REFERENCE DATA BOOKLET

VOLUME II

1976

ARMY AVIATION ANNUAL WRITTEN EXAMINATION

REFERENCE DATA BOOKLET

VOLUME II

UNITED STATES ARMY AVIATION
ANNUAL WRITTEN EXAMINATION

TABLE OF CONTENTS

ERRATA SHEET
1976 REFERENCE DATA BOOKLET
VOLUME II

The following tables of contents with RDB page numbers should be substituted for those shown in Volume II of the RDB. Paragraph numbers indicated in the original tables of contents are correct as shown.

Table of Contents, FM 1-1 (Extract), Terrain Flying (RDB II, page 6).

FINAL MANUSCRIPT DRAFT

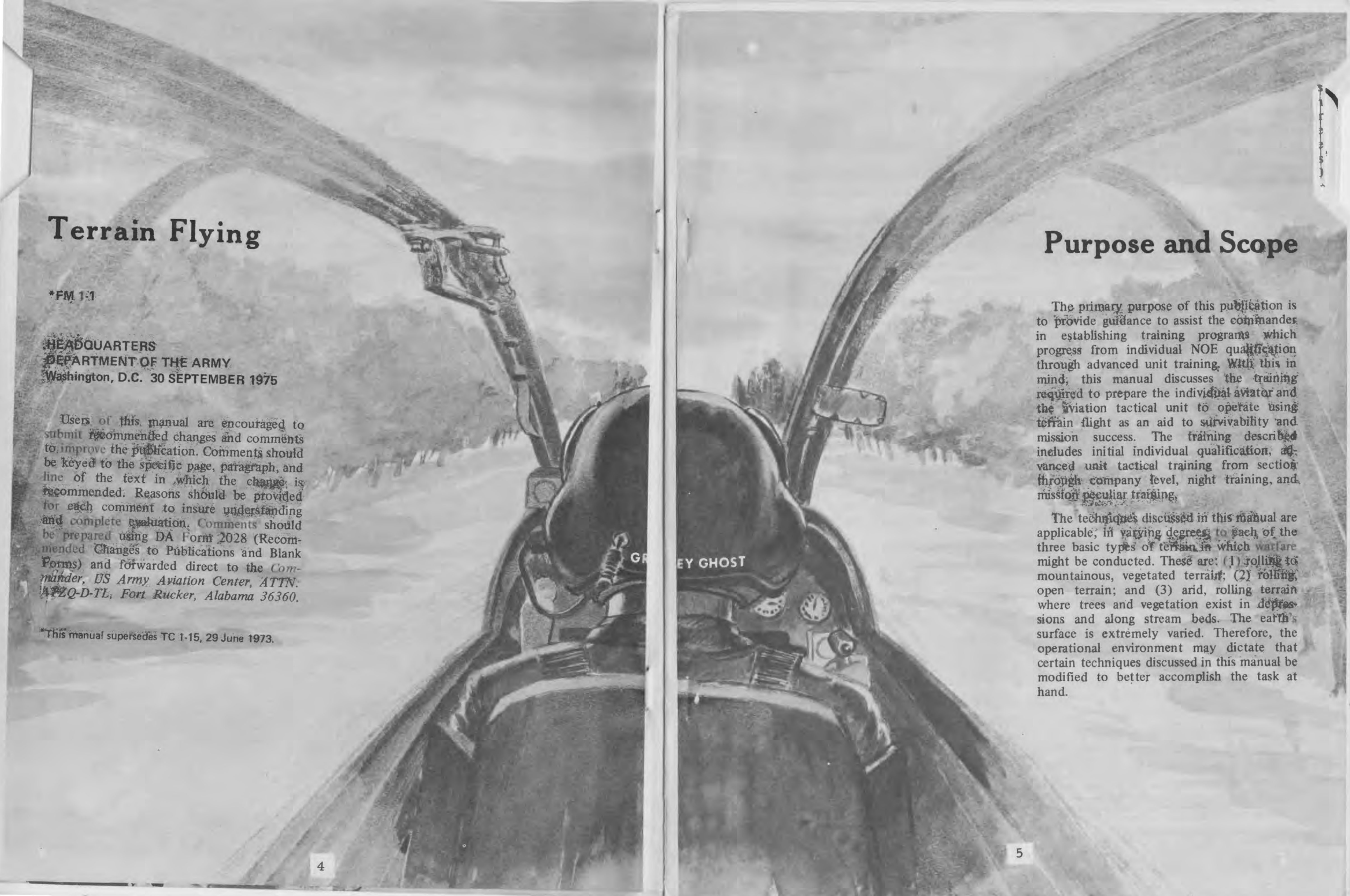
FM 1-1 TERRAIN FLYING

Preface

This manual was originally published as TC 1-15, Nap-of-the-Earth Flight Training. However, nap-of-the-earth was not truly descriptive of the flight profiles required for the High Threat Environment. Rather, terrain flight is a broader and more meaningful term relating to battlefield survivability. While it generally is true that reasonable altitude is desired for flight safety considerations, for operational considerations, flight at altitude may well be lethal. Thus, pure flight safety cannot be paramount in the determination of tactics but must support operational capabilities and mission accomplishment.

Where the terrain permits within the context of the enemy, the aviator will employ such altitude and airspeed as best enhances safety and his mission. However, enemy detection and engagement capabilities may dictate combinations of low level, contour, and nap-of-the-earth flight as well as hover, pop-up, sideslip, dash, quick-stop, and land. In the face of the high threat enemy, the aviator must keep in mind that what can be seen can be hit. Therefore, he must use the terrain to provide protection from detection and engagement by the enemy and to use the terrain so that he, not his enemy, has the tactical advantage. In other words, he exposes himself only when he is ready. In order to accomplish this, he will often have no choice but to use NOE. On other occasions he may be able to use low level or contour flight with just as great a degree of protection from enemy detection.

Regardless of whether the aviator is performing NOE, contour, or low level flight, he must use the terrain to his advantage if he is to survive and complete his mission. This is the concept of terrain flying. This is what the aviator must learn and practice.



Terrain Flying

*FM 1-1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C. 30 SEPTEMBER 1975

Users of this manual are encouraged to submit recommended changes and comments to improve the publication. Comments should be keyed to the specific page, paragraph, and line of the text in which the change is recommended. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to the *Commander, US Army Aviation Center, ATTN: ATZQ-D-TL, Fort Rucker, Alabama 36360.*

*This manual supersedes TC 1-15, 29 June 1973.

Purpose and Scope

The primary purpose of this publication is to provide guidance to assist the commander in establishing training programs which progress from individual NOE qualification through advanced unit training. With this in mind, this manual discusses the training required to prepare the individual aviator and the aviation tactical unit to operate using terrain flight as an aid to survivability and mission success. The training described includes initial individual qualification, advanced unit tactical training from section through company level, night training, and mission peculiar training.

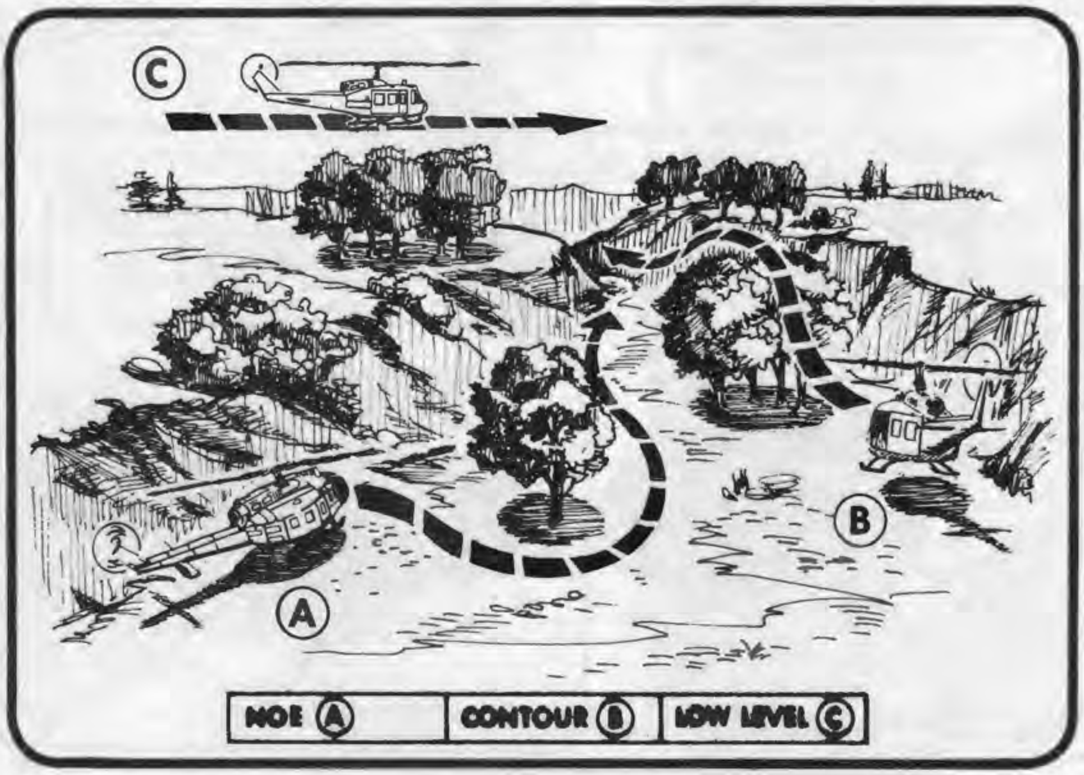
The techniques discussed in this manual are applicable, in varying degrees, to each of the three basic types of terrain in which warfare might be conducted. These are: (1) rolling to mountainous, vegetated terrain; (2) rolling, open terrain; and (3) arid, rolling terrain where trees and vegetation exist in depressions and along stream beds. The earth's surface is extremely varied. Therefore, the operational environment may dictate that certain techniques discussed in this manual be modified to better accomplish the task at hand.

Table Of Contents

What Is Terrain Flying?

It is flight in the face of the enemy. It is to the aviator what creeping and crawling is to the infantryman - a means of survivability.

Specifically, *terrain flying* is the tactic of employing aircraft in such a manner as to utilize the terrain, vegetation, and man-made objects to enhance survivability by degrading the enemy's ability to visually, optically, or electronically detect or locate the aircraft. This tactic involves a constant awareness of the capabilities and position of the enemy weapons and detection means in relation to available masking terrain features and flight routes. Terrain flying of necessity involves flight close to the earth's surface and includes the tactical application of low level, contour, and NOE flight techniques as appropriate to the enemy's capability to acquire, track, and engage the aircraft.



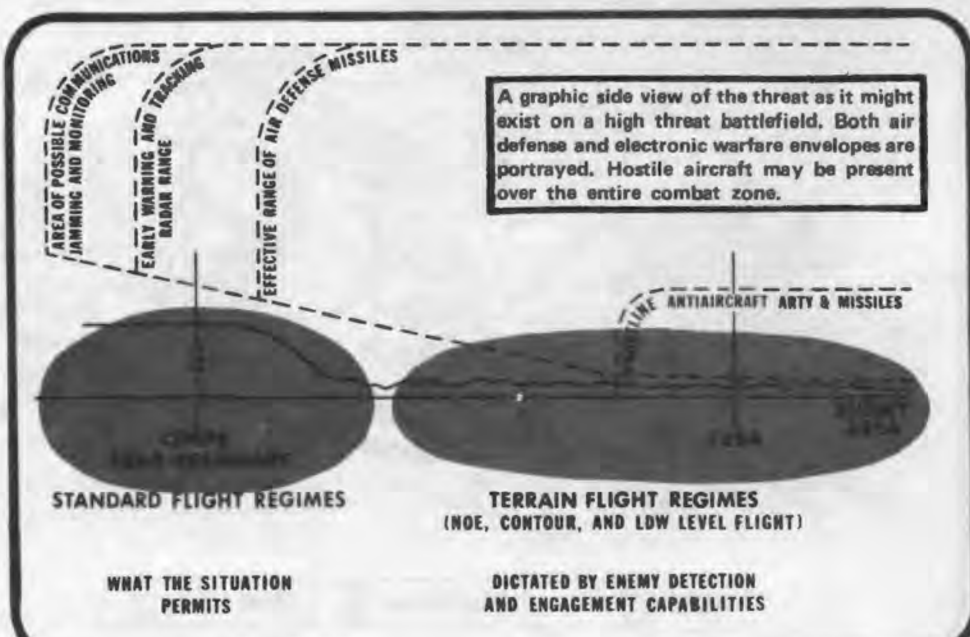
Nap-of-the-Earth Flight *Nap-of-the-earth flight* is flight as close to the earth's surface as vegetation or obstacles will permit, while generally following the contours of the earth. Airspeed and altitude are varied as influenced by the terrain, weather, ambient light, and enemy situation. The pilot preplans a broad corridor of operation based on known terrain features which has a longitudinal axis pointing toward his objective. In flight, the pilot uses a weaving and devious route within his preplanned corridor while remaining oriented along his general axis of movement in order to take maximum advantage of the cover and concealment afforded by terrain, vegetation, and man-made features.

Contour Flight *Contour flight* is flight at low altitude conforming generally, and in close proximity, to the contours of the earth. This type of flight takes advantage of available cover and concealment in order to avoid observation or detection of the aircraft and/or its points of departure and landing. It is characterized by a varying airspeed and a varying altitude as vegetation and obstacles dictate.

Low Level Flight *Low level flight* is flight conducted at a selected altitude at which detection or observation of an aircraft or of the points from which and to which it is flying is avoided or minimized. The route is preselected and conforms generally to a straight line and a constant airspeed and indicated altitude.

The preceding illustration and definitions provide a specific answer to the question: "What is terrain flying?" However, the answer is not complete because as an aviator you should also know when to use terrain flying and why you are using it. Figure I-4 provides a graphic description of when to use the terrain flight by comparing standard and terrain flight regimes to the threat. To answer "why," figure I-5 portrays your chances of survival in various flight situations against specific detection systems.

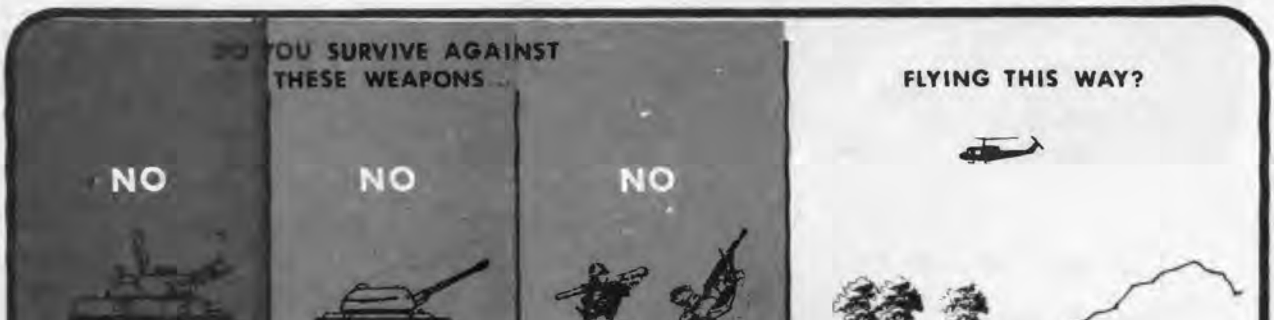
Figure I-4. Threat Profile.



The choice of whether low level, contour, or NOE flight will be used at a specific time and place will be determined primarily by the threat.

Whether the aviator will use low level, contour, or NOE flight, or a combination of these techniques, is influenced by three factors. First and most important - the threat and availability of masking terrain will dictate whether NOE, contour, or low level flight is used in a given situation by imposing maximum altitude restrictions. When no suitable terrain mass exists to provide masking so the aviator can fly low level or contour, he will fly NOE in order to take advantage of any vegetation and even the most subtle depressions in the surface. Secondly, time considerations influence the selection of a flight technique. When masking exists which allows contour or low level flight to be flown, either is usually preferable to NOE because more sorties can be flown or greater distances covered due to the high airspeed characteristics of low level and contour flight. The third consideration is safety. The higher the altitude, the greater the reaction time in an emergency and the higher the probability of obstacle and hazard avoidance. For that reason, the highest altitude below the masking terrain should be used.

Figure I-5. Survival Probabilities.



Terrain Flying In The High Threat Environment

This chapter has two major functions. The first is to explain to the aviator that if he is to accomplish his mission in future wars he must employ new tactics. To do this, the chapter describes the combat environment in which terrain flying is employed and the threats we must operate against. The second major function of this chapter is to present fundamental techniques and considerations for performing terrain flight. Techniques discussed include, among others, multihelicopter operations, terrain flight planning and navigation, flight maneuvers, and inadvertent IFR procedures. Also, safety considerations are discussed and include hazard avoidance, aircraft maintenance standards, and weather. A final area discussed includes those human factors which impact on terrain flying such as fatigue and the use of peripheral vision for obstacle clearance and checkpoint identification.

1-1. THE HIGH THREAT ENVIRONMENT

The term mid-intensity is often used to describe conventional warfare employing the most modern technology and doctrine. However, this term belies the intensity of the conflict especially as it relates to aviation operations in future wars where we can expect to operate against a combination of sophisticated lethal threats. To more accurately describe this environment and to make the aviator constantly aware of the threat he will operate against, the term *high threat environment* is used throughout this and other texts written by the Aviation Center.

The high threat environment is an enemy combat posture wherein modern, sophisticated weapons and techniques create a highly lethal situation with the intention of establishing control over territory and airspace contiguous to that territory. Such a posture could include armor, field and antiaircraft artillery, surface-to-air missiles, and tactical fighters which would be directed by radar, infrared, optical, electro-optical, and visual means, and might be supplemented by electronic warfare methods to include interception, jamming, and deception.

Friendly tank, infantry, artillery, and aviation units will work together to accomplish the Army mission of conducting sustained land combat. To do this, ground fighting elements can add their fires to help suppress the enemy's air defense capability. The air defense umbrella provided by supporting and organic air defense units accompanying the tanks and infantry will assist aviation units in the area to survive against enemy aircraft. Friendly artillery should be used to degrade the enemy's surveillance capability and suppress his air defense weapons. While the ground forces help the aviation unit maintain freedom of movement, the aviation forces will provide the ground forces mobility, eyes and ears, and will help suppress the threats they operate against.

As the helicopter has become a more effective combat vehicle, the threats faced by Army aircraft have become more deadly. Early during the Vietnam conflict, air defense weapons were generally limited to small arms weapons and flying at altitude was a suitable tactic to counter this threat. However, during Lamson 719 and the 1972 North Vietnamese Spring Offensive, aviators saw the use of increasingly sophisticated air defense weapons such as radar-directed automatic weapons and heat-seeking missiles. Thus, in the late stages of that war, the few aviators who remained in country learned that they had to adjust their tactics to meet the threat. Especially in the northern provinces of South Vietnam where enemy positions became well defined, aviators began operating at low altitudes (less than 50 ft AGL) using terrain and vegetation to mask their movements.

During the 1973 Middle East War, a formidable air defense threat emerged that emphatically confirmed the terrain flying doctrine. In this high threat environment, heat-seeking missiles were used in vast quantities by frontline infantry; long range radar guided missiles provided an air defense umbrella extending well beyond the forward edge of the battle area; self-propelled, radar-guided air defense artillery was used to protect armor formations; and individual soldiers were well trained to utilize their small arms as air defense weapons. Although the helicopter was not used extensively by either side in this war, when it was used it generally operated at low altitudes utilizing the terrain to avoid detection.

Unlike the early days of Vietnam when Army aircraft were free to roam the skies virtually unimpeded, the threat that we must now be prepared to face has become much more sophisticated and intense. Today only a properly prepared aviator and unit can successfully operate in the high threat environment. The aviation unit must function as a member of the combined arms team and utilize certain basic tactics. These tactics include terrain flying, night operations, limited communication, tactical instrument flight, and frequent movement. The success of a unit in combat will be directly proportional to its ability to operate as a member of the combined arms team and effectively employ the tactics listed above. Proficiency in these essential tactics is the key to winning the first battle of the next war!

GENERAL CONDITIONS FOR AVIATION OPERATIONS IN A HIGH THREAT ENVIRONMENT

- Units will operate as members of the combined arms team.
- Operations will be conducted in both nuclear and nonnuclear environments.
- Units will be required to conduct both day and night missions.
- Units will operate in adverse weather conditions.
- Enemy electronic warfare, especially jamming and voice deception, will be employed against aviation units.
- Units will often operate under conditions of radio silence.
- Attacks by enemy tactical fixed wing aircraft and helicopters can be anticipated.

Threat

The specific threats and employment doctrine against which we will operate in the high threat environment are discussed in FM 90-1, Employment of Army Aviation Units in a High Threat Environment. We face a threat not only when we are in the air but also when we are on the ground. The threat includes sophisticated air defense weapons and complementary electronic warfare, attacks by high performance aircraft and attack helicopters, and the use of artillery to destroy our maintenance facilities and rearm/refuel points. Basically, what the threat analysis tells us is that if we expose ourselves during flight the enemy can locate and hit us. Due to the lethality of his weapons, if he can hit us he

can eliminate us from the battlefield. *But he has the advantage only if we make the first mistake* - if we expose ourselves by not properly using the terrain, darkness, weather, suppressive fires, smoke, and radar deterrents (chaff, jamming). The combat experience of 1972 in Vietnam, the knowledge gained from the 1973 Middle East War, and the results of aircraft survivability tests have proven that terrain flying can minimize the effectiveness of the enemy weapons and weapon systems. Simply stated *terrain flying* is the fundamental element for mission success in the high threat environment.

Can you identify these threat weapons? Check your answers with the correct answers on page 36.

Figure 1-3.

1-2. TERRAIN FLYING CONSIDERATIONS

Terrain flying imposes additional factors on the aviator and unit that may not be encountered on missions flown at higher altitudes. Because these factors impact on mission planning and execution, it is essential that each aviator and commander understand them. These factors with their associated problems and ways to minimize or solve them are described below.

Terrain and Enemy Electronic Warfare Restrict Communication.

When conducting terrain flying, communications will often be limited or restricted. The line of sight radios currently available may be restricted by mountainous terrain and in certain cases it will be impossible to maintain contact with a unit outside the immediate vicinity of the aircraft. Since most communication with ground units will be with FM radio, the aviator must prepare during planning to operate around the limitations of the system. To do this, the aviator should identify those "dead areas" where he may not be able to communicate with his commander or supported unit due to terrain restrictions. The construction of a terrain profile diagram might assist in identifying dead areas. During certain operations, the commander may choose to assign aircraft, pathfinders, or retransmission equipment for radio relay purposes.

Alternate communication signals should be standardized.

In addition to the restrictions imposed by the terrain, it will often be essential in the high threat environment to limit communications due to the ability of the enemy to electronically locate the aircraft if it transmits. In the high threat environment, radio communications should always be limited to the absolute minimum and operating under radio silence will be very common. Therefore, alternate communication procedures must be developed for use between aircraft and ground units. Light signals and hand signals could be used for communication between aircraft. Marker panels, smoke canisters, and light signals could be used for communication between ground elements and the aircraft. To prevent confusion, all signals used should be standardized and protected against compromise. Even though the communication system may not be as responsive when conducting terrain flight, the effects of the lack of communication can be minimized with proper planning.

Lack of Communication Results in Decentralized Control.

The lack of communication when terrain flying causes a significant change in the procedures for control of a tactical operation. This affects both the ground and aviation commander. The ground commander will no longer be able to use his C&C aircraft to supervise the activities of several units simultaneously from altitude. Rather, he will have to use it primarily as a means of mobility between his units. Typically, aircraft communications will only be a supplement to his ground communications network. When communications are not limited, it is possible for the aviation commander to operate a centralized control system. However, when conducting terrain flying, control procedures will have to be tailored to the specific situation. The following conditions will normally apply to control of aircraft by the aviation commander:

- A commander's direct control over his unit will be limited by his ability to communicate with his subordinate elements.
- The aviation commander controlling the operation must participate as an integral part of the unit conducting the operation.
- When terrain flying, control will often be the responsibility of the platoon, section, or team commanders. They must be able to execute the mission as planned and, equally important, they must be able to make sound tactical judgments when the plan must be modified en route.
- Mission planning should be detailed and include primary and alternate routes. Control points and time should be used as control measures. Once the operation is underway, modifications to the plan must be held to the minimum necessary to accomplish the mission.

Control must come from within a unit, not from a commander circling high overhead.

ADA Must be Able to Identify Friendly Aircraft.

In addition to communication and control, identification of friendly aircraft by friendly air defense and ground units is an area which must be considered in both mission planning and execution. It is critical that aviation missions be coordinated with friendly air defense artillery (ADA) units. Each aviator should be especially cognizant of the location of ADA units, know ADA unit criteria for identifying and engaging targets (visual recognition based on size, shape, markings, and color), and insure that onboard identification equipment (Identification Friend or Foe (IFF)) is functioning and properly coded.

Increased Maintenance Requirements.

When a unit is habitually conducting terrain flight, the commander should expect and plan for increased maintenance requirements. Blade strikes will probably increase, skin punctures may be more common, and maintenance inspections should be more timely and complete. The higher power settings required for NOE flight impose a heavy strain on aircraft dynamic components (e.g., engines, blades, and transmissions) that could result in reduced mean time between failure. In a combat situation, maintenance teams will be required to perform in the field maintenance when aircraft are operating out of forward positions removed from unit maintenance facilities.

1-3. MULTIHELICOPTER OPERATIONS

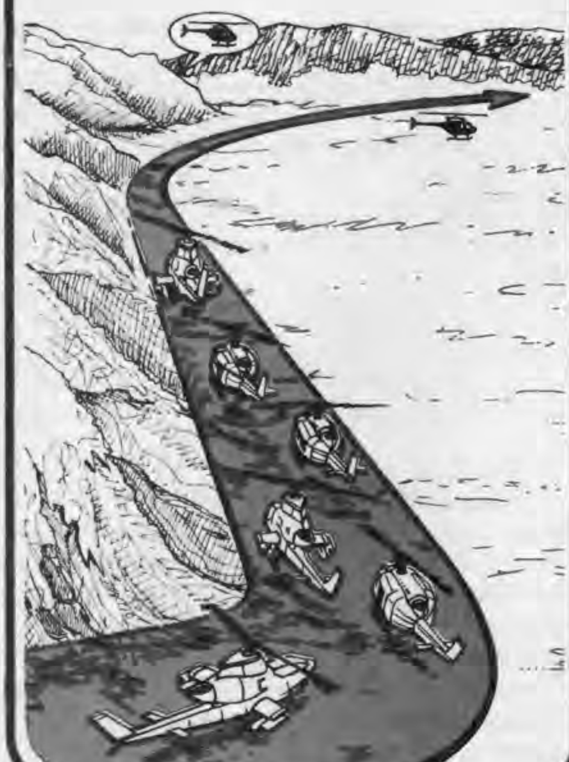
In the high threat environment, a formation's specific shape is defined by terrain, situation, and desired degree of control. Regardless of the specific formation, the aircraft will be staggered and the distance between aircraft will vary according to the terrain being crossed. Each aircrew in the flight is responsible for the accuracy of navigation and must be prepared to take the lead at anytime and proceed to the destination. Light signals and code words should be used to assist in reducing radio communications and in the event of lost communication or radio jamming by the enemy.

When terrain flying, the greater the number of aircraft in a group, the more easily they can be detected. In addition, a large group requires more terrain relief to remain masked than does a small group. When large groups of aircraft are required to accomplish the mission, dispersion can be achieved by using numerous routes into an area with small groups of aircraft utilizing each route. However, it will often be necessary to use a single route in order to concentrate available suppressive fires.

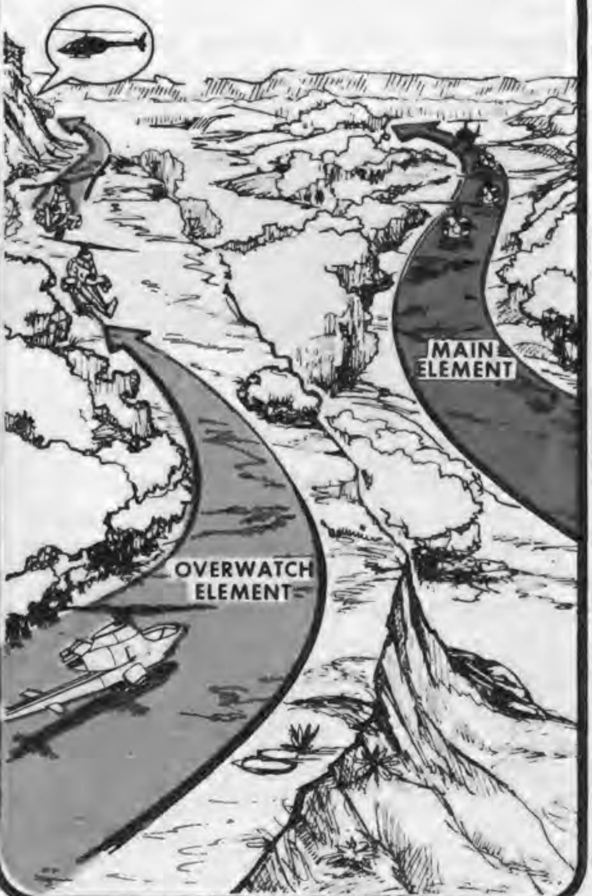
When moving, a small team of two or three helicopters should normally maintain its integrity so as to return an adequate volume of fire if attacked. Sections or larger units should employ traveling, traveling overwatch, and bounding overwatch as depicted in the following illustrations. When using nap-of-the-earth flight, individual aircraft within the formation (or element) move as do individual infantrymen in a squad. The squad leader picks the general direction of travel but each infantryman picks his terrain and moves by rushes or bounds within the loose formation. He is not required to step in the footprints of every man ahead of him. With aircraft formations, following aircraft pick their own terrain, moving by bounds independently from point to point within the formation. The pilot must be particularly careful not to maintain standard distances from preceding aircraft or exact flight routes which can aid enemy gunners. Each pilot must be aware of the situation, the terrain, and the mission. He must not follow blindly the tailpipe of the aircraft ahead.

If attacked, disperse immediately! Proceed, with each aircraft maintaining its own cover and concealment. Regroup when clear.

Traveling can be used when contact is *not* likely such as in corps and division rear areas. Low level flight will most often be used when employing the traveling technique. During traveling NOE and contour flight, the unit will normally move in loose trail or staggered trail. When low level flight is used, more formation flexibility is possible. The dispersion will be determined by the desired degree of control, visibility, terrain restrictions, and tactical considerations.



When contact is possible, *traveling overwatch* should be used. Traveling overwatch is characterized by continuous movement of the main elements (during an air assault operation, the lift platoons). The overwatch elements (the gunships) move at variable speeds and may even pause for short periods if necessary. The overwatching element keys its movements to the terrain and is always prepared to fire or maneuver, or both, to support the main elements.



