AN EVALUATION OF REMOTELY
PILOTED VEHICLES IN THE
ANTIARMOR ROLE

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements of the degree

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by

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The opinions and conclusions expressed herein are those of the individual student author and do not necessarily represent the views of either the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

There exists a need in the United States Army for a weapons system that is capable of engaging armored vehicles at ranges far exceeding the range of the main armament of the tank. This need is currently being filled by the TV guided bomb and the helicopter mounted TOW missile. However, both of these systems suffer from the drawbacks of high cost and high vulnerability to antiaircraft artillery and missiles. The Remotely Piloted Vehicle (RPV) is a new weapons concept that is examined and compared with the two existing systems. The RPV is found to be far less expensive and much less vulnerable to antiaircraft fire but suffers some possible problems in an electronic countermeasures environment. Some possible solutions to this ECM problem are offered which promise to make the RPV a superior antitank weapon when used as a laser designator for a terminally guided, laser homing weapon.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

BACKGROUND

On the 17th of December, 1903, two bicycle mechanics took a home made airplane to the sands of Kitty Hawk, North Carolina, for a test flight. The brief flight that followed transported man into an era of powered, manned flight that has revolutionized our society.[1]

Only a short 11 years later, in 1914, the Germans conceived the idea of using radio signals to control a powered aircraft loaded with explosives in order to guide it into enemy fortifications. They did not exploit the idea, but it planted a seed in the minds of scientists that was to bear fruit during World War II.

The first actual flight of a pilotless, manned, controllable aircraft occurred in Dahlgren Virginia, in September of 1924. This radio controlled seaplane, flown by the U.S. Navy was the forerunner of the drones and Remotely Piloted Vehicles that we know today and

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[1]William E. Butterworth, Flying Army, (Garden City: Doubleday & Company, Inc., 1971) p. 18.

that are the subject of this study.[2]

Before proceeding with the history and development of Remotely Piloted Vehicles, (hereinafter referred to as "RPV"), it is necessary at this juncture to define some terms so that a distinction can be made between the various types of pilotless, powered aircraft. The "drone" is defined by The American College Dictionary as "3. a remotely controlled mechanism, as a radio-controlled airplane or boat."[3] This implies that a drone must be guided by an external source using radio signals to transmit commands to alter the flight path. Common usage has made this definition somewhat restrictive. For the purposes of this paper, the definition will be expanded to include any pilotless aircraft which is capable of effecting a change in its flight path, either as a result of radio signals received from an external source or because the internal guidance mechanism senses a deviation from a preprogrammed flight path and sends the proper corrective signals to the control surfaces on the aircraft. This definition is very broad and includes nearly every type of pilotless aircraft used by the military, but common usage in the literature has dictated this broad definition.

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[2]Arthur S. Locke, Guidance, Principles of Guided Missile Design series, Grayson Merrill (ed.) (Princeton: D. Van Nostrand Company, Inc., 1955), p. 52.

[3]C. L. Barnhart (ed.), The American College Dictionary (New York: Random House, 1964).

The name Remotely Piloted Vehicle or RPV is widely accepted as the name for a drone which has a television camera mounted on it so that the pilot located at the remote site can see a video image of what he would see if he were the actual pilot of the RPV.[4] It is always subject to external controls so that the pilot can adjust the flight path depending upon what he sees on the TV screen.

World War II provided a stimulus to the development of drones for use in combat. Probably the most infamous of all was the German V-1 "Buzz-Bomb" which terrorized the citizens of London during the Battle of Britain. These were drones powered by pulse jets and guided internally by use of a magnetic compass, gyroscopes and a wind speed sensing device.[5] It was not subject to external control but still proved to be a reasonably reliable drone.

The German V-2, on the other hand, was not a drone under the definition given earlier. It was the first true ballistic missile, which means that it was aimed and fired in a manner very similar to that of a howitzer or gun. That is, the angle that the longitudinal axis made

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[4]Barry Miller, "RPV's Provide U.S. New Weapon Options," Aviation Week and Space Technology, January 22, 1973, p. 39.

[5]Locke, *op. cit.*, p. 35.

with the ground and the direction that the launcher was pointed was computed based upon a prescribed length of time that the motor would be firing. This length of time of motor burn could be varied according to the range desired. The only control that the Germans had was to vary the angle above the ground, the direction in which the launcher was pointed and the time of motor burn. Once the motor shut off in flight, no further course corrections could be made. The V-2 followed a ballistic path from that point on until it impacted near the target. It was suject only to aerodynamic and gravity forces after motor shut off.[6]

Significant U.S. developments during World War II included the "Weary Willy." This was an air-to-surface missile which was controlled in flight by the pilot of the launch aircraft. He sent guidance signals to the missile by way of a radio command link based upon the observed flight path of the missile.[7]

Another related development was in the field of guided bombs. Although these do not fit into the definition of drones since they were not powered, their guidance systems were similar to those used on drones and those which will be discussed later in connection with RPV employment.

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[6] *Ibid.*, p. 37.

[7] *Ibid.*, p. 34.

There were three types of guided bombs which were tested and developed during the last two years of the War. The first type was guided by radio command, similar to the afore mentioned "Weary Willy." The difference was that the pilot or bombardier guided the bomb along his line of sight to the target rather than tracking its location on radar. The second type was a homing type bomb wherein the internal guidance system steered it towards a source of infrared energy such as an enemy factory or else towards radar energy which was being bounced or reflected off of the enemy target by the pilot or bombardier of the mother ship.[8] The third type of guidance was a system which used a TV transmitter in the bomb to send signals to the TV screen in the airplane, giving the operator a picture of where the bomb was headed. He could then correct the flight path through a radio command link. This type of bomb first saw employment in August, 1944.[9]

After World War II and the formation of the United States Air Force, the Army concentrated on the development of drones for targets and for use as reconnaisance vehicles in the immediate area of the battlefield, while the Air Force worked on drones for strategic reconnaisance. In 1958, the Army conducted tests at Fort Huachaca, Arizona, on the first operational drone, named the AN/USD-1 (Fig 1), which achieved a high degree of success with a mission

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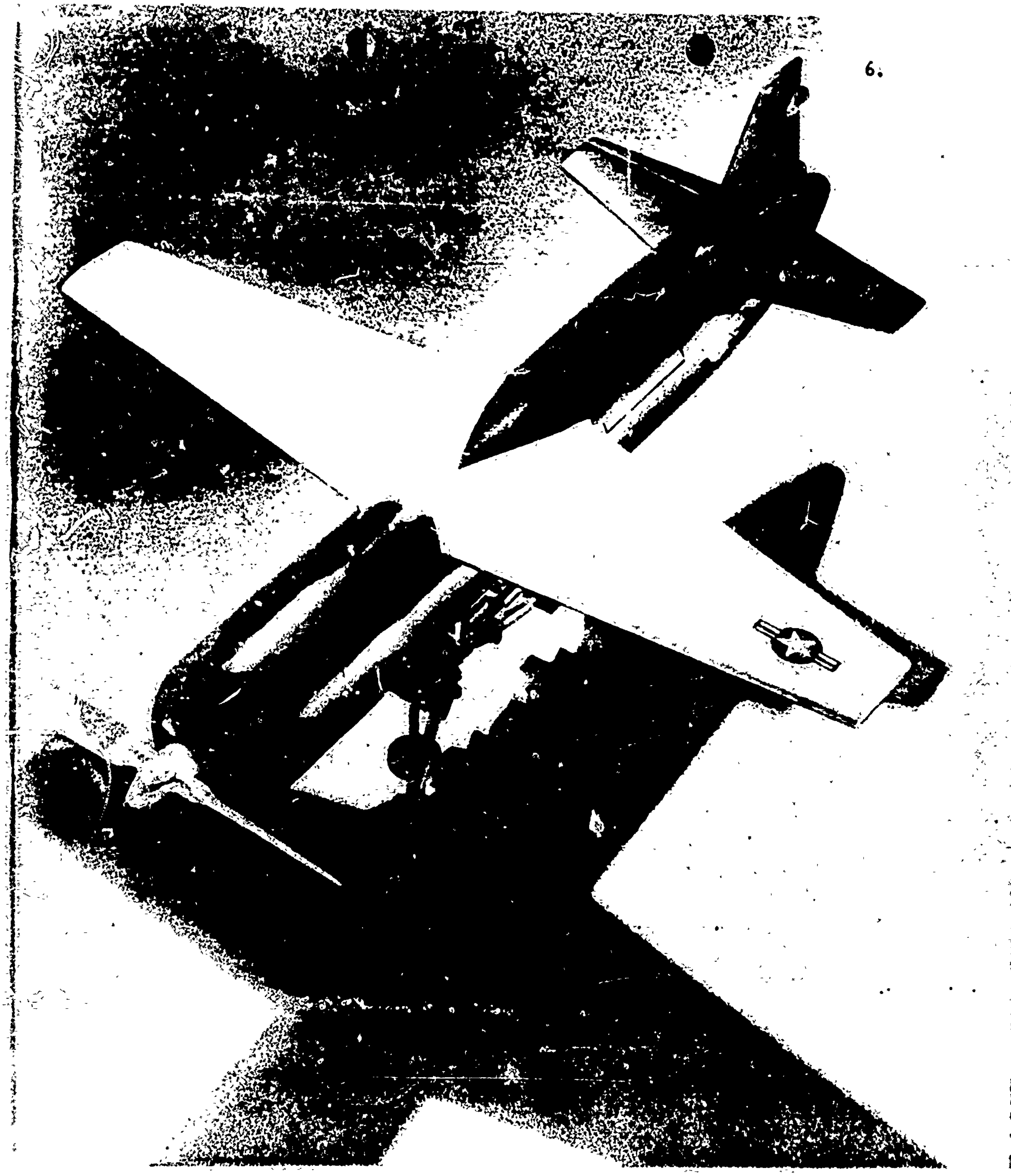
[8] Ibid., p. 43.

[9] Ibid., p. 44.



Fuselage Length - 160 inches, Wing Span - 138 inches

Height - 31 inches

Figure 1. AN/USD-1 Combat Surveillance Drone

accomplishment rate in excess of 93%. But both the USD-1 and its successor, the USD-2 which never even reached the field, were highly susceptible to electronic countermeasures by the enemy.[10] This means that the enemy could use its own electronic devices to interfere with the guidance commands sent to the drone via the radio link with the remote pilot or to make it difficult for the operator to track the drone with radar. This weakness to electronic countermeasures proved to be the biggest disadvantage with the two drone systems and caused the reconnaissance drone inventory to be shelved until a less susceptible drone could be developed.[11] The concept of vulnerability to enemy electronic countermeasures will be discussed at greater length later in this paper.

Although the active reconnaissance drones were shelved, the Army continued its development efforts towards a feasible unmanned reconnaissance aircraft and in 1964 began a program to evaluate various types of drones to include the common fixed wing, propeller driven, launched type such as the USD-1 had been, a tethered rotary wing and even a pure rocket.[12] But none of these

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[10]U.S. Army Combat Surveillance Agency, Management Manual AN/USD-1, (Arlington, Va.: n.n., 1961), p. 2.

[11]Ibid., p. 12.

[12]U.S. Army Electronics Research and Development Laboratories, Final Report on Project Ping Pong, (Fort Monmouth, N. J.: n.n., 1961), p. 4.

have been accepted into the active Army inventory because they were overtaken by the events which have occurred during the past decade and which will be outlined shortly.

During the time that the Army was conducting research on small tactical drones, the U.S. Air Force was developing and testing strategic reconnaisance drones. Spurred on by such events as the capture of Gary Powers and the insertion of missiles into Cuba, they worked closely with Teledyne-Ryan in building the QM-34 series drones (see Fig 2). These jet powered drones had been used for target drones since the early 1950's and were ideally suited for use as reconnaisance drones.[13]

The most significant event with respect to unmanned reconnaissance vehicles which occurred during the past decade was the onset of the war in Vietnam at a time when the Air Force strategic reconnaissance drones had achieved a fairly high degree of reliability. Late in 1964, the Strategic Air Command deployed a group of AQM-34 drones to Kadena, Okinawa, to begin overflights of mainland Communist China. Launched from C-130 aircraft, these drones flew prescribed courses and photographed intelligence targets. Upon completion of the mission, the drones were returned to Formosa for a ground recovery. Lator, these same drones operated out of Bien Hoa in South

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[13] William P. "Doc" Sloan, "RPV: The Background," Teledyne Ryan Aeronautical Reporter, Summer 1971, pp. 14-21.

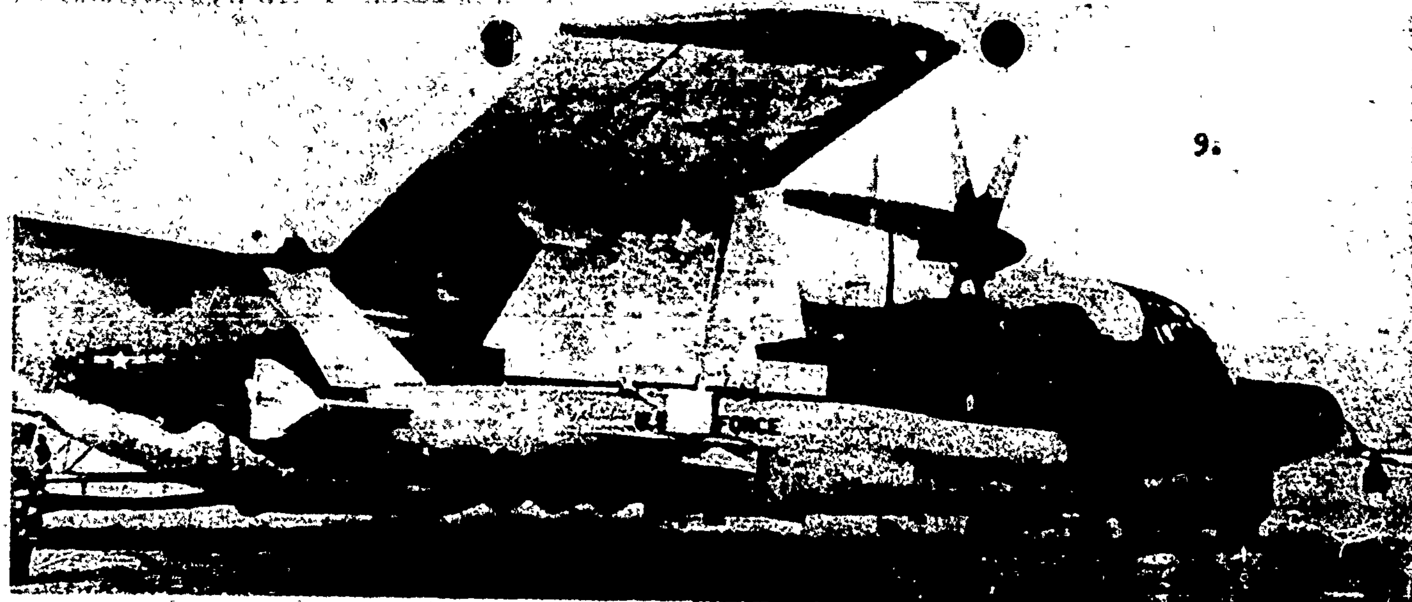

Figure 2a. MQM-34 Drone Mounted on a C-130 Aircraft

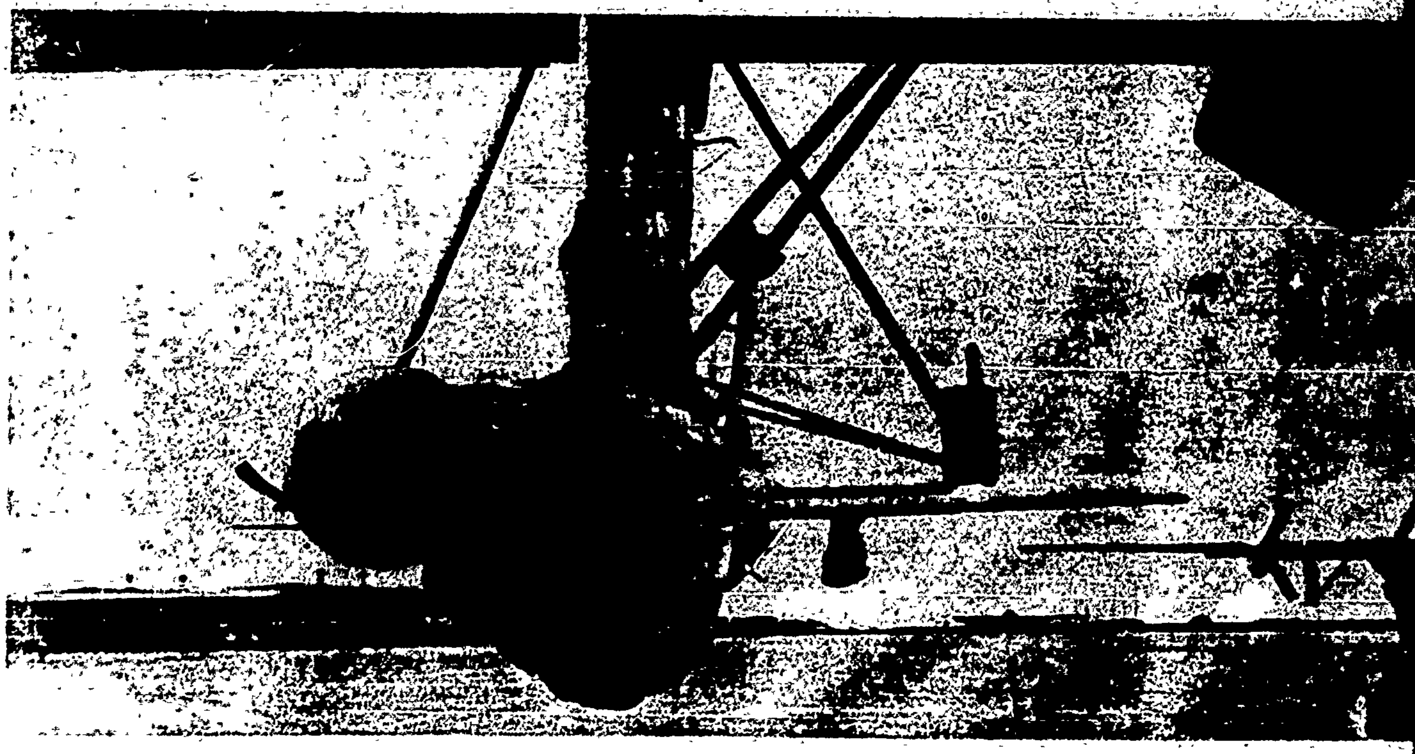

Figure 2b. Rear View of MQM-34 Drone
(Reprinted from Aviation Week and Space Technology,
April 15, 1974, p. 59.)

Vietnam, with a mission of overflying North Vietnam on photo intelligence missions. The same launch procedure was used, but the drones were recovered in flight by a helicopter.[14] This increased the development pace to a point where in 1969, industry was investing $100 million annually in the development of unmanned surveillance aircraft.[15] Today, advanced versions of the AQM drone, known as the AQM-34L and the AQM-34M operate out of Osan, Korea, photographing Southeast Asia and dispensing propaganda leaflets.[16]

The other events which stimulated the development of the RPV were the many advances in technology which made the unmanned, remotely piloted vehicle a much more feasible entity. One of these advances is the development of lighter, cheaper materials such as composite reinforced plastics which allow the industry to build rugged and durable, but light airplanes. Another development is the miniaturization of the electronic circuitry and the improvements in techniques which combine to give greater capabilities for guidance, control and navigation with smaller packages. Finally the emergence of the laser (light amplification by stimulated emission of radiation) beam as an illuminator for terminally guided weapons made

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[14] "RPV's to Play Electronic Warfare Role," _Aviation Week and Space Technology_, January 22, 1973, p. 57.

[15] Miller, _op. cit._, p. 38.

[16] "RPV's to Play..." _loc. cit._

possible the designation of targets for indirect fire weapons with resulting extremely high probabilities of a direct hit.[17]

The laser concept is so new that it deserves further explanation. One author stated that, "Terminal guidance promises to be the first real revolution in land combat weaponry since the military adaptation of the internal combustion engine."[18]

Terminal guidance simply means that the weapon is guided to the target by energy that either is emanating from the target or else is being reflected by it. As can be seen from the previous background discussion, this in itself is not a new concept. The new element is the laser beam and this is what threatens to revolutionize weaponry. The laser beam is characterized as a beam of monochromatic light waves (meaning that they are all of the same wavelength or color) which travel in parallel paths. This means that a beam which is very narrow at its origin will remain very narrow until it strikes a target, so that if it is pointed at a tank, it will illuminate only the tank and not the surrounding terrain. Thus a missile whose internal guidance is steering it towards the reflected

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[17] Robert Hotz, "The Promise of RPV's" Aviation Week and Space Technology, January 22, 1973, p. 7.

[18] Eric C. Ludvigsen, "Army Missiles, a New Generation," Army, June 6, 1973, p. 10.

energy will strike the tank unless there are errors in the internal guidance syster The concept of illuminating a target for a laser homing weapon was first tried by the Air Force in 1966. At that time the Army was embroiled in the Vietnam war and did not capitalize on the new idea.[19] However, in 1972 the Army tested it's own system and scored direct hits on a target with a laser-seeking missile that was illuminated by a 1-foot beam from a distance of 1 kilometer.[20]

RPV's then, are not a new concept. The technology base exists to support the production of an RPV which is capable of performing in the manner that will be described in this study. The model to be used for this analysis will be a generic RPV which represents a cross section of the many different designs and concepts which are currently under development in the industry (see Fig. 3 for a typical RPV). It will also be in consonance with the specifications given to industry by the Department of Defense in the spring of 1972.[21] The specifications are as follows:

1. Speed: 50 knots cruising speed

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[19] Ibid., p. 14.

[20] "Laser Guidance Systems Passing Tests at Redstone Arsenal," Army, February, 1972, p. 55.

[21] "Army Seeks RPV for Laser Designator," Aviation Week and Space Technology, May 21, 1973, p. 17.

