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This study attempts to determine if tactical air support of an airborne battalion is feasible in adverse weather. The investigation is focused on an analysis of close air support, reconnaissance, and aerial resupply.

Investigation reveals that the Air Force is capable of providing tactical reconnaissance and aerial resupply in adverse weather. Further examination reveals that the Air Force is only capable of very limited close air support in adverse weather. Hence, at the present time, tactical air support of an airborne battalion in adverse weather is not feasible.

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# Is Tactical Air Support of an Airborne Battalion Feasible in Adverse Weather?

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Fort Leavenworth, Kansas 66027

Final report 8 June 1979



A Master of Military Art and Science thesis presented to the faculty of the U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027

# IS TACTICAL AIR SUPPORT OF AN AIRBORNE BATTALION FEASIBLE IN ADVERSE WEATHER?

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

MASTER OF MILITARY ART AND SCIENCE

by

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# ABSTRACT

IS TACTICAL AIR SUPPORT OF AN AIRBORNE BATTALION FEASIBLE IN IN ADVERSE WEATHER? by Major Howard D. Barnard, III, USAF, 64 pages.

This study attempts to determine if tactcal air support of an airborne battalion is feasible in adverse weather. The investigation is focused on an analysis of close air support, reconnaissance, and aerial resupply.

Investigation reveals that the Air Force is capable of providing tactical reconnaissance and aerial resupply in adverse weather. Further examination reveals that the Air Force is only capable of very limited close air support in adverse weather. Hence, at the present time, tactical air support of an airborne battalion in adverse weather is not feasible.

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CHAPTER I

INTRODUCTION

Historically, the capabilities of the airborne have been twofold: executing strategic deployments on short notice and conducting airborne assaults. The airborne has been tailored for air movement, and as a result it can be deployed more rapidly than any other United States division. All of its personnel are trained for airborne operations. Due to these reasons, the airborne has been assigned contingency missions throughout the world.

Prior to 1974 the Army conducted airborne operations under visual flight conditions. Visual flight conditions occur when the pilot can see the ground using only his unaided eyesight. Visual flight conditions are defined as ceilings of a 1000 feet or more and visibility of 3 miles and greater. Under visual flight conditions the airborne's mission has been and continues to be to conduct airborne assualt in the enemy's rear to secure key terrain or to interdict routes of resupply or enemy egress. The airborne can not be used against a superior armor force in unfavorable terrain without unacceptable losses.[1]

In 1974 the United States Air Force (USAF) certified the adverse weather aerial delivery system (AWADS) for the C-130E aircraft. The introduction of AWADS added to and made a third capability of the airborne: achieving surprise due to its all-weather drop capability. The airborne can now achieve surprise by timely arrival on or near the battlefield. The range of USAF aircraft and the use of AWADS have produced unprecedented accuracy in virtually all weather conditions.[2]

## BACKGROUND

Before discussing the AWAD system, one must be familiar with the definition of adverse weather. Adverse weather is when the pilot can not see the ground using only his unaided eyesight. Adverse weather is a ceiling of less than 1000 feet and visibility less than three miles. It may also be caused by darkness. The Army considers wind to be adverse weather due to its effect on jumpers and equipment. General James M. Gavin indicates that wind is not considered when a unit is dropped in combat.[3] Wind is not considered to be a limitation by the USAF, as it may be compensated for. The USAF definition will be used in this paper.

The AWADS is a self-contained system that uses doppler radio detecting and ranging (radar) to determine ground speed and a computer that stores flight route information: start point, route checkpoints, windspeed and direction, and airspeed. These two instruments depict the aircrafts position in relation to the programmed checkpoints. This information enables the pilot to fly a specific route to a drop zone in adverse weather, thus eliminating the restriction for paratroopers and equipment to be delivered in visual flight conditions.[4]

The Army considers AWADS to be fully operational for personnel and equipment. The use of AWADS provides the airborne with greater flexibility and increased capabilities to accomplish its missions. AWADS is particularly effective in large joint operations, tactical reinforcements, and special missions. Specifically, AWADS allows rapid, continuous aerial deployment and resupply in adverse weather or darkness.[5]

The use of AWADS makes it possible for a parachute assault to be conducted without a prepositioned USAF combat control team (CCT) and/or an army assault team (AAT). This increases the element of surprise and only requires the air corrider to the drop zone be cleared by fighter aircraft one time. AWADS permits the use of vertical reinforcement of units threatened by an enemy penetration during adverse weather.

Using AWADS in adverse weather will reduce the vulnerability of the aircraft to anti-aircraft guns with only visual tracking capability, reduce the vulnerability of parachutist to small arms, and reduce the enemy's fighter air-to-air capabilities. In addition the enemy's ability to reinforce or counter an airborne assault by airmobile operations will probably not be feasible during adverse weather conditions.[6]

## PURPOSE OF THE STUDY

Initial testing indicates that tactical air support for an airborne unit may not be feasible in adverse weather. This study was undertaken to determine whether current tactical air support (airlift, close air support, and reconnaissance) can support the increased capabilities of the airborne using AWADS. The Army's Field Manual (FM) 100-5. Operations states, "At critical times and places where victory or defeat may hang in the balance, the Army requires close air support of the engaged ground forces."[7] In a similiar manner tactical reconnaissance is needed to provide timely intelligence as to approaching enemy units, their direction and size. Also tactical airlift is required to resupply the airborne unit. If the concept of victory on the modern battlefield requires the integrated operations of air ground forces, the Air Force must be able to perform its part in adverse weather conditions.

We now possess the capability to air drop paratroopers in adverse weather. If after the initial insertion of the airborne, the Air Force can not provide tactical air support in adverse weather, then the airborne capabilities which AWADS provides are severely limited. Airborne units inserted without proper support can be expected to sustain unacceptable losses.

Given these facts, this study will research the following question:

-- Is tactical air support of an airborne battalion feasible in adverse weather?

## ASSUMPTIONS

This study is based on the assumption that the Army will continue to have the responsibility for airborne operations and that the Air Force will continue to have the responsibility for tactical air support and will fulfill that responsibility in all kinds of weather during both day and night. It is also assumed that the concept of an integrated Army and Air Force task force will continue to be used as an operational concept as a means to win in war.

## LIMITATIONS

This study is based on the following limitations:

1. Support is limited to an airborne battalion. The airborne battalion was chosen for two reasons: a) The infantry battalion (airborne) is the basic maneuver unit of the airborne division. b) The battalion is the lowest unit to which an Air Force tactical air control party (TACP) is furnished.

2. In an attempt to limit the scope of the study, communications and electronic countermeasures are not considered.

3. Crew limitations are not considered. The crew is assumed to be fully qualified in the aircraft.

4. Tactics are not considered. If an aircraft has a capability to work in adverse weather, it is assumed that its crew is familiar with the tactics which allow it to exercise this capability.

5. The study is unclassified in an effort to encourage dissemination of the information.

## METHOD

To address the problem statement, related literature is reviewed in Chapter II on the use of tactical airlift to provide aerial resupply to an inserted airborne battalion, Chapter III on close air support of the inserted airborne battalion, and Chapter IV on tactical reconnaissance in support of the inserted airborne battalion. These chapters deal with historical perspectives and determining current capabilities. Current capabilities will be determined by using test data for each system.

Chapter V is the final chapter; each hypothesis is analyzed to see if the findings of the study support or refute it. Finally, a conclusion and recommendations are made based on the analysis of the findings.

## CHAPTER END NOTES

[1]U.S. Army Command and General Staff College, Infantry and Airborne Division and Brigade Operations, RB 71-102 (July 1978), p. 10-2.

[2]Department of the Army, 82D Airborne Division, Division Airborne SOP, Div Reg 525-2 (February 1976), p. 5-1.

[3]James M. Gavin, On to Berlin, (New York, N.Y.: The Viking Press, 1978), p. 19-20.

[4]Department of the Army, 82D Airborne Division, Division Airborne SOP, Div Reg 525-2 (February 1976), p. 5-1.

[5]Ibid., p. 5-1.

[6]Ibid., p. 5-1.

[7]Department of the Army, Operations, FM 100-5 (April 1977), p. 3-8.

## CHAPTER II

## TACTICAL AIRLIFT

### ANALYSIS OF PRESENT ADVERSE WEATHER DELIVERY SYSTEMS (AWADS)

General James M. Gavin in his book On to Berlin points out that every airborne force that drops into territory strongly held by an alert enemy is dependent upon aerial resupply. Any serious failure in resupply of the task force would result in its loss.[1] The necessity of aerial resupply is just as important today as it was in World War II.

The C-130 is the only tactical airlift aircraft the regular Air Force now has in its inventory. While it is true that the C-141 and C-5 aircraft can be used in a tactical situation, they are normally employed in a strategic role. In addition the C-130 is the only aircraft equipped with the adverse weather aerial delivery system (AWADS).

The AWADS can assist the aircrew in aerial resupply missions as well as the initial drop of the airborne task force. Under conditions of zero visibility and/or darkness, the AWAD system provides capabilities for maintaining precision intra-formation flying and performing paradrop operations as required by the Army. The AWAD system employs a four-function forward-looking radio detection and ranging (RADAR) that provides the precision navigation required for adverse weather deliveries.

The four functions performed by the radar are ground mapping, weather detection, precision ground mapping, and beacon interrogation. Automatic calculation of the computed air release point (CARP) and airplane steering information used in guiding the airplane to the CARP is updated using navigational check points. The system has the ability to update present airplane position using ground based radio navigation aids; however, the primary function is to perform AWADS missions without the use of ground aids. When missions are flown where ground aids for navigation are nonexistent, the aircraft will use the radar to fix on preplanned radar identifiable points enroute to the target area. Radar fixes provide the means for maintaining the desired courses using navigational updating.[2]

A significant operational limitation exists in using preplanned radar identifiable points due to aerial photo availability to support the use of AWADS on a worldwide basis. Maps and charts in the scales necessary for accurate determination of offset aiming point (OAP) distances are not available for all parts of the world, and the inaccuracies in uncontrolled photos will not provide the required accuracies.[3]

The AWAD system primary mode of operation uses doppler dead reckoning. (The determination without celestrial observations of the position of the aircraft from the record of the courses flown, the distance made, and the known or estimated drift.)[4] Using this mode of operation the system accepts doppler radar imputs and compass imputs. By continually updating the present position of the airplane, these imputs provide the system with enroute navigation information. The present position of the aircraft is accurate within two percent (or less) of the distance traveled. Updating of present position can be accomplished by taking a radio navigation fix, a manual fix, or a radar fix.

The AWAD system provides steering signals to the pilot or the autopilot to fly the aircraft to the CARP, which corresponds to an air drop point located at the beginning of the drop zone. The system continually corrects for wind conditions, parachute parameters (drift and descent rate), parachute loads, altitudes, and airspeeds. In addition, the system continuously updates the azimuth and range to the drop point and generates a visual display showing the beginning and end of the drop zone.