At times it will be necessary for the aviation unit to employ a *bounding overwatch.* Elements move by bounds with one element in position to fire or maneuver, or both before the other element moves. Once in position, the bounding element becomes the overwatching element and vice versa. This technique will be especially applicable in a situation where enemy contact is expected.

1-4. TERRAIN FLIGHT PLANNING

The requirement for accurate intelligence data (e.g., mission, enemy situation, terrain and weather, troops available, time, and space (METTS)) is fundamental to planning. During highly fluid situations, intelligence information can change rapidly. This requires that field reports be constantly evaluated, especially as they affect previous intelligence information related to the ability of the enemy to detect and engage an aircraft.

[redacted]

Following the operations (G3/S3) and intelligence (G2/S2) briefing, the aviator will plot the selected landing zones, ambush and/or firing positions, aircraft control points, the FEBA, and known or suspected enemy positions. He will then select possible flight routes and alternate routes if not given in the mission briefing. The routes are then carefully studied to determine their susceptibility to visual or electronic detection by enemy forces. Altitude restrictions based on enemy threat analysis are then determined and marked on the map. The terrain in the immediate vicinity of the routes should be studied to familiarize the aviator with any potentially hazardous areas along his route of flight. Identified hazards will be marked on the map. Key terrain features should be noted along the route and especially at or near turning points. The aviator should, after performing the map reconnaissance, be able to visualize the entire route of flight. When available, current aerial photographs of the area should be used during the map reconnaissance to insure map accuracy and to check for hazards.

[redacted]

When planning a flight utilizing terrain flying, the aviator is actually planning detection avoidance. Unfortunately, the terrain does not always lend itself to our advantage for conducting terrain flight. Therefore, even when using NOE flight, there will be times when detection must be expected. This dictates that mission planning also provide for suppressive fires (attack helicopters, artillery, high performance aircraft, and naval gunfire), smoke, chaff, standoff jamming, or any other means available which can prevent the enemy from locating and/or attacking the aircraft. Whenever operating inside or near the range of enemy air defense weapons and/or artillery, the need for suppressive fires should be considered and, if necessary, requested.

[redacted]

Whereas thorough planning and training are the keys to mission success, preplanning is the key to rapid response and flexibility. In order to retain these capabilities in spite of the greatly increased planning requirements inherent with tactical operations in the high threat environment, the aviator and aviation unit commander must plan well ahead. They must anticipate *what* may be required of aviation assets and *where* they may be needed. They must habitually start early a detailed map reconnaissance of likely areas of operation to determine possible routes of flight, landing zones, rearm and refuel points, and the other elements essential for rapid and flexible response. To insure that ground and air tactical factors are coordinated and projected as far into the future as possible, they must work closely with the planning staff of the ground commander.

FLEXIBILITY WILL BE IN DIRECT PROPORTION TO PREPLANNING

Route Planning Considerations

The first consideration in route planning is to know the local enemy threat and how he has been employing his air defense weapon systems. Routes can thus be planned to keep the highest possible terrain and/or thickest vegetation *between* the enemy and aircraft.

To do this in mountainous or rolling terrain, plan the route on the friendly side and below the crest of a ridgeline. In very gently rolling terrain, plan the route across the low terrain such as stream beds where it does not serve as an avenue of approach to the enemy position. In arid or open areas, plan the route along stream beds or depressions where trees may exist. When feasible, routes should avoid population concentrations due to the large number of hazards. Routes should not follow man-made linear features such as roads, canals, or pipelines unless required because of restricted visibility. These linear features normally do not follow a course which offers the greatest masking opportunity. To the maximum extent possible, routes should be planned over heavily vegetated areas as opposed to open terrain. This is especially true near enemy positions because the vegetation further restricts the ability of the enemy to detect the aircraft. Also, by flying over vegetation the aircraft shadow, which is the primary means by which high performance aircraft visually locate low flying helicopters, can be broken and lost in the darker vegetation. Because helicopters are susceptible to radar or visual detection on the side of a slope facing the enemy regardless of altitude, ridgelines should be crossed at low points. The ridgeline should be crossed so as to reduce exposure time to a minimum. When crossing the ridgeline, avoid silhouetting the aircraft on the horizon. Plan primary and alternate routes into and out of the objective area.

Checkpoints used along a route should be terrain features in preference to man-made objects. This is because man-made features are subject to change or destruction and unplotted features may be confused for intended checkpoints. When man-made objects are used, they should be used primarily to help confirm the identity of terrain features. To emphasize this point, the Canadian Army uses special maps during training with no man-made objects depicted on them.

Specific altitude restrictions should be determined for each route. When operating within range of enemy air defense weapons, maximum altitude is determined based on the masking offered by available terrain and vegetation. When operating beyond the range of enemy air defense weapons but within range of enemy surveillance equipment, altitude is determined based on friendly tactical considerations such as airspace management for aircraft, artillery, and air defense weapons. Friendly tactical considerations also include counterintelligence considerations. For example, altitude should be below enemy surveillance capability in the vicinity of command posts (CP), assembly areas, Forward Area Rearm and Refuel Points (FARRP's), etc., to prevent enemy radar from locating these positions because of the high density of traffic in the areas.

A note of caution is pertinent at this point. Route planning can only be as good as the map is accurate. In some cases, we may be working with an out-of-date map or maps on which the contour interval is too large to show terrain relief adequately. Therefore, changes to the route, based on observation of the actual terrain, should be made if necessary to remain masked.

ROUTE PLANNING CONSIDERATIONS SUMMARY

- Keep a terrain mass and/or vegetation between the enemy and the aircraft.
- Avoid using man-made objects as checkpoints.
- Do not follow man-made linear features.
- Avoid silhouetting the aircraft when crossing ridgelines.
- Plan primary and alternate routes.
- Avoid open areas when terrain permits.
- Determine altitude restrictions based on threat, masking offered by the terrain, and friendly tactical considerations.

TERRAIN FLIGHT PLANNING EXAMPLE

MISSION: An aircrew is assigned the mission to pick up a TOW team near the FEBA (FK 088898) and insert the team at FK 039984 and bring two men back to the PZ (FK 088898).

SITUATION: The US Forces are presently in a mobile defense southwest of Brundidge (see map A (insert)). The FEBA generally runs along the ridgeline west of the Pea River. The general outpost (GOP) is approximately 15 kilometers northwest of the Pea River where the division's armored cavalry troop is deployed. An enemy mechanized division, operating from its headquarters near Spring Hill (EL 9806), has been observed deploying its tanks and self-propelled antiaircraft weapons along highway 125 and adjacent roads near Tarentum (FL 0601) and as far south as the intersection at FK 063977. A cavalry troop aeroscout has reported ZSU 23-4 and SA7 positions at FL 039018 which have clear fields of fire on aircraft approaching the GOP.

PLANNING: Using all intelligence information available to him and making a thorough map study during his premission planning, the pilot determines his best course of action along with alternate courses of action should the situation change en route. He determines that because of the high ridge on the south side of the Pea River, which will mask his approach from the enemy, he can fly at contour altitudes from home base (located off the SE corner of the map) to the ridge (FK 136883). He further determines his route of flight from the PZ to the LZ (sketched on map) and back to the PZ. The route is selected to follow the low terrain, cross ridgelines at low points, and make maximum use of vegetation to remain masked from optical and electronic observation by all known and suspected enemy locations. In order to remain masked, the pilot decides to employ NOE flight after crossing the ridgelines on the south side of the Pea River. He indicates on his map with arrows the wire hazard which crosses the route. He will depart the LZ at 1035 local time. Artillery (HE and smoke) will be available on call for suppression of known enemy locations.

1-5. PERFORMING TERRAIN FLIGHT

The manner in which the pilot performs terrain flying is directly influenced by his mission. The scout who is searching for the enemy will use NOE extensively. He will sneak and peak, dash across open fields, and use many other techniques which the cargo pilot will seldom, if ever, use. Even with the differences in the way terrain flying will be conducted for any given mission, there are three fundamental elements necessary to successfully conduct any terrain flight. These are crew integration, navigation, and aircraft handling.

Crew Integration

Terrain flying is a crew activity conducted by at least two qualified aviators or an aviator and a qualified aeroscout observer. A qualified aviator is one who has completed an authorized terrain flight qualification training program such as outlined in this manual and meets all other required criteria to perform flight. To be considered qualified to function as a member of a crew conducting terrain flight, an aeroscout observer must have successfully completed all aspects of an authorized terrain flight qualification training program except those tasks only a rated aviator can perform. This training is necessary to train the observer to assist the pilot by navigating and to familiarize the observer with the high threat environment. This training is in addition to other training the aerial observer receives.

Terrain flight is a crew activity. It can only be performed successfully with teamwork!

During flight, the division of duties is well defined. The pilot must concentrate on clearing obstacles and maintaining direction and airspeed. He must be free to keep his vision outside the aircraft at all times. The copilot/observer is responsible for accurate navigation. He must remain oriented at all times and inform the pilot of the direction to be flown and requirements to increase or decrease speed in order to arrive at the next checkpoint on time. He also assists the pilot by monitoring instruments and tuning radios. Position reports should normally be made by the copilot/observer.

A cockpit SOP should be established prior to conducting terrain flying. This SOP should include the division of duties/responsibilities and the following additional points:

- *Mission essential equipment* - In addition to the required flight and protective clothing, and emergency and survival equipment normally carried onboard an aircraft, onboard equipment should include local area maps, CEOI, and a -10 operator's manual.
- *Power checks* - Engine health indicator tests should be conducted in accordance with unit maintenance SOP. A hover check will be conducted prior to each takeoff and an out-of-ground effect hover check will be conducted prior to NOE flight.
- *Safety precautions* - There will be no smoking by either the crew or passengers when conducting terrain flying. Under most conditions, crewmembers should wear their visors down during flight. The visors must be clean and free of scratches. Armor plate should be in place. During terrain flight, all personnel will be seated and restrained by belts. Exceptions to this policy during tactical operations should be made only in accordance with unit SOP by the pilot in command.
- *Inflight emergency procedures* - Emergency procedures should be established by each crew prior to conducting terrain flight. Due to the critical shortage of time for the crew to react to an in-flight emergency, each member of the crew should know what he will do in the event of an emergency. There is normally not enough time to transfer aircraft control during an emergency requiring autorotation when terrain flying. Therefore, an attempt to transfer controls should not be made. The crewmember not flying will make the emergency radio calls.

Navigation

Experienced aviators have navigated successfully at altitude and most of us think that we can satisfactorily transfer this skill to accomplish navigation at terrain flight altitudes. This unfortunately is not true as indicated by the following quote from the US Army Research Institute report entitled "Navigational and Flight Proficiency Measurement of Army Aviators Under Nap-of-the-Earth Conditions." The high experience group referred to in the quote below had a mean flight experience level of 1378 hours, while the low experience group had 214 hours.

> "The basic lesson to be learned from these data is that flight experience per se does not yield better performance in a highly specialized task like NOE navigation. It is hypothesized that the low experience group performed better because it had recently received, as part of its undergraduate tactics course, an NOE flight familiarization sequence. The high experience group had received its NOE training 'on the job' at unit level. In fact, some of the high experience group had received no real NOE training at all."

To successfully navigate, the aviator must be able to visualize the actual terrain as depicted on a map.

Terrain flight navigation is difficult because the flat visual angle distorts shape compared to the map and because vertical relief is the most suitable means of identifying checkpoints. To conduct terrain flight navigation with proficiency requires training and practice. Checkpoint identification is the critical task for successful terrain flight navigation. This requires that the crewmember navigating be proficient in map reading, terrain interpretation, and terrain/map correlation. He must be able to visualize from the map how the terrain around him should appear. He must also be able to look at the terrain, identify his location, and then locate that position on the map. The navigational difficulty is greatest when NOE because the aviator navigates primarily by vertical relief which must be interpreted from the map. Low level navigation is easier because at the higher altitudes associated with low level flight, the aviator can more accurately identify shapes which are depicted directly on the map.

Terrain flight navigation requires an exchange of information between the crewmembers. The crewman navigating furnishes the pilot with the information that is required to remain on course. To assist the crewmember navigating, the pilot points out approaching terrain features. Standardized terms should be agreed upon to identify terrain features because terrain features are often identified by different names in various parts of the country. For example, a body of water called a creek in some parts of the country might be referred to as a stream or brook in other areas. Standardized terms will help prevent misinterpretation of information and reduce unnecessary cockpit conversation.

Certain aspects of terrain flight navigation differ depending on whether low level, contour, or NOE flight is being performed. Because terrain flying will normally involve a combination of these flight techniques during any given flight, the aviator must be familiar with the navigational techniques associated with all three.

A turning point.

NOE navigation requires continuous orientation unlike contour and low level navigation when the aviator follows the desired route by identifying a series of successive checkpoints. To remain continuously oriented, the crewmember navigating must identify all terrain features depicted along his route on the map with the actual terrain feature. This requires that he be highly proficient in map/terrain correlation and that he and the pilot work together as a team. Specific techniques for providing the pilot NOE navigation instructions are discussed below:

- When possible, the pilot should be told to follow an identifiable terrain feature such as a stream bed, draw, or spur.

- Guidance information should be provided to the pilot in small increments. Generally, it need not be provided beyond the next turning point. A turning point is a point where the route makes a major change in direction. Several terrain features should be used to identify a turning point to prevent confusion.

- Heading information should be provided in such a manner that the pilot does not have to focus his attention inside the cockpit. He should be told to turn to a "clock" position or recognizable terrain feature or tree. "Rallye terms" such as "... turn left, start turn, stop turn. . ." can be used when necessary. Rallye terms are single words or pairs of words which describe a particular action and are used to tell a pilot what to do to follow the course rather than where to go to follow the course.

■ The pilot should not be told to fly a specific airspeed because this requires him to look in the cockpit. He should be told to increase or decrease airspeed.

Whereas NOE navigation requires precise following of a well defined route, contour navigation is less precise because the contour route is more sweeping. This does not mean that contour navigation can be sloppy - it can't. Since the contour route is planned to utilize the terrain to achieve cover and concealment, it must be followed closely. Due to the constant (and generally high) airspeed which characterizes contour flight, checkpoints on the route should be spaced according to the planned airspeed to be flown and should be easily identifiable.

When performing contour flight, the pilot and the crewmember navigating must work together well. As with NOE, it is important that the pilot focus attention outside the aircraft and not be required to use the instruments to follow navigation instructions. The most effective technique for providing navigation instruction is to combine the use of terrain features and rallye terms (fig 1-13). The crewmember navigating is also providing the pilot with airspeed information so that checkpoints are crossed on schedule.

Many of the techniques relating to NOE and contour navigation are applicable for low level navigation. However, several techniques can be used for low level navigation which cannot be used for contour or NOE navigation. Computed time-distance can be used effectively for low level navigation since low level flight is characterized by constant airspeed and distance can be accurately measured. The pilot can be told to fly specific headings and airspeeds since he has increased reaction time and obstacle clearance. Also, radio may be an effective navigation aid.

Procedures for navigating when terrain flying and related techniques for map preparation are discussed in more detail in FM 1-5, Instrument Flying and Navigation for Army Aviators.

When contour flying the crewmember navigating should point out to the pilot a prominent terrain or man-made feature some distance ahead of the aircraft and along the course. Rallye terms can then be used to provide the pilot the information he needs to follow the exact course.

Figure 1-13.

Aircraft Handling

To perform terrain flying, the pilot must handle his aircraft with skill and finesse. Aircraft handling is a much more critical task when terrain flying than when flying at altitude because the pilot is flying in much closer proximity to terrain, vegetation, and hazards. This requires that the pilot be acutely aware of the dimensions of the aircraft and the time it requires for the aircraft to react to the pilot's input.

When operating at near gross weight the pilot's aircraft handling skill will be severely tested. Because he is operating close to vegetation, often at slow airspeeds or hovering, the pilot must know the performance capabilities and limitations of his aircraft. He must plan his mission correctly, employing the -10 performance charts, and adhering to the go/no-go takeoff data placard in the aircraft.

Aircraft handling also involves the skill of the pilot to judge obstacle clearance. He must be able to quickly and accurately decide when to go over obstacles rather than between or under them. He must know how to use vegetation and shadows to reduce glare.

Another critical task relating to aircraft handling when terrain flying is that flight maneuvers be executed precisely. The specific flight maneuvers required to perform low level and contour flight differ only slightly. However, certain flight maneuvers required for NOE flight differ significantly from low level and contour flight maneuvers. For example, to stop abruptly when NOE (a quick stop), the aircraft must pivot around the tail rotor's horizontal plane (fig 1-15). This requires that power be increased prior to beginning the deceleration so that the nose comes up and the tail doesn't drop. The amount of power applied is dependent upon forward airspeed and load on board the aircraft. Specific procedures for conducting the quick stop and other basic NOE flight maneuvers are discussed in appendix C.

Certain emergency procedures (i.e., engine failure, antitorque failure (especially a complete loss of thrust), low side governor failure, and hydraulics failure) become more critical when terrain flying. Most aviators need additional training to satisfactorily cope with emergency situations at the low altitudes associated with terrain flying, especially NOE. The aviator must be able to perform low level and hovering autorotations safely. He must be able to discuss the procedures for dealing with engine failure, low side governor failure, and loss of antitorque thrust at low altitudes and slow airspeeds. He must also be able to discuss procedures for hovering autorotations between 50 and 100 feet AGL.

Emergency situations when terrain flying require instinctive reactions.

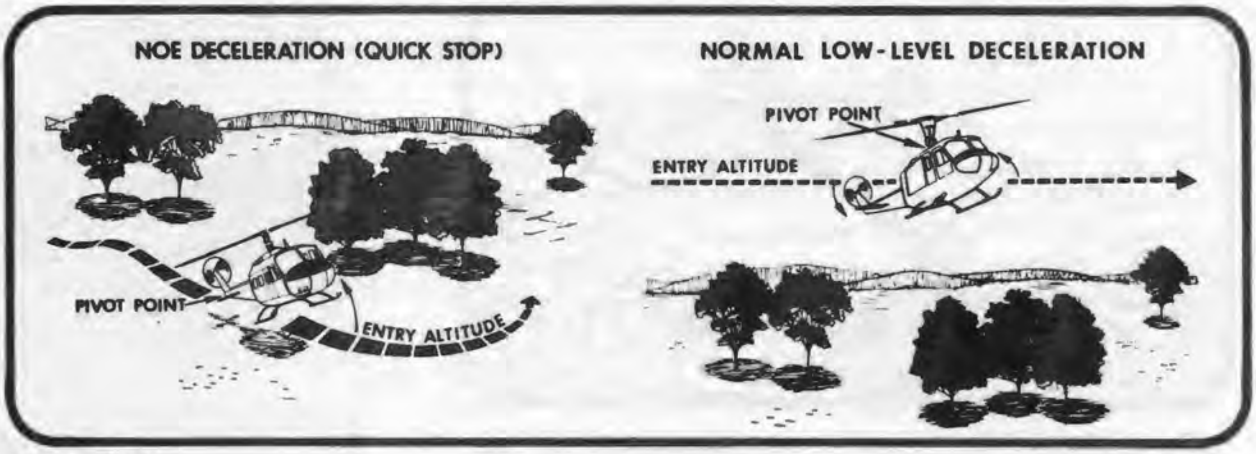


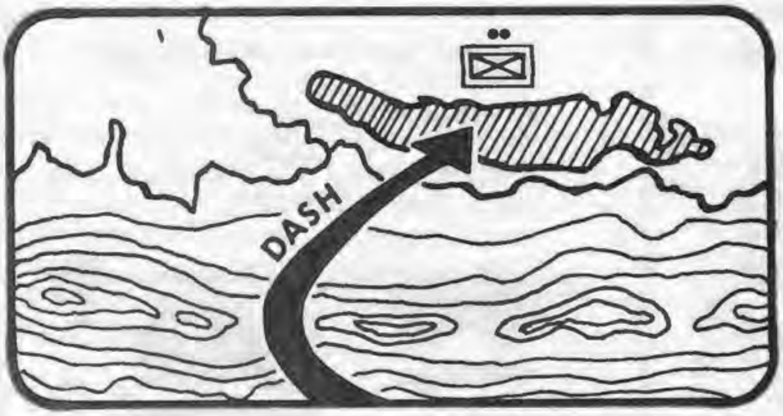
Figure 1-15.

How to Move

The rules depicted on this and the next two pages will aid the pilot in moving about the battlefield undetected, especially when searching for the enemy or when enemy positions and capabilities are unknown. The rules presented are applicable to single ship and small group movements. As practical, these rules should also be employed when moving in a large group.

The cardinal "how to move" rule is -

KEEP LOW AND VARY AIRSPEED AND COURSE TO REMAIN MASKED.



When crossing a ridgeline which may be exposed and can't be bypassed, pick your way to the lowest crossing point, dash across the forward slope to the next cover.

When crossing open flat areas, cross at the narrowest point and dash across, moving constantly. Try to keep vegetation between you and the enemy and follow low terrain. Remember, keep your exposure time to less than 10 seconds.

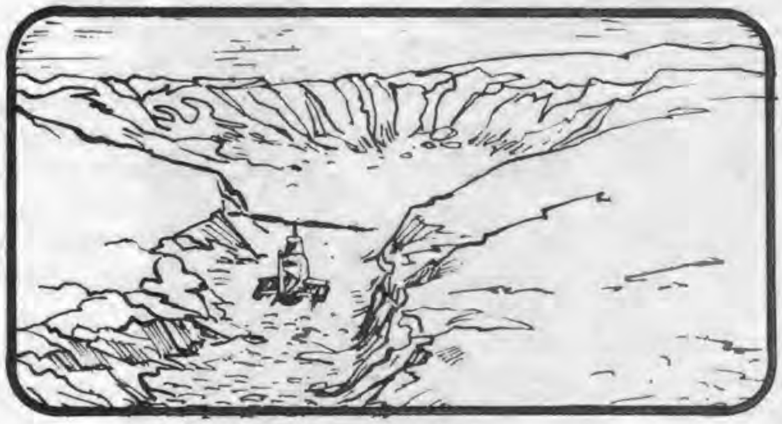
When paralleling a vegetated area fly below and near the vegetation.

Decrease altitude when overflying fields and other open areas.

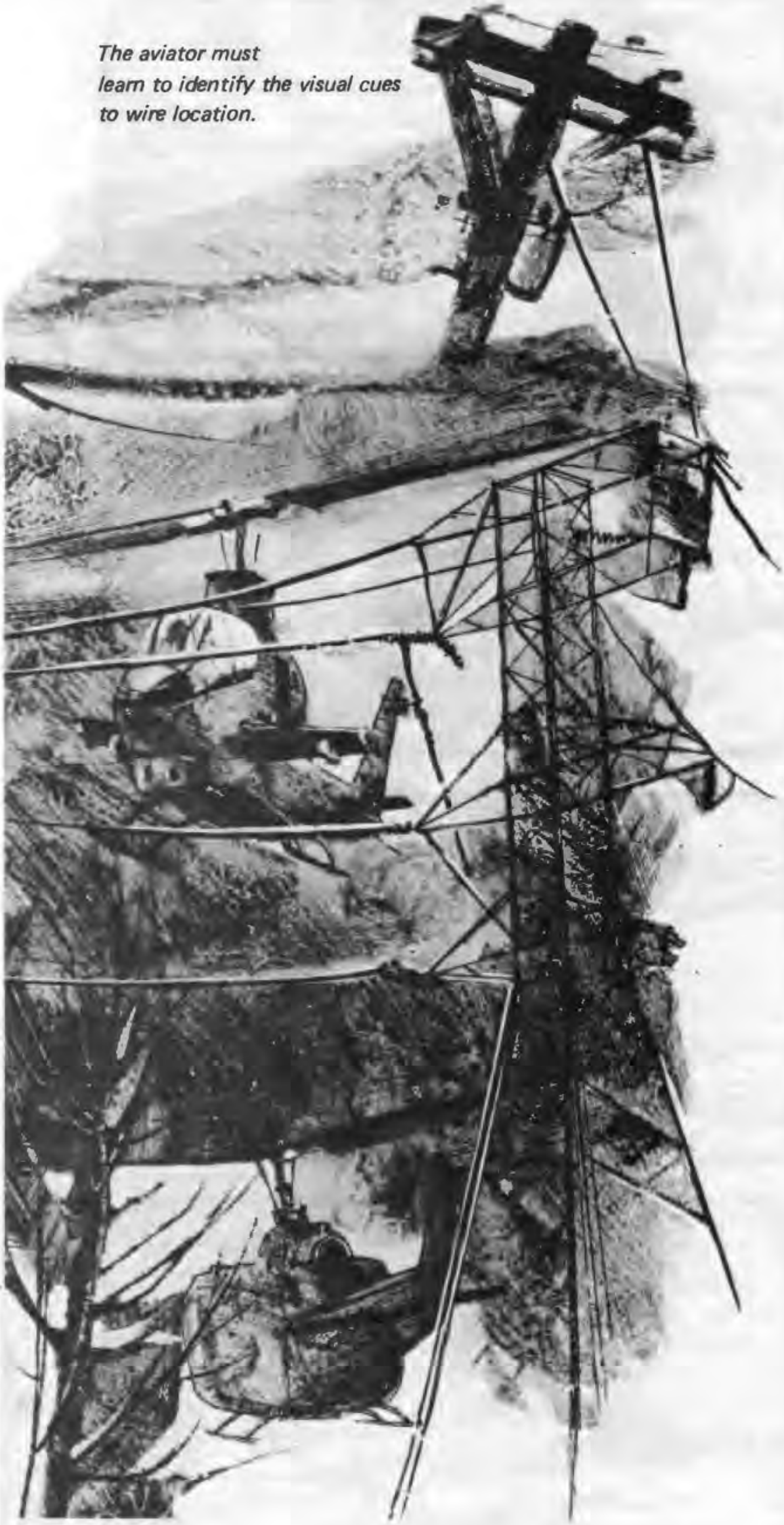
Hover or land whenever necessary to reconnoiter an area prior to proceeding. If necessary, dismount! Try to look through or around vegetation rather than over it.

When flying over dense vegetation, follow the lowest contours of the vegetation rather than the lowest contour of the earth.

Do not fly into a situation where you have no room to maneuver if attacked.



Always have an evasive maneuver planned if attacked. CAUTION: Never turn your tail directly toward the enemy if any other choice exists.



The aviator must learn to identify the visual cues to wire location.

1-6. BATTLEFIELD FLIGHT SAFETY

On a battlefield where we may be highly outnumbered, we cannot afford losses caused by accidents and carelessness. Safety must therefore come second only to mission requirements when conducting terrain flying.

Physical Hazards

When conducting terrain flying during tactical operations or training, a number of wire hazards must be contended with - some of which are power lines, communications wire, TOW missile guidance wire, and fences. Wire strikes have been and are a significant hazard to Army aircraft. To minimize the danger of wire strikes, each aviator should make a detailed map study prior to each flight specifically to identify and mark wire hazards. After each flight, unmarked wires should be plotted on a hazards map (the hazards map is discussed later). When communications wire is laid by aircraft, the route should be plotted on the hazards map. Areas in which large numbers of TOW missiles have been fired from aircraft and in which the wires may be resting in the tops of trees should be identified.

Attempts to provide the aviator with a reliable means of detecting and/or coping with wires have been and are continuing to be made by Army research activities. However, the availability of such systems is not foreseeable in the near future. Presently, the only means of coping with wires when conducting terrain flight is to avoid them. This requires map and aerial photo reconnaissance, maintaining an accurate hazards map, and understanding the relationship between airspeed, wire detection, and avoidance. Because wires themselves often cannot be seen until it is too late, the aviator must learn to identify the visual cues to wire location - look for the swath through the vegetation on aerial photos, spot poles during scanning, and expect wires along roads, near towers, and in the vicinity of buildings. Slower airspeeds in unreconnoitered areas must be emphasized to avoid wire strikes. Suggested guidelines for crossing wires are presented later in this paragraph.

In addition to wires, there are other physical hazards such as trees and birds with which crewmembers must cope. Helicopters are particularly vulnerable to blade strikes at NOE altitudes. Therefore, aviators must insure clearance during flight and when using trees for masking and unmasking maneuvers. Also, a dead tree or tree without leaves which is taller than the surrounding vegetation is easy to miss if the pilot constantly focuses his attention too far ahead of the aircraft. Bird strikes can cause damage to the aircraft. As a rule of thumb the pilot should not try to avoid birds unless they are in a very large flock. Generally they will avoid the aircraft. To guard against personal injury from tree branches or birds striking and shattering the plexiglass, crewmembers should wear their visors down and insure that aircraft armor is in position.

When terrain flying, *the most important factor in hazard avoidance is for the pilot to keep "his head out of the cockpit."* He must use the proper visual scanning technique (discussed in paragraph 1-8), interpret visual cues, and recognize blind spots from which other aircraft might be approaching (or setting up an ambush).

The development and maintenance of an accurate and complete hazards identification map by each aviation unit covering those areas in which it operates and trains is *essential* for aviation safety. Maintaining the hazards map should be the responsibility of a specified individual in the unit. The map should depict all established routes and the hazards encountered along those routes. When the hazard is a linear (wire) rather than spot feature, the entire route of the hazard through the area should be marked. Each aviator will mark all hazards which affect his route or routes on the map that he will use in the aircraft.

A hazards map showing hazards within the area of operation must be maintained by each unit and updated after each flight when an unplotted hazard is located.

Weather Hazards

Weather can also be a hazard if proper precautions are not taken. Any time visibility is reduced because of flight into the sun or adverse atmospheric conditions (haze, drizzle, fog, rain, or snow), altitude must be increased and/or airspeed decreased to provide the aviator added reaction time to avoid obstacles. Flight into the sun is particularly tricky - planning should avoid flights into the sun whenever possible. This is extremely important when contour flying because of the aircraft's high airspeeds and close obstacle clearance. In a combat situation, it will not always be possible to increase altitude because of enemy air defenses, so in this case airspeed would have to be reduced. Exiting from a thermal can be dangerous if the pilot does not anticipate the loss of altitude. This is especially dangerous when terrain flying with loads.

Terrain flying in winds in excess of 30 knots, downwind between 15 and 30 knots, and when gust spread exceeds 15 knots, requires a greater power reserve (i.e., less weight can be carried) for safe flight. Unit SOP should prescribe a reduction in allowable cargo load in the conditions described above.

Because of the low altitudes associated with terrain flying, there is absolutely no margin for maintenance error. Also, stringent preflight, postflight, and periodic inspection standards are essential for safety.

