). The UAV SSG chairmanship rotates among the Services and reports to the JROC through the Joint Staff's Director for Force Structure, Resources & Assessment (J-8). From May 1995 through November 1996, the JROC has issued 13 memoranda (JROCMs) regarding UAVs, both to support OSD program decisions and to address military requirements and priorities. These memoranda are identified below. The JROC also sponsored the Reconnaissance Study Group (RSG), which was constituted to ascertain the costs and benefits of airborne reconnaissance assets (see page 43).

JROCM-	Date	Highlights
062-95	9 May 95	Designated USACOM as HAE ACTD lead CINC
069-95	19 May 95	Addressed SSG charter and actions regarding *Hunter, Predator,* and endurance UAVs
125-95	13 Oct 95	Endorsed redesignation of Maneuver UAV as an ACTD, and requested acceleration
126-95	13 Oct 95	Recommended ending the *Hunter* program "by allowing the current contract to expire"[1]
131-95	26 Oct 95	Identified UAV priorities (see p. 4, 1995 JROC Priorities), and recommended development of a common, interoperable UAV ground reception, processing & control system (which became TCS)
135-95	31 Oct 95	Reiterated JROC's tactical UAV requirements, endorsed the ACTD approach, and sought focus on "a single best platform" within a $300,000/AV target cost[2]
150-95	15 Dec 95	JROC definition of Tactical UAV ACTD requirements
151-95	16 Dec 95	Recommended the Air Force as Service lead for *Predator,* with USACOM to continue as Combatant Command, the UAV JPO to retain responsibility for system development and procurement, and the Navy to lead if a marinized version evolved[3]
004-96	17 Jan 96	Directed the DARO to work with DARPA and PEO(CU) to assure UAV interoperability
010-96	12 Feb 96	Endorsed *Predator's* transition to production; recommended 16 systems, plus spares. Identified system upgrades and need for interoperability with TCS
016-96	4 Mar 96	Recommended that DARO await JROC's payload prioritization to support initiatives
064-96	28 May 96	Asked the Services (and CINCs via msg) to prioritize UAV mission areas/capabilities as inputs to the SSG's payloads prioritization process
173-96	12 Nov 96	Updated UAV priorities: #1: Tactical UAV (remains JROC's highest priority; also, maintain *Pioneer* as "bridge" and accelerate TCS development to parallel *Outrider's* and also support *Predator*) #2: *Predator* (transition/fielding to meet the MAE requirement; 16 systems required) #3: HAE UAVs (with Air Force as lead Service, and CGS as HAE UAV ground station

1 Implemented via USD(A&T) memo of 31 January 1996.
2 Tactical UAV ACTD approved by USD(A&T) Acquisition Decision Memorandum of 21 December 1995.
3 Implemented via SecDef memo of 9 April 1996.

Tactical

To support: Army battalions, brigades, and light divisions; Marine regiments; and deployed Navy units – Near-real-time reconnaissance, surveillance and target acquisition (RSTA), and battle damage assessment (BDA)

Pioneer & Hunter

Costs	*Pioneer*	*Hunter*
FY96	$28.3M	$38.0M[a]
FY97	$25.6M	$12.0M[b]

[a]Reprogramming in process [b]Addition to Army O&M

Program Requirements/Objectives

- Operate up to 15,000 ft and at ranges ≥ 100 nm
- ***Pioneer***: Interim IMINT for tactical commanders. Operations to be extended until TUAV is fielded
- ***Hunter***: Originally developed to meet Short Range requirement, support corps/division & naval operations with IMINT for tactical commanders

Acquisition Strategy

- ***Pioneer***: Contractor: Pioneer UAV, Inc. Sustain nine systems; current acquisition of attrition spares and AVs; plan extension through FY 2003, vice FY 2000
- ***Hunter***: Contractor: TRW. Initial contract expired with delivery of seven LRIP systems: Army maintains one at Ft. Hood, TX, to support CONOPS development including Force XXI and sufficient assets at Ft. Huachuca for training

Major Accomplishments

- ***Pioneer***: Deployed on three Navy LPD-class ships. Readiness Improvement Program continuing. Marine VMU-1 deployed to Bosnia. VC-6 deployed on USS Shreveport, USS Austin, and USS Denver
- ***Hunter***: Since flying resumed (Feb 96), *Hunter* has flown 1,050+ hours without a hardware or software failure, and has supported key exercises, demos, and tests

Outrider (TUAV)

Costs	*Outrider*[c]
FY96	$71.9M
FY97	$64.6M

[c]Includes CSD, TCS

Program Requirements/Objectives

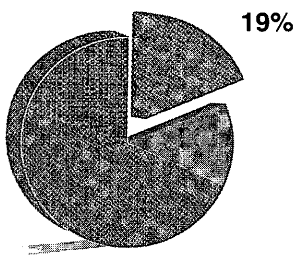
- **Cost:** $350,000 @ 33rd AV, $300,000 @ 100th AV, witl sensor
- Operate ≥ 200 km range, with >4 hrs on station
- Compliance w/Joint Integration Interface standards
- Demonstrate military utility for reconnaissance anc surveillance, tactical situational awareness, gun fire support, BDA

Acquisition Strategy

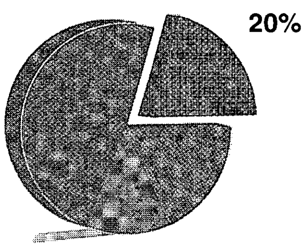
- Contractor: Alliant Techsystems
- 24-month ACTD: 6 systems and support. Focus on systen integration, shipboard & interoperability demos, exercise support, and logistics definition
- 18-month LRIP option: 6 systems and support. Continued integration, testing, exercise support, and logistics development

Major Accomplishments

- ACTD contract award 2 May 96
- Inertial navigation system developed
- Prototype system delivered to System Integration Lab (SIL), Huntsville, AL
- First ACTD flight on schedule for mid-Nov 96



SHARE OF FY96 DARP UAV INVESTMENT ($354M)



AV	Air Vehicle	CSD	Common System Development	IMINT	Imagery Intelligence
LPD	Landing Platform Dock	TCS	Tactical Control System	VTOL	Vertical Takeoff and Landing

Endurance

To support: Joint Task Force Commanders and Theater/National C2 nodes; goal of sensor-to-shooter interface – Long-range, long-dwell, near-real-time theater/tactical intelligence via deep penetration/wide-area surveillance

Predator (MAE UAV)

	Predator
FY96	$44.9M
FY97	$121.9M[d]

[d]Includes U-CARS integration

Program Requirements/Objectives

- Long-range/dwell, near-real-time tactical intelligence, RSTA, and BDA
- Operate up to 25,000 ft and at radius up to 500 nm
- EO/IR and high-resolution SAR for IMINT

Acquisition Strategy

- **ACTD:** Contractor: General Atomics. Determine optimal technical approach for endurance UAVs; maintain production base following first 10 AVs
- **Production**: Baseline configuration (to include de-icing, IFF, and voice radio relay) and P3I
- **Basing**: Assigned to Air Combat Command

Major Accomplishments

- 30-month ACTD completed 30 Jun 96
- Military utility validated in demos and two contingency deployments
- Two deployments to Bosnia (Jul–Nov 95 and Mar 96-on) to support UN, NATO
- Interoperability demos with U.S. Customs Service, Navy battle group, and Navy submarine/SEAL operation
- First ACTD approved for transition to production
- Ops responsibility passed to Air Force 2 Sep 96
- Marinization study complete 1Q/FY 1997

HAE UAVs (CONV & LO HAE)

Costs	*Global Hawk*	*DarkStar*	HAE CGS
FY96	$55.4M	$65.3M	$50.2M
FY97	$71.2M	$45.9M	$71.6M

Program Requirements/Objectives

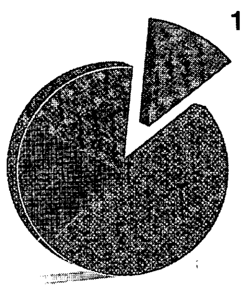
- Military utility w/UFP ≤$10M (FY94 $), AVs #11–20 (average)
- RSTA w/hi-alt, long-range/dwell & wide-area surveillance
- *Global Hawk*: 24 hrs at 65,000 ft and 3,000 nm radius
- *DarkStar*: >8 hrs at >45,000 ft and 500 nm radius

Acquisition Strategy

- **ACTD**: Two HAE AVs with CGS to explore military utility and roles/capabilities (USACOM as lead-CINC). DARPA used Other Agreements Authority to streamline contracting and conduct tech demos
- *Global Hawk*: Competitive award to Teledyne Ryan
- *DarkStar*: Sole-source development by Lockheed Martin
- **Demo Eval**: Demo military utility (FY 1998-1999)
- **Production**: Planned for FY 2000 (post-ACTD)

Major Accomplishments

- *Global Hawk*: Final design review (May 96); AV #1's wing loading test (Jun 96), fabrication complete (Sep 96), subsystem integration and checkout (Oct-Dec 96); 1st flight on schedule for 3Q/FY 1997.
- *DarkStar*: 1st flight 29 Mar 96; AV crash during 2nd flight (22 Apr). RCS test complete (Jul 96); system configuration review (Sep-Nov 96). (To resume flight test schedule in 3Q/FY97)
- **HAE CGS**: MCE virtual prototype experiment (May 96); LRE completing assembly and checkout (Nov 96)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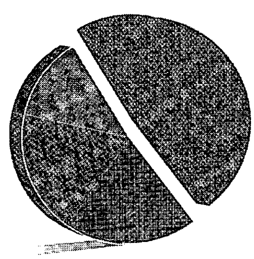
SHARE OF FY96 DARP UAV INVESTMENT ($354M)

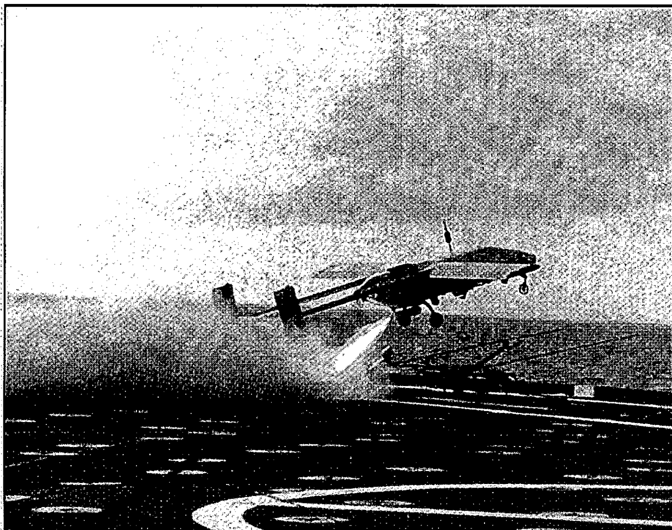

48%

AEW	Airborne Early Warning	LRE	Launch and Recovery Element	MCE	Mission Control Element
RCS	Radar Cross-Section	U-CARS	UAV Common Automatic Recovery System	UFP	Unit Flyaway Price

Pioneer UAV Program

General

Pioneer was procured starting in 1985 as an interim UAV capability to provide imagery intelligence (IMINT) for tactical commanders on land and at sea (originally launched from Navy Iowa-class battleships, today from LPD-class ships). In ten years, *Pioneer* has flown nearly 14,000 flight hours and supported every major U.S. contingency operation to date. It flew 300+ combat reconnaissance missions during Persian Gulf operations in 1990-91. Since September 1994, it has flown in contingency operations over Bosnia, Haiti and Somalia; most recently it flew in Task Force Eagle and IFOR operations again over Bosnia. Prime contractor is Pioneer UAV, Inc., Hunt Valley, MD.



SUBSYSTEMS

- 5 Air Vehicles
- 1 Ground Control Station
- 1 Portable Control Station
- 4 Remote Receiving Stations (max)
- 1 Truck-Mounted Launcher

KEY OPERATIONAL FACTORS

Sensors:	EO or IR
Deployment:	Multiple* C-130/C-141/C-17/C-5 sorties; also shipboard
Radius:	185 km (100 nm)
Endurance:	5 hrs
Max Altitude:	4.6 km (15,000 ft)
Cruise Speed:	120 km/hr (65 kts)

*Depends on equipage and duration

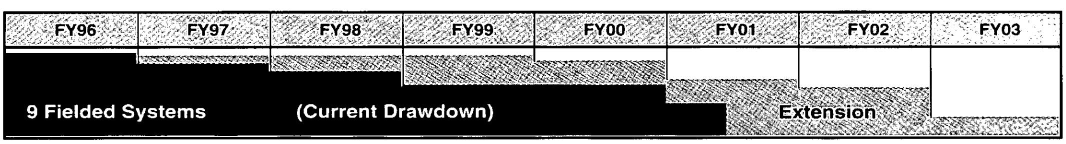
Flight Data[a]	Bosnia	FY96	Total to Date
• Flights / Hours	33 / 89	629 / 1,554	4,000+ / 13,798

[a]As of 30 Sep 96

Funding ($M):	FY96	FY97
Procurement (Defense-wide)	28.3	
Procurement (Navy)		25.6

Program Status

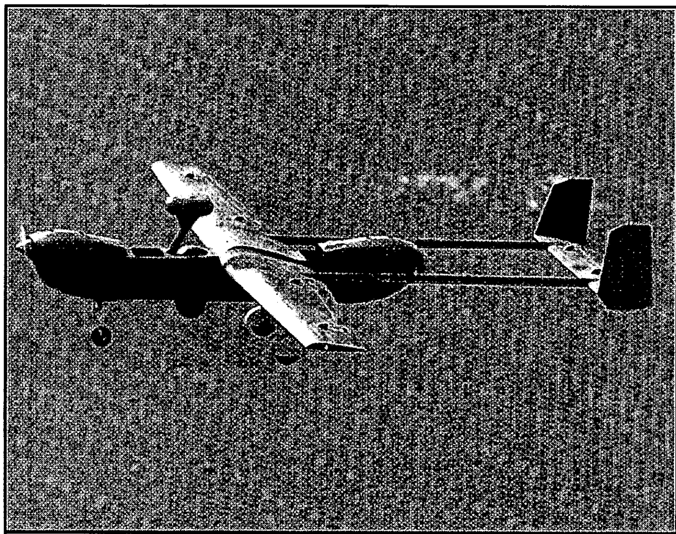
Pioneer continues to operate as the DoD's first operational UAV system. Currently, there are nine systems in the active force: the Navy operates five, the Marine Corps three, and one is assigned to the Joint UAV Training Center (JUAVTC) at Ft. Huachuca, AZ. The Navy system at Patuxent River Naval Air Station (NAS), MD, supports software changes, hardware acceptance, test and evaluation of potential payloads, and technology developments to meet future UAV requirements (see p. 40). An additional 30 *Pioneers* (procured in FY 1994) were delivered from September 1995 through November 1996, along with continuing support kit and spares procurement. These aircraft are in the Option 2+ configuration, which has slight increases in air vehicle weight and fuel capacity. A third extension of the *Pioneer* force's operational life is being planned through FY 2003, until TUAV systems are fielded and able to meet tactical-level UAV requirements. During FY 1996, one Marine unit deployed to Tuzla, Bosnia, to support peacekeeping operations ashore, and two Navy units successively deployed aboard USS Shreveport and USS Austin to support fleet operations and contingency operations ashore as needed.



Hunter UAV Program

General

The *Hunter* Joint Tactical UAV was originally developed to provide both ground and maritime forces with near-real-time IMINT within a 200-km direct radius of action, extensible to 300+ km by using another *Hunter* as an airborne relay. *Hunter* can operate from unimproved air strips to support ground tactical force commanders. Prime contractor is TRW, San Diego, CA.



SUBSYSTEMS

8 Air Vehicles
4 Remote Video Terminals
3 Ground Control/Mission Planning Stations
2 Ground Data Terminals
1 Launch & Recovery System
1 Mobile Maintenance Facility

KEY OPERATIONAL FACTORS

Sensors:	EO and IR
Deployment:	Multiple* C-130 sorties
Radius:	267 km (144 nm)
Endurance:	11.6 hrs
Max Altitude:	4.6 km (15,000 ft)
Cruise Speed:	>165 km/hr (>89 kts)

*Depends on equipage and duration

Flight Data[a]	**FY96**	**Total to Date**
• Flights / Hours	350 / 1,051	1,575 / 4,590

[a]As of 30 Sep 96

Funding ($M):	**FY96**	**FY97**
Procurement (Defense-wide)	38.0[b]	
Opns & Maintenance (Army)		12.0[c]

[b]Reprogramming to TUAV/TCS, *Predator* and *DarkStar* RDT&E in process
[c]Addition to Army O&M Account

Program Status

Following an October 1995 JROC recommendation, in January 1996 the USD(A&T) decided to let *Hunter's* contract expire after delivery of its seven LRIP systems. Currently, the Army is operating a single *Hunter* system at Ft Hood, TX, to support operations, concept development, and continuation training; additional assets support initial operator and maintainer training at the Joint UAV Training Center (JUAVTC) at Ft Huachuca, AZ, and interoperability, test and evaluation work at the Joint UAV Systems Integration Laboratory (SIL) at Huntsville, AL. All other *Hunter* equipment remained in Army storage.

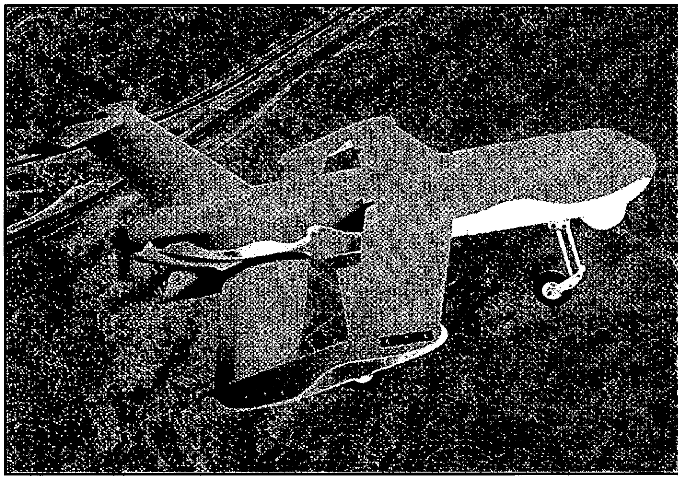
Hunter resumed flight operations in February 1996 at Ft Hood and in April at Ft Huachuca. As of 30 September, it has flown 1,050+ hours in support of Army and joint operations and training, and payload testing. In April, a *Hunter* demonstrated a VHF/UHF radio relay capability between two ground stations. In July, *Hunters* deployed from Ft Hood to support tactical warfighter training at the National Training Center (NTC), Ft Irwin, CA, where they flew nearly 200 hours supporting reconnaissance, surveillance, live-fire and maneuver operations. In an August live-fire demonstration at Eglin AFB, FL, a *Hunter* was a testbed for a laser designator demo. In September, *Hunter* successfully demonstrated several payloads for the Joint Command and Control Warfare Center (see page 39).