In addition to navigation the radar can be used to analyze weather ahead of the airplane and to interrogate beacons from line-of-sight distances up to 240 nautical miles.

The AWAD system uses more than one subsystem to accomplish a mission successfully. The long-range ground-map capability is provided by the radar and is used as an aid to navigation. It can detect targets such as shore lines and mountain ranges in excess of 150 nautical miles provided the aircraft is high enough for radar line of sight. In the weather mode, weather cells can be detected at ranges in excess of 150 nautical miles. When the radar is placed in the beacon mode, a coded series of targets (beacon returns) will be displayed.

The radar can interrogate and receive replies at ranges up to 240 nautical miles.

In the precision ground map mode of operation, a map is displayed out to 30 nautical miles. The radar uses the Ka-band in this mode. (The military has divided the radar frequency spectrum into alphabetical bands.) It uses the X-band in the other modes. When these systems are functioning normally the computer performs the dead reckoning mode of enroute navigation. It requires the latitude, longitude, and elevation of the desired destination points to have been stored into the computer memory.

The beacon mode provides for greater flexibility in resupply due to the ability to drop either directly on the beacon or using offset aim points. The rapid movement and changing ground situation may not allow the necessary mission planning to provide for arrival at the computed air release point without the use of supplementary electronic/ground navigational aids.[5] The radar beacon which the AWAD system will interrogate will be described in detail in Chapter III.

Tactical Air Command test 70A-037A and the Joint Test of AWADS Employment Phase II demonstrated that the AWAD system is acceptable for employment in an adverse weather environment. Although the circular error probable (CEP) of AWADS exceeds that demonstrated by visual means, the CEP using both the Ka-band and X-band was under 250 yards.[6]

## STATION KEEPING EQUIPMENT (SKE)

Using the AWADS concept, only specified aircraft in a formation are equipped with the AWAD system. The Air Force only has 53 C-130Es equipped with the AWAD system.[7] The other aircraft used in AWADS are equipped with station keeping equipment (SKE). The SKE provides an aural and visual proximity warning to the aircrew. The radar will display relative position of the aircraft (in track, cross track, and altitude) with respect to selected aircraft while continuing to display the entire formation. It will also provide maneuvering orders from the lead aircraft to the following aircraft.[8]

The SKE is an independent sub-system which provides capability for up to 36 aircraft to maintain fixed formation separation. The Air Force has more than 420 SKE equipped aircraft in its inventory.[9]

The SKE system functions in the following manner: an azimuth range indicator (PPI) shows the location of each aircraft in the formation relative to its own aircraft, a track-while-scan capability enables the pilot to maintain relative position in all three perpendicular coordinates (x, y, and z) to a selected aircraft in the formation, a data transfer function allows transmission of maneuver messages, and a proximity warning signals if the aircraft enters a preset warning sphere. The AWAD navigational system, along with SKE, gives an entire aircraft formation the capability of dropping supplies during adverse weather conditions.[10]

ZONE MARKER (ZM)

The addition of the ground-based zone marker (ZM) has provided the SKE an added capability to perform adverse weather airdrop. The zone marker is designed to operate within 1500 yards of a drop zone. The zone marker is a specially designed, portable station keeping set that is assigned a time slot in the flight formation's time-shared station keeping system. Its automatic transmissions enable pilots to direct their aircraft into the designated approach path. In considering employment of the SKE/ZM system, it is assumed to be present in the drop zone area for resupply operations.

A pictorial representation of this technique is shown in figure 1. In this figure, the initial ZM acquisition point is 20 miles or less from the ZM. During this flight leg the ZM provides position updating information to the SKE inertial navigation system. At a selected range to the ZM the updating is discontinued and the inertial navigation alone provides navigation to the computed air release point. It should be pointed out that the flight path to the ZM and to the computed air release point need not be a straight line. The system is capable of handling a more complex path if the terrain or mission so require.

This system is ideally suited to resupply missions because it is not necessary to know the ZM's location with respect to the drop zone. The aircraft need not overfly the ZM but only come within several miles. For overflight positions extending to 5 miles from the ZM, the inertial navigation system update is less than 200 yards. Recent airdrop tests using SKE/ZM resulted in drops of less than 100 yards from the aim point.[11] Figure 2 shows the individual errors (SKE/ZM update and the inertial navigation system). The update error of 100 yards is used for the aircraft at low altitude and a final update range of less than 1 nautical mile. For a drop zone 10 nautical miles from the ZM, the error is about 180 yards at an airspeed of 150 knots. For a drop zone 20 nautical miles away, the error is slightly over 300 yards at 150 knots.

Figure 3 depicts a situation similar to figure 2 with the update range increased from 1 to 5 miles. The SKE/ZM update error increases to 200 yards because of the increased distance from the ZM. With a 5 mile update, the error at 150 knots is 240 yards for 10 miles traveled from the ZM and 340 yards for 20 miles.

The error is not a function of airspeed but of time. Therefore, an increased airspeed will result in a reduced time and improved accuracy. For large offset ranges, a high speed approach with slowdown prior to drop will improve accuracies. It should be noted that this system can be used on C-141 aircraft as well as the AWAD C-130 aircraft. The zone marker also may be used to guide the aircraft to low altitude parachute extraction. The low altitude parachute extraction system (LAPES) is the delivery system in which ring-slotted extraction chutes are used to withdraw pallet loads from low-flying aircraft. The SKE/ZM system can provide an almost instant instrument landing system capability. No site preparation or surveying is necessary.

THE RADAR BOMB DIRECTING SET

In addition to these systems, the Air Force has the radar bomb directing set (AN/TPB-1C). This system is the only tactical ground-directed bombing radar that provides complete day/night and all-weather capability for aerial resupply. The radar bomb directing set can automatically acquire and direct an aircraft to any selected point in space within radar range of the system. This selected point can be a cargo release point. It can direct the aircraft along a fixed, predetermined flight path; or it can have the aircraft fly the shortest path to the desired release point.

All these systems allow for aerial resupply of an airborne battalion. Their limitations and commonality with reconnaissance and close air support will be discussed in Chapter V.

