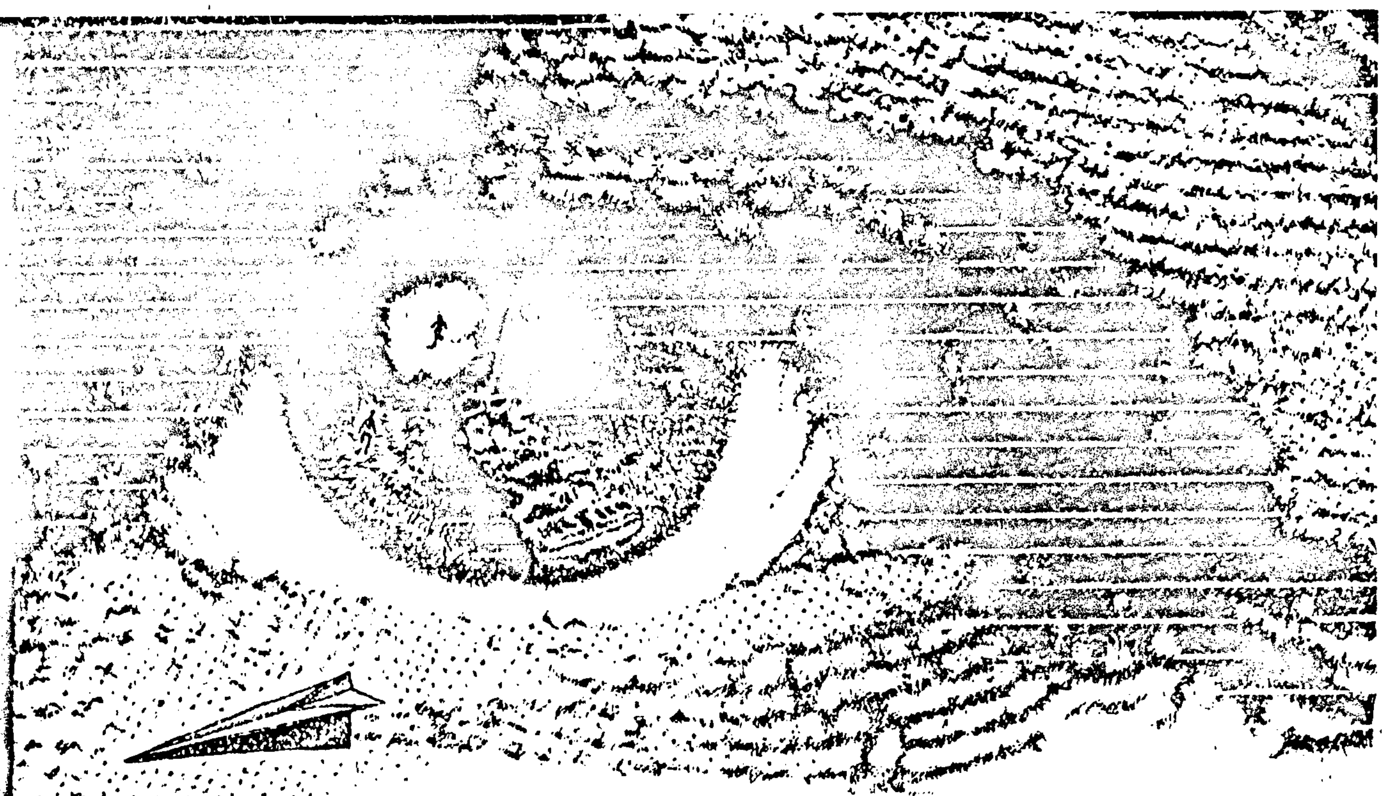

Role of UNMANNED AERIAL VEHICLES

IN FUTURE ARMED CONFLICT SCENARIOS

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Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios

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This publication has been reviewed by security and policy review authorities and is cleared for public release.

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Foreword

To ensure tomorrow's battles are won with minimal loss of friendly resources requires that technological advances are applied with wisdom and foresight. Americans have come to expect that their losses in conflict will be minimal, at least relative to the enemy we are fighting. The use of unmanned aerial vehicles (UAV) is one way to ensure that loss of lives are minimized. With current technology and further advances in the not-too-distant future, the employment of UAVs on the battlefield should continue to be studied.

This paper provides a look at the development and early uses of UAVs, showing that the concept is valid, and that they have already played a significant role in the combat capability of our armed forces. On the unknown battlefields of tomorrow, it is essential that our aircrews and commanders have accurate, real-time information. UAVs, along with other systems in use and under development, can provide some of that capability.

For sure the world of weaponry is not static, as neither are the organizational structures that are designed to bring new systems on-line. Both will change, and indeed have changed since this paper was first written. Despite continuing changes, this paper will leave you with an appreciation of the development of UAVs, and an understanding of improved capability as technological advances further refine the role of remote sensors to monitor and observe the battlefield.

About the Author

Lt Col Dana A. Longino

Lt Col Dana A. Longino attended the University of Florida, receiving a degree in journalism with a major in public relations. He was commissioned through AFROTC in 1974 and began pilot training at Webb Air Force Base, Texas, in January 1975. His first assignment took him to Kadena Air Base, Japan, flying the F-4D. Following his first fighter tour he was assigned to Reese Air Force Base, Texas, where he was a T-37 instructor pilot.

Lieutenant Colonel Longino's next assignments took him to England Air Force Base, Louisiana, to fly the A-10 and then to a staff tour at the Air Force Military Personnel Center at Randolph AFB, Texas. He then went on to the Royal Air Force (RAF), Alconbury, United Kingdom, where he was commander of the 509th Tactical Fighter Squadron.

Following his tour at the Airpower Research Institute, Air University Center for Aerospace Doctrine, Research, and Education, Maxwell Air Force Base, Alabama, Lieutenant Colonel Longino went to Sheppard Air Force Base, Texas, as the Deputy Commander for Operations, Euro-NATO Joint Jet Pilot Training Program.

Lieutenant Colonel Longino is married to the former Judy Kim Bridwell of Littlefield, Texas. They have two daughters, Brooke and Brittany.

Preface

In the late winter of 1991 my wing commander, Col James C. Evans, asked me to select a topic that would be worthy of study and research as a command-sponsored research project. In an effort to find something new I thumbed through *Aviation Week & Space Technology*. Unmanned aerial vehicles (UAV) caught my attention in an article about their use in the then, very recent Gulf War.

Being a fighter squadron commander, I had an appreciation for the importance of timely battlefield imagery. I thought of the lessons learned over the years at Red Flag, Maple Flag, Cope Thunder, and numerous other exercises and operational readiness inspections. Target identification was the single most challenging aspect of many of the missions I had flown. UAVs just might provide an answer to what I already knew had been a problem in the Gulf—at least with the A-10s. During the past year at Air War College, I've talked to several squadron commanders who participated in the Gulf War, and their views confirmed my assessment—there was a critical shortage of imagery available for the guy in the cockpit who had to face the flak and the missiles in the Gulf.

Fortunately, the lack of imagery was not directly responsible for the loss of lives as it might have been in a different scenario and in a different environment which could confront us in the future. When the war went high, the desert environment left little capability for most ground forces to hide, as would be the case in a heavily forested or foliaged area. The environment of the last war then has kept the issue of getting target-area pictures to aircrews in a timely manner off the front burner. Implications of the low priority accorded to tactical battlefield imagery for the war fighters could be significant in the future.

In a combat zone the threat to attacking aircraft is directly proportional to the level of defenses multiplied by the amount of time spent within lethal range of the threats. Time in the threat area is minimized by finding the target on the first pass and not unnecessarily revisiting the area. Increased photoreconnaissance would have helped in the Gulf, and it will save lives as well as impact the outcome of battles in the future. UAVs can help.

There are numerous people to thank for their assistance in this research effort. Maj Scott Frazier at Headquarters Tactical Air Command (now part of Air Combat Command) pointed me in the right direction. His knowledge of UAV and reconnaissance issues will be invaluable to the Air Force in the future. Numerous people at the UAV joint project office provided information on the history of UAV development and the current program to bring the different UAVs on-line.

In the office, all inmates showed extraordinary patience in listening to a fighter pilot's view of the world for over nine months. In my view, you're all exceptional scholars too. Jim Marshall's library of information provided a glimpse of how much more complicated getting information to the fighting aircrews is than just the introduction of another platform. Ways to accomplish the delivery of information to the aircrews warrants additional studies to provide a better understanding of the intelligence system.

Introduction

Unmanned aerial vehicles (UAV) are not something new to write about. Especially since the Gulf War numerous articles on the subject have been published in military and aviation periodicals. The war added significantly to the information available on the capabilities of UAVs and provided increased support for an expanded role for UAVs on the modern battlefield.

In a 20 March 1991 interview with *Defense News*, US Adm David E. Jeremiah, vice chairman of the joint chiefs of staff (JCS), stated, "The outcome of Operation Desert Storm might not have been as swift or decisive if U.S. and allied forces had not made use of intelligence-gathering and tactical reconnaissance platforms such as the Israeli-designed Pioneer. . . . We witnessed a high payoff to the commander who's been able to field UAVs."[1] As will be pointed out later in this paper, there were intelligence "gaps" during Desert Shield that could have been partially filled with increased use of UAVs.

The objective of this paper is to document the success of unmanned aerial vehicles in contributing to the war-fighting capability of those forces that have employed them in combat over the last 25 years and to support the use of UAVs in future operations. One of the significant points to make up front for the critics of UAVs is that in almost every case during my study, interviews, or readings, support for UAVs is restricted to complementing the manned mission, not replacing it. The exception is in limited and obvious roles such as decoy and deception. Certainly, in the photoreconnaissance mission, the UAV is just one more tool for the war-fighting commander in chief and commanders in the field to use in gaining information on enemy activity. I will discuss the capabilities of UAVs, how UAVs can benefit the Air Force, and how they can help fill a void in photoreconnaissance information flow to unit commanders executing the war, a problem recognized in Desert Storm.

Chapter 1 is a review of the development of the modern UAV in the late 1950s and how political events had as much to do with the creation of this new system as the military requirement. The Cuban missile crisis highlighted the need for an unmanned system, and Vietnam provided a proving ground for the concept. In addition to the US experience in Vietnam, the Israelis exploited the capability of unmanned systems to provide critical battlefield information to commanders.

Chapter 2 provides a review of the lessons of Desert Storm applicable to the employment of UAVs. On the positive side, the Army, Navy, and Marine Corps successfully employed UAVs for a variety of photoreconnaissance missions (fig. 1). The Air Force, on the other hand, experienced a shortage of target imagery at the unit level.

Chapter 3 presents current developmental programs to bring UAV capability online for the USAF in a way that supports fighter units. The new system to be adopted by the Air Force is a few years down the road. The system will support all of the services to some degree, as well as the top theater leadership.