For FY 1997, the Congress provided an additional $12 million to the Army "to remove three *Hunter* systems from storage to provide a capability to further develop UAV concepts of operation."

Outrider TUAV Program

General

The *Outrider* Tactical UAV (TUAV) program is an Advanced Concept Technology Demonstration (ACTD) to support tactical commanders with near-real-time imagery intelligence (IMINT) at ranges beyond 200 km and on-station endurance greater than 4 hours. This ACTD replaces the *Hunter* and Maneuver UAV programs in seeking to provide reconnaissance, surveillance and target acquisition (RSTA) and combat assessment (CA) at Army brigade/battalion, Navy task force and Marine Corps regimental/battalion levels. The ACTD involves a two-year cost-plus contract with a low-rate initial production (LRIP) option, and is valued at $52.6 million. Prime contractor is Alliant Techsystems, Hopkins, MN.



SUBSYSTEMS

4 Air Vehicles
4 Modular Mission Payloads
2 Ground Control Stations and Data Terminals
1 Remote Video Terminal
Launch & Recovery and Ground Support Eqpt

KEY OPERATIONAL FACTORS

Sensors:	EO/IR (SAR growth)
Deployment:	Single C-130
Radius:	≥200 km (≥108 nm)
Endurance:	>4 hrs (+ reserve) @ 200 km
Max Altitude:	4.6 km (15,000 ft)
Cruise Speed:	167 km/hr (90 kts)

Funding (TUAV) ($M):	**FY96**	**FY97**
RDT&E (Defense-wide)	71.9	64.6
• *Outrider*	(47.6)	(51.4)
• Tactical Control System	(18.3)	(7.1)
• Common Systems Dev't	(5.9)	(6.1)

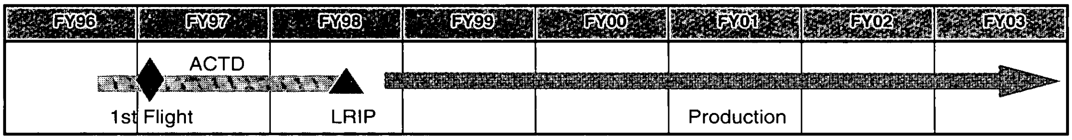
Program Status

On 21 December 1995, the USD(A&T) approved initiation of an ACTD for a single TUAV system to meet joint Service requirements. The ACTD's primary objective is to develop a joint tactical UAV that best meets basic performance requirements, as defined by the JROC, within target costs of $350,000 for the 33rd basic air vehicle (AV) with sensor and $300,000 for the 100th AV with sensor. The system must also demonstrate military utility and comply with Joint Integration Interface (JII) standards. (The Tactical Control System [TCS] concept for interoperable UAV command and control will be developed as a parallel program; see pages 24-25).

On 2 May 1996, Alliant Techsystems won the ACTD contract to develop its *Outrider* UAV system. The contract included delivery of six *Outrider* systems, eight attrition AVs, two Mobile Maintenance Facilities (MMFs), and an LRIP option for six additional systems and two additional MMFs; first flight was required in six months, first system delivery in one year, and the remaining five systems delivered during the second ACTD year. The basic *Outrider* ACTD includes the mandatory options of a heavy fuel engine (HFE) and the UAV Common Automatic Recovery System (U-CARS); non-mandatory options include incorporation of a tactical data link and a synthetic aperture radar (SAR) sensor. On 13 September 1996, the USD(A&T) reaffirmed these *Outrider* options in an Acquisition Decision Memorandum by directing risk mitigation in preparation for the acquisition of U-CARS and HFE, and an executive review of the initiatives for a SAR sensor and a tactical variant of the Common Data Link (CDL).

Support for Joint Force Tactical Operations

Schedule



Requirements

ACTD Performance Requirements*		
Parameter	**Basic**	**Option**
Range:	200 km	
Target Location Error:	Best possible using state-of-the-art GPS (NTE 100 m)	
On-Station Endurance:	3 hrs	4 hrs
Launch and Recovery:	Unprepared surface/large deck amphibious ships	Add Automatic TO&L
System Mobility:	2 HMMWVs/1 Trailer	
System Deployability:	Single C-130 (4 AVs & ground equipment)	
Payload:	EO/IR	SAR
Integration:	EMI shielding/corrosion inhibition	
Data Link:	Compliant with JII (200 km LOS at sea level)	Common Data Link
Propulsion System:	As provided by Contractor	Heavy Fuel Engine
Cost (AV & Sensor):	$350,000 at 33rd AV; $300,000 at 100th AV	

EMI Electromagnetic Interference; GPS Global Positioning System; JII Joint Integration Interface
LOS Line of Sight; NTE Not to Exceed; TO&L Takeoff and Landing

* Ref: Sec C – System Performance Document, TUAV ACTD RFP, 31 Jan 96.

Transition Integrated Product Team (IPT)

Outrider's prospective transition from ACTD to a formal acquisition program will involve a significant level of preparation. A Transition IPT, co-chaired by the ACTD Acquisition Manager and a representative from the USD(A&T)'s Advanced Technology directorate, was established in June 1996. It will ensure that the necessary preparations are made during the ACTD for an effective transition into LRIP (given a favorable decision in FY 1998). Its four working-level IPTs are focusing on the areas of requirements, military utility, supportability, and acquisition — all of which are addressing the preparations needed to achieve both operational as well as acquisition transition functions.

> *The tactical UAV is absolutely critical to our brigade and division commanders.... it is their confirming sensor, and the "eyes" which enable commanders to see critical portions of their battlefield and target anything they can see.*
>
> *Lieutenant General Paul E. Menoher, Jr.*
> *Deputy Chief of Staff for Intelligence, U.S. Army*
> *5 August 1996*

Predator (MAE UAV) Program

General

Predator, also identified as the Medium Altitude Endurance (MAE) or Tier II UAV, is a derivative of the Gnat 750 (Tier I) UAV. In July 1996, *Predator* completed its 30-month ACTD program and is transitioning to low-rate initial production (LRIP) in the formal acquisition arena. The system provides long-range, long-dwell, near-real-time imagery intelligence (IMINT) to satisfy reconnaissance, surveillance and target acquisition (RSTA) mission requirements. The air vehicle carries both EO/IR and SAR sensors which, with Ku- as well as UHF-band satellite communication (SATCOM) links, enable the system to acquire and pass imagery to ground stations for adverse weather, beyond-line-of-sight (BLOS) use by tactical commanders. Recent addition of de-icing equipment now allows transit and operation in adverse weather conditions. This capability was deployed to Bosnia in October 1996. As production assets augment ACTD assets, *Predator* will be the operational endurance UAV workhorse for the next several years. Prime contractor is General Atomics – Aeronautical Systems, Inc., San Diego, CA.

SUBSYSTEMS
- 4 Air Vehicles
- 1 Ground Control Station
- 1 Trojan Spirit II Dissemination System
- Ground Support Equipment

KEY OPERATIONAL FACTORS

Sensors:	EO, IR, and SAR
Deployment:	Multiple* C-130 sorties
Radius:	926 km (500 nm)
Endurance:	>20 hrs
Max Altitude:	7.6 km (25,000 ft)
Cruise Speed:	120-130 km/hr (65-70 kts)

*Depends on equipage and duration

Flight Data[a]	Bosnia	FY96	Total to Date
• Flights / Hours	159 / 1,169	537 / 2,477	1,575 / 4,590

[a]As of 30 Sep 96

Funding ($M):	FY96	FY97
RDT&E (Defense-wide)	44.9	6.1
Procurement (Navy)[b]		115.8

[b]Includes $8 million for U-CARS

Program Status

After a November 1995 return from Albania and support of United Nations operations in Bosnia, *Predator* AVs incorporated both a SAR sensor (with imagery transmitted through the Ku-band SATCOM link) and initial ice sensing features to enable poor weather operation. *Predators* redeployed in March 1996 to Taszar, Hungary, supporting NATO operations in Bosnia; return is currently planned for February 1997. Concurrently, other *Predators* participated in a succession of interoperability demonstrations, specifically with the U.S. Customs Service (Fall, 1995), a Navy carrier battle group (CVBG) (Fall, 1995), and a Navy submarine with SEAL team aboard (Spring, 1996); details are on pages 32-33.

On 30 June 1996, *Predator* completed its 30-month ACTD. On 26 July, General Atomics received a $23 million contract for another five AVs and ancillary equipment. On 2 September, the Air Force Air

The Predator has proved its ability to provide a significant and urgently needed reconnaissance capability in many mission areas and the continued participation of each Service must be maintained.

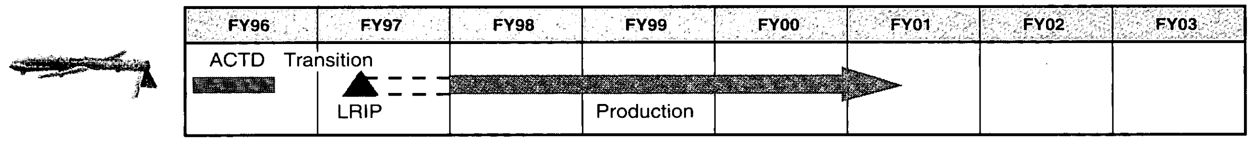
Dr. William J. Perry, SecDef
Memo for Secretaries of the Military Departments (et al.)
on Assignment of Service Lead for Operation of the Predator UAV, 9 April 1996

Providing Multi-Role Support to All Operational Echelons

Combat Command's 11th Reconnaissance Squadron, Nellis AFB, NV, assumed operational control (OPCON) of assets.

In the Defense Appropriations Act for FY 1997, the Congress transferred *Predator's* production funding from the Defense-wide Procurement account to the Navy's Procurement account and increased the amount by $50 million to $115.8 million for the year (which included funding for U-CARS integration on *Predator* and *Outrider*).

Schedule



Transition and Acquisition Program Features

Predator constituted a Class II (weapon/sensor system) ACTD and will enter formal acquisition as an LRIP program. The JROC recommended an initial force of 16 systems (plus attrition spares) (JROCM 010-96), including one system for R&D, or more than 60 AVs, counting the retrofitted ACTD versions. Resource programming to support life-cycle acquisition, operations and support is ongoing and candidate capabilities are listed below. The DoD plans to continue all system development and procurement through the Navy's UAV JPO, while the Air Force manages system operations and maintenance. *Predator's* LRIP production configuration and longer-term P3I program will be more fully defined in FY 1997.

Configuration Feature	Baseline	P3I*	Remarks
De-icing system	X		Required for reliable all-weather operation
Onboard UHF voice radio	X		For BLOS communications with ATC
Improved identification friend-or-foe (IFF)	X		Positive airborne control requirement
Engine upgrade		√	Rotax 914 to replace Rotax 912
Heavy fuel engine (HFE)		√	Mandatory for a marinized *Predator*
UAV Common Auto Recovery System (U-CARS)		√	Feasibility study to be completed Dec 96
Engine and propeller quieting		√	Exhaust system muffler, variable-pitch prop
Upgraded IR sensor		√	Under study for near-term P3I
Moving target indication (MTI)		√	Under study for near-term P3I
Improved GPS		√	Under study for longer term
SATCOM suite (Trojan Spirit) replacement		√	Under study for longer term
Upgraded GCS communications suite		√	Under study for longer term
Communications relay		√	Under study for longer term
Laser designation/rangefinder		√	Under study for longer term
SIGINT payload		√	Under study for longer term

*Recommended P3I candidates

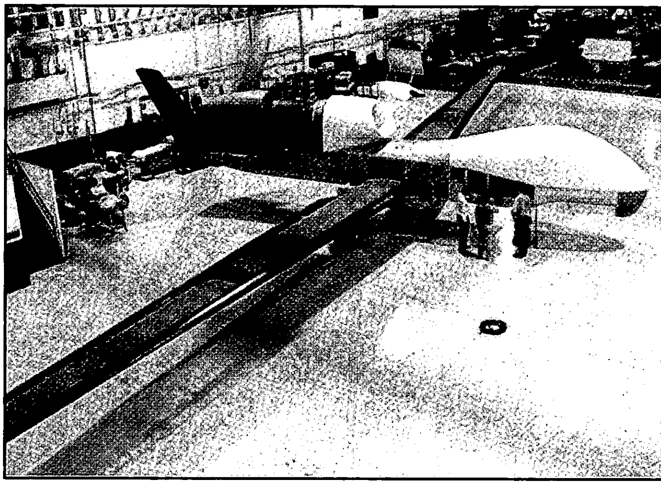
The operational capabilities embodied in the Predator UAV system are a significant first step toward the continuous, real-time Reconnaissance, Surveillance and Target Acquisition (RSTA) required by 21st century joint warfighters. ACC is committed to developing our ability to employ the family of UAVs in that role.

General Richard E. Hawley
Commander, Air Combat Command
August 1996

Global Hawk (CONV HAE UAV) Program

General

Global Hawk, also identified as the Conventional High Altitude Endurance (CONV HAE) or Tier II+ UAV, is intended to be employed as the HAE UAV "workhorse" for missions requiring long-range deployment and wide-area surveillance or long sensor dwell over the target area. It will be directly deployable from well outside the theater of operation, followed by extended on-station time in low- to moderate-risk environments to look into high-threat areas with EO/IR and SAR sensors in order to provide both wide-area and spot imagery; survivability will derive from its very high operating altitude and self-defense measures. The HAE Common Ground Segment (CGS) (see page 26) will provide launch and recovery and mission control elements (LRE and MCE) that are common and interoperable with *DarkStar.* Prime contractor is Teledyne Ryan Aeronautical (TRA), San Diego, CA.



SUBSYSTEMS

Air Vehicles (TBD)

1 Common Ground Segment

KEY OPERATIONAL FACTORS

Sensors:	EO, IR, and SAR
Deployment:	AV: self-deployable; multiple C-141/ C-17/C-5 sorties for other eqpt*
Radius:	5,556 km (3,000 nm)
Endurance:	>40 hrs (24 hrs at radius)
Max Altitude:	19.8 km (65,000 ft)
Cruise Speed:	639 km/hr (345 kts)

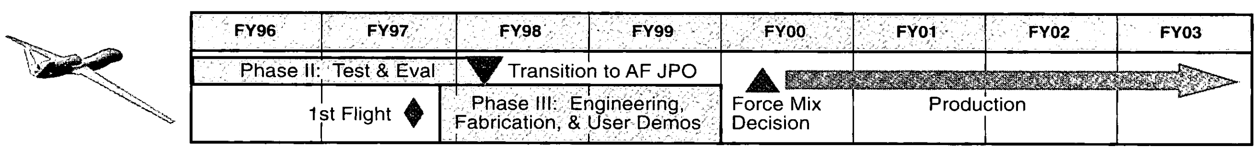
*Depends on equipment deployed and deployment duration

Funding ($M):	**FY96**	**FY97**
RDT&E (Defense-wide)	55.4	71.2

Program Status

Since contract award for Phase II in June 1995, the TRA team has fabricated the first AV and is performing subsystem and system tests. Phase II comprises an extensive fabrication and system test program to assure air vehicle-ground segment integration, demonstrate system capabilities, and reduce risk. Final design review was completed in May 1996, the wing loading test in June, full air vehicle assembly in September, and subsystem checkout continues in October. First flight is planned for Spring 1997, to be followed by a series of AV flight and system tests and initial demonstrations. Meanwhile, fabrication of AV #2 began in July 1996. Phase II will extend through 1Q/FY 1998. Phase III's operational demonstrations of the full HAE UAV system are scheduled to begin in mid-FY 1998. Program management is scheduled to transition from DARPA to an Air Force-led joint program office at the end of December 1997.

Schedule



Deep-Look Wide-Area Reconnaissance for Commanders

Advanced System Concept

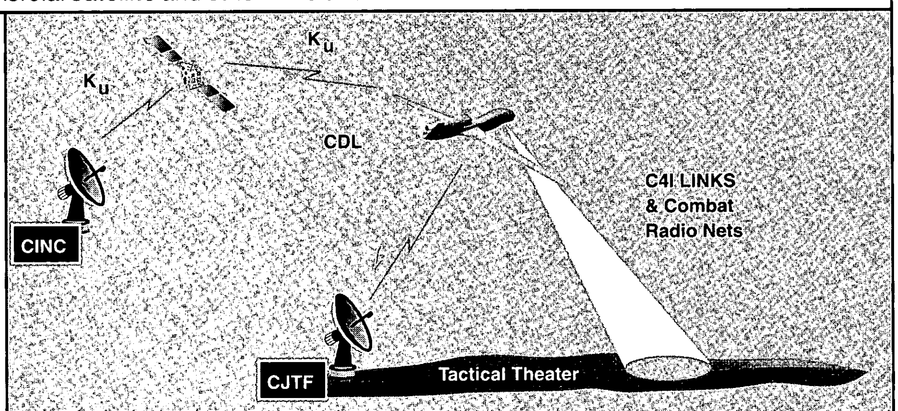
Global Hawk's role in the HAE UAV CONOPS is illustrated on page 30. Meanwhile, in light of *Predator's* wide dissemination of imagery via JBS satellites during its second Bosnia deployment, comparable scenarios are being examined for this longer-range UAV under a Global Hawk-Airborne Communications Node (ACN) system concept. The ACN concept envisions a communications node payload for a UAV to provide gateway and relay services to surface and air forces. This capability would specifically enhance long-range/endurance deployment of a HAE UAV to meet contingency requirements. Options and features are summarized below.