Maintenance

When conducting terrain flight, proper maintenance of the machine is of the utmost importance. The aircraft must be constantly maintained in peak condition to insure reliability. Personnel must perform by-the-book inspections and take necessary and prompt action to correct any problems encountered. During postflight inspections, special emphasis should be placed on inspection of the rotor blades, bottom fuselage, tail boom, and tail rotor for tree strike damage. To aid in avoiding maintenance problems, aviators should thoroughly understand why certain components are checked during preflight, runup, shutdown, and postflight and what the consequences would be if a component failed to function properly during flight. Aviators must insure that any deficiency discovered during inspection is entered and accurately described on DA Form 2408-13. Especially when NOE flight will be flown, commanders must select the best aircraft available from both a structural and mechanical standpoint. He must also insure that sufficient time is allowed for the aircraft to be continually maintained in the best possible conditions. Using aircraft that have a past history of maintenance problems, particularly with the engine or transmission, is asking for trouble. Windshields are another area of concern and must be cleaned at least daily to avoid any obstruction to visibility. Windshields scratched to the extent that they are unacceptable for night flight should not be used when conducting terrain flying, especially NOE.

Wire Crossing Guidelines

Wires are a significant hazard to aircraft when terrain flying because they are difficult for the pilot to see. To locate the wires is the pilot's most critical responsibility. Once he has located the wires, he can cross them safely using the techniques described below.

The safest way to cross wires is by overflying them at a pole. This is because the pole can be seen more easily than wires. However, the pilot must beware of the guy wires supporting the poles. The next safest way to cross wires is by overflying them between poles. When doing this, the pilot must positively identify the highest wire prior to crossing. The highest wire is often a wire between the tops of two poles and is usually very difficult to see.

In combat, it may be necessary for the aviator to underfly wires to prevent exposing himself to enemy visual or electronic detection. Flight between two wires or sets of wires should not be attempted. When the tactical situation requires that wires (or other man-made structures) be underflown, the aviator must insure that enough clearance exists to provide for extreme aircraft height (if level), plus hover height, plus a "margin for error." *Caution: The highest point of most helicopters is at the rear of the main rotor tip path plane or the high point of the tail rotor arc. During forward hover, this point is higher than when the aircraft is level because the aircraft is in an accelerating attitude. Since the aviator can't determine the exact height of the highest point, he must allow for a height increase along with possible judgment errors relating to hover height and wire height when he determines his margin for error.*

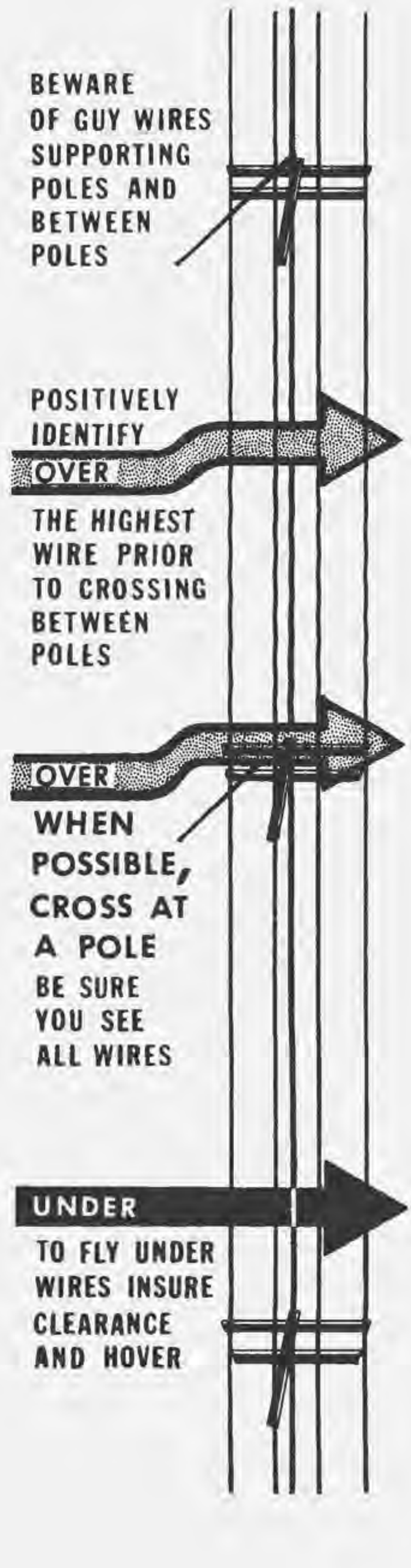
When underflying wires:

- Airspeed should be no greater than hover speed (brisk walk).
- Cross near a pole because the wires are higher and the pole aids visual perception. However, insure lateral clearance from guy wires and poles.
- Use another aircraft or a dismounted crewmember as a guide if clearance is marginal.
- If a pilot suspects that a rotor blade has hit a wire, he should land and inspect for damage and wire entanglement.

Minimum Clearance Requirements	
OH-58	20 feet* + hover height
OH-6	17 feet* + hover height
UH-1	25 feet* + hover height
AH-1	25 feet* + hover height

*Extreme aircraft height, aircraft on the ground, flight controls neutral plus a ten foot margin for error.

To underfly wires safely, the pilot must estimate accurately the clearance of the wires above the ground. In some cases, there is no doubt that the wires are high enough to insure clearance; in other cases, a judgment will be required. Therefore, it is important that the aviator receive training in estimating clearance. This can be done by having the aviator estimate clearance of wires at selected sites in the training area. The actual clearance should be known. Also, slides showing wires with known clearance can be used for training in an academic environment. It is suggested that aviators be required to make between 40 and 50 correct clearance estimations to develop proficiency.



1-7. TERRAIN FLYING IN ADVERSE WEATHER

The staying power of Army aircraft is increased significantly when aviators and units are so well trained that they can perform terrain flying in adverse weather. The capability of a unit to conduct terrain flying in adverse weather must be highly developed because during war Army aviation units must perform both day and night and in good and bad weather. In adverse weather the aviation commander must carefully weigh the mission requirements against the capabilities of his equipment and the state of training of his aircrews.

Terrain flight can be conducted successfully in adverse weather so long as sufficient visibility exists to navigate accurately and allow obstacle avoidance.

There are two major aspects peculiar to adverse weather that influence the ability of the pilot to conduct terrain flying. They are ceiling and visibility. Low ceiling and poor visibility can be assets when flying in the high threat environment. Reduced visibility is an asset because the enemy's optically and visually guided antiaircraft weapons will be less effective or even neutralized. In addition, IR seeking missile's effectiveness will probably be reduced. This is because the target must be optically acquired and in low visibility the enemy can often hear the helicopter but will not be able to pinpoint its location or judge its heading or distance by sound. A low ceiling can also be an asset to the pilot if he is operating in an area where friendly forces have at best only air parity. A low ceiling forces enemy high performance tactical aircraft to work in or above the instrument meteorological conditions thereby reducing their ability to locate and attack low flying helicopters.

When combined with the need to conduct a critical mission, these assets may make it advantageous to conduct terrain flying in adverse weather. Visibility is the primary limiting factor which will determine whether the flight can be conducted successfully. With current equipment terrain flying is most difficult and extremely hazardous in dense ground fog, but certain missions can be accomplished in very low visibility conditions. If the mission requires flight from point A to B, it can be accomplished in very poor visibility by following linear features such as roads or rivers which are not exposed to enemy radar directed air defense weapons. If by following a linear feature the aircraft remains unmasked long enough for the enemy to shoot at it, navigation must then be based on terrain orientation and greater visibility will be required to accomplish the flight. If the mission is a Cobra Tow attack, success will be influenced by visibility in the objective area as well as en route visibility.

In addition to normal planning, terrain flight in adverse weather imposes further planning requirements. A detailed map study of the route and the areas adjacent to it is essential. The aviator must identify every obstacle, hazard, road, trail, and prominent terrain feature which will influence his flight.

Since weather is often unpredictable, forecasts should be confirmed by troops in the area. When a multihelicopter operation is necessary, it may be desirable to send an aircraft into the area of operation to confirm the weather. The planning must also address mission termination criteria and inadvertent Instrument Meteorological Conditions (IMC) procedures.

During flight the most important considerations are to maintain visual reference with the ground and to maintain a slow enough airspeed to stop in time to avoid hitting an obstacle. Also, when flying along a road, altitude must be high enough to clear wires which even in only slightly limited visibility are almost impossible to see. If the crew suspects that they have strayed from the desired route, they should stop until their exact location is determined or return to the last known checkpoint and try again.

Inadvertent IMC Procedures

The inadvertent IMC procedures discussed below are suitable if the aviator loses visual reference with the ground or visibility is too poor to locate obstacles and hazards. When the visibility conditions reach the point where the crew cannot navigate and the threat makes it impossible to climb to a high enough altitude to use tactical instrument flying, the best course of action may be to land prior to being forced to use the procedures discussed below. Visual reference with the ground can be lost on clear days as well as during adverse weather in dusty areas or areas of loose snow. Exercise extreme caution in such areas when hovering (even out of ground effect), and be sure to provide for adequate separation.

If visual reference with the ground (in weather) is lost, the most appropriate procedure for a single aircraft over level terrain might be to establish a climb and execute a 180° turn. This presumes the aircraft will not climb into the "kill zone" of enemy air defense weapons and that the terrain along the turn radius is free of obstacles. When the aviator is unsure of the

Terrain flying under adverse weather conditions sounds like a pretty stringent requirement, but a well trained crew exercising sound judgment and possessing an understanding of weather trends, can accomplish many missions.

Maintaining visual reference with the ground is essential when terrain flying in adverse weather.

conditions to his left or right or cannot return to Visual Meteorological Conditions (VMC) using a 180° turn due to terrain or obstructions, he should begin an immediate climb to an altitude at least 100 feet above the highest obstacle within 2,000 meters of either side of the course. Upon reaching a safe altitude, he should initiate a 180° turn and return to VMC or initiate calls for appropriate assistance.

The inadvertent IMC procedures for multiple aircraft formations discussed in this paragraph may be appropriate if each aircraft is in the relative position depicted in figure 1-29. Upon entering IMC, an attempt to reverse course should not be executed until vertical separation has been achieved. With full consideration for terrain obstructions in the flightpath, the lead aircraft directs the formation to maintain altitude, airspeed, and heading. After a few seconds or immediately if the formation is tight or the terrain sharply diverse, the lead aircraft issues a command to execute the dispersion procedures. At this time the lead aircraft begins a climb straight ahead. Each following aircraft turns in accordance with the SOP for the formation being flown. On initiating the turn each aircraft increases power as necessary to establish a 500 fpm climb maintaining cruise speed. All aircraft in the formation proceed to a predetermined altitude for level off and monitor the lead aircraft calls for appropriate assistance.

In adverse weather conditions, flights should consist of as few aircraft as possible. When two or more flights are operating in an area simultaneously, separation must be insured by time and/or distance. If the flights are operating in close proximity and one reports entering IMC, the other flight or flights must remain under visual meteorological conditions, stopping if necessary.

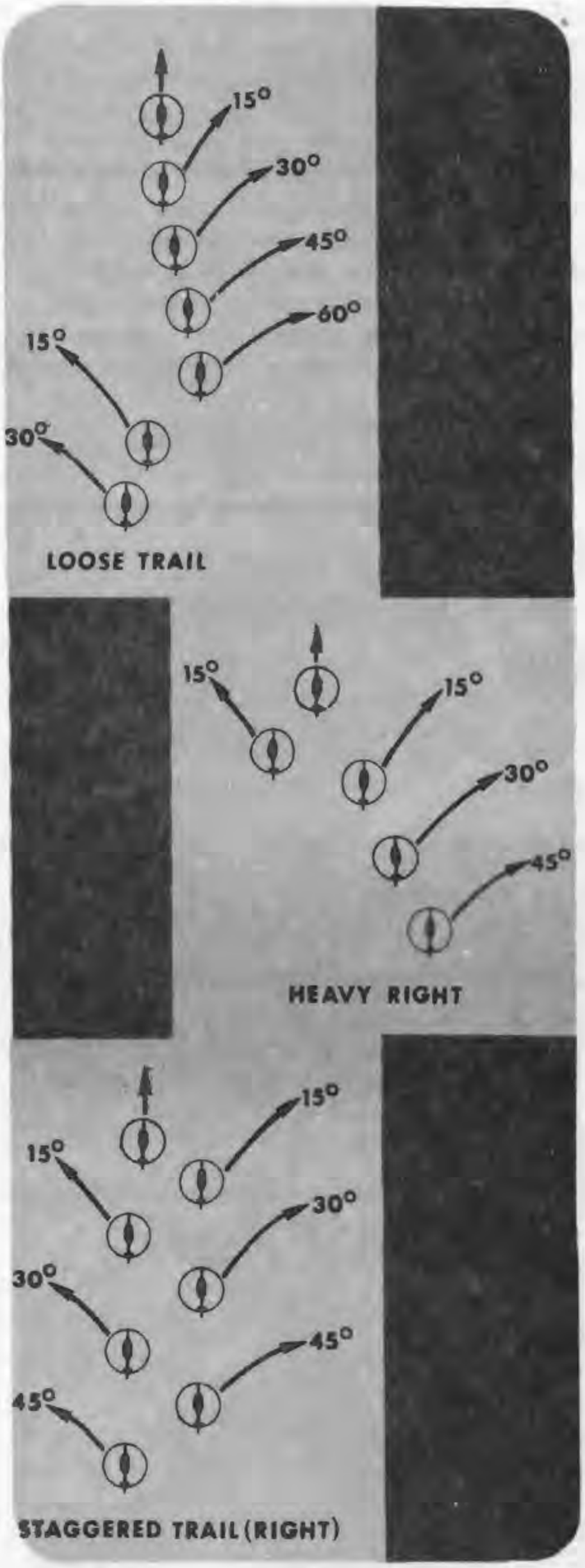


Figure 1-29. Inadvertent instrument procedures.

1-8. HUMAN FACTORS IN TERRAIN FLYING

Because of the precision and concentration demanded to accomplish terrain flying, it is extremely fatiguing. Fatigue is a difficult problem to cope with because it cannot be measured and often goes unrecognized by the individual or his supervisor. It can only be averted by minimizing the physical, emotional, and self-imposed stresses that produce fatigue. A few of the common stresses are prolonged flight, temperature extremes (especially heat), colds, flicker vertigo, poor eating habits, overweight, alcohol and tobacco indulgence, and personal problems. Some of the ways to minimize fatigue in both training and combat environments include -

■ Establishing flight time limitations and crew rest periods. Tests are being conducted to determine average terrain flight endurance limits; however, this will always vary from individual to individual. Therefore, it is important that the aviator recognize fatigue and be able to admit being too tired to function safely. In combat, 140 flight hours per 30-day period is considered the maximum that should be flown when flying at altitude. It is likely that these limits will have to be reduced in those units which habitually conduct terrain flying.

■ Routine, supervised physical fitness training. Physically fit people have an increased ability to endure physical and mental stress, control emotions, relax, and sleep soundly.

■ Training to develop and maintain proficiency. Teamwork can greatly reduce fatigue by division of duties and a reliance on the other individual. Teamwork and training repetitiveness until a task becomes second nature are additional keys to reducing fatigue.

The most common signs of fatigue are deterioration of aviator performance and judgment causing poor coordination, daydreaming, object fixation, and slowed reaction time.

Terrain and obstacle clearance is a critical task during terrain flight, especially NOE and contour flight. The pilot's peripheral vision is probably the key to terrain and obstacle clearance for the aircraft in daylight conditions. The use of peripheral vision is a process learned through experience by operating near obstacles. The pilot who is skilled at using his peripheral vision sees a large area to his side and rear without concentrating his vision in a particular area.

Also, the aviator must be aware of the size of the aircraft. He must "feel" the extent of the aircraft around him since he can't see it all. Where are the tips of the main and tail rotors? Where are the skids or wheels? Remember the terrain just negotiated when masking and unmasking - those tall trees must be cleared by the tail boom. Aircraft size appreciation and the development of the use of peripheral vision can be practiced on courses such as the preliminary training course discussed in appendix B. In very tight clearance situations, the pilot should use his crew to help insure clearances in those areas he cannot see well. If necessary, the pilot should have a crewmember dismount and ground guide the aircraft through or under an obstacle.

When terrain flying, the aviator relies heavily on his peripheral vision to insure obstacle clearance and for checkpoint identification.

Whereas obstacle clearance permits the mission to be conducted, mission accomplishment depends upon visual search. When terrain flying, visual search is required for navigation and target or objective acquisition. When navigating, visual search is the ability to promptly and effectively identify recognizable reference points (checkpoints) in your field of vision. Visual search is accomplished by both the central and peripheral fields of vision, but again the peripheral field of vision plays a decisive role. To conduct visual search, the individual must first have some concept of what he will see. Checkpoints or targets must be thoroughly characterized before the mission. The aviator must have definite understanding of the effects of surrounding terrain, light and shadows, and seasonal changes on the appearance of the objective. A 4-hour change in time of day or a 10° change in direction of approach can dramatically and significantly alter visual expectation. Thus, the aviator especially must learn to *see* in his mind all the possibilities. Having this concept, his peripheral field of vision scans for forms that come close to the expectation for a given target or checkpoint. Each form is accepted or rejected peripherally and the central vision is used to identify the form when it matches his expectations. The probability of seeing and identifying the target will be determined by the size of the target and the distance of the observer.

The human factors just discussed - recognition of fatigue and its consequences, obstacle clearance factors, and visual search - significantly influence the ability of an aviator to perform terrain flight. Additional human factors relating specifically to night flight are discussed in TC 1-28, Rotary Wing Night Flight.

SUMMARY

The high threat environment is a potentially deadly environment built around an array of sophisticated weapons. These weapons pose a threat to us while we are in the air and while we are in fixed positions on the ground. To defeat the threat, certain tactics are required. These tactics include terrain flying, night operations, limited communication, tactical instrument flight, and frequent movement. Of these tactics, terrain flying is the fundamental element for mission success in the high threat environment.

To successfully perform terrain flight, the aviator must do more than simply reduce his altitude to suitable levels. He must solve the problems peculiar to terrain flight; he must plan his mission thoroughly; he must navigate accurately but, when necessary, be flexible; he must cope with man-made and natural hazards; and he must be mentally and physically fit. Flight planning involves not only the selection of routes, landing zones, and/or firing positions but also coordination, control, and possible suppression of enemy weapons.

Terrain flying is difficult even for experienced aviators and requires training and practice. Therefore, the remainder of this manual is devoted specifically to discussing terrain flight and related training.

The enemy air defense weapons depicted in figure 1-3 are identified in the following illustration.

1. MIG-25 FOXBAT
2. MIL 24 ATTACK HELICOPTER
3. ZSU 23-4
4. 7.62mm AKM ASSAULT RIFLE
5. ZPU-4
6. ZSU 23-4
7. ZSU-57-2
8. SA-6 GAINFUL
9. S-60 MILLIMETER GUN
10. SA-4 GANEF
11. ZSU-23-4 - GUNDISH RADAR
12. SA-3 GOA
13. SA-7 GRAIL

The following mission scenario is primarily intended to show how terrain flying is used in conjunction with other basic tactical concepts to accomplish a mission. In so doing, many of the techniques which have been discussed previously will be highlighted.

SITUATION: See figure 1-30, page 38. The Corps has been attacking to seize the city of LAGO which is a major communication and industrial center. The 7th Armored Division, which is the primary attacking force, has encountered heavy enemy resistance in the vicinity of the village of MOTSHA. The adjacent 93d Mechanized Infantry Division has successfully captured the high ground to the west of MOTSHA. The 1-29th Attack Helicopter Battalion (a Corps asset) has been attacking enemy armor in conjunction with the 7th Division attack. The 7-11th Air Cavalry Squadron has been screening the exposed right flank of the 93d Division.

MISSION: At 1510 hours, Army OV-1D reconnaissance aircraft report the movement on Highway 1 toward MOTSHA of a battalion size enemy armored force. The enemy armor was 33 miles north of MOTSHA moving at 20 mph. The 1-29th is assigned the mission of destroying the reinforcing armor before it reaches MOTSHA.

EVENT 1. MISSION PLANNING: In this scenario, planning was influenced by two considerations. First, was the saturation of the area by enemy air defense weapons with radar acquisition capability. Figure 1-31 depicts the area in which the enemy has radar acquisition capability. The second consideration was the urgency of the mission. In order to attack the enemy armor before it reached MOTSHA, the 1-29th had to be in its attack positions within a very short period of time.

Initially the area in which the enemy would be engaged was selected (fig 1-32, pg 39). Tentative attack positions were assigned to the two companies which would conduct the attack. Supplemental attack positions were also identified. Holding areas masked from enemy air defense weapons were selected. The 7-11th, which had been operating in the area, was assigned the mission of confirming the suitability of the attack positions and locating attack routes from the holding areas. Routes were also selected between the staging areas and holding areas. These routes were selected to minimize the flight time between the staging area and the holding areas. Artillery and TAC Air were requested to suppress known enemy air defense weapon locations. Friendly air defense artillery units were advised of the time and route of the unit's movement. Due to the minimal planning time and relative security of the routes to the holding areas, the same routes were used when exiting the area.

A key to successful execution of the mission is the mission briefing. It is important that each crew understand the mission and its duties. A thorough mission briefing will eliminate confusion and unnecessary radio communication. For this reason, even in this scenario where time was limited, all crews received a detailed mission briefing. Each crew also conducted a map reconnaissance to identify hazards along the routes to the holding area and to become familiar with the terrain between the holding area and attack positions.

EVENT 2. EXECUTION OF THE PLAN, FOLLOWS ON PAGE 40.

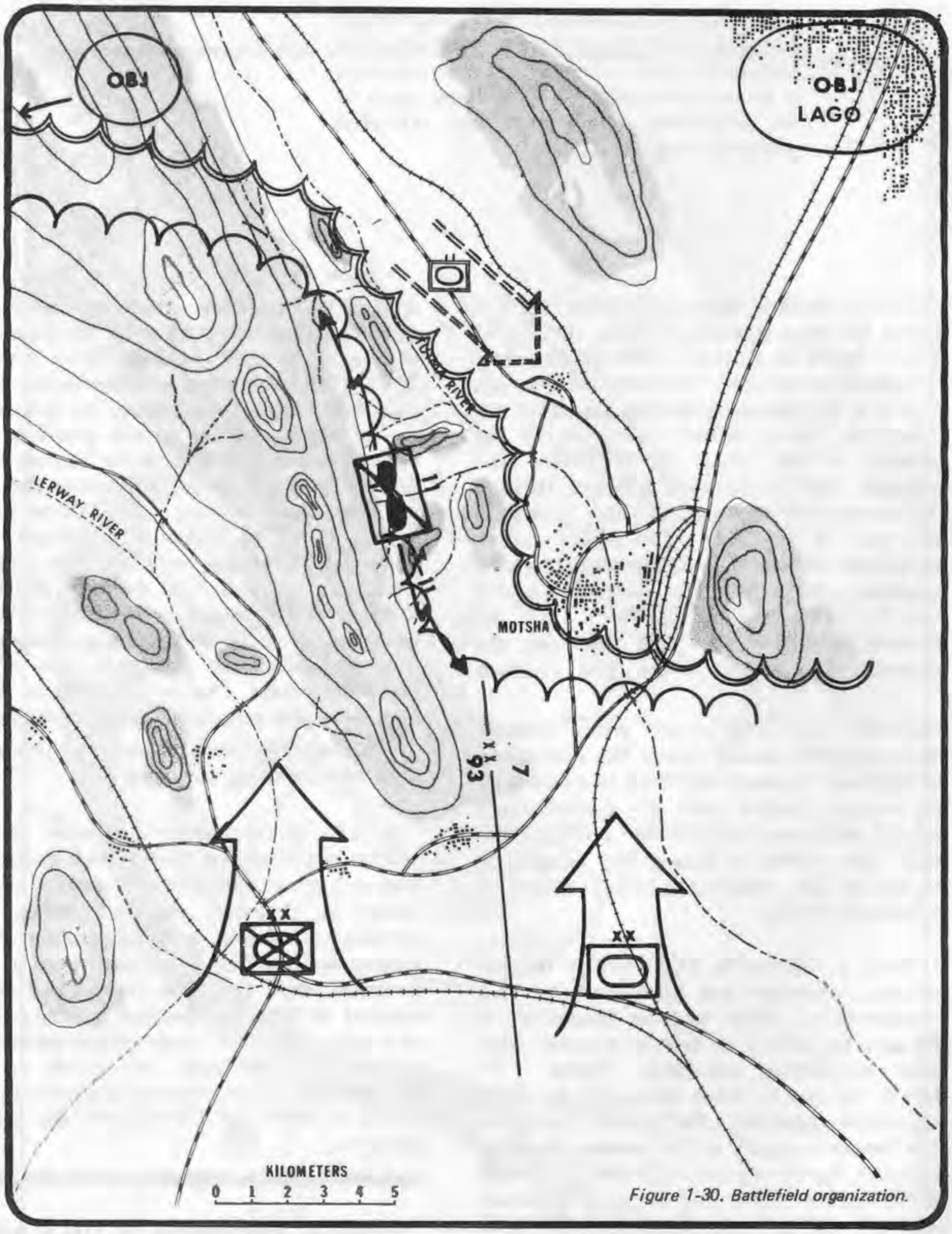


Figure 1-30. Battlefield organization.

Figure 1-31.
Enemy air defense radar acquisition.

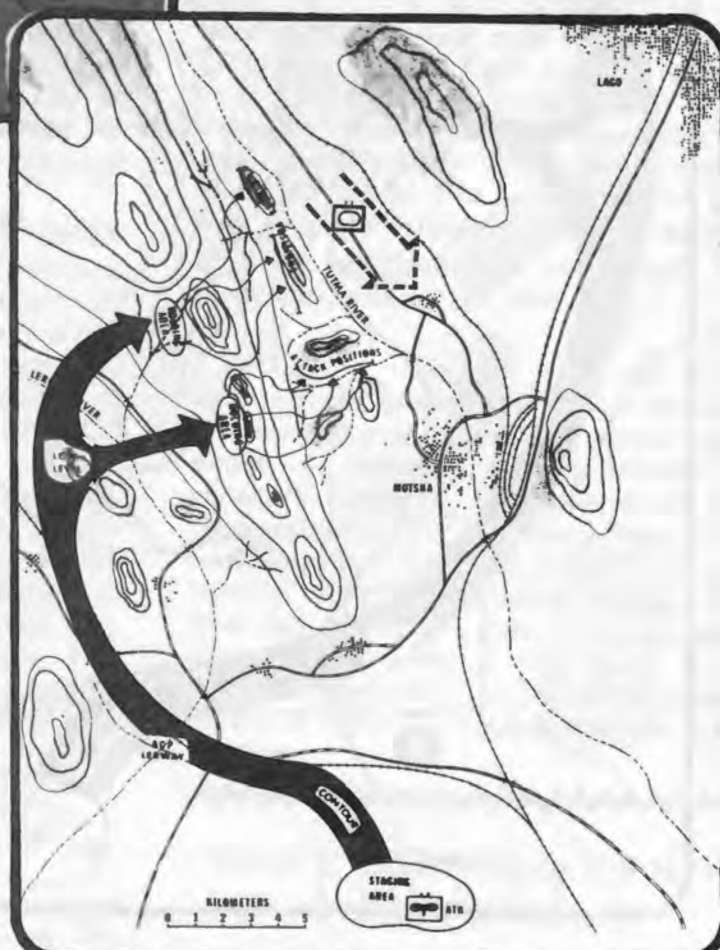


Figure 1-32.
The mission as planned.

EVENT 2. EXECUTION OF THE PLAN.

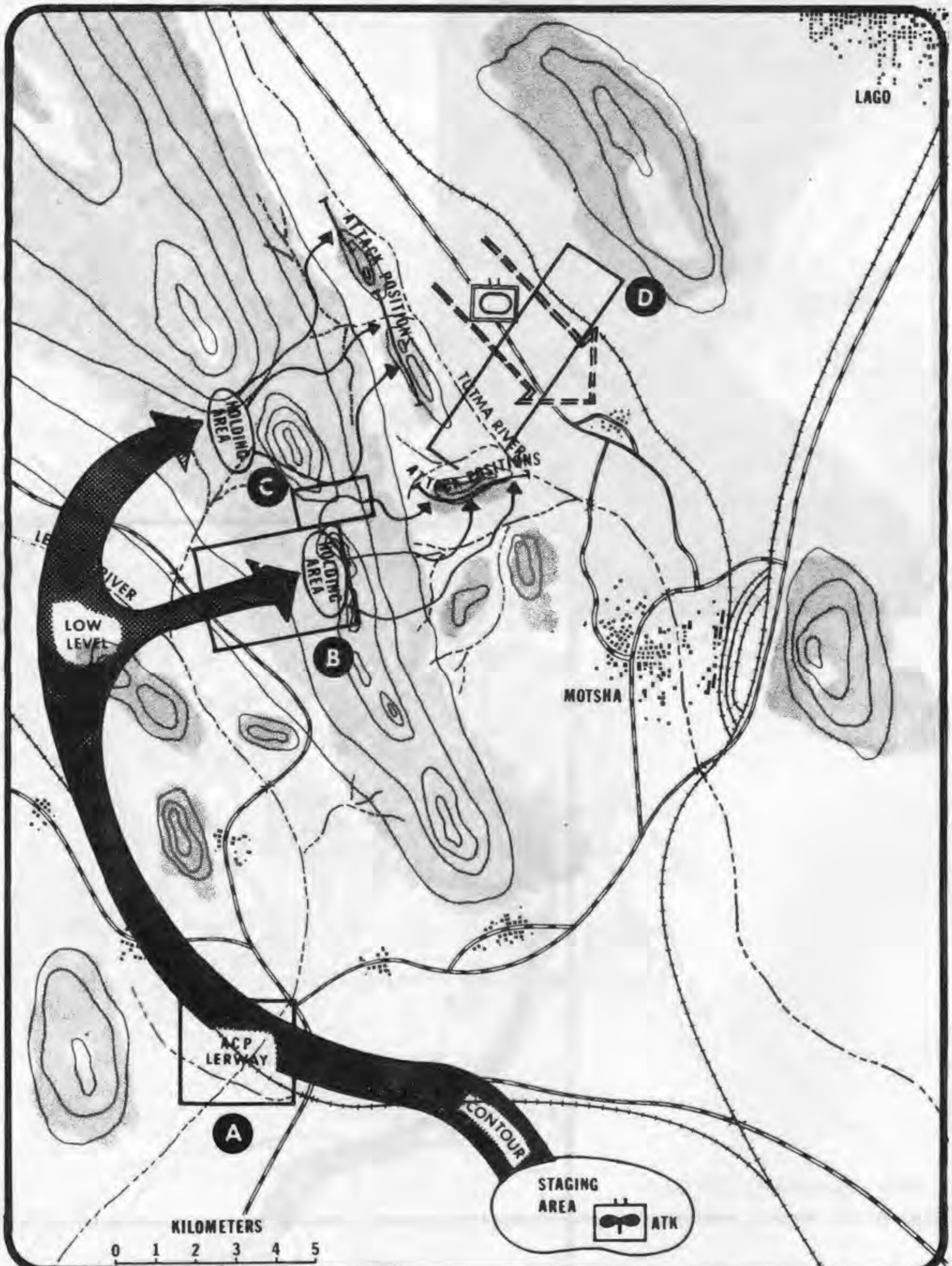


Figure 1-33. Execution of the plan.