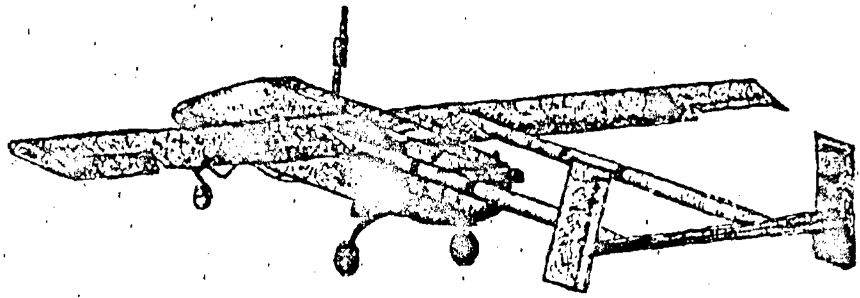


Figure 1. Pioneer on Mission during Desert Storm

Chapter 4 discusses specific beddown issues and doctrinal questions that apply to maximizing the inherent capabilities of a UAV in the context of the envisioned Air Force mission of tomorrow. Battlefield environmental issues that make the UAV a desirable reconnaissance platform, mentioned throughout this paper, are pulled together in this chapter.

The final chapter provides a summary and recommendations for bringing the UAV on board in the Air Force. Emphasis is on the importance of battlefield information in future fluid combat environments and the significance of getting that information to fighting unit commanders. The bottom line is that the mid-range UAV development process should more actively involve future operators in further development and testing. Also, at Department of Defense (DOD) and senior Air Force levels priority must be increased to fill the shortage of battlefield imagery intelligence that will be experienced throughout the remainder of this decade.

The reader, I envision, is a novice in the area of UAVs—a fighter pilot who sees UAVs as some threat to the way he or she does business. If existing barriers are removed in viewing the capability of UAVs, it will become clear that there are numerous instances when using a UAV becomes the tactically smart thing to do. A common argument from the critics is that hanging a UAV on the weapon station of an F-16 is a waste of a sortie. Consider what a waste an F-16 flight of four is that doesn't find the target due to lack of intelligence or that risks life and airframe to hit a defended target that was already destroyed.

Tactical battlefield intelligence is something that must not be underrated. The U-2, Joint Surveillance Target Attack Radar System (JSTARS), and national systems are high-budget programs that demonstrate our recognition of the importance of intelligence. The UAV brings to the table capabilities that are complementary of those and other systems and that we will need against a less-known and less-capable enemy on a fluid battlefield. UAV systems have the capability to become a significant force multiplier. Integrated with existing and future systems, UAVs could beam real-time information to commanders at virtually all levels. This would ensure that the right tactical decisions are being made to mass the right weapon system at the right place and at the right time.

Many of the publications I used as references for this paper go into great detail in defining exactly what a UAV is. The evolution over the years in the terminology seems to have started generally with the term *drone*, then progressed to *remotely piloted vehicle* (RPV). Over the last five or so years the evolutionary process has seen the development and wide acceptance of the term *UAV* in both military and industry circles. For the purpose of this paper, the terms are interchangeable and indicate more a period of time in the development of unmanned air-breathing aircraft than a difference in concept or system characteristics. Technological advances in the mode of operation have been mostly responsible for the changes in terminology. In the early years the vehicles were either free flying or were remotely piloted in much the same way as model airplane enthusiasts control their homemade aircraft. Now, sophisticated UAV technology also allows preprogramming for autonomous and very accurate navigation. In the years ahead there will likely be other designations reflecting advancements in such areas as artificial intelligence as well as expanding missions.

Within the topic of UAV technology and capability there are numerous subareas that justify lengthy and focused study. However the scope of this paper is limited to a discussion of the employment of UAVs in gathering photographic intelligence on a modern battlefield. I have purposely avoided other missions that lead into areas involving a significant amount of classified information, such as electronic warfare. Even in the area of photoreconnaissance there is some classified information which (although a limiting factor) I have intentionally steered away from. The paper is unclassified and does not have a classified annex.

As Napoléon learned during the great "maneuver" warfare of the early nineteenth century, the ability to know the enemy's location and his movement on the battlefield is paramount to victory. In today's environment, and even more so in tomorrow's, the ability to know more about the enemy than he knows about you may determine the outcome, regardless of other numerical imbalances or technological offsets.

Notes

1. "Unmanned Vehicles Use to Rise," *Defense News*, 15 April 1991, 66.

Chapter 1

Historical Development and Employment

Interest in the development of unmanned aerial vehicles (UAV) in the United States has waned since their beginnings in the late 1950s. (Target drones were actually developed in the late 1940s.) This is the typical pattern for war-fighting technologies during peacetime. It has always taken an international incident or a major conflict to stir interest in the three arenas that are critical to the development of any weapon system. The difficulty of getting the military, the Congress, and industry all moving in the same direction at the same time has been the leash that has prevented UAVs from reaching their full potential. A historical event, such as the downing of Francis Gary Powers in a U-2 spy plane over the Soviet Union on May Day 1960, is a classic example. This incident kicked off US development and deployment of remotely piloted vehicles (RPV) as platforms for the collection of photoreconnaissance.

William Wagner, author of *Lightning Bugs and Other Reconnaissance Drones*, describes in exciting detail the circumstances that led to the decision to conduct overflights of the Soviet Union and the events that followed the downing of the U-2 by the Soviet (surface-to-air missile) SAM-2.[1] As the story goes, the United States was interested in finding out what the Soviets were up to in the development of the emerging technologies of rocket building. After the Soviets declined to submit to President Dwight D. Eisenhower's proposed Open Sky policy, the U-2 flights were authorized.[2] Americans at that time still remembered the lessons learned from a relaxed posture before the Japanese attack on Pearl Harbor. The approach seemed to be: do whatever it took to stay abreast of the Soviet activities. According to Wagner, "Only 18 months were to lapse [after the U-2 was downed] before the first photographic inventory of Soviet missile sites along the Trans-Siberian Railroad was obtained by the early satellite and missile observation system (SAMOS) vehicles."[3] Also, the SR-71 was rapidly brought to the planning board in a highly classified effort to expand our intelligence-gathering capability.

Another incident two months after the Powers incident put the development of the reconnaissance UAV on track. The Soviets downed another US plane, an RB-47, over the Barents Sea on 1 July 1960. Two of the crew members were held prisoner for several months; the others did not survive. The loss of American lives brought about increased pressures on the government from within and embarrassed the United States in the international community.

One of the results was Project Red Wagon, the initial feasibility study contracted to Ryan Aeronautical Company that effected the development of our first reconnaissance UAVs. As studies intensified into alternatives to gather the information lost with the discontinuing of U-2 overflights of the Soviet Union, drones kept coming to the surface as one option. Wagner quotes a report from the office of Dr Harold Brown, director of Defense Research and Engineering (before his appointment as secretary of the Air Force), that identifies some of the major reconnaissance requirements at the time:

> *The suspension of overflights and peripheral operations by U-2 aircraft is political in nature and has deprived the United States of its most effective aerial intelligence collection capability.
>
> *The fact that the Sino-Soviet Bloc capabilities, both offensive and defensive, are dynamic and aggressive, dictate that an almost constant surveillance be maintained to insure maximum US combat effectiveness. This requires high resolution (1-foot) photographic coverage of selected areas and of specific targets within these areas.
>
> *Based on the foregoing, the following criteria are proposed for use in the selection of any future vehicle that will be used for overflight.
>
> **Unmanned. . . .
>
> **Operate independent of foreign and US overseas bases. . . .
>
> **Feasibility and costs . . . [not to exceed current capability]
>
> **Lead Time—it is recommended that the study phase of a drone program be undertaken immediately.[4]

The debates over whether to develop the drone reconnaissance systems continued for months. In the minds of many, drones would provide a significant capability toward the specifications laid out. However, the concept would have intermittent support in light of the budgetary requirements of developing the new satellite systems and the SR-71. Ironically, Harold Brown was one of the primary decision makers to turn off reconnaissance drone development. The termination came in a period between the initial Red Wagon program demonstration in 1960 and the letting of the first developmental program contract—Fire Fly (later designated Lightning Bug)—shortly after the Cuban missile crisis.

The Cuban missile crisis was the impetus that was needed to show the uncertain nature of committing forces on short notice in support of the national strategy of containment. A U-2 was downed while overflying Cuba to gather information on the missile sites being prepared for the Soviet intercontinental missiles, and the pilot was killed in the crash. This incident spurred on the development of a new UAV reconnaissance system from a target drone airframe that was begun earlier in 1962 under the streamlined and accelerated Big Safari acquisition program.[5] The Cuban situation vividly demonstrated the need for quick intelligence while also demonstrating the political sensitivity involving the use of manned platforms.[6]

From the Big Safari acquisition program came the first US operational photoreconnaissance unmanned aircraft. In 1964, the Air Force deployed to

Southeast Asia 148 AQM-34 Ryan Aeronautical reconnaissance Lightning Bug drones (fig. 2). These drones were designed from off-the-shelf Ryan Aeronautical Company BQM-34 target drones.[7]

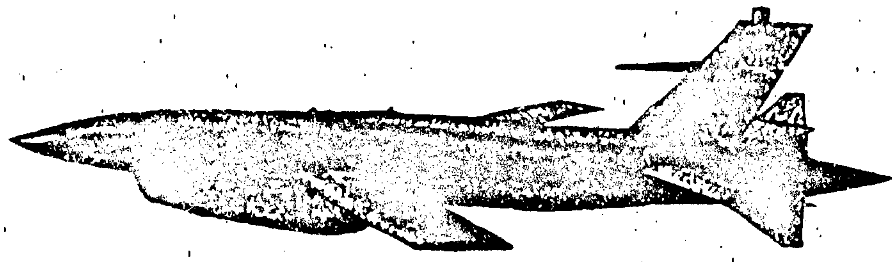


Figure 2. AQM-34 Lightning Bug

Strategic Air Command (SAC) was the operating command for the new UAVs. In an 11-year period from 1964 to 1975, SAC flew a total of almost 3,500 UAV missions in support of photo, communications, and electronic reconnaissance requirements in the war in Southeast Asia.[8]

During the course of that war the classified program was to play an impressive role. Some of the photo mission accomplishments of the Ryan Lightning Bug drones tasked under an operations order code-named Buffalo Hunter were:

- Obtained the first photographic evidence of the SA-2 Guideline missile in North Vietnam (NVN). . . .
- Took first photo closeups of MiG-21D and MiG-21E Soviet aircraft in North Vietnam.
- Provided photographic evidence of Soviet helicopters in NVN.
- Provided photographic evidence of the "Cheesebrick" Passive Tracking Station in NVN.
- Photographed launch of an SA-2 missile against a drone flying at an absolute altitude of 600 feet. . . .
- Photographed an SA-2 detonation at close range, 20 to 30 feet, and returned to fly another mission. . . .
- Provided continuous low-altitude, high-resolution photography of an area denied by political edict to manned aircraft. . . .
- Provided the only daily low-level BDA (bomb damage assessment) of B-52 raids during "Linebacker II" in the closing days of the war.[9]

The unmanned drones also gathered a significant number of photos of prisoner of war (POW) camps, including the famous Hanoi Hilton. Returning US POWs considered the low-altitude overflights by the unmanned aircraft a real morale booster.[10] Because of the high-risk mission profiles, the loss rates were significant in those operations, but well within acceptable limits for an unmanned system (fig. 3).