General:

- *Global Hawk* coverage available at H-hour (vice weeks to deploy and start operating)
- Less vulnerable (at 65,000 ft altitude, 200 km slant range) than overflight and local signal sites
- Open system architecture w/software-reconfigurable communications payload
- Exploitation of military & commercial satellite and other links and networks for wide dissemination

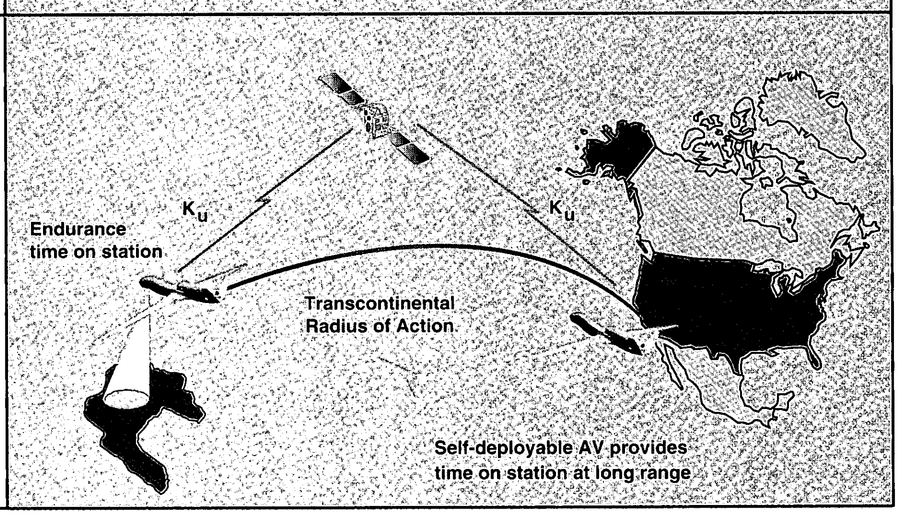
In-Theater Coverage:

- *Global Hawk* provides 500 km LOS
- Connectivity for:
  - Isolated/maneuvering forces
  - Forward elements (back to U.S.)
  - Dissimilar radios via ACN gateways
  - Developing crises without large in-theater assets
- AV self-deployment eases lift needs



Coverage from CONUS:

- Trades *Global Hawk's* 40+ hrs endurance vs. 25,000 km max range
- Intercontinental ops could involve 12+ hrs on-station (w/6,500 km round trip)
- With ≈4 hrs AV ground maintenance, 4 GH-ACN assets could cover crisis areas indefinitely from CONUS
- AV self-deployment + out-of-theater support = *no* need for lift
- Recce equivalent of strategic bombing

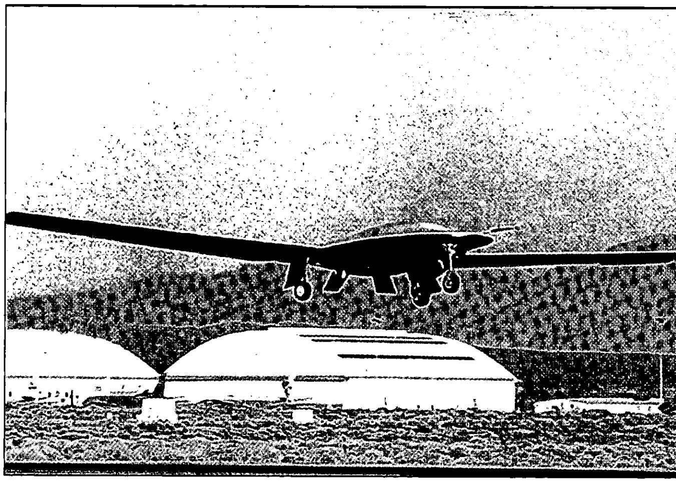


> *It all started 93 years ago with two brothers from Ohio.... Think where we will go in the next 93 years.*
>
> *General Joseph W. Ralston, USAF*
> *Vice Chairman, Joint Chiefs of Staff*
> *Address to the National Aviation Club, 9 October 1996*

DarkStar (LO HAE UAV) Program

General

DarkStar, also identified as the Low Observable High Altitude Endurance (LO HAE) or Tier III– UAV, is intended to provide critical imagery intelligence from highly defended areas. *DarkStar* trades air vehicle performance and payload capacity for survivability features against air defenses, such as its use of low observable technology to minimize the air vehicle's radar return. Its payload may be either SAR or EO. The air vehicle may be self-deployable over intermediate ranges. The HAE Common Ground Segment (CGS) will provide launch and recovery and mission control elements (LRE and MCE) that are common and interoperable with *Global Hawk*. *DarkStar's* prime contractor is the Lockheed Martin/Boeing team.



SUBSYSTEMS

Air Vehicles (TBD)

1 Common Ground Segment

KEY OPERATIONAL FACTORS

Sensors:	EO or SAR
Deployment:	Multiple C-141/C-17/C-5 sorties
Radius:	>926 km (>500 nm)
Endurance:	>8 hrs (at 926 km/500 nm)
Max Altitude:	>13.7 km (>45,000 ft)
Cruise Speed:	>463 km/hr (>250 kts)

Funding ($M):	**FY96**	**FY97**
RDT&E (Defense-wide)	65.3	45.9

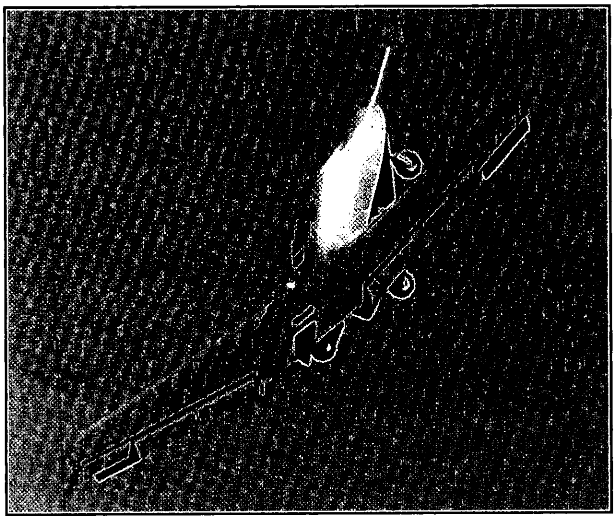
Program Status

Following its 1 June 1995 rollout and a series of ground tests, *DarkStar* flew successfully on 29 March 1996, a first fully autonomous flight using differential GPS. On its 22 April second flight, however, its "wheel-barrowing" characteristic on takeoff roll increased to uncontrollable "porpoising" oscillations after breaking ground, and the aircraft stalled nose-high and crashed. The accident board identified the cause as inaccurate prediction of air vehicle/ground interaction, which had led to an engineering change to the flight control system before the second flight. Corrective action will include "hiking" the nose gear at rotation during takeoff, simplifying flight control laws during the takeoff phase, and adding the capability to abort takeoffs. Software testing and reconfiguration of AV #2 are currently projected to allow the Phase II flight test program to resume in 3Q/FY 1997. Meanwhile, radar cross-section (RCS) test results validated *DarkStar's* low-observable design.

The Congress has provided an additional $28.5 million for FY 1997, of which $22 million supports design changes and their integration into AV #2, $3.5 million is for further EO sensor development, and $3 million is for long-lead procurement of AV #5. One effect of the program delay has been to realign *DarkStar's* flight and system test schedules to better support user demos and provide comparable *DarkStar-Global Hawk* maturity for DARO's force mix study, both of which will be key to a HAE UAV production decision in FY 2000.

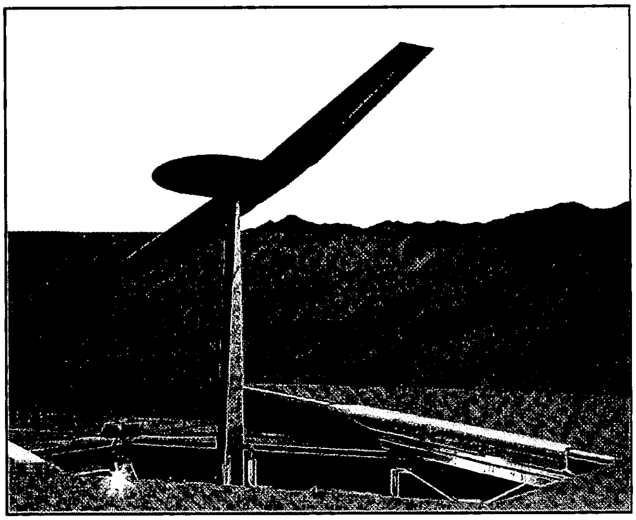
Deep-Look Reconnaissance of Highly Defended Areas

***DarkStar's* Second Flight, 22 April 1996**



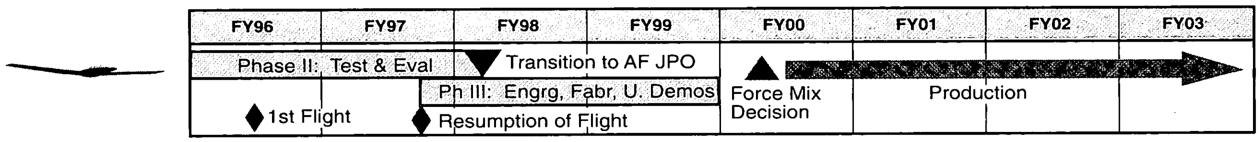
Aircraft's porpoising motion increases to a nose-high stall as it leaves the ground-effect régime

***DarkStar's* Radar Cross-Section Test**



AV #2 in position on "the pole" for RCS testing, May 1996

Schedule



The high-priority DarkStar *program will demonstrate a warfighting capability that the U.S. has not had since the early days of the SR-71 and U-2. While the program experienced an unfortunate setback with the crash last April, I am confident that it will demonstrate outstanding performance as it begins flying again in FY 1997. The* DarkStar's *ability to penetrate heavily defended areas and collect significant amounts of high-resolution imagery will provide the Joint Forces Commander with unprecedented access to battlefield information.*

Larry Lynn
Director, Defense Advanced Research Projects Agency
October 1996

The HAE UAV System

DarkStar and *Global Hawk,* with their Common Ground Segment (see page 26), form the HAE UAV system. The two air vehicles are complementary: *DarkStar* will provide a capability to penetrate and survive in areas of denied airspace, while *Global Hawk's* even greater range, endurance and multi-sensor payload will provide broad battlefield awareness to senior command echelons. Their CGS will assure both their interoperability and relay of their sensor products to the C4I infrastructure. Thus, the HAE UAV system will provide the joint warfighter with an unprecedented degree of broad reconnaissance-surveillance coverage and flexibility.

Ground Station Programs

The Department is developing two UAV ground control station (GCS) types: the Tactical Control System (TCS) for tactical UAVs, and the Common Ground Segment (CGS) for the HAE UAVs (see page 26). The key reason for two GCS types is to support system requirements for two complementary UAV classes:

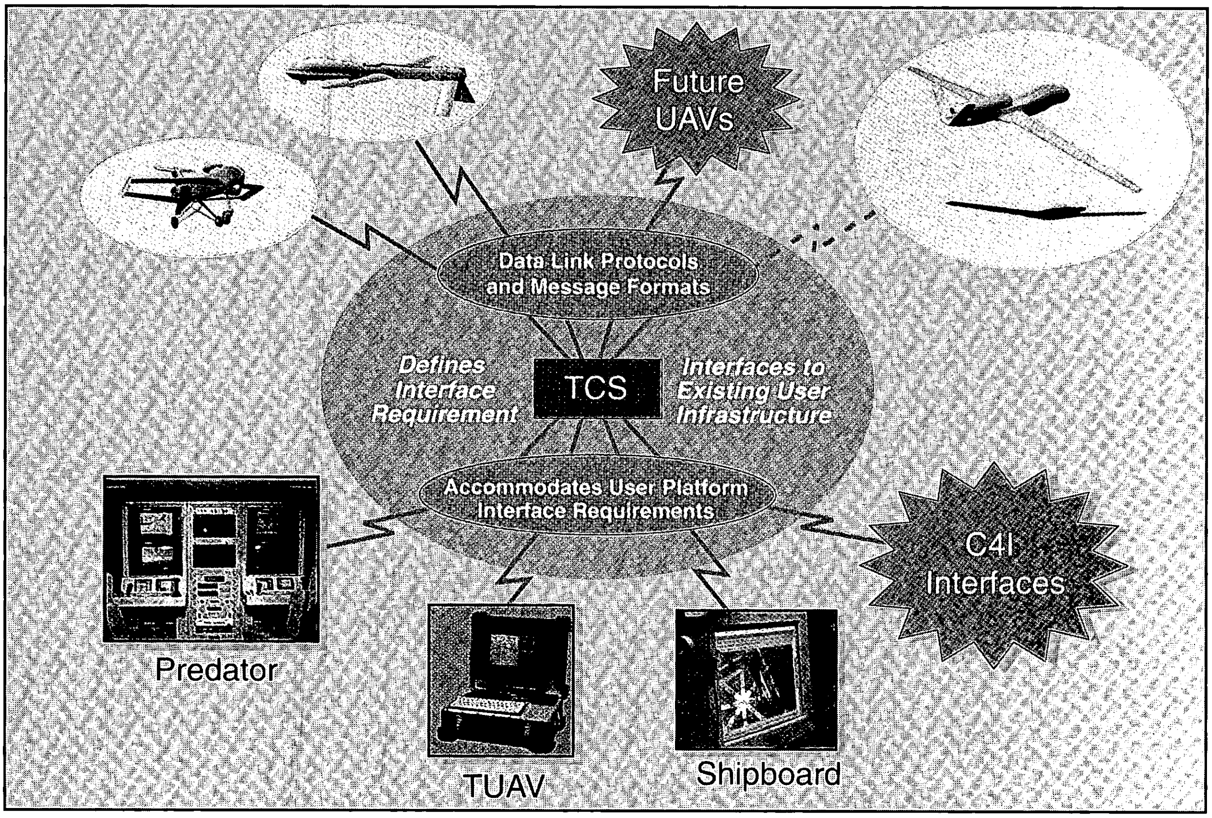
- UAV support to the tactical commander requires a GCS with a relatively small logistics footprint and open systems design to meet joint tactical needs.
- By comparison, the long-dwell and relatively autonomous HAE UAV requires a GCS with high data rates, multi-payload functionality, and the capability to handle significantly more complex missions.

The concept for two GCSs came from the DARO-initiated Common Ground Station Interoperability Working Group (CGSI WG) that addressed the possibility of developing a single GCS for all UAVs. The WG determined there were numerous risks in the single-GCS approach and that it was not an optimal solution.

At the same time, lessons learned from Bosnia clearly illustrate the value of interoperable GCSs and the ability to receive timely information. Field commanders request this capability be enhanced by the addition of video downlinks and the ability of commanders to influence UAV operations in real-time. DARO is pursuing advanced development in tactical data links, open systems architectures, and common modular GCS components.

Tactical Control System

On 21 December 1995, the Department initiated development of the TCS to provide warfighters with a scalable command, control, communications and data dissemination system for tactical UAVs. This program supports the JROC's recommendation for "...development of a common ground reception, processing and control system to ensure full interoperability with other UAVs and collection systems."[1]



[1] JROCM 131-95, 26 October 1995

The TCS Will Assure Interoperability

The TCS program will be developed in two phases:

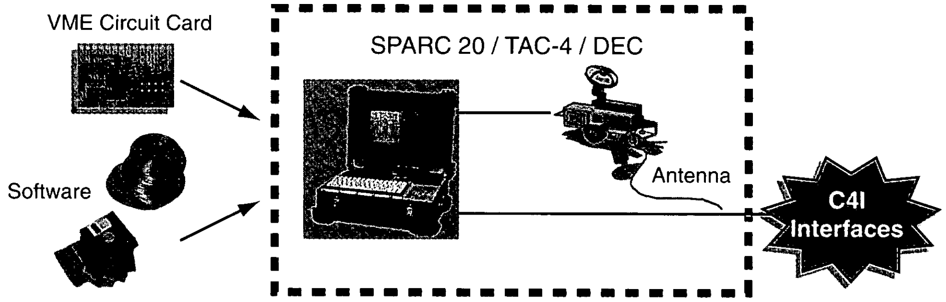
- Phase I (24 months) is an incremental build that demonstrates increasing TCS functionality from passive receipt of data to payload control to multi-UAV control. This phase focuses on demonstrations to generate early user input and evaluation.
- Phase II (duration TBD) will continue demonstrations and system integration, and also include low-rate initial production.

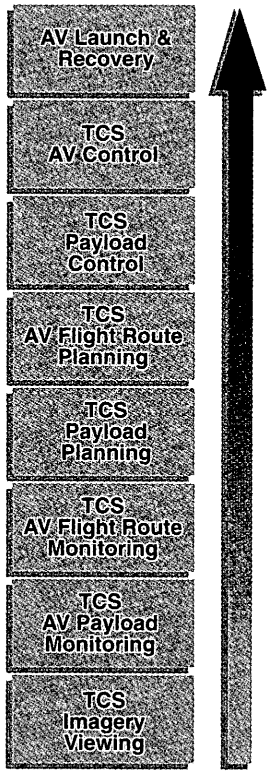
The TCS will provide a migration path to interoperable UAV employment by operators and a common interface to joint and Service C4I systems. It will also establish an interoperability standard for operations and data dissemination for both current and future UAV systems.

The key characteristics of the TCS will involve scalable functionality and flexible capabilities that may be adapted to the characteristics of the user systems. Specific functionality implemented will be in accordance with user doctrine. These concepts are illustrated below.

TCS	Army / Marines	Navy	Air Force
Hardware*	SPARC 20s	TAC-4s	SGI / DECs
Software	Common Core AV-Unique Payload-Unique	Same	Same
Data Links	LOS/SATCOM Analog/Digital	Same	Same
C4I Interfaces	ADOCS AFATDS ASAS IAS Joint STARS / GSM / CGS JDISS (JAWS) MIES ETRAC	JSIPS-N / PTW JMCIS JDISS CCTV TAMPS	CIS CARS JSIPS JDISS

* New hardware provided only when required; otherwise, software hosted on existing computer





Increased Functionality

ADOCS	Advanced Deep Operations Center System
ASAS	All-Source Analysis System
CCTV	Closed Circuit Television
CIS	Combat Intelligence System
GSM	Ground Station Module
JAWS	JDISS Army Work Station
JMCIS	Joint Maritime Command Information System
JSIPS-N	Joint Service Imagery Processing System-Navy
PTW	Precision Targeting Workstation
AFATDS	Advanced Field Artillery Target Data System
CARS	Contingency Airborne Reconnaissance System
CGS	Common Ground Station
ETRAC	Enhanced Tactical Radar Correlator
IAS	Intelligence and Analysis System
JDISS	Joint Deployable Intelligence Support System
JSIPS	Joint Service Imagery Processing System
MIES	Modernized Imagery Exploitation System
TAMPS	Tactical Aircraft Mission Planning System

Ground Station Programs (Cont'd)

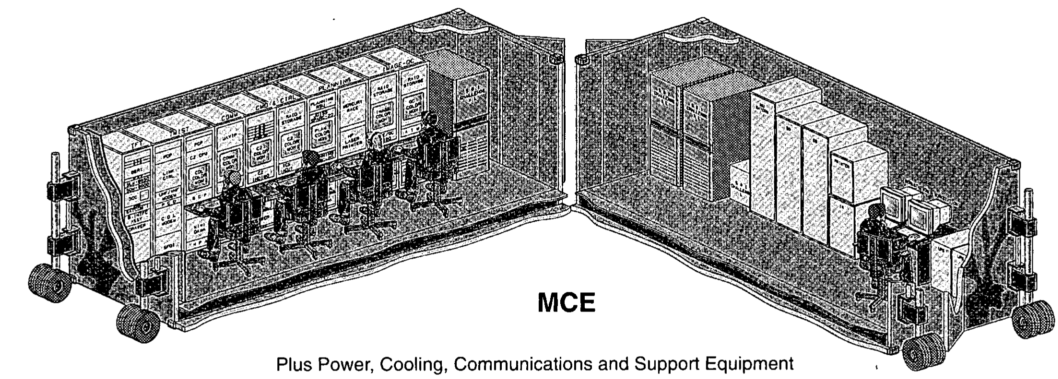
HAE Common Ground Segment

The third component of the three-part HAE UAV system is its Common Ground Segment (CGS). The CGS includes a Launch and Recovery Element (LRE), a Mission Control Element (MCE), associated communications, and a support segment of spares, maintenance and support elements. The LRE prepares, launches and recovers the AV. The MCE plans and executes the mission, dynamically re-tasks the AV (including its sensors), and processes and stores/disseminates imaging and ground MTI data. The MCE and LRE will work with both HAE UAV types; these interfaces will be verified during the ACTD's Phase II. All elements will be available for Phase III exercises, demonstrations (which will also show interoperability with current and planned C4I architectures), and possible contingency deployments.