Since the terrain allowed the aircraft to remain masked, contour flight was used between the staging area and ACP LERWAY. Over most of this terrain the aircraft were able to fly up to 50 feet AGL and remain masked. However, when crossing the higher elevations the aircraft flew NOE below tree lines in order to insure that they remain masked. The contour routes were planned to follow streambeds since the ground is low and navigation is easier. At ACP LERWAY the flight climbed to low level altitude since the hill mass to the east provided terrain masking between 200 and 300 feet AGL. Between the staging area and holding areas contact with the enemy was not expected and the unit employed the traveling technique for movement.

Each company proceeded to its assigned holding area and held until artillery and TAC Air suppression of known enemy air defense positions began. This time was used to coordinate the attack by each of the various elements of the combined arms team. At the holding area the scouts who had been reconnoitering the area rendezvoused with the attack helicopters. They informed the 1-29th leaders of the location of the enemy armor, firing positions, and attack routes.

As the aircraft departed the holding areas, they crossed the ridgeline and became exposed to enemy air defense weapons. To minimize the loss of aircraft when exposed, several precautions were taken. First, the artillery and TAC Air were used to suppress the known air defense weapon locations. Secondly, the scouts led the Cobra's along the attack routes. Third, to reduce the effectiveness of antiaircraft fire from unknown enemy air defense weapon locations and from the ZSU 23-4's and SA-9's which may have been in the area as escorts for the armor, NOE flight was used. This allowed each aircraft to make maximum use of vegetation, draws, and other terrain features to remain masked. Even with these precautions, attack by the enemy was expected both when crossing the exposed ridgeline and when the Cobra TOW's exposed themselves to fire. Therefore, AH-1G Cobra's equipped with 2.75 HE and smoke rockets were assigned the task of providing overwatch for the AH-1Q Cobra TOW's.

The exact firing positions were selected to enable the AH-1Q's to fire the TOW's from maximum range. Positions for the overwatching elements were selected based on the range limitations of the rockets and to enable the crew to employ smoke rockets effectively against the optically guided SA-9's. When the enemy armor moved within range, the attacking helicopters unmasked and fired. Immediately upon missile impact the AH-1Q's remasked and moved on order to supplementary firing positions. Specific aircraft were assigned the task of attacking the ZSU 23-4's and other supporting air defense weapons. The scouts served as primary rescue aircraft for downed crews.

The attack was a success because the commander successfully massed the available firepower, enemy air defense weapons were attacked as priority targets, and the enemy was surprised.

CHAPTER 2

The Training Program

> This chapter presents an overview of a training program which will prepare an aviation unit to conduct its missions utilizing terrain flight. Chapters 3 and 4 present the details of the suggested terrain flight training program which is organized in two phases - initial qualification training and advanced training, as shown in figure 2-1. In addition, this chapter discusses command responsibility, safety, control of training, selection and training of instructor pilots, and selection of training areas.

2-1. TERRAIN FLIGHT TRAINING PROGRAM ORGANIZATION

The nature of the high threat environment in which Army aviation must operate has become increasingly clear since the 1973 Middle East War. Training requirements to prepare the aviator to operate in the high threat environment are equally clear. Therefore, no commander should hesitate to conduct individual and unit training. "We should not spend the bravery of our people to make up for our lack of preparation." This comment from a senior Army commander is especially applicable to aviation unit training today.

Certain fundamental training requirements must be satisfied if an aviator and unit are to be able to perform terrain flying in the high threat environment. These training requirements are (1) a need for each aviator to be aware of the high threat environment; (2) day low level, contour, and nap-of-the-earth flight; (3) night low level and contour flight; (4) night NOE flight with night vision devices; and (5) execution of team, section, platoon, and company missions when terrain flying. The training program which this chapter introduces is specifically organized to satisfy these training requirements. While it may have to be modified based on local conditions, the goal of each tactical unit's training program must be to attain a true night fighting capability.

The first of the two training phases - initial qualification training - is designed to familiarize the aviator with aviation

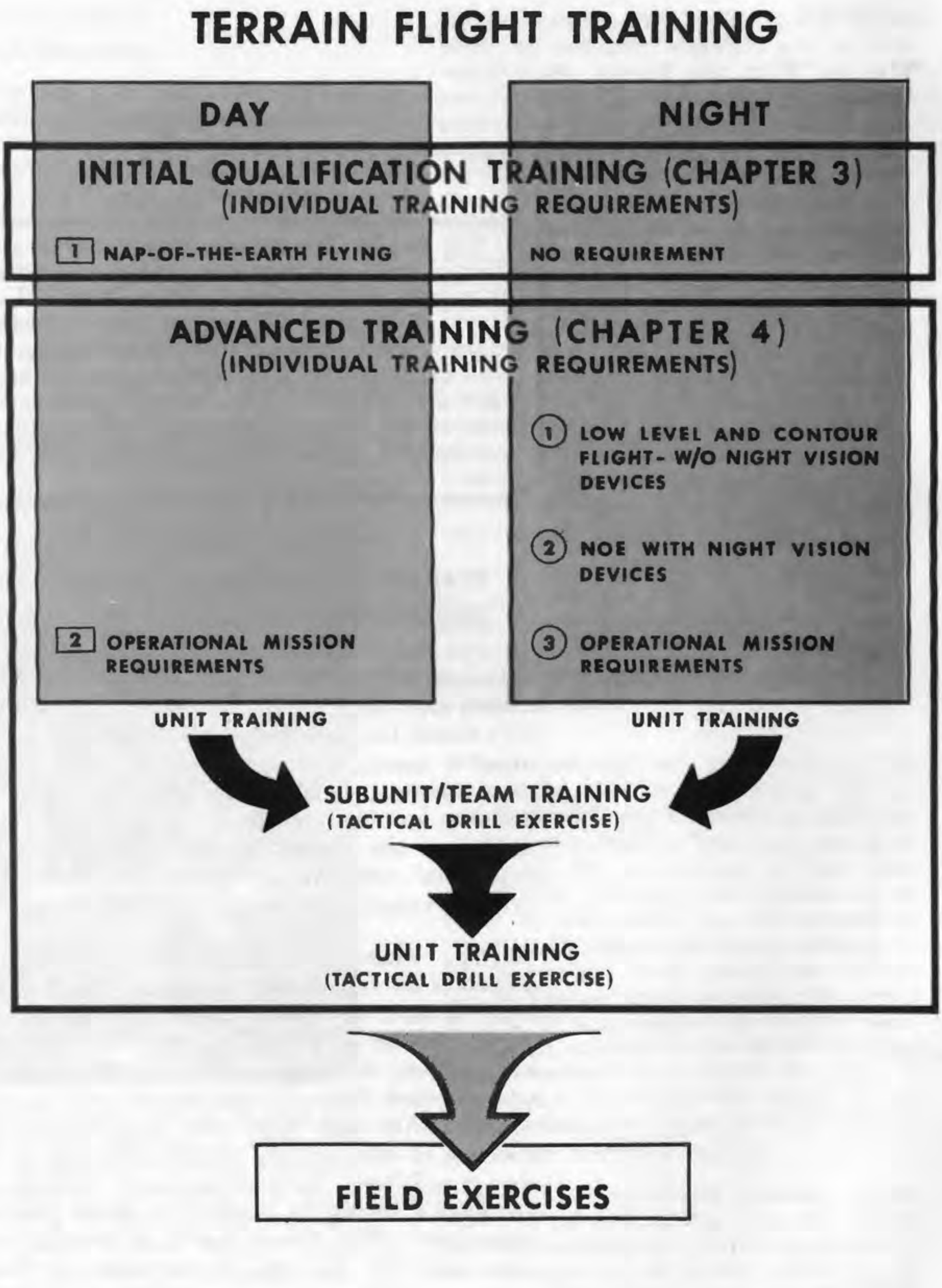


Figure 2-1. The training program.

operations in the high threat environment and teach him the navigation and flight skills he needs to conduct terrain flight. Upon completion of initial qualification training, the aviator is ready to participate in advanced training. Advanced training is designed to train the individual to accomplish the unit mission in the high threat environment utilizing terrain flight during both daylight and darkness. It will include employment of aircraft, planning and coordination between ground and aviation units, explains teamwork required between aircraft, and will be tactically realistic. Once the unit proficiency has reached a suitable level, it should operate in a simulated high threat environment to the maximum extent possible to maintain individual and unit proficiency.

The need to maintain individual aviator proficiency in low level, contour, and NOE flight is as critical a training requirement as is qualification. In those units which normally conduct terrain flying, maintaining individual proficiency will be achieved along with maintaining unit proficiency; however, there are numerous aviators who do not frequently conduct terrain flying. To assist commanders in developing a training program to maintain the proficiency of these aviators, a terrain flying confidence course is outlined in chapter 5.

COMMAND RESPONSIBILITY

For effective accomplishment of initial and advanced training, commanders should plan and supervise training to insure -

- Training develops aviator proficiency to operate aircraft at all altitudes associated with terrain flying and in all conditions necessary to accomplish the unit mission. Also, the training must prepare him to meet the range of in-flight emergencies that can occur close to the surface.

- Training is standardized.

- Aviators are given adequate opportunities to maintain the knowledge and skill required to conduct terrain flying.

- Establishment of criteria to help prevent operational skill fatigue (para 1-8). If for any reason, an aviator's ability to conduct terrain flying is impaired or subject to doubt, the commander should prohibit that individual from participating in training or operations until the circumstances causing that condition have been corrected.

- That terrain flying, whether it be training or mission, is as closely supervised as conditions permit.

- That unit training programs are conducted under simulated conditions of the high threat environment. Because aviation units often conduct training in conjunction with training exercises of ground units, one of the primary requirements for the aviation unit commanders must be to insure that the ground commanders are aware of the training requirements of the unit and that the training is conducted in a simulated high threat environment. It is the aviation unit commander's responsibility to insure that his aircraft are employed in training as they would be in the high threat environment.

2-2. SELECTION AND TRAINING OF INSTRUCTOR PILOTS

If there is a single most important ingredient for aviation training success, it is the instructor pilot (IP). The instructor pilot is primarily concerned with teaching survival and success on the battlefield, but he must also teach flight maneuvers and emergency procedures. When selecting an instructor pilot, his skill is the critical consideration, but his desire to instruct directly influences the quality of training. Other considerations include his appreciation and understanding of the ground maneuver force, aviation tactical concepts, and the operational requirements and limitations in the high threat environment.

SKILL AND DESIRE ARE THE IMPORTANT CONSIDERATIONS WHEN SELECTING AN INSTRUCTOR PILOT

Instructor pilots and standardization instructor pilots (SIPs) will be appointed in accordance with chapter 1, AR 95-63. In addition to the requirements outlined in AR 95-63, before conducting terrain flight training, the IP and SIP must have completed a terrain flight training course; demonstrated to an SIP his ability to instruct in the various modes of flight; and be a currently rated rotary wing IP in the type and model aircraft in which flight maneuvers will be accomplished.

Each instructor pilot must be given thorough instruction on the flight techniques, methods of instruction (MOI), and hazards of terrain flight training. He should receive a minimum of 15 hours flying the aircraft and 15 hours navigating prior to instructing. In addition to learning what is to be taught and how to teach it, the IP must become familiar with the training area so that he can determine his location at all times without having to divert his attention to a map.

When the instructor pilot is teaching terrain flight, he has three primary training responsibilities. He must teach the aviator the techniques of handling the aircraft with skill and finesse. He also teaches navigation and related map reading and planning skills. The third primary training responsibility of the instructor pilot is crew integration and teamwork which ties together the other two. Also, during initial qualification training the instructor pilot will be teaching or supervising academic instruction. During advanced training he will be an important part of the training process insuring standardization and proficiency.

PRIOR TO TEACHING TERRAIN FLIGHT, THE INSTRUCTOR PILOT SHOULD BE THOROUGHLY FAMILIAR WITH THE TRAINING AREA

The commander is the final authority on the capability of his unit to perform properly on the high threat battlefield. This authority and responsibility cannot be delegated. Rather it must be exercised by personal participation in training and in close monitorship of unit IPs, SIPs, and progress of individual helicopter crewmembers.

[illegible] PILOTS MUST DEMON- STRATE [illegible] COMPETENCE AS AN [illegible] PART OF THEIR [illegible] TO INSTRUCT.

2-3. TRAINING SAFETY

Commanders may feel that individual and unit terrain flying programs will introduce unacceptable training risks and therefore jeopardize mission accomplishment. It is possible that some aircraft may be lost in training, but the magnitude of the threat dictates that training be conducted now, prior to an outbreak of hostilities. It can be done without neglecting the controls and safeguards needed to help prevent accidents. To help minimize the safety risks, commanders and leaders must strictly supervise and control the training to insure no independent experimentation is conducted. Unwavering adherence to flight standardization procedures is also essential to reduce training risks.

The risks associated with terrain flying can be minimized with adequate supervision, control, and adherence to flight standardization procedures.

Control of Training

Control is essential to insure safe training but the commander must establish the proper balance between control, training realism, and supporting resources. The techniques suggested below provide a balance of control and tactical realism but require a relatively high amount of supporting resources. These techniques are suggestions and should be modified as required based on the local situation, degree of aviation proficiency, and available resources.

During *initial qualification training* and the *individual night training* phases of advanced training, a commander should operate a centralized control system. To do this the following techniques should be used:

- Safety and control (S&C) aircraft should be used when several aircraft are training simultaneously to control training areas, insure traffic separation, create tactical situations, and provide rapid response in emergencies. The S&C aircraft should operate at an altitude so as not to interfere with the training aircraft. If the commander chooses not to employ an S&C aircraft, he should develop a "buddy system" to be used between training aircraft to help insure separation and provide rapid response.

■ Air control points (ACP), boundaries, and air (flight) corridors can be used effectively to control aircraft in training as well as during tactical missions.

■ Position reports should be used to maintain the location of each aircraft when numerous aircraft are training simultaneously. In addition to position reports being made at appropriate ACP's they should be made any time the aircraft leaves the planned route.

■ A radio search should be conducted if a training aircraft has not reported to the S&C or his buddy aircraft within the preceding 15 minutes. To eliminate unnecessary air searches in the event a training aircraft experiences "lost commo," a lost commo rendezvous point should be identified in the training area. After experiencing lost commo the training aircraft would proceed to the rendezvous point. Upon completing its radio search the S&C aircraft would check the rendezvous point.

During the *unit training* phases of advanced training, the commander should decentralize control to realistically reflect operational control procedures which would be used during combat. He should rely heavily on his subordinate leaders to provide the necessary control. He should closely monitor planning to insure that adequate control is planned by subordinate leaders and that training is realistic.

Safety and Control Helicopter Pilot Responsibilities

When the S&C aircraft is used, the pilot's duties should include those discussed below. The crew will assist the S&C pilot as he directs.

■ He will receive a briefing from the training officer on the contents of the S&C pilot's SOP and the specific duties of the S&C aircraft crew. He should be familiar with the training and safety SOP's.

■ He monitors the preflight briefing of aviators and conducts preflight preparations. He must be familiar with the weather to include the density altitude, ceiling, visibility, and wind velocity, direction, and gust spread. He must prepare a flight-following map and conduct a hazards map check. The flight-following map should depict all routes (corridors), air control points, landing zones, restricted areas, and hazards. Used in conjunction with the flight-following map is the flight-following log. This locally prepared form is used to log position reports from numerous aircraft operating simultaneously. The sequence block is used if two or more aircraft

During training, when feasible, safety and control (S&C) aircraft should be used to control the aircraft which are terrain flying.

share a route and are separated by a constant time interval (requires one form per aircraft).

■ During training he maintains the flight-following log and should have available the flight-following map, reporting requirements, operation orders for each route, and the training communications - electronics operating instructions (CEOI). He must remain in radio contact with each aircraft. If more than 15 minutes have elapsed since the last call from an aircraft, the S&C pilot will initiate a radio search. Also, he reports any unanticipated hazards (i.e., stray aircraft and inclement weather) to the training aircraft. He issues and/or answers tactical calls while acting as the combined arms team's higher and adjacent headquarters (knowledge of the tactical mission and situation for each aircraft is a must).

■ A critical responsibility of the S&C pilot is to control the entry of observer aircraft into the training area. There will be a tendency for many people to want to observe individual and advanced training because terrain flying is a high interest item in the Army today. Uncontrolled, this can lead to serious problems, and there have been near misses as a result of observer aircraft becoming intermingled with training aircraft.

■ He remains on station until all training aircraft have departed or designates another (training) aircraft as an alternate S&C if he must leave station.

■ Each S&C helicopter should have, in addition to its required crew, one medic and two rappel-qualified personnel with appropriate equipment if an air ambulance is not available. The medic should also be rappel qualified and have adequate first aid equipment.

FLIGHT-FOLLOWING LOG							
ROUTE 1		ROUTE 2		ROUTE 3		ROUTE 4	
ACFT NO 0/87	CALL SIGN BULLDOG 15	ACFT NO	CALL SIGN	ACFT NO	CALL SIGN	ACFT NO	CALL SIGN
IP WEAVER	SEQUENCE	IP	SEQUENCE	IP	SEQUENCE	IP	SEQUENCE
STUDENT SMITH	STUDENT JOSSEN	STUDENT	STUDENT	STUDENT	STUDENT	STUDENT	STUDENT
POSITION SP	TIME 1038	POSITION	TIME	POSITION	TIME	POSITION	TIME
ACP RED	1101						
ACP BLUE	1114						
LZ	1126/1130						
ACP GREEN	1144						
ACP ORANGE	1158						
RP	1211						

Hazards Identification Map

One of the most important aids in helping to insure safety is the hazards map. A hazards map will be maintained depicting hazards and restrictions within the unit's training areas. The map must be updated after any flight when an unplotted hazard is located. Prior to conducting training, hazards will be marked on maps used in the aircraft by aviators and instructor pilots.

Crossing Wires

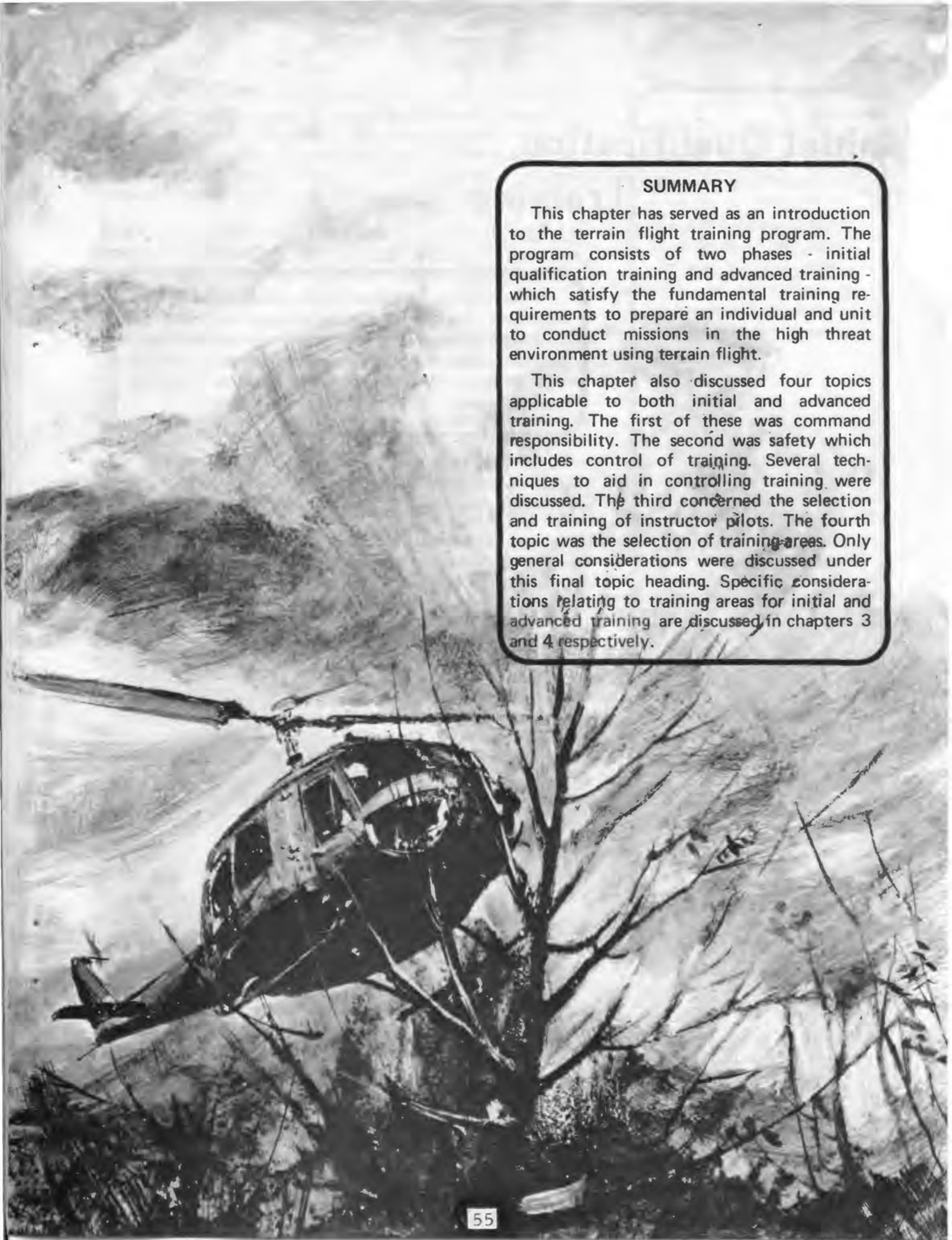
To conduct realistic terrain flight training, it is necessary to fly under wires if the simulated enemy threat demands it and if adequate clearance exists. However, during training, flight under wires must be stringently controlled to prevent accidents from occurring. Therefore, wires should be underflown only at points where clearance has been predetermined to be sufficient. Wire obstacles built as training aids should utilize low tensile strength wire and have a break-away capability. Thin wires can be made more visible by wrapping the wire in masking tape.

2-4. TRAINING AREAS

Prior to conducting training, permission to use property not within the confines of a military reservation for landing zones must be secured from property owners. This may be accomplished through coordination with the local installation engineer element which will obtain assistance through the district engineer headquarters. Because the noise associated with training at the low altitudes utilized during terrain flying can be irritating, every effort should be made to familiarize people in affected areas with the need for the training. Good public relations are absolutely essential. Specific considerations relating to the training areas for initial qualification training are discussed in chapter 3. Those considerations relating to advanced training are discussed in chapter 4.

TRAINING AREA CONSIDERATIONS

- The initial qualification training areas should be selected to develop the ability of the aviator/crewmember to navigate NOE as well as familiarizing him with the tactical applications of terrain flying.
- For advanced training the training area must be selected to provide a realistic training environment based on unit mission.
- Army Regulations and Federal Aviation Regulations pertaining to controlled airspace can induce additional restrictions or restrict training areas.
- A critical task associated with terrain flying is the continuing evaluation of the aircraft location and its relationship to enemy air defense weapons and intermittent terrain. Therefore, the training area should offer a wide range of terrain relief in order to train the aviator to evaluate his altitude options during planning and flight.
- The training area should have as few hazards and obstacles as possible.
- The training area should be selected to avoid population concentrations.
- The training area should also provide suitable space for performing all out-of-ground-effect hover checks required prior to conducting NOE flight and to conduct instruction in NOE flight maneuvers.
- Training areas should include alternate landing zones to be used for preplanned or on-order missions. Landing zones should be free of crops and sod based.



SUMMARY

This chapter has served as an introduction to the terrain flight training program. The program consists of two phases - initial qualification training and advanced training - which satisfy the fundamental training requirements to prepare an individual and unit to conduct missions in the high threat environment using terrain flight.

This chapter also discussed four topics applicable to both initial and advanced training. The first of these was command responsibility. The second was safety which includes control of training. Several techniques to aid in controlling training were discussed. The third concerned the selection and training of instructor pilots. The fourth topic was the selection of training areas. Only general considerations were discussed under this final topic heading. Specific considerations relating to training areas for initial and advanced training are discussed in chapters 3 and 4 respectively.

CHAPTER 3

Initial Qualification Training

This chapter describes initial qualification training objectives, provides a suggested program of instruction, outlines techniques of instruction, and includes flight period outlines that will prepare the aviator to conduct terrain flight and begin participating in advanced training.

3-1. INTRODUCTION

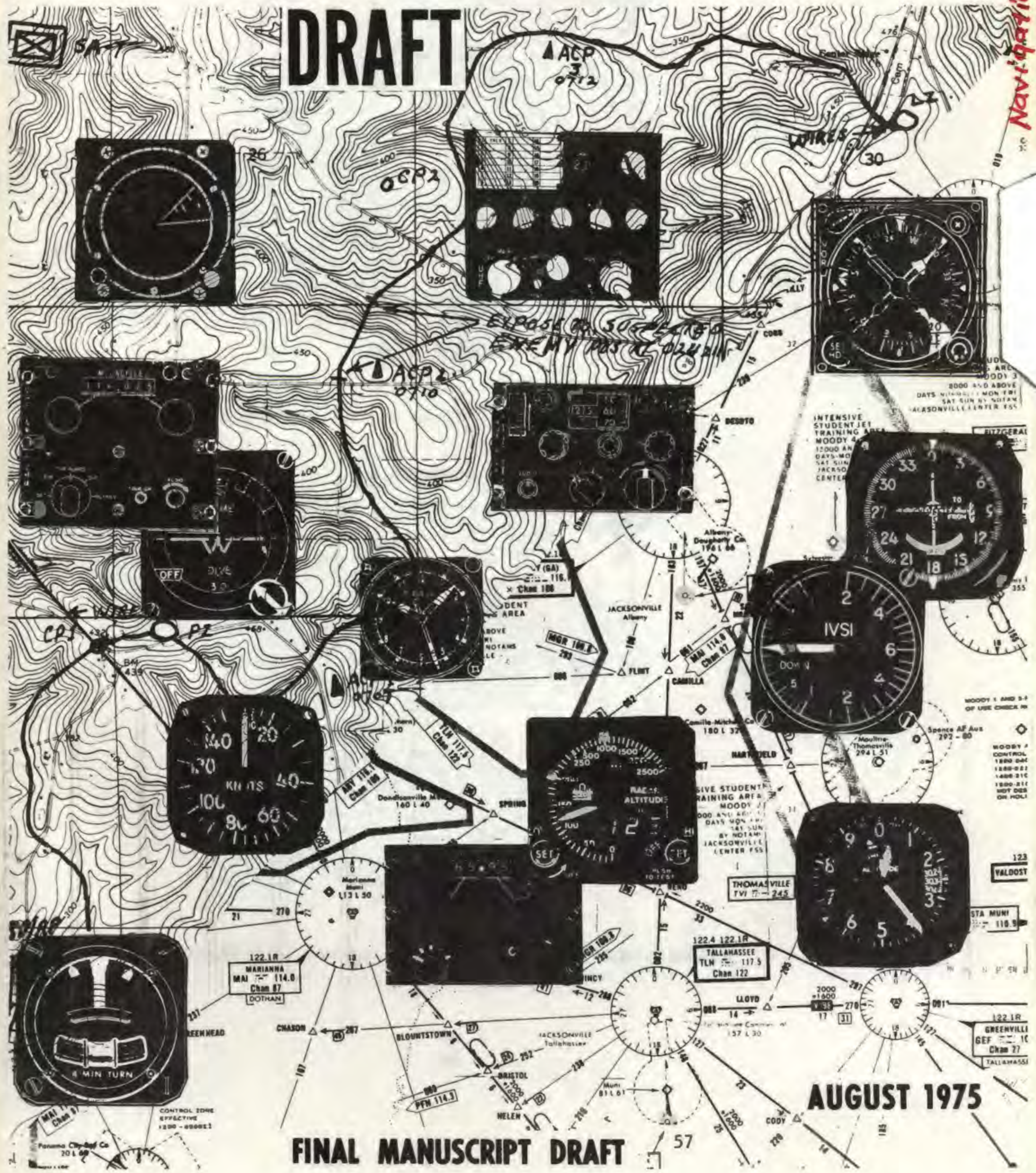
To perform terrain flying the aviator must be able to conduct low level, contour, and NOE flight. Army aviators are familiarized with low level and contour flight during training in flight school and most have been further trained in units. Therefore, it is not generally necessary to retrain an aviator in these flight techniques. However, many aviators are not prepared to operate utilizing NOE techniques since they have not received the additional training required. This additional training is required because of the increased navigation difficulties at NOE altitudes, flight maneuvers peculiar to NOE, and emergency procedures more critical during NOE flight. Aviators graduating from flight school since 24 September 1974 have received the additional training required to conduct NOE flight. It is a unit training requirement to train the aviators who graduated prior to this date.

The initial qualification training course is designed to familiarize the aviator with the high threat environment and the employment of Army aircraft in that environment, to refresh the pilot's skill in low level and contour flight, and to qualify the aviator in nap-of-the-earth (NOE) flight. After completing the initial training course, the aviator will possess the basic individual knowledge and skills required to operate on the modern battlefield. Advanced training will refine these skills and apply them to unit operations for both day and night flying.

INSTRUMENT FLYING AND NAVIGATION FOR ARMY AVIATORS

FM 1-5

DRAFT



AUGUST 1975

FINAL MANUSCRIPT DRAFT

INTENTIONALLY
LEFT
BLANK

FIELD MANUAL)
)
No. 1-5)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., August 1975

INSTRUMENT FLYING AND NAVIGATION FOR ARMY AVIATORS

*This manual supersedes TM 1-215, 8 September 1964, including all changes; and TM 1-225, 9 December 1968, including all changes.

INTENTIONALLY
LEFT
BLANK

CHAPTER 14

THE DEAD RECKONING (DR) COMPUTER

Section I. GENERAL

14-1. Construction and Purpose

A dead reckoning computer is a combination of two devices, one a specially designed instrument for solving wind triangles and the other a circular slide rule for solving mathematical problems.

14-2. The CPU-26A/P DR Computer

Many different types of dead reckoning navigation computers exist, but the construction and design features of the major types are very similar. For illustrative purposes, the standard Army DR computer, type CPU-26A/P, is used throughout this chapter.