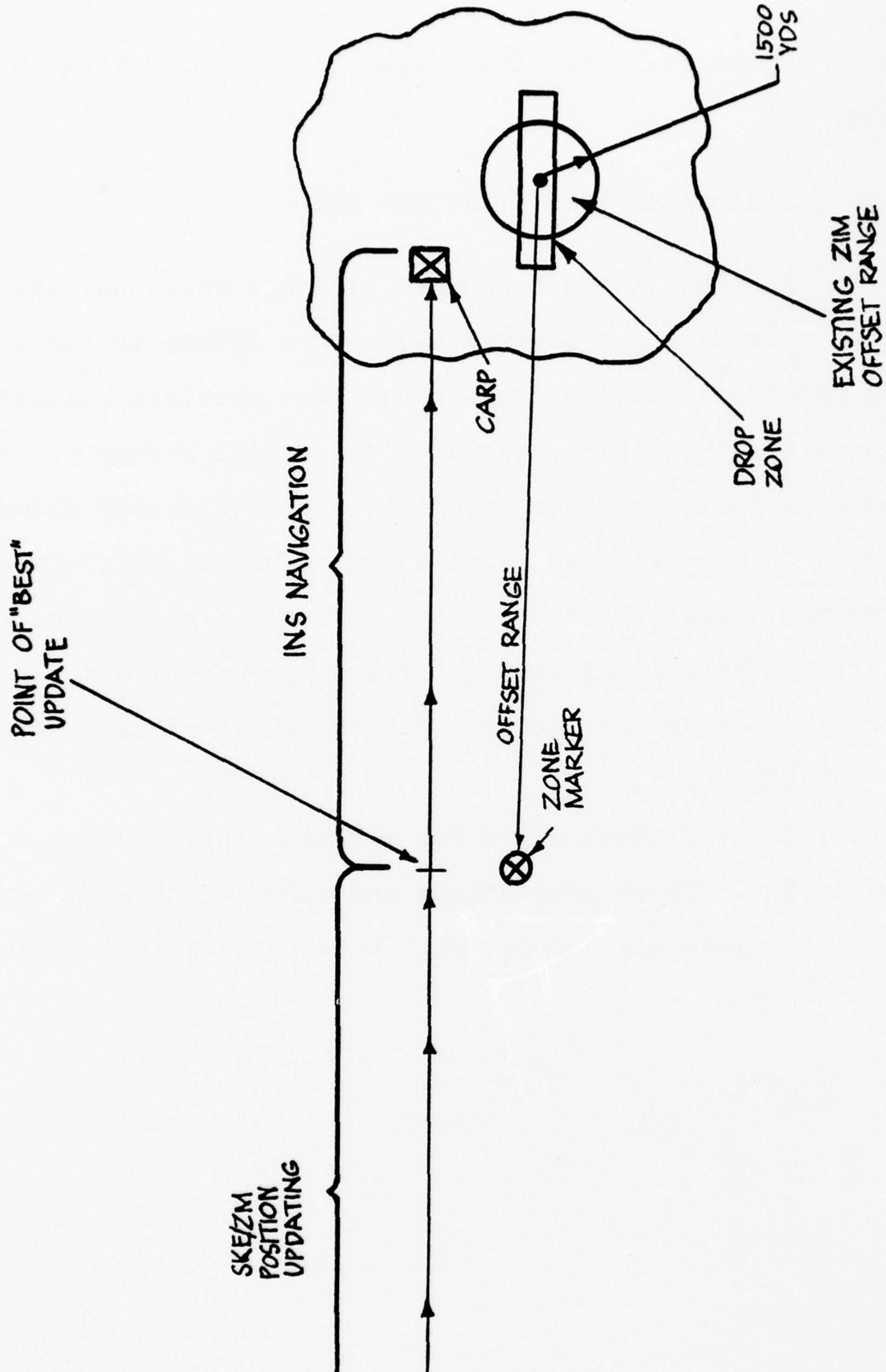


FIGURE 1. SKE/ZM/INS AIR DROP

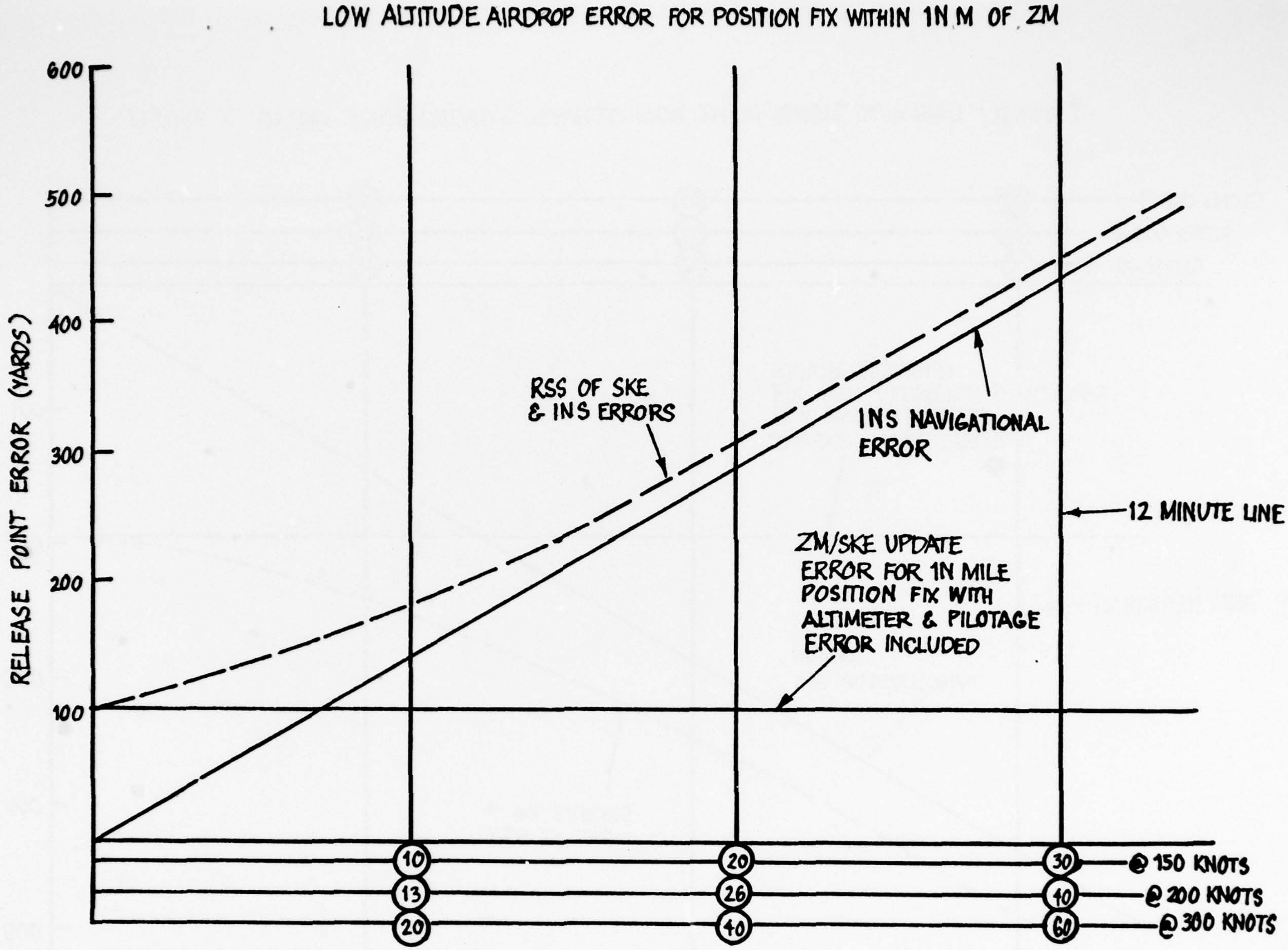


FIGURE 2. OFFSET RANGE DISTANCE TRAVELED FROM ZM TO REMOTE DROP POINT (N MILES)

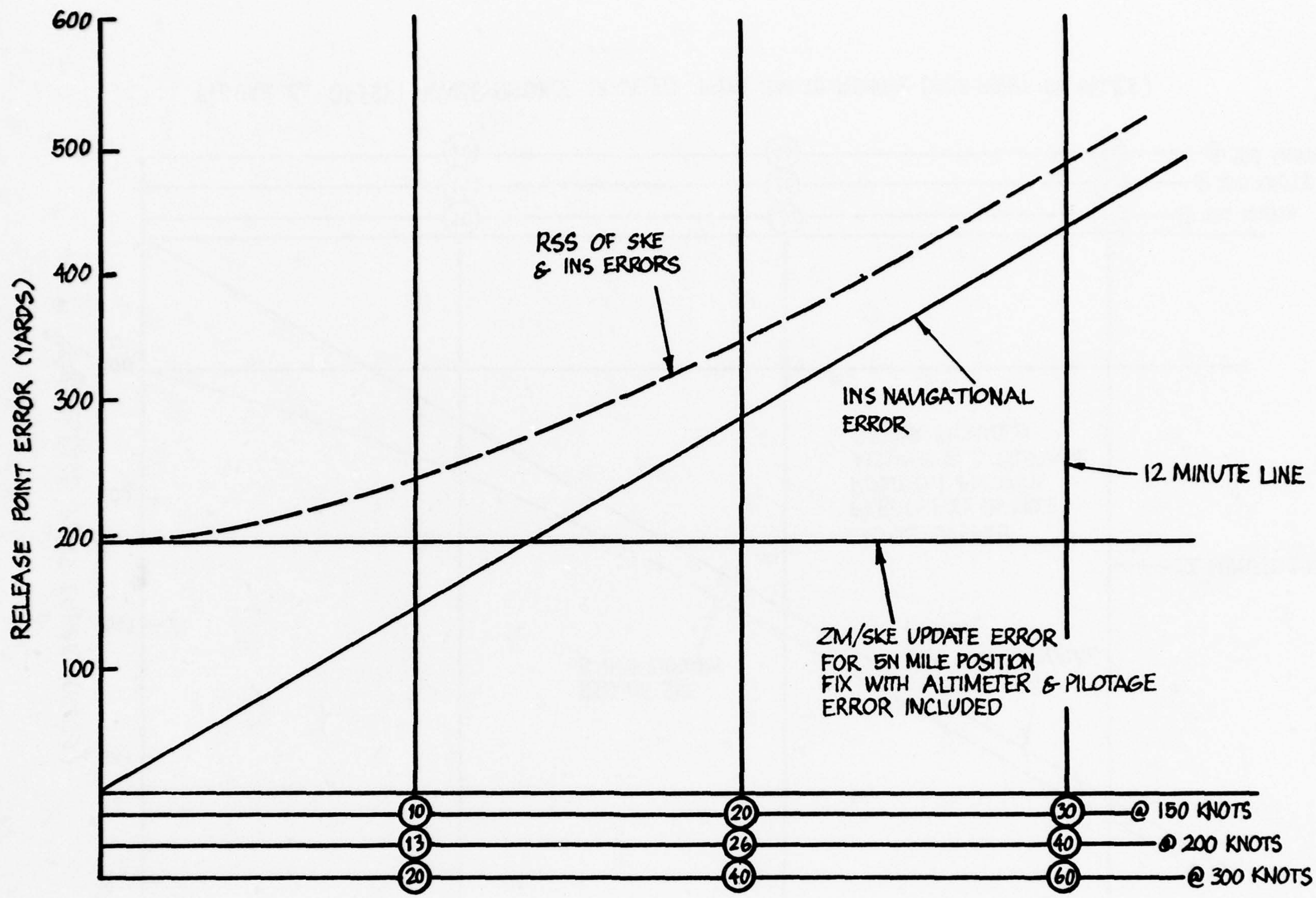


FIGURE 3. OFFSET RANGE DISTANCE TRAVELED FROM ZM TO REMOTE DROP POINT (N MILES)

## CHAPTER END NOTES

[1]James M. Gavin, On to Berlin, (New York, N.Y.: The Viking Press, 1978), p. 57.

[2]Department of the Air Force, Partial Flight Manual USAF Series C-130E Aircraft (AWADS), T.O. 1C-130E-1-2 (September 1977), p. 4-4.

[3]Department of the Air Force, Tactical Air Command, TAC Test 70A-037A, p. V.

[4]Webster's Seventh New Collegiate Dictionary, (Springfield, Ma: G.&C. Merriam Co., 1963), p. 211.

[5]TAC Test 70 A -037A, p. V.

[6]Ibid., p. V-VI.

[7]Sierra Research Corporation, AN/TPN-27, Zone Marker Enhancement, (July 1976).

[8]Sierra Research Corporation, Stationkeeping, United States Air Force, C-130 E/H Aircraft.

[9]Ibid.

[10]Ibid.

[11]Ibid.

## CHAPTER III

## CLOSE AIR SUPPORT

Close air support consists of air strikes against enemy targets that are located in close proximity to friendly forces. To be effective, close air support must be coordinated with the fire and maneuver of the supported ground forces. Close air support must be responsive, integrated, and controlled. Typical targets for an airborne battalion are enemy troop concentrations, fixed positions, and lines of communications. Close air support missions are flown at the request of the airborne battalion commander. They are planned, directed, and controlled by the Air Force through the airborne battalion's USAF tactical air control party (TACP). The missions may be either preplanned or immediate.

Preplanned missions are submitted through Army channels via the battalion's fire support elements. Preplanned missions insure better integration with the ground tactical plan due to better matching of the delivery system and ordnance with the target. This is possible because of the longer lead time which enables the aircraft to be properly loaded for the target. When targets of opportunity develop as a result of ground action, requests for immediate close air support are submitted through the Air Force immediate air request net operated by the battalion's TACP. When possible, ordnance and aircraft are selected according to the target; otherwise, the most readily available ordnance and aircraft are used. Immediate sorties are flown from those set aside for this purpose or by diverting preplanned or other Air Force sorties.[1] The same tactical air control system is used for airlift and reconnaissance.

## ORDNANCE

Prior to discussing the methods of delivery available in adverse weather, close air support ordnance will be briefly described. The ordnance considered most effective against the target will be loaded. This selection is subject to inventory and environment, political restrictions, carriage and delivery restrictions, and loading time restraints.

The first type of air-delivered ordnance is by means of the gun. The 20-mm M-61 vulcan cannon is the standard gun for fighter and gunship aircraft. The M-61 has six rotating barrels and a maximum firing rate of 6,000 rounds per minute. The GAU-8 is a seven-barrel 30-mm cannon in the A-10; it can fire 4,200 rounds per minute. The C-130 gunship has a 40-mm and a 105-mm gun in addition to its 20-mm guns. The most common types of ammunition are high explosive incendiary (HEI) and armor-piercing incendiary (API). Strafing employs the pinpoint accuracy of the gun against personnel and light vehicles. In addition, the 30, 40, and 105-mm API round can penetrate tank turrets.

Cluster bomb units (CBU) are the next and one of the best weapons to use in adverse weather. A cluster bomb unit consists of a container/dispenser which is loaded with the CBU's. There are many types of dispensers, bomblets, and combinations of the two. Depending on the type, the bomblets are effective against area targets consisting of personnel or armor. The dispensers are free fall and may be delivered from an angle or level delivery. The dispenser may be fitted with terminal guidance kits.