The HAE CGS will be able to control up to three HAE UAVs at a time by LOS data link and SATCOM relay, thus enabling a single system to maintain a continuous presence for extended days and ranges. The AVs will transmit digital imagery to the MCE via wideband LOS or satellite links for initial processing and relay to theater/CONUS imagery exploitation systems (IESs) using standard (CIGSS-compliant) formats. Selected reports and imagery frames will be broadcast directly to warfighters. When linked with systems such as the Joint Deployable Intelligence Support System (JDISS) and the Global Command and Control System (GCCS), unexploited digital imagery can be transferred in near-real-time to the operational commander for immediate use. Thus, the HAE CGS will provide digital, high-quality, near-real-time imagery to warfighters and users at various command levels.

Although the HAE CGS has no fixed design price, a $20M price goal has been established and substantial use of off-the-shelf software and hardware is planned.

Funding ($M):	**FY96**	**FY97**
RDT&E (Defense-wide)	50.2	71.6

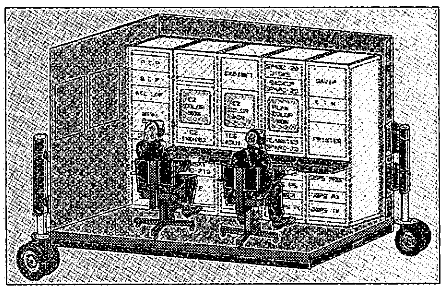


MCE

Plus Power, Cooling, Communications and Support Equipment

CDL Common Data Link
CGS Common Ground Segment
ECU Environmental Control Unit
Gen Generator
HAE High Altitude Endurance
LRE Launch & Recovery Element
MCE Mission Control Element
MIST Modular Interface Surface Terminal
TFT Tactical Field Terminal

HAE CGS		MCE	LRE
Shelter:	*Volume*	*3,072 ft³*	*694 ft³*
	Weight	36,000 lb	13,000 lb
Shelter Payload – Racks, Equipment, Cables, Operators		7,111	2,634
ECU		10,200	2,000
Gen		10,000	3,000
CDL/MIST		6,500	
Ku-band TFT		13,950	
Airlift Weight		83,761 lb	20,634 lb



LRE

HAE Common Ground Segment (CGS) Concept

C4I and Airspace Interfaces

Common Imagery Ground/Surface System

The Common Imagery Ground/Surface System (CIGSS) is a joint DARO-National Imagery and Mapping Agency (NIMA) program to define and ensure interoperability among imagery systems. It involves an open system approach (based on commercial standards and military adaptations thereof) to provide functional and performance envelopes to guide imagery system design and component selection. Just as it will for manned reconnaissance exploitation systems, CIGSS will enable UAV ground (or airborne) imagery processing and exploitation components to conform or migrate to a common image file format, via common physical and data link standards, common media inputs and outputs, and an interoperable imagery architecture by FY 1998, and thereby meet joint requirements.

Our UAVs will be CIGSS-compliant through their ground control systems and data links. The TCS will be the interface for tactical UAVs, and the HAE CGS for the HAE UAVs; the data link for CIGSS compliance and wider imagery dissemination will be the Common Data Link (CDL), which is also needed to transmit SAR and other payload products, such as nuclear-biological-chemical (NBC) sensor data.

Specific UAV-CIGSS compliance plans are currently as follows:

- **TUAV**: Addition of a tactical (i.e., small/limited) CDL terminal is an *Outrider* P3I program. The first TUAV objective is the dissemination of imagery to tactical commanders, after which wider distribution will be pursued. Meanwhile, a Joint Operational Requirements Document (JORD) is in draft to include CDL in the TCS.
- **HAE UAVs**: *DarkStar's* EO and SAR are planned to be CIGSS-compliant during FY 1997, and *Global Hawk's* EO and SAR during FY 1998, with the HAE CGS as their interface. The CGS is expected to incorporate the Common Imagery Processor (CIP) when available, which will process *DarkStar's* EO and SAR imagery, with growth to process *Global Hawk's* EO, IR and SAR imagery.
- ***Predator***: Addition of a tactical CDL terminal is currently a P3I program; meanwhile, TCS and HAE CGS upgrades will enable its EO/IR and SAR dissemination after CDL is aboard.
- **Interim UAVs**: *Pioneer* and *Hunter* will comply with CIGSS standards via their ground control stations, as feasible.

Thus, both the tactical and endurance UAV systems planned as major components of the Objective Architecture of 2010 should be CIGSS-compliant within the next few years.

Joint Airborne SIGINT Architecture

Similar activities are underway to achieve an open, interoperable joint airborne SIGINT architecture (JASA), with compliant payload and processing equipment. During the past year, the systems approach to implementing SIGINT on airborne reconnaissance platforms has yielded to a more flexible approach emphasizing modularity. Thus, the former Joint Airborne SIGINT System (JASS) has been renamed Joint SIGINT Avionics Family (JSAF). As SIGINT payloads are actively developed for UAVs, they will be made JASA-compliant.

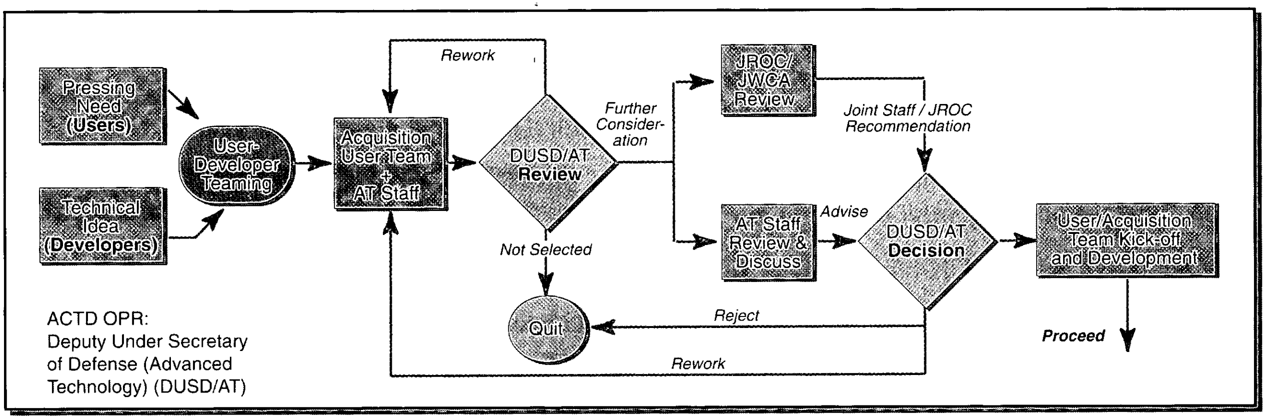
Controlled Airspace Coordination

For the past five years, the Federal Aviation Administration (FAA) has been developing advisory circulars to address airworthiness, maintenance, operator and operating criteria for civil remotely piloted aircraft (RPAs) flying in the National Airspace System (NAS). These circulars are consistent with the way the DoD has been operating its military UAVs (e.g., at the Joint UAV Training Center at Ft Huachuca, AZ, and at the National Training Center at Ft Irwin, CA), and we expect final publication during the next two years. In addition, FAA initiatives with the International Civil Aviation Organization (ICAO) seek to establish regular procedures for RPA/UAV operations in controlled airspace potentially worldwide.

Advanced Concept Technology Demonstrations (ACTDs)

With the exception of *Pioneer* and *Hunter* (as existing systems), all DARP UAV developments are (or have been) ACTDs. *Predator* is the first DoD ACTD to transition to a formal acquisition program, and its lessons-learned are being applied to the DARP's newest system, the TUAV or *Outrider*. The others, *Global Hawk* and *DarkStar* (together with their Common Ground Segment), are complementary air vehicle designs within the HAE UAV ACTD, and have been underway since 1994.

ACTDs are quick-development programs designed to get mature technologies into the hands of users for early evaluation of operational utility; they normally cover two or three years, vs. ten equivalent years for the traditional acquisition program. Further, focus is on their essential capabilities and mission potential; thus, many of their features may need to be revisited, depending on each ACTD's outcome. The ACTD initiation process and ACTD outcome options are as follows:



User Not Prepared to Acquire	User Wants to Acquire	
Options:	**In large numbers:**	**One or a few:**
• Terminate (not cost-effective) • Place "on the shelf" (time not right) • Develop further (good idea; improve implementation)	• Enter acquisition process at the appropriate stage (=*Predator*)	• Fix demonstrator to be operationally suitable, and replicate as required

Predator ACTD Transition

As the first ACTD required in large numbers, *Predator* has been "writing the book" on ACTD issues to be resolved, the reconciliation and phasing of full-acquisition features, and programming of sufficient funds. Four DoD-wide working groups are helping the Transition Integrated Product Team (IPT) resolve three major issues:

- **System numbers**: What is the objective force size and allocation among users?
- **System configuration**: Which capabilities are to be included in the production baseline, as preplanned product improvements (P3I), or as a separate program (see page 19)?
- **Funding**: What is the total system cost, both investment and operations and support (O&S)?

Configuration modifications include:

- Integration of IFF, UHF radio and active de-icing as part of the baseline; and
- A (less mature) heavy fuel engine as part of the P3I program.

The Navy is deciding its course with respect to *Predator* marinization.

Funding is being identified to acquire new systems through FY 2000, to include their necessary development and support items. Total program cost will be identified in the FY 1998 President's Budget.

ACTD Lessons Learned

As a result of the *Predator* and other ACTD experiences, some additional features are being "designed-into" newer ACTDs. For example, the *Predator* ACTD had no projected procurement budget: at its outset (January 1994), nobody knew how well it would perform. Further, while ACTD unit costs may be low (often representing off-the-shelf [OTS], components), militarizing some capabilities and realizing logistics support needs both increase program acquisition costs. For example, while an ACTD *Predator* demo system cost about $15 million, a combat-ready production system (with configuration changes, added payload and link subsystems, and full integrated logistics support [ILS] provisions) requires about twice that sum.

By comparison, the TUAV ACTD includes funding provisions for transition plus significant out-year procurement funds. Eight IPTs are active to assure integrated system development. Thus, rather than committing prematurely to a production program before the ACTD results are known, early planning and an LRIP option will optimize the ACTD-to-formal acquisition transition process if the ACTD is deemed successful.

In parallel, an OSD policy document on Transition of ACTDs to the Acquisition Process has recently been published to guide all ACTDs, if successful. The key challenges to maintaining momentum during the transition period are:

- Formalize military requirements and CONOPS (which drive configuration and numbers)
- Complete any needed testing and documentation (especially if new features are to be added)
- Assure system/force affordability (e.g., as ACTD criteria for the TUAV and HAE UAV production air vehicles)
- Optimize the acquisition strategy
- Program the necessary acquisition funding (as determined by the system's demonstrated utility)
- Identify and program for life-cycle costs.

Future ACTDs

Future-year ACTDs are being defined for high-potential, maturing technologies, many of which will apply to UAVs in the key areas of payload options, information processing, and additional mission applications. The ACTDs initiated during FY 1996 and 1997 that are applicable to UAVs are indicated below.

UAV-Relevant ACTDs	
Initiated in FY96	**Initiated in FY97**
Air Base/Port Biological Warfare Detection	Counter Concealment, Camouflage & Deception (CCD)
Battlefield Awareness and Data Dissemination	Counter-Proliferation II
Combat Identification	Cruise Missile Defense II
Counter-Proliferation	Global Grid Tactical Fiber
Joint Logistics	Integrated Collection Management
Miniature Air-Launched Decoy	Military Operations in Urban Terrain
Semi-Automated IMINT Processing	Rapid Battlefield Visualization
Tactical UAV	Survivable Armed Reconnaissance on the Digital Battlefield
	Unattended Ground-based Sensors (UGSs)
	Wide Area Tracking System

I see ACTDs as creating three opportunities. First, they give us the ability to reduce operational risk early in the acquisition process. Second, they provide us with an approach for compressing acquisition cycle time—the time it takes to develop and field weapon systems. And third, ACTDs are a mechanism for stimulating the innovations needed to implement a revolution in military affairs.

Dr. Paul G. Kaminski, USD(A&T)
Keynote Address at the ACTD Manager's Conference
Defense Systems Management College (DSMC), Ft. Belvoir, VA, 10 September 1996

UAV Concepts of Operation (CONOPS)

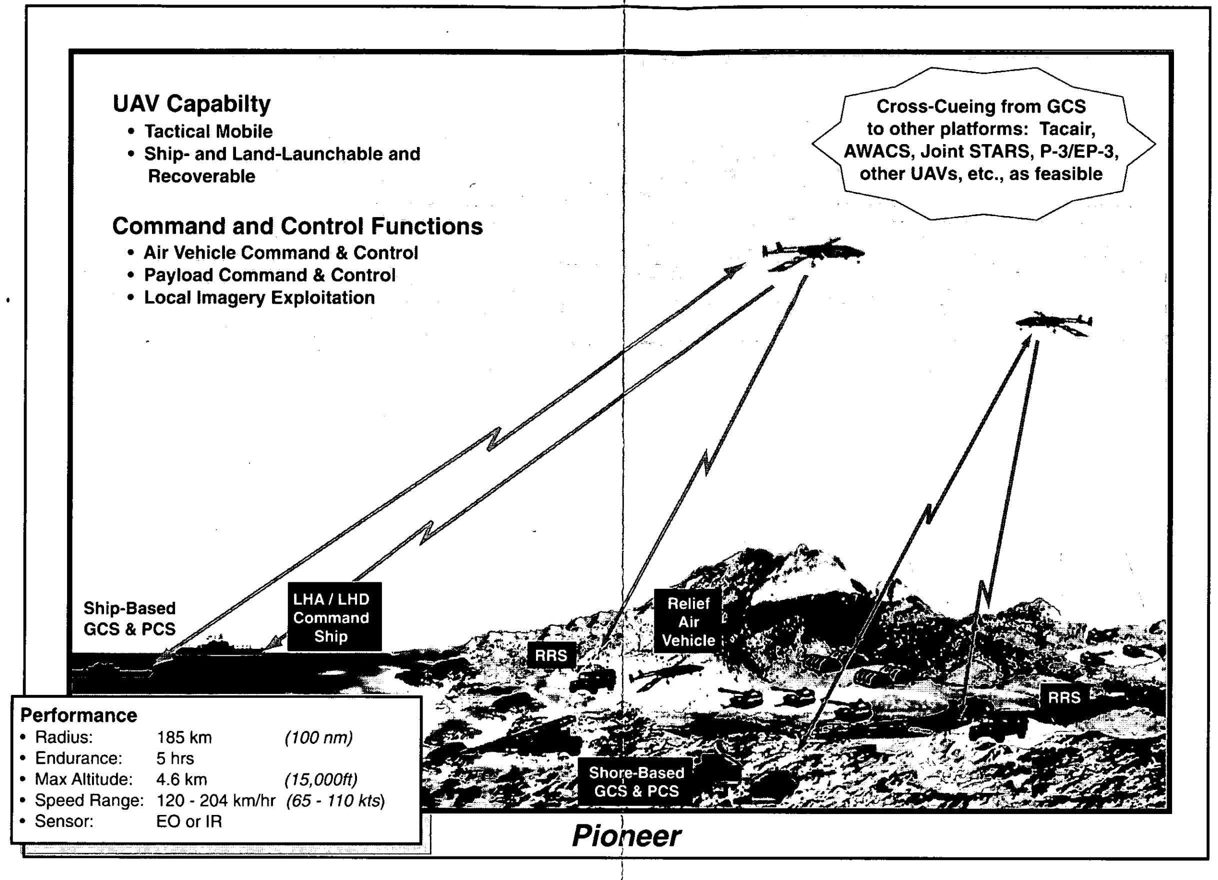
Notional CONOPS for each UAV shows:

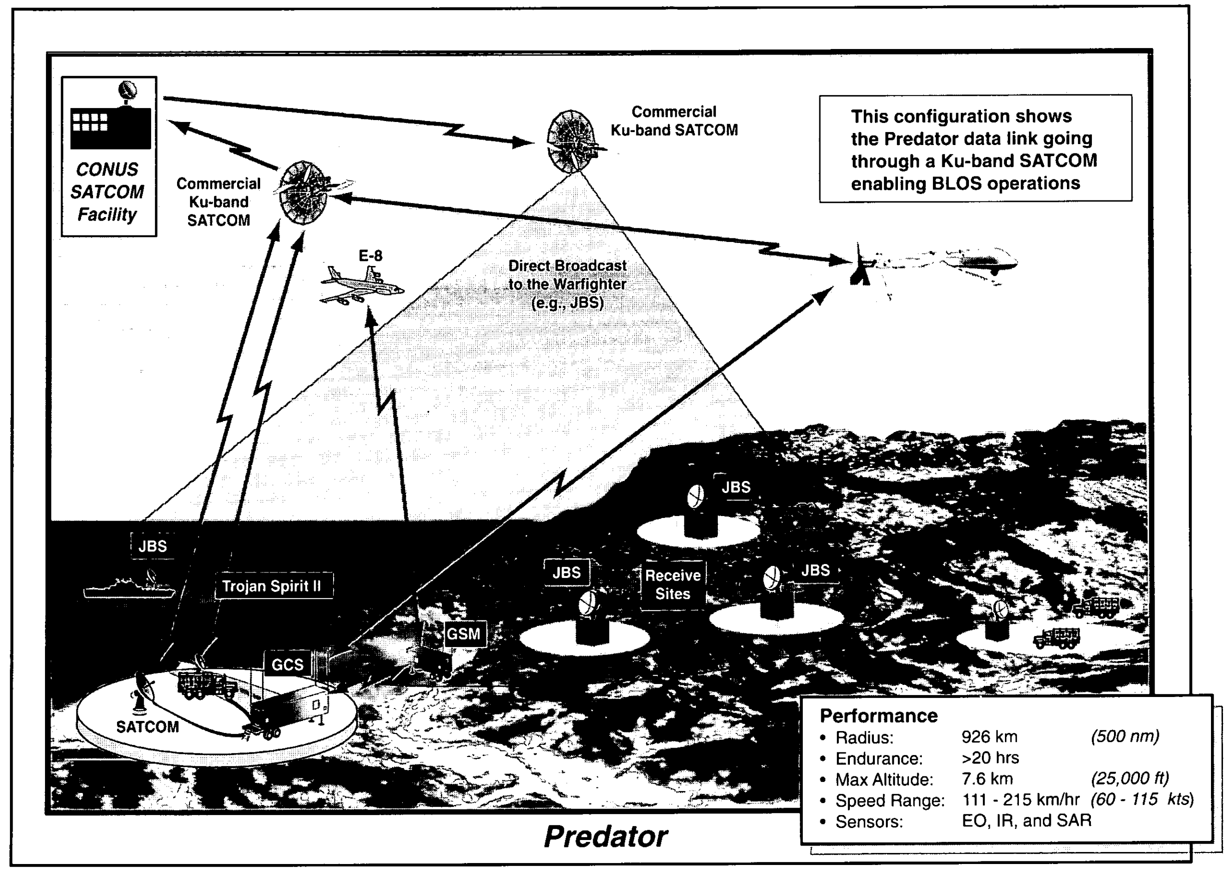
- **Relationship to the user;**
- **Operational area covered; and**
- **Communication paths to control the UAV and disseminate information**