Section II. THE SLIDE RULE FACE

14-3. The Slide Rule

a. Scales. The slide rule of the CPU-26A/P computer consists of two circular scales. The outer scale is stationary and is called the MILES scale. The inner scale rotates and is called the MINUTES scale.

b. Scale values. The numbers on any computer scale, as on most slide rules, represent multiples of 10 of the values shown. For example, the number 24 on either scale (outer or inner) may represent 0.24, 2.4, 24, 240, or 2,400. On the inner scale, minutes may be converted to hours by reference to the adjacent hour scale. For example, 4 hours is found in figure 14-1 adjacent to 24, in this case meaning 240 minutes. Relative values should be kept in mind when reading the computer. For example, the numbers 21 and 22 on either scale are separated by five spaces, each space representing two units. The second division past 21 would be read as 21.4, 2,140, etc. Spacing of these divisions should be studied, as the breakdown of dividing lines may be into units of 1, 2, 5, or 10.

c. Indexes. Three of the indexes on the outer stationary scale are used for converting statute miles, nautical miles, and kilometers. These indexes are appropriately labeled "Naut" at 66, "Stat" at 76, and "Km" at 122. On the inner rotating scale are two rate indexes. The large black arrow at 60 (called the SPEED index) is the hour index, and the small arrow at 36 is the second ("Sec") index (3,600 seconds equal 1 hour). The "Stat" index on the inner scale is used in mileage conversion. Each scale has a "10" index used as a reference mark for multiplication and division. The application of these scales in solving computer problems is illustrated in the specific problems that follow.

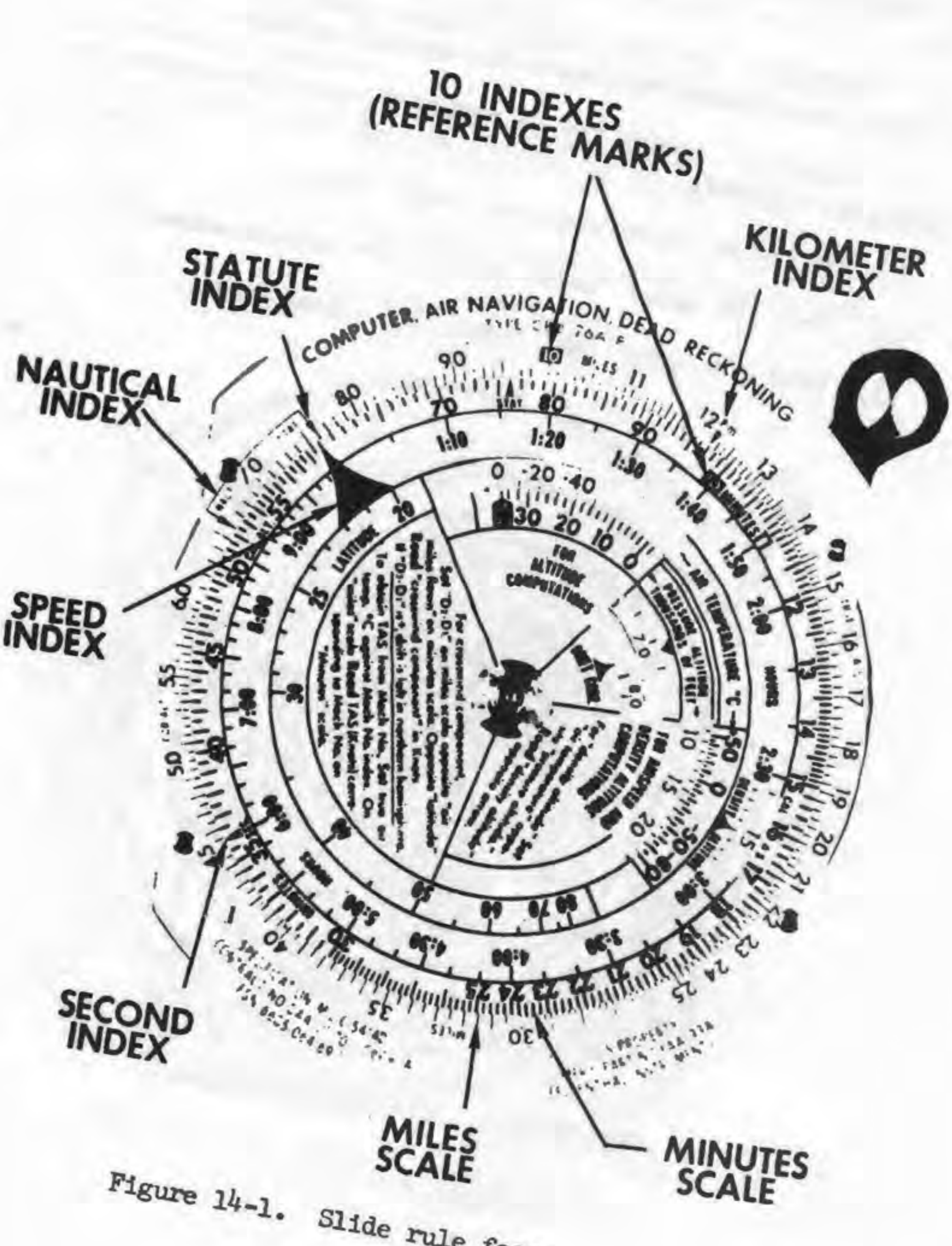


Figure 14-1. Slide rule face.

14-4. Distance Conversion

a. Problem. How many statute miles equal 90 nautical miles? How many kilometers equal 90 nautical miles?

b. Solution. Using the DR computer, refer to figure 14-2 and solve as follows:

(1) Set 90 on inner scale to "Naut" index.

(2) Read 104 under "Stat" index (104 statute miles).

(3) Read 166 under "Km" index (166 kilometers).

Figure 14-2. Distance conversion.

NOTE

When several distance conversion problems are to be solved between statute and nautical miles, set the "Stat" index on the inner scale under the "Naut" index of the outer scale and read any ratio around the entire slide rule; i.e., 13 statute miles is 11.3 nautical miles, 13 nautical miles is 15 statute miles, etc. (fig. 14-3).

Figure 14-3. Converting several distances simultaneously.

14-5. Simple Proportion

The slide rule face of the DR computer is so constructed that any relationship between two numbers, one on the stationary scale and one on the movable scale, will hold true for all other numbers on the two scales. For example, if the two "10" indexes are placed opposite each other (fig. 14-4), all other numbers around the entire circle will be identical. If 20 on the inner scale is placed opposite the "10" index on the outer scale, all numbers on the inner scale will be double those on the outer scale. If 12 on the outer scale is placed opposite 16 on the inner scale, all numbers will be in a 3 to 4 (3/4) relationship. This scale design enables the aviator to find the fourth term of any mathematical proportion when three of the values are known.

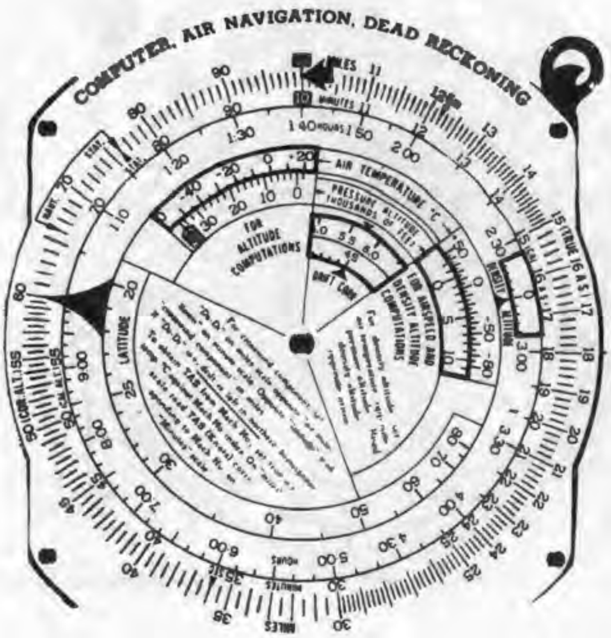


Figure 14-4. Numerical relationship between the two scales.

14-6. Distance

Time-distance problems are worked on the inner (MINUTES) scale and the outer (MILES) scale.

a. Problem. If 50 minutes is required to travel 120 nautical miles, how many minutes are required to travel 86 nautical miles at the same rate?

b. Solution. Using the DR computer, refer to figure 14-5 and solve as follows:

(1) Set 50 (inner scale) under 120 (outer scale).

(2) Under 86 (outer scale), read 36 (inner scale) minutes required.

Figure 14-5. Time and distance.

14-7. Determining Groundspeed

Groundspeed equals distance divided by time.

a. Problem. What is the groundspeed if it takes 35 minutes to fly 80 nautical miles?

b. Solution. Using the DR computer, refer to figure 14-6 and solve as follows:

(1) Set 35 (inner scale) opposite 80 (outer scale).

(2) Over 60 index read groundspeed (137 knots).

Figure 14-6. Determining groundspeed.

14-8. Determining Time Required

Time equals distance divided by groundspeed.

a. Problem. How much time is required to fly 333 nautical miles at a groundspeed of 174 knots?

b. Solution. Using the DR computer, refer to figure 14-7 and solve as follows:

(1) Set rate of 60 index on 174 (outer scale).

(2) Under 333 (outer scale) read 115 minutes (inner scale) 1 + 55 (hours scale).

Figure 14-7. Determining time.

14-9. Determining Distance

Distance equals groundspeed multiplied by time.

a. Problem. How far does an aircraft travel in 2 hours and 15 minutes at a groundspeed of 138 knots?

b. Solution. Using the DR computer, refer to figure 14-8 and solve as follows:

(1) Set 60 index at 138 (outer scale).

(2) Over 135 (inner scale) or 2 hours and 15 minutes (hours scale), read 310 nautical miles (outer scales).

Figure 14-8. Determining distance.

14-10. Use of the 36 Index

The number 36 on the inner scale is used in solving rate-time-distance problems in instrument flight when time must be calculated in seconds and minutes instead of minutes and hours. For example, determine the time required to fly from the final approach fix to the missed approach point on an instrument approach (chap 18).

a. Formula. Problems where seconds must be used as a unit of time may be solved by the formula

$$\frac{GS}{36} = \frac{\text{Distance}}{\text{Seconds}}$$

in which GS is the groundspeed; 36 represents the number of seconds in 1 hour (3,600); distance is the number of miles or decimal parts of miles to be flown; and seconds is the time required to fly that distance.

b. Problems involving less than 60 seconds.

(1) Problem. What is the time required from the middle marker to the point of touchdown if the groundspeed is 100 knots and the distance between these points is 0.5 nautical mile?

(2) Solution. Set 36 (inner scale) under the groundspeed of 100 knots (10 on the outer scale). Under 50 (0.5 nautical mile) on the outer scale, read 18 seconds on the inner scale (fig. 14-9).

c. Problems involving more than 60 seconds.

(1) Problem. What is the time required to fly from the outer marker to the middle marker if the groundspeed is 95 knots and the distance between the two points is 5 nautical miles?

(2) Solution. Set 36 (inner scale) under the groundspeed of 95 knots (95 on the outer scale). Under 50 (5 nautical miles) on the outer scale, read 19 (190 seconds), or 3 minutes and 10 seconds on the inner scale (fig. 14-10).

Figure 14-9. Rate-time-distance problems using minutes.

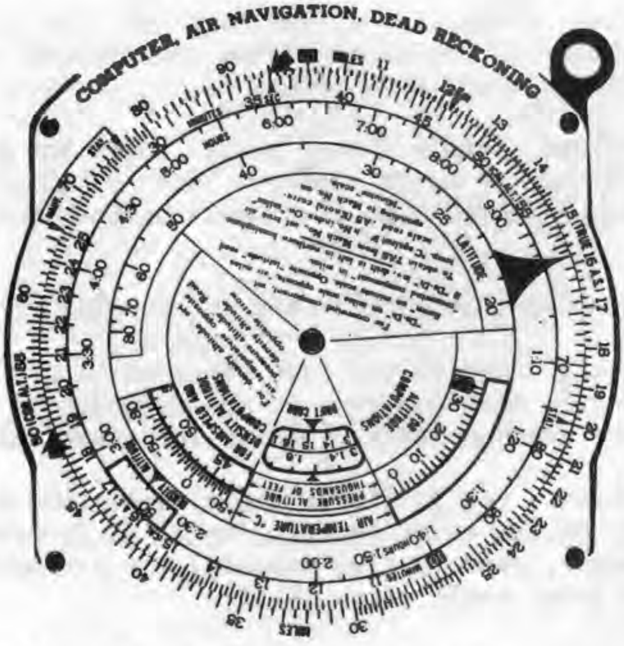


Figure 14-10. Rate-time-distance problems using seconds.

NOTE

When using the minutes scale as a seconds scale, the hours scale becomes a minutes scale.

14-11. Determining Gallons or Pounds Used in a Given Time

Place the 60 index under rate (gph) and read gallons used over the given time. To convert gallons to pounds or pounds to gallons, the following conversion factors are used in simple proportion (para 14-5):

a. Gasoline. 6.0:1.

b. JP-4 fuel. 6.5:1.

14-12. Determining Rate of Fuel Consumption

Rate of fuel consumption equals gallons of fuel consumed divided by time.

a. Problem. What is the rate of fuel consumption if 30 gallons of fuel are consumed in 111 minutes (1 hour and 51 minutes)?

b. Solution. Using the DR computer, refer to figure 14-11 and solve as follows:

(1) Set 111 (inner scale) under 30 on outer scale (in this case, outer scale is used to represent gallons).

(2) Opposite the 60 index, read 16.2 gallons per hour (gph).

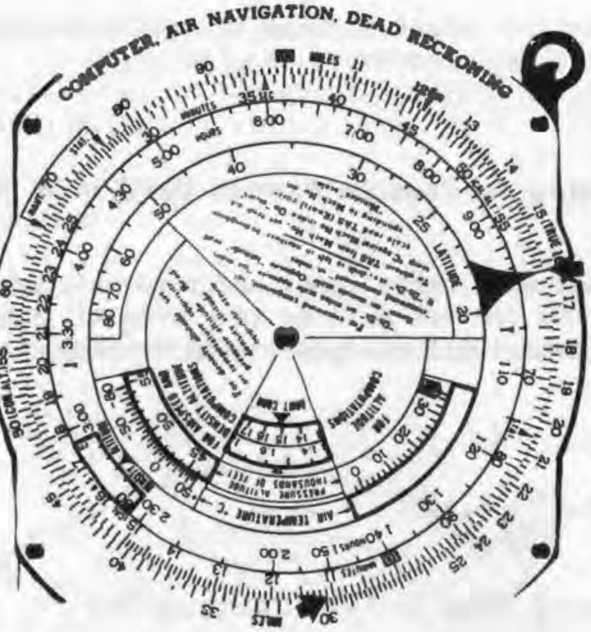


Figure 14-11. Determining rate of fuel consumption.

14-13. Fuel Consumption

Use same scales as used with the time-distance problems discussed in paragraph 14-6 and solve the following fuel consumption problem:

a. Problem. Forty gallons of fuel have been consumed in 135 minutes (2 hours and 15 minutes) flying time. How much longer can the aircraft continue flying if 25 gallons of available fuel (usable fuel not including reserve) remain and the rate of consumption remains unchanged?

b. Solution. Using the DR computer, refer to figure 14-12 and solve as follows:

(1) Set 135 (inner scale) under 40 (outer scale).

(2) Under 25 (outer scale), read 84.5 (inner scale) minutes fuel remaining.

Fig. 14-12. Fuel consumption.

14-14. Fuel Consumption (Distance, Weight, Time)

Aircraft performance data charts used in determining maximum flying range sometimes base fuel consumption rates on nautical miles flown per pound or gallon of fuel consumed. The aviator often desires to compute maximum flying range based on fuel consumption rate in pounds or gallons per hour. This conversion is accomplished as follows:

a. Formula. The relationship between nautical miles per pound and pounds per hour is expressed as -

$$\frac{\text{Nautical miles per pound (or gallon)}}{\text{1 pound (or gallon)}} = \frac{\text{TAS (miles flown per hour)}}{\text{Pounds (or gallons) per hour}}$$

b. Problem. The maximum flying range based on fuel consumption is indicated on the aircraft performance chart as .231 nautical mile per pound. At a true airspeed of 196 knots, what is the aircraft fuel consumption rate in pounds per hour?

c. Solution. Using the DR computer, refer to figure 14-13 and solve as follows:

(1) Set .231 (nautical miles per pound) on the outer scale over the "10" index (1 pound) on the inner scale.

(2) Under the TAS (196 knots) on the outer scale, read pounds per hour (850) on the inner scale.

Figure 14-13. Converting nautical miles per pound to pounds per hour.

14-15. Airspeed Computations

The window marked FOR AIRSPEED AND DENSITY ALTITUDE COMPUTATIONS provides a means for computing true airspeed when indicated airspeed, temperature, and altitude are known or vice versa. To change from one to the other, it is necessary to correct for altitude and temperature differences existing from those that are standard at sea level. Free-air temperature is read from a free-air thermometer and the pressure altitude is found by setting the altimeter at 29.92" Hg and reading the altimeter directly.

a. Problem. The indicated airspeed is 125 knots, free-air temperature is -15° C., and the pressure altitude is 8,000 feet. What is the true airspeed?

b. Solution. Using the DR computer, refer to figure 14-14 and solve as follows:

(1) Set 8,000 against -15° C. in the airspeed computation window.

(2) Over 125 knots (inner scale), read true airspeed 137 knots (outer scale).

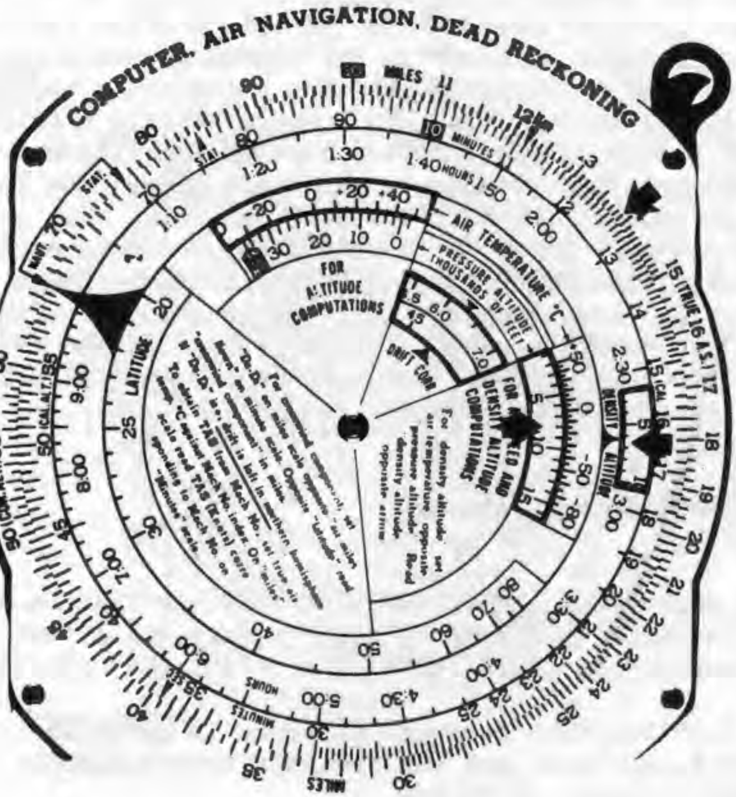


Figure 14-14. Airspeed computation.

NOTE

In solving for IAS when TAS is known, locate TAS on outer scale and read answer (IAS) on inner scale.

14-16. Density Altitude

Density altitude is that altitude in the standard atmosphere at which a given air density exists. Because of variations of temperature and pressure, the density of the air on a given day at any given pressure altitude may be that density found several thousand feet higher or lower in the standard atmosphere. Such conditions can be critical in aircraft operations, especially in the operation of helicopters. To compute density altitude, rotate the movable scales of the computer so that the free-air temperature is set above the pressure altitude in the window labeled FOR AIRSPEED AND DENSITY ALTITUDE COMPUTATIONS. When set in this manner, the density altitude is read above the pointer in the window labeled DENSITY ALTITUDE. Using the same flight condition as in paragraph 14-15, density altitude is read as 6,200 feet (fig. 14-14). Accurate results can only be obtained by using pressure altitude. Pressure altitude can be read directly from the altimeter when the altimeter setting is 29.92.

14-17. Altitude Computations

The window marked FOR ALTITUDE COMPUTATIONS provides a means for computing corrected altitude by applying any variations from standard temperature to indicated (or calibrated) altitude.

a. Problem. The pressure altitude is 9,000 feet, indicated altitude is 9,100 feet, and the free-air temperature is -15° C. What is the corrected altitude?

b. Solution. Using the DR computer, refer to figure 14-15 and solve as follows:

(1) Set 9,000 against -15° C. in the altitude computation window.

(2) Above 9,100 feet indicated altitude (inner scale), read corrected altitude 8,700 on the outer scale (corrected altitude).

Figure 14-15. Altitude computation.

14-18. Off-Course Correction (Rule of 60)

An aircraft headed 1° off course will be approximately 1 mile off course for each 60 miles flown. This is the rule of 60. Inversely, for each mile an aircraft is off course after each 60 miles of flight, 1° of correction will be required to parallel the intended course. Applied to other distances (multiples of 60), such as 1.5 miles off course in 90 miles, 2 miles off course in 120 miles, or 2.5 miles off course in 150 miles, a correction of 1° will be required to parallel the intended course. To converge at destination, an extra correction must be made based on the same rule of 60.

a. Formulas. The degrees correction required to converge at destination is determined by adding the results of the following formulas:

Correction to parallel course.

$$\frac{\text{miles off course}}{\text{miles flown}} \quad \frac{\text{degrees correction}}{60}$$

Additional correction to converge.

$$\frac{\text{miles off course}}{\text{miles to fly}} \quad \frac{\text{Degrees correction}}{60}$$

b. Problem. An aircraft is 10 nautical miles to the left of course when 150 nautical miles from departure point A. How many degrees correction are required to parallel course? If 80 nautical miles remain to destination B, how many additional degrees are required to converge? In what direction is the correction applied?

c. Solution. Using the DR computer, refer to figures 14-16 and 14-17 and solve as follows:

(1) Set 150 (inner scale) under 10 (outer scale) (fig. 14-16).

(2) Over the 60 index, read 4° (correction required to parallel).

(3) Set 80 (inner scale) under 10 (outer scale) (fig. 14-17).

(4) Over 60 index, read 7.5° to converge.

(5) $4^{\circ} + 7.5^{\circ} = 11.5^{\circ}$, total correction to converge at destination. Since aircraft is off course to the left, correction will be made to the right or added to the original heading. For example, if the original heading was 090°, the new heading is 101.5° or 102° to the nearest degree.

14-19. Off-Course Correction (Drift Correction Window)

This scale in the drift correction window of the CPU-26A/P computer is a refinement of the rule of 60 (para 14-18). Actually an arc of

Figure 14-16. Off-course correction to parallel.

Figure 14-17. Off-course correction to converge.

1 mile subtends an angle of 1° at a distance of 57.3 miles rather than 60 miles. The drift correction window scale incorporates this relationship correctly.

a. Problem. After traveling 400 miles, and the aircraft is 30 miles off course -

(1) What drift correction angle is necessary to parallel the desired course?

(2) What drift correction angle is necessary to intercept the desired course in 150 additional miles?

b. Solution.

(1) Set the miles off course (30) on the outer scale over the distance traveled (400) on the inner scale and read the correction angle to parallel the desired course in the drift correction window (4.3°) (fig. 14-18).

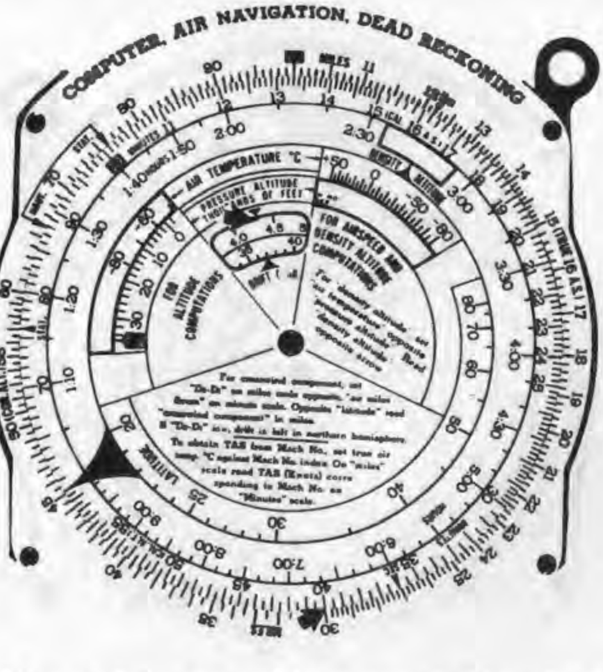


Figure 14-18. Drift correction computation to parallel.

(2) To find the angle to intercept the desired course, place the miles off course (30) on the outer scale over the course miles to interception point (150) on the inner scale. Read the additional angle to intercept in the drift correction window (11.3°) (fig. 14-19). The total correction angle to intercept the desired course is therefore 15.6° (4.3 + 11.3).

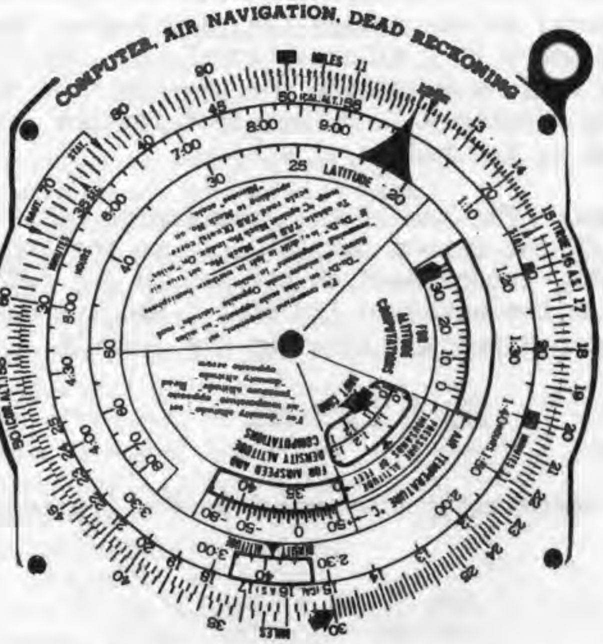


Figure 14-19. Drift correction computation to converge.

NOTE

The drift correction window, together with the $D_2 - D_1$ data and the latitude scale on the face of the computer, is also used in pressure pattern flying. Since the Army does not use this navigation technique, it is not explained herein.

14-20. Radius of Action (Fixed Base)

Radius of action to the same base refers to the maximum distance an aircraft can be flown on a given course and still be able to return to the starting point within a given time. The amount of available fuel (not including reserve fuel) is usually the factor determining time.

a. Problem. The groundspeed on the outbound leg of the flight is 160 knots; on the return leg, 130 knots. Available fuel permits 4.5 hours (270 minutes) total time for the flight. How many minutes will be available for the outbound leg of the flight? How many minutes will be required for the return leg of the flight? What is the radius of action?

b. Solution. The sum of the groundspeed out (GS_1) and the groundspeed on the return leg (GS_2) is to the total time in minutes (T), as the groundspeed on the return leg (GS_2) is to the time in minutes on the outbound leg (t_1). Minutes on the outbound leg of the flight can be calculated by the formula

$$\frac{GS_1 + GS_2}{T} = \frac{GS_2}{t_1}.$$

The formula for calculating time required for the return leg of the flight is

$$\frac{GS_1 + GS_2}{T} = \frac{GS_1}{t_2}$$

in which t_2 is the time required for the return leg of the flight. These formulas can be calculated on the DR computer as ratio and proportion problems and appear on the DR computer as they appear in mathematical form. To solve radius of action fixed base problems with the DR computer, use the problem given in a above, referring to figures 14-20 and 14-21, and proceed as follows:

(1) Find the sum of the groundspeeds (160 + 130 = 290).

(2) Set the total time (T = 4.5 hours or 270 minutes) under the sum of the groundspeeds (290) (fig. 14-20).

(3) Under 130 (GS_2), read the time on the outbound leg, 2 hours + 1 minute or 121 minutes (fig. 14-20).

Figure 14-20. Radius of action time computation.

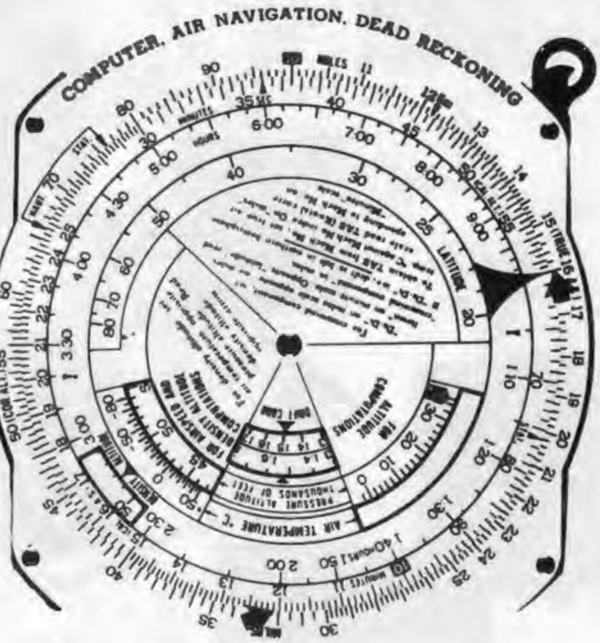


Figure 14-21. Radius of action distance computation.

(4) Without changing the setting of the computer, under 160 (GS_1), read the time required for the return leg, 2 hours + 29 minutes or 149 minutes (fig. 14-20).

(5) These two amounts of time should be equivalent to the total amount of time of the flight.

(6) Place the 60 index under 160 (GS_1) and over 121 minutes (time on the outbound leg), read the radius of action, 322 nautical miles (fig. 14-21).