RYAN 147 MODEL	MIL MODEL	LT	SP	MISSION	DATE OPR	NO LAUNCH	PERCENT RETURNED	MSN PER BIRD
A		27	13	Fire Fly-First Recce Demo	4/62-8/62			
B		27	27	Lightning Bug First Big-Wing High Alt Photo Bird	8/64-12/65	78	61.5%	8
C		27	15	Tng and Low Alt Tests	10/65			
D		27	15	Electronic Intelligence	8-65	2		
E		27	27	High Alt Elect Intelligence	10/65-2/66	4		
F		27	27	Elect Counter Measures	7/66			
G		29	27	Longer b w/ Larger Engines	10/65-8/67	83	54.2%	11
H	AQM-34M	30	32	High Alt Photo	3/67-7/71	138	63.8%	13
J		29	27	First Low Alt Day Photo	3/63-11/77	94	64.9%	9
N		23	13	Expendable Decoy	3/66-C/66	9	0	
NX		23	13	Decoy and Med Alt Day Photo	11/66-6/67	13	46.2%	6
NP		23	15	Interim Low Alt Day Photo	6/67-9/67	19	63.2%	5
NRE		28	13	First Night Photo	5/67-9/67	7	42.9%	4
NQ		23	13	Low Alt Hand Controlled	5/68-12/68	66	66.4%	20
*NA/NC	AQM-34G	26	15	Chaff and ECM	8/68-9/71			
NC	AQM-34H	26	15	Leaflet Dropping	7/72-12/72	29	89.7%	8
NC (m1)	AQM-34J	26	15	Day Photo \ Training				
S/SA		29	13	Low Alt Day Photo	12/67-5/68	30	63.3%	11
SB		29	13	Improved Low Alt Day Photo	3/68-1/69	159	76.1%	14
SRE	AQM-34K	29	13	Night Photo	11/68-10/69	44	72.7%	9
SC	AQM-34L	29	13	Low Altitude Workhorse	1/69-6/73	1651	87.2%	68
SC/TV	AQM-34L/TV	29	13	SC with Real Time TV	6/72-	121	93.4%	42
SD	AQM-34M	29	13	Low Alt Photo \ Real Time Data	6/74-4/75	183	97.3%	33
SDL	AQM-34M(L)	29	13	Loran Navigation	8/72	121	90.9%	36
SK		29	15	Operation From Carrier	11/69-6/70			
T	AQM-34P	30	32	High Alt Day Photo	4/69-9/70	28	78.6%	
TE	AQM-34Q	30	32	High Alt Real Time COMINT	2/70-6/73	268	91.4%	34
TF	AQM-34R	30	32	Improved Long Range	2/73-6/75	216	96.8%	37
						3435		

*NA/NC Combat Angel birds were operated on standby in the US by Tactical Air Command for possible prestrike electronic countermeasures (ECM) chaff-dispensing missions

68 Missions by Tom Cat
63 Missions by Budweiser
52 Missions by Ryan's Daughter
46 Missions by Baby Duck

Source: William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, Calif.: Aero Publishers, 1982).

Figure 3. Different Types of Ryan UAVs

Many other missions were conducted or experimented with in Southeast Asia with varying degrees of success. Next to the photo mission, electronic combat (EC) was probably the most successful. Although those EC missions are beyond the scope of this paper, it is significant to note that increased capabilities were possible because of the investment in and perfection of the basic system. One of the most significant contributions of the electronic version of the UAV was the recording of SA-2 missile fuzing and guidance signals. This allowed technical exploitation, which led to the development of defensive measures for US pilots on combat missions over the North.[11] Also, UAVs conducted psychological operations in dropping leaflets and accomplished some experimentation in the dropping of chaff to hide the identity of incoming fighters or bombers.

The employment concepts for the drones evolved as operating techniques and technologies improved. It is easier to follow the numerous versions of the AQM-34 using the Ryan Aeronautics designation, which is the 147 model with letter suffix designations for the different versions. There were eventually 24 versions built. The 147A was the AQM-34 prototype, and the 147B was the first built in significant numbers (34).[12] The system included a programmed navigation unit incorporating a Ryan doppler radar that corrected drift rates to increase the navigational accuracy to 3 percent of the distance traveled.[13]

The wing area was expanded to a 27-foot wing span, allowing an operating altitude of 62,000 feet and a range of 1,680 nautical miles.[14] Later modifications would further increase the range and altitude capabilities.

Early on there was considerable interest in the "stealthiness" of the drones, obviously a security and survivability issue. To reduce the radar signature of the drones, a screen mesh was placed over the engine intake, a special blanket was fitted to the sides of the vehicle to reduce the radar return, and the nose was painted with radar-absorbing paint.[15] Tests against F-106 interceptor aircraft proved the value of the stealth efforts. According to Wagner, five F-106s intercepted a reduced-signature drone in a test off the coast of Tyndall Air Force Base (AFB), Florida. Each of the aircraft "salvoed four GAR-3A air-to-air missiles with live warheads from the tail chase position but none found their mark."[16] Another significant effort was the reduction of contrails produced by the UAV. This included several techniques, the most significant of which was the increased-altitude capability, to get above the condensation level.

The launch procedures in the early models, and essentially in all models employed in Southeast Asia, called for an air launch from a specially modified C-130. After flying the preprogrammed (and in some cases the remotely piloted) route, the drones would recover using a parachute system that would automatically deploy over a predesignated area and bring the vehicle somewhat softly to earth. The vehicle would be recovered by helicopter in most cases and returned for film retrieval and refurbishing for the next mission. The damage sustained during the "landing," though moderate, required time to repair. Sometimes the landing resulted in the vehicles coming down in the water, which necessitated extensive decontamination before reuse. In 1966 a new midair retrieval system (MARS) was adopted. This is a process by which a helicopter snatches the parachute of the drone, reels the drone in to just below the helicopter, and then returns it to the recovery location for a soft letdown. The procedure was fairly successful in Southeast Asia: "2,655 MARS catches were made in 2,745 attempts."[17]

The most significant adjustment to the manner in which the 147 was employed was the change from high-altitude to low-altitude operations. Although there were several variants, the 147SC was the most widely used low-altitude vehicle. It flew a total of 1,651 sorties with a return rate of 87.2 percent.[18] The low-altitude decision was probably based on several factors—survivability in light of the growing missile threats, the desire to get higher-resolution photographs, and the need to get under the weather. Also, there must have been some consideration that the products of manned aircraft and other systems were accomplishing much of the high-altitude mission.[19]

Effective employment of UAVs was an integral part of the Israeli doctrine in 1973 and again in 1982, helping to accomplish the first objective in air power operations: the attainment of air superiority. In the 1973 Yom Kippur War, the Israelis used UAVs as decoys on a first-wave assault. The Arab forces opened fire with their antiaircraft missiles, downing an unknown number of drones, but as the SAMs were reloading, the Israeli fighter and bomber aircraft slipped through the defenses.[20] In 1982, the Israelis were again poised for war. They had learned some hard lessons in previous conflicts, and newer and more sophisticated air defense systems presented them with major challenges. Before the fighting, UAVs were used to locate the position of air defenses in Lebanon and Syria and, at the same time, to map out the air and ground order of battle, including critical electronic emission information. Also, the Israelis used UAVs during the course of the war to monitor airfield activity, passing the information to airborne controllers to be used in the direction of defense fighters. The results: the essential destruction of the Syrian SAMs. All but two of the 19 SA-6 missile sites were destroyed on the first day of operations.[21] Israeli successes with UAVs seem to be largely the result of three factors. First, the way they were employed supported fundamentals of war and of air power including clearly established objectives, surprise, intelligence, concentration on centers of gravity, and tempo of operations. Second, the Israelis had obviously concentrated their training toward the final objectives involving all levels of players and decision makers. This is one area that is generally taken for granted within most circles when discussing Israeli military operations. The third factor, and the most important, the Israelis clearly focused in on the threat, the resources, and their objectives, and adjusted not only their tactics but also their doctrine to fit the situation. The significance then of the Israeli UAV operations was how they apparently assessed the situation and utilized the resources they had available to overwhelmingly beat the surface-to-air threat. It just so happens that in their scenario UAVs played a major role in the operation, one that could not have been accomplished by any other system in their inventory.

The technical capabilities of the UAVs employed in Southeast Asia are impressive, and their contributions to the collection of intelligence information apparently justified the program and the concept. The applicability of UAVs to the US force structure today, however, is based on one's view of other systems' capabilities and the nature of future warfare. In any case, past UAV employment highlights the advantages that will appear repeatedly in review of the feasibility of UAVs. Three recurring themes are: (1) UAVs reduce the risk to human life; (2) they are cost-effective; and (3) there are certain times when their use is advantageous due to political or environmental conditions that prohibit use of other systems. Of course, none of those are important if the system cannot accomplish the mission.

Notes

1. William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, Calif.: Aero Publishers, 1982), 1–22. Mr Wagner's book is an exciting account of the early years of UAV development. The frustrations and successes he and his associates experienced should be remembered when, in the future, UAVs are as common as the fighter plane has been for the last 50 years. Anyone interested in the subject of UAVs should make every effort to read this work. Other sources may be more "official," but none are as enlightening or as entertaining.
2. Ibid., 3–4.
3. Ibid., 5.
4. Ibid., 17–19.
5. Ibid., 23.
6. Ibid., 42.
7. Briefing, Air Force Directorate of Reconnaissance and Electronic Warfare, subject: History of Buffalo Hunter Drone Program, Washington, D.C., 1973. Briefing script located in the Air Force Historical Research Center files at Maxwell AFB, Alabama.
8. Benjamin F. Schemmer, "Where Have All the RPVs Gone?" *Armed Forces Journal International*, February 1982, 38.
9. Wagner, 24–25.
10. Ibid., 201–6.
11. Briefing, 1973.
12. Ibid.
13. Wagner, 49.
14. Ibid., 42.
15. Ibid., 15.
16. Ibid., 32.
17. Ibid., 109.
18. Ibid., 213.
19. Ibid. To get a full appreciation of the number of vehicles developed and the missions they performed, refer to figure 3.
20. Comptroller General of the United States, *Report to the Congress: DOD's Use of Remotely Piloted Vehicle Technology Offers Opportunities for Saving Lives and Dollars* (Washington, D.C.: General Accounting Office, 1981), 2.
21. Clarence A. Robinson, Jr., "Surveillance Integration Pivotal in Israeli Successes," *Aviation Week & Space Technology*, 5 July 1982, 16–17; and John F. Kreis, "Unmanned Aircraft in Israeli Air Operations," *Air Power History* 37, no. 4 (Winter 1990): 46.

Chapter 2

Desert Storm

The operational commander's ability to see the battlefield, understand the enemy, and apply capabilities will ultimately shape the battlefield and create the conditions which will permit decisive operations.