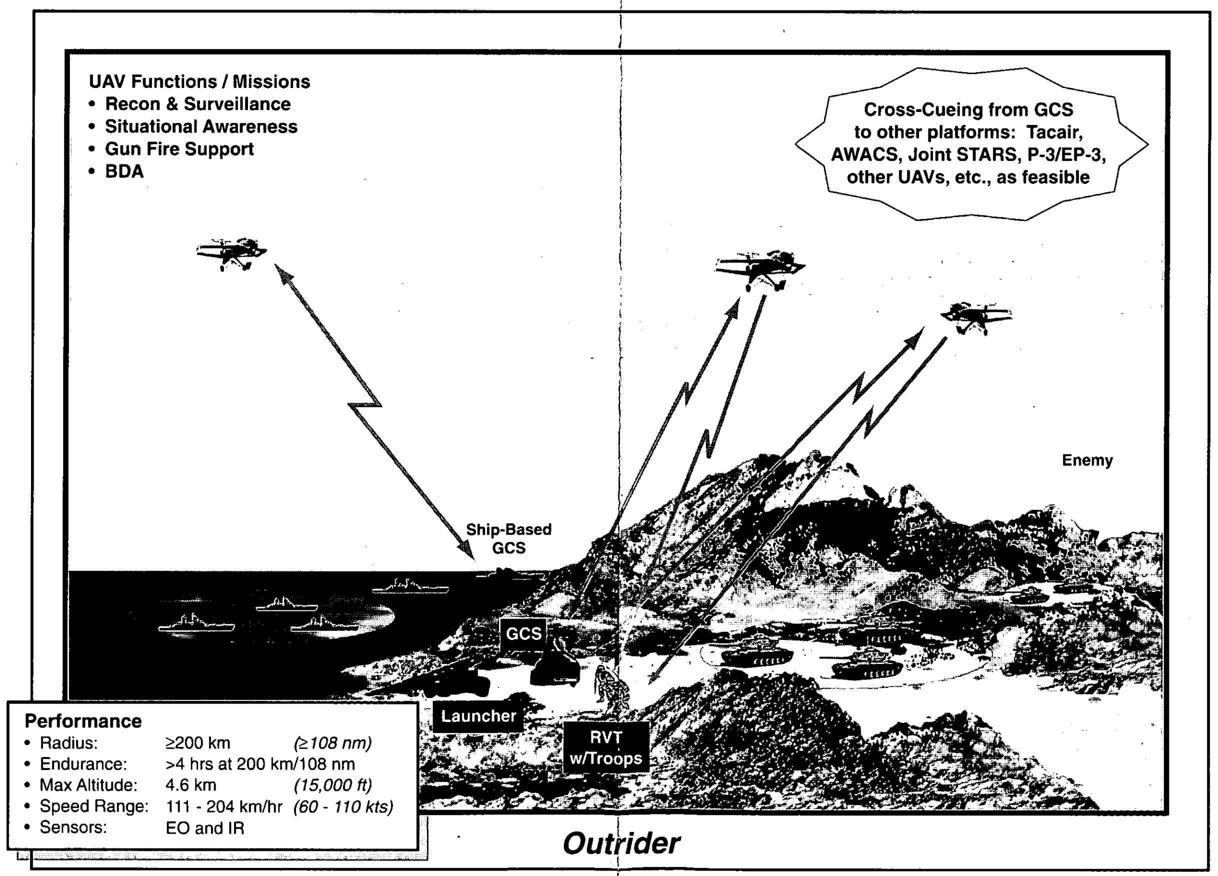
Graphic terrain is based on Digital Terrain Elevation Data (DTED) from Bosnia

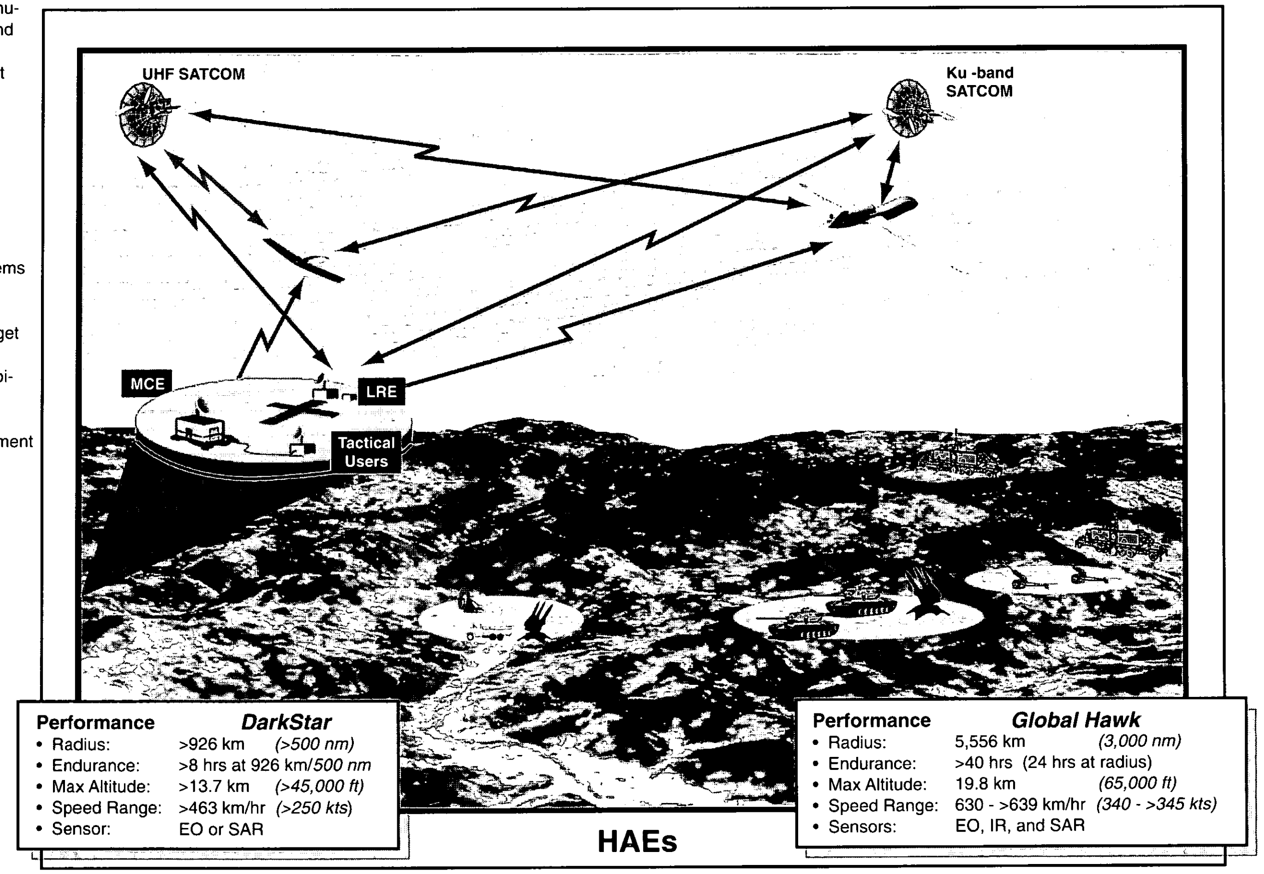
Legend:

AWACS	Airborne Warning and Control System
BDA	Battle Damage Assessment
BLOS	Beyond Line of Sight
C4I	Command, Control, Communications, Computers, and Intelligence
CGS	Common Ground Segment
COMSAT	Communications Satellite (Commercial)
CONUS	Continental United States
EO	Electro-Optical
GCS	Ground Control Station
GPS	Global Positioning System
GSM	Ground Station Module
HAE	High Altitude Endurance
IES	Imagery Exploitation Systems
IR	Infrared
JBS	Joint Broadcast System
Joint STARS	Joint Surveillance and Target Attack Radar System
LHA/LHD	Landing Helicopter Amphibious / Dock
LOS	Line of Sight
LRE	Launch and Recovery Element
MCE	Mission Control Element
PCS	Portable Control Station
RRS	Remote Receiver Station
RVT	Remote Video Terminal
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency





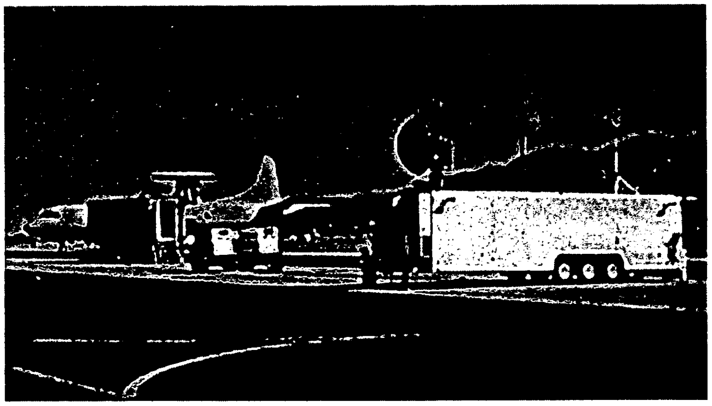




	CHARACTERISTICS	Pioneer	Hunter	Tactical UAV Outrider	Tier II, MAE UAV Predator	Tier II+, CONV HAE UAV Global Hawk	Tier III–, LO HAE UAV DarkStar
Operational	ALTITUDE: Maximum (km, *ft*) Operating (km, *ft*)	4.6 km *15,000 ft* ≤4.6 km *≤15,000 ft*	4.6 km *15,000 ft* ≤4.6 km *≤15,000 ft*	4.6 km *15,000 ft* 1.5 km *5,000 ft*	7.6 km *25,000 ft* 4.6 km *15,000 ft*	19.8 km *65,000 ft* 15.2–19.8 km *50,000–65,000 ft*	>13.7 km *>45,000 ft* >13.7 km *>45,000 ft*
	ENDURANCE (Max): (hrs)	5 hrs	11.6 hrs	>4 hrs (+ reserve) @ 200 km	>20 hrs	>40 hrs (24 hrs at 5,556 km/*3,000 nm*)	>8 hrs (at 926 km/*500 nm*)
	RADIUS OF ACTION: (km, *nm*)	185 km *100 nm*	267 km *144 nm*	≥200 km *≥108 nm*	926 km *500 nm*	5,556 km *3,000 nm*	>926 km *>500 nm*
	SPEED: Maximum (km/hr, *kts*) Cruise (km/hr, *kts*) Loiter (km/hr, *kts*)	204 km/hr *110 kts* 120 km/hr *65 kts* 120 km/hr *65 kts*	196 km/hr *106 kts* >165 km/hr *>89 kts* <165 km/hr *<89 kts*	204 km/hr *110 kts* 167 km/hr *90 kts* 111-139 km/hr *60-75 kts*	204-215 km/hr *110-115 kts* 120-130 km/hr *65- 70 kts* 111-120 km/hr *60- 65 kts*	>639 km/hr *>345 kts* 639 km/hr *345 kts* 630 km/hr *340 kts*	>463 km/hr *>250 kts* >463 km/hr *>250 kts* >463 km/hr *>250 kts*
	CLIMB RATE (Max): (m/min, *fpm*)	[N/A] [N/A]	232 m/min *761 fpm*	488 m/min *1,600 fpm*	168 m/min *550 fpm*	1,036 m/min *3,400 fpm*	610 m/min *2,000 fpm*
	DEPLOYMENT NEEDS:* *Depends on equipage & duration	Multiple* C-130, C-141, C-17 or C-5 sorties Ship: LPD	Multiple* C-130 sorties	Single C-130 (drive on/drive off) Ship: LHA/LHD (roll on/roll off)	Multiple* C-130 sorties	AV: Self-Deployable GS: Multiple* C-141, C-17 or C-5 sorties	Multiple* C-141, C-17 or C-5 sorties
Air Vehicle	PROPULSION: Engine(s) – Maker – Rating – Fuel – Capacity (L, *gal*)	One Recip; 2 cylinders, 2-stroke – Sachs & Fichtel SF 2-350 19.4 kw *26 hp* AVGAS (100 octane) 42/44.6 L *11/12 gal*	Two Recips: 4-stroke – Moto Guzzi (Props: 1 pusher/1 puller) 44.7 kw *60 hp* MOGAS (87 octane) 189 L *50 gal*	One Recip; pusher prop – McCulloch 4318F Short Block/Diesel 37.3 kw *50 hp* Heavy Fuel (JP-8) 48 L *12.7 gal*	One Fuel-Injected Recip; 4-stroke – Rotax 912/Rotax 914 63.4/75.8 kw *85/105 hp* AVGAS (100 Octane) 409 L *108 gal*	One Turbofan – Allison AE3007H 32 kN *7,050 lb static thrust* Heavy Fuel (JP-8) 8,176 L *2,160 gal*	One Turbofan – Williams FJ 44-1A 8.45 kN *1,900 lb static thrust* Heavy Fuel (JP-8) 1,575 L *416 gal*
	WEIGHT: Empty (kg, *lb*) Fuel Weight (kg, *lb*) Payload (kg, *lb*) Max Takeoff (kg, *lb*)	125/138 kg *276/304 lb* 30/ 32 kg *66/ 70 lb* 34/ 34 kg *75/ 75 lb* 195/205 kg *430/ 452 lb*	544 kg *1,200 lb* 136 kg *300 lb* 91 kg *200 lb* 726 kg *1,600 lb*	136 kg *300 lb* 39 kg *85 lb* 27 kg *60 lb* >227 kg *>500 lb*	544 kg *1,200 lb* 295 kg *650 lb* 204 kg *450 lb* 1,043 kg *2,300 lb*	4,055 kg *8,940 lb* 6,668 kg *14,700 lb* 889 kg *1,960 lb* 11,612 kg *25,600 lb*	1,978 kg *4,360 lb* 1,470 kg *3,240 lb* 454 kg *1,000 lb* 3,901 kg *8,600 lb*
	DIMENSIONS: Wingspan (m, *ft*) Length (m, *ft*) Height (m, *ft*)	5.2 m *17.0 ft* 4.3 m *14.0 ft* 1.0 m *3.3 ft*	8.9 m *29.2 ft* 7.0 m *23.0 ft* 1.7 m *5.4 ft*	3.4 m *11.0 ft* 3.0 m *9.9 ft* 1.5 m *5.0 ft*	14.8 m *48.7 ft* 8.1 m *26.7 ft* 2.2 m *7.3 ft*	35.4 m *116.2 ft* 13.5 m *44.4 ft* 4.6 m *15.2 ft*	21.0 m *69 ft* 4.6 m *15 ft* 1.5 m *5 ft*
	AVIONICS: Transponder Navigation	Mode IIIC IFF GPS	Mode IIIC IFF GPS	Mode IIIC IFF GPS and INS	Mode IIIC IFF GPS and INS	Mode I / II / IIIC / IV IFF GPS and INS	Mode IIIC IFF GPS and INS
	LAUNCH & RECOVERY:	Land: RATO, Rail; Runway, (A-Gear) Ship: RATO; Deck w/Net	RATO, Unimproved Runway (200 m)	75m x 30m x 10m "box" (dependent on weight and altitude)	Runway (760 m/*2,500 ft*)	Runway (1,524 m/*5,000 ft*)	Runway (<1,219 m/*<4,000 ft*)
	GUIDANCE & CONTROL:	Remote Control/Preprogrammed	Remote Control/Preprogrammed	Prepgmd/Remote Con/Autopilot & -land	Prepgmd/Remote Control/Autonomous	Preprogrammed/Autonomous	Preprogrammed/Autonomous
Payload & Links	SENSOR(S):	EO or IR	EO and IR	EO and IR (SAR growth)	EO, IR, and SAR	EO, IR, and SAR	EO or SAR
	DATA LINK(S): Type	Uplink: C-band/LOS & UHF Downlink: C-band/LOS	C-band/LOS	C-band/LOS (Digital growth)	C-band/LOS; UHF/MILSATCOM; Ku-band/SATCOM	Ku-band/SATCOM; X-Band CDL/LOS	Ku-band/SATCOM; X-Band CDL/LOS
	Bandwidth: (Hz)	C-band/LOS: 10 Mhz UHF: 600 MHz	20 MHz	4.4–5.0/5.25–5.85 GHz	C-band/LOS: 20 MHz UHF/MILSATCOM: 25 kHz Ku-band/SATCOM: 5 MHz	UHF/SATCOM: 25 kHz Ku-band/SATCOM: 2.2-72 MHz X-band CDL/LOS: 10-120 MHz	UHF/SATCOM: 25 kHz Ku-band/SATCOM: 2.2 MHz X-band CDL/LOS: 10-60 MHz
	Data Rate: (bps)	C-band/LOS & UHF: 7.317 kbps	7.317 kbps	Full Duplex: 9,600 baud	C-band/LOS: 20 MHz Analog UHF/MILSATCOM: 4.8 kbps Ku-band/ SATCOM: 1.544 Mbps	UHF/SATCOM: 19.2 kbps Ku-band/SATCOM: 1.5-50 Mbps X-band CDL/LOS: 274 Mbps	UHF/SATCOM: 19.2 kbps Ku-band/SATCOM: 1.5 Mbps X-band CDL/LOS: 137 Mbps
	C2 LINK(S):	Through Data Link	Through Data Link	Through Data Link	UHF/MILSATCOM	UHF MILSATCOM: Ku-band/SATCOM; UHF/LOS; X-band CDL/LOS	UHF MILSATCOM: Ku-band/SATCOM; UHF/LOS; X-band CDL/LOS
System & Support	SYSTEM COMPOSITION:	5 AVs, 9 payloads (5 day cameras, 4 FLIRs), 1 GCS, 1 PCS, 1–4 RRSs, 1 TML (USMC units only)	8 AVs, 8 MOSPs, 4 ADRs, 4 RVTs, 3 GCSs/MPSs, 2 GDTs, 1 LRS, 1 MMF	4 AVs, 2 GCSs, 2 GDTs, 1 RVT, 4 MMPs, LRE, GSE	4 AVs, 1 GCS, 1 Trojan Spirit II Dissemination System, GSE	AVs (TBD); HAE CGS	AVs (TBD); HAE CGS
	PRIME/KEY CONTRACTOR(S):	Pioneer UAV, Inc.	TRW Avionics & Surveillance Group	Alliant Techsystems	General Atomics-Aeronautical Systems	Teledyne Ryan Aeronautical	Lockheed Martin Skunk Works/ Boeing Military Aircraft Division
	MAJOR SUBCONTRACTORS: – Air Vehicle, Propulsion, Avionics, Payloads, Information Processing, Communications, Ground and Support Systems	AAI Corp; Computer Instrument Corp; General Svcs Engrg; Humphrey; Israel Aircraft Industries (IAI); Sachs; Trimble Navigation	Alaska Ind.; Burtek; Consolidated Ind.; Fiber Com; Gichner; IAI/Malat; IAI/Elta; IAI/Malat/Tamam; ITT/Cannon; Lopardo: Mechtronics; Moto Guzzi	Bendix King; BMS; Cirrus Design; CDL; FLIR Systems; GS Engineering; IAI Tamam; IntegriNautics; Lockheed Martin; Mission Technologies; Phototelesis-TI; Rockwell International; SwRI; Stratos Group; Teftec Inc.	Boeing Defense & Space; Litton; LMTCS (Ku-band SATCOM); Magnavox/ Carlyle Gp; Northrop Grumman (SAR); Rotax Cp; Versatron Cp	Allison Engine/Rolls Royce; Raytheon E-Systems; GDE Systems/Tracor; Héroux; Hughes Aircraft; Lockheed Martin Wideband Systems; Rockwell International; Aurora Flight Sciences	ABS Cp; Advanced Composites; Aydin Vector; CI Fiberite; Hexcel; Honeywell Avionics; Litton G&C; Lockheed Martin Wideband Systems; Recon/Optical; Rockwell Collins; Rosemount Aerospace; Northrop Grumman; Williams International
	Column Notes:	*AV weights: Option 2 / Option 2+*		*Developmental estimates*		*Developmental estimates*	

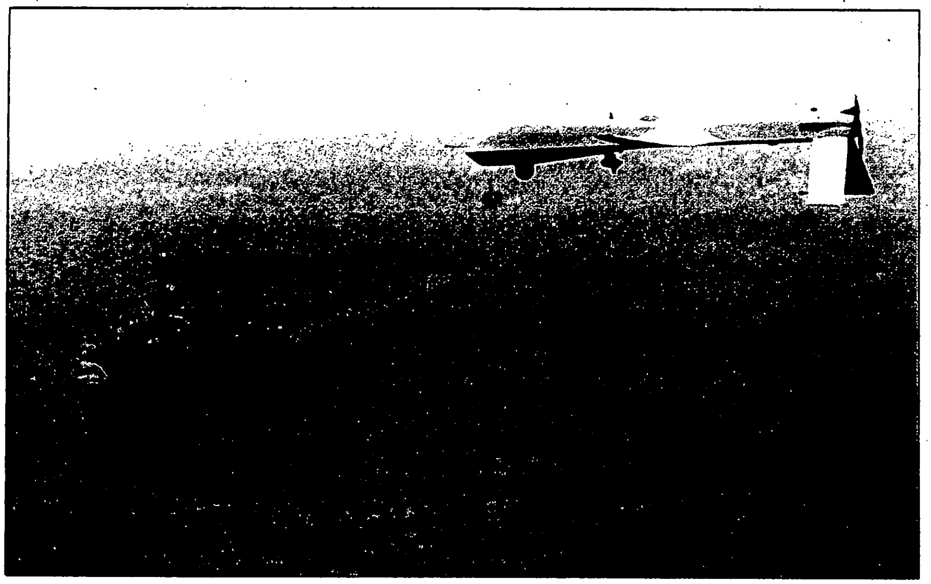
Legend:

- ADR Air Data Relay
- A-Gear Arresting Gear
- AV Air Vehicle
- AVGAS Aviation Gasoline
- CDL Common Data Link
- CGS Common Ground Segment
- EO Electro-Optical
- FLIR Forward-Looking Infrared
- GCS Ground Control Station
- GDT Ground Data Terminal
- GPS Global Positioning System
- GSE Ground Support Equipment
- HAE High Altitude Endurance
- IFF Identification Friend or Foe
- INS Inertial Navigation System
- IR Infrared
- JP Jet Petroleum
- kHz Kilohertz
- LHA Landing Helicopter Amphibious
- LHD Landing Helicopter Dock
- LOS Line of Sight
- LPD Landing Platform Dock
- LRE Launch & Recovery Equipment
- LRS Launch & Recovery System
- MAE Medium Altitude Endurance
- MHz Megahertz
- MMF Mobile Maintenance Facility
- MMP Modular Mission Payload
- MOGAS Mobility Gasoline
- MOSP Multi-mission Optronic Stabilized Payload
- MPS Mission Planning Station
- PCS Portable Control Station
- RATO Rocket-Assisted Takeoff
- RRS Remote Receiving Station
- RVT Remote Video Terminal
- SATCOM Satellite Communications (Military)
- TML Truck-Mounted Launcher
- UHF Ultra High Frequency

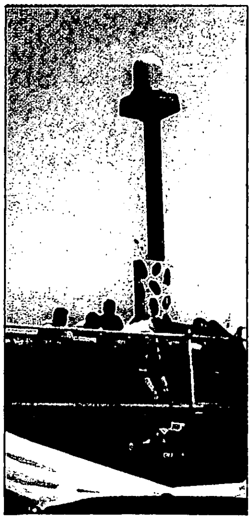


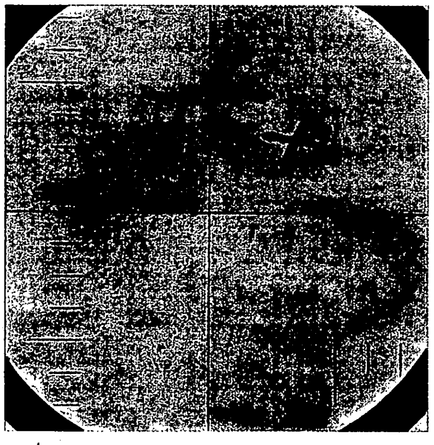
U.S. Customs Service P-3 AEW and *Predator* ground control station (GCS)

Predator imagery of simulated drug transfer



Predator images USS Carl Vinson during COMPTUEX 96-1A





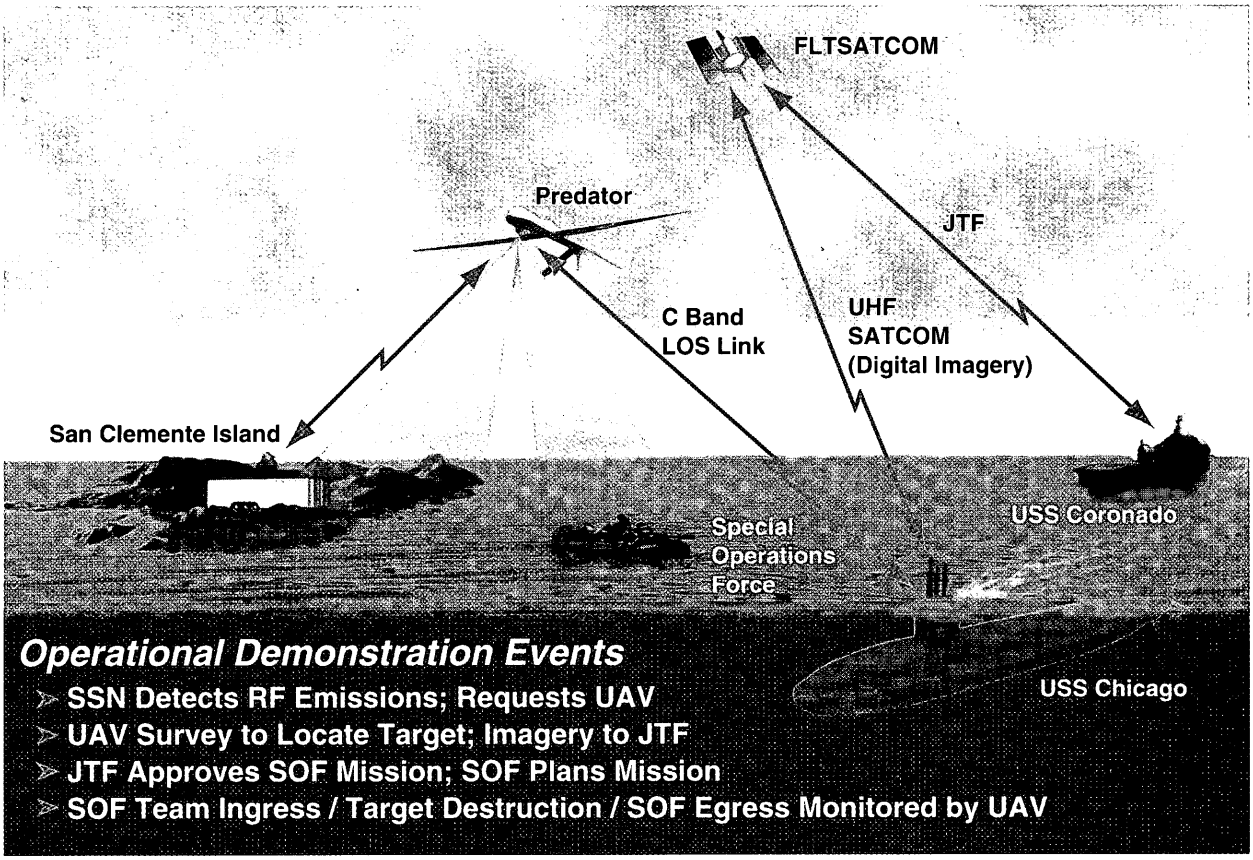
Left: *Predator* system antenna mounted atop USS Chicago's periscope
Center: *Predator* viewed through USS Chicago's periscope
Right: Operating *Predator's* mini-GCS aboard USS Chicago

UAV Demonstrations

FY 1996 UAV demonstrations are summarized below. In all cases, their results reflected the situations that applied at the time for the assets used and concepts explored.

What, Where, When, Why	Goals and Main Features	Findings and Documentation
U.S. Customs Service (USCS) P-3 /UAV Interoperability Demo • Ft Huachuca, AZ, test area • 20 Oct – 2 Nov 95 • Congressional direction to DoD (HR Report 103-747)	Test UAV support of USCS P-3 AEW (using MAE *Predator*) • Acquire/track people and vehicles in representative scenarios • Test/evaluate other UAV applications to USCS work	Worked best in daylight, rural areas Need better all-weather/all-environment ops & sensors, data correlation, and interoperability UAV air traffic control a constraint in unrestricted airspace UAV detectability, costs also limit USCS utility • *Report to Congress, 1 May 96*
Navy Carrier Battle Group (CVBG) Exercise • COMPTUEX 96-1A off the coast of Southern California • 28 Nov – 10 Dec 95 • Part of Maritime Evaluation Phase of *Predator* ACTD	Eval integration of *Predator* system with CVBG operations • Real-time operations & intel support to CVBG missions: air strike, combat search & rescue, visit-board-search & seizure, non-combat evacuation, mobile missile targeting, and war-at-sea • Main UAV products: live video to carrier C2 nodes; imaging of mission areas & ops; BLOS transfer of UAV control; threat detection, tracking & cueing; target location, recognition & eval for air strikes; & long-range ship ID (in haze/night)	"This first-ever integration of *Predator* UAV support for a (CVBG) was an unqualified success." Two *Predators* flew 83 hrs; lost 43 hrs for weather, maintenance, and flight operations restrictions Prior familiarization w/CVBG ops should be routine; range safety workarounds needed SATCOM time is expensive, could be limited; access could be critical to ops success Digital video signal preferable to the analog signals used UAV needs better connectivity to naval units; UAV would be enhanced with SAR, VHF/UHF radio, SIGINT, and laser rangefinder/target designator • *29 Dec 95 msg from Cmdr, Carrier Group 1, to CINCUSACOM (et al.)*
Predator-SSN Interoperability • Nuclear sub (SSN) control of *Predator* to support Navy SEAL team incursion • 30 May – 6 Jun 96 • Office of Naval Intelligence feasibility assessment of littoral missions for forward-deployed submarine (e.g., intel collection/surveillance, special forces operations, and strike)	Estab UAV-SSN link to demo SSN: • Control of UAV payload & AV • Receipt of UAV status info • Receipt, processing, display & recording of UAV imagery • Retransmission of UAV imagery using Joint Deployable Intel Support System (JDISS) UAV control system aboard SSN	UAV provided "a 15,000-ft-high periscope" for the SSN in: supporting initial surveillance, mission planning & SEAL team ingress; imaging target destruction & relaying imagery to JTF for real-time BDA; and monitoring SEAL team egress & recovery. Successful control transfer of UAV from/to its land base, & conduct of operations under at-sea/submerged conditions Small size of UAV-SSN interface system good for other ops – especially if: add SAR, second tracker display, more image processing; encrypt link; and improve target location accuracy • *Project and after-action reports*
Hunter *Support for Joint Ops* • 15th Mil Intel (MI) Bn support to 4th Inf Div ops at National Training Center (NTC), Ft Irwin, CA • 8 – 27 Jul 96 • *Hunter* support for ops concept refinement and continuation training (per USD(A&T) memo, 31 Jan 96)	*Hunter* support for 2nd Bde, 4th Inf: • Route recon and security, 24-hr coverage of battlefield; detected all live-fire tgts, enabled destruction of 42% of enemy *before* battle • Harmonized ftr-UAV ops: training, tactics, and procedures. Found and marked targets (tac recce); BDAs after notional strikes	UAVs gave "unprecedented view of the enemy" and credited with "major contribution to the fight" (informal report msg). Flew every mission (181.5 hrs), none lost to maintenance Improvements in managing fighters and UAV: *Hunter* flying a fixed altitude; fighters approach area high, then descend (in special area) below UAV for bomb runs Commander of 4th Inf Div "would like his division to train with UAVs as much as possible to further integrate the intel and targeting capabilities of the system...." *(reporting msg)*

Assuring a Developer-Warfighter Partnership



Valuable lessons learned, both from these demonstrations and exercises and from the operational deployments of *Predator* to Bosnia, have influenced flight and ground operational procedures, operator training, logistics concepts, and C4I interfaces. Direct dissemination of *Predator* video to a wide audience has also been a byproduct of these deployments as various command elements of the joint forces learned of this highly useful intelligence source.

Further, the *Predator*-COMPTUEX and -SSN demonstrations helped to explore maritime-unique as well as joint concepts. The Navy's three basic UAV marinization requirement levels are:

1. Shipboard receipt of UAV imagery;
2. Shipboard control of UAV and payload; and
3. Shipboard launch and recovery of the UAV.

The two demonstrations illustrated multiple opportunities for the first two levels, and contributed inputs to the Navy's recent *Predator* marinization study (see pages 5 and 43).

During FY 1996, most *Predator* assets have been committed to support Bosnia operations and the training base. For FY 1997, however, exercises such as the Army's Force XXI Warfighter Experiment and the joint exercise Roving Sands 97 plan to include *Predator.* These efforts will assist in the refinement of operational concepts and rigorously evaluate *Predator's* military utility against various battlefield situational awareness challenges. Over time, similar participation is anticipated from the HAE and TUAV ACTDs.

At the Fall 1996 Air Force Chief of Staff Corona Conference, a decision was made to establish a UAV Battle Lab at Eglin AFB, FL, to explore emerging areas of warfare for the next century. Details will be provided in next year's edition of this report.

UAV Roles in the Objective Architecture

Background

Concepts of Operations (CONOPS), based on demonstrated capabilities and emerging user needs, are being developed and refined. The tactical and endurance UAVs continue to project expanding technical and operational capabilities for increasing mission applications. In DARO's airborne reconnaissance Objective Architecture for 2010, UAVs will complement manned and space-based systems in their support of both combat operations and military operations other than war.

During the next few years, *Pioneer* and residual *Hunter* assets will be progressively replaced by *Outrider* systems for tactical mission support. In parallel, *Predator,* followed by a mix of *Global Hawk* and *DarkStar* systems, will be used to provide deep-look information for extended periods of time and varying conditions of risk. Thus, both tactical and endurance UAV systems will complement each other in performing a full range of surveillance and reconnaissance functions. They will help commanders at different echelons to (1) know what is on or approaching the battlefield before their forces get there, and (2) employ forces and weapon systems more efficiently as the result of precision targeting and BDA information.

UAV Operations in the Theater of the Future

A representative view of our UAVs' roles in a projected future contingency is shown on the next page. It depicts the key requirements, concepts and UAV capabilities discussed above, and shows how a mix of UAVs will support theater- and tactical-level operations. The illustration contains:

- A typical theater ground force (left), facing its area of influence across the forward line of own troops (FLOT) (to the right);
- Its echelons' areas of interest and nominal time-cycles (below), which illustrate each command level's operating context in terms of their differing range and time dynamics;
- UAVs depicted according to gradations of operating radius and area coverage capability, from *Outrider* (bottom left) to *Global Hawk* (top right), with their defining mission parameters (to the right of the operating area); and
- Generic communication links (LOS, and aircraft and satellite BLOS relays) that connect the UAVs with their joint force users, from ground force echelons to naval assets to close support and deep-strike tactical strike aircraft.

Key considerations (applying to the graphic overleaf) include the following:

1. Relative UAV area coverage and imaging capabilities vary considerably, according to system performance and payload, mission objectives, and primary user level.

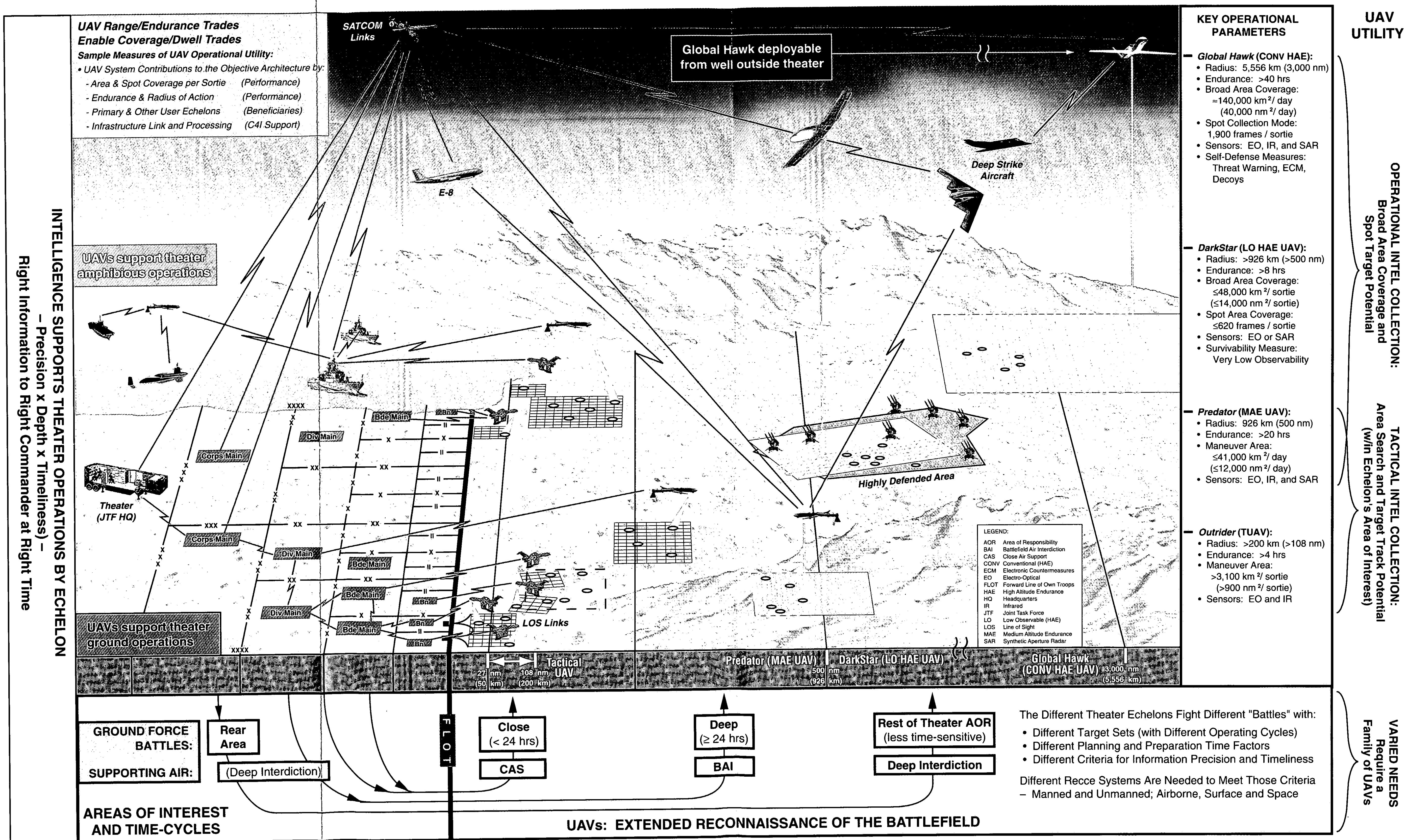
2. Different UAV capabilities respond to different user needs — in terms of quantity, quality and timeliness (QQT) of information needed to support each user's "battle." The main distinction is between target-spotting tactical UAVs and area-sweeping HAE UAVs, with *Predator* able to perform both functions to a degree.

3. UAV reconnaissance products require an advanced C4I infrastructure, comprising collection links (shown), and TCS, HAE CGS and imagery exploitation system (IES) processing facilities and dissemination links (not shown), to reach all users.

4. Two connectivity exceptions are (a) links to JSTARS (or other manned assets), and (b) the projected sensor-to-shooter link from endurance UAVs to strike aircraft, which symbolizes the goal of sending targeting data directly to weapon systems (on land and sea, as well as in the air) — thereby using reconnaissance as a means to achieve battlespace dominance.

5. Thus, this UAV "operational laydown" and different threats in a representative theater environment support the need for a UAV family of systems to meet expanding user requirements and to enhance joint force operations.

UAV Objective Operations in the Theater of the Future



Technologies and Applications

On 16 January 1996, USD(A&T) Dr. Kaminski first discussed ten primary "enabling technologies and architectural concepts that are needed to build dominant battlefield cycle times...." All are relevant to airborne reconnaissance.

Key Enabling Technologies	
1. Advanced Processing	2. Automatic Target Processing (ATP)
3. A Common Grid	4. Distributed and Open Architectures
5. Sequential Application of Off-Board Collectors	6. Data Compression
7. Very Large, Dynamic, Object-Oriented Data Bases	8. Data Storage
9. Data Dissemination	10. Planning Analysis Tools

Background

Over the past year, DARO has focused its technology budget on those technologies that best support the realization of the airborne reconnaissance Objective Architecture for 2010. The Advanced Technology budget includes investments in maturing, high-payoff technologies that facilitate the timely attainment of the Objective Architecture. Other technologies sponsored by Government and industry are also monitored and funded pending their availability for direct application to reconnaissance platforms and ground stations.

The nine technology transition programs comprising DARO's Advanced Technology plan for FY 1996 (as defined in the Airborne Reconnaissance Technology Program Plan of December 1994) have evolved into ten technology transition focus areas for FY 1997, with additional initiatives supported by the Congress. The transition areas, all of which impact UAVs, are described below.

Airborne Reconnaissance Technology Transition Areas

FY96	FY97	*Remarks*
Low-Cost Reconnaissance Pod	Reconfigurable Pods	*Near-term focus on manned recce; UAV applicat'ns later*
Integrated Avionics	Integrated Avionics	*(See MIAG discussion on page 41)*
Exigent Target Detection	Exigent Tgt Detection	*E.g., MSI, HSI, and FOPEN SAR*
Precision Geolocation	Precision Geolocation	*SIGINT & imagery all-wx precision targeting & mapping*
SIGINT Technology	SIGINT Upgrades	*Modular, incremental JSAF approach*
Imagery Screening & Analyst Cueing	Screening & Cueing	*Reducing wide-area search time for critical targets*
Auto Target Recognition (ATR) & Correlation	ATR & Correlation	*Algorithm development & data correlation*
Common Data Link (CDL) Advanced Technology	CDL Advanced Tech	*Enabler of UAV interoperability*
High-Data-Rate (HDR) Uplinks & Crosslinks	HDR Links	*EHF/Laser alternatives under study*
	Fusion	*Goal of multi-sensor fusion to locate hidden targets*
Congressional Technology Initiatives (added)	Cong'l Tech Initiatives	*EO Framing Sensor; Multifunction Self-Aligned Gate*

EHF Extra High Frequency; FOPEN Foliage-penetration (radar); HSI Hyperspectral Imagery
JSAF Joint SIGINT Avionics Family; MIAG Modular Integrated Avionics Group; MSI Multispectral Imagery

During the Advanced Technology programming process, DARO carefully considers applications and priorities in terms of their ultimate utility to the warfighter. This criterion is applied within each of the four technology categories defined for airborne reconnaissance: platforms, sensors, information processing, and communications. As an example, the sensing/exploitation roadmap on the next page shows how specific sensor and processing technologies are being developed to meet evolving mission needs.

Sensing/Exploitation Roadmap

Term	Technologies	Capability
Near Term: 0 – 5 yrs. Integrate state-of-the-art	• Synergistic SAR/moving target classification • High-resolution MTI, SAR, Inverse SAR • Interactive target recognition • Digital recce implementation • Real-time video exploitation	Find isolated targets and military formations operating in simple scenes: – Targets moving or stationary – Limited number of target models Stylized force structures
Mid Term: 5 – 10 yrs. Increase target features	• Polarimetric SAR • Coherent change detection • VHF/UHF SAR/MTI and ATR • Multi- /hyperspectral imagery and ATR • Ultra-high-resolution SAR • Sensor fusion	Find targets in more difficult scenes: – Targets in tree lines or partially obscured by foliage and camouflage – Medium number of targets; rapid target insertion Adaptable to force structures
Far Term: 10 – 20 yrs. Increase tgt exposure & features	• Numerous sensor platforms • Dialable sensor disciplines • Agile beam SAR • 3-D SAR and ATR • Integrated system	Find reduced-signature targets in complex scenes – With intense camouflage, concealment and deception (CC&D) or in foliage – Large number of targets Diverse mix of platforms and sensors

Micro-UAVs

In addition to rationalizing, focusing and prioritizing relatively mature technologies, DARO also supports more revolutionary initiatives — especially where they show promise of meeting needs that could not otherwise be satisfied by incremental developments.

One example is a new DARPA initiative to develop a micro-UAV. This class is defined as a UAV measuring less than 15 cm (≈ 6 inches) in any dimension, yet carrying a miniaturized payload, simple avionics and a communication link sufficient to perform needed missions. Following an MIT Lincoln Laboratory proposal, a November 1995 DARPA workshop explored concepts and technologies to accelerate the development of this UAV type. Many challenges were identified for such small UAVs, from their physics of flight to integration of even simplified functions — developing an "airplane on a chip"; however, their six-degree-of-freedom flexibility offers high military potential in constrained operating environments, such as within urban areas or supporting small unit operations. DARPA's project will focus on:

- Critical flight-enabling technologies (e.g., aerodynamics, flight control, navigation, and propulsion);
- Integration strategies that maximize range-payload performance and mission utility; and
- Near-term operational concepts, with an emphasis on those that lend themselves to early operational demonstration.

Current Technology Applications

Many more technology initiatives are being pursued via DARO sponsorship or support. The facing table lists relatively mature technologies that will be leveraged across airborne reconnaissance systems. Some may be incorporated into current DARP UAV program baselines (following their transition from ACTD to acquisition status); others may be incorporated within later P3I efforts. Several of these technologies offer potential for new surveillance and reconnaissance missions with relatively small investment. Several also meet emerging requirements for special functions and military operational conditions other than war, thereby providing our forces with contingency capabilities as the new century approaches.

Current UAV Technology Applications

Heavy Fuel Engine (HFE)
- Objective: Provide UAVs with a safe, readily available fuel source for DoD system commonality
- Status: In FY96, the UAV JPO released a Request for Information to industry for engines applicable to *Outrider* and *Predator*. A Request for Proposal to pursue this technology may follow in early FY97

Communications Relay Payload (CRP)
- Objective: Routinely use UAVs for airborne relay to free manned aircraft for other missions
- Status: A CRP has been integrated into a *Hunter* and was successfully demonstrated in April 1996

Joint SIGINT Avionics Family (JSAF)
- Objective: Open systems architecture suite of SIGINT sensor equipment with standardized interfaces and multi-platform applicability (based on Joint Airborne SIGINT Architecture [JASA])
- Status: Prototype systems under development; plans made for a moderately paced acquisition

Laser Designator/Rangefinder (LDRF) Payload
- Objective: Accurate targeting for precision guided munitions without risk to aircraft or ground spotters
- Status: An off-the-shelf payload was integrated into a *Hunter* and successfully demonstrated in FY96. An effort is in planning to demonstrate an LDRF application for *Outrider*

Mine Countermeasures Payload
- Objective: UAV-borne mine detection capability to avoid risk to ground troops and naval forces
- Status: The Coastal Battlefield Reconnaissance and Analysis (COBRA) payload has been integrated into a *Pioneer* for flight test in early FY97

Common Data Link (CDL)
- Objective: Interoperability of data links and data exchange among sensors, platforms, and their users
- Status: An upgraded light-weight, low-power digital data link, interoperable with CDL, is planned for development and integration on *Outrider*

Hyperspectral Imaging (HSI)
- Objective: Improved detection of hidden or camouflaged objects by spectral discrimination
- Status: Hyperspectral sensors for *Pioneer* and *Predator* tested and real-time tactical cueing of onboard cameras demonstrated. *Predator* HSI will be integrated with the CC&D ACTD in FY 1998

Downsized Synthetic Aperture Radar (SAR)
- Objective: Smaller, lighter, cheaper SAR sensors to increase UAV payload and performance
- Status: In addition to DARPA's Low Cost Radar components development program, DARO and the UAV JPO are co-chairing an IPT to plan the development of an adverse-weather imagery payload for *Outrider*

Wideband SAR (Foliage Penetrating [FOPEN] Radar)
- Objective: Improve all-weather detection of targets concealed by foliage or camouflage
- Status: FOPEN SAR scheduled for integration on *Predator*; integration on other UAVs via the Counter CC&D ACTD in FY 2000

Focal Plane Arrays (FPAs)
- Objective: Develop large-format FPAs for improved imaging compared to film or line scanning sensors
- Status: 25-Megapixel FPAs demonstrated; under consideration as *DarkStar* EO sensor upgrade

Video Imagery (per DSB Task Force on Improved Applications of Intelligence to the Battlefield, Jul 96)
- Objective: Improve video image quality, and provide cataloguing, retrieval and exploitation capabilities
- Status: Studies on improvement of *Predator* imagery quality and imagery archival

Global Positioning System (GPS) Pseudolites
- Objective: Enhance warfighter resistance to GPS jamming by rebroadcasting GPS data from UAVs
- Status: Planning and concept development underway for pseudolites on UAVs

Automatic Target Recognition (ATR)
- Objective: Improve target discrimination in wide-area imagery, and minimize data link bandwidth
- Status: Demo of multi-platform moving target imaging and ATR exploitation scheduled for 1998 on an endurance UAV. On-board ATR to reduce data link loading under development

Payload and Modification Programs

Payloads

Last year's UAV report summarized a variety of payload and related technology demonstrations and experiments. This year, work has continued in specific areas with renewed top-level planning in light of the recent changes in UAV acquisition. Payload activities include:

- Specific payload demonstration projects managed or supported by the UAV JPO (some of which were in the "Technology" section last year); and
- A payload prioritization process, under the aegis of the JROC's UAV Special Study Group (SSG), with inputs from the CINCs and supported by DARO.

UAV JPO Payload Projects

The UAV JPO conducts proof-of-principle demonstrations of mature UAV sensor payloads to evaluate their suitability for tactical UAV applications. This activity provides a systematic approach to the integration of common growth mission payloads across the UAV family. During the FY 1995 – FY 1996 time frame, fourteen payloads have been demonstrated aboard *Pioneer* and *Hunter,* as representative UAV testbeds — lighter payloads aboard *Pioneer,* and heavier payloads aboard *Hunter.* Most of the demo reports were issued during FY 1996; the rest will be completed early in FY 1997. Additional payload demonstrations are planned for *Predator,* starting in FY 1996/97. All results are inputs to the JROC SSG's payload prioritization process.

Demonstration Payload	Potential Mission Application	Platform	Report
Meteorological Sensor	- Systematic atmospheric readings	Pioneer	Nov 95
Radiac Sensor	- Plot suspected NBC contamination	Pioneer	Nov 95
Lightweight Standoff Chemical Detector	- Detect and plot toxic agents	Pioneer	Nov 95
Lightweight Comms Intelligence (COMINT) Payload	- Find/ID ground comms emitters	Pioneer	Nov 95
Surface Acoustic Wave (SAW) Chemical Detector	- Detect/plot low-level chem agents	Pioneer	Nov 95
Hyperspectral Sensor (HSS)	- Detect hidden/difficult targets	Pioneer	Aug 96
Coastal Battlefield Recon and Analysis (COBRA) [1]	- Detect mines (day/limited visibility)	Pioneer	Nov 96
Tactical Remote Sensor System (TRSS) [1]	- BLOS ground sensor data relay	Pioneer	Nov 96
Communications Relay	- BLOS comms relay for gnd forces	Hunter	Aug 96
Laser Designator/Rangefinder (LDRF)	- Demo LDRF for *Hunter's* payload	Hunter	Oct 96
Electronic Intelligence (ELINT) Payload[2]	- Locate/ID enemy ground radars	Hunter	Nov 96
Radar Jammer Payload[2]	- Jam enemy ground radars	Hunter	Nov 96
Lighter-Weight COMINT Payload[2]	- Find/ID ground comms emitters	Hunter	Nov 96
Communications Jammer Payload[2]	- Jam both radios and data links	Hunter	Nov 96
HSS/FOPEN Radar/Air Traffic Control Compliance System (ATCCS) [3]	- Demo for SOUTHCOM and Central MASINT Office (CMO)	Predator	(TBD)
Tactical Meterological (Dropsonde) System (TMS) (mounted in a conformal pod)[4]	- Demo of near-real-time weather data from remote/denied areas	Predator	(TBD)

ID Identify MASINT Measurements and Signatures Intelligence NBC Nuclear, Biological, Chemical

1 Joint UAV JPO-Marine Corps Systems Command project.
2 Joint UAV JPO-Joint Command and Control Warfare Center (JC2WC) project.
3 Supported by UAV JPO's MAE UAV Project Team and the National Reconnaissance Office (NRO).
4 Supported by UAV JPO's MAE UAV Project Team and the Naval Research Laboratory's Tactical Oceanographic Warfare Support (NRL/TOWS) Program Office.

Specific FY 1996 accomplishments include:

- Hyperspectral Imaging *(Pioneer)*: HSS detection of hidden targets showed the feasibility of location and tracking missions against non-visible targets and activities.
- Comm/Data Relay *(Hunter)*: VHF and UHF half-duplex voice and data relays to a range of 120 km showed the feasibility of longer UAV ranges while maintaining a BLOS link.
- Laser Designator/Rangefinder *(Hunter)*: Four successful ground launches of Hellfire missiles against *Hunter*/LDRF-designated targets demonstrated the feasibility of precision targeting by UAVs.

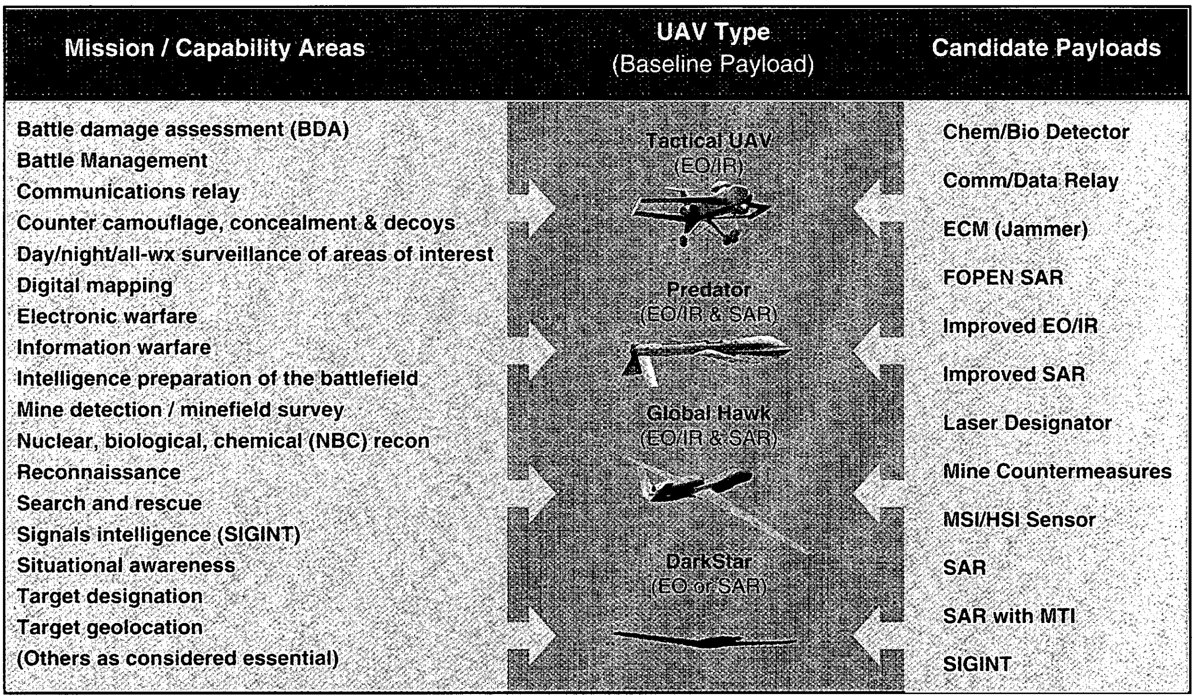
Additional payload projects include demonstrations of: a UAV electronic decoy to support tacair strike forces; all-weather imaging of moving ground targets using an Army moving target indicator (MTI) radar; and the Airborne Standoff Minefield Detection System (ASTAMIDS) as key to future Army mine countermeasures.

JROC Special Study Group Activities

The JROC's UAV SSG resumed its follow-on payload prioritization work in the Spring of 1996. Following a DARO payload briefing, the SSG asked the CINCs and Services to submit priorities for 17 mission areas and capabilities for the four primary UAV types *(Global Hawk, DarkStar, Predator,* and Tactical UAV). With these inputs and parallel payload inputs by DARPA, the UAV JPO and DARO, the SSG is currently developing a prioritized payloads list by UAV. (A representative matrix is shown below.)

Results will first be presented to the JROC for approval and then forwarded to the USD(A&T) in early FY 1997.

JROC UAV SSG's Payload Prioritization Process



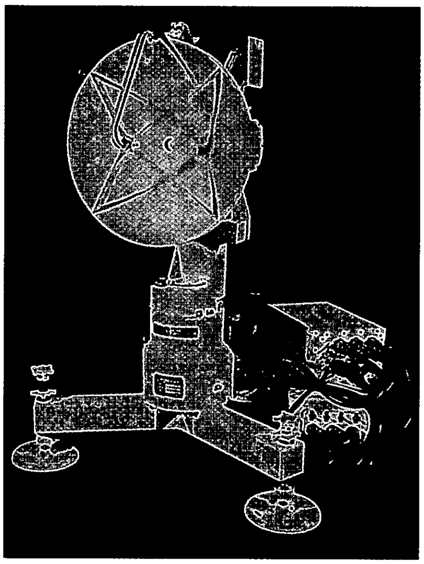
Current Technology Applications

Each of the four primary UAVs anticipates a vigorous preplanned product improvement (P3I) program, as their ACTDs help to identify needed features, which are then (1) mapped against existing requirements and emerging needs, and (2) matched to technology maturity, feasible schedules, and available funds. The main current activities are:

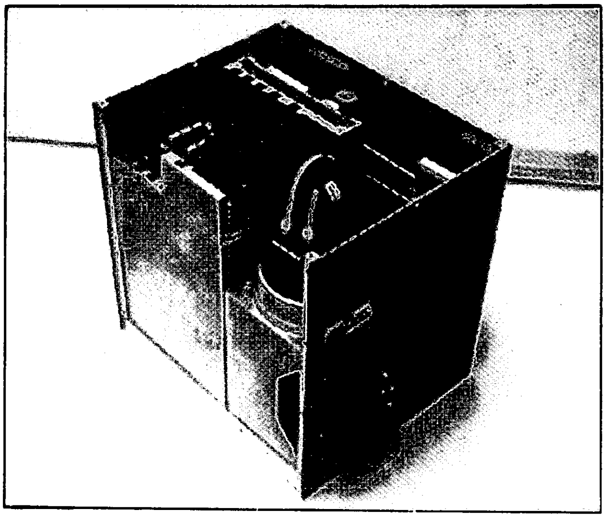
- Incorporation of a UAV Common Automatic Recovery System (U-CARS) and improved avionics (via the Modular Integrated Avionics Group [MIAG] program) — both potentially for all tactical UAVs; and
- Definition of the LRIP configuration and P3I program for *Predator,* as part of its transition from ACTD to full acquisition program.

Predator's P3I program was addressed on page 19; U-CARS and MIAG updates are presented here. Both of these programs are managed by the UAV JPO.

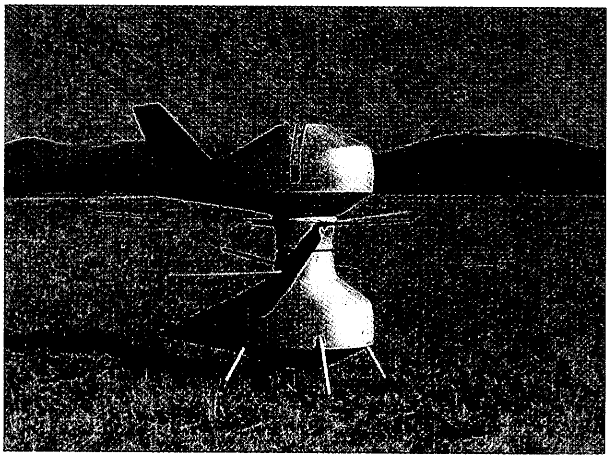
U-CARS. The purpose of this program is to provide system positioning data that will enable automatic land or shipboard recovery of UAVs, thereby reducing operator training needs and fatigue, the risk of mishaps, and associated costs. Initially supported by Congress for *Pioneer,* U-CARS is being tested for land-based operation in 4Q FY 1996 and sea-based operation in 1Q FY 1997. Plans also include integration into both *Predator* and *Outrider:* a *Predator* integration study is currently underway, and integration into *Outrider* is an option on its current ACTD contract.



MIAG. This program's objective is to improve UAV flight performance via a common, modular, smaller and lighter vehicle/flight management system. Functions include: AV subsystem monitoring and control, flight control, navigation, guidance, and payload control. Engineering development models will be flight-tested aboard *Pioneer* in early FY 1997, with production of 66 MIAGs planned to start thereafter; an IFF module is also undergoing development for later procurement. In addition, MIAG may be incorporated into *Predator, Outrider,* and target drones.



VTOL Evaluation. For FY 1997, the Congress provided $15 million for the flight testing of the Puma VTOL tactical UAV, which was one of the candidates in the TUAV ACTD competition. Planning for this evaluation will begin shortly.



Issues and Challenges

Our principal challenge is to efficiently acquire UAV systems that support valid warfighter requirements and are consistent with Joint Vision 2010 in providing dominant battlespace awareness. We focus our efforts in four areas: acquisition, technology initiatives, architecture, and operations.

Acquisition

UAV systems must be compatible with JROC-validated requirements. Fiscal plans must support a balanced approach to the current JROC priorities for UAVs: Tactical UAV *(Outrider* and *Pioneer),* MAE UAV *(Predator),* and HAE UAVs *(Global Hawk* and *DarkStar*). In a resource-constrained environment, DARO is challenged to provide adequate funding to sustain existing UAV systems (e.g., *Pioneer* until *Outrider* is evaluated, acquired, and fielded). In addition, for all our ACTDs we must plan for transition to production, logistics support and training, and test and evaluation. We will implement acquisition streamlining principles using cost as an independent variable (CAIV) and capitalizing on commercial off-the-shelf technology and opportunities.

Our major acquisition issues are summarized in the table below.

UAV Issue	Issue Aspects	Major Considerations
***Predator* Production and Cost**	• Enhanced configuration vs. force size objective vs. budget constraints	• A baseline configuration plus P3I program to meet user needs • Initial limitation of force size/production rate to meet funding • System production cost reflects incorporation of all the 'Ilities (vs. ACTD demo system's "flyaway" cost). — *Not* "cost growth"
***Outrider* ACTD**	• Application of lessons learned from the *Hunter* program and *Predator* ACTD	• ACTD structured to reflect those lessons-learned, to include: – Adopting the ACTD approach to resolve requirements and utility issues early and with streamlined pgm management – User involvement through IPTs – Controlling costs from the start, to assure affordability
***Outrider* LRIP**	• Exercise of LRIP option prior to ACTD results	• Provides an orderly and formal process for timely ACTD transition to a DoD production program to procure and field systems
Tactical UAV Availability	• #1 priority for ground forces, but still unmet • Limited assets cannot meet multiple needs	• Tactical UAV ACTD structured for flexibility, hence success; meanwhile — • *Pioneer* programmed for extension of operational life • Current/near-term *Predator* assets can meet some needs
HAE UAVs	• Demo of military utility • Force size and mix • Capabilities vs. cost	• Flight test & demo pgms realigned (for *DarkStar's* return to flight) • Ultimate *Global Hawk-DarkStar* mix subject to demo & eval • Added capabilities and cost impacts under study; P3I possible
UAV Interface w/C4I Infra-structure	• Need end-to-end UAV system operation • Systems to function in evolving architectures • Emphasis on timely use of UAV *products*	• Common TCS and interoperable HAE CGS to assure UAV cross-use. Resolving TCS program/budget issues is a high priority • Standard interfaces and high-data-rate robust links to assure connectivity & interoperability across the operating environment – Per guidance by the Joint Technical Architecture (JTA) and DARO's Airborne Reconnaissance Information Technical Architecture (ARITA)

Technology Initiatives

This year, we focused on critical technology and high-payoff industry R&D initiatives, coupled with off-the-shelf software and hardware to leverage UAV capabilities. We identified near-term fixes that are compatible with the CINCs' annual Integrated Priority Lists and validated by the Chairman's Program Assessment for the Intelligence, Surveillance and Reconnaissance (ISR) functional area to meet UAV requirements. Initiatives include the Tactical Common Data Link (TCDL) and enhanced sensor capabilities.

The TCDL) provides a family of CDL-compatible, lower-cost, lightweight digital data links with variable data rates. This effort will support both manned and unmanned programs (including *Pioneer, Predator,* and *Outrider),* and will emphasize an open architecture with CDL interoperability at the 10.71 Mbps (downlink) and 200 kbps (uplink) rates.

Enhanced sensor capabilities proceed with critical payload technologies (subject to the ongoing JROC payload prioritization process), and provide for adverse weather sensing capabilities (such as a lightweight tactical SAR) and other promising technologies (like longwave infrared sensing, FOPEN radar, and HSI).

Architecture

Dr. Kaminski's "ten enabling technologies and architectural concepts" are listed on page 37. DARO will continue to exploit distributed, open architectures that use CIGSS for imagery-based platforms and JASA for SIGINT applications. This approach will provide cost savings, emphasize the application of best commercial practices, and support adaptability through an open, flexible, digital family of processors, software, and operating systems. In addition, DARO is developing the TCS architecture to ensure interoperability between different UAVs and ground stations to share sensor data, control the sensors themselves, and (when appropriate) control the UAV platforms.

Operations

UAV ACTDs, such as *Predator's,* have already markedly improved the way operational forces can receive intelligence support and view the battlefield. Ground commanders want responsive collection systems that provide critical information to enhance battlefield situational awareness, and developmental UAV systems must support user-validated CONOPS. Here, four UAV subareas are noteworthy: multiple-UAV operations, airspace management, marinization, and imagery archival/retrieval. They are summarized below.

Multiple-UAV Operations	We are just beginning to understand the operational impact of multiple-UAV operations. Issues such as air traffic separation, weapons deconfliction, sensor priorities and battle management integration must be resolved
Airspace Management	We are continuing both national and international coordination to permit UAVs to share airspace with manned platforms (see page 27). We are resolving near-term airspace issues through field activities, and working with FAA headquarters to understand the new procedures and capabilities needed for more general unmanned flight. FAA involvement and acceptance are essential to the coordination of UAV flight and control procedures for all types of air operation
UAV Marinization	In consonance with JROC priorities for Navy and Marine Corps requirements, marinization seeks to provide UAV support for deep-water, littoral and amphibious operations, through either the flexible TCS for control of UAV imagery products and sensors, modification of UAV platforms to operate from large air-capable ships, or both. A preliminary feasibility study on marinizing *Predator* will be published in early 1997 (see page 5)
Imagery Archival/ Retrieval	Data management systems need to leverage all commercial developments. We will need very large, dynamic, object-oriented databases that will allow us to store and transport imagery to support the warfighter wherever deployed

Management Approach

DARO builds solutions to the above issues through policy, management and programmatic oversight of DARP acquisition programs. In addition, we provide the warfighter with ready access to technology breakthroughs, set standards for interoperability and commonality, and are establishing a migration path to achieve the airborne reconnaissance Objective Architecture by 2010. In these functions, we are guided by the DARSC (see page 11) and the JROC's ISR JWCA (see page 6).

Resolution of issues presents a significant challenge to our vision, our processes, and our resources. To meet the challenge, DARO has undertaken two major initiatives:

- Formation of the new DARO Architecture Development (DAD) Team, which will definitize a candidate Objective Architecture and plan investment strategies; and
- Participation in the JROC's recent Reconnaissance Study Group (RSG) to perform cost/benefit analyses to identify optimal force packages for varying funding levels.

Both activities consider information needs, integrate military worth into force mix decisions, and identify optimal investment strategies given future resource constraints.

Plans and Projections

UAVs and Joint Vision 2010

UAV systems will contribute to the capabilities envisioned in JV 2010, and may be used to support all four of its operational concepts. By the time JV 2010 is implemented in FY 1998, *Predator* will be in production and the other UAVs will be demonstrating their capabilities in representative operational environments for joint warfighters.

UAV Type	*JV 2010* Concept	UAV Contributions
Tactical:	• Dominant Maneuver	– All-weather, accurate and timely RSTA imagery for tactical units
	• Precision Engagement	– Shorter-range target ID, geolocation and cueing, plus BDA
	• Full-Dimension Protection	– Direct support to tactical echelons with reduced risk to personnel
	• Focused Logistics	– Simplified support via HFE, sensor commonality, standard links
Endurance:	• Dominant Maneuver	– All-weather RSTA imagery at long ranges to meet theater needs
	• Precision Engagement	– Longer-range target ID, geolocation and cueing, plus BDA
	• Full-Dimension Protection	– Wide-area/long-dwell/stealthy increase situational awareness
	• Focused Logistics	– Simplified support via sensor commonality, info and link standards

Specific UAV program decisions planned to occur by the year 2000 include:

- Extension of *Pioneer's* phasedown;
- *Predator* production and support programming;
- *Global Hawk* and *DarkStar* force mix, production and configuration/P3I, with HAE CGS production determined by the UAV production decision;
- *Outrider* conversion from an ACTD to an acquisition program; and
- Priority development of TCS, to assure interoperability of tactical UAVs and connectivity with the HAE UAVs.

In parallel with these platform/facility decisions, (1) series of payload and technology application decisions will be made to expand and improve the mission capabilities of their host systems, and (2) architecture and infrastructure technical interface standards will be inherent in (or incorporated into) their interfacing links and information processing and exploitation functions.

Specific UAV payload developments planned by the year 2000 include: MTI, SAR, HSI, and NBC detection and meteorological sensors; a communications data relay; an electronic warfare decoy; a laser designator/rangefinder; and SIGINT. Other P3I will include the integration of U-CARS and MIAG equipments. Additional payload applications to the HAE UAVs will be studied as their ACTD matures. Maturing technologies will also emerge as new demonstration programs.

Specific C4I interface and infrastructure decisions planned by the year 2000 will involve the integration of:

- CIGSS standards for imagery; and
- JSAF standards and/or modules for SIGINT applications.

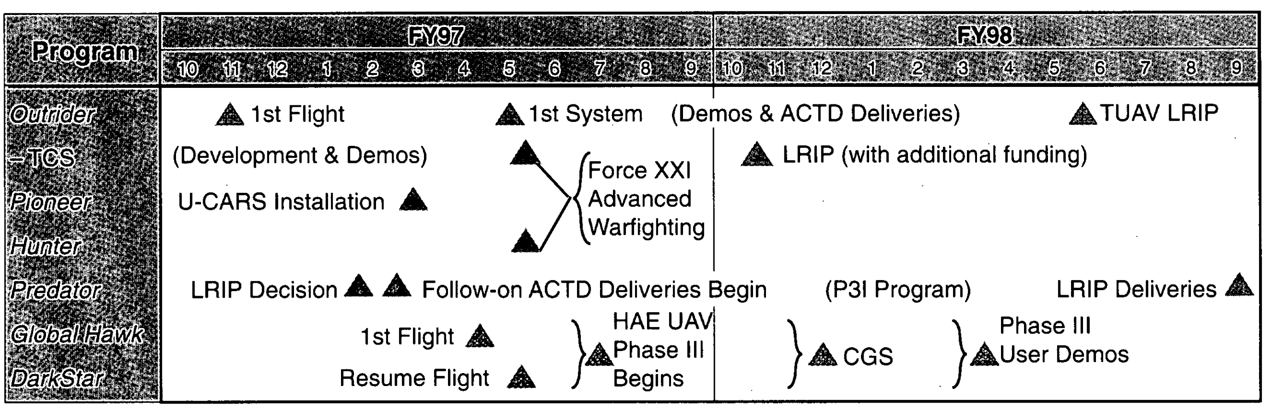
In this manner, UAV systems will complement manned systems in the airborne reconnaissance Objective Architecture and, at the same time, conform to the emerging Joint Technical Architecture and the concepts of JV 2010. The actual pacing functions for these interrelated program events will depend on:

- The relative success demonstrated by the UAVs and their related infrastructure and subsystems;
- The support they receive from the JROC (representing warfighters and other users) via the JWCA and JV 2010 implementation processes; and
- Stable funding levels over the next decade.

Director's Forecast

Near Term	Longer Term

During the next year I expect to see:
• Outrider's *first flight (November 1996)*
• *Completion of* Predator's *Marinization Study*
• *Continued* Predator *support in Bosnia*
• Global Hawk's *first flight (3Q/FY 1997)*
• *U-CARS integration on* Pioneer
• *Focus on* Predator's *transition to production:*
  – *P3I program defined; and*
  – *Initiation of LRIP program*
• *Programming for the Tactical Control System*
• *Additional de-icing capability on* Predator
• *The first* Outrider *system delivered*
• DarkStar's *return to flight*
• *A Force XXI advanced warfighting experiment to explore and validate new uses of UAVs in operational scenarios*
• *Continuing growth payload demos on UAVs*
• *Submission to Congress of a funding and testing profile for Puma*
	Our longer-term plans include:
	• *Prioritization and programming of payloads*
	• *Continuation of* Predator *P3I upgrades*
	• *Demonstration of military utility of the HAE UAVs,* Global Hawk *and* DarkStar, *in a series of exercises*
	• *Demonstration of military utility on land and sea for* Outrider
	• *Funding to sustain* Pioneer *through FY 2003*
	• *Focus on transition to production for* Outrider, *and fielding to tactical units*
	• *Preparations for HAE UAV production decisions*
	• *A focus on migration steps toward the DARO's Objective Architecture, and key roles to be played by UAVs*
	• *Fielding of lightweight, tactical, low-cost SAR and accompanying digital data link*



Conclusion

This past year we have made great strides toward developing a family of tactical and endurance UAVs that will meet new warfighting requirements. Contingency deployments as well as CONUS demonstrations continue to reveal new ways UAVs can be used to meet the needs of joint warfighters. Our acquisition reform and integrated architecture efforts are receiving widespread support both within the DoD and from the Congress as we seek to attain a balanced unmanned/manned/space-based surveillance and reconnaissance capability. As UAVs prove their military utility and affordability, they will increasingly become an integral part of our nation's reconnaissance force.

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