Section III. GRID SIDE OF THE DR COMPUTER

14-21. Plotting Disk and Correction Scales

The grid side of the DR computer (fig. 14-22) enables the **aviator**

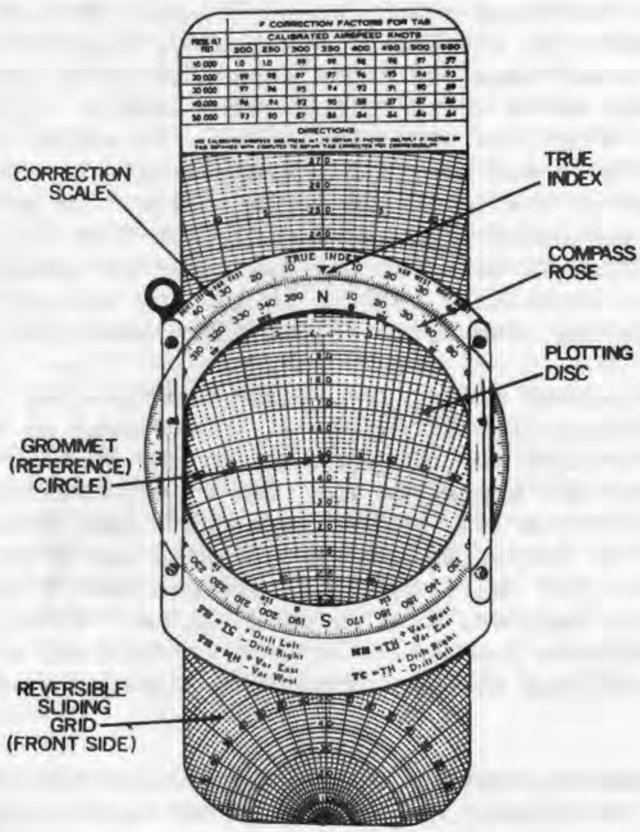


Figure 14-22. Grid side.

to solve wind problems. It consists of a transparent, rotatable plotting disk mounted in a frame on the reverse side of the

circular slide rule. A compass rose is located around the plotting disk. The correction scale on the top frame of the circular grid is graduated in degrees right and left of the true index (labeled TRUE INDEX). This scale is used for calculating drift or drift correction and is labeled drift right and drift left. A small reference circle, or grommet, is located at the center of the plotting disk.

14-22. Sliding Grid

A reversible sliding grid (fig. 14-22) inserted between the circular slide rule and the plotting disk is used for wind computations. The slide has converging lines spaced 2° apart between the concentric arcs marked 0 to 150 and 1° apart above the 150 arc. The concentric arcs are used for calculations of speed and are spaced 2 units (usually knots or miles per hour) apart. Direction of the centerline coincides with the index. The common center of the concentric arcs and the point at which all converging lines meet is located at the lower end of the slide. On one side of the sliding grid, the speed arcs are scaled from 0 to 270; on the reverse side, from 70 to 800. The low range of speeds on the sliding grid is especially helpful in solving navigational problems for aircraft having slow-speed flight characteristics.

a. Rectangular grid. The rectangular grid on the reverse side of the sliding grid (fig. 14-23) is designed so that the left half can be used for calculations on the 70 to 800 side of the sliding grid and the right half can be used with the 0 to 270 side of the sliding grid. On the left half, each small division has a value of 10 units; each large division has a value of 50 units. On the right half, the small squares have a value of 3 units; the large squares, a value of 15 units. This grid is used for solving problems such as off-course correction, air plot, and radius of action, and for correcting reported wind (para 14-30).

b. Correction factors. The F correction factors on the front side of the sliding grid are used for calculating TAS caused by compressibility of air at high airspeeds and altitudes. Army aircraft do not require the application of these correction factors to their TAS (fig. 14-22).

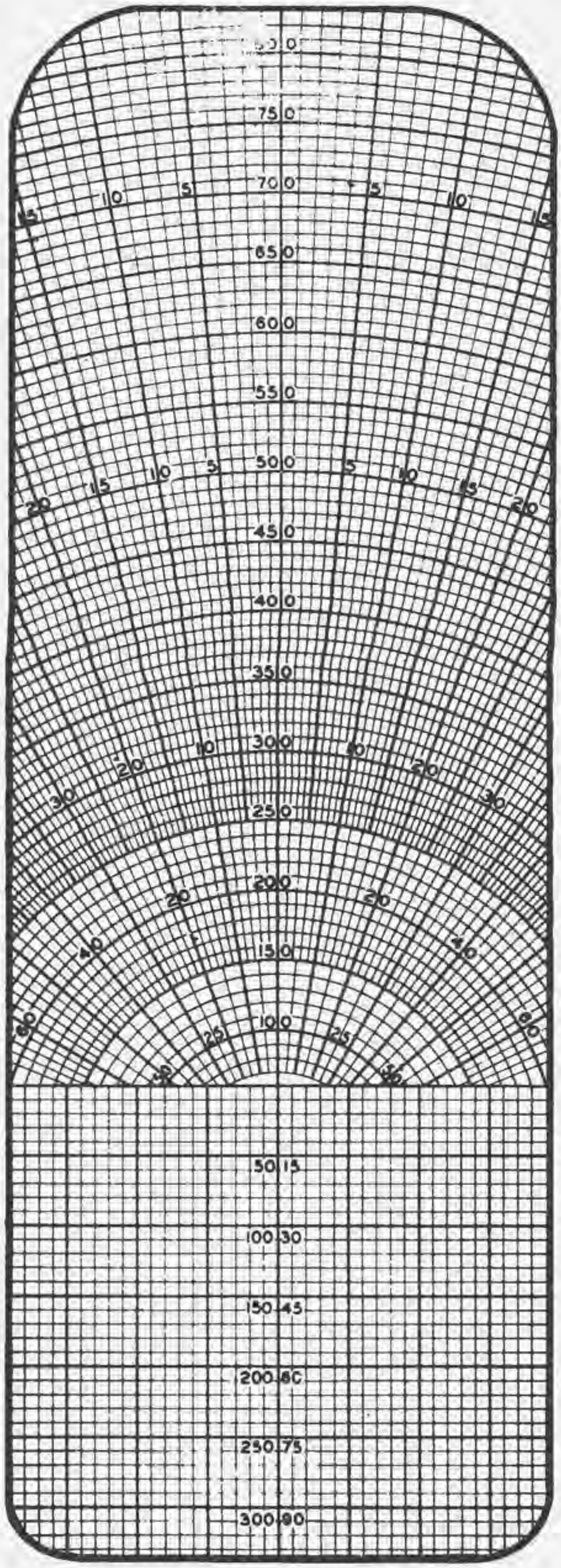


Figure 14-23. Reverse side of sliding grid.

Section IV. WIND TRIANGLES

14-23. Wind Triangle Construction

a. Problems involving wind can be solved by constructing a wind triangle. In its simple form, this triangle is made up of three vectors (six vector quantities) whose elements are always the same. The vectors (fig. 14-24) are -

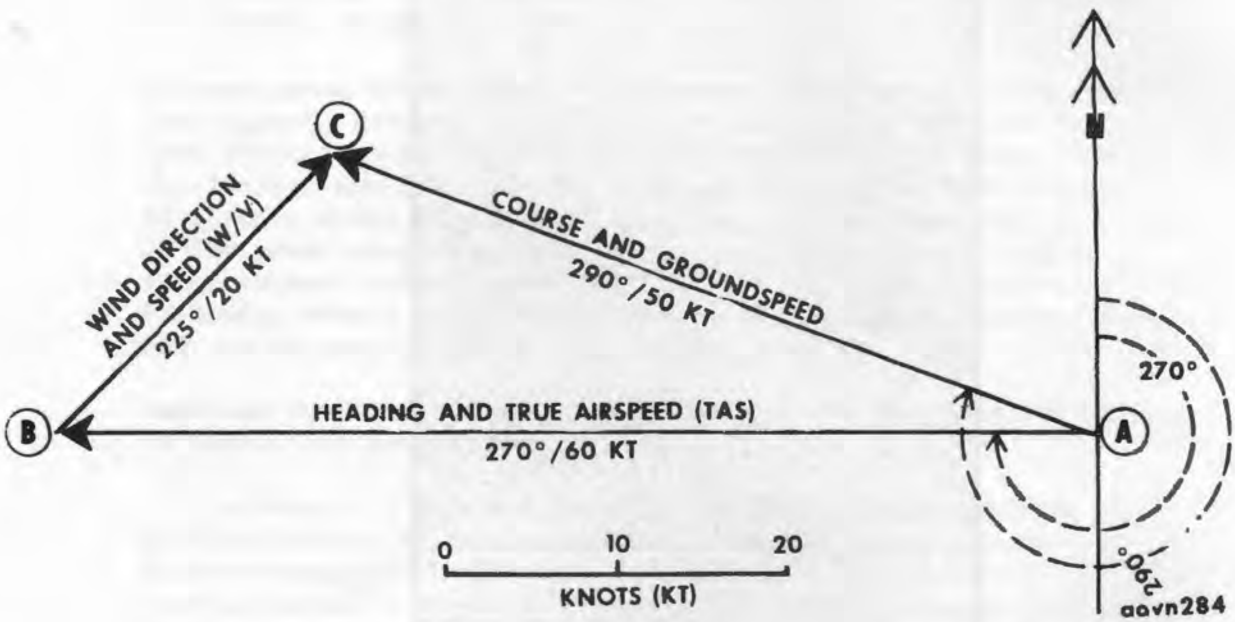


Figure 14-24. Representing the six vector quantities in a wind triangle.

(1) A wind vector, consisting of the wind direction and speed.

(2) A ground vector, representing the movement of the aircraft with respect to the ground, and consisting of the course (or track) and the groundspeed.

(3) An air vector, representing the movement of the aircraft with respect to the airmass, and consisting of the heading and the true airspeed.

b. The direction of such vectors is shown by the bearing of a line with reference to north. The magnitude of the vector is shown by comparing the length of a line with an arbitrary scale. For example, if 1 inch represents 10 knots, then a velocity of 50 knots would be shown by a line 5 inches long (fig. 14-24).

c. Necessary steps for drawing the wind triangle are -

(1) Draw a vertical reference line with an arrow at the top indicating north.

(2) Draw a very short line intercepting the reference line at a convenient point to indicate the point of origin in the diagram.

(3) Draw in the known vectors (a above).

(4) Close the triangle to determine two unknown factors. (Known and unknown factors will vary; but each factor can be determined, provided each vector includes its own factors, namely direction and length.)

14-24. Wind Triangle Solution

Figure 14-25 illustrates the construction of a wind triangle to solve for heading and groundspeed when the course, wind velocity (W/V), and TAS are known. Similar triangles are used to solve for heading and TAS or for wind velocity.

a. Plot the wind vector first (AB).

b. Plot the course for an indefinite distance from the point of origin (AD).

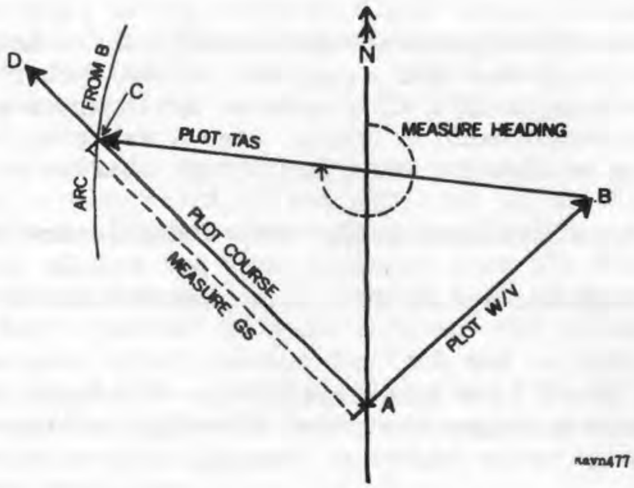


Figure 14-25. Solving for heading and groundspeed.

c. Swing an arc from the end of the wind vector (B) (using the TAS as the arc radius) to intersect the course line (C). Draw the air vector (BC).

d. Measure the heading by determining the angle formed between the vertical reference line and the air vector.

e. Measure groundspeed along the ground vector (AC).

Section V. WIND PROBLEMS

14-25. General

In solving wind problems on the computer, part of a triangle is plotted on the transparent surface of the circular disk. Lines printed on the slide are used for the other two sides of the triangle. The center of the concentric arcs (fig. 14-26) is one

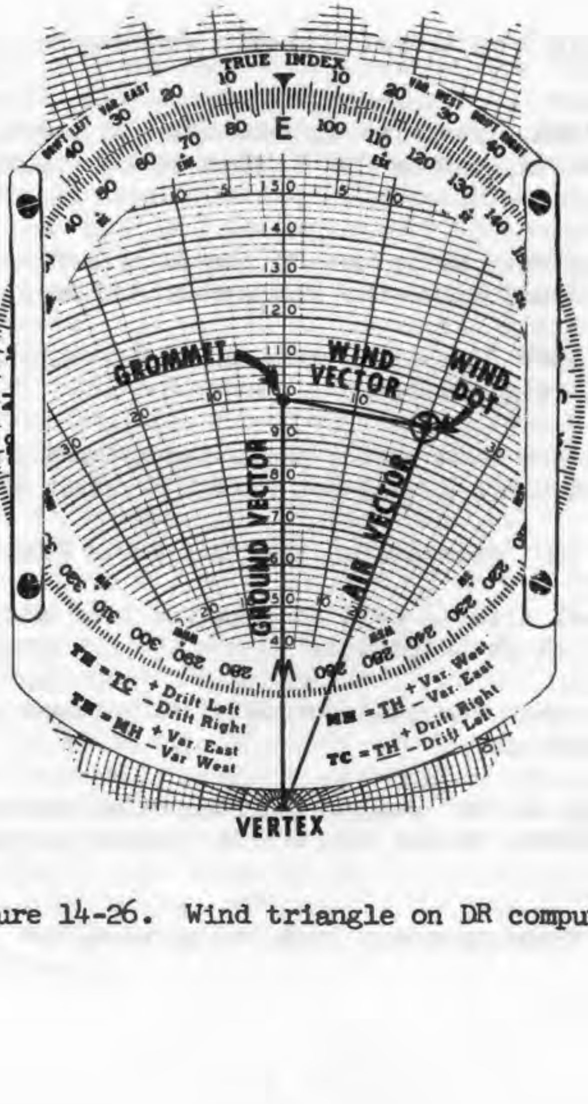


Figure 14-26. Wind triangle on DR computer.

vertex of the triangle. There are many methods applicable for computing any one problem, but the following method for each type of problem is standard for use by the Army aviator. This section includes problems where the centerline is used as ground vector and the wind vector is plotted above the grommet.

NOTE

Directions used in solving wind problems must be compatible; i.e., all in reference to true north or all in reference to magnetic north.

14-26. Heading and Groundspeed Computation

a. Problem. The wind is from 160°/30 knots, the true airspeed 120 knots, course 090°. What is the heading and groundspeed?

b. Solution. Using the DR computer, refer to figures 14-27 and 14-28 and solve the problem as follows:

(1) Set 160° (direction from which the wind is blowing) to the TRUE INDEX (fig. 14-27).

(2) Plot the wind vector above the grommet 30 units (windspeed) and place a wind dot within a circle at this point.

(3) Set 090° (course) at the TRUE INDEX (fig. 14-28).

(4) Adjust sliding grid so that the true airspeed arc (120 knots) is at the wind dot.

(5) Note that the wind dot is at 14° converging line to the right of centerline.

(6) Under the 14° correction scale (labeled drift right) to the right of center at the top of the computer, read the heading (104°).

(7) Under the grommet, read the groundspeed (106 knots).

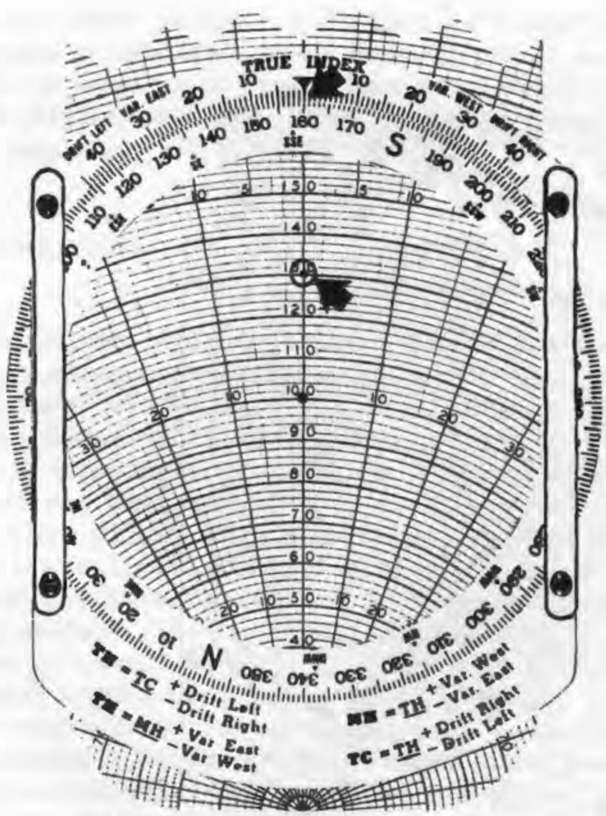


Figure 14-27. Plotting the wind vector to solve for heading and groundspeed.

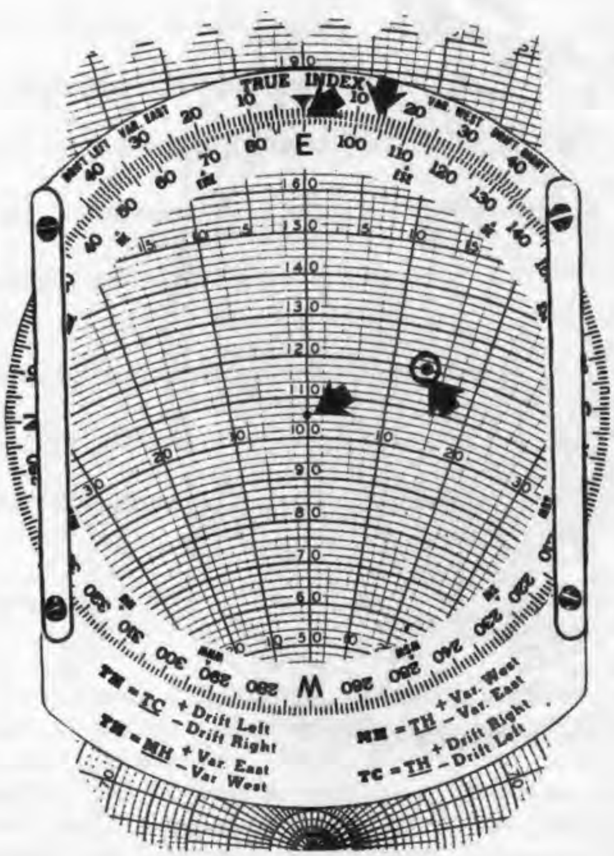


Figure 14-28. Reading heading, wind correction, and groundspeed.

14-27. Heading and True Airspeed Computation

a. Problem. The wind is from 090°/20 knots, course 120°, groundspeed 90 knots. What is the heading and true airspeed?

b. Solution. Using the DR computer, refer to figures 14-29 and 14-30 and solve as follows:

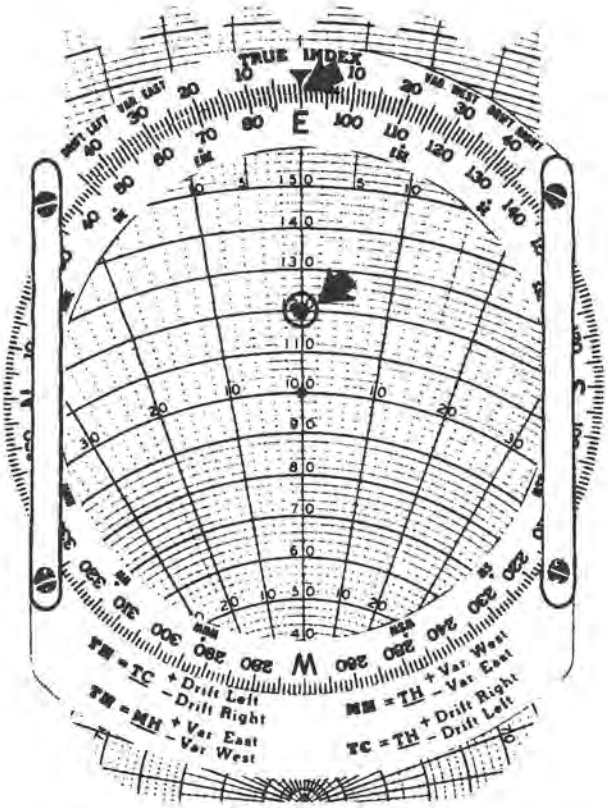


Figure 14-29. Plotting the wind vector to solve for heading and true airspeed.

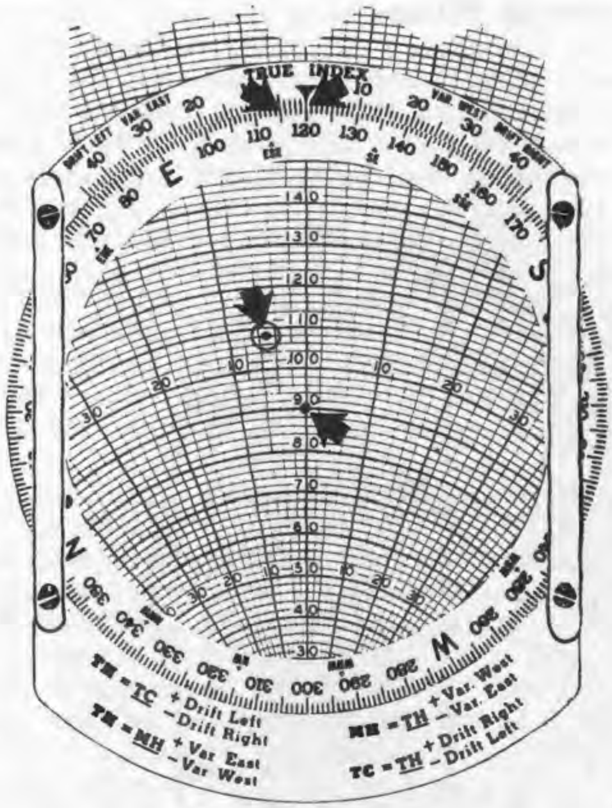


Figure 14-30. Reading heading, drift correction, and true airspeed.

(1) Set 90 (090° wind direction) under the TRUE INDEX and plot wind vector 20 units above the grommet using dot within circle (fig. 14-29).

(2) Set course (120°) to the TRUE INDEX (fig. 14-30).

(3) Move sliding grid so that groundspeed (90 knots) concentric circle is at the grommet.

(4) The wind dot is now on the converging line 5° to the left of centerline. Read the heading (115°) 5° left of TRUE INDEX on correction scale.

(5) Under the wind dot, read the true airspeed (108 knots).

14-28. Wind Velocity Computation

a. Problem. Heading 130°, true airspeed 100 knots, track 140°, groundspeed 90 knots. What is the wind velocity?

b. Solution. Using the DR computer, refer to figures 14-31 and 14-32 and solve as follows:

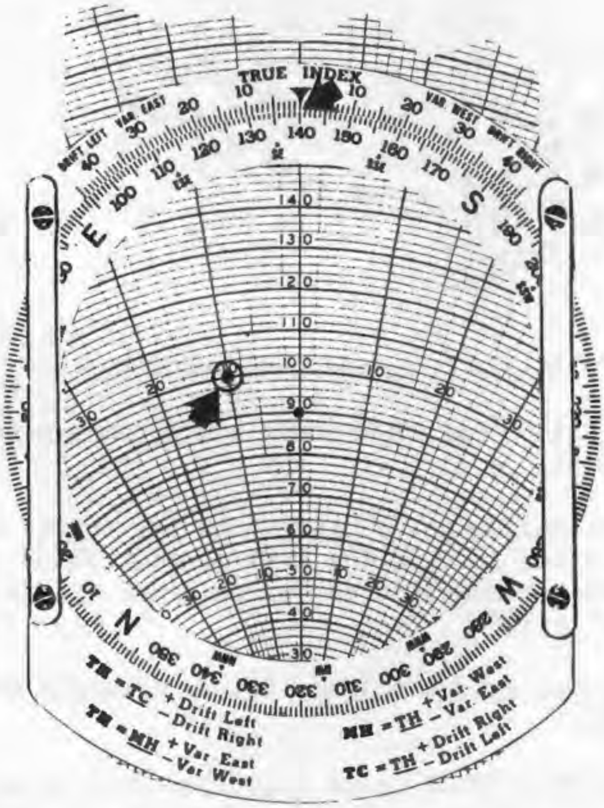


Figure 14-31. Solving for wind velocity.

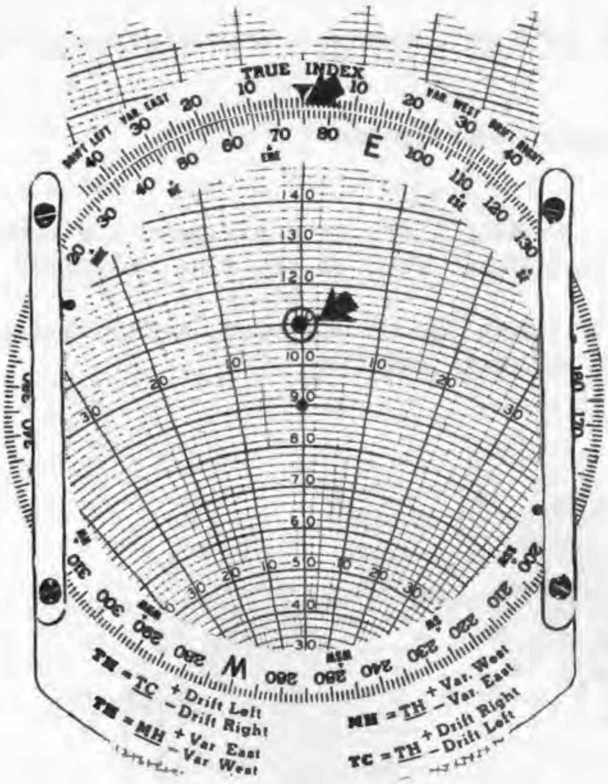


Figure 14-32. Reading wind velocity.

(1) Set track (140°) at TRUE INDEX and grommet over the groundspeed (90 knots).

(2) Since the heading is 10° less than the track, find where the 10° converging line to the left of centerline crosses the 100-knot (true airspeed) line and place a dot within a circle at this point (fig. 14-31).

(3) Turn circular grid until the dot is directly above the grommet (fig. 14-32).

(4) Under the TRUE INDEX, read direction from which the wind is blowing (075°). The distance in units between the dot and the grommet indicates the speed of the wind (20 knots).

14-29. Correcting the Reported Wind

A pilotage fix, furnishing information on track and groundspeed, can be used for correcting the reported wind using the rectangular grid portion of the sliding grid.

a. Problem. After flying for 30 minutes, an aviator establishes a fix on a navigational chart and finds he is 6 miles north of his oncourse dead reckoning position. The reported wind for the flight was 30 knots from 125°. What is the actual wind condition?

b. Solution. Place the rectangular grid of the slide under the transparent disk.

(1) Rotate the compass rose until the wind direction (125°) is under the TRUE INDEX (fig. 14-33).

(2) Draw the wind vector down from the grommet (at O) to the 30-knot point (A, fig. 14-33).

(3) Reason the additional wind component; i.e., since the aircraft is 6 miles north of the desired position after 30 minutes flying time, the wind component is 12 knots (the aircraft would blow off course twice as far in 1 hour), and since the aircraft is drifting to the north, the wind is from the south.

(4) Rotate the compass rose until S appears under the TRUE INDEX (fig. 14-34).

(5) From the end of the first wind vector ((2) above), plot the additional wind component vertically downward 12 knots to scale (B, fig. 14-34).

(6) Connect the end of this second wind vector with the point of origin of the first wind vector (the center of the disk) (C, fig. 14-34).

(7) Rotate the compass rose until the corrected wind vector (C) lies along the centerline downward from the center of the disk (fig. 14-35). Read the actual wind direction (140°) under the TRUE INDEX, and read the actual windspeed (38 knots) as the length of the vector (C) along the centerline.

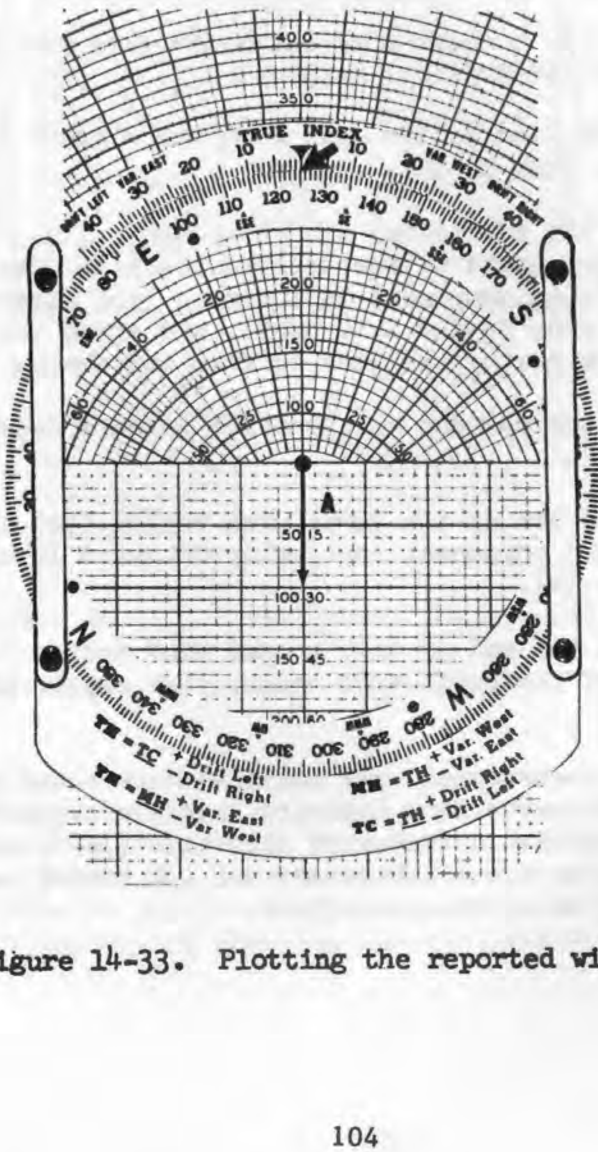


Figure 14-33. Plotting the reported wind.

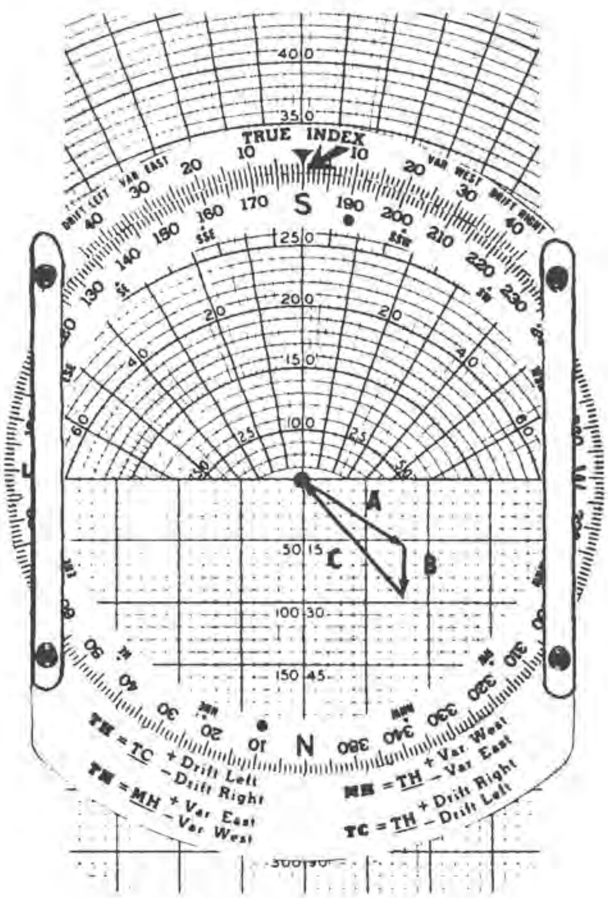


Figure 14-34. Plotting the assumed wind.