—Training and Doctrine Pamphlet 525-5, *Airland Operations*, 1 August 1991; signed by Gen John W. Foss, USA, and Gen John M. Loh, USAF

During Operation Desert Storm, the concept that commanders could see the battlefield, understand the enemy, and apply capabilities proved once again to be critical to the success of military operations. The Army, Navy, and Marine Corps capitalized on the use of unmanned aerial vehicles to help accomplish the task of battlefield-intelligence gathering. The information gathered by the unmanned vehicles was crucial to the employment of Army units as they swept through Iraq during the celebrated Hail Mary maneuver that crushed Iraqi resistance and encircled the enemy forces in Kuwait. Naval units used UAVs to spot their artillery fire, greatly increasing effectiveness and efficiency of operations. The Marines' UAV employment provided targeting information and battlefield damage assessment of tactical battlefield targets. The employment of UAVs clearly demonstrated their ability to complement other information systems, providing an unprecedented view of the tactical battlefield for field commanders and operational-level combat decision makers. According to an interim Department of Defense (DOD) report to Congress on operations in the Gulf, UAVs were employed for "direct and indirect gunfire support, day and night surveillance, target acquisition, route and area reconnaissance and BDA."[1] The Pioneer system "appears to have validated the operational employment of UAVs in combat based on preliminary data."[2]

A symposium sponsored by the UAV Joint Project Office (JPO) in August 1991 included presentations by the military organizations that employed UAVs during the war and other organizations that are involved in the development and future use of UAVs. The primary US UAV employed during the war was the Pioneer. Forty-three Pioneers were deployed to the theater and flew 330 sorties for over 1,000 flight hours. In the buildup period of Desert Shield, the Pioneers logged 200 sorties for almost 700 flight hours.[3] During the Army's assault on Iraqi forces, UAVs were credited with enabling the services to take out every piece of enemy artillery that could have been a threat to friendly forces as they breached Iraqi's forward defensive positions. Gen Paul Menoher, commanding general of the US Intelligence Center and School at Fort Huachuca, Arizona, gave a briefing at the conference that highlighted the success of Pioneer operations. Because of the UAV's ability to see, the enemy's artillery was taken out before US troops were within their firing range. As a result, "not a single round of Iraqi artillery landed on 7th Corps Infantry which raced through the opening in Iraqi lines."[4]

The Navy's success with UAVs was equally impressive. Used to observe the waters off the Kuwaiti coast, UAVs identified enemy naval operations that were then targeted by naval forces. UAVs helped search for mines, and, most significantly, they were used to spot every 16-inch round fired by US battleships.[5] The ability to spot each round in a real-time manner allowed a significant increase in the accuracy of the big guns.

Marine Corps's use of the Pioneer UAV systems filled a gap that was created due to the retirement of RF-4s from the Marine aircraft active inventory. Because the Pioneer was an organic Marine asset, information from the UAVs went directly to the First Marine Aircraft Wing. This provided a notable increase in the availability of imagery for Marine aviation, which had experienced problems obtaining information from external sources. Despite requirements for resolution imagery higher than the Pioneer was able to provide, the increased information it did supply seems to have been significant in the application of Marine air power in the Gulf.[6]

The importance of the UAV operations in the Persian Gulf War lies not so much in the successes but in the displayed capabilities of the concepts and the equipment. Combined with the future capabilities of systems in the design and production phases and the anticipated conflict scenarios that the US faces in the future (discussed later in this paper), UAVs have the potential to fill an intelligence void for battlefield commanders.

Many of the systems, however, have limitations and are not easily accessible to commanders at the war-fighting level. If current coverage doesn't include the area of operations, the use of overhead systems for battlefield reconnaissance has limitations of weather and the inability to always be employed in a timely manner. According to the DOD report, "In general, the need for improved, reliable, all-weather surveillance capabilities (both wide-area and discrete) responsive to tactical users was reaffirmed in the Gulf War."[7] Joint Surveillance Target Attack Reconnaissance System (JSTARS) was also successful in providing real-time targeting information to fighting forces. Although still in the developmental stages, this airborne radar system was invaluable in identifying ground targets inside the southern borders of Iraq. Despite all the technology available to gather intelligence information, however, there was a recognized need for "imagery collection systems with real-time, all-weather, and night capabilities with greater range."[8]

Tactical reconnaissance performed well in the Gulf but with some significant problems that are being addressed. Some of the limitations were related to organizational structure and some can be attributed to limitations that suggest a look at UAVs in a complementing role. First, when RF-4s deployed from Bergstrom AFB, Texas, to Saudi Arabia on about 12 January 1991, the crews had little time for preparations and optimum time-zone adjustments before they were flying combat missions. Next, aircrews of the RF-4s found the situation very difficult in terms of planning and flying "tactical" missions because the flight profiles were required to cover as many as 10 to 15 targets on each flight.[9] The typical RF-4 mission includes less than five targets. The additional targets made it necessary that the crews direct their attention into the cockpits while maintaining a predictable flight path, which left them susceptible to enemy defenses. To overcome this, the RF-4s were deployed in pairs for mutual support, a good decision but one that was essentially a force divider—that is, it reduced the number of missions available. Another reason for the deployment in pairs was the advantage of having redundant sensors.[10]

RF-4s were successful in the Gulf War, but there are significant circumstances surrounding their success that must be clearly and objectively analyzed in working tactical reconnaissance issues in the future. One of the subtle issues recognized by the after-action committee at Bergstrom AFB was that there was little integration of the tactical reconnaissance operations into the strike packages. This was due partly to the late deployment of RF-4 assets and partly to the heavy tasking during the latter stages of Desert Shield. Because of the heavy tasking, aircraft and crews were not available to train with the strike packages.

The limited intelligence available to pilots flying strike missions inside Iraq was a problem during Desert Storm. A complicated mix of shortfalls in the areas of collection, processing, interpretation, and dissemination caused the shortage of information. The operations of the A-10s in the Gulf illustrate some of the areas that provided less-than-optimum support of photo intelligence.

Since most of the war did not involve direct support of ground troops, the A-10s were tasked on mostly interdiction missions. The targets usually were provided, but in reality the A-10s went to a set of geographic coordinates within a kill box where the earth was "peppered" with many targets that all looked the same from high altitude.[11] The result was that the missions were more like armed recce up to 200-miles deep in enemy territory. Tactical imagery was virtually nonexistent, according to Col Ervin ("Sandy") Sharpe, commander of the A-10 wing in the war. Colonel Sharpe stated that although the A-10s were being tasked to do precision bombing on specific targets, the "tools" were not provided to allow that to happen. Specifically, he was referring to the lack of imagery intelligence. "We do not currently have the systems to provide the pilot with adequate imagery—something that goes from big to small so the pilot can get his eyeball on the exact target." Colonel Sharpe's perception is that if there is going to be a daily "frag," there needs to be a system that works in concert with the tasking mechanism to provide adequate target intel to the pilot. In the Gulf War there was a "pull system" (a system whereby a user can selectively call up needed information) for intel at the wing level. According to Colonel Sharpe, the system should provide target intelligence in a push fashion (a lot of information is given to the user at wing level in a "dump" manner). "We couldn't be sure whether we'd have photos from day to day." In fact, the wing sent people by car to Bahrain to obtain pictures that otherwise would not have been available.[12]

Some of these limitations will be overcome with the employment of the Advanced Tactical Air Reconnaissance System (ATARS) pod. Other limitations may need more creative options to ensure the availability of tactical information on tomorrow's battlefield. In the Gulf War we had overwhelming air superiority, which allowed the RF-4s to fly straight and level for extended periods of time, possible only because of the nonexistent air threat.

These shortfalls in the collection of enemy intelligence should not be construed as an unsuccessful intelligence operation in the Gulf War. Quite the opposite in fact, the intelligence support for Desert Storm operations was a success story. The work of thousands of professionals and the heavy investment in intelligence system technology provided the best picture of an adversary ever obtained by any "nation or coalition of nations."[13] Many of the improvements that will likely be made as a result of Desert Storm will be made in the structure of the intelligence-gathering, analysis, and dissemination process. As the war demonstrated, flexibility will be a key in the design of intelligence systems to meet a diverse group of users. A complex combination of systems to meet user demands at all levels will need to address interoperability between different systems and the application of sound doctrine.

In close analysis of the Gulf air war it is imperative that the Air Force look at what could have been accomplished with UAVs to support the air war efforts and apply that to whatever environment may be faced in the future. In this respect nonlethal UAVs may have been the answer to several key problems in the conduct of the Gulf War.

The four major areas identified from Gulf operations that a fully mature UAV system could have contributed to are:

1. increase the total number of reconnaissance platforms available, allowing the flexibility of manned flights to be better used against mobile targets or late mission changes;

2. provide greater di· ·emination of information due to wider basing of the systems and ground receiving stations;

3. reduce or eliminate the need for support packages; that is SAM suppression, electronic countermeasures, air refueling, Airborne Warning and Control System (AWACS), and/or Airborne Battlefield Command and Control Center (ABCCC) support for reconnaissance missions; and

4. allow coverage of high-threat areas without risking the lives of aircrews.

Support for the increased use of UAVs is presently at the secretary of defense and presidential levels because of the recognition that without a pilot involved, the chances of serious international incidents and prisoner-of-war situations decrease significantly.[14] This will be a major factor as we face regional contingencies around the globe in the future.

Notes

1. Secretary of Defense Dick Cheney, *Conduct of the Persian Gulf Conflict, An Interim Report to Congress*, July 1991, 6–8.
2. Ibid.
3. "UAVs Used to Support Breach of Iraqi Defenses in Desert Storm," *Defense Daily* 172, no. 33 (15 August 1991): 259. Information derived from Edward Davis, deputy program manager, at the UAV JPO.
4. Ibid.
5. *Stars and Stripes*, 9 April 1991. Reported by the AAI-IAI field operations manager for the Pioneer Project.
6. Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project Letter, 26 August 1991, "Executive Summary of the Conference on Unmanned Aerial Vehicles in Operation Desert Storm." (U) This document is classified confidential only when the summaries are considered "in the aggregate."
7. Cheney, 15-5.
8. Ibid., 14-3.
9. Notes from Desert Storm Reconnaissance Working Group, chaired by Lt Col James H. Mills. Unclassified report provided by Capt Scott Frazier, HQ TAC/DR.
10. Ibid.
11. Col Ervin C. ("Sandy") Sharpe, Jr., commander AUCADRE, interview with author on 18 November 1991. Colonel Sharpe was the commander of the 354th TFW (P) located at King Fahd International Airport, Saudi Arabia, during operations Desert Shield and Desert Storm.
12. Ibid.
13. Cheney, 14-1.
14. "An Interview: You Are the Key to the Success of This Program," *Achiever*, December 1989, 6–7. The article is an interview in Teledyne Ryan Aeronautical's company magazine with Capt A. J. Olmstead, Jr., US Navy program manager, Navy Unmanned Aerial Vehicles.

Chapter 3

Development of the Medium-Range Unmanned Aerial Vehicle

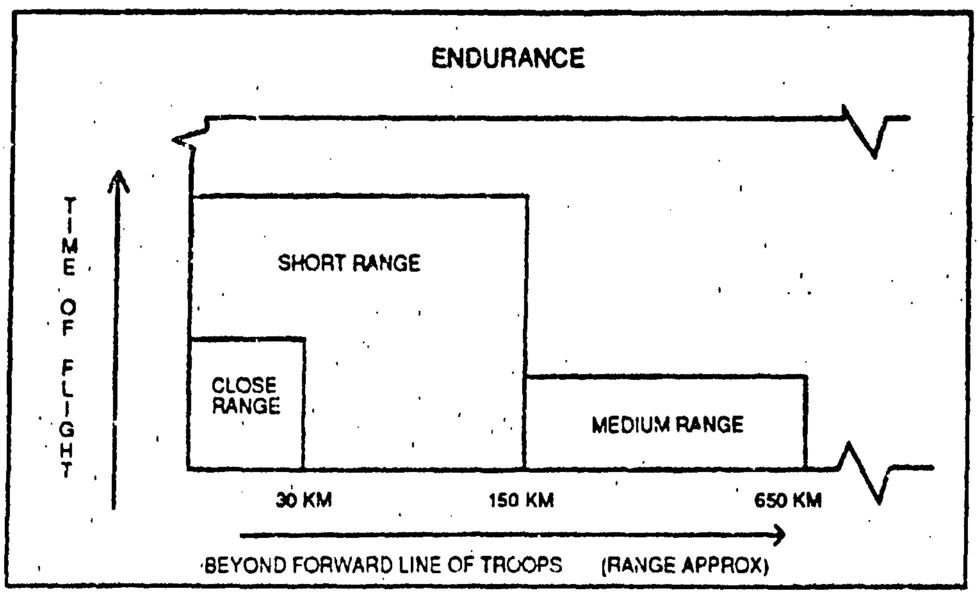
Discussion of current unmanned aerial vehicle programs directed at improving battlefield intelligence requires a look at several interrelated concepts and systems. At the head of the effort to bring new UAVs on-line is the UAV Joint Project Office headed by the Navy.

The UAV JPO was created in 1988 in a congressionally directed effort to streamline the services' nonlethal UAV developmental efforts. Congressional intentions were to avoid duplication of effort, provide joint development to ensure interoperability and interchangeability to the maximum extent possible, and to expedite the fielding of operational systems to the services.

The UAV JPO is currently working four major families of UAVs: close, short, medium, and endurance. Also, the Air Force is heading development of the Follow-On Tactical Reconnaissance System (FOTRS). FOTRS includes as major components the Advanced Tactical Air Reconnaissance System and the Joint Service Imagery Processing System (JSIPS), the F-16(R), and the medium-range unmanned aerial vehicle (UAV-MR). ATARS is the imaging system that will be adapted to a UAV or manned aircraft. JSIPS is the ground station that is being built for the Air Force, Navy, Marine Corps, and the Army to receive, process, and distribute digital imagery from several sources.

The UAV being developed for the Air Force is the medium-range vehicle which will employ the same imagery pod that will be carried by the manned F-16(R). The Navy and Marine Corps will also employ the UAV-MR in conjunction with their Tactical Air Reconnaissance System pod-equipped F/A-18s. Figure 4 shows the interrelationships of the new systems.[1]

Teledyne Ryan Aeronautical is building the UAV-MR vehicle, designated the BQM-145A. It is based on the Model 324 UAV in production for the Egyptian government. The UAV-MR vehicle (fig. 5) is a metal structure with a gross weight of over 1,900 pounds. It is about 18 feet in length with a wingspan of 10.5 feet. The original design called for a composite structure, but this was changed to metal due to concerns that the saltwater environment in naval use would cause delamination problems with the composite materials. Lack of shipboard capability to repair composites would have hampered vehicle turnaround and repair work. The nose section and wings are constructed so that they can be removed for shipping



Source: Department of Defense, *Unmanned Aerial Vehicle Master Plan*, 1 March 1991.

Figure 4. Categories of Required UAV Capabilities

and easily assembled in the field. The overall height is just over 31 inches at the twin-tail section with the main body just over 25 inches. The movable flight control surfaces are the elevons and a single rudder. The engine is a Teledyne-CAE Model 382-10C low-bypass turbofan with 970 pounds of thrust that can be adjusted to run on a variety of jet fuels including JP-4, JP-5, JP-8, or JET-A. Total usable fuel capacity is 66 gallons, and the fuel control system ensures operation throughout the launch and all phases of flight. An automated flight control system integrates inputs from two air-data sensors—an inertial navigation system and a global positioning system. The mission system will relay battlefield imagery to a receiving station. The system will include either the electro-optical or the infrared system with a data-link

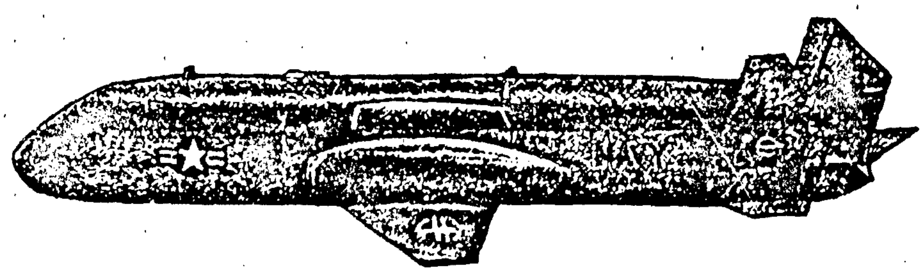


Figure 5. UAV Medium-Range Vehicle

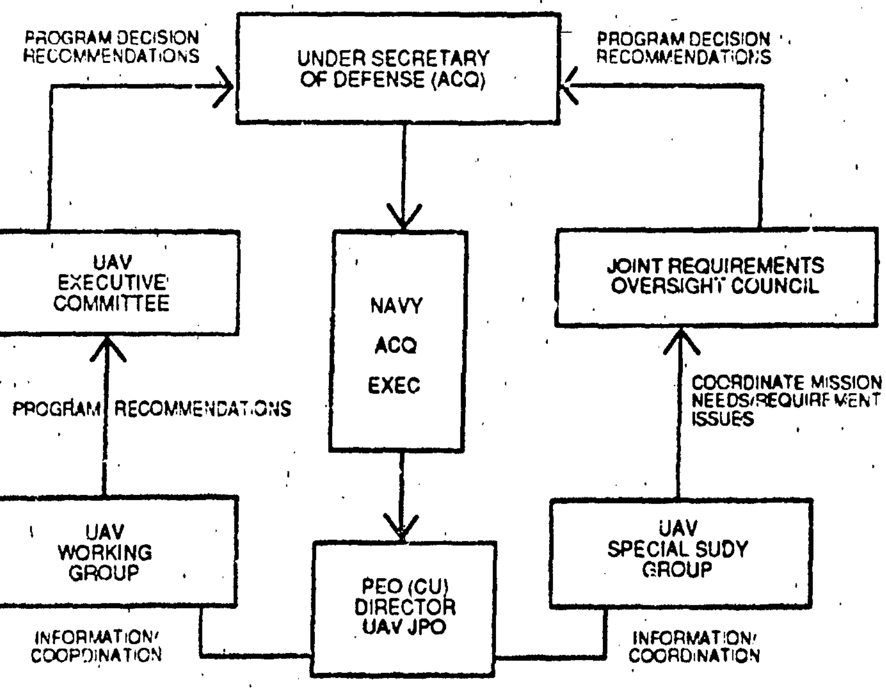
capability that will allow either real-time transmission to a receiving station or a burst-transmission capability once the vehicle is within line of sight of the receiving station.[2]

Launch operation alternatives include either an airborne option or a ground-launch option. The Navy and Marine Corps intend to use exclusively the airborne option from the F/A-18 while the Air Force plans to use both the air- and ground-launch capabilities. For the air-launch capability the necessary hardware is being developed to connect the UAV to the F/A-18 and F-16(R) in an underwing configuration. The "mother ship" will have electrical and communication connection with the UAV before launch as well as operation of UAV payload prior to engine start. The ground-launch system employed by the Air Force will consist of a launch pallet installed on either a truck or a mobilizer. For the ground launch, an electro-hydraulic erector will be used for positioning the aircraft. A rocket booster motor with over 14,000 pounds of thrust will initially assist in propelling the craft off the erector and then the motor will separate from the UAV.[3]

The recovery system for the UAV-MR will allow retrieval via land, sea, or air. A parachute system located in the upper aft section of the UAV will be used for all three recovery options. At sea the vehicle will be recovered by helicopter, and on land either by helicopter or land vehicle. The capability will exist to retrieve the UAV-MR within a predesignated area of 1,000 by 3,000 feet. For the air-recovery option the UAV-MR will deploy the parachute with an engagement parafoil above the main chute that will be engaged by a retrieval pole attached to a helicopter. The air-recovery system is envisioned as a Navy/Marine option. The Air Force envisions using the ground-recovery system only.

In the most recent budget legislation Congress voted with the checkbook on the importance of tactical battlefield intelligence. They approved funding for the full-scale development for the UAV-MR and even voted additional funds to better standardize the intelligence-processing and dissemination systems between the services.

The tasking of the UAV JPO is to perform as the "central management authority for all DOD nonlethal UAV acquisition efforts. . . . Composed of technical, business and program management personnel, the organization is responsible for planning and executing UAV development and acquisition programs."[4] The UAV JPO is part of the office of the program executive officer for the Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project. Guidance for program direction comes through a UAV executive committee that has overall responsibility for DOD UAV programs. Figure 6 shows how the established committees report through the normal acquisition system to the under secretary of defense (acquisition). Members of the executive committee include representatives of Office of the Secretary of Defense (OSD), Joint Staff, and the services. Representatives from other defense agencies are also included in the working groups depicted in figure 6.



Source: Department of Defense, *Unmanned Aerial Vehicle Master Plan*, 1 March 1991.

Figure 6. UAV Development Management

Central to UAV JPO's development of the UAV systems is the "family architecture" concept. This concept focuses on developing a core set of technologies that can be applied to the systems development of all of the vehicle designs. An expectation is that systems commonality for all except the UAV-MR will be as high as 85 percent. The cost of the vehicle airframes will be only 15 percent of the total program costs. Other cost estimates are ground control, 16 percent; payloads, 20 percent; and training and support, 34 percent. Because the UAV-MR was in the design phase before the creation of the JPO, that system's interoperability and commonality is based on the concurrent development of the JSIPS and the ATARS. In the medium-range UAV program, the airframe will cost about $1 million while each reconnaissance payload is valued at $1.5 million.[5]

At the heart of the commonality efforts is the development of a shared avionics group being managed by the Flight Control Division of the Wright Laboratory, Dayton, Ohio. These systems will include a common package of flight control, inertial navigation, global positioning subsystems, and data-link management. Also under development is an automatic recovery system. The JPO is working hard to ensure interaction between users and industry while working the technology transfers between government, industry, and engineering centers. The intent is to maximize the commonality and interoperability during systems design and test phases.[6] Two organizations conduct the work. The Joint Technology Center Systems Integration Laboratory (JTCSIL) at Redstone Arsenal, Alabama, provides simulation and testing of UAV software and hardware during and after the developmental phase. The Joint Interface Development Facility in Washington, D.C., provides engineering support for interoperability and commonality issues. The latter organization also provides a capability for evaluating new technology payoffs and investment strategies.[7]

The purpose of the UAV-MR program, as stated in the JPO's published *Concept of Operations,* 11 June 1991, is to provide "a fully autonomous, high speed, survivable vehicle that provides high quality, real and near-real-time digital reconnaissance imagery of heavily defended targets."[8] The operational concept is one of a complementing role to manned aircraft and will be discussed in more detail later in this paper.

The UAV-MR has three specific missions. They are, as defined in the Joint Chiefs of Staff (JCS) Pub 1-02:

> Reconnaissance: A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy; or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.
>
> Target Acquisition: The detection, identification and location of a target in sufficient detail to permit the effective employment of weapons.
>
> Battle Damage Assessment: An evaluation of information to determine the potential or actual nature and objectives of an attack for the purpose of providing information for timely decisions.[9]

The ATARS system employed on the UAV-MR will provide two of the three imagery capabilities that will be available to the F-16(R) and F/A-18 ATARS-equipped manned aircraft. The UAV-MR ATARS equipment will provide low-altitude electro-optical (LAEO) sensor capability—essentially television—and an infrared line scanner (IRLS) sensor capability. The system capabilities of the UAV-MR allow a low-altitude 140-degree electro-optical scan of the target area or a high-altitude 140-degree infrared scan. The additional capability of the ATARS-equipped manned aircraft will include a medium-altitude electro-optical capability.[10]

The JPO efforts of maximizing the capabilities available from current and emerging technologies and applying them to all UAV systems is centered on the mission need statements from the different services. The missions vary significantly, and the outcome of their efforts are key to the envisioned capability of providing enemy information to all levels of command in a format that will allow an almost real-time evaluation of the battlefield. Figure 7 identifies an abbreviated description of the mission needs of each system. Refer to figure 4 for the design ranges of the different systems that will be required to meet the mission needs of each of the UAV aircraft. Detailed examination of the close, short, and endurance vehicles is beyond the scope of this paper.

Mission Need Statement, Requirements Categories, and Family Concept

	Close	*Short*	*Medium*	*Endurance*
OPERATIONAL NEEDS	RS, TA, EW, MET, NBC	RS, TA, MET, C^2, EW	PRE/POST STRIKE RECONNAISSANCE	RS, TA, C^2, MET, NBC, SIGINT, SPEC OPS
LAUNCH AND REC	LAND/SHIPBOARD	LAND/SHIPBOARD	AIR/LAND	LAND
RADIUS OF ACTION	50 km	150K km BEYOND FLOT	650 km	CLASSIFIED
SPEED	NOT SPECIFIED	DASH >110 KNOTS CRUISE <90 KNOTS	.9 MACH	NOT SPECIFIED
ENDURANCE	8 HRS MINIMUM	8–12 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/NGT IMAGING EW, MET, NBC	DAY/NGT IMAGING DATA/COMM RELAY RADAR, SIGINT, MET MASINT, TD, EW	DAY/NGT IMAGING SIGINT, MET, EW	SIGINT, MET, DATA/ COMM RELAY, NBC, IMAGING, MASINT, EW
AIR VEH CONTROL	PREPROGRAMMED/ REMOTE	PREPROGRAMMED/ REMOTE	PREPROGRAMMED	PREPROGRAMMED/ REMOTE
GROUND STATION	VEHICLE & SHIP	VEHICLE & SHIP	JSIPS	VEHICLE & SHIP
DATA LINK	WORLDWIDE/LOW HIGH INTENSITY	WORLDWIDE/LOW HIGH INTENSITY	WORLDWIDE/LOW/ HIGH INTENSITY	WORLDWIDE/LOW HIGH INTENSITY
CREW SIZE	MINIMUM	MINIMUM	MINIMUM	MINIMUM
SERVICE NEED/ REQUIREMENT	ARMY, NAVY, MC	ARMY, NAVY, MC	NAVY, AF, MC	ARMY, NAVY, MC

Legend:

- C^2 - Command and Control
- COMM - Communications
- EW - Electronic Warfare
- FLOT - Forward Line of Own Troops
- JSIPS - Joint Service Imagery Processing System
- MASINT - Measurements and Signatures Intelligence
- MC - Marine Corps
- MET - Meteorology
- NBC - Nuclear, Biological, and Chemical
- RS - Reconnaissance and Surveillance
- SIGINT - Signals Intelligence
- SPEC OPS - Special Operations
- TA - Target Acquisition/Target Spotting
- TD - Target Designator

Source: Department of Defense, *Unmanned Aerial Vehicle Master Plan*, 1 March 1991.

Figure 7. UAV Mission Need Statement

Critical to the success of the UAV mission is, of course, the mission planning function. As now envisioned, this will be performed at the squadron level in all services. In the Air Force the Mission Support System (MSS) currently in use in fighter squadrons and the flight plan used to perform the preprogrammed mission profiles include all climbs, descents, ground-track, and sensor-activation commands. The other services have similar systems they will use to plan the mission for their UAV-MRs.

The following is a typical Air Force mission profile as envisioned in the current *Concept of Operations*. It does not include detailed considerations such as threat, weather, command and control, possible political considerations, airspace management, and so forth.

Once tasking for the reconnaissance mission has been directed and the decision is made to employ a UAV-MR, mission planning will be conducted by a designated group at the flying squadron consisting of operations (pilots), intelligence, weather, and imagery interpretation personnel. Concurrently a maintenance team will prepare the vehicle for launch. Preparation will require three hours to uncrate and assemble the vehicle and another 15 minutes for conducting checkout, loading mission profiles, attaching of the rocket booster, and final arming. An alert status will reduce this time significantly.

Following launch the UAV-MR will fly the programmed profile that could include high-, medium-, or low-altitude coverage of one or several target areas within a radius of 360 nautical miles. The flexibility of the system will allow changes in altitude, airspeed, and ground track to minimize known threats. The target coverage could be either a point or area target, or a combination of both. Upon completion of the mission the vehicle will arrive at a predetermined position that puts it in line of sight of the ground station, at which time it will downlink the digital-data imagery. The ground station may be either the Air Force's or one from another service. While the data is being processed, the vehicle will arrive at the recovery sight and automatically deploy its parachute for a "soft" landing. Following retrieval the data can again be downloaded, as a backup to the airborne information transfer, before beginning a six-hour refurbishing process prior to the next mission. Other UAVs could be kept on "alert" status, considerably reducing the response time following tasking.

This capability overlaid on a map of the Kuwaiti theater of operations gives a glimpse at the capability of the system. With a mission radius of 360 nautical miles, the UAV-MR could have been ground launched from well inside Saudi Arabia and easily have provided information on Republican Guard forces dug in along the North Kuwaiti border. Coverage also could have been provided for the entire ground offensive and for the road north through Basra. The UAV-MR capability would have lent itself to limited Scud reconnaissance, but due to the flexibility required in locating mobile targets, the more important role of the UAV-MR would have been to relieve manned platforms of fixed-site missions. Figure 8 shows the radius of operation had the UAV-MR been launched from a safe 100 miles inside Saudi Arabian territory.

Coverage of the Baghdad area would have required an air launch. In this case, an F-16(R) would have delivered the UAV to a launch position inside Iraqi territory but well outside heavily defended Baghdad. From the launch point the UAV could have easily conducted its reconnaissance mission over/around Baghdad and returned for a recovery in friendly territory.

In this combat mission profile a number of questions arise that must be addressed for the mission to be successful. They include some complicated issues that require close scrutiny of current doctrine, survivability, operational procedures and tactics, and command and control. These issues are addressed in chapter 4 along with an analysis of considerations for the bed-down of UAV operations in the restructured Air Force.

The schedule for the initial operational capability of the UAV-MR at the time this paper was written shows a production milestone date of early 1996. The vehicle is now in full-scale development with operational testing that began in calendar year 1992. With the defense drawdown that is currently under way, force multipliers such as improved command and control, weapon-system reli-

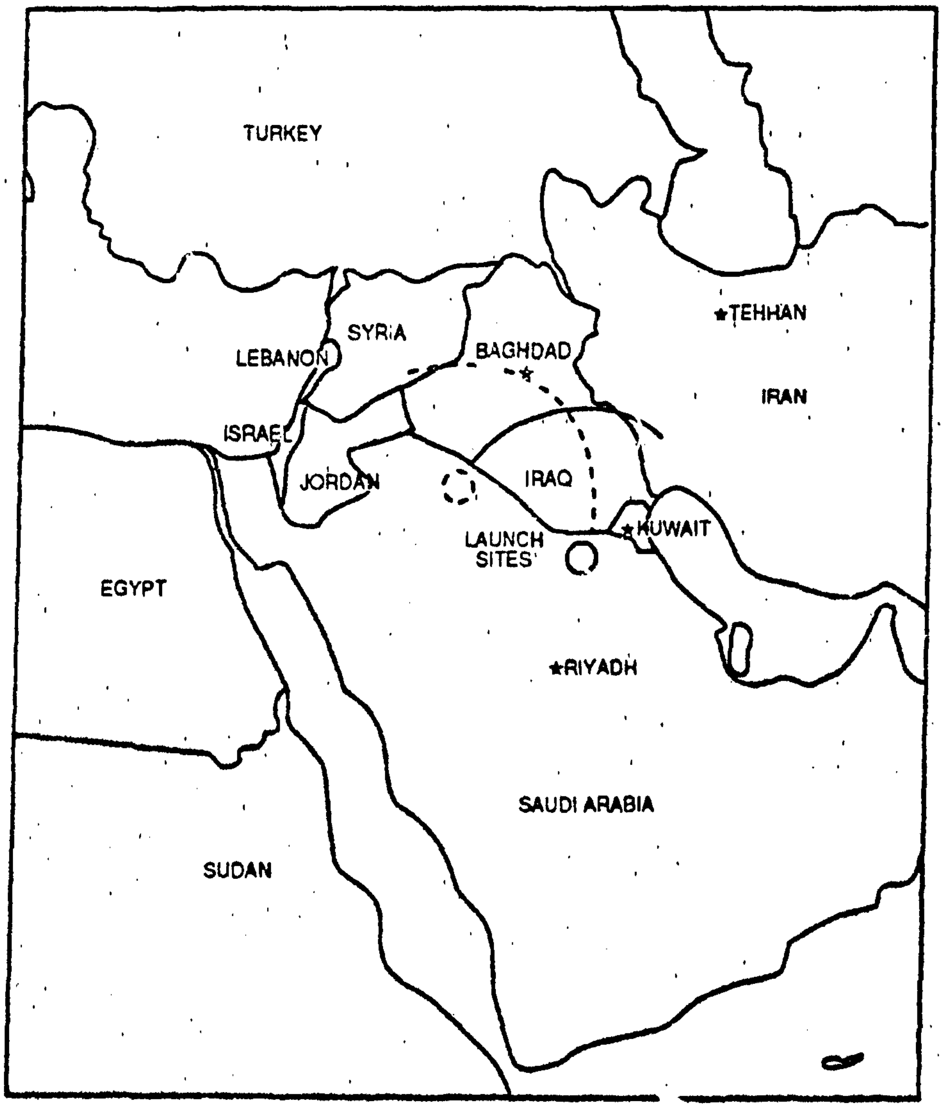


Figure 8. Gulf War Overlay of Medium-Range UAV Capability

ability, technological superiority, and maintainability become even more important. Intelligence will be one of the key force multipliers that will allow the US and/or US-supported coalitions to attain maximum use of available combat equipment and personnel.

Operation Desert Shield/Storm proved that even with sophisticated equipment and a huge peacetime intelligence-gathering empire, we still lacked information on what Saddam Hussein was up to before and after his invasion of Kuwait. The threat assessment of the world situation for the remainder of the 1990s and into the next century indicates that conflicts will most likely occur on a regional basis and be somewhat limited in scope. "In the emerging post–Cold War world, international relations promise to be more complicated, more volatile, and less predictable."[11] Having to employ forces in a region against enemies and under conditions that didn't exist until very recently will undoubtedly leave us with a lack of information on the intentions and capabilities of new leaders and organizations. For example, as this paper is being written it appears likely that United Nations forces will be committed to Yugoslavia to oversee a cease-fire agreement between their internal warring factions. Our knowledge of the forces pitted against each other is, at best, limited. Also, the tensions caused by former Soviet states vying for political, economic, and military power create an environment rich for conflict in an arena of which we have little information. Deployment of forces to one of these areas would require us to have an unprecedented ability to gather information on the disposition of belligerent forces.

What this has to do with unmanned aerial vehicles lies in the importance that must be placed on information-gathering capabilities of our forces in a rapidly changing world. To maintain a current data base of information on all areas of the globe is not possible. The reestablishment of national boundaries and the creation of new nation-states and coalitions are occurring faster than map makers can update their products. If Secretary of Defense Dick Cheney is right in his assessment of the future threats around the globe, the "next war" will most likely be fought in support of a counterinsurgency or counternarcotics operation or a small regional conflict that could occur in any number of areas around the globe.[12] UAVs could play a critical role in providing key information to military and political leaders in obtaining the necessary information to prevent armed conflict. Or, UAVs could work in conjunction with other information-gathering systems to ensure maximum effectiveness of our forces on the battlefield. Below is a schematic that highlights the assessment by Secretary Cheney upon which our defense establishment is being restructured.

Scenarios for Conflict

Scenario	*Probability of Occurrence*	*Consequences of Failure*	*Level of Violence*
Peacetime engagement (counterinsurgency/ counternarcotics)	Medium to high	Very low	Low
Lesser regional to contingencies	Medium	Low	Low to medium
Major regional contingency, West (Asia, Pacific)	Low to medium	Medium	Medium to high
Major regional contingency, East (Middle East, Persian Gulf)	Medium to high	High	High
War escalating from European crisis: potential for global conflict	Very low	Very high	Very high

Source: John T. Correll, "The New Defense Strategy," *Air Force Magazine*, July 1991, 27.

The advantages of the UAV-MR—no risk to human life, ability to get under the weather, relatively low cost, real-time digital information, rapid-deployment capability, and interoperability with the other services—make it a weapon system whose contribution to tomorrow's battlefield cannot be taken lightly. To ensure the UAV-MR is maximized as it is brought on-line will require an absolute commitment on the part of senior leaders and combat planners. The restructuring of the Air Force provides a great opportunity to implement a coherent plan to integrate this new system into the force structure. An open mind and careful planning will ensure that the Air Force will make the most of this new system on tomorrow's battlefield.

Notes

1. Briefing, Secretary of the Air Force/Acquisition (SAF/AQ), subject: FOTRS, n.d.
2. Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, *Concept of Operations, Unmanned Aerial Vehicle-Medium Range (UAV-MR), BQM145A* (Washington, D.C.: 11 June 1991), 6–22. Hereafter referred to as *Concept of Operations*. Also, some information was gained from the author's conversations with JPO officers during a visit to the JPO office in August 1991.
3. Ibid.
4. Department of Defense, *Unmanned Aerial Vehicle Master Plan*, 1 March 1991, M-U42214-111, 4.
5. "Gulf War Successes Push UAVs into Military Doctrine Forefront," *Aviation Week & Space Technology*, 9 December 1991, 38–39.
6. *Master Plan*, 7.
7. Ibid.
8. *Concept of Operations*, cover letter.
9. Ibid., 3, quoted from the Department of Defense, Joint Chiefs of Staff (JCS) Publication 1-02, *Dictionary of Military and Associated Terms*, 1 December 1989.
10. SAF/AQ Briefing.
11. *National Security of the United States*, The White House, August 1991, 2.
12. John T. Correll, "The New Defense Strategy," *Air Force Magazine*, July 1991, 26–30.

Chapter 4

Doctrine, Beddown, and Employment

This chapter addresses some of the principles and considerations that should be used in the Air Force's adoption of the medium-range unmanned aerial vehicle as a major contributor to improving tactical battlefield intelligence. Because most of the issues have been addressed to varying degrees by the organizations working the UAV and associated programs, I will review the background, status, and direction of the program.

First, basic and operational doctrine as it applies to battlefield intelligence deserves reexamination. Basic doctrine has been published recently, while operational doctrine has not been updated in published form since 1977, likely because it is fundamentally solid. This is apparent if you compare its major components to lessons learned from Operation Desert Storm discussed in chapter 2.

By definition, Air Force doctrine is derived from "what we have learned about aerospace power and its application since the dawn of powered flight."[1] It should guide our efforts, keeping us focused on the best way to accomplish our mission while evolving to stay applicable in light of new technologies, threats, and experiences.[2] Current doctrine states that as a major aspect in providing force-enhancement capability tactical air reconnaissance "includes support of Air Force counterair, air interdiction and close air support operations and includes direct support of surface forces."[3] Current doctrine also recognizes major objectives and operational determinants in providing sufficient battlefield intelligence. "The overall objective is the timely collection of information throughout the conflict spectrum . . . for all friendly forces"[4]—information related to the disposition and intent of enemy forces. Even before the advent of such new technologies as refined inertial capability and the highly accurate Global Positioning System (GPS), doctrine manuals recognized the capability of UAVs to complement manned and unmanned systems in the collection of intelligence information. AFM 2-6, *Tactical Air Operations—Reconnaissance*, states that multisensored manned and unmanned aircraft are necessary to collect information in a high-threat environment. Although a common argument against the use of UAVs is their inability to survive in a hostile environment, Desert Storm experience was significant in demonstrating the opposite. Few of the systems lost during operational missions were lost to enemy fire.[5] Although the UAV-MR may sometimes operate in a somewhat different environment than the Pioneer did in Desert Storm, the apparent success of the Tomahawk cruise missile tends to give credence to the survivability of a small low-flying, high-subsonic unmanned vehicle.

In reviewing the likely conflict scenarios as seen by Secretary Cheney (discussed in chapter 3), it becomes apparent that the high threat of the future may lie in either the enemy's defensive firepower or the political sensitivity of missions involving manned aircraft. Addressing the political sensitivity issue would lead to a suggestion that other national systems would be employed for imagery intelligence in times when manned flights were inappropriate. A lengthy discussion of the ability and availability of those systems is beyond the purview of this paper. It is sufficient to say that, in general, information from national systems will not always fulfill the doctrinal objectives of tactical battlefield intelligence as discussed above. Foreseeing a need for imagery then becomes a major issue, when manned vehicles may not be available or appropriate, in determining the requirement for the Air Force to employ UAVs. Another restriction that limits manned systems is weather.

A lesson learned in the deserts of Iraq is that cloud cover can limit collection of imagery. Information in the appendix provides a look at several randomly selected areas around the globe with respect to the amount of cloud cover that would be faced during military operations. Information available provides the percentage of the month that there is a ceiling of 3,000 feet/1,000 feet or less respectively and/or visibility of 2.5 miles or less. Either condition would create complications for manned or national systems to gather imagery through electro-optical or infrared systems. UAVs, however, increase the capability to operate in marginal weather due to their impervious attitude towards being highlighted by ground-defense systems against cloud ceilings or having to operate with reduced visibility. What the information in the appendix does *not* do is provide the time during each month that there is a ceiling above 3,000 feet.

The data clearly shows, for example, that during a conflict in Korea the weather would interfere significantly with the collection of imagery in the worst case more than one out of every four days. In the best case, during a 90-day conflict, weather would be a significant factor an average of 13 percent of the time. A look at the terrain in the southern part of North Korea shows considerable mountainous areas where the weather would be even worse and the risk to pilots greater.

The manner in which the system is bedded down within the existing force structure will impact the doctrinal implications in the employment of the UAV-MR. Command and control, mission planning, launch and recovery, airspace control, supportability, deployability, interoperability (within the attached unit and in the joint arena), and training will be major considerations in the beddown plans for the UAV-MR. Preliminary plans being worked at the UAV JPO and at Langley AFB, Virginia, address these areas and more. At this stage the plans are most certainly flexible, with the initial operational capability not expected until near the end of the decade.[6]

Because the UAV-MR vehicle is only part of the complete reconnaissance system—UAV vehicle, Advanced Tactical Air Reconnaissance System payload, F-16(R), Joint Service Imagery Processing System ground station, ground-launch vehicle, and the mission planning system—coordination is complex and initial operational capability is dependent on other systems. The integration of the UAV-MR will likely parallel the deployment of the F-16(R), which is to be a modified F-16 capable of conducting its full range of missions plus carrying the ATARS pod. The current plan calls for incorporating the F-16(R) into existing F-16 squadrons in the active duty in "six packs." The National Guard would have the only dedicated reconnaissance squadrons with F-16(R)s and presumably would be equipped with the UAV-MR. Active duty composite wings would have both F-16(R) capability and UAV-MRs. This would provide a significant capability that would fully support stated reconnaissance doctrine, as discussed earlier. The plan for the UAVs is to bed them down in 20-PAA (primary assigned aircraft) units, using a total of 100 vehicles, while the remainder of the total inventory would be used for testing and training, or placed in war reserve materiel storage.[7]

This concept allows UAV-MR integration into combat operations in a way that will allow maximum opportunity for streamlined command and control, operational flexibility in mission execution, airspace coordination, and composite/joint training. Deployment with composite wings will ensure that the systems are in the "first to go" organizations, maximizing the force-multiplier effects the system should provide.

Complications created with integration into existing fighter squadrons include four significant points. First is the possible conflict with mission prioritization. The UAV mission would be third priority behind fighter operations and manned reconnaissance flights. This could impact training as well as combat operations. Next, there is a significant challenge to developing a personnel support structure that works well in peacetime with limited required training but becomes manpower intensive during contingency/combat operations. Third, the lift requirements for a fighter squadron to deploy will increase significantly, and will be complicated, in conjunction with the fourth problem—dispersion of squadron assets and leadership if the UAVs are needed at a separate location. Always being able to deploy with the parent unit is an eventuality that will be determined by situations beyond the control of a policymaker designing operational concepts years ahead of time.

It's a phenomenon hard to document, but there also seems to be a prevailing attitude in parts of the fighter community and in some leadership circles that is resistant to the idea of using UAVs to complement manned aircraft. This, if indeed true, will be stronger in units that have a "shooting" mission. Combining the reconnaissance mission with fighting units may not be energetically supported at first because the employment of the UAV may be viewed as another level removed from the primary mission. Without getting into detailed recommendations, this appears to be a leadership and professionalism issue that can be adequately addressed, but will need attention if the current concept of operations is implemented.

The personnel issues involved with bringing the unmanned aerial vehicle on-line are significant and are being worked hard. Because the system is "peacetime dormant," it will require little day-to-day attention to maintain. Beyond initial qualification, continuation training will likely include limited captive carry and mostly "all but launch" preparation and planning, with few actual flights. Mission planning will be done by pilots with the existing mission-planning system, and existing squadron-intelligence support will be used to help plan the UAV missions. Currently, the estimation on the number of additional personnel to support a UAV operation stands at 60. One of the major issues here is how do you operate in wartime conditions if during peacetime your UAV technicians are functioning in dual roles such as crew chiefs, transportation specialists, and others. Also, deployability becomes complicated if there is a need to deploy a UAV unit to a separate location from the parent unit or individually move just a UAV capability into an area of operations without the flying unit. In this case, chain of command and unit leadership problems could arise.

To deploy a fighter squadron with a 20-PAA unmanned aerial vehicle subunit will push lift requirements up significantly. The operation will involve shipping ground vehicles, air vehicles, personnel, and support equipment. The more significant aspect is the increased scope of responsibility placed on the squadron commander. With the recent decision to subordinate maintenance organizations to the flying squadrons, adding a third major function may significantly detract from the supervision of manned operations. The Navy is proceeding in this direction, but their employment philosophy lends itself better to this mode of operations. The Navy intends to use the UAV-MR more as just another store to mount on the F/A-18, where the Air Force concept of operations is to use the vehicle mostly as a ground-launched system. This may be a good decision, but it differs significantly from the Navy operations.

Using the ground-launch system for a projected 80 percent of the envisioned Air Force sorties allows an opportunity to dislocate the launch area from the base of operations due to mission requirements (range, airspace, etc.) or for survivability considerations, but it requires additional support for security. Planning for this capability greatly increases the complexity of operations; not planning for this flexibility greatly limits the capability of the system.

Notes

1. Air Force Manual (AFM) 1-1, *Basic Aerospace Doctrine of the United States Air Force*, 1 March 1992, vii.

2. Ibid.

3. AFM 2-6, *Tactical Air Operations—Reconnaissance*, 4 February 1977, 1-3.

4. Ibid.

5. Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, *Concept of Operations, Unmanned Aerial Vehicle-Medium Range (UAV-MR), BQM145A* (Washington, D.C.: 11 June 1991), 2.

6. The date for initial operational capability is, as with many systems in today's changing environment, a floating target that is likely to undergo more changes as the budget priorities are reevaluated from year to year. The late 1990s was the latest available date at the time this paper was being written. That date comes from discussing the programs with officers at

Wright-Patterson AFB, Ohio, concerning the ATARS and the UAV JPO and at Headquarters TAC (now ACC) concerning the UAV-MR.

7. Many of the details of the requirements and specifics for the employment of the UAV are classified; therefore, more detail is not provided. Also, as with any system that is several years from initial operational capability, the deployment/employment concepts and plans are subject to revision. Some of the shortcomings that still exist in the beddown of the UAV include personnel planning, training, and logistical support. As is discussed in the next chapter, there seems to be a conflict in the purpose of the UAV-MR: is it to help provide information to the battlefield commanders or will it be just an improved system to support theater-level battle managers without helping to correct the lack of information flow to the unit commanders?

Listening and talking to A-10 and F-16 commanders who participated in Desert Storm teaches that there was, without a doubt, a significant lack of battlefield reconnaissance information provided to flying units. That war was fought against an essentially static enemy (except for the mobile Scuds, which helps to illustrate my point) with plenty of time to gather a tremendous amount of information before fighting started. Future conflicts, no matter the size, may not provide the same advantages.

Chapter 5

Summary and Conclusions

The first two chapters of this paper reviewed the development of unmanned aerial vehicles and their combat employment in Vietnam, the Arab-Israeli conflicts, and the Persian Gulf War. In chapter 3 I reviewed the design and objectives of the joint project office that is spearheading the development of the Navy and Air Force medium-range unmanned aerial vehicle that will be on board by the end of this decade. The fourth chapter highlighted major beddown and employment considerations for the UAV-MR that are being worked or are on the agenda.

Staffs at the UAV JPO in Washington, D.C., and Air Combat Command (ACC) at Langley AFB are working all the issues and have considerable expertise in the areas of UAVs and tactical reconnaissance. There are, from my perspective, no issues that haven't been addressed or at least put on the table for discussion. My intent is to highlight where it appears effort needs to be focused to ensure the US stays on track in developing UAV capability with an aim to complement existing and future force structure.

My recommendations include four major points. First, Air Force leadership must come on-line with clear support for the development and employment of the UAV-MR. This includes increasing the UAV budget priority. Second, tactical intelligence operational doctrine should be revised to match our development and employment concepts. Next, UAV employment should be readdressed to assure it matches likely future scenarios and operational constraints. Lastly, emphasis on total joint interoperability should be stressed to ensure all information available gets to the appropriate battlefield users.

Among officers working UAV issues there is a consensus that of all the services, the Air Force displays the least enthusiasm in supporting acquisition and employment of UAVs. Reasons for this may include the influence of narrow views on manned versus unmanned aircraft, concern that political support is building from a perspective that this is a way to replace increasing numbers of expensive manned aircraft, a genuine feeling that manned platforms and other systems can accomplish the mission without UAVs, a lack of desire to sacrifice any firepower capability for a "drone," and a lack of understanding of the capabilities and potential mission uses of UAVs.

At least three things are required to alleviate the skepticism. First, leadership should come on-line with increased support for the system and the mission. With a five-year void between phasing out the RF-4 and introducing the F-16(R), the mission appears to have low priority. Second, funding should be diverted to support UAV development and the other components of the follow-on reconnaissance system at an increased rate, in order to field the system sooner. Third, ACC should take advantage of the new alignment that gives them control of U-2 training assets to develop a new battlefield reconnaissance operational doctrine. ACC should publish a doctrine manual for combat operations, developed by experienced RF-4 crews and UAV experts with lessons learned from the Gulf War, to include experience gained from the employment and integration of the Joint Surveillance Target Attack Reconnaissance System and national capabilities.

The manual should be designed as a guide on how to fight and be a road map for the development of new systems. It should be specific on how to integrate all battlefield intelligence information and disseminate it to the users, at both the theater level and war-fighting level. Such a document will inevitably be written as the reconnaissance system now on the drawing board, or in development, comes into the active inventory. The establishment of such a document at this stage would be invaluable to ensure a focused guidance through developmental and operational test and evaluation phases. It would also serve as initial guidance on employment concepts, that is, in identifying when it would be appropriate to employ a UAV versus a manned aircraft or other systems.

Concerning employment concepts, there appears to be some discrepancy between the stated objective of the UAV-MR in the *Concept of Operations* and the acquisition of the ground stations that will receive information from the ATARS-equipped UAV or F-16(R). The operational concept supports the idea that battlefield information needs to get to the war-fighting commanders, but the current plan is to buy a limited number of ground stations and locate them at the theater level—the Tactical Air Control Center (TACC). Although this will significantly increase the capability at the theater level, it doesn't completely address the lesson learned from the Gulf that more information needs to flow to the operational commanders. Systems under development—Joint Service Imagery Processing System and associated communication networks and hardware—have the capability to ensure that all commanders receive ample intelligence imagery as well as other intelligence information if properly fielded and employed.[1]

In developing employment guidelines, personnel at both the JPO and HQ ACC expressed the caution that operational restrictions not be placed on UAVs due to a financial decision that a mission is too risky. If this type of employment philosophy were to develop, it is clear that the primary reason for developing UAVs—to prevent unacceptable risk taking by a manned aircraft—would be negated.

To ensure UAVs are used to their maximum capability, considerably more effort should be put into the Air Force's concept of operations. The issue of incorporating UAVs with F-16 units, whether or not in a composite wing, needs further review. If the capabilities of the UAV are going to be maximized, there needs to be a capability to deploy individual units autonomously. This concept will come under increased scrutiny as more details are hammered out and such problems as the manning issues and mission priorities within the flying units are addressed.

What should be done to ensure effective operational procedures are developed is to put the user in the driver's seat from here on out. The players are numerous and the organizations that impact decisions on the continued development and operation of the UAV-MR are complex, leading to a situation that has resulted in unnecessary major changes in the program.[2] The driving factor should be mission need, and no one is better suited than ACC to espouse that perspective.

The *UAV Master Plan* states that the "JPO is charged to maintain leadership in UAV system acquisition and to advocate UAVs as a significant war-fighting advantage to operational commanders."[3] This isn't necessarily wrong, but somehow seems to be a reverse from the ideal process of the war-fighting commanders being the drivers in requesting acquisition of demonstrated technologies/systems. A more interactive effort on the part of the unified/specified commands with the ACC on the universal acceptance and in-depth development of employment concepts would put this system more on track.

Another issue that needs review is the 80 percent ground-launch plan. A thorough review by the war-fighting commands would identify whether that employment concept would give the range and flexibility required to accomplish the mission and maximize the capability of the system within each theater of operations. A major determinant is the limited number of ground stations and their locations relative to the expected target area. For instance, had the ground station been employed in the Gulf War and located far from the area of employment, the system would have required a relay system not yet developed.

Interservice compatibility is an ongoing major issue that is being worked hard and needs continued efforts. The ability to use the ground stations of the other services will significantly add capability to UAVs and to F-16(R) and F/A-18 ATARS-equipped aircraft. All ground stations should have access to information from the ATARS-equipped aircraft and UAVs. At the time this paper was written it appeared uncertain that this was the case, with the Army possibly not buying the capability to receive information from the ATARS system. Future conflicts will be fought in the joint arena, which will demand that we have the ability to communicate and exchange information freely, even though any of the single services could perform limited operations. This exchange in itself could be a force multiplier that we can ill afford to be without.

In summary, it should be clear that we must maintain sight of the importance of battlefield reconnaissance and surveillance. The Gulf War caught us with a drastic shortage of tactical photographic reconnaissance capability, especially at the unit level; for example, only one and one-half squadrons of RF-4s were available when many more were needed.[4] If the next war occurs in this decade, we may be in even worse shape.

The concept of employing UAVs on the modern battlefield is proven. Reconnaissance doctrine supports their use and lessons learned from the Gulf War reinforced the need to further capitalize on this capability. The UAV-MR has unique characteristics that can add significantly to the capabilities of the Air Force if given the right budget priorities and integrated in support of proven doctrine.

Considering the likelihood that we will fight on someone else's turf in the future, we cannot afford to get to the playing field only to find that the weather won't let space-based national systems or high-altitude manned reconnaissance flights see the enemy or that the political situation or combat threat is too high to risk manned platforms over enemy territory. The inherent capabilities of UAVs fill the voids left by other systems. However, without the right direction in bringing this weapon system on board, it may take another "lesson learned" to realize its true capability on tomorrow's battlefield.

Notes

1. Program Executive Officer, Cruise Missiles Project and Unmanned Aerial Vehicles Joint Project, *Concept of Operations, Unmanned Aerial Vehicle-Medium Range (UAV-MR), BQM145A* (Washington, D.C.: 11 June 1991), 1.
2. Delays that have occurred in the program caused by apparent oversight include readjusting the UAV-MR vehicle to accommodate uncoordinated changes to the ATARS pod and a change in the UAV-MR vehicle structure from composite to metal because of complications due to possible delamination if exposed to sea water. This information was obtained from several individuals working closely with the UAV project.
3. Department of Defense, *Unmanned Aerial Vehicles Master Plan*, 1 March 1991, 4.
4. "Gulf War Successes Push UAVs into Military Doctrine Forefront," *Aviation Week & Space Technology*, 9 December 1991, 39.

Appendix

Weather Patterns

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Vientiane, Laos												
Ceiling <3,000 ft.	12	17	21	22	26	28	29	30	27	15	9	20
* <1,000 ft.	10	14	18	16	11	12	12	16	15	7	4	5
Mean Precip (%)	.3	.6	1.5	3.8	10	12	11	13	14	4	.7	.2
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Osan, Korea												
Ceiling <3,000 ft.	20	16	18	17	16	24	30	20	18	20	20	20
* <1,000 ft.	12	9	8	9	8	12	11	8	10	14	11	11
Mean Precip (%)	7	5	6	8	7	9	15	12	8	7	9	7
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tehran, Iran												
Ceiling <3,000 ft.	21	16	4	3	1	3	1	1	1	2	3	21
* <1,000 ft.	15	9	2	1	-	1	-	1	1	1	2	13
Mean Precip (%)	2	5	5	3	2	1	1	-	-	2	2	5
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minsk, Belarus												
Ceiling <3,000 ft.	76	69	57	45	35	37	41	35	47	63	79	83
* <1,000 ft.	45	42	32	15	7	7	7	8	18	29	44	53
Mean Precip (%)	data not available											

*Data is for ceiling as stated and/or visibility less than 2.5 miles. Numbers indicate percentage of days in the month that meet the 3,000/1,000 visibility criteria.

Source: USAF Environmental, Technical, and Applications Center, *Station Climatic Summaries*, DS 89/036, 266, 444, 130, DS/037, 32.

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