General purpose bombs are the most common type of ordnance. The bombs are available in 500, 750, 1,000, 2,000, and 3,000 pound sizes. The high-explosive charge, which makes up 35 to 60 percent of the total bomb weight, is enclosed in a steel case. Bombs normally have a nose (instantaneous) and a tail (delay) fuse, with the fusing option being selectable by the pilot for the particular target. Instantaneous fusing is selected for maximum blast and fragmentation. Delay fusing is selected when penetration of hard targets or cratering is desired. Proximity (variable time or radar), long-delay, magnetic, and seismic fuses are available, as well as nose fuse extenders for maximum above-ground blast and fragmentation effect. Bombs are available with both high-drag fins for low-angle or level delivery and low-drag fins for high-angle dive delivery.

Firebombs may also be used. They are thin-skinned metal tanks filled with thickened fuel (napalm) and equipped with white phosphorus or electrical fuses. Napalm has the consistency of honey, clings to the target, and burns for up to 15 minutes. Napalm is suited for a wide range of targets. Napalm has a tremendous shock and psychological effect. Napalm has little blast and fragmentation effect and may be used close to friendly troops. Napalm may be finned or unfinned and may be delivered from level or angled deliveries.

Guided weapons may also be used in close air support. Guided weapons are classified generally as bombs or missiles and are additionally classified by guidance systems. The laser guidance system acquires and guides to a point illuminated by a laser beam. The illuminator (designator) can be on the delivery aircraft, another aircraft, or on the ground. Presently only the 500 and 2,000 pound laser-guided bombs are available. The electro-optical guidance system consists of a television camera in the nose of the bomb or a missile which guides the weapon to a point of dark/light contrast on the target. This guidance system is normally limited to daylight use in reasonably good weather but has the advantage of "fire and forget." The Maverick missile and the Hobo and Walleye bombs are examples of TV-guided weapons. The last system is comprised of the antiradiation missiles. Antiradiation missiles (ARM) home on energy transmitted by enemy radars and are used for air defense suppression. The Shrike and the Standard Arm are examples of antiradiation missiles.

Nuclear weapons and chemical agents may also be employed in tactical roles. The characteristics of these weapons are classified and will not be discussed. The procedures for requesting these munitions are the same as those for requesting any other close air support mission.[2]

ADVERSE WEATHER DELIVERY SYSTEMS

GROUND DIRECTED RADAR

The first system discussed is the only tactical ground-directed bombing radar that provides a complete day/night and all-weather capability for tactical air forces' missions related to close air support, reconnaissance, and aerial resupply. The latest in ground-directed bombing radar systems is the radar bomb directing set AN/TPB-1C. The AN/TPB-1C can automatically acquire and direct any aircraft to a selected point in space within radar range of the set. The point may be a navigation point, an initial point, a bomb or cargo release point, or a reconnaissance photo strip starting or stop point. The precision radar is capable of accurately tracking an aircraft in angle and range while operating in either a skin-track mode or a beacon-track mode. Radar-derived information is combined with the desired approach heading, target coordinates, ballistics of the ordnance, and meteorological data to compute automatically aircraft guidance and ordnance release signals.

The guidance information is available for automatic presentation to the pilot in two forms: (1) bearing to the desired point is displayed on aircraft navigation systems, and (2) dynamic corrections in flight direction are conveyed by of tone signals. The tone signals are coded to provide information to the pilot concerning the direction and magnitude of turn. As an alternate, dynamic data may be displayed so that the radar operator's voice commands may be used for guidance of the aircraft. Five seconds prior to release, a countdown is generated which culminates in a release tone. Automatic ballistic computations aid in the generation of the release tones. Accurate aircraft position, velocity, and guidance information are computed continuously; therefore, evasive maneuvers (jinking) can be carried out until shortly before release. The system works extremely well, and test results as well as use in combat have demonstrated the system's accuracy which is nearly as precise as visual deliveries. The only drawback to the system is that it is not air droppable. It must be airlanded or airlifted by helicopters into the airborne airhead.[3]

## AIRCRAFT RADAR SYSTEMS

Fighter and bomber aircraft equipped with radar can provide limited close air support using radar offset bombing. The aircraft use the same techniques as the AWADS equipped C-130's except that they drop ordnance instead of people or equipment. The demonstrated precision of radar offset bombing in most aircraft is not accurate enough for close air support. The F-111 is an exception to this rule. Good radar scope interpretation (RSI) is required to prevent misidentification of the radar aimpoint (a major source of error). Time sensitive targets may preclude extensive mission planning and target study. The problem of adequate maps, charts, or photos discussed in chapter two also applies to radar offset bombing.

GROUND RADAR BEACON

The use of a radar beacon by the airborne battalion's TACP provides the radar bombing role a capability and flexibility that is not available in the normal radar ground mapping mode. The radar scope interpretation problem is eliminated by using the beacon. As a result, the proficiency and experience level of the radar operator required for beacon bombing is not as stringent as that required for normal radar bombing. It is also possible to assign new targets in flight using the beacon.

There are several types of beacons currently in use with TACPs.[4] Each of the beacons is capable of being interrogated from the air and positively indentified prior to weapon release. Some beacons have the capability of emitting coded response/s. The coded beacons allow the flexibility of using several beacons in the same area. The beacon is triggered by the attack aircraft's radar. By using the aircraft's offset bombing mode, the radar aiming point (cross hairs) is placed on the beacon while the aircraft attacks a target at the prescribed range and bearing from the beacon. All beacons have a delay between reception of the triggering pulse (from the aircraft radar) and the transmission of the beacon response.

This causes the beacon to appear further away from the aircraft than it actually is. Therefore, a compensation factor must be applied by the aircrew or aircraft system to prevent bombing inaccuracy.

The beacon can be used in three principal ways:

(1) Beacons can be placed in semi-fixed positions with multiple preplanned targets identified within the beacon's coverage.

(2) Additional targets can be identified with the beacon's coverage, and immediate strikes can be called in on the new targets.

(3) In a rapidly changing situation, the beacon can be mobilized with the TACP and used for immediate strikes. The beacon can move after each airstrike.

It is possible for aircraft which are not capable of beacon offset radar bombing to join up with an aircraft that is beacon-capable and expend its ordnance. This type of mission is called pathfinding. Rendezvous of the strike aircraft is accomplished well away from the target. The pathfinder aircraft then leads the other strike aircraft to the ordnance release point.

All beacons have one major deficiency. The beacon reply strength is severely attenuated by heavy precipitation, dense foliage, terrain masking, and a weak battery or power source. This problem can be reduced by placing the beacon in the highest and most open area available and by close monitoring of the power supply.[5]

## THE AC-130 GUNSHIP

The AC-130 is designed to provide night all-weather close air support. It can provide extremely accurate fire and illumination for extended periods of time. The sensor target acquisition capabilities coupled with ground radar beacon systems provide all weather support. This is done with the beacon-tracking radar, the Black Crow direction finder, and the inertial navigation system. The ground controller must give all target ranges and bearings from the location of the beacon. The shorter the beacon offset, the more accurate the weapon delivery will be. In adverse weather conditions the aircrew does not know where the weapon is hitting in relation to where they are aiming. Since weapon impact information comes from the ground observer, the aircrew does not know whether a miss was caused by alignment error, wind error, estimating error on the part of the ground observer, or a combination of all three. Essentially, all rounds fired from the same quadrant or heading will impact at the same point on the ground.

The AC-130 has a unique beacon called Temig. Temig provides untrained personnel the ability to identify a target, estimate its range, determine its azimuth, encode the information, and transmit the information to an AC-130 in less than 60 seconds. This beacon may be used in addition to the normal radar beacons.

## FIGHTER AIRCRAFT

The following Air Force aircraft are capable of radar bombing and close air support using a beacon. The F-111A/E has an attack radar set (ARS) the AN/APQ-113 and operates in the Ku-band. The manual frequency control (MFC) is used for radar beacon bombing. The radar receiver is manually tuned to the radar beacon transmitting frequency. Offset aim point (OAP) information is entered in the form of handset range (in feet) and bearing (in degrees from true north) from the target to the OAP. The F-111F is compatible with the AN/PPN-18, SST-122K, AN/TPN-23, and AN/TPN-26. The attack radar is the AN/APQ-144 and operates in the Ku band. Offset aim point information is entered in the aircraft computers in the form of range (in feet) and bearing (in degrees true) or in geographic coordinates (nearest one-hundredth of a minute) of the OAP and target.

The ARS of the F-111D is the AN/APQ-130 and operates in th J-band. The ground mapping mode is available while utilizing the beacon submode of the ARS. OAP is entered manually in the form of range (in feet) and bearing (in degrees from true north) from the target. The A-7D forward looking radar operates in the J-band. The radar must be in the beacon mode to see present beacons. The A-7 has no capability to display terrain information while in the beacon mode as a result the A-7 has no close air support capability in adverse weather. The F-4E has the AN/APQ-120 that operates in the X frequency band. Radar beacon bombing combines three operating modes to provide a level radar offset beacon bombing capability: radar beacon mode, map plan position indicator (PPI) display, and weapons release computer set (WRCS) offset bombing mode. The OAP is provided to the WRCS in the form of offset components stated in feet North/South and East/West from the OAP to the target.

The radar offset and beacon offset of the F-111 is the Air Force's primary adverse weather capability. The Air Force indicated in hearings before a Subcommittee of the Committee on Appropriations of the House of Representatives of the Ninety-fifth Congress that the Air Force does not want to send the F-111s after armored vehicles. In the hearings the Air Force indicated it would rather use imaging infrared equipment, the forward-looking infrared system (FLIR) because it provides better resolution of targets than currently be obtained with radar.[6] The April 1979 issue of the Air Force Magazine subtantiates this view in stating, "The F-111, considered the most effective deep penetrating aircraft in the US arsenal, is not involved in the mission performance debate, though there are studies also to expand its uses."[7]

FORWARD LOOKING INFRARED RECEIVER (FLIR)

The Air Force is working on several systems: a Pave Tack Pod, which is a forward-looking infrared radar combined with a laser designator and the imaging infrared system in the Maverick program. These systems are designed to see at night through fog and rain. They can guide a weapon to an armored vehicle. The classification of these systems prevents further discussion. However, in September 1978, Vought Corparation announced the first production of an A-7E aircraft equipped with a new sensor system which turns night into day for Navy A-7 pilots. While this is a Navy system, it can be used on Air Force aircraft and provides an unclassified discussion of a forward looking infrared receiver (FLIR).

Using the new system, the pilot can see even in total darkness. He can call up on a display unit TV images of potential targets much clearer and more revealing than those presented by his radar system. The heart of the FLIR system is a forward-looking infrared heat-measuring sensor and related equipment housed in a pod carried on one of the aircraft's six wing weapon stations. The sensor is linked to the already installed precision navigation and weapons delivery system. It provides a magnified view projected on the pilot's head-up display (HUD) in the cockpit. The system also has provisions for a video recorder which can play back the infrared imagery obtained during a flight for study by intelligence personnel at the end of a mission.