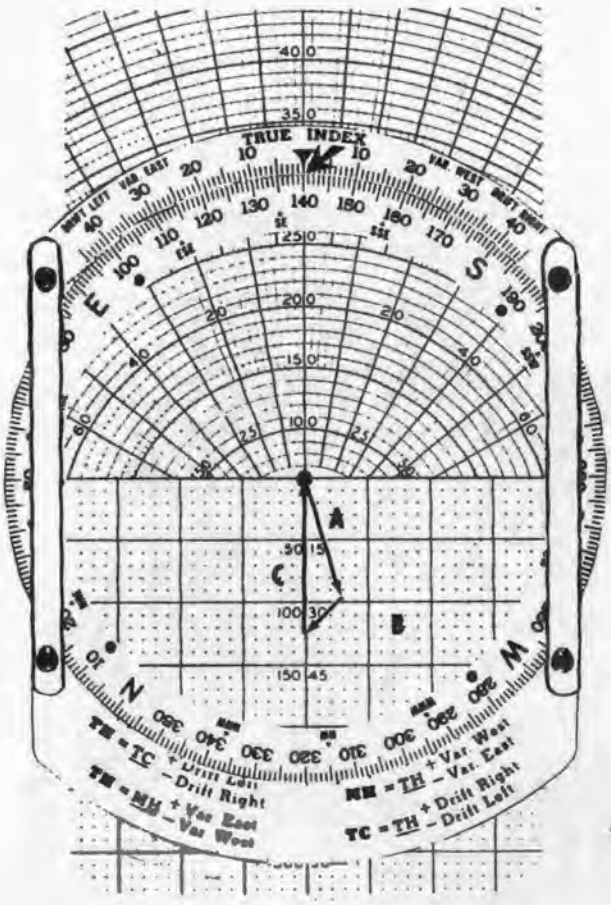


Figure 14-35. Plotting the actual wind.

14-30. Wind Triangle Variations

a. Many other wind problems can be solved using the grid face of the CPU-26A/P computer, including track and groundspeed, wind and groundspeed from double or multiple drift, wind from groundspeed and drift, and correction for reported wind. Wind triangles may also be plotted on the computer, using the centerline as the air vector, by plotting the wind vector below the grommet.

b. Since the mastery of the wind triangle problems discussed in this section is adequate for flight planning with Army aircraft, a complete discussion of the variations mentioned in a above is not essential or within the scope of this manual.

INTENTIONALLY
LEFT
BLANK

CHAPTER 22

TACTICAL NAVIGATION AND INSTRUMENT FLIGHT

22-1. General

It is essential that Army aviation elements be able to provide firepower, movement of troops, logistical support, and surveillance and reconnaissance for the ground tactical elements of the Army even during periods of adverse weather when visual flight for all portions of a mission is impossible, undependable, or is questionable. Tactical situations can be expected to require the commander to use his aviation assets within the threat environment during instrument meteorological conditions. In order to survive during such missions, aviation units must operate under instrument conditions at altitudes well below the altitudes specified in civil instrument flight rules. While standard civil rules may be compatible with threat conditions in rear areas, they will be inadequate for forward areas. Tactical instrument flight provides the means to insure maximum support of ground tactical units by allowing aircraft to move about the battlefield even in adverse weather under high threat conditions. Survivability will require techniques which go beyond the use of today's conventional airways and navigational aids. Sophisticated approach procedures and equipment will not be available. Instead, sophisticated flight will be performed under austere conditions requiring the highest level of aviator proficiency rather than equipment. Aircraft will operate routinely at reduced altitudes with minimum navigational aids and minimum air traffic control facilities and regulations. Increased dependence on preflight planning and aircrew proficiency will be essential to accomplish the mission using the tactical instrument mode of flight. Commanders will consider tactical instrument flight to be a basic aviator qualification and will train their aviators to achieve an acceptable level of proficiency.

As an example, imagine the following tactical situation. An emergency exists in the forward area of the battlefield. Several outposts along the general outpost line (GOPL) are under attack and have received heavy enemy pressure. They are unable to break contact with the enemy and are expected to be overrun soon unless extracted. You, as an aviator, have been assigned the mission to extract and reposition the outposts. To complete the mission, you must fly low-level to a location just short of the forward edge of the main battle area and then use nap-of-the-earth (NOE) altitudes to the GOPL for the extraction. Presently, you are located at a basefield in the division rear area.

The weather is forecast to remain marginal until your intended departure time. You plan your mission accordingly. Shortly after takeoff from the basefield, you encounter "0-0" conditions due to heavy fog which precludes even NOE flight. However, you have radio contact with the unit at the FEBA and it reports that the ceiling there has lifted to 200 to 400 feet overcast - acceptable visual flight conditions. The problem that faces you now, is how to get from your present location to the forward area where visibility exists that will allow mission completion and then return to the basefield. Will you cancel the mission due to the weather? Will you wait for conditions to improve and risk the outposts being overrun in the meantime? Neither of these courses of action are suitable solutions. How can you proceed with the mission even in the adverse weather condition? How can you return to the basefield or a refuel or rearm point after completing the mission?

Since you knew while planning the mission that the weather was marginal and forecast to remain the same, you were able to plan ahead and develop a tactical instrument flight plan at an altitude which was commensurate with intelligence indications of enemy air defense threat capabilities within your area of operation. You made contact with units along your intended flightpath and at the destination and arranged to have small man-portable pathfinder beacons deployed at preplanned locations. Confirmation of their placement and operation was received. You then coordinated instructions for their activation and deactivation (upon request only, or activation at a preselected time). As a standard operating procedure, you planned your tactical instrument flight as a backup for visual flight in the event weather prohibited using visual flight. You were able to plan the flight, using the lowest possible safe altitude, to the vicinity of the FEBA where adequate ceiling and visibility conditions existed and to execute a letdown approach to VFR conditions. Upon completing your mission, your plan provided for return to the rear area or to an alternate or subsequent location to perform other missions as needed.

This chapter discusses some of the basic considerations, principles, and procedures that are an integral part of planning and conducting tactical instrument flight in a high threat environment.

A model tactical instrument system is described in paragraph 22-8. This method is the first of its kind for the United States Army. It is presented as a model to be used, modified, tested, and improved upon as appropriate. When more suitable systems tailored to the tactical environment and the mission requirements are developed through troop use, they also will be published.

22-2. Definition

Tactical instrument flight is defined as flight under instrument meteorological conditions in an area directly affected by the threat. It is used as a normal means to complete assigned missions when ceiling or visibility conditions preclude visual flight or normal regulated IFR flight.

22-3. Capabilities

Tactical instrument flight provides the commander the capability to extend aviation operations against the enemy during periods of severely reduced visibility. It is a forward area operational capability. Using tactical instrument flight, the commander can accomplish a mission under instrument meteorological conditions in a high threat environment that could not be accomplished utilizing other flight techniques. It is also possible for the aviator to transition from conventional instrument flight in rear areas to low altitude operations in forward areas where enemy electronic warfare (EW) capabilities and weapons threaten. A combination of terrain flight and tactical instrument flight will enable aerial scouts to provide reconnaissance and early warning, attack helicopters to provide firepower, and utility and cargo helicopter operations to continue, even under extremely low visibility conditions. All aircraft operating in forward areas should plan on the possibility of transitioning from VFR tactical operations to and from tactical IFR flight to enhance mission accomplishment and tactical staying power.

22-4. Threat

Aviation operations against an enemy equipped with sophisticated air defense and electronic weapons will be significantly affected by the following factors. The commander may be faced with any of the following, singly or in combination, and must consider these factors in planning and execution of air operations.

- Air-to-air weapons.
- Surface-to-surface weapons.
- Surface-to-air missiles.
- Air-to-ground missiles.
- Jamming of aircraft traffic management systems.
- Jamming of command and control frequencies.
- Monitoring of communications among aircraft traffic by the enemy.
- Monitoring command control radio nets by the enemy.
- Helicopter attacks on helicopters.
- High-performance aircraft attacks on helicopters.

22-5. Training

Tactical instrument flight can be successfully accomplished through diligent and thorough training of aircrews, air traffic management, and pathfinder personnel. Through testing, training, and practice, the capability can become a reality. Tactical instrument flight training not only should familiarize aviators with the principles and employment of tactical instrument flight in the high threat environment, it must teach them to execute an instrument flight and approach into a landing zone (LZ) utilizing minimum electronic communication and navigation devices and that such flight can be accomplished safely. Unit training must be oriented toward accomplishment of the unit's mission under adverse weather and threat conditions with a minimum of assistance from electronic communication and navigation devices. Air traffic management and pathfinder personnel, as well as aircrews, also must be integrated into the training. Units must incorporate tactical instrument functions into their everyday missions. Flying at lower altitudes, minimal use of available navigation and communication equipment, detailed premission planning, and postmission debriefing are training practices that can be used on a routine basis during normal operations. Training must emphasize flexibility in order for aviation elements to be able to respond quickly and reliably in a wide range of adverse weather situations.

22-6. Basic Principles

Because tactical instrument flight on a high threat battlefield will be required for successful around-the-clock operations, it must be a standard, well-rehearsed technique in which aircrews are highly proficient. Radio navigation routes for aircraft to follow at survivable altitudes and approach facilities in the area of operation must be established. Flight-following procedures must be established and used when possible to assist aviation crews. These procedures should reveal little to the natural and electronic listening devices of the enemy, yet be sufficiently practical for the aircraft to reach the target or destination and return. In addition to the expected air defense mission deterrents on the high threat battlefield, the enemy can jam, monitor, and acquire as potential targets, friendly electronic navigational communication devices and radar emitters. This threat makes minimum communications, preferably radio silence, a requisite for aviation operations and dictates the basic doctrine of orienting all signal-emitting devices away from the FEBA, moving them frequently, and activating them only when necessary.

Tactical instrument flight should be controlled primarily through the use of standing operating procedures (SOP). An example of a typical SOP for planning and flying a mission using tactical instrument procedures is at paragraph 22-8. It is mandatory that procedures be established and exercised and that aircrews and air traffic management personnel be thoroughly trained before this type of flying is conducted on the battlefield. Some of the more significant basic principles that must always be considered are discussed in this chapter. The combat situation will impose variations on procedures, but the basic principles and considerations will remain essentially unchanged.

22-7. Basic Considerations

a. Flight altitudes. Flight altitudes will be dictated by the enemy air defense threat. The limits will be less than those specified in AR 95-1 and may be as close to the ground as the terrain obstacles permit. Figure 22-1 shows an example of how the air defense threat will appear on the modern battlefield. The illustration graphically shows the relationship of standard instrument flight and tactical instrument flight to the air defense threat and terrain obstacle clearance considerations. The overriding concern in tactical instrument flight is to remain below the enemy air defense threat and continue to maintain a safe altitude above terrain obstacles in order to complete the mission. As the aviator flies toward the forward edge of the battle area (FEBA), he must lower the flight altitude in order to remain below the air defense threat. He can use standard instrument flight rules and procedures in rear areas where the effective range of the enemy air defense missiles and other weapons do not threaten. Of course, the aviator must constantly be alert to the threat of possible communications jamming and monitoring throughout the battle area. Nearer the FEBA he will encounter the range of the enemy early warning and tracking radar. It is important for the aviator to be aware of when he is in this radar range even though he is still outside the effective range of the enemy air defense missiles and other weapons. Although he may be beyond the range of ground-based weapons, he may be engaged by enemy aircraft. The aviator may still be able to use standard instrument flight procedures in this area but should be transitioning to the lower flight altitudes of tactical instrument flight.

As the aviator continues to move forward toward the FEBA, he will come within the effective range of the air defense weapons. At this point he must always remain low enough to avoid acquisition by the early warning and tracking radar. In doing so, he must reduce the flight altitude to a level below the enemy threat, yet high enough to provide a safe clearance of terrain obstacles. Naturally, as the aviator flies toward the FEBA, the capability of the enemy radar to acquire him will continue to increase even at lower levels. The aviator must continue to adjust his altitude and flight route accordingly to remain below this threat or to be masked by the terrain.

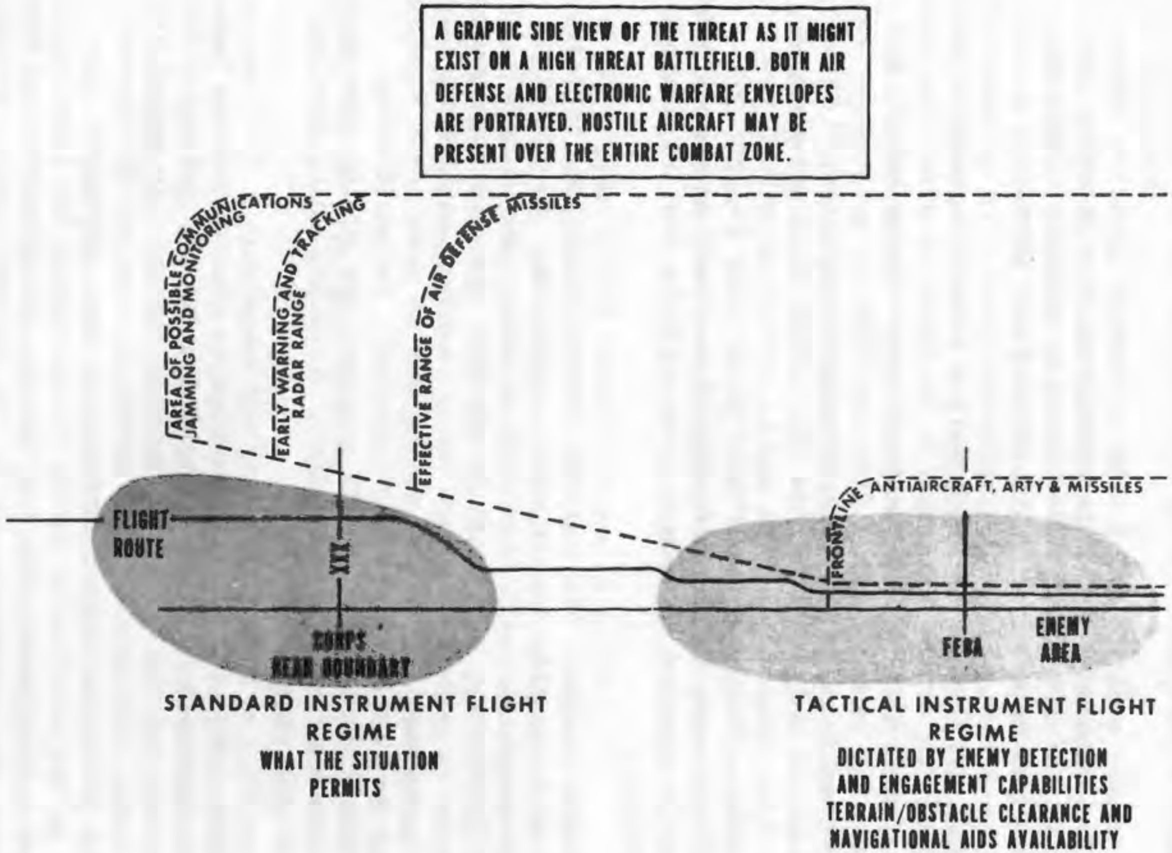


Figure 22-1. Threat profile.

Upon reaching the forward area or the destination point, the aviator will use a tactical instrument beacon to make the approach if visual flight (VFR) conditions have not been encountered. If VFR conditions are encountered at the destination, then the aviator will make the approach visually and use terrain flying to continue the mission and to avoid the enemy threat.

Conversely, as the aviator flies from a forward location toward the rear of the battlefield, he can progressively increase the flight altitude to provide an added terrain obstacle clearance safety margin, yet remain below the air defense threat.

Echelon or unit forward or rear boundaries cannot be used as a reliable indication of the altitude to be flown to avoid the enemy air defense threat since these boundaries are highly mobile and are not always the same distance from the FEBA or subject to the same terrain formations. The unit boundaries depicted on figure 22-1 are presented only to show how the threat will increase as the aviator flies nearer the FEBA and is forced to select lower flight altitudes. Each mission requiring the use of tactical instrument flight must be individually planned and an appropriate altitude profile planned to remain clear of both the threat and terrain obstacles.

b. Flight routes. The current threat situation, terrain, and weather will directly affect route selection. In addition, the route navigational facilities must be mobile and highly responsive. Routinely, they must be capable of rapid displacement on short notice to provide support for a tactical instrument flight. Air traffic management personnel can expect to move their equipment as frequently as every 4 hours, if necessary, to avoid enemy electronic detection and to prevent repeated use of the same airspace. Factors that must be considered in establishing tactical instrument flight routes include:

(1) Terrain and threat. Straight-line flight between takeoff point and destination will be precluded in many instances by both the terrain and the enemy air defense threat. In selecting the flight route, the aviator must carefully analyze the threat as it affects potential flight routes. In most instances, the threat will be the overriding factor in dictating (or limiting) flight routes. Consistent with the threat, the aviator must then make a thorough map reconnaissance of the possible routes to the destination and return to determine the best route which will provide threat avoidance and terrain obstacle clearance. Efforts

should be made to use terrain for masking from the enemy threat whenever possible, especially in the more forward areas of the battlefield. In tactical instrument flight, terrain obstacles can serve as valuable assets to deny enemy electronic detection just as they are used for concealment and masking during visual terrain flying.

After selecting potential routes based on the enemy threat and terrain obstacle considerations, the aviator must then consider other factors that will affect his choice of a route.

(2) Navigational aids. The availability and location of navigational aids will be a significant factor in route selection. Premission planning and briefings, whether in VFR or IFR flight, should include the exact location and availability of aids to navigation and how they can be used to support the tactical instrument flight. En route navaids farther from the FEBA may be relatively easy to coordinate, locate, and use; however, as the navaid location is nearer the FEBA, availability as well as flexibility of a navaid may well be limited by the intensity of the fighting and the density of other air traffic. Planning must include provisions for alternate navaids when available and if the alternate navaid will still contribute to the completion of the mission. An alternate termination point or letdown navaid should not be used if it will not contribute to mission accomplishment or provide visual flight conditions to the intended destination. Planning must include navigational aids for the return flight, if necessary.

(3) Communications. The enemy will employ highly sophisticated electronic warfare systems. Defeating this capability and protecting aviation assets will require maximum tactical ingenuity and resourcefulness. One of the most effective tactics will be to keep radio communications to the minimum. This can be accomplished through the use of arm and hand signals, lights, and SOP. In selecting a route, communications security and a capability for maintaining communications should be prime considerations. Using terrain to mask the aircraft from possible acquisition by the enemy early warning radar may also mask the aircraft from navaids and from communications with friendly units. Routes should be selected which provide reliable communications whenever feasible considering also the threat and the terrain.

c. Approaches. Tactical instrument flight approaches will vary considerably in their sophistication and reliability. Conventional ground-controlled and ILS approaches may be used when available. However, because of the dynamics of future battlefields, these sophisticated facilities will be available only in rear areas. Approaches in forward battle areas will more likely be limited to using area surveillance radar, nondirectional beacons, and FM homing until a tactical derivation of the National Microwave Landing System becomes available. The altitude to which descent can be made will depend on factors such as crew proficiency, aircraft instrumentation, approach navaids, terrain, and visibility. The ultimate goal of an approach is to allow the aircraft to descend through restrictive weather conditions to an altitude where conditions exist that will permit mission accomplishment. Regardless of the kind of approach, the navigational aid at the letdown point should be oriented so that it emits its signal away from the FEBA in order to minimize enemy detection.

In rear areas where standard instrument flight procedures may be followed, ground-controlled approach (GCA) radar can be used for instrument approaches. However, in the forward areas, the limited availability of GCA equipment and the most intense electronic enemy threat will make the aviator primarily dependent on low power nondirectional beacons to aid in the instrument approach and letdown to visual flight conditions. Approaches using FM homing should be used only when an emergency situation exists and the aviator is highly proficient.

Tactical instrument flight approaches may be classified according to facilities as follows:

--Class I - Approach using ground-controlled approach (GCA) or a derivative of the National Microwave Landing System with its distance-measuring equipment. Guidance to the ground is reliable with no minimums required for properly trained aviators in appropriately instrumented aircraft and Air Traffic Management (ATM) personnel trained in installation and operation of the equipment.

--Class II - Approach using one of the following: An instrument landing system, an area surveillance radar, or a nondirectional beacon. Centerline guidance is reliable with a positive position indication (fix) prior to start of letdown. Descent to 50 feet above ground level (AGL) is allowed for properly trained ATM personnel and aviators using appropriately instrumented helicopters. Visibility must be such that aviators can proceed visually following the approach.

--Class III - Approach using FM homer. Reliability of directional guidance and station-passage indication close to station is questionable. Descent altitude is dependent on terrain, and visibility conditions must be such that aviators can operate visually before touching down or continuing the mission. Aviators and ATM personnel must be highly proficient.

d. Navigational aids. Because of the threat in forward areas of the battlefield, it will not be possible to operate navaids full time. Operating nondirectional beacons and surveillance radar navaids full time risks enemy acquisition of both the navaid and the aircraft as targets, or of having the enemy disrupt the mission by jamming the navaid signal. All reasonable means should be used to minimize the time that navigational aids emit a signal. In rear areas where more sophisticated navaids can be used along with standard instrument flight rules, efforts should also be made to limit the signal transmission time to only those times when needed as an aid. In the fast-moving and increased threat environment nearer the FEBA, the limited low-power beacons and navaids should be operated intermittently or only upon request as a standard procedure to lessen the chance of enemy detection. In this austere situation, aviator proficiency and knowledge of the capabilities and characteristics of the navaids are important.

Research and development efforts are continually striving to provide more advanced, portable navigational aids to supplement the requirements of tactical instrument flight.

(1) Radio Beacon Set, AN/TRN-30(XE-1)V. One of the latest innovations is the portable Radio Beacon Set, AN/TRN-30(XE-1)V currently used by field units. It transmits a homing signal that can be used in conjunction with the airborne direction finder (ADF) sets AN/ARN-59 and AN/ARN-83 installed in most Army helicopters. The radio beacon set provides an amplitude-modulated (AM) radio frequency signal on any one of 964 channels in the frequency range from 200 to 535.5 kHz and 1605 to 1750.5 kHz in tunable increments of 500 Hz.

The range of the beacon depends upon the wattage and configuration of its operation. The beacon can be used in two basic configurations:

(a) Pathfinder. In this mode the system is a low-power, short-range, man-portable direction finder beacon. This equipment will be used in this mode extensively in intermediate and the most forward areas to lessen the chance of enemy detection and provide the greatest degree of flexibility and transportability. In most cases, the aviator will be required to track outbound on a stronger navaid located in a rear area until he is close enough to intercept and use an intermediate low-power beacon en route to the FEBA where he will receive and use a reliable signal from another low-power beacon operating in the pathfinder mode.

(b) Tactical and semi-fixed. In these modes, the beacon is located at a semi-fixed facility and operated at medium to high power. These modes include the basic man-portable radio, a power supply, and an amplifier. In these modes the beacon is used in rear areas for instrument flight en route to and returning from forward locations. The beacon will generally be located beyond the effective range of long-range enemy artillery and emits a signal strong enough to assist in transition to and from tactical instrument flight using low-power beacons. Even though the beacon operated in these modes is located in a semi-fixed rear location, it also will be operated intermittently or on request to reduce the electronic signature and to reduce its desirability as an enemy target for long-range weapons.

(c) The capabilities of the AN/TRN-30(XE-1)V are shown below. The range data in the pathfinder mode is based on conventional tracking methods at altitudes less than 500 feet AGL. In the tactical and semi-fixed modes, the range data is based on flight at altitudes of 500 feet AGL and higher. At the low altitudes we expect to fly near the FEBA, the aviator cannot receive the tactical beacons at conventional distances. At altitudes of 200 to 500 feet above the highest obstacle (AHO) over uneven, broken, or rolling terrain, the mean reliability distance of the beacon in the pathfinder mode is a maximum of 15 km using the 15-foot mast antenna; however, at altitudes above 500 feet (AHO) the signal reliability increases. Additional altitude or increased antenna height does not significantly affect reliable reception distance at altitudes lower than 500 feet above the highest obstacle. If care is taken to position beacons requiring maximum reception distance on dominating terrain, the reliable reception distances may be increased. Conversely, if a lesser reception distance is adequate and usable, the signal may be masked by positioning the beacon in low terrain. As a general rule for planning purposes, the ranges listed below should be used.

	Pathfinder Mode (V1)	Tactical Mode (V2)	Semi-Fixed Mode
Frequency Range	200 - 535.5 kHz 1605 - 1750.5 kHz	200 - 535 kHz	200 - 535 kHz
Range (km) Below 500 ft AHO	15 km w/15 ft Mast Antenna		
Range (km) Above 500 ft AHO	25 km w/Whip Antenna		
	40 km w/30 ft Mast Antenna	85 km w/60 ft Mast Antenna	180 km w/60 ft Mast Antenna
Power Output	25 W	60 W	180 W
Weight	39 lbs	175 lbs	175 lbs
Channels	964	672	672
Power Source	6V Battery or Jeep Battery (26V)	Jeep Battery (26V)	Jeep Battery (26V)

(2) FM homing. FM homing can be used as an emergency tactical instrument navigational aid to serve as a backup in the event the onboard ADF equipment malfunctions or the ground-based non-directional beacon becomes unreliable or inoperative. In tactical instrument flight, as in visual terrain flying, it is extremely important for the aviator to remain aware of his position as closely as possible at all times in the event he must resort to emergency backup homing procedures. By knowing his position and using FM homing as an emergency navaid, the aviator can home:

- To an alternate FM transmitter location in order to encounter VFR flight conditions when onboard equipment malfunctions.

- To the original point of departure in order to use an operational or more reliable ground-based navaid.

As a general rule, FM homing should be used only as backup navaid to return the aircraft to VFR conditions or to a rear area.

(3) Night operation aids. Tactical instrument flight at night is conducted primarily in the same manner as it is conducted in the day. However, during transition from tactical instrument flight to visual flight at the point of letdown, a light source must be present to provide a visual reference point for the aviator. The lighted "T", "Y", or similar reference symbol may be used. If the landing site is located at a location other than the letdown point, a second light source to assist in landing is also necessary.

22-8. Flight Planning Procedures

Standard operating and planning procedures should be established in individual units to insure complete and thorough premission tactical instrument flight planning. The importance of detailed planning prior to conducting a tactical instrument flight cannot be overemphasized since both successful mission accomplishment and crew survival will depend heavily on the degree of prior planning. The procedures and steps outlined and discussed in this paragraph can be used as a guide or sample Standing Operating Procedures (SOP) for the lowest echelon units and modified to meet specific mission requirements and unit needs. Because of the wide range of planning considerations and significance of each consideration, a standard procedure or checklist is an essential item to be used in the unit. Each individual step in the planning process should be followed from a standard procedure or checklist with nothing committed to memory or left to chance. The thoroughness required in the planning process for tactical instrument flight cannot be overstressed.

a. Essential planning considerations. In planning prior to a tactical instrument flight or a visual flight when resort to IFR flight is a possibility, the aviator should use a checklist to aid in planning and to insure completeness. The essential planning considerations listed here can be used as a checklist and expanded or modified as the specific mission requirements dictate. This checklist of planning considerations is in no way all-encompassing and can be improved with use. However, it does provide the fundamental points that must be considered in planning the flight.

(1) Operations.

(a) Mission requirements. The first step in planning for the tactical instrument flight is to analyze the mission in order to determine all the requirements that are inherent in it. For example, knowing if the mission is a single aircraft flight, a multiple aircraft operation, or a multiple sortie mission will significantly affect the aviator's planning process. Analyzing the mission as a first step will insure that all subsequent necessary steps are taken and unnecessary steps omitted.

(b) Operations/intelligence briefing. A complete briefing by the operations officer or his representative is a keystone in the planning process. Information to be sought includes:

- Threat information: Threat information should be kept available that is specifically applicable to the area of operations. This data should include types of weapons, air defense weapons and missiles, effective range of weapons, detection and acquisition ranges, a record of "shot at" reports, and other pertinent threat information that may affect the unit mission. It is imperative that threat data be kept up-to-date so that the mission can be accomplished with minimum risk of hostile interference. The threat situation is a primary factor and affects all other mission planning steps.

- Friendly forces: Location, identification, and posture of friendly supporting/supported forces is essential information. En route and terminal planning depends heavily on the friendly force situation. Unexpected movements of units or the supported unit can be critical to mission accomplishment using tactical instrument flight.

(c) Frequencies and call signs. Insure that communications-electronics operation instruction (CEOI) information is current and communications with navigational aids can be established and maintained.

(d) Weather information. As in any form of instrument flight, weather information is critical. Current weather information should be maintained for the area of operations and may depend heavily on forward ground weather reports by untrained observers. Weather information may be obtained through division artillery elements if more formal weather information sources are not available. Wind information is extremely important to flight planning. Wind conditions at the point of departure, en route, and at the termination point must be obtained and rechecked immediately prior to departure. For planning purposes, surface winds should be used.

(2) Map study/analysis.

(a) Route selection. A detailed map study is necessary to determine the best possible route or routes that will contribute most readily to mission accomplishment. Primary, alternate, and return routes must be selected based on analysis of the following factors:

- Enemy air defense threat: Map study is necessary to plot the route that provides the maximum concealment and masking from hostile air defense weapons.

- Terrain obstacles and hazards: Prominent terrain obstacles and features must be identified and plotted. This allows steps to be taken to avoid hazards and also to use the features to the best advantage for masking.

- Navigational aids requirements: During this phase of planning, the aviator determines and coordinates his requirements for navigational aids with those navaids available to him for use. Detailed map study will allow the aviator to plan the use of navigational aids to insure reliable reception distances or plan for "dead spots" when he will dead-reckon navigate until intercepting a reliable signal. He may need to re-route or modify the plan based on the navigational aids that can be used. At the earliest possible time, the aviator must coordinate his route and navigational aids needs with the operations in order to allow the maximum reaction and movement time by forward navaid and air traffic management elements. Alternate navaid facilities should also be considered and coordinated during this phase of planning.