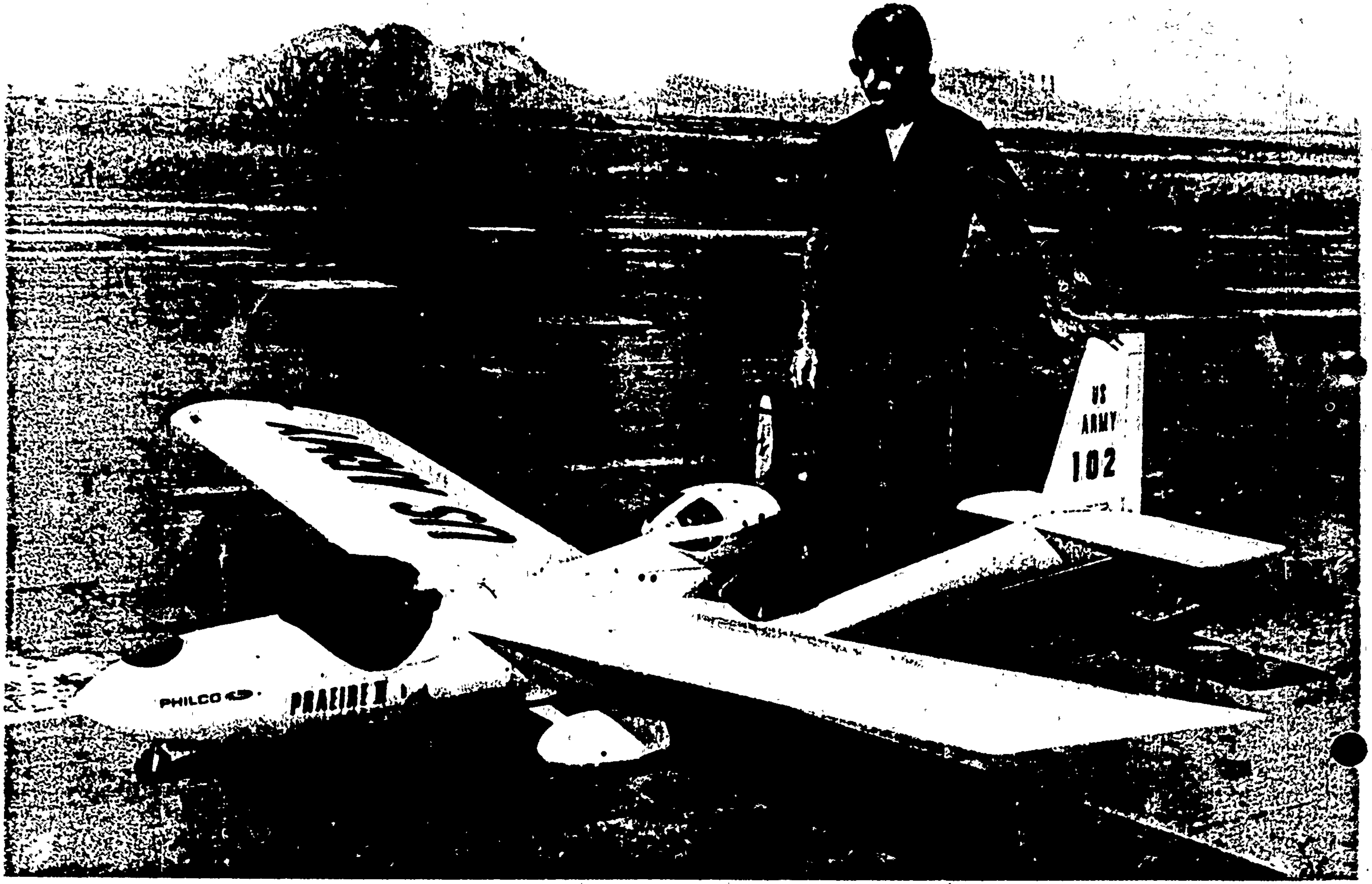

Figure 3. Praerie II, Philco-Ford's Entrant in Mini-RPV Competition

2. Weight: Not to exceed 300 pounds

3. Duration: 8 hours of continuous flight

4. Payload: 50 pounds

5. Material:: Radar absorbent and translucent so as to be invisible to the naked eye at distances greater than 1 kilometer

6. Guidance: Radio command.

In addition to the above specifications, the overall system should have an operator's console from which the operator controls the flight of the RPV and monitors both the TV display and a radar position plot so that the location of the RPV is known to him at all times. The 50 pound payload will be sufficient for a TV camera and a laser beam designator or the camera and a conventional shape charge type warhead.[22]

This study will examine two possible uses for the RPV. The first is as a laser designator for another terminal guidance weapon system. This means that the RPV will locate a target based upon a general location determined by another intelligence source, then illuminate it for the terminally guided weapons system (see Fig. 4). One such weapon that is currently under development is the cannon launched guided projectile which will be fired from a 155mm howitzer and will home on reflected laser

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[22] "Army to Test RPV's in Battlefield Use," <u>Aviation Week and Space Technology</u>, June 19, 1972, p. 13.

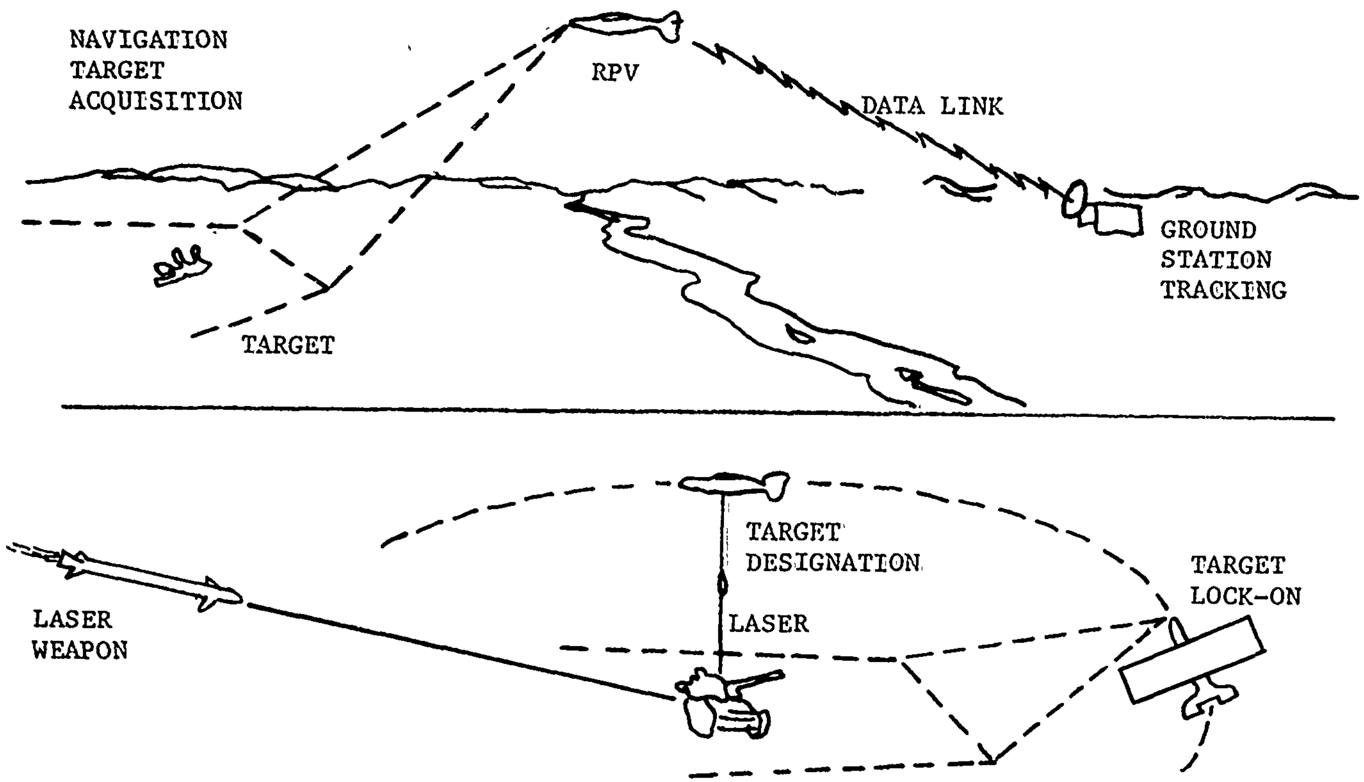

Figure 4. Operational Concept for RPV Designating a Target for Terminally Guided Weapon

energy. Another is the Hellfire missile which is expected to replace the TOW missile. This concept has already been proven feasible by Philco-Ford whose RPV successfully designated a target for a laser guided bomb, dropped by an Air Force F-4. The accuracy of the designation was so great that "one bomb cratered directly beneath a truck target."[23]

The second use for the RPV will be as a carrier for the weapon itself, in which the RPV will locate the target as before but will then be homed in on the target by the pilot and destroy it with its own onboard explosive. The advantages of each type of usage will be discussed in Chapter IV.

The foregoing has been a brief background on the history, concept and possible manner of employment of the RPV. Chapter II will establish that there is a need for a system which is capable of engaging tanks at long ranges with great accuracy. Today's weapons inventory in the United States has only two systems that are capable of performing this mission; namely, the armed helicopter, equipped with a guided missile and the high performance Air Force fighter-bomber, employing a guided bomb or guided missile. This chapter will show that these two systems suffer serious drawbacks.

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[22]"Industry Observer," Aviation Week and Space Technology, July 9, 1973, p. 9.

Chapter III sets forth some criteria for a weapons system capable of engaging enemy armor at long ranges. Each of the criteria is discussed fully and evaluated in view of current tactics and theory of armor employment. The last portion of the chapter is devoted to a statement of the hypothesis for this study.

Chapter IV is a comparison of the RPV with the helicopter and the guided bomb to see how well each one meets each criterion outlined in the previous chapter. Advantages and disadvantages of each weapons system are discussed and compared to arrive at a conclusion as to which of the three best satisfies the criteria.

Chapter V summarizes the study and outlines further areas for possible study. Included in this chapter are some ideas on other possible uses for the RPV which are currently undergoing studies, as well as some implications of a nuclear environment on the usefulness of the RPV.

CHAPTER II

WHY RPV'S?

> "In the armored battle it is the velocity and weight of the initial assault which decides."[24]

The above quote from J. F. C. Fuller helps to introduce the point which will be made in this chapter, that there exists a need on the modern battlefield for a weapons system that is capable of engaging tanks and armored vehicles at ranges greater than the maximum range of the armament of the main battle tank with a reasonably high degree of accuracy. This weapons system will give the defender a reasonable hope that he can diminish the attacker's assault to the point that the initial assault is not overpowering. Likewise, the system will give the attacker a reasonable chance for success, without the problem of massive armor counter-attacks.

The tank originally gained status as a fighting vehicle during World War I when it was seen as a panacea for the stalemate in warfare which had been caused by the machine gun and the resulting reliance on trenches for

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[24]J. F. C. Fuller, Machine Warfare (New York: Hutchinson & Co. Ltd., 1943), p. 183.

protection.[25] Winston Churchill has been called one of the first proponents of the tank and was largely responsible for its deployment during World War I.[26] However, after the war, the glamor of the tank faded rapidly everywhere except in Germany. There Heinz Guderian foresaw the future applications of the tank in warfare and began developing the concept that would soon become known as Blitzkreig.[27]

The concept of Blitzkreig is not important to the discussion at hand per se, but it is important in that it was the forerunner of today's theory and tactics of armor employment. The concept employed the combination of tanks and airplanes in lightning fast attacks which swept around and over static defenses to strike the enemy in his vulnerable rear areas. The success of this type of offensive action was vividly demonstrated by the Germans in 1939 when in less than three weeks they utterly destroyed the Polish Army of 30 Infantry divisions and 12 Cavalry brigades.[28]

This led to today's theory of armor employment which calls for the use of tanks where firepower, mobility

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[25] Ibid., p. 40

[26] Paul C. Raborg, Mechanized Might (New York: McGraw-Hill Book Company, Inc., 1942), p. 58.

[27] B. H. Liddell Hart, Strategy (New York: Frederick A. Praiger, 1954), p. 237.

[28] Ibid., p. 238.

and shock action are desired.[29] The tank can be categorized as a mobile, direct fire weapons platform.[30] As such, in order to capitalize on its capabilities, one must use it in a fast moving situation where the tank can see its opponent and engage him with its direct fire weapon. This is what generates the firepower and shock action characteristic of armor operations. It must be noted then that, since it is a direct fire weapon, the tank must see its target and have line-of-sight in order to be effectively employed.

The ideal antitank weapon then would be one which would be capable of engaging and destroying the tank without the probability of itself being destroyed first. To do this, the weapons system must possess mobility equal to or greater than the tank itself or else the tank would be able to maneuver around or avoid the weapon. The system must be relatively immune to detection by the target tank or be protected from the effects of its main weapon or else it is subject to being destroyed by the tank first. Finally, the system must be capable of delivering accurate fire to insure destruction of the tank since tanks are rarely affected by anything but a direct hit which can

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[29]Department of the Army, FM 17-1, Armor Operations, 14 October, 1966, p. 6.

[30]Robert M. Ogorkiewicz, Design and Development of Fighting Vehicles (Garden City, New York: Doubleday & Company, 1968), p. 51.

penetrate their armor.[31] The foregoing analysis gives three general criteria for an ideal antitank weapon to use as a basis for evaluation of the types of weapons systems currently in the U. S. inventory. These criteria are: (1) mobility equal to or greater than the tank, (2) relative invulnerability to detection by the tank or destruction by the tank's weapons, and (3) the accuracy of the weapon itself.

For discussion purposes, current weapons will be divided into three categories. These are: (1) direct fire weapons, (2) indirect fire weapons and (3) airborne weapons. Each category has several different types of systems which will be discussed in turn.(see Table 1)

In the direct fire weapons category, the first type to be discussed are the unguided, hand held weapons such as the LAW (Light Antitank Weapon) or the older bazooka. At close rages, an infantryman armed with this type of weapon is capable of engaging tanks with a fair probability of success. The Russian version of this type of weapon, the RPG7, was used by the Egyptians with great success against Israeli tanks during the recent Yom Kippur War.[32] However, the weapon lacks the mobility of the tank and lacks

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[31] Robert J. Icks, Ralph Jones and George H. Rarey, The Fighting Tanks from 1916 to 1933 (Old Greenwich, Conn.: WE Inc., 1969), p. 184.

[32] Kenneth S. Brower, "The Yom Kippur War," Military Review, March 1974, p. 26.

Table 1: Antitank Weapons Categories

1. Direct Fire Weapons
   a) Unguided, hand-held
   b) Guided missile
   c) Tank
2. Indirect Fire Weapons
   a) Artillery
   b) Mortars
   c) Guided missile
3. Airborne
   a) Helicopter with TOW
   b) Guided bombs

protection from small arms fire delivered either by the infantry that may well be accompanying the tank or by machine gun fire from the tank itself. The operator is relatively invulnerable to detection by the tank due to his small size which allows him to hide easily, but if he is detected while he is exposing himself to fire, he is subject to rapid destruction. Thus this weapons system meets only the criterion of accuracy.

The next type of weapon in this category is the guided missile weapons such as the TOW (which is guided to the target by the operator who transmits guidance commands over a thin wire which plays out from the rear of the missile as it speeds towards the target.) This type of system is essentially the same as the first category except that they are guided all the way to the target which makes them much more accurate than the unguided weapon. During the first portion of the Yom Kippur War, the Arabs employed the Soviet built Sagger and Snapper antitank, wire guided missiles which succeeded in destroying about 25% of the Israeli tanks which were deployed against them. These missiles were either hand held or mounted on armored personnel carriers.[33] Once this type of weapon is mounted on a personnel carrier, it gains equal mobility with the tank and

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[33]Robert Hotz, "The Mideast Surprise," Aviation Week and Space Technology, October 15, 1973, p. 7.

a measure of small arms protection which the hand held versions lacked. However, the larger vehicle now becomes more difficult to conceal and hence a much easier target for the main armament of the tank. So although mobility is now equal and the weapon is extremely accurate, the tank and the antitank armored vehicle are on a par as far as vulnerability to counterfire. Moreover, the tank fires a high velocity projectile while the guided missile, of necessity, flies much more slowly so that the operator can see it and guide it to its target. Thus the tank has the advantage in rapidity of engagement. This brings up the next type of weapons system in this category, the tank.

"The best antitank weapon is the tank."[34] This statement is found throughout the literature on armored warfare and is accepted by many as gospel. However, the statement seems to be self contradicting, especially when considering the criteria for an antitank weapon which were developed earlier in this chapter. If the attacker's tank is the best weapon against the enemy's tank, then is not the enemy's tank the best weapon against the attacker's tank? It seems that at best we have a stalemate. True, if the defending tank is partially concealed behind an

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[34] Icks, _op_. _cit_., p. 257.

obstacle it would have a definite advantage over a tank which is attacking across an open field. However, by placing the tank in this static position, the defender has lost the advantage of mobility and faces the possibility that the attacker may envelop or outflank him. If he brings his tank out of hiding, then he is back on equal terms with the attacker. In light of the criteria, it is obvious that in the overall consideration, a tank is equal to another tank in mobility, unless one is hiding from the other and hence surrenders its mobility parity, in accuracy of fire, and in relative invulnerability to counterfire, unless one is hiding from the other in which case the hidden tank has a slight advantage. The conclusion that this leads to is that the tank may be an effective anti-tank weapon, but it still does not meet the three criteria for the ideal antitank weapon.

The systems discussed up to this point all have one feature in common: they must have line-of-sight with the tank in order to effectively engage it. In other words, they are all direct fire weapons just like the tank itself. It follows that if the antitank weapon has line-of-sight with the tank, then the converse must be true, and the tank is capable of engaging the antitank weapon. This leads to a discussion of the next category of weapons as possible antitank weapons. The indirect weapon has the distinct advantage that it can fire at the tank from behind a terrain mask when the tank is unable to effectively engage it.

The principal weapons system in the Army inventory which employes indirect fire is the artillery. If we include in this category the mortars and the family of tactical guided missiles such as the Lance, then we have included essentially all of the indirect fire weapons systems. The problem with employing artillery and mortars or guided missiles against tanks is two-fold. First, it takes as a minimum a matter of minutes to compute the data to be used in pointing the tube or launcher in the direction of the tank, in actually pointing the tube/launcher in that direction and for the round/missile to move from the tube/launcher to the point where the tank was when the computations were made. In the meantime, the tank has probably moved to a new location and the weapon, which is pointed at or guided to a specific spot on the ground where the tank was and not at the tank itself, will fall on vacant terrain. Even if the tank would oblige and remain immobile, the inaccuracies of artillery and mortars are such that their tactics of employment call for accuracies no greater than 25 meters in computing the data necessary to bring the rounds in on the target. The guided missile may have greater accuracy, but the radius of a circle around the

the calculated impact point in which the round will most probably land for today's guided missiles is on the order of tens of meters at best. As mentioned earlier, the conventional round must strike the tank itself in order to penetrate the armor so that an error of more than 2 or 3 meters may be excessive for employing an expensive guided missile against such a point target. Nuclear warheads would greatly increase the effect of a near miss on the tank itself, but that brings up the dilemma so well stated by an author who observed, "There are two ways to kill a gnat: hit it with a sledge hammer or stick it with a pin. He won't hold still for the pin so we use the hammer - and knock a hole in the wall at the same time."[35] It should be fairly obvious that we do not want to employ a nuclear warhead against a single tank. First of all, there is the danger of using nuclear weapons for fear that they may cause rapid escalation up to a strategic exchange of ICBM's. But even if nuclear weapons are being used, the cost of the weapon in terms of money and residual effects such as terrain contamination just does not justify its use. In conclusion then, although the artillery fills the criterion of invulnerability to counterfire and perhaps may be said to possess superior mobility in that it can shift its fires from one point to another faster than

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[35] John T. Burke, "'Smart' Weapons: A Coming Revolution in Tactics," Army, February, 1973, p. 20.

a tank can move, it fails miserably in the area of accuracy.

At this point, the hand-held or ground-mounted, guided or unguided missile, the tank and the artillery have all failed to meet the criteria for an ideal anti-tank weapons system. This does not mean that they do not have a place on the battle field. They all serve a very useful function. On defense, they are usually employed when the front lines are under attack by enemy armor. All of the systems discussed will probably be firing from concealed positions to maximize their protection against the tanks and accompanying infantry. The attacker will be "buttoned up," that is with all the crew inside the tank and with all hatches closed to afford maximum protection against small arms fire and fragments from exploding shells. Also, the attacker can be expected to employ the principle of mass and attack only when he has a superior number of tanks over the defender. This puts the defensive weapons to the test to successfully defend and hold the front line. The outcome of the battle at best will be in great doubt and at worst, if the attacker has sufficient number of tanks, will be disastrous. We need only refer back to the opening quote from J. F. C. Fuller to reinforce this doubt as to the outcome.

On the offense, all of the weapons lose their invulnerability to detection and counterfire because they are now on the move and are exposed while their targets are concealed. The artillery has not lost effectiveness due to this fact but does not have much to begin with. The tanks still retain the advantage of mobility over the defenders so they become the principal antitank weapon on the offense.

Although this is not an impossible situation, a weapon capable of engaging opposing tanks at ranges greater than that of the armament of their main gun would greatly enhance the probability of success in any armor operations. If this system could accurately attack the tanks as they prepared for an attack in their assembly areas or moved towards the battle area without exposing itself to too much risk, then the odds of success in an armor battle could be greatly improved for the owner of such a system. On defense, this weapons system could begin to thin the ranks of the attackers as they moved towards the defender's position, making the task of the direct fire weapons on the front line much easier. On offense, this weapons system could be used to neutralize the enemy's tank reserve which would be employed in his counterattack. This principle of a tank heavy reserve to execute a counterattack is a concept which has been proven successful in past battles.[36]

Such a weapon has recently been added to the Army inventory in the form of the third category, airborne weapons.

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[36] Icks, op. cit., p. 281.

This weapons is the helicopter armed with guided antitank missiles. The most common example of this and the standard system in the Army today is the TOW missile mounted on the Huey Cobra (see Fig. 5). This weapon system meets all three criteria established with adequate margin left over. It is vastly more maneuverable and mobile than a tank, being able to fly over most obstacles that would stop a tank and able to fly at speeds more than three times that of the average tank. The accuracy of the TOW mounted on the Cobra is the same as the ground mounted TOW which is extremely good, as will be shown shortly. Finally, it is relatively invulnerable to counterfire from the tank. This last statement is true for two reasons: first, it can hover behind a hill mass or other terrain mask, pop up to fire the missile, guide it to the target tank and then move down behind the mass again. This exposes the helicopter to possible view from the tank for only a short period of time. Secondly, even if the tank sights the helicopter immediately, the only weapon that the tank can use effectively against the helicopter would be the machine gun and there is not much time to engage the helicopter.

The helicopter mounted antitank missile has had its baptism under fire, both in Vietnam and in maneuvers conducted in the United States and Europe. In Vietnam, the weapon was highly successful. In two months of operation

Figure 5. Huey Cobra Helicopter

[redacted]

during May and June of 1972, 101 TOW missiles were fired from Huey and Huey Cobras helicopters with only 12 misses being recorded, and those were attributed to pilot error, not to system failures. The missiles that struck their targets accounted for the destruction of 26 tanks, 6 trucks, 4 personnel carriers, 3 automatic weapons, 1 fuel dump and other miscellaneous targets.[37] Tests conducted in Ansbach, Germany, in the spring of that same year, showed a kill ration of an average of 18:1 using Cobra mounted TOW's against tanks.[38]

Another airborne weapons system, not in the Army inventory but available to the ground commander is the Air Force's terminally guided bomb systems such as the Maverick. This bomb uses a TV guidance system similar to that used on the TV guided bombs developed during the World War II. The success of the Maverick bomb against tanks was noted by both sides of the conflict during the recent Yom Kippur War.[39]

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[37] "Army's Tank," Armed Forces Journal, July, 1972, p. 16.

[38] John W. I. Ball, "Cobra Vs. LOH in the Antiarmor Role," Infantry, May-June 1973, p. 6.

[39] U.S., Congress, House, Committee on Armed Services, Report of the Special Subcommittee on the Middle East, (H.A.S.C. No. 93-32) (Washington: Government Printing Office, 1973), p. 8.

But both the helicopter firing the TOW and the fighter aircraft dropping the Maverick suffer from three distinct drawbacks. First of all, they are quite vulnerable to enemy detection devices that employ radar or infrared seeking devices and to tracking by guided missiles or automatic weapons that use these same principles. Secondly, they are very expensive to purchase, maintain, and operate which serves as a severe limitation on them in view of our dwindling energy sources, manpower ceilings and DOD budget. Third, they all require at least one and usually two men as pilots who become casualties or prisoners if the aircraft is shot down. These three areas will be discussed and developed in greater detail in Chapter IV, but at this point it becomes expedient to look for a weapons system which still fills the criteria for the ideal one but which does not suffer the three disadvantages listed above. Then this system can be compared with the helicopter and the fighter dropped bomb to see which can best accomplish the mission with the least expenditure of resources.

The new system which shows great promise in filling this role is the RPV. This system has all of the capabilities of the manned aircraft without the three disadvantages. Therefore, the remainder of this study will be devoted to a comparison between the RPV and the helicopter launched guided missile as well as the Maverick type guided bomb.

CHAPTER III

EMPLOYMENT CRITERIA

The purpose of this chapter is to outline the criteria which must be met by a weapons system that will serve the purpose described in the last chapter, namely the successful engagement of enemy armor at distances from the front lines in excess of the effective range of the main armament of the enemy tank. The final portion of this chapter will delineate the hypothesis for the remainder of the study.

The three criteria for an ideal antitank weapon which were outlined earlier serve as a starting point for the weapon system which is under study. In review, they are restated below. First, the weapon must possess mobility in at least as great a degree if not a greater one than the enemy tank. Second, it must be accurate enough to insure direct hits on most of its rounds. Third, the system must be relatively invulnerable to counterfire from the tank target itself. These three criteria have been explained and justified previously and will not be discussed further in this chapter. However, they will be assimilated into the list of criteria against which the three weapons systems to be studied will be compared.

The fourth criterion is dictated by the budgetary constraints imposed on the military services by the Congress. In terms of money, the Defense budget is 40% below the level of 1968.[40] At the same time, manpower ceilings for all four of the services are lower than at any time since before the Korean War, shrinking by more than 1.3 million men in the last five years.[41] This dictates that any weapon system in existance or proposed must be inexpensive both in terms of dollars and the manpower to operate it. These costs must be low not only during the actual utilization phase of the weapon, but during the research, development, testing and deployment phases also. The manpower and dollar operating costs must consider all people and money directly associated with the operation of the equipment as well as all of those people involved in the support of the system, such as fuel resupply, repair, spare parts supply, etc. Thus the fourth criterion is that the weapon system must be relatively inexpensive in terms of monetary and manpower costs.

The fifth criterion is implicit in the definition of the system itself. That is that it must be able to engage tanks that appear within the area of influence of the commander

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[40] Juan Cameron, "The Rethinking of U. S. Defense," Fortune, December 1973, p. 83.

[41] Ibid., p. 182.

who controls or directs the employment of the weapon system. The area of influence is defined as "that portion of the assigned zone or area of operations in which the commander is capable of directly affecting the course of combat by the employment of his own available combat power."[42] This area is normally taken to be a distance from the front line into enemy held territory equal to two-thirds of the range of the direct support artillery weapon of the commander. It represents that area of the battlefield under the control of that commander to the extent that he must grant or deny permission to any other friendly commander to fire into or otherwise bring combat power to bear in his area of influence. If the weapon system does not have sufficient range so that it is capable of covering this entire area, there would be a region where enemy armor could operate, relatively free from immediate antitank fire and could mass for an assault or assemble his reserves for a counterattack. The weapon could be designed to operate at ranges greater than the area of influence, but the target acquisition means of the commander are somewhat lacking outside of his area.[43] The fifth criterion is that the weapons system must be capable

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[42] Department of the Army, FM 30-5, Combat Intelligence, 12 February, 1971, p. 2-2.

[43] *Ibid.*, p. 2-3

of operating fully within the area of influence of the commander who controls or directs the fire of the weapon.

The sixth criterion is related to the mobility criterion but is sufficiently important to justify inclusion as a separate item. This stipulation is that it must be capable of operating in all terrain environments and over terrain obstacles. This capability is essential in order to deny the adversary any safe havens in which to hide armor forces until they are committed to battle. For example, if this criterion were not met by the weapon then the defender could keep reserve armor forces isolated from the attacker's main attack by an unfordable river that ran perpendicular to the direction of attack. The defender would then be free to counterattack after a small bridgehead had been established, the time when attacking forces are exposed to the risk of defeat in detail.[44] All of this could be accomplished without interference from antitank weapons which would be just beginning to cross the river with the assault echelons. Criterion six then is that the system must be capable of operating in all terrain environments and over all terrain obstacles.

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[44]Department of the Army, FM 31-60, River Crossing Operations, 27 March, 1972, p. 1-3.

The seventh criterion relates to the degree of responsiveness to the commander inherent in the system, both with respect to time and to degree of control. The system must respond quickly to the person who controls it because of the high mobility of the target tank. The normal tank could move from the outer edge of the area of influence to the front lines in a matter of one-half hour if the terrain is reasonably good.[45] Any weapons system which took longer than this to bring its destructive power to bear on the tank will not be of much use since the tanks will have reached the front lines and will be under fire from the direct fire weapons located there. Not only must the weapon be responsive in terms of time, but also directly responsive to the control of the commander in whose area of influence it is operating since, as mentioned earlier, he is the one who gives permission for the employment of combat power within that area. If the controls were given to another person, then excess coordination might be necessary, involving a further loss of time. To summarize the seventh criterion, the system must be responsive to the field commander in whose area it will be employed and must respond quickly to requests for antitank fire in that area.

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[45]This computation is based upon the 155mm howitzer as the direct support artillery weapon and a cross country speed for the tank of 25mph.

The last criterion arises from the fact that all three systems to be discussed are airborne systems. If they are to be effective in accomplishing their mission, they must be relatively invulnerable to countermeasures employed by the enemy. The most common countermeasures used against airborne weapons are surface-to-air guided missiles (SAM), and antiaircraft artillery and automatic weapons fire (AA). Although no system can be expected to be completely invulnerable to SAM's and AA fire, the survivability must be such that there is a reasonable chance of success for the mission and that the losses to be risked are not unacceptable in light of the results expected. In addition to the measures mentioned above that are used against airborne systems, electronic countermeasures (ECM) can be used by the enemy. These will hinder the operation of the electronic devices onboard the flying weapon. Examples of ECM are jamming the communications net between the airborne weapon and its home station, jamming the navigational radar being used to steer the weapon towards its designation by jamming return radar signals or producing stronger infrared signals from a dummy target. A more complete discussion of these techniques is in Chapter IV. Suffice it to say that our weapons system must be relatively invulnerable to these countermeasures or they will not be able to perform their mission successfully. The eighth criterion then is that it must be relatively invulnerable to SAM's, AA fire and ECM employed against it by the enemy.

These represent the eight criteria that will be used as a basis of comparison for studying the three weapons systems and their relative merits and weaknesses. There may be others that could be considered, but these eight are deemed essential to a successful antitank weapon that will truly offset the shock action and mobility of the tank.

HYPOTHESIS

Based upon the preceding findings, the following hypothesis can now be stated and tested:

1. Present weapons systems provide an adequate antitank capability at long ranges but
2. The presence of SAM's and AA fire make the use of manned aircraft expensive both in terms of money and lives lost and
3. RPV's can accomplish the task as well or better with less cost in both money and lives.

CHAPTER IV

COMPARISON

"Through the use of drones, or remotely piloted vehicles we avoid exposure of our aircrews to heavily defended areas. These remotely piloted vehicles can be designed to be light, relatively inexpensive and far more maneuverable than human tolerance would permit if a pilot were aboard."[46] This often quoted statement by Air Force General George S. Brown, former commander of Air Force Systems Command, serves as a good introduction to this chapter which will be devoted to the evaluation of the three systems that are to be considered.

The three criteria discussed in Chapter II will not be discussed in any great detail here since they were used to eliminate all existing systems except the three that are now being studied. Only the salient features of each and how they relate one to another will be discussed.

Mobility

That the fighter, the helicopter and the RPV are more mobile than the tank is obvious even to the uninitiated

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[46]"Reporter Notes," Reporter, Teledyne Ryan Aeronautical Magazine, Vol 32, No. 2, p. 1.

reader. But in comparison, each has a mobility feature that is superior to the other. The fighter usually flies at much faster speeds, even when it slows down to ground attack speeds of around 450 knots as opposed to the top speeds of the helicopter of 200 knots and of the RPVof 70 knots. This gives the fighter the edge on speed. However, due to this higher speed, the fighter takes a much longer time and requires a greater radius in which to turn around. This is due to the fact that the "G" force exerted on the pilot and the plane during a turn is directly proportional to the square of its velocity and inversely proportional to the radius of the turn. Therefore, a plane which is flying fast must turn a very wide turn with a large radius or the pilot will feel too many "G's" and black out. Conversely, a slow flying plane can turn a fairly tight circle. The high performance fighters are usually designed with small wing surfaces to optimize their performance at high speeds. This small wing surface means that the plane must be flown at high speeds in order to develop enough lift force to keep it in the air. Its minimum speed, known as the stall speed because it is the speed at which the airplane develops enough lift to keep from stalling the wings, is usually in excess of 120 knots.

The helicopter, on the other hand, can hover or fly at a speed of zero knots, which is its effective stalling speed. This means that the helicopter can turn in a radius of zero, or turn in place, a fact that is well known by anyone who has ever watched a helicopter performance demonstration. Thus the helicopter is superior to the fighter in its ability to turn in a small area.

The RPV (whose stalling speed would be on the order of 20 -- 30 knots) seems to lag behind the fighter and the helicopter in these two areas. However, one must keep in mind that there is no pilot on board an RPV so that if it is built sufficiently well, it can withstand forces in excess of the "G" loading that would cause a pilot to black out. So the RPV lacks the high speed of the fighter and the low speed maneuverability and hover capability of the helicopter, but it possesses potentially superior intermediate speed maneuverability due to the absence of the human consideration in determining the maximum acceleration forces that can be withstood.

<u>Accuracy</u>

The relative accuracy of the three systems is a subject for an exhaustive testing program and not a Master's thesis. In general, it would seem that potentially, the RPV and the TV-in-nose guided bomb have the greatest potential for accuracy since they do not rely on the ability of a gunner to keep a cross hair on the target, but rather on the ability of electronic equipment to perform a relatively simple task. Thus the human element is removed in these two systems. However all three have proven to be effective against point targets as was shown in Chapter II.

Invulnerability to Counterfire from the Tank

In this area, the helicopter is a definite step below the other two. It needs to remain relatively still with respect to the target tank so that the gunner can keep his cross hairs on the tank. This makes the helicopter subject to being fired upon by the tank while the missile is in flight.[47] It is argued that the high tank kill ratios reported in the Chapter II amounted to a "series of ambushes against advancing tanks."[48]

The RPV's must keep the target designator illuminating the target tank, but current models are capable of doing this while maintaining what is known as a jinking orbit.(see Fig. 6). This amounts to a slow orbit above the target with a sporadic, side-to-side and up-and-down movements superimposed on the flight path. This moving,

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[47]John T. Burke, "'Smart' Weapons: A coming Revolution in Tactics," Army, February, 1973, p. 13.

[48]Richard M. Ogorkiewicz, "Antitank Weapons, A Reappraisal," Armor, May-June, 1973, p. 25.

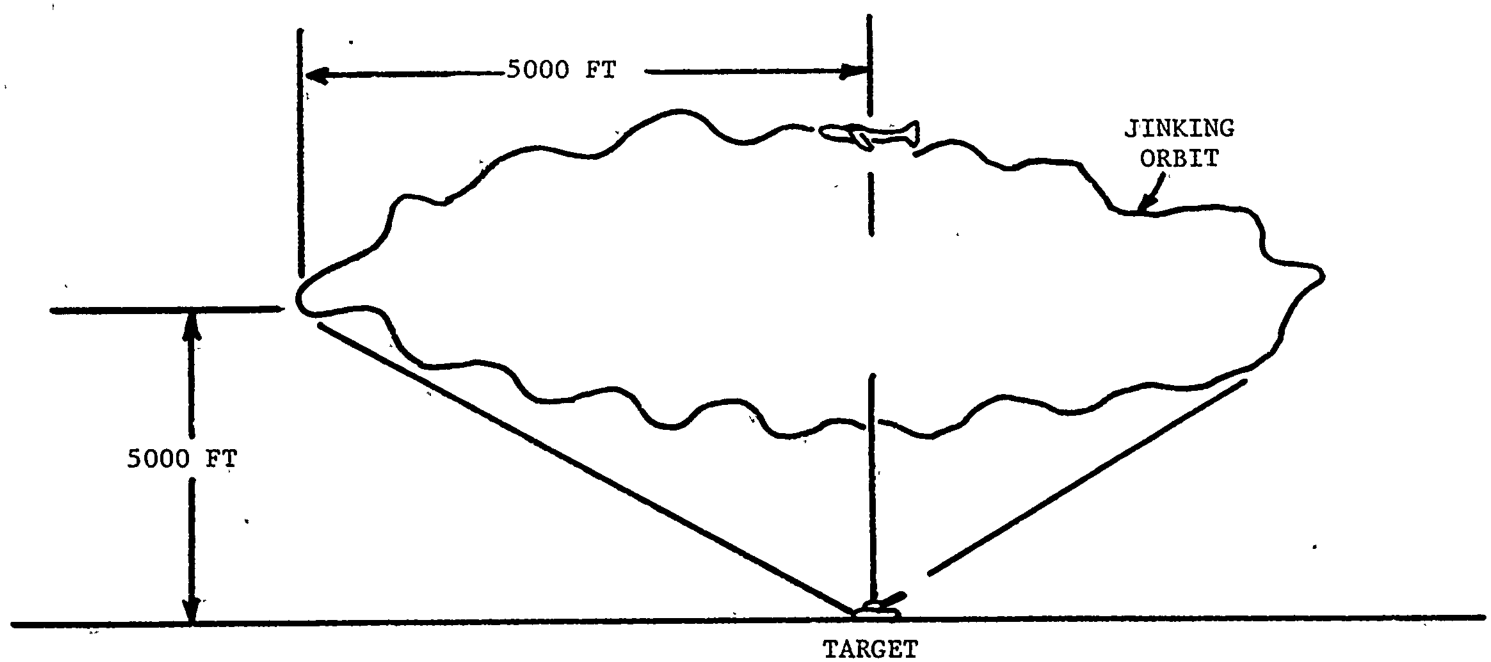

Figure 6. Typical Jinking Orbit

bouncing target would be very difficult for the tank, which would probably be moving to avoid the illumination, to engage with any degree of success.[49] The fighter makes its attack so quickly and from a high enough altitude that it has little to fear from the enemy tank, a fact borne out by the success of the Israeli Air Force against the Syrian and Egyptian tanks in the Yom Kippur War alluded to earlier.

Low Cost

This brings us to the fourth and one of the more significant criterion for discussion, that the system should be low in cost both in terms of manpower and money. In terms of actual equipment costs, the RPV stands out as the cheapest weapon by far. If we exclude the costs of the actual ordnance delivered on the target (Maverick for the fighter, TOW for the helicopter and the terminal weapon for the RPV) which are comparably priced in the neighborhood of less than $30,000 then the RPV is by far the least expensive delivery system. It has been estimated that a model such as the one prescribed in Chapter II would cost on the order of $20,000.[50] This amount is insignificant when compared to the cost of a Huey Cobra of nearly

[49] Burke, op. cit., p. 19.

[50] "Electric Motor Powered RPV's Studied for Battlefield Recon," Aviation Week and Space Technology, June 4, 1973, p. 76.

one-half million dollars and the cost of fighters which is currently approaching the $15 million mark for each airplane. It has been estimated that at the rate that the price of fighters is climbing, the services would be able to buy only one airplane a year by the year 2020 if the DoD budget slice remains proportionately the same as it is today.[51] So the cost of the RPV weapons system itself is far lower than that of the fighter or the helicopter. This big advantage is off-set somewhat however by the fact that the fighters and helicopters are now in production while the RPV is still in the test and development phase. Also, most of the support equipment for these two weapons has been purchased. These facts will raise the initial procurement cost of the RPV's somewhat.

In terms of manpower, the RPV is potentially less expensive. The AN/USD-1 drone system of the early 1960's operated with a 12-man section which controlled 12 drones and one launcher.[52] Although the sophisticated RPV will undoubtedly require a few more men to maintain the communications equipment, this number should not increase by more than one or two men. Thus fewer than 15 men would be

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[51] Barry Miller, "RPV's Provide U. S. New Weapon Options," Aviation Week and Space Technology, January 22, 1973, p. 40.

[52] U. S. Combat Surveillance Agency, Management Manual AN/USD-1 Combat Surveillance Drone System, 1961, p. 6.

required to keep one RPV over enemy territory at any time with one more prepared for launch to replace it upon its return or demise. Contrast this with the 450 men in an F-4 squadron that supports 24 aircraft, a ratio of nearly 20:1. The helicopter does not fare much better than the fighter when the TO&E of an Airborne Division is examined. The Attack Helicopter Company has 143 officers and men to support 12 birds, or a ratio of about 12:1. But if one considers their appropriate slice from the battalion headquarters company of 93 men and their slice of the Transportation Aircraft Maintenance Company of 217 people, then the ratio moves up beyond that of the RPV. Not included in this numbers analysis are the many men involved in the logistical support for the systems, providing a supply of fuel and oil and the repair parts necessary to keep the equipment in the air. It is obvious that complex and fuel-devouring fighters and helicopters will require a much larger supply system than the smaller RPV. But the biggest selling point for the RPV is the fact that no pilot is on board. This means that if the RPV is shot down, there is no one to be killed or captured. A vivid illustration of this consideration is the fact that 200 reconnaissance drones were lost over Southeast Asia during the Vietnam War,[53] but no pilots were on board

[53]"National RPV Policy Needed?" Armed Forces Journal, February 1973, p. 19.

so no additional casualties or inhabitants of the "Hanoi Hilton" resulted. These drones represent a savings of at least 200 and maybe 400 lives or prisoners, had these missions been performed by airplanes which were flown by one or two men. Therefore, in terms of dollars and manpower, the RPV is clearly the most economical weapon system.

Cost	Helicopter	Fighter	RPV
Development	None	None	None
Testing	None	None	Unk.
Purchase	$500,000	$15 million	$20,000
Manpower	20+/plane	20/plane	15/plane
Pilot	2	1 or 2	None

Table 2: Cost Comparison for the Three Systems

Area of Influence Coverage

The size of the area of influence varies greatly with the situation and the size of the unit under consideration. For a division size unit, in normal operations, with the 155mm howitzer as the direct support artillery weapon, the area of influence would be a rectangle, roughly 12 km deep behind the front lines and 20 to 40 km long. This area could easily be covered t all three weapons systems under consideration. The fighter can cover the whole area faster due to its high speed, but it cannot remain over one point in that area for more than an instant due to the high speed and the resulting large turning radius discussed earlier. The helicopter would cover the area more slowly but is capable of slowing down further and hovering over a particular spot in the area to observe what transpires and engage any targets found therein. The RPV is the slowest of the three and can remain over one spot in the area only by entering into a jinking orbit over the desired spot. Thus, within the area of influence the helicopter has the best target acquisition capability and can cover the area more thoroughly than the other two, but the fighter can cover it faster.

All Terrain Environments

Terrain serves as no restriction to the movement of any of the three systems due to the fact that they are airborne. The helicopter is unique among the three in that it can actually take advantage of certain terrain by flying along the ground, in and out of trees, behind hills and so forth. The high performance fighter has only a limited success in this endeavor due to the high speed and maneuverability problem. Any attempt by a remote pilot to use these techniques are certainly fraught with danger. But the helicopter can suffer offsetting disadvantages from terrain environments such as a desert or other dry, dusty terrain. Witnesses to recent maneuvers in Texas related that the dust column blown up by the downwash of the helicopter's rotor blades rose to a height greater than that of the hovering helicopter, making an easily identifiable signature of its presence. Many of these hiding helicopters were "destroyed" by artillery that was adjusted onto the dust column. So terrain is neither a significant hindrance nor a substantial aid to the high flying fighters and RPV's but it can work to the advantage or disadvantage of the helicopter depending upon its nature and how the helicopter uses it. However, it does not prevent the accomplishment of the mission by any one of the three.

Responsive to Field Commander

This criterion proves to be one of the serious drawbacks to the Air Force fighter. As mentioned in Chapter III, both control and speed are involved when the concept of responsiveness is discussed. As far as control is concerned, this argument has gone on since the Air Force became a separate service after World War II. Does the Army control the employment of the Air Force close air support missions? The answer to this question could be a study within itself and is not worth the space required in this study. Suffice it to say that there is some disagreement as to the answer to this question as evidenced by the on and off battle at the JCS level as to whether the Army or the Air Force should own the weapons for close air support.[54] The RPV and the helicopter are both Army weapons and would be in Army hands,

[54]Maxwell D. Taylor, The Uncertain Trumpet (New York: Harper & Brothers, 1960), p. 169.

controlled by Army commanders. There should be no question as to their responsiveness.

In the realm of timely response, again the Air Force fighter must take a back seat to the other two. Air Force missions are broken down into two categories, preplanned and immediate. The preplanned missions are planned a day in advance of their anticipated requirements and are programmed against probable targets that will arise during the day's fighting. The ordnance or bomb load on the aircraft that will fly these missions is based upon the type of target that the aircraft is assigned to destroy. The immediate missions are those that are saved for an emergency target that was not anticipated. The immediate missions can be flown by airplanes that are already airborne, in which case the ordnance mix aboard the fighter is already set or they may be on alert on the landing strip, waiting to be loaded with the desired ordnance. Thus if the field commander becomes involved in an armor battle which he does not anticipate or which is larger than planned for and all of his preplanned missions which are armed with antitank ordnance such as the Maverick are exhausted, he must resort to the immediate type of mission. If the airplane that is to be used for the immediate mission is already airborne with ordnance that is not effective against tanks, then it can be used but without much effect on the target tank. If the airplane is back at its home base on strip alert, then it can be loaded with the proper weapons load. But by the time it is loaded and then flies from its home base which is usually back in the far rear of the battlefield, more than the desired one-half hour would have elapsed when it arrived at the target area. Also, once the preplanned and immediate strikes allocated to the commander have been exhausted, the commander must turn to his higher headquarters and plead for more air sorties.

The helicopter can be expected to respond more quickly since the aircraft organic to or attached to a maneuver unit will be located at the unit airstrip which will be in or near the unit support area. This area is normally located behind front lines a distance sufficient to keep it out of range of the enemy direct support artillery, usually a distance of about 15 km. Thus if the proper ordnance is on the chopper, it can be over the area of influence in a matter of 10 to 15 minutes. If not, then loading time must be added to this time to determine the total response time. However, due to the greater control that the field commander exerts over the helicopter, it is resonable to expect that it would be loaded with the proper ordnance just as soon as an armor battle broke out.

The RPV should be located a shorter distance behind front lines since the launcher and guidance modules can be widely dispersed so as not to present a lucrative target for the enemy artillery. It might take the RPV an amount of time comparable to the helicopter to get to the target due to its slower speed. However, once the RPV has arrived on the scene, there is no need to be concerned about the ordnance load that it carries on board if it is being used as a laser designator. The desired ordnance is fired in the direction of the target and terminally guided in by the laser designation (see Fig. 6, page 44).

If the RPV carries the warhead itself, kamikaze style, then the type of warhead is important and the responsiveness is considerably lessened. This type of RPV employment will be discussed at the end of this chapter.

The biggest advantage of the RPV that is being used as a designator in the area of responsiveness derives from its ability to sustain continuous attacks on the enemy armor formations. The helicopter and the fighter must return to their base areas to reload once their ordnance has been expended. The Huey Cobra normally carries 8 TOW missiles per helicopter.[55] while the fighter carries six Mavericks under its wings in the normal load.[56] However, the commander who is employing the RPV has available to him as many laser guided rounds as are in his supply lines.

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[55]"Helicopter Antitank Role Expanded," Aviation Week and Space Technology, November 12, 1973, p. 54.

[56]U.S. Army Command and General Staff College RB 110-1, US Air Force Basic Data, 1 August 1973, p. A-40.

Thus the initial responsiveness of an RPV is not outstanding compared to the other systems, but the system's sustained responsiveness is. This lack of initial responsiveness can be overcome by maintaining one RPV in jinking orbit over the battlefield at all times so that it could be over the target in a matter of minutes. To do this with the expensive Cobra would lead to a dangerous as well as fatiguing situation for the pilots.

To summarize this criterion, the fighter lacks the responsiveness with respect to control and has only limited responsiveness with respect to time, that is if everything is planned properly. The helicopter is very responsive in control and reasonable so with respect to time, as is the RPV system. However, the RPV itself has the potential of remaining in the air over the battlefield for a longer time while continuing to deliver ordnance on the target. It also is able to be over the action more quickly with less risk to human life if it remains in orbit over the battlefield as long and as much as possible. So the RPV is the far more responsive and flexible weapon of the three.

Vulnerability

Once again this criterion is a subject for a study in and of itself, and many such studies are currently in progress. However, some of the unclassified results of tests and actual encounters will be used to show the relative vulnerability of the three systems, first to SAM's and AA fire and then to ECM.

The Yom Kippur War showed "increasing vulnerability of piloted aircraft to a heavy belt of antiaircraft missiles."[57] During the encounter, the Israeli Air Force (IAF) lost 115 aircraft, including six helicopters, which amounts to about 1 airplane for every 100 sorties.[58] In the first afternoon alone, they lost 30 A-4's and several F-4's to SAM and AA strikes.[59] Eventually, the IAF recovered and destroyed 50% of the SAM and AA batteries on the Arab side.[60] The record in North Vietnam is equally frighteneing, with 117 fighters lost to SAM's and 750 to ground fire from AA weapons and other conventional types. This loss was sustained during the four years prior to the bombing halt in 1968.[61] As SAM's become more and more sophisticated, this vulnerability of fighter aircraft to missiles and AA fire cannot help but intensify.

Helicopters have not really been tested in a high SAM and AA environment. They were used by the Israeli

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[57] Robert Hotz, "The Mideast Surprise," Aviation Week and Space Technology, October 15, 1973, p. 7.

[58] Herbert J. Coleman, "Israeli Air Force Decisive in War," Aviation Week and Space Technology, December 3, 1973 p. 18.

[59] Ibid., p. 19. [60] Ibid., p. 18.

[61] Larry H. Addington, "Antiaircraft Artillery Versus the Fighter-Bomber," Army, December, 1973, p. 19.

Air Force only for logistics type operations since the commander of the IAF did not believe that helicopters belonged on the battlefield.[62] In some U.S. Army tests, TOW's mounted on Huey gunships have scored kill ratios as high as 7:1 against mobile AA weapons.[63] But critics of these tests say that they were unrealistic due to a lack of enemy air threat in the exercise. These same maneuvers brought considerable complaints from the local residents about the noise generated by the helicopters. This indicates that a surprise attack by them would not be feasible.[64] The noise also detracts from the one defense measure that it has against anti-airmissiles, the technique of nap-of-the-earth flying, or flying as close to the ground as practical as mentioned in the discussion on terrain earlier in this chapter. The helicopter's noise makes them easy to detect by defending ground troops and thus vulnerable to ground fire. This technique of low flying resulted

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[62] U.S. Congress, House, Committee on Armed Services Report of the Special Subcommittee on the Middle East, (H.A.S.C. No. 93-32) (Washington: Government Printing Office, 1973), p. 5.

[63] David A. Brown, "Army May Speed Program to Arm Cobras with TOW," Aviation Week and Space Technology, July 17, 1973, p. 17.

[64] "Helicopter Antitank Role..." op. cit., p. 55.

partly from the Viet Cong use of the Russian made, hand held Strella missile which was credited with downing three U.S. helicopters during the Vietnam conflict. All of the helicopters that were hit were flying above 500 ft. The subsequent lowering of operational altitude helped defend against the Strella but resulted in poorer weapons delivery results.[65]

The feature of relative invulnerability to SAM's and AA fire proves to be the single biggest advantage that the RPV has over the fighter and the helicopter. In order for the SAM or the AA gun to be effectively employed against the RPV, it must be able to locate and track the RPV either by radar or by sensing the infrared (IR) signals of the RPV motor. The radar signature of an RPV has been estimated to range from that of a bird,[66] to about one-tenth that of a typical fighter.[67] The IR signature will be essentially nonexistant also. It is a well known fact that target drones frequently require IR augmentation to allow IR seeking missiles to properly track and home in on them. But even if the IR or the radar guided missiles are able to lock on

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[65]"Army Plans Helicopter Changes as Strella Missile Use Continues," Aviation Week and Space Technology, July 17, 1973, p. 18.

[66]"Electric Motor Powered PRV's Studied for Battlefield Recon," Aviation Week and Space Technology, June 4, 1973, p. 75.

[67]"National RPV Policy Needed?" Armed Forces Journal, February 1973, p. 19.

and track the RPV, the RPV is still capable of maneuvering so that the missile will miss and of performing maneuvers developing "G" forces far in excess of what a man could stand. Even if these evasive maneuvers are unsuccessful and a round or missile detonates near the RPV due to the detonation of its proximity fuze, the burst must be much closer to an RPV than to a fighter. The smaller size of the RPV gives it a smaller vulnerable area (see Fig. 7). Thus a near miss which would down a fighter may have no effect on the RPV. Some sources are so confident of the success of the RPV that they have claimed that the missile and radar directed AA guns will not be effective against the RPV.[68] The RPV's quietness and small size make it difficult for the soldier on the ground to detect it and to fire his individual weapon at it with any reasonable degree of success. The conclusions of this paper do not warrant quite as optimistic an outlook as to say that the RPV will be unaffected by SAM's or AA fire, but it can be safely predicted that the survivability of an RPV on the battlefield may be far superior to that of the helicopter or the fighter.

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[68] U.S. Army Electronics Research and Development Laboratories, Final Report of Project "Ping Pong," 166-40906-D-508-04-04, (Fort Monmouth, N. J.: n.n., n.d.), p. 22.

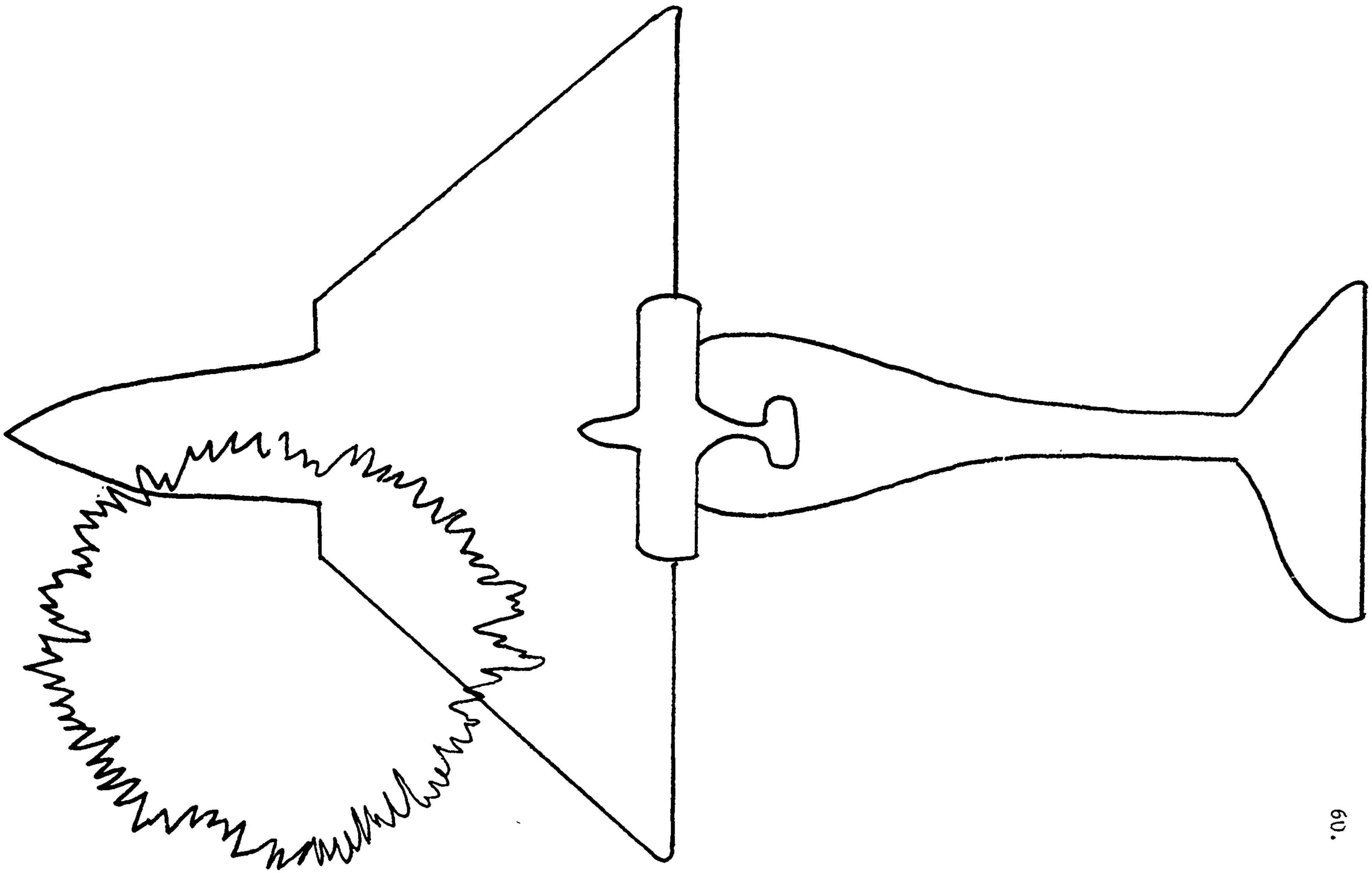

Figure 7. Effect of a 100 mm AA Round Near Miss on a Fighter and an RPV

The other counter measure to be employed against the three weapons systems is jamming or ECM. It is here that the RPV has its greatest potential weakness. As stated earlier, the USD series drones were dropped from the Army inventory in the early 1960's because of their vulnerability to ECM and the RPV has the same potential problem. The enemy needs only to interrupt successfully or otherwise impede the flow of information between the RPV and the remote pilot or guidance signals and the RPV can be prevented from accomplishing its mission. The same could be said of the Maverick bomb system which relies on information exchange between the pilot and the weapon. Only the helicopter is relatively immune to this form of countermeasure since communications between the helicopter and the missile are accomplished over the guidance wire. This system cannot be jammed unless the enemy can tap the wire between the helicopter and the missile, which is highly unlikely. However, the enemy can jam the communications link between the helicopter and its field commander, with a resulting loss of responsiveness. But jamming could not prevent the pilot from engaging an individual tank as it could with the RPV and the Maverick.

Much research is being done in this area and the potential for breakthrough is high.[69] One method that is

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[69]"Industry Observer," Aviation Week and Space Technology, August 20, 1973, p. 111.

under investigation is frequency jumping. This technique involves sequencing both the receiver and the transmitter to jump from one frequency to another at prescribed intervals. In this manner, no one frequency is used for more than a few microseconds so that jamming would be difficult.

In summary then, the RPV is far superior to its competitors in the field of survivability in a high AA or SAM environment, but suffers possible problems in an ECM atmosphere, from which the helicopter is relatively secure.

One more subject should be addressed before concluding this study. This is the manner of employment of the RPV, as a target designator for a terminally guided weapon or as the weapon itself, somewhat like a kamikaze airplane without a pilot. As mentioned earlier in the discussion about responsiveness, the latter method would negate one of the inherent advantages of the RPV, its ability to stay over the target and to continue delivering accurate fire as long as necessary or until it must return to refuel. If the RPV is used as the weapon itself, then this flexibility is lost. The expense of using the RPV as the weapon might seem prohibitive at first glance; however, when considering that it has been calculated that it took almost $120,000 in artillery rounds just to kill one enemy soldier in our past wars,[70] then the expense of one RPV for a

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[70] Burke, op. cit., p. 19.

sure kill of a tank would be slight indeed. But if the RPV is being used as a designator, it could continue gathering intelligence data during lulls in firing, or it could perform its own damage assesment after the tanks have been hit. Therefore, because of the loss in flexibility and intelligence gathering capability, the use of the RPV as a designator and not as the weapon itself would be the only way to truly reap the advantages that the RPV has to offer over the other three systems.

CHAPTER V

SUMMARY AND RECOMMENDATIONS

Summary

Table 3 shows the advantage and disadvantages of the three systems which have been compared in the last chapter. The salient features are discussed in the following paragraphs.

The fighter-guided bomb combination has as its most important advantage the speed with which it covers an area of influence and that same speed which makes it a very difficult target for the tank or the soldiers individual weapon. But its vulnerability to both SAM's and AA fire as well as to ECM, coupled with the extremely high cost of building and maintaining the sophisticated fighter make it a less desirable antitank weapon than the other two.

The helicopter armed with the TOW does not have the speed of the fighter, but it can maneuver better over the area of influence and serve as a source of intelligence. It is much more responsive to the field commander than is the fighter and is invulnerable to ECM in so far as the weapons system itself is concerned. However, the helicopter is vulnerable to small arms fire from automatic weapons and

Table 3: Comparison of Advantages and Disadvantages of the Three Weapons

Weapon	Advantages	Disadvantages
Fighter	High Speed	High cost in money and manpower
	Difficult target for small arms	Vulnerable to SAM and AA fire
Helicopter	Highly maneuverable	High cost in money and manpower
	Responsive to Field Commander	Vulnerable to SAM, AA and small arms fire
	Invulnerable to ECM	
RPV	Low cost in money and manpower	Vulnerable to ECM
	Responsive to Field Commander	Not highly maneuverable
	High survivability in an AA and SAM environment	

individual rifles at low altitudes as well as missile and AA fire when at higher altitudes. It does not cost as much as the fighter, but is still very expensive when compared to the RPV.

The biggest advantages for the RPV are low cost both in terms of money and manpower and higher survivability in an AA and SAM environment. These two advantages work hand-in-hand to reinforce each other. Even if RPV's were vulnerable to the SAM and AA fire, their low expense means that the mission could still be accomplished at lower costs than using one of the more expensive systems. To illustrate, one could afford to lose almost 50 RPV's to each helicopter to accomplish what the helicopter could do and nearly 1000 RPV's could be expended to do the job of one downed fighter. This does not even consider the lives of the pilots that would be saved. Conversely, even if the RPV were priced comparably to the other two, its low vulnerability would still make it the least expensive weapon. The other less significant advantages of the RPV are its responsiveness to the commander and its flexibility in remaining over the battle area to guide whatever amount of ordnance is fired to accomplish the mission.

The greatest disadvantage of the RPV is its vulnerability to ECM. This puts it in the same category as the fighter but inferior to the helicopter-TOW combination. Now that technology has developed secure voice radio that can be uncoded only by a particular device, anti-jamming communications links cannot be far away. Perhaps even the laser beam itself could be used to send and receive messages from an airborne relay which would be in orbit over the RPV control station. The line-of-sight laser beam would be very difficult to jam since the enemy would have to place its jamming device on a line between the RPV and the relay. The other disadvantage, that the RPV is not as maneuverable as the helicopter, is insignificant in comparison to the ECM disadvantage.

If the problem of ECM vulnerability is solved, then the conclusions of this study are that the RPV is by far the superior antitank weapon for use by the U.S. Army. This is not to say that the fighter and the helicopter should be eliminated from the antitank role. The Yom Kippur War showed that all antitank weapons are effective against an all out massive armor assault. The fighters could be used at ranges exceeding those that the helicopter or the RPV would be able to achieve. The helicopter could be used in terrain where its low level techniques would give it the desired protection. The RPV would be used where the AA and SAM defense systems were heavy, and where the likelihood of survival for the fighter or helicopter would be small. However, the prime long range antitank weapon would be the RPV.

If the problem of ECM invulnerability is not solved through technology, the RPV still offers potentially the best antitank weapon. As mentioned, the fighter is equally vulnerable to these measures and the helicopter suffers some detriment to its mission when subject to ECM, so none of the systems is clearly superior in this regard. Also, if the enemy ECM is to be successful in stopping the RPV, their jamming equipment must be ubiquitous on the battlefield, capable of around the clock operations. Another consideration is that the jammer is an emitter of radiated energy which could be used as a terminal guidance beam for a weapon designed to home in on that energy. So the ECM vulnerability is a drawback to the RPV, but there are some measures that could be taken to offset this disadvantage.

Implications of a Nuclear Battlefield

Up to this point, this paper has not addressed the effects that a nuclear environment would have on the three systems. The presence of nuclear weapons and the threat of their employment would not change the relative advantages and disadvantages of the three systems studied. The biggest effect that nuclear weapons will have on the battlefield itself is that it will demand much greater dispersion, both between individuals and between units. This does not affect the manner in which the three systems are employed, other than requiring greater range capabilites from them.

But the dispersion that is required gives even greater reasons for employing RPV's. When units disperse to the degree that is envisioned on a nuclear battlefield, there will be spaces of hundreds of meters between battalions. The RPV would be ideal in this situation to provide "eyes in the sky" to keep these gaps under constant surveillance while maintaining a jinking orbit over friendly lines. In this manner, probes or penetrations could be detected early and countered with laser guided weapons, counter-attacks or other conventional means. The helicopter could perform this same function except that pilot fatigue and constant exposure to AA fire would be signigicant problems.

<u>Areas for Further Study</u>

Because the RPV concept is in the development stage, it is replete with areas for further study. A few suggested areas of significance are as follows:

1. ECCM (Electronic Counter Counter Measures) that would successfully counter any enemy jamming should be studied. Several possible solutions were mentioned in this chapter and Chapter IV.

2. A multi-purpose RPV should be studied to determine its usefulness and feasibility. Some of the uses to which it could be put are outlined in the next section of

this chapter.

3. The level of employment for the RPV is another area which should be examined. This study concentrated at division level employment, but brigade or lower levels as well as higher levels should be considered also.

4. The vulnerability of the RPV to SAM's and AA fire needs to be actually tested to see if it can survive an attack from these weapons. Also methods of improving the survivability of the RPV in this environment should be developed.

Other Uses for RPV's

Many possible uses for RPV's have been proposed by the industry and by combat developers. Some of the more promising uses are listed below:

1. A photo-reconnaisance vehicle (already a proven concept.)

2. A radar homing device to eliminate SAM and AA radar sets or jamming devices.

3. A chaff dispenser (chaff consists of small bits of metal which reflect electromagnetic energy and when dispensed into the air form a cloud that negates the transmission of radar or other electromagnetic radiation through the cloud.)

4. A resupply vehicle for troops surrounded by attackers."

5. A test vehicle for research and development to eliminate the risk to a test pilot.

6. A forward air controller to direct Air Force combat strikes.

7. An air superiority fighter to be used in the air-to-air combat role.

8. A weapons platform to deliver bombs or missiles to highly defended areas.

Allied and Sister Service Use of RPV's

The United States Air Force has been concentrating its efforts in two directions. The Compass Cope program is devoted to developing a jet powered reconnaissance drone. The specifications call for a jet powered craft, capable of carrying 700 pounds on a flight lasting 30 hours. The flight envelope includes altitudes of between 50 and 70 thousand feet and speeds of between Mach 0.6 and Mach 0.9. Both Teledyne Ryan and Boeing built and flew prototypes in early 1974, but budgetary constraints have postponed the purchase of the aircraft indefinitely.[71]

The other program being pursued by the Air Force is the conversion of the MQM-34 reconnaissance drones into

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[71]"Future of USAF RPV Program Unclear," Aviation Week and Space Technology, January 21, 1974, p. 53.

strike RPV's. These are designed to designate targets for laser seeking weapons. The conversion of the drone to the RPV is done by installing target acquisition means such as the TV camera in the MQM-34.[72]

The United States Navy has also looked into these two uses for RPV's. In conjunction with Northrop Corporation, the Navy is testing RPV's based upon the MQM-74 target system which is standard in the Navy today.[73] This drone is preprogrammed to fly a specific route but may be reprogrammed in flight or controlled completely by the ground station.[74]

The Navy has also shown an interest in the Mini-RPV idea that the Army is pursuing. A contract was let with Philco-Ford to begin testing an RPV to designate targets for laser guided weapons fired by the ship. These tests were scheduled to begin in April, 1974.[75]

The search of the literature showed that several allied countries, to include France and Belgium are using

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[72] "Strike Drone Begins Flight Testing," Aviation Week and Space Technology, April 15, 1974, p. 59.

[73] K. H. Rogers, NV-126 Demonstration Flight No. 1 with Camera and Loran, (Newbury Park, Calif: Northrop Corporation, Ventura Division, 1973), p. i.

[74] Ibid., p. 2.

[75] Barry Miller, "Mini-RPV Research Programs Expanded," Aviation Week and Space Technology, March 4, 1974, p. 17.

and experimenting with reconnaissance drones, but no evidence of the use of RPV's as envisioned in this study was uncovered. The Israelis considered developing RPV's to eliminate Egyptian missile sites, but discarded the idea because they believed that piloted planes could "do the job without heavy loss."[76] Perhaps the loss of 115 planes will be considered too heavy and their decision will be reversed.

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[76] Robert Hotz, "The Mideast Surprise," Aviation Week and Space Technology, October 15, 1973, p. 7.

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