The range of the system was not disclosed, but Navy officals said the system permits the pilot to detect and identify ships at sea at sufficient distance for a first pass attack. In addition to showing bridges, roads, airfields, and similar potential targets, the system can portray in magnified form details (such as the fuel levels in field storage tanks) which are not visible to the pilot's naked eye even during daylight.

Vought has been developing the FLIR system under contract to the Naval Air Systems Command since 1972. Pre-production models have been extensively tested in both night and day flights by company and Navy pilots across the United States. In all, more than 250 flights, including bombing and gunnery missions, have been made to verify the performance, accuracy, and effectiveness of the system. The Navy is buying 175 pods and modifying 340 A-7s for the installation of the FLIR. As a cost-saving measure the pods can be rotated between aircraft by simply attaching the pod to the selected aircraft.[8]

The problems associated with IR are discussed by H.W. Wessely in a report on Limiting Factors in Tactical Target Acquisition. Mr. Wessely wrote the report using current defense concepts of applying tactical aircraft to counter an attack by armored vehicles. Due to surface-to-air missle (SAM) defenses, he chose a continual low altitude, high speed flight profile against the target. This makes target acquisition difficult due to the limited time available for search. The problem is especially severe in night and/or during adverse weather conditions. Under these conditions Mr. Wessely believes FLIR sensors offer the best means for acquiring targets. However, because the field of view of a typical high resolution FLIR is only a few degrees, the observer is handicapped by "tunnel" vision as he searches for the target. In a dense clutter environment there is a significant probability that the target will not be seen at all. Figures 1-5 show the relationship between recognition and range under different conditions. 50 percent weather is the condition one would expect in the Berlin area about 50 percent of the time. The 90 percent curve includes the worse expected weather in the Berlin area. Figure two shows the effects of adverse weather with all other factors held constant. There is significant reduction in the probability of long range acquisition due to the decreased performance of the sensor. The acquision probability at very short ranges is only slightly reduced. The other figures indicate for the assumed environment that there are relatively few times in which the long range recognition capability of a high resolution sensor can actually be realized. The Figure 4 indicates that terrain masking is one of the major limiting factors in long range target acquisition.

Wessely concludes his article by stating that the effects of terrain masking appear to be an important limiting factor in target acquisition. The weather is not the dominant limiting factor. Poor weather makes the problem more difficult, but acquisition probability is low even for good weather. The results challenge the belief that low level tactical missions can be performed effectively at night or in adverse weather. Further analysis and tests are needed to establish the validity of this conclusion.[9]

OTHER SYSTEMS

There are two other systems which can be used in adverse weather; they are the navigational bombing system and the long range navigation (LORAN) bombing system. The navigational bombing system uses the aircraft's inertial navigation system to bomb on target coordinates which are entered into the weapons computer. The LORAN system works in a similar manner except it determines the target's location using pulsed signals sent out by two pairs of radio stations.[10] Both of these systems are currently in use by the Air Force; however, the accuracy of these systems is not good enough to permit the close support of Army troops.

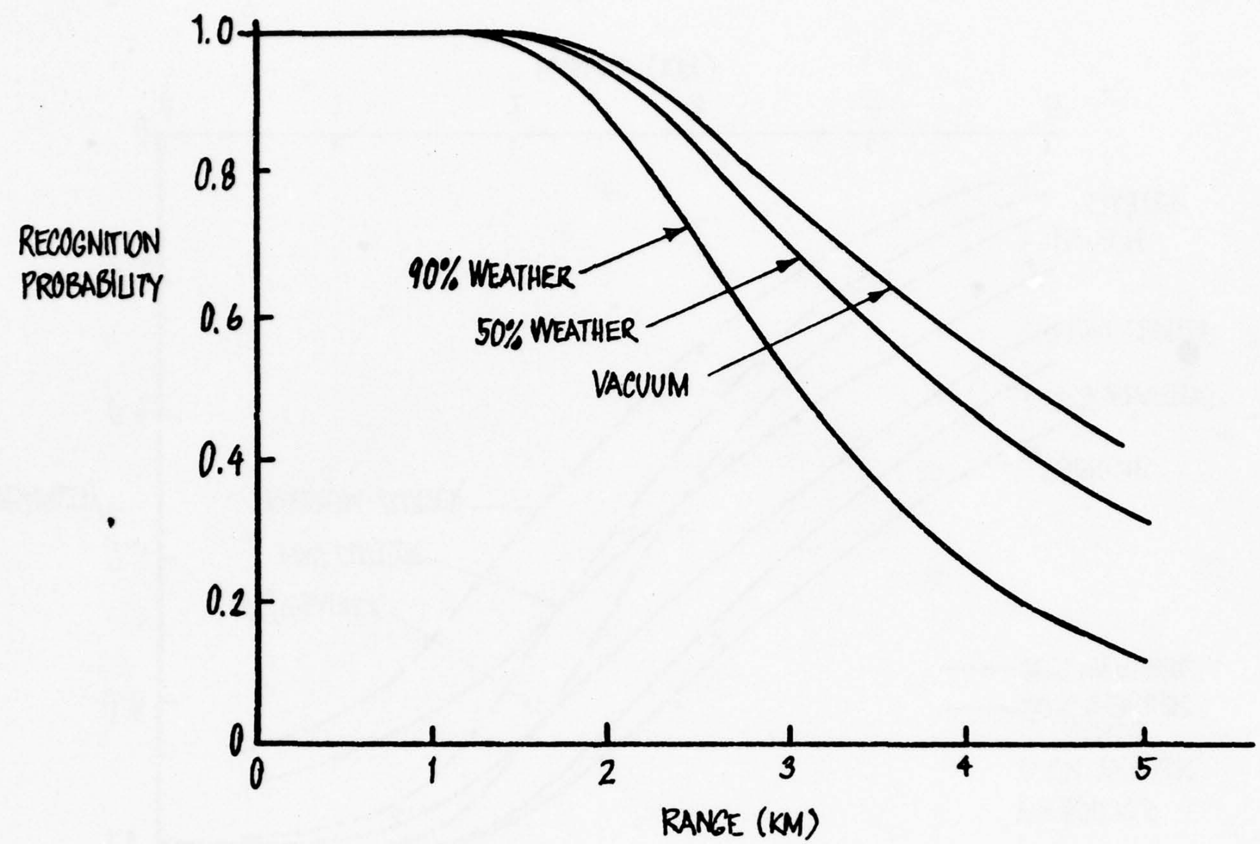


FIGURE 1. SENSOR PERFORMORMANCE VS RANGE AND WEATHER

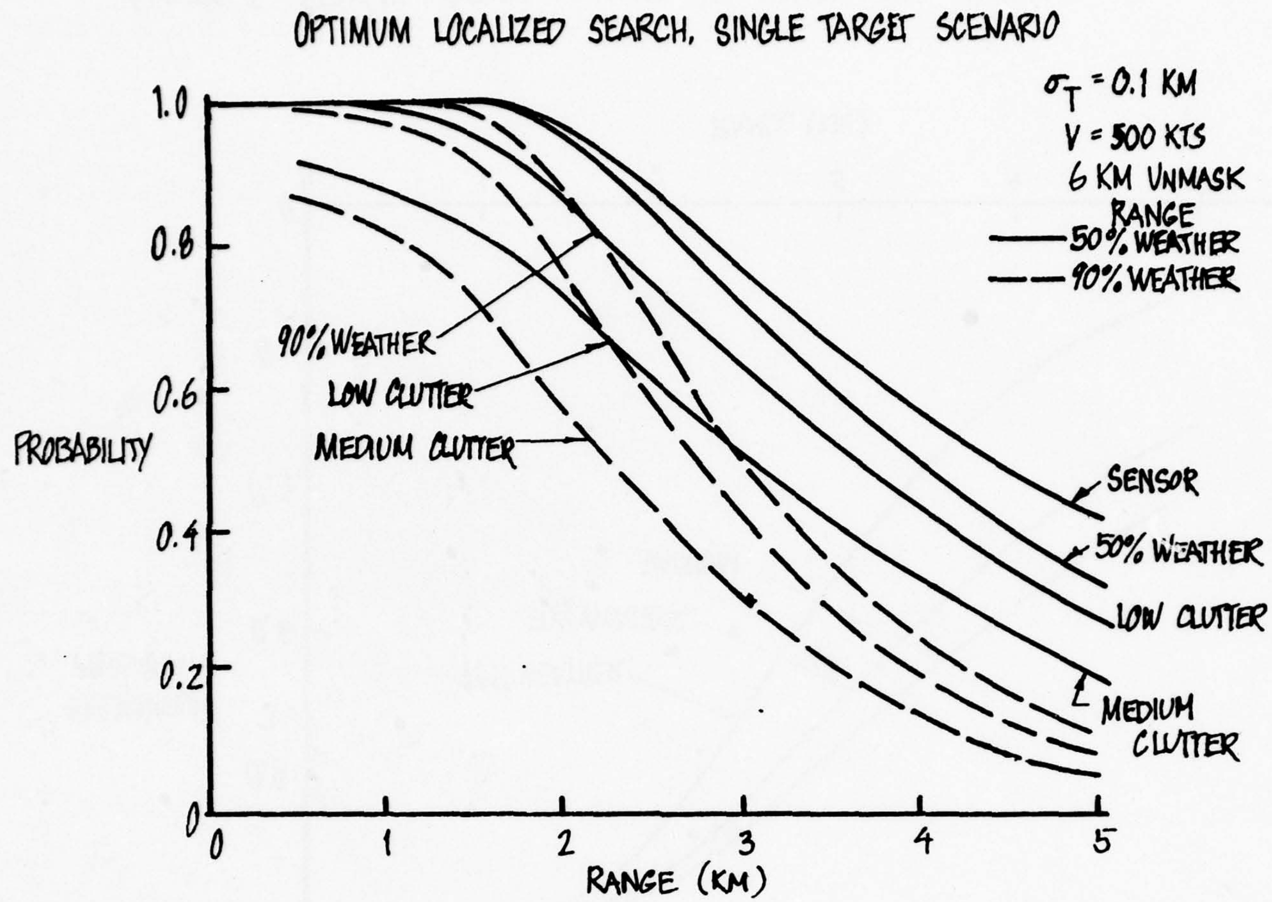


FIGURE 2. ACQUISITION PROBABILITY VS WEATHER

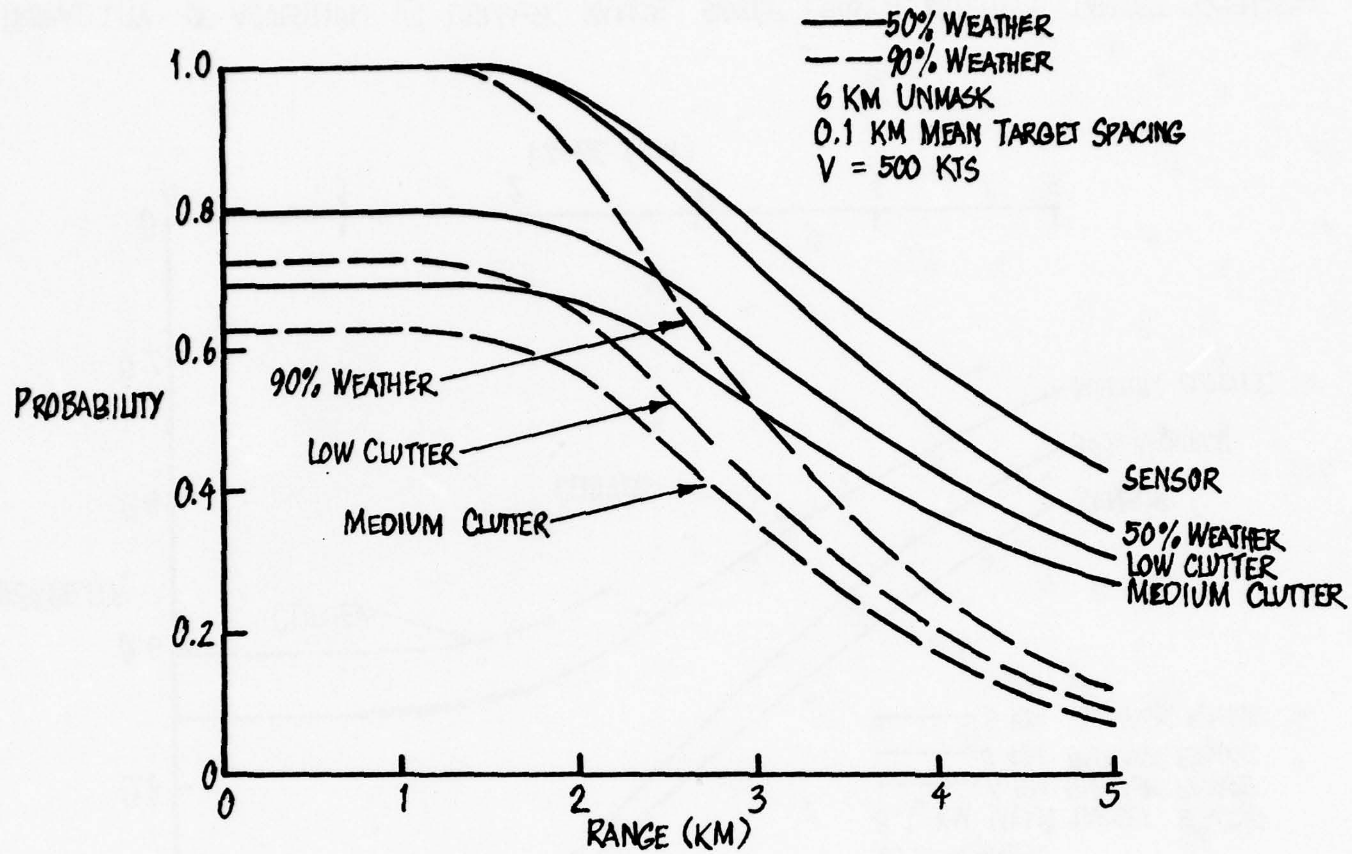


FIGURE 3. PROBABILITY OF ACQUISITION VS WEATHER SWEEP SEARCH MULTIPLE TARGET SCENARIO

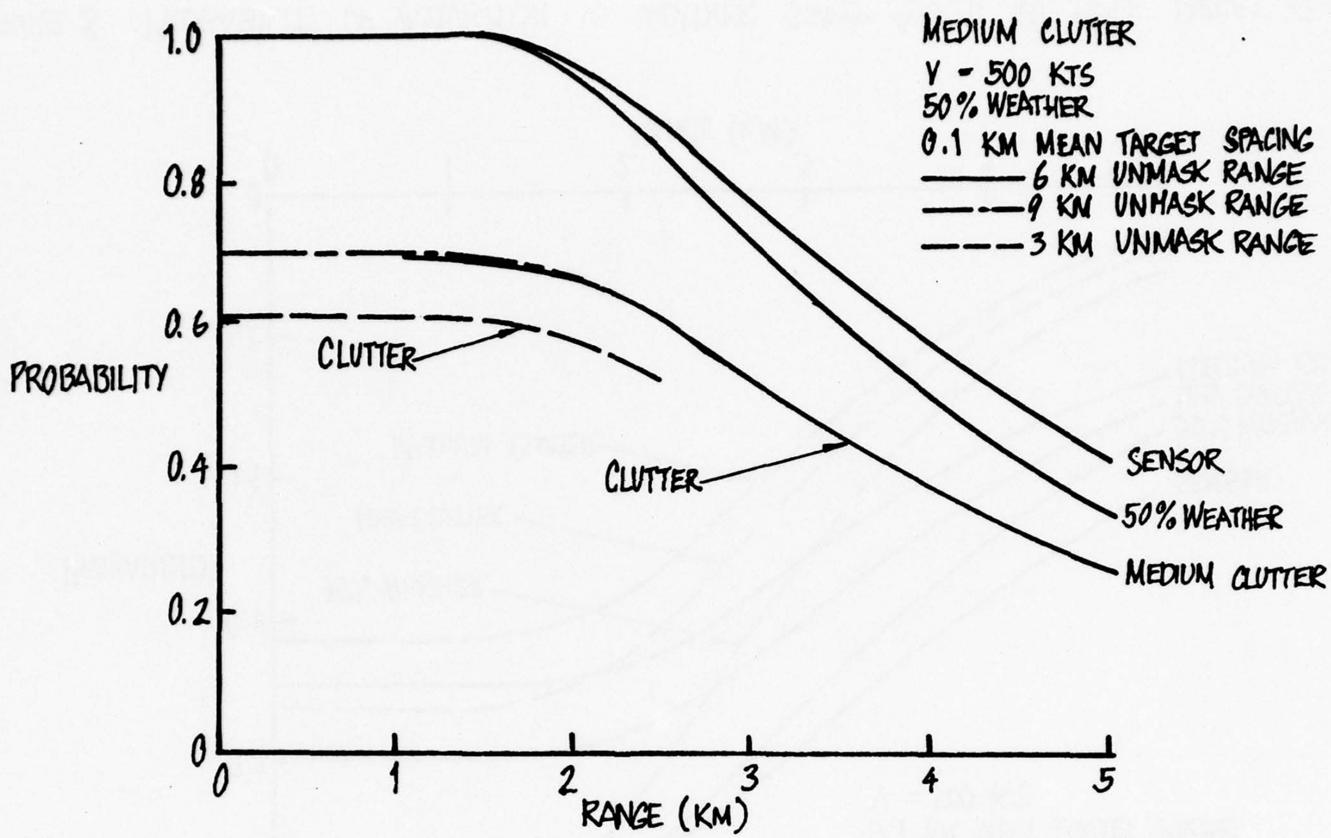


FIGURE 4. PROBABILITY OF AQUISITION VS UNMASK RANGE, SWEEP SEARCH, MULTIPLE TARGET SCENARIO

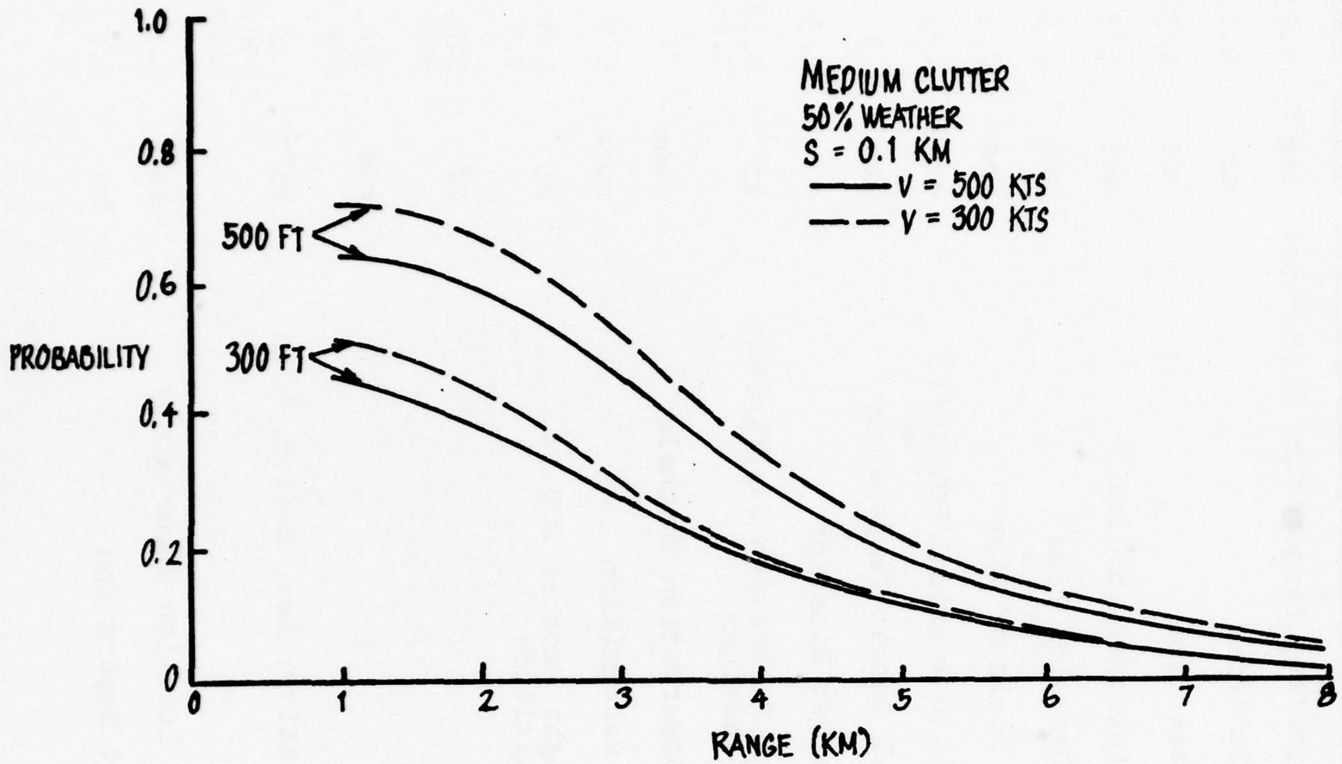


FIGURE 5. PROBABILITY OF ACQUISITION VS ALTITUDE SWEEP SEARCH, MULTIPLE TARGET SCENARIO

TABLE 1

PARAMETER LIST

| Symbol | Definition | Units | Values |
|---|---|---|---|
| (NETD) | Noise Equivalent Temperature Difference | deg C | 0.15 |
| $\alpha_D$ | Detector Subtense | mr | 0.15 |
| $t_F$ | Sensor Frame Time | sec | 1/30 |
| $t_I$ | Observer Integration Time | sec | 1/3 |
| $t_D$ | Observer Decision Time | sec | 1/3 |
| $\alpha_F$ | Azimuthal Field of View | deg | 2.5 |
| $\varepsilon$ | Horizontal to Vertical FOV Ratio | none | 4/3 |
| $\Delta T$ | Incremental Target Temperature | deg C | 5 |
| $x_T$ | Minimum Target Diameter | m | 2.3 |
| $\sigma_A$ | Atmospheric Extinction Coefficient; 50%, 90% Weather | $km^{-1}$ | 0.18<br>0.65 |
| k | Parallel Observation Channels | none | 7 |
| $N_o$ | Lines for Recognition | none | 8.4 |
| $c_h$ | Line-of-Sight Factor; 200 ft, 500 ft Altitude | km | 1.8<br>4.3 |
| h | Altitude | ft | 200,<br>500 |
| v | Velocity | kts | 300,<br>500 |
| n | Clutter Density; Low, Medium, High | $km^{-2}$ | 100,<br>400,<br>1600 |
| $\sigma_y$ | RMS Target Location Uncertainty | km | 0.1 |
| S | Mean Target Separation | km | 0.1 |

## CHAPTER END NOTES

[1]Department of the Army, Fire Support in Combined Arms Operations, FM 6-20 (September 1977), p. D-10.

[2]Ibid., p. D-9 - D-10.

[3]Sierra Research Corporation, Close Air Support GDB Capability, (August 1978).

[4]A detailed listing of current Air Force beacons is shown in the Department of the Air Force, Tactical Air Command, Beacon Bombing Handbook, p. 33-34.

[5]Department of the Air Force, Tactical Air Command, Beacon Bombing Handbook, p. 9.

[6]Ibid., p. 1-80.

[7]Air Force Magazine, The Pros and Cons of a Multi-mission Fighter Force, (April 1979), p.60.

[8]Vought Corporation, News Release, V 78-98, (September 1978) p. 1-3.

[9]H.W. Wessely, Limiting Factors in Tactical Target Acquisition, (Santa Monica, Ca.: The Rand Corporation, March 1978), p 1-29.

[10]Webster's Seventh New Collegiate Dictionary, (Springfield, Ma.: G.& C. Merriam Co., 1963), p. 499.

[11]Department of the Air Force, Tactical Air Command, Tactical Air Operations, TACM 2-1 (April 1978), p. 4-38.

## CHAPTER IV

## TACTICAL RECONNAISSANCE

The first requirement to win the battle is that the airborne commander see the battlefield. The commander requires timely intelligence to concentrate his combat power at critical places and at critical times. The Air Force systems that provide tactical reconnaissance include: reconnaissance aircraft equipped with infrared (IR) mapping, slide-looking airborne radar (SLAR), position locating systems, and real-time sensor and data links. These systems, along with the Air Force strategic reconnaissance and the Army systems, provide the airborne commander with a near real-time composite picture of the battlefield.[1]

The Army recognizes three distinct intelligence disciplines: electromagnetic spectrum, imagery from overhead platforms, and human intelligence (Humint) which includes direct observation. The Air Force's tactical reconnaissance operates in all three of these disciplines. Electromagnetic intelligence is derived from electronic detection and exploitation of enemy emissions. Electronic intelligence is also called signal intelligence (Sigint). Sigint is generally timely and has a 24-hour, all-weather capability. Imagery intelligence is primarily derived from radar, infrared, and photographic sensors carried by overhead platforms. To assure timeliness, the imagery intelligence must be disseminated to the Army commander electronically as opposed to photographically. Imagery data are normally the most accurate, but they can be limited by weather and frequently by lack of timeliness. Human intelligence encompasses what the aircrew may observe. This type of intelligence may be limited or nonexistant due to adverse weather.[2]

## AIR FORCE TACTICAL RECONNAISSANCE SYSTEMS

### REMOTE SENSORS

The remote sensor system consists of a sensor, a relay, and a monitoring device with an on line display. The sensor may be one of five different types: seismic, which detects the target's movement over ground; infrared, which detects ambient heat difference between the air and the target; acoustic, which detects the noise created by the target and is usually triggered by the seismic sensor; magnetic, which is influenced by the movement of ferrous metal; or electro-magnetic, which detects the movement of the target through an electromagnetic field. The second part of the system is the relay which helps to overcome line-of-sight communication problems and enhances the range capability of unattended remote sensors. Maximum ranges of 250 miles can be obtained with relays. The final part of the system is the monitor which allows the operator to receive the sensor's signal for analysis on the audio and visual display systems of the monitor. The on-line display allows the operator to analyze the target in terms of target(s) size, speed, direction, and possibly, content.

Sensors can generally be grouped into three areas: alert and warning against surprise (cueing), general surveillance of the battle area, and target acquisition means for artillery or aircraft. Delivery of sensors can be by means of hand emplacement (the most accurate, but the most time-consuming) or by aircraft. The pinpoint accuracy required for an aircraft sensor requires that the sensor be dropped in visual flight conditions. This requirement is a limitation of the air emplaced sensor.

Sensors are usually placed linearly along avenues of approach and lines of communication. A normal configuration would consist of seismic sensors at each end of the string with target confirmation sensors of other types in the center of the string. There are usually at least five sensors in a string. The normal placement is 1,000 meters between sensors when vehicular targets are expected and 500 meters when footmobile targets are expected. The detection radius around each sensor varies between 3 and 800 meters, depending on sensor type, soil, and atmospheric conditions. One advantage of a sensor is that it can "see" into a woodline, something that radar can not do. The most obvious shortcomings are that sensors require accurate emplacement and they are constrained by terrain line-of-sight considerations.[3]

AIRBORNE SENSORS

The ALQ-125 Tactical Electronic Reconnaissance Sensor (TEREC) is an airborne receiver that detects, identifies, and locates radar emitters and reports them to ground or airborne terminals via narrow band data link. The sensor, which is internally installed in the RF-4C aircraft, uses left and right side antenna arrays to determine direction of arrival data of radar emissions. Location of tactical targets such as surface-to-air missile systems are computed using triangulation techniques as the aircraft flies along.

The TEREC sensor measures the frequency, pulse repetition interval, and pulse width of each emitter's signal, and compares these with the preprogrammed parameters for up to ten priority emitter types. The priority emitter data are airborne processed to determine the emitter locations plus an error ellipse as a self-computed confidence factor. These locations are displayed and data-linked to ground terminals. The TEREC data is also stored on magnetic tape for postflight study and anlysis. TEREC is normally used from standoff ranges of 50 miles or more to enhance aircraft survivability. A cockpit readout display is provided to cue the aircraft to a detected target so additional reconnaissance information can be obtained using infrared or standard imaging sensors. This imagery is automatically annotated with LORAN navigation data to assist the interpreters in extracting precise target location coordinates suitable for air or ground radar directed bombing.

Postflight analysis of TEREC mission tapes is sorted and processed to obtain radar parameters and ground-computed locations of all detected emitters. A typical user of the TEREC computed locations would be an F-111 unit, whose aircraft would seek out and destroy emitters using information provided by the TEREC data link.[4]

The main limitation of this sensor is that the enemy must turn on its radar emitters for the system to work. If the enemy moves without turning on its radars then no warning will be given using TEREC. Also when using TEREC an analysis is made to determine what enemy array is normally associated with the type radar emitter. The analysis may be faulty in either an under or over estimation of the enemy's strength.

RADAR RECONNAISSANCE SYSTEM

The AN/UPD-4 is an all-weather airborne reconnaissance system that uses an advanced design, synthetic aperture, side-looking radar. The radar returns of the ground terrain are recorded in an airborne recorder and later coherently processed in a ground based correlator-processor to produce high resolution radar imagery. This radar system uses X-band terrain illumination that pierces cloud cover and eliminates dependence on daylight observation. Its ability to resolve targets accurately at long range is unique, and it provides the aircraft with a standoff capability.

The system records radar returns from terrain and both moving and stationary targets. The reconnaissance sensor provides a high-resolution, fixed target imagery collection from very high or very low altitudes, over a wide range of ground speeds, in daylight or darkness, in all-weather conditions, from either side of the aircraft. It has a variety of operating modes that allow specific missions to be planned carefully for optimum results and executed with a minimum possibility of detection and interception since the aircraft need not fly directly over the target. The system has a moving target indication mode that enables detection and separate display of moving objects within the area under surveillance.

Merely detecting suspicious activity is not always enough. By the time the information reaches the airborne commander, it it is often too late to take effective action. With the system's data link, it is no longer necessary to wait for the aircraft to complete the entire mission and return to its base before the information can be processed. The radar returns are transmitted instantaneously to distant ground stations where they are processed and imagery is made available soon after target acquisition, with data link. The only limitations on data collection are aircraft fuel constraints and aircrew fatigue. With the use of in-flight air refueling, crew fatigue is the only limiting factor. The data link gives the airborne commander the added advantage of being able to redirect the radar reconnaaissance aircraft in flight as a result of analysis of target activity detected earlier in the mission or from information from other sensors such as a remote detector sensor. Recent experience has shown that when timeliness is a factor, a data-linked side-looking airborne radar is a primary sensor capable of providing tactical reconnaissance for rapid decision-making.

The radar's high-resolution imagery makes it especially suited for tactical target detection, strike assessment, and monitoring lines of communication. The system provides accurate location of detected targets and the scale of the imagery remain constant regardless of aircraft altitude or standoff. The radar system was designed originally for internal installation in RF-4C aircraft, it is adaptable for use in other aircraft and has operated with equal effectiveness in C-130 and C-141 aircraft.

The main limitation to this system is that the airborne commander's data link is not air droppable but must be air landed. The information can be processed and relayed to the airborne commander but timeliness could become a problem.

INFRARED RECONNAISSANCE

A brief description of infrared reconnaissance will be given. The sensors and problems are the same as discussed in Chapter III. The reconnaissance aircraft records the IR returns either on film or tape for playback after landing. The main problem for the airborne commander with this system is timeliness. The system does not have a data link and the aircraft must return to its base to have the reconnaissance data analyzed.

REMOTELY PILOTED VEHICLES

Tactical reconnaissance sensors are also carried by the AQM-34 series remotely piloted vehicles (RPVs). The primary sensors are optical and IR and the RPVs can be employed from low through medium altitudes. RPVs can fly either preprogrammed routes or use flight heading commands from an airborne control station. RPVs are used to augment manned systems and can be used when the political situation or the threat dictate. The use of RPVs presents a timeliness problem to the airborne commander since most RPV information has to be sent to the Army indirectly.

## CONCLUSION

The purpose of tactical reconnaissance is to provide the airborne commander with timely, high-quality information prior to hostilities and then to support planned or ongoing operations. The time responsiveness of information varies from a few seconds to a few hours depending on the sensitivity of the information, how long we can rely on the information, and the reconnaissance system being used. Information must reach the airborne commander in sufficient time and in a usable format.

The most current reconnaissance systems, TEREC and UPD-4 SLAR, are all-weather systems. The TEREC has a near-real-time capability. It should be pointed out, however, that these systems are limited in number, and routine surveillance of specific areas is normally performed using visual or optical means from the RF-4C.

## CHAPTER END NOTES

[1]Department of the Army, Operations, FM 100-5 (April 1977), p. 8-4.

[2]Ibid., p. 7-2 - 7-3.

[3]U.S. Army Command and General Staff College, The Commander and Staff--Operation Jayhawk, P111-2, p. L2-I-2.

[4]Glenn Burleson, personal letter from Tactical Air Command training division.

[5]Department of the Air Force, Tactical Air Command, Tactical Air Operations, TACM 2-1 (April 1978), p. 4-12.

# CHAPTER V

## DISCUSSION OF TACTICAL AIR SUPPORT

Close air support, reconnaissance, and aerial resupply in support of an airborne battalion in adverse weather all have the commonalty in the Army's dependence on all three systems. The airborne requires all three to win the battle, and the Air Force requires all three for its support of the Army to be successful. If the Air Force is not able to provide all three, then the remaining elements which it can provide are inadequate. For example if the Air Force can provide aerial resupply and reconnaissance but no close air support, the airborne will be a well-informed, well-equipped unit that will be destroyed by enemy armor or superior firepower. If the airborne has the close air support and aerial resupply without reconnaissance, then it will not be capable of timely massing of its firepower to defeat the enemy. The same is true of reconnaissance and close air support without aerial resupply, timely intelligence and aerial firepower can not substitute for the lack of well-armed and resupplied soldiers.

One of the first systems discussed can be used by close air support, reconnaissance, and aerial resupply aircraft. The ground radar beacon is small and can be carried by a parachuting member of the TACP. It is easy to operate, and its location does not require pinpoint accuracy. Aircraft may drop resupply and ordnance or conduct reconnaissance missions by just being given positions relative to the beacon. The F-111 is the only aircraft capable of delivering ordnance using the beacon. Past Reforger exercises in Germany have indicated the only aircraft which could deliver ordnance with great accuracy in close air support during adverse weather is the F-111.[1] The F-111 was the only fighter aircraft that was capable of providing close air support in adverse weather in Southeast Asia. The aircraft continues to demonstrate its capability to support the airborne in yearly Brave Shield joint exercises which are held in the United States. As was discussed in Chapter III, there appear to be two limitations to the use of F-111s: a) congressional testimony indicates the Air Force does not plan to use the F-111 in close air support and b) assuming it were used, the availability of these sophisticated aircraft would diminish rapidly when used constantly in combat. Including combat damage, losses, and aircrew-to-aircraft ratios (1.5 to 1), the use of the F-111 will be limited. The F-111 also suffers from ordnance problems to be discussed later in this chapter.

Another system that is used by aerial resupply, reconnaissance, and close air support aircraft is the ground directed radar system. The system proved to be reliable and easily maintainable when used in combat in Vietnam in 1972. The current radar bomb directing set, AN/TPB-1C, incorporates the expertise acquired in Vietnam with increased reliability, performance, and economy of modern technology.

The system is transported without the use of special loading, tiedown, and unloading equipment; only the items normally associated with the transporting vehicles are required. The system can be towed or transported by cargo trucks, airlifted in cargo aircraft, or airlifted by helicopters. It is not air droppable. This is the main problem with the ground directed radar system. Unless the airborne operation is within the range of it, the system can not be used until it can be air landed or airlifted in by helicopter. This means that in the critical first few hours or days of an airborne operation the ground directed radar system would not be available. After it arrives, it can be put to immediate use. However, there is another major limitation: when being used in close air support against moving armor, its accuracy is not adequate enough to destroy the target.

The limitation is due primarily to ordnance problems. In order to damage or destroy armor, a direct hit is required. General purpose bombs and firebombs are virtually incapable of destroying or damaging moving armor when delivered by ground radar because of the requirement for delivery accuracies within 5-6 feet (width of Soviet armor). The same problem is true to a lesser extent with the cluster bomb unit (CBU) weapon. The major obstacle is the current lack of a munition that can be fitted with a terminal guidance kit that will work in adverse weather.

In reviewing self-contained systems the first system to be discussed is the C-130's AWADS. This system is an excellent one that can use self-contained information or utilize the ground radar beacon to deliver aerial resupply to the airborne battalion in adverse weather. Test results discussed in Chapter II demonstrated circular error probable (CEP) and system maintainability. Although the CEP of AWADS exceeds that of visual means, the system is acceptable for employment in adverse weather. The CEP for airdrops was 213 yards. The test results have been verified by operational use of the AWADS equipped C-130s.

The airborne commander also has an all-weather long range radar reconnaissance system in the RF-4. He can monitor activity as it happens, collect tactical information on time-sensitive targets, and use the information to allocate his forces against the threat. Using the UPD-4 radar the RF-4 can monitor the enemy's movement. Darkness and adverse weather no longer provide the enemy with cover for its deployment of men and equipment. With the system's data link, it is no longer necessary to wait for the aircraft to complete the mission and return to its base to process the information. This system described in Chapter IV has proved to be so successful that the Federal Republic of Germany has purchased the system. The utilization of this high resolution fixed target and moving target radar data is limited only by the ability of the Army and the Air Force to coordinate radar flights to provide timely surveillance data to each user. With the proven application of the wide band data link the airborne has the potential of receiving radar data directly at a processor organic to the Army at the same time it is received by the Air Force.

The self-contained systems of fighter aircraft also allow them to drop ordnance using radar or navigation system information, but the accuracy of these systems combined with the previously discussed ordnance problems will only allow for area targets, not in close proximity of troops to be struck. The F-111 is an exception to this limitation, but still has the ordnance problems discussed earlier.

The C-130 gunship has a system capable of delivering ordnance by use of its guns in adverse weather. The gunship demonstrated considerable success in Southeast Asia. The C-130 is a relatively low-performance aircraft and its adverse weather sensors are early-generation equipment. Their dynamic range and resolution are adequate for the low-performance C-130s which operate in permissive environments, but they would be inadequate in high-performance fighters. The gunship is also a very limited resource due to the limited number of gunships in the Air Force inventory; therefore, it may not be available for use by the airborne.

The follow-on system for high-performance aircraft is the forward looking infrared receiver (FLIR). These systems usually combine a forward-looking infrared radar and a laser designator. Early testing as reviewed in Chapter III indicates some unusual problems. The first problem is the assumed search behavior of the observer. Using analytical results an observer finds a target with a probability of 63 percent within a single fixation of the eye. The probability increases to 95 percent in three fixation times (1 second). At this point, we not able able to model an observer more accurately. Terrain masking also appears to be a limiting factor in the target acquisition process. The data used in testing the FLIR is based upon a sample of United States terrain thought to be similar to that of North Central Europe. Whether a different sample of terrain data would result in a significantly different statistic is unknown.

The hypothetical FLIR sensor used in the analysis is modest in comparison to the best that can be achieved under static conditions. Analysis indicates that little improvement results from the use of a better sensor. A more optimistic acquisition probability must be based upon a more optimistic quantification of the observer's search problem. The weather, according to this analysis, is not the dominant limiting factor in target acquisition. Poor weather makes the problem more difficult, but the acquisition probability is discouragingly low even for good weather. The results of testing challenge the belief that low level close air support missions can be performed effectively in adverse weather.[2]

## CONCLUSIONS

The Air Force can support the airborne's airlift requirements in adverse weather using AWADS equipped C-130s. The C-130 test results and everyday use of the AWADS proves the dependability of the system. The Air Force can insert and resupply the airborne in adverse weather. The C-130 is capable of providing this support with or without the external aid of radar or radar beacons. The airborne is only required to give the location of the desired drop zone.

The Air Force can also provide timely reconnaissance in adverse weather using the UPD-4 side looking radar on the RF-4. The system can be data linked to ground receivers, providing a real time readout capability to the Army. Enemy movement is detected immediately without waiting for the RF-4 to land and have its film developed and analyzed. This provides the airborne battalion commander with the unique opportunity to know exactly where and in what strength the enemy is attacking. This knowledge allows the commander to defend, using the maximum of his forces in the proper positions.

In the area of close air support, the Air Force can provide, at best, only extremely limited support in adverse weather. The AC-130 is the best equipped aircraft for adverse weather close air support operation, but its support is limited to a surface-to-air missile and anti-aircraft weapon free environment. The F-111 is the only fighter aircraft capable of adverse weather close air support, and it will most likely be unavailable for support of the airborne due to its primary mission of interdiction. Even if available, the F-111 is limited in its support due to the lack of precision-guided munitions which can function in adverse weather. All other fighter aircraft require an external radar for guidance to enemy targets or a forward looking infrared receiver. The external radar, such as the ground directed radar system, will not be available during the the initial airborne operation; and even after it becomes available, it is limited by the restriction on terminal guided munitions described on the F-111. Initial testing of the FLIR systems indicate that the limitations on the operator's eyesight challenge the belief that low level tactical missions can be performed effectively in adverse weather by fighter aircraft.

In the final analysis, the limited ability to provide close air support in adverse weather restricts the entire capability of the airborne to function in adverse weather. Accurate resupply and timely reconnaissance can not make up for the lack of firepower that only close air support is able to provide. Hence, at the present time, tactical air support of an airborne battalion in adverse weather is not feasible.

## RECOMMENDATIONS

According to the 82D Airborne Division Airborne SOP it does not appear that the airborne is aware of the limitations in close air support during adverse weather.[3] The Army should be made aware of these limitations and the effects they have on airborne operations in adverse weather. As a result, airborne operations should not be planned during extended periods of forecasted bad weather. Operations should be planned for

for periods of adverse weather for insertion of the airborne followed by periods of good weather which will allow for visual close air support.

The Air Force needs to continue research aimed at providing a new all-weather ground attack aircraft capable of striking targets in adverse weather using self-contained systems. In addition, the Air Force needs to develop precision guided munitions that will work in adverse weather. The Air Force also needs to further analysize and test the FLIR systems to establish their validity to operate on fighter aircraft in adverse weather. The ongoing success of airborne operations depends on support of these recommendations.

## CHAPTER END NOTES

[1] International Defense Review, "The Combat-Proven F-111 NATO'S Main All-Weather Attack Aircraft" March 19, 1975.

[2] H.W. Wessely, Limiting Factors in Tactical Target Acquisition, (Santa Monica, Ca.: The Rand Corporation, March 1978), p. 1-29.

[3] Department of the Army, 82D Airborne Division, Division Airborne SOP, Div Reg 525-2 (February 1976), p. 5-3 - 5-4.

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