(b) Flight altitudes. Terrain and obstacles, along with the enemy air defense threat, determine the altitude the aviator will fly using tactical instrument procedures. Map analysis is the primary source for determining a flight altitude that provides clearance and obstacle avoidance along the selected route.

- Altimeter setting: Elevation data obtained from the map will be the primary input for altimeter settings whenever up-to-date barometric pressure information is not available. Even when reliable altimeter settings can be obtained from meteorological sources, the aviator must carefully calculate altimeter indication variations to insure terrain or obstacle clearance. Altimeter mechanical error, changes in meteorological conditions, and irregular vegetation on the terrain can combine to produce a significant difference between the indicated altitude and the actual height above the terrain. Insuring that the altimeter is set to the terrain elevation, learned from close and intensive map study, can be a valuable aid in holding altimeter error to a minimum. When aircraft are equipped with radar altimeters, altitude verification can be made at known map locations when in flight.

- En route and approach minimums: In the absence of standard, published en route and approach diagrams, map study is the only way the aviator has to determine clearance altitudes en route and to calculate safe letdown minimum altitudes for his approach at the destination.

(c) Navigation preplanning. A thorough map study prior to a tactical instrument flight can make navigation and inflight tasks much easier. For example, a knowledge of the terrain throughout the area of operations can be obtained beforehand by becoming familiar with all the major terrain features. By doing this, the amount of time spent referring to the map during flight can be reduced appreciably. Additionally, the aviator is much better prepared to cope with unexpected changes in the flight by having a prior knowledge of his surroundings.

Fuel requirements must be established and planned during this phase of the flight planning. Map study - coupled with wind information - provides the aviator an early indication of fuel requirements so that he can plan routes and refueling stops as necessary. Time-distance computations to assist in navigation can be accomplished as a result of the map study.

(d) Magnetic conversion and deviation. A significant error can result if the planner fails to convert grid azimuths to magnetic azimuths and then to apply the specific aircraft compass deviation information while performing and using map study and analysis. To determine the correct compass heading required to maintain the desired true course, use the following formula:

$$TC \pm VAR = MC$$

$$MC \pm WIND\ DRIFT = MH$$

$$MH \pm DEV = CH$$

(3) Equipment requirements.

(a) Maps and navigational aids. The aviator must make an inventory to insure that all map sheets and charts or aids to navigation are present for the flight.

(b) Aircraft equipment. Weight and balance computations, performance charts, and special mission equipment should be checked and secured during this part of planning. Survival equipment, a necessity for all modes of flight, should also be checked for the mission.

b. Planning a basic model. The method for conducting a tactical instrument flight discussed here is one possible way to perform the mission in IFR conditions using a minimum number of navigational aids. It discusses the flight from the first steps in planning to the termination. You may be able to improve on this method in order to tailor it or similar methods to fit your standing operating procedures and mission needs.

(1) En route planning.

(a) One navaid beacon (fig. 22-2).

Step 1 - The pilot first identifies the takeoff point (T) and the beacon location (L) on a standard 1:50,000 tactical map. Once these points have been determined, the course line is drawn connecting the two points.

Step 2 - Determine the total distance from (T) to (L) in kilometers (km). Normally, the total distance (D) should not exceed 30 km. Because the reliable reception distance of the beacon signal is approximately 15 km, it is necessary to use "dead-reckoning" navigation initially. Using dead-reckoning for a distance more than 15 km before receiving a reliable signal may allow the aircraft to exceed the limits of the safety zone. If the total course distance is greater than 30 km, then a second beacon should be used at the takeoff point or at an intermediate location.

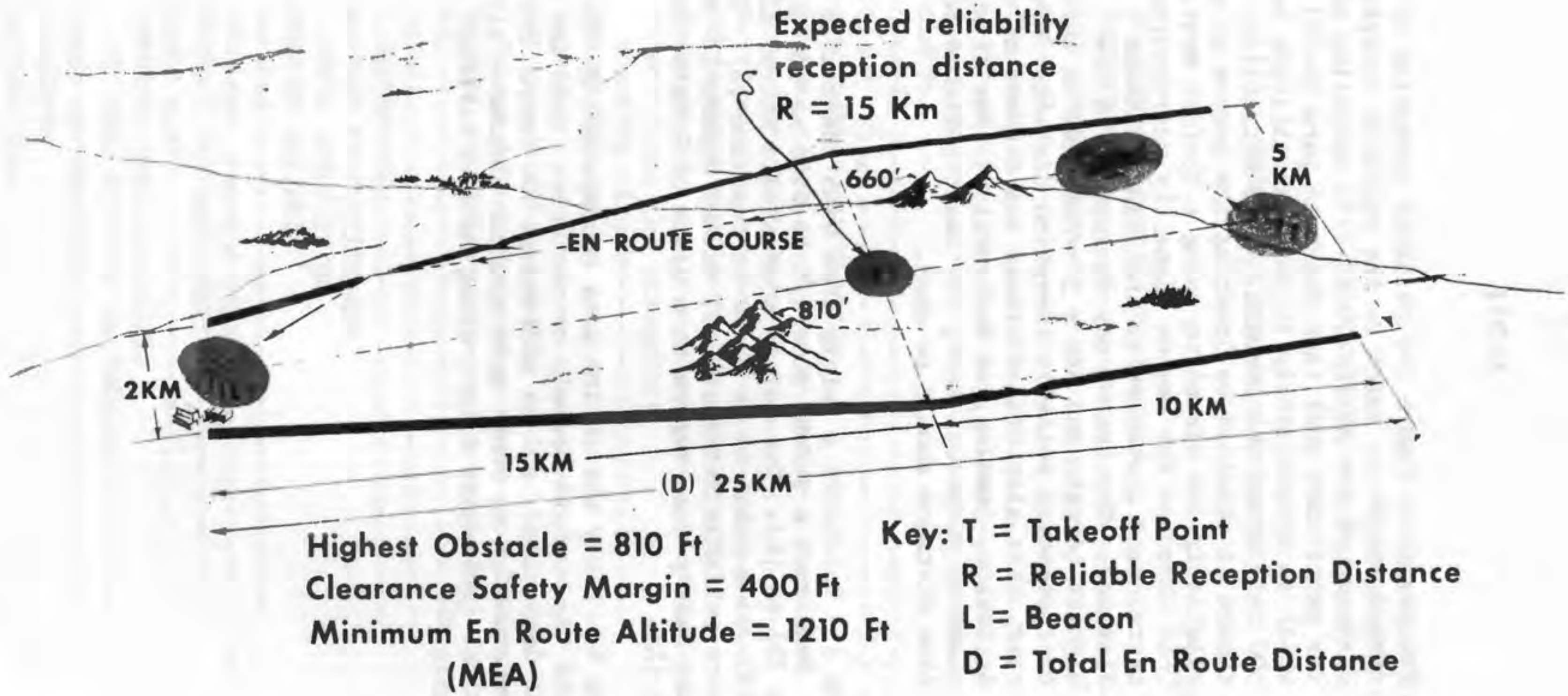


Figure 22-2. One navaid beacon at, or in the vicinity of, the intended point of arrival.

NOTE

The planning figure for reliable reception of the navaid beacon is based on the reliable reception distance of the AN/TRN-30(XE-1)V1 operating on the pathfinder mode (see chart in para 22-7d) which is approximately 15 km at an altitude below 500 feet above the terrain. This reliability figure is obtained by locating the beacon at a relatively low elevation using a 15-foot mast. This obscures the beacon signal by surrounding terrain and obstacles to the least reliable distance. The beacon may be located on the highest terrain and use a 30-foot mast to increase the potential reliable reception distance; however, this also will increase the chances of enemy detection, jamming, or destruction. For flight planning purposes, then, the least reliable reception distance should be used.

Step 3 - Construct a safety zone with the course line as the center. Construct a safety zone 1/5 as wide as the total distance (D) from (T) to (L). The safety zone should extend along the course line to a point 15 km prior to reaching (L). This is the point where reliable reception (R) can be expected. From that point, the safety zone tapers to a width of 2 km at the beacon location (L).

Step 4 - Study the entire area encompassed by the safety zone and locate the highest terrain or obstacle. Once the highest obstacle is determined, add an additional 400 feet. This altitude is the recommended en route safe minimum clearance altitude for the tactical instrument flight using current aircraft instruments and navaids.

NOTE

The recommended safe minimum clearance altitude of 400 feet above the highest obstacle (AHO) incorporates a safety margin for the variables of altimetry (altimeter error - mechanical or induced), vegetation and manmade obstacle elevations not depicted on tactical maps, and pilot error. At 200 feet AHO, the lowest beacon reliable reception altitude, there is no adequate safety margin for the variables. Altimetry, vegetation, and obstacles can amount to greater than 100 feet. Flights at 300 feet AHO would be satisfactory without considering potential pilot error. To allow for pilot error, an additional 100 feet is added as a safety margin; making the recommended safe minimum clearance altitude 400 feet AHO.

However, depending on the type of terrain (flat desert, broken woodlands, or mountainous), the safe minimum clearance altitude for flight planning purposes can and should be adjusted commensurate with the threat and terrain. For example, the safety margin can be reduced over flat desert terrain since vegetation or manmade obstacles are usually absent; in mountainous terrain the margin may need to be increased to provide for unexpected downdrafts and unexpectedly high terrain obstacles.

(b) One beacon in the vicinity of the arrival point and one beacon en route (fig. 22-3).

Step 1 - Identify the takeoff point (T), the location of the intermediate beacon (L1) and the location of the beacon at the letdown point (L2). Draw the course line connecting these points.

Step 2 - Determine the distance of the first leg (D1) from (T) to (L1). This distance should not exceed 30 km.

Step 3 - Determine the distance of the second leg (D2) from (L1) to (L2). This distance should not exceed 45 km.

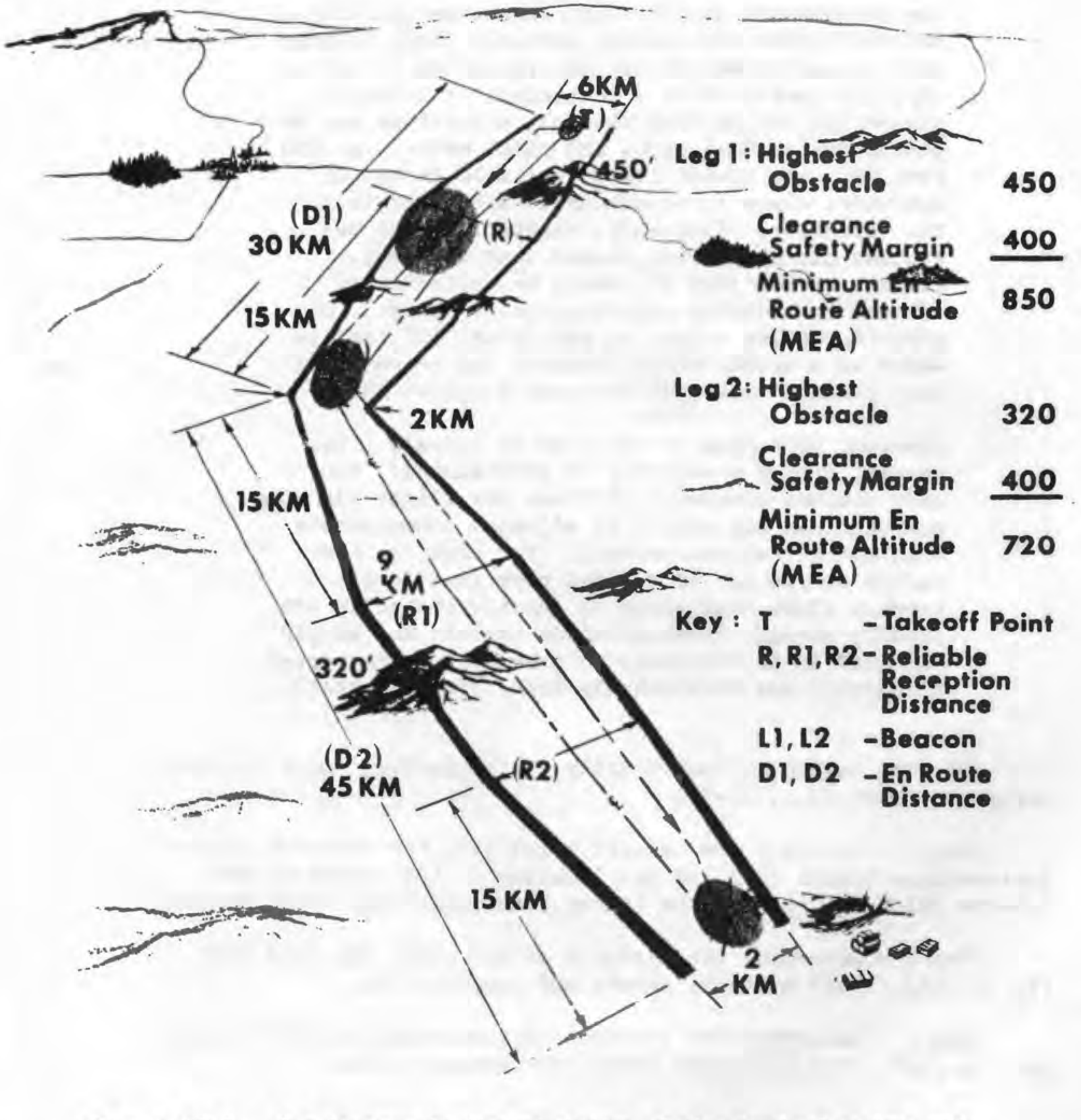


Figure 22-3. One beacon in the vicinity of the arrival point and one beacon en route.

NOTE

For planning purposes, the distance (D2) between the intermediate beacon (L1) and the terminal beacon (L2) can be as great as 45 km. This requires that the aviator track outbound for 15 km from L1, dead-reckon for 15 km, until intercept of L2, and track inbound on the reliable signal for 15 km.

Step 4 - The safety zone for the first leg (T) to (L1) is again constructed to be as wide as 1/5 the en route course leg length. For example, the width of the safety zone is 6 km since the total distance from (T) to (L1) is 30 km. The safety zone extends along the course line to the point of reliable reception (R). From that point, the safety zone tapers to a width of 2 km at the intermediate beacon (L1).

Step 5 - The safety zone for the second leg is constructed along the course line from (L1) to (L2). The point of reliable reception (R1) for the intermediate beacon is located along the course line 15 km from (L1). The point of reliable reception (R2) for the beacon at the letdown point is located 15 km from (L2). The width of the safety zone from (R1) to (R2) must be 1/5 of the distance of the second leg (D2). From (R1) the safety zone tapers to 2 km at the intermediate beacon (L1). From (R2) the safety zone tapers to 2 km at the letdown point beacon (L2).

Step 6 - Study the entire area encompassed by both safety zones to determine the highest obstacle. Once the highest obstacle has been determined, add 400 feet to that altitude to obtain the safe minimum clearance altitude. If there is a difference in the resulting en route altitude on the two legs of flight, the pilot must determine the rate of climb/descent necessary to clear obstacles at station passage of the intermediate beacon to transition to the remaining en route altitude. Routes should be selected to take advantage of the lowest terrain and obstacles in order to remain below the enemy air defense threat.

NOTE

This same procedure is used for planning a flight with a beacon at the takeoff point and one at the letdown point.

(2) Takeoff planning. After en route planning is completed, begin the takeoff and climb planning. Planning for the takeoff should include all the factors of a normal VFR takeoff, i.e., wind direction, longest axis of the area, barriers and their effect on a takeoff path, and power required. In addition, since the takeoff may be an instrument takeoff, pilots must evaluate the terrain around their climbpath. The tactical situation may be an influencing factor on takeoff planning and require that the takeoff be made over the least desirable terrain or away from the en route flightpath.

Whenever possible, takeoffs should be made on the heading that will maintain the desired course. However, if this is not possible, there are simple procedures that will allow the pilot to establish himself on course. If there is a navigational aid at the takeoff point, after takeoff establish the en route course by standard tracking procedures back to the beacon. It may be necessary for a mission to require a takeoff from a location without a navaid. This requires the pilot to establish his course by dead-reckoning until a navaid can be received some distance after takeoff.

Step 1 - The first step in planning a takeoff is to establish a 6 km square clear zone around the takeoff point. Study this area and identify the highest obstruction within it. Also, determine the desired takeoff path considering all the factors previously discussed.

Step 2 - Draw the takeoff climbpath on the tactical map and a takeoff climb zone 15° either side of the climbpath (fig. 22-4). Mark key obstructions and terrain elevation in the 6 km square clear zone and the takeoff climb zone and convert these altitudes to heights above the takeoff point. Check each significant elevation with the climb safety chart to see that a climb can be completed in the desired direction of takeoff (fig. 22-5). The takeoff climb zone should be adjusted laterally to place significant obstacles outside the climb zone. If the climb zone cannot

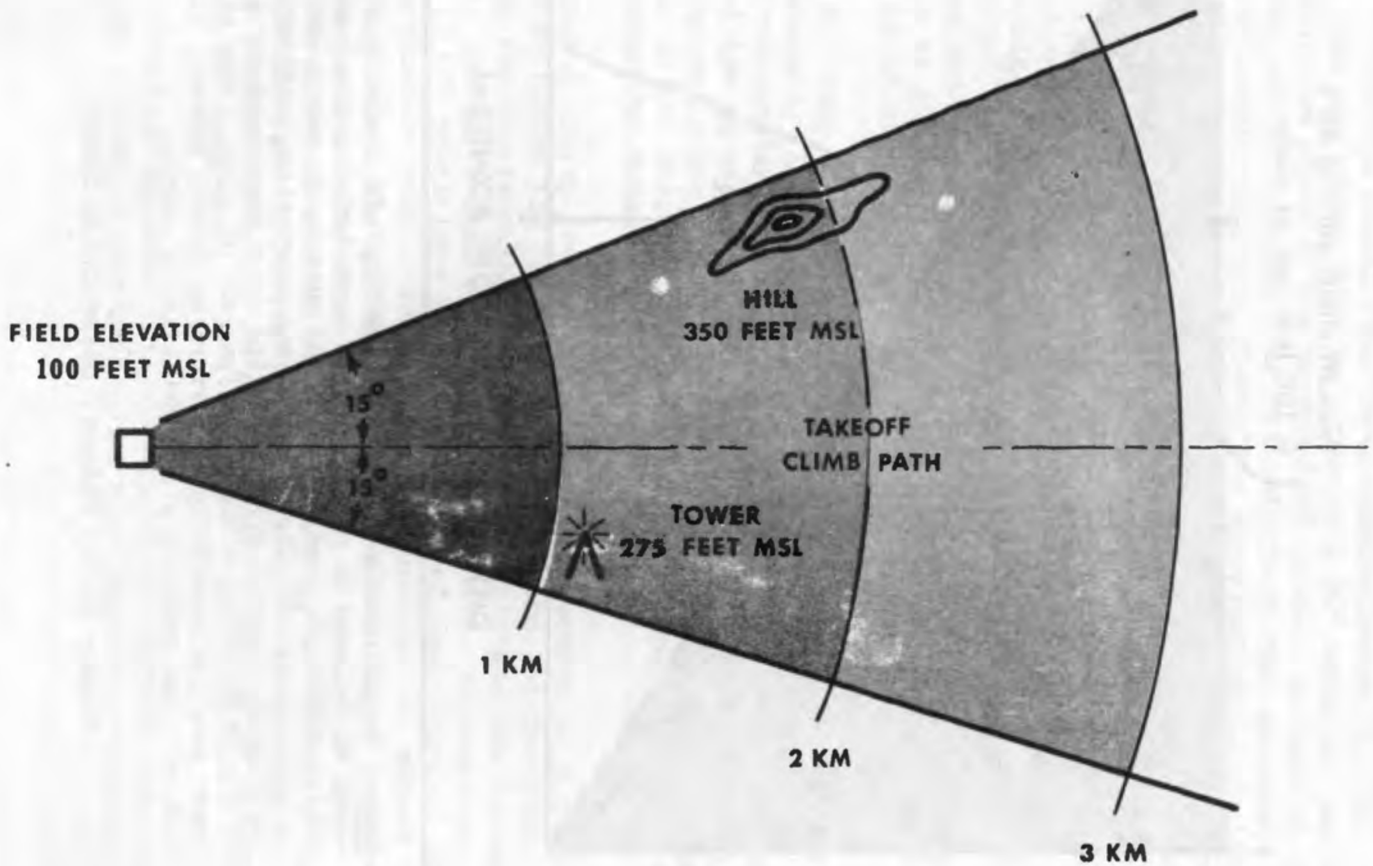
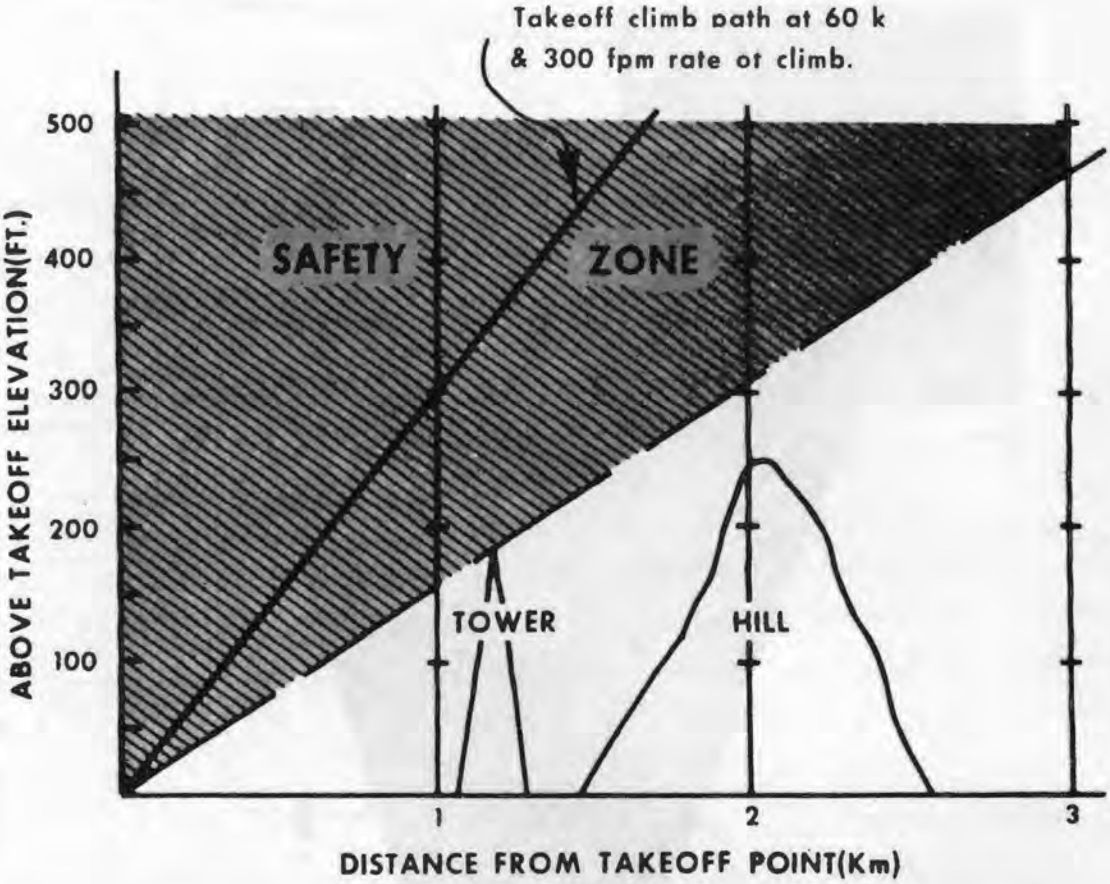


Figure 22-4. Takeoff planning.

be adjusted laterally to exclude all such obstacles, then consideration must be given to adjusting the rate of climb to insure obstacle clearance.



Note: Representative data charts for Army helicopters are provided in Appendix E. This chart is constructed from representative data to be used as a planning guide only, and is not to be substituted for pilot judgment and appropriate publication performance charts. The line on the chart represents the line of flight at 60 knots and a 300 fpm rate of climb. Army aircraft have the capability of performing better; however, this rate of climb provides a reasonable safety margin.

Figure 22-5. Takeoff obstruction chart.

Execution:

NOTE

> The chart in figure 22-5 is presented solely as an aid in visualizing how obstacle clearance affects takeoff planning in the climb safety zone. It should be used only as a planning guide and should not be substituted for pilot judgment and using the appropriate technical reference publications and performance charts for the specific aircraft.

Instrument takeoff (ITO) technique for tactical flight differs only slightly from normal procedures. Before takeoff, the pilot must check his hover power and go-no-go limitations. Due to the nature of the takeoff, location, and limited navaids, climbs should be made as quickly as power permits. Initially, the pilot will use 5 pounds torque above that required to hover; then, after the climb is established and airspeed is increased, use maximum rates of climb as described in appropriate performance charts. During the takeoff, 60 kt IAS is a suitable airspeed to be used until the en route altitude is reached.

There are two primary reasons for using 60 kt IAS during the climb:

- At slower airspeeds, less terrain is covered during the climbing maneuvers. This is important because of the limited area of protected airspace around the takeoff point.

- This airspeed also offers an average optimum airspeed for climb performance.

When an altitude of 100 feet above the highest obstruction (minimum obstruction clearance altitude - MOCA) in the 6 km clearance zone is obtained, the pilot can turn to intercept the desired en route course. The method he uses to intercept the course may be varied with experience, but the following are general guidelines for this procedure (fig. 22-6):

- When takeoffs are made on headings within 90° of the en route course, a direct turn to the en route course heading will be made after reaching MOCA. Planning for winds, magnetic deviation, and variation will allow the pilot to remain well within the limits of the planned course over short distances even without

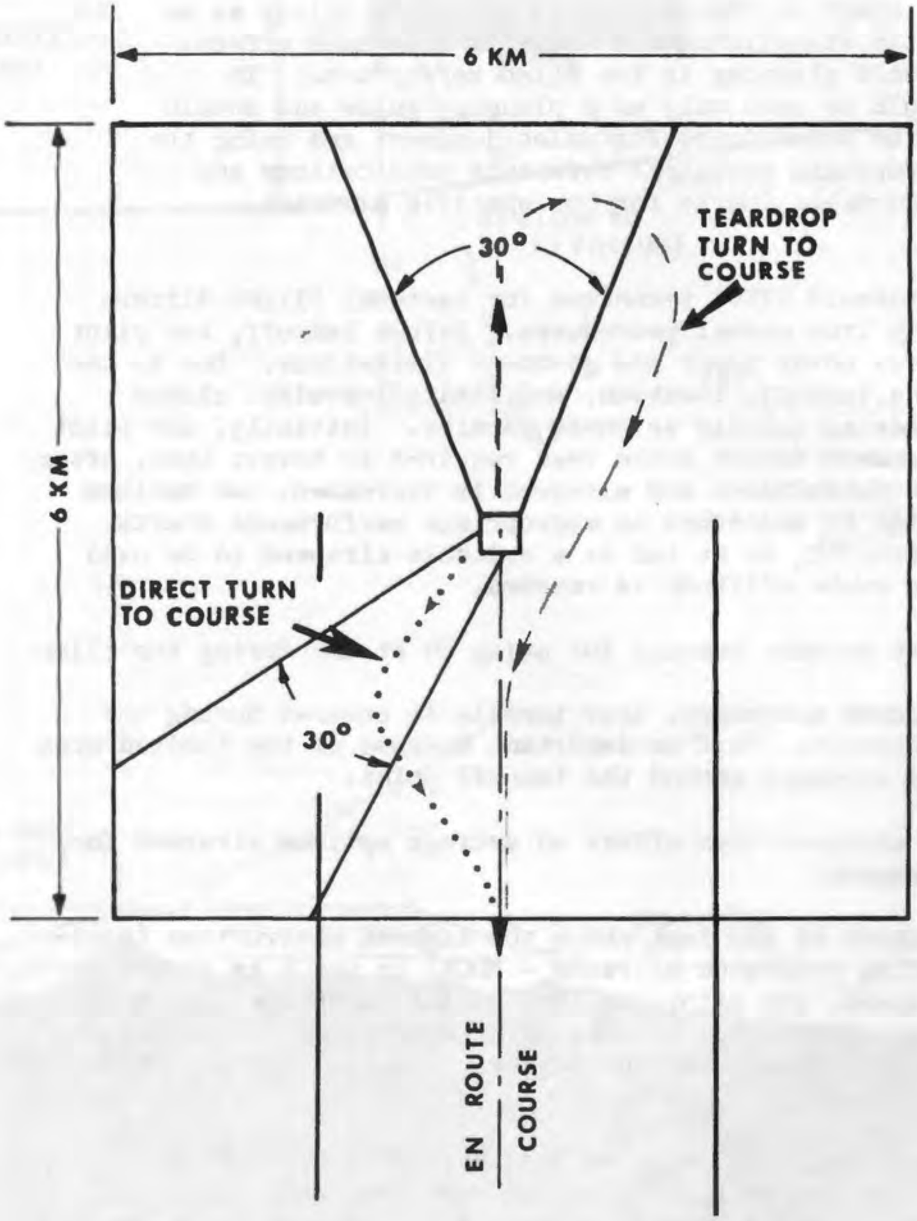


Figure 22-6. Takeoff to intercept en route course.

receivable navaids. Pilots should try techniques of dead-reckoning navigation to build confidence in this method during VFR conditions before attempting actual IFR. If a navaid is present at the takeoff point, standard tracking procedures should be used to intercept and track outbound on the en route course.

- If a takeoff is to be made more than 90° from the en route course heading, a teardrop turn may be used to reverse the direction and establish the course heading. During the takeoff, time the climb to the MOCA, and then execute a 210° turn. Fly this heading, continuing climb to the en route altitude if necessary, for the same amount of time required to climb to MOCA, then turn to course. This turn should be made into the wind if a takeoff is made with a crosswind component to reduce the terrain covered during the turn. This procedure is much like a teardrop turn used in holding pattern entry and will place the aircraft at altitude generally over the takeoff point where the en route course can be established. If a navaid is at the takeoff point, use standard tracking procedures to return to the beacon and track outbound on the desired en route course.

(3) Approach planning.

(a) Corridor approach (fig. 22-7). This approach is used when a secondary beacon (L) is available to provide intersection information along the course line prior to reaching the en route course beacon. The main advantage of this approach is that it can be planned and executed at any location along the course line between (R) and (L) provided that a secondary beacon (L) is available. Through the use of the two beacons, the letdown and approach can be executed at a location where it is otherwise impossible or impractical to position a terminal beacon for tactical or geographical reasons.

Step 1 - Complete en route planning steps.

Step 2 - Determine the location along the course between the reliable reception point (R) and the beacon (L) where the letdown and approach are to be made.

Step 3 - Plot the location of the secondary beacon (L). Due to the low en route altitude (400 feet AHO) and its effect on signal reliability, the secondary beