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TACTICAL RECONNAISSANCE: UAVS VERSUS MANNED AIRCRAFT

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The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the US government or the Department of Defense.

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Preface

An intense debate rages today about the utility of unmanned aircraft vis-à-vis manned aircraft. My reason for choosing this topic was to have a better understanding of unmanned aerial vehicles and how they compared with manned aircraft. I selected the role of tactical reconnaissance as UAVs offered the greatest promise in that area.

I wish to acknowledge that during this entire process of learning I had the guidance and support of ACSC Faculty Research Advisor Maj Charles Cunningham, USAF. Without his constructive involvement this project could not have been completed.

Abstract

Ever since the Isrealis demonstrated how Unmanned Aerial Vehicles (UAVs) could be effectively used in operations, interest in UAVs has intensified. Following their successful employment on the battlefield in Desert Storm, technology has driven the development of more capable UAVs. The major improvements in UAVs in recent years have been in the role of tactical reconnaissance. In this role the UAV has significant capabilities to offer, some that are unmatched by other platforms. This paper will demonstrate that with the growing importance of information in warfare the UAV is suited to fill the information gap on the battlefield. The doctrine for UAV operations has not kept pace with the fast paced developments in this field. Their organization also needs to break out of the traditional mind-set. When employed in an efficient manner, the inherent qualities of expendability and low cost make the UAV capable of significantly complementing manned aircraft platforms in the role of tactical reconnaissance.

Chapter 1

Introduction

An unadulterated picture still tells a thousand words.

—Anthony M. Thornborough

Interest in unmanned aerial vehicles has persisted sporadically ever since the first experiments of the mating of aerodynamic, light-weight engine, and radio technologies was first attempted in 1917. While the results of these initial tentative steps are of interest to serious historians our focus shifts to the era of development since the early sixties when the United States began to deploy unmanned platforms operationally in the reconnaissance role.[1] The United States, not wanting to be caught in a Pearl Harbor like situation again, took an aggressive approach to stay abreast of Soviet activities. The ordering of high altitude reconnaissance flights over the Soviet Union entailed the risk of having an aircraft shot down and this spurred the development of early RPVs of the Teledyne Ryan family.

The operational experience of the United States commenced with the Ryan 147 series, the development of which had been speeded up following the shooting down of a U-2 on 27 October 1962 over Cuba. The B version was designed for high altitude reconnaissance while the C version was modified for electronic intelligence (ELINT) work. The first strategic reconnaissance squadron using the Ryan 147 series was declared operational in 1963 and was extensively used following the Gulf of Tonkin incident in

1964. Early teething troubles apart, the missions validated that UAV operations in the roles of reconnaissance and signal intelligence (SIGINT) were possible and that the political fallout of downed manned aircraft could be avoided. The extensive use of drones during the Vietnam war provided the stimulus for the development of the Microwave Command Guidance System (MCGS), a mid-air retrieval system (MARS), and the Hycon camera.[2] The payloads evolved over the war to include photographic cameras, electronic reconnaissance equipment, chaff, and night reconnaissance equipment.

During the operations in the Far East the survivability question was answered by the development of higher flying UAVs with greater range and endurance. The information gathered therefore tended to be at the level of theater-strategic. This led to problems of lower resolution and interference of operations by weather. The Ryan 147SC was then developed to fly low level missions under the missile and radar detection envelope. It flew 1651 missions with a return rate of 87.2%. [3]

The development of newer and more sophisticated air defense systems raised new questions about the survivability of UAVs until the successful Israeli demonstration of the flexibility of use of truly small size UAVs (being inherently stealthy because of size) in Bekaa Valley. The successful marriage of a Ground Control Station (GCS) with a two way data link, a small UAV, and the gyro-stabilized TV camera had made history. The Syrians lost 19 SAM batteries and 86 aircraft for the loss of one Israeli aircraft.[4]

During Desert Storm the Pioneer UAV was used extensively to provide near real-time imagery. At least one Pioneer was in the air at all times during the war and only one machine was lost to enemy fire out of 522 sorties (1641 hours).[5] With technology in computing power, sensor miniaturization, and the capacity of satellite data-linking making rapid advances it is now possible to deploy the Predator in Bosnia which allows the vehicle to be "piloted" from a cabin in nearly all weather conditions through a hostile environment and transmit its images in real time to Washington and the theater commander for effective analysis.

UAVs In Tactical Reconnaissance Today

In spite of the initial problems of Predator operations in Bosnia (three Predators have crashed to date)[6] the system has provided enough intelligence to enforce the peace for over a year at the time of writing this paper. With the follow on developments of the Tier II-plus and Tier III-minus UAVs (described later) using cheap commercially available technology the unmanned platform is evolving into a reliable system. This evolution of the unmanned aerial vehicle into a mature platform capable of diverse tasks make it capable of significantly complementing manned aircraft in the tactical reconnaissance role. The removal of the human operator from the cockpit make it the logical choice to replace the manned aircraft in high risk missions.

Notes

[1]Armitage, Air Chief Marshal Sir Michael *Unmanned Aircraft* (Brassey's Defence Publishers), 1, 65.

[2]Ibid., 65-73

[3]William Wagner *Lightning Bugs and other Reconnaissance Drones* (Aero Publishers, 1982), 213.

[4]Armitage, Air Chief Marshal Sir Michael *Unmanned Aircraft* (Brassey's Defence Publishers), 86.

[5]J R Wilson "Suddenly Everyone Wants a UAV" *Interavia Aerospace Review*, December 1991, p43.

[6]Breen, Tom & Bender, Bryan "Predator Crashes In Bosnian Minefield" *Defense Daily*, October 2, 1996, p15.

Chapter 2

Capabilities of Manned Aircraft and UAVs

> *As we search for that correct balance we can neither adopt the unrealistic assumption that* nothing *has changed nor the historically naive position that* everything *has changed* [emphasis in original]
>
> —The Air Force and US National Security:
> Global Reach–Global Power

Technically it is possible to fly almost any manned aircraft by "remote control" indeed many aircraft have been converted into single flight target drones for practice to missile and gun crews after their service life is over. One prominent example of such types is the Mig-15 used by the Russians in live missile fire tests. Despite this capability there are limitations on what commands can be sent to the autopilot on board the flying platform and the what the autopilot can do with those commands. Thus manned aircraft and unmanned aerial vehicles have evolved around different design philosophies. The former has always remained at the cutting edge of technology and has used performance or agility as a primary means of survival in a hostile environment. The unmanned aerial vehicle on the other hand has always had modest performance targets and has relied on its size and unconventional flight profiles to survive in a high threat environment. This fundamental difference has led to two different approaches on how to solve the reconnaissance problem and has prompted the question—which approach is better?

Manned Aircraft

Though reconnaissance was the first military task performed by an airplane there have been few aircraft that have been designed purely for reconnaissance in the post World War II era. Even in aircraft like the SR-71 and U-2 the design features have been maximized for high speed or high altitude to ensure survivability. This led to high cost and increased mission support making them suitable mainly for the purpose of strategic reconnaissance. Rarely could these national assets be spared or coordinated for tactical reconnaissance tasks.

In the field of tactical reconnaissance—on which this paper focuses—the preferred solution was modification of existing fighter designs by fitting internal or podded specialist sensors or equipment. Taking advantage of the role flexibility of existing designs a number of aircraft like RF-4, RF-111, and EF-111 were created. The RAAF has even set the stage for a dual role tactical reconnaissance-strike aircraft type by the manner in which it has modified and the way it employs the RF-111C. The internal sensor suite of KS-87C day and night cameras, KA-93A4 horizon-to-horizon panoramic cameras, AN/AAD-5 variable-swath IRLS, and AN/APQ-113 attack radar set has in no way compromised the overall strike capability of the aircraft.[1] Similarly a TARPS (Tactical Airborne Reconnaissance Pod System) equipped F-14 with its complement of four air-to-air missiles and 20mm "Gatling" gun is not a reconnaissance aircraft you want to pick a fight with![2]

The development and retro-fitting of 'near real-time' capable systems that are able to record data in D-500 format and transmit digitized images over existing HF/UHF radio communications systems to ground receiving stations has enhanced the capability of manned aircraft in the tactical reconnaissance role manifold. They have all the advantages of fighter aircraft of speed and flexibility of operations and have a quick response time. In addition, manned aircraft have integral self defense and are capable of multiple roles and can carry a number of payloads both by day and night. Further, features like GPS, advanced navigation and landing systems, autopilot coupled TFR, SAR, and mission planning systems capable of generating digital terrain maps have provided the manned aircraft increasing capability to perform in all-weather conditions.[3]

The capabilities of manned aircraft are impressive, however they are extremely expensive complex machines that require specially trained pilots to fly and frequently the limiting factor in their operation is pilot related—operational training status for the mission at hand, rating, training continuity and the like. A case in point is the learning curve required on USAF F-111 squadrons beginning with 'Strike Day' followed by 'Strike Night' before transitioning to reconnaissance roles.[4] The multiple role capability of these aircraft also makes aircrew training and currency difficult, expensive (despite simulators), and time consuming.

Another factor that complicates the mission is that reconnaissance is frequently required in a hostile environment and 'alone, unarmed, and unafraid' aircraft are always at risk of being lost to enemy hostile action. This is especially true in the pre-hostilities phase when the reconnaissance requirement is acute and the enemy air defenses are at full capacity and on alert status. The non-stealth features and the relatively large signatures of these aircraft only compound the problem.

Intelligence needs today differentiate between the terms reconnaissance and surveillance. The former is associated with a snapshot view of the battlefield while the latter is analogous to continuous monitoring of the situation as it unfolds on the battlefield.[5] In modern wartime situations—for reasons discussed later in the paper—there is an increasing trend towards surveillance. This requirement involves long duration sorties which may be within the capabilities of aircraft but will increasingly become beyond the endurance of pilots. In theory it is possible to overcome this problem by replacing aircraft on station but the strain of keeping and maintaining a large fleet of aircraft and pilots will tell on any modern economy.

Unmanned Aerial Vehicles

Unmanned aerial vehicles have always relied on already developed aviation technologies to meet their relatively modest performance criteria. Most airframe designs have evolved out of the body of knowledge of aerodynamic design. Reciprocating engines and propeller designs have been matched with UAV design from proven research. The only major design areas exclusive to UAV development were guidance and control technology and small jet engines. Even in small jet engine design the real breakthrough came from the designers of United States Navy's cruise missile research team with the development of the WR-19 that delivered 430 lb. of thrust at .71 lb./hr/lb. thrust for an engine weight of only 68 lb.[6]

Today's UAVs employ the latest sensor and communication technologies to deliver a capability that cannot be ignored. Improvements in miniature solid state gyros and sensors have made the platform reliable in terms of flight control. The revolution in communication technology has made uplinking of flight and mission commands to the vehicle and downlinking of data from the vehicle possible at much larger rates and over further distances than what was predicted just a few years ago.

The term UAV is very broad and encompasses vehicles such as cruise missiles (which can be described as single mission UAVs), target drones, and decoys; therefore the following discussion will be confined to multi-mission, man-in-the-loop machines specifically designed and employed for the purpose of surveillance and reconnaissance. The capabilities of the most recently deployed UAV—Predator—include carriage of Electro-Optical (EO), Infra-Red (IR), and SAR sensors, flying at altitudes up to 25000 feet, endurance up to 40 hours (including 24 hour autonomous operation on station), and speeds of 110 knots.[7] Imagery and commands can be transmitted to and from the UAV either by C-Band line -of-sight or one of two SATCOM data-links (UHF or Ku-Band). Its radius of action is 500nm. Its performance in the early missions in Bosnia caused Admiral William A. Owens, VCJCS to say:

> I was looking at Predator [imagery display] yesterday.…It was flying over an area…at 25,000 feet. It had been up there for a long time, many hours, and you could see the city below, and you could focus on the city, you could see a building, focus on a building, you could see a window, focus on a window. You could put a cursor around it and [get] the GPS latitude and longitude very accurately, remotely via satellite. And if you passed that information to an F-16 or an F-15 at 30,000 feet, and that pilot can simply put in that latitude and longitude into his bomb fire control system, then that bomb can dropped quite accurately onto that target, maybe very close to that window, or, if it's a precision weapon, perhaps it could be put through the window…I'd buy a lot of UAVs in the future.[8]

The United States has attempted to harness the current capabilities of UAVs by ordering the development of a family of UAVs based on altitude, range, endurance and role criteria. Tier I referred to close range, medium endurance, and low-medium altitude vehicles like the Hunter, Tier II was the classification for Predator—medium altitude, medium range, and high endurance vehicle. Under study are Tier II plus—a long range, high altitude and endurance vehicle called Global Hawk, and the Tier III minus—a low observable, high altitude and endurance vehicle called Dark Star, that sacrifices some of its performance for stealth. These programs have been renamed as Joint Tactical UAV, Medium Altitude Endurance UAV, Conventional High Altitude Endurance UAV, and Low Observable High Altitude Endurance UAV respectively but the old and new designations are used interchangeably. A new program for maneuver UAV has also been initiated. A summary of their performance parameters is shown in Table 1.

Table 1. Categories and Proposed Capabilities of Current US UAV Programs

Category	Designation	Altitude	Range	Speed (Cruise)	Endurance	Sensors	Status
Tier I	Joint Tactical	15,000 ft	108 nm	65 kts	12 hrs	EO/ IR	Hunter in service
Tier II	Medium Altitude Endurance	25,000 ft	500 nm	110 kts	40 hrs	EO/IR/ SAR	Predator in service
Tier II Plus	Con High Altitude Endurance	65,000 ft	3000 nm	340 kts	40 hrs	EO/IR/ SAR	Global Hawk in development
Tier III Minus	LO High Altitude Endurance	45,000 ft	500 nm	250 kts	8 hrs	EO/IR	Dark Star under testing

Source: Defense Technical Information Center *Annual Report Unmanned Aerial Vehicles August 1995*. Ft. Belvoir, VA. p27.

This array of capabilities tend to underscore the limitations that include being capable of single role, low payload, and low speed. The initial flight profile and small size may mask the initial entry but once detected the system is vulnerable to enemy air defenses and fighter aircraft. A single type of UAV will not meet all requirements and frequently more than one type of vehicle will be needed to complete the task. Also, though the UAV overcomes many of the limitations of manned aircraft in weather, some UAVs suffer from their inability to operate in icing conditions due to the inherent disadvantages of incorporating extra weight into such small vehicles.

Notes

[1]Thornborough, Anthony M., *Sky Spies Three Decades of Airborne Reconnaissance.* Arms & Armour Press, London 1993. p93-94.

[2]Ibid p77

[3]Ibid p65-101. Describes in detail all the mentioned systems and their evolution on a multitude of western and Soviet aircraft types.

[4]Ibid. p97.

[5]Marshall, James P., *Near Real-Time Intelligence On The Tactical Battlefield* AU Press, Maxwell AFB, 1994. p13

[6]Armitage, Air Chief Marshal Sir Michael *Unmanned Aircraft* (Brassey's Defence Publishers), p89.

[7]DOT&E. *Predator Medium Altitude Endurance Unmanned Aerial Vehicle.* 27 Nov 96. Available on line from http://www.dote.osd.mil/.

[8]Defense Technical Information Center *Annual Report Unmanned Aerial Vehicles August 1995.* Ft. Belvoir, VA. p7.

Chapter 3

Organizational Structure of Manned Aircraft and UAV Squadrons

> *The most sophisticated intelligence collector in the world is worthless if the information it provides does not reach the commander in a timely manner.…The US has very efficient battlefield collection systems today, but management of these collection assets.… extremely inefficient.*
>
> —Brig Gen William E. Harmon

Manned aircraft tactical reconnaissance squadrons are organized along the conventional structures of operations and maintenance. Flying is a specialty business that is supported by its own training structures. Maintenance provides the mission support to the machines. Logistic functions also support the entire effort of launching and ensuring the success of the mission. Mission planning is the responsibility of the operations department as this is the place where the task is analyzed and the planning done. The collected data is handed over to intelligence authorities for analysis. These well defined functions become a little fuzzy when systems like JSTARS are considered that also serve as command posts or direction centers. Analysis is done on board itself and disseminated to the warfighter as the situation unfolds. These systems are however controlled and tasked at the theater level. The organizational structure of manned aircraft squadrons is therefore time tested and clearly defined.

By contrast UAV operations have had a myriad of organizational structures due to the different means of launch and recovery, and their reliability. A desirable organizational structure is still evolving. The operations in South-East Asia were characterized by strong support from the manufacturers as the systems were hurriedly transitioned into operations as new concepts were tried in quick succession. This was demonstrated in the case of the change from the high flying 147G to the low flying 147J that was completed by modifying its wing in early 1966. The contractor personnel were involved in actual flight operations until mid-1967 long after the formation of the Airborne Missile Maintenance Squadron (AMMS).[1] Following the development of MARS the effort required to recover the UAV was linked to tasking of helicopters and had to be coordinated leading to decisions at the staff level. All UAVs were assigned to Strategic Reconnaissance Wings and operated by Strategic Reconnaissance Squadrons that operated not only the UAV and its launch aircraft (if air launched) but manned reconnaissance aircraft as well.[2]

Following the experience of the Pioneer in Desert Storm a 'concept of operations' similar to manned aircraft reconnaissance squadrons was proposed. This has been described in an Airpower Research Institute paper as follows:

> Once tasking for the reconnaissance mission has been directed and the decision is made to employ a UAV-MR (UAV-medium range), 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. ... 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 ... 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 an 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 site ... 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.[3]

It is important to recognize that human control is retained from the outside in a UAV mission and while the operator is removed from the cockpit he is not removed from the mission.[4] In recognition of this fact the USAF is using rated pilots to control Predator UAVs; the decision being based on lower accident rates for rated pilots as compared to others.[5]

Thus while the operator will remain a key part of the mission the increasing endurance of UAVs will require multiple shifts to enable success of the mission. In addition, with increasing data being gathered as the time passes, and with more analysis the mission is likely to be modified during its flight. The mission will be focused around the activity in the Ground Control Station. The organizational structure therefore also needs to be versatile and flexible. If operations, maintenance, and mission planning functions are stovepiped then the organization will become unwieldy. The various specialist personnel need to be cross-trained to perform multiple tasks. Mission planning is a promising area of commonality especially in sensor programming -- for example a communication specialist responsible for maintaining the data link is qualified to assist in sensor programming and can be easily trained to do so. Multiple function is also highlighted by the realization that qualified pilots are always going to be in short supply and a large fleet of UAVs may put a strain on pilot availability. The 11th Reconnaissance Squadron at Nellis AFB which inducted the Predator formally on 29 July 1995 is already aware that its expected 125 person strength (comprising half operators and half maintenance personnel) is going to have problems filling its operator assignments from amongst qualified officer pilots. The following report outlines a possible solution:

> With pilot shortages looming, the Air Force is eyeing a compromise. Officials believe that once training procedures have been set in place by a convention cadre of pilots, the role might then be transferred to enlisted personnel who are experienced, FAA-certified pilots. In fact, 11th RS officials said they already are aware of a number of airmen, through a stream of unsolicited telephone calls to the unit, who are pilots and are interested in flying UAVs.[6]

In future operations the JFC will have the option of co-locating the GCS with the launch unit or the supported unit.[7] Multiple function training will increase the operational effectiveness in such situations.

Notes

[1]William Wagner *Lightning Bugs and other Reconnaissance Drones* (Aero Publishers, 1982), p112-113.

[2]Ibid. p193-199.

[3]Longino, Lt Col Dana A., *Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios*, AU Press, Maxwell AFB, p20-21.

[4]Wg Cdrs Mark Lax and Barry Sutherland *An Extended Role for Unmanned Aerial Vehicles in the Royal Australian Air Force,* p5.

[5]Ibid. p10.

[6]David A. Fulghum, “Air Force Prepares New UAV Acquisitions, Operations” *Aviation Week & Space Technology,* November 27, 1995. p 54.

[7]US Department of Defense, *Joint Publication 3-55.1 Joint Tactics, Techniques. and Procedures for Unmanned Aerial Vehicles.* Washington 1993. p II-9,10&11.

Chapter 4

The Emerging RMA And Its Effect On The Needs Of Tactical Reconnaissance

> *Something occurred in the night skies and desert sands of the Middle East in 1991 that the world had not seen for three hundred years—the arrival of a new form of warfare.*
>
> —Alvin and Heidi Toffler

The aftermath of Desert Storm has heralded a new era in the annals of warfare. The increased tempo of operations and the enhanced ability to fight efficiently at night has changed the way future wars will be fought. The employment of precision weapons and their demonstrated effectiveness has redefined the concept of mass. The success of these weapons has also created the realization that to employ precision sensibly and to sustain the tempo of operations, there is a need to have access to updated information. The fast paced operations require continuous updating of known intelligence especially at the operational and the tactical level. Much of this change has been driven by the available technology and its incorporation on the battlefield.

This new way of warfare has been characterized by leading military writers (originating from the Russian General Staff studies of the late 1970s) as the beginning of a Revolution in Military Affairs (RMA).[1] RMAs normally follow four stages—technological change, military systems evolution, operational innovation, and organizational adaptation.

Full exploitation of emerging technology can span a large length of time. Consequently while a high level of information and sensor technology is available today it has been integrated to only a fraction of its combat potential following the Gulf War. The Russian studies indicate that there will be a " greater reliance placed on rapidly acquiring, processing, and moving surveillance and targeting information" in future warfare.[2] According to one of the leading writers on military technological revolutions Andrew F. Krepinevich Jr., the nature of warfare would then be characterized by:

> A mix of ranged-fire systems, information systems, and the growing ability to exercise automated troop control.…When integrated these form the basis for…a reconnaissance strike complex (RSC).
>
> This network of networks (command and control, data acquisition, fusion, and dissemination, and weapon systems) can, theoretically, engage a wide array of critical targets at extended ranges with a high degree of accuracy and lethality. The growing capability for rapidly executed extended-range engagements employing non-nuclear weapons implies (in the Russian view) that, in crisis or in war, warning time is becoming progressively reduced, and that time will become an increasingly scarce commodity in future conflicts. Entire countries will become the battlefield. The distinction between "front lines" and "rear areas" will be blurred beyond recognition. In future wars, there will only be "targets" and "nontargets" In other words, it is becoming ever more practical to contemplate near-simultaneous operations against the entire array of high-priority enemy targets, a dramatic change from the "traditional" sequential nature of operations. As this occurs, we will see the lines between tactics, operational art, and strategy disappear.[3]

The critical factor, in this form of warfare, that will prove decisive is the ability to acquire and move information rapidly and deny the enemy the ability to do the same, or at the same pace. Information processing will become central to the outcome of future battle scenarios. While information has always played a major role in any past conflict, establishing information dominance over the enemy will become a major focus of the operational art in the future.[4] One of the key elements of this information dominance will be sensor-to-shooter fusion. Information systems will be required to collect data in a form that is directly interpretable and useable by the shooter.

The information factor directly impacts the mission of tactical reconnaissance. As far back as 1979, General Charles A. Gabriel (then the Air Force deputy chief of staff for plans and readiness) had summarized the needs for an ideal surveillance and reconnaissance system as "what is needed is a single invulnerable system that sees the entire battlefield 24 hours a day under all weather and light conditions, filters the information according to individual commander's needs and instantly transmits all pertinent information directly to the user just as events are occurring on the battlefield".[5] The need of such a system will not diminish in the future, in fact the requirements are going to become more stringent. Tactical reconnaissance is going to be just one of the processes within that system.

The threat environment in the future is also going to characterized by increased threat density and lethality, complex orders of battle, smaller and more mobile targets, all-weather 24-hour operations, and increasingly responsive enemies.[6] The tactical reconnaissance mission is going face increasing resistance by enemy forces as they try to deny us the means to collect information.

As the enemy develops effective counter measures to the warfighting philosophy of the future the effect of cover and concealment, underground and subsurface operations, and increased mobility will create a challenge for reconnaissance, surveillance, and target acquisition (RSTA) systems. The need for more detailed, faster, and more precise information will continue to increase. Modern and future war will continue to impose exacting requirements on tactical reconnaissance systems. The systems will be required to provide operational information to decision makers in a timely manner.

Space based systems, airborne stand-off surveillance platforms, unmanned aerial vehicles, and manned penetrating aircraft are going to be the core of reconnaissance and surveillance in the next century. These systems are complimentary as they provide separate and synergistic capability. Present day airborne reconnaissance is performed almost solely by a manned aircraft force. The increasing demand for continuous coverage of the battle area will require that an increasing load be taken on by UAVs to meet the demands of the warfighter. Some of the missions at the high risk spectrum currently undertaken by manned aircraft will be assumed by UAVs.

Notes

[1]Andrew F. Krepinevich, Jr. *The Military-Technical Revolution: A Preliminary Assessment.* Air Command and Staff College War Theory Coursebook, AY 1997. p47.

[2]Ibid. p48.

[3]Ibid. p 48.

[4]James R. Fitzsimonds and Jan M. Van Tool, "Revolutions in Military Affairs", *Joint Force Quarterly,* Spring 1994. p27.

[5]Major James P. Marshall, *Near-Real-Time Intelligence on the Tactical Battlefield,* AU Press, Maxwell AFB, 1994. p79.

[6]Ibid. p79.

Chapter 5

Integration Of Intelligence Needs And Tactical Doctrine

> *What is called "foreknowledge" cannot be elicited from spirits, nor from gods, nor by analogy with past events, nor from calculations. It must be obtained from men who know the enemy situation.*
>
> —Sun Tzu

Present reconnaissance assets available to the commander are manned reconnaissance aircraft and UAVs. Manned aircraft are treated as combat missions and find a place on the air tasking order (ATO). UAVs are treated as single role, single sensor, single service, and single mission platforms. Current doctrine tends to treat them as special missions and, even though some UAV mission may be found on the ATO or special instructions (SPINS), deconfliction with other traffic is normally done by establishing restricted area zones (ROZs) over the launch and recovery sites (LRS) and the mission area.[1] This may work well for short range UAVs, but, the increasing capabilities and roles of UAVs, and their capacity to undertake a larger variety of tactical reconnaissance missions necessitates an update on how UAVs should be tasked and employed.

UAV Missions

Tactical reconnaissance is an all encompassing term and includes the commander's ability to see the battlefield. Technically it is different from surveillance, however for the purpose of mission tasking the terms reconnaissance and surveillance are interchangeably used. According to current US joint doctrine, UAVs are capable of a large variety of missions that include but are not limited to:

- RSTA
- Surveillance for peacetime and combat SAR
- Deception operations
- Maritime operations (Naval fire support, OTH targeting, ASW, anti-ship missile defense, ship classification)
- EW and SIGINT
- NBC reconnaissance
- Special and psyops
- Meteorology missions
- Route and landing zone reconnaissance support
- Adjustment of indirect fire and CAS
- BDA
- Radio and data relay[2]

As can be seen from the above list a lot of these missions can fall under the category of "tactical reconnaissance". Thus different services and agencies within the US look at UAVs in their own way and use them as organic or joint assets. The Marines treat them as organic assets supporting the operations of the Marine Air-Ground Task Force (MAGTF) but could make them available to the joint force commander for long range reconnaissance.[3] Keep in mind that the Marines employ only short range UAVs and "long range reconnaissance" means a distance of 150 km (68 nm); the Air Force may have much longer range UAVs at the disposal of the JFC that is already flying in support of the Army; and the Army may be flying its own short range UAVs in its operating area. In such a scenario tactical reconnaissance needs to be coordinated according to the needs of the joint forces. The present day doctrine allows for coordination of single role and single mission UAVs into the tactical mission needs. Future UAVs will not only be multi-sensor but capable of satisfying the needs of multiple users in the same mission. Thus current doctrine does not fully exploit, nor fully support the potential of UAV operations.

Limitations Of Current Doctrine

Current US joint doctrine suggests that the JFC should exercise OPCON of UAV assets only through his service component commanders.[4] The doctrine also discourages multi-service tasking of UAVs. Finally current doctrine also does not clearly define whether the UAV is an intelligence or operational asset leading to an overlap in the responsibility areas of the J-2 and J-3.[5] What is needed is the resolution of these issues to improve the employment of UAVs. Except for short range UAVs that are employed directly in fire support role or engaged in reconnaissance behind the fire-support-coordination-line, all UAVs should be centrally controlled by the JFACC to enable a manned aircraft like command and control structure. This will also enable prioritization of intelligence requirements by the J-2 and deconfliction and prioritization of competing requirements by the J-3. Further airspace control will become easier leading to reduced chances of UAVs being shot down by friendly fire. This doctrinal structure will support future scenarios and allow faster flow of information within the system.[6] Multiple mission and mid-flight tasking will become possible for advanced endurance UAVs while single mission UAVs will also be able to operate autonomously.

Ground Stations

It is thus clear that a number of platforms, each capable of different mission(s) are going to be operating to support the information needs of the future warfighter. It is important that the ground stations are interoperable between the diverse types of UAVs and compatible with user systems, so that information can be collected and disseminated in a timely manner.[7] The current developments in ground control stations are already looking at a Common Imagery Ground/Surface System (CIGSS) that will be able to aggregate all UAV systems together and also bring JSTARS data into the system. Future systems will also be able to mix imagery, video, SIGINT, and other sensor data to produce a near-real-time, fused picture.[8]

Once these intelligence needs and doctrinal issues are sorted out UAVs will be able to be tasked, operated, and used in a manner similar to manned aircraft today. They will then be able to significantly complement existing systems in collecting and transmitting information.

Notes

[1]US Department of Defense, *Joint publication 3-55.1 Joint Tactics, Techniques, and Procedures for Unmanned Aerial Vehicles.* Washington 1993. p I-1,2&3.

[2]Ibid. p II-1,2.

[3]Defense Technical Information Center *Joint Doctrine and UAV Employment* Ft. Belvoir. p 4-5.

[4]Ibid. p 5.

[5]Ibid. p6-9.

[6]Ibid. p10-12.

[7]Defense Technical Information Center *Executive Summary: The Integrated Airborne Reconnaissance Strategy.* Ft. Belvoir, VA. Apr. 94. p *v*.

[8]Defense Technical Information Center *Annual Report Unmanned Aerial Vehicles August 1995.* Ft. Belvoir, VA.

Chapter 6

The Likely Cost of UAV and Manned Aircraft Operations

Worldwide interest in the development and use of unmanned aircraft…predicts production of nearly 8000 recoverable UAVs and targets, valued at almost $4 billion during the decade 1994-2003

—Kenneth Munson, Editor
Jane's Unmanned Aerial Vehicles and Targets

That costs of military aircraft are rising and that they will continue to rise is a fact accepted by most observers. At constant prices (1985 index) the F-100 (1954) cost $2 million, the F-4 (1962) $6 million, the F-15 (1974) $25 million.[1] The cost of the F-22 is likely to be in line with the historic annual increase of 7 percent in fighter aircraft prices even after taking inflation and production rates into account. What needs to be kept in mind is the increase in price has come at an increased performance, and that despite cost the capabilities and the multi-mission capacity of fighter aircraft have increased substantially over the years. Empirical evidence tends to suggest that cost corrected for performance has actually declined over the four decades from 1940 to 1980.[2] Does this suggest that increasing development of existing aircraft is the best and most cost effective solution to mission needs? The answer lies in the fact that while performance-corrected-cost may have come down, the absolute cost per unit has gone up, and, budgetary constraints have forced a choice between numerous but less capable aircraft, and fewer but more capable aircraft. Most air forces have chosen the latter option and have faced the dilemma of having multi-mission capable aircraft but being unable to employ then in multiple missions at the same time. Thus for example, an aircraft like the F-111 may be capable of strike and reconnaissance, at a given time it can be employed in only one mission. If another mission came up simultaneously another F-111 would have to be employed to meet that task.

Cost Benefit of UAVs

The characteristics, capabilities, roles, and missions of UAVs and the way that they differ from manned aircraft make direct comparisons difficult. The fact that current fighter designs are at least half a decade older than modern UAV designs complicates the process. Looking at mission employment it is also possible that in some cases multiple single mission UAVs will be employed to achieve the same results as a single manned aircraft mission while conversely many sorties of manned aircraft may be needed to accomplish the outcome of a single UAV mission. Most analysts however agree that the cost of UAV operations in the same role as manned aircraft is less. The Defense Airborne Reconnaissance Office (DARO) has developed and evaluated a performance indicator "pound hours per kilo per 1000 dollars" that indicates the cost of placing and maintaining a reconnaissance payload on station. This standard indicates that the cost of UAVs is less than manned aircraft.[3] Other metrics are also in development to assess payload product utility (measured in pixel quantity over time per dollar).[4]

The important cost reduction in UAVs occurs due to availability of commercial-off-the shelf technologies. It is this approach that has led to the cost of the Predator and the

Dark Star to be fixed at $3 million[5] and $10 million respectively.[6] The cost of airframes however are only 15 percent of total costs, while ground control accounts for 16 percent, payloads 20 percent, and training and support 34 percent.[7]

Even so it is cheaper and faster to produce an entire squadron of medium range UAVs for the price and effort required to replace a single F-14.[8] This trend is likely to continue as the newly heightened awareness of UAVs and their increasing demand in non-military sectors will increase demand for UAVs leading to lower platform and GCS costs. Though the UAVs are not strictly comparable to the F-14 due to the large differences in capabilities of the platforms the figures do tend to highlight the fact that UAVs can be produced cheaper than adding to existing inventories of sophisticated aircraft. If however more capable UAVs with increased survivability and performance (high speed and maneuverability) are developed then the difference in cost may reduce.

Payload costs are generally similar for both manned and unmanned craft with UAV payloads being slightly more expensive due to their requirement of smaller size and weight. In future however there is likely to be increasing commonality between the payloads and their components on manned aircraft and UAVs.

Operating costs for the RF-11C and the F/A-18 of the Royal Australian Air Force are Quoted as A$ 50,836 per hour and A$ 32,781 per hour. The operating costs of the Predator though not available is expected to be much lower.[9] Lower operating costs are not the only factor in favor of UAV cost effectiveness. Total in service support costs for the F-15A are expected to be $64.2 million. Since typically these are twice to two-and-half times the vehicle costs the expected costs for the Predator are expected to be much lower.[10] Transportation and logistics requirements for UAV systems are also smaller than for other airborne resources.[11]

In spite of such considerations UAV systems are certainly not cheap. A squadron of twelve Global Hawks with its package of and ground support is likely to cost A$ 500 million.[12] But its capacity to loiter for 24 hours on station 3000 nm away is going to be unmatchable. Even lesser capable UAVs like the IAI Searcher slated for India will cost $300,000 a piece and the total package of twelve vehicles and support costs will total $15 million.[13]

Survivability of the UAV is dependent on its size. Its inherent ability to operate without being easily detected contributes to its cost effectiveness due to the low investment required in self defense systems. The caveat however is that should the enemy find a way to quickly detect and destroy UAVs the cost effectiveness factor would be rapidly eroded. In the immediate future however, the above mentioned scenario is unlikely. Further into the future are stealthy UAVs that will overcome the problem, albeit at a higher price. Even so the cost of stealthy UAVs will be lower than that of stealth aircraft.

The tactical reconnaissance role will continue to be more cost effective for UAVs in spite of high total costs due to the time on station and the low requirements for performance and survivability. As more and more countries adopt UAV programs the cost of operating UAVs will continue to decrease.

Notes

[1]Armitage, Air Chief Marshal Sir Michael, KCB, CBE, RAF *Unmanned Aircraft* Great Britain, Brassey,s Defence Publishers 1988. p99.

[2]Franck, Raymond E. Jr., Col, *Cost Performance Choices in Post-Cold War Weapon Systems*. Maxwell AFB, AU Press, 1992. p11-14.

Notes

[3]Lax & Sutherland, Wing Commanders M. & B., *An Extended Role for Unmanned Aerial Vehicles in the Royal Australian Air Force.* RAAF Air Power Studies Centre, 1996. p30-31.

[4]Defense Technical Information Center *Annual Report Unmanned Aerial Vehicles August 1995.* Ft. Belvoir, VA. p35

[5]Glenn W. Goodman, Jr., *Flying High: Air Force Finally Embraces Unmanned Aerial Vehicles. Armed Forces Journal International*, Oct. 95, p18.

[6]Ibid. p1.

[7]Longino, Lt Col Dana A., USAF, Role of Unmanned Aerial Vehicles in Future Armed Conflict Scenarios. Maxwell AFB, AU Press, 1994. p18.

[8]Lt Cdr. F. Karen Coyle *Unmanned Aerial Vehicles: Operational Implications for the Joint Force Commander.* Defence Technical Information Center, Ft Belvior, VA. p14.

[9]Lax & Sutherland. p39-40.

[10]Armitage. p99-100.

[11]Koyle. p13.

[12]Lax and Sutherland. p38.

[13]Ibid. p41.

Chapter 7

Conclusion

> *[U]nmanned aircraft may perform as effectively and more cheaply than either satellites or manned aircraft. Thus, UAVs complete the array of capability necessary to fully populate this vertical dimension of the rapidly growing information world.*
>
> —Richard T. Wagaman
> Past President, Association of Unmanned Vehicle Systems (AUVS)
> Address at UV-95 Conference, Paris

The debate on whether manned aircraft or unmanned aerial vehicles are the most effective means of employing combat power has intensified over the last few years. While manned aircraft have been employed to good effect the potential of UAVs is just beginning to be explored. The technology for the employment of UAVs is evolving quickly and new uses are being developed rapidly. The technology for the application of UAVs in the tactical reconnaissance role has matured. The capabilities on offer rival those of manned aircraft and satellites.

The most obvious advantages of UAVs in the tactical reconnaissance role are cost, the capacity to undertake missions where expendability is an issue, and endurance. Manned aircraft offer the advantages of flexibility, quick response, and survivability. Certainly missions that require the use of human inductive reasoning for survival are still outside the purview of UAVs. The UAV survives by hiding, but once it is found it has little chance of survival. Peacetime and pre-hostilities phase political fallout can be avoided by using UAVs, and it is in this phase that they seem to be the most attractive option. Also, hostile air defense environments, with a high density of lethal weapons, that are high-risk for the employment of costly piloted aircraft are suited for UAV operations. They are also capable of all weather operations. Clearly the utility of UAVs is undeniable and we can ignore them only at our peril.

Experience with manned aircraft has cast the organization of UAV units along traditional operations and support structures. Future developments indicate that the concept of operations should focus on the GCS as the hub of activity. This will lead to a more efficient means of employment. Future doctrine refinements of centrally tasking UAV assets for multi-service tasks, and in-flight mission tasking will also increase efficiency.

The requirement for information is likely to keep increasing as warfare becomes more oriented towards reconnaissance-strike. In future scenarios, no one system is going to be able to meet all data collection requirements. Manned aircraft will not be available for all the intelligence needs of the warfighter. Satellite systems also have limitations that will prevent them from being the sole suppliers of information. The capabilities of UAVs make them ideally suited to fill the increasing void between intelligence requirements and existing data collection capability.

As more experience is gained in UAV operations invariably there will develop means to counter UAVs. The platform is far from perfect as it is low on performance and self defense. It is therefore not intended to replace the manned aircraft in the tactical reconnaissance role but complement it, so that it can close the information gap and "preserve the high cost systems for combat missions for which they were specifically designed".[1]

Notes

[1]Lt Cdr. F. Karen Coyle *Unmanned Aerial Vehicles: Operational Implications for the Joint Force Commander.* Defense Technical Information Center, Ft Belvior, VA. p24.

Glossary

AMMS	Airborne Missile Maintenance Squadron
ATO	Air Tasking Order
ASW	Anti-Submarine Warfare
BDA	Battle Damage Assessment
CAS	Close Air Support
ELINT	ELectronic INTelligence
EO	Electro-Optical
EW	Electronic Warfare
GCS	Ground Control Station
GPS	Global Positioning System
IRLS	Infra Red Line Scan
JSTARS	Joint Surveillance and Target Attack System
JFC	Joint Force Commander
LRS	Launch and Recovery Station
MAGTF	Marine Air-Ground Task Force
MARS	Mid Air Retrieval System
MCGS	Microwave Command Guidance System
OTH	Over The Horizon
RAAF	Royal Australian Air Force
ROZ	Restricted Operating Zone
RPV	Remotely Piloted Vehicle
RMA	Revolution in Military Affairs
RSTA	Reconnaissance Surveillance and Target Acquisition
SAR	Synthetic Aperture Radar
SIGINT	SIGnals INTelligence
SPINS	Special Instructions

TARPS	Tactical Advanced Photo Reconnaissance System
TFR	Terrain Following Radar
UAV	Unmanned Aerial Vehicle
UAV-MR	Unmanned Aerial Vehicle Medium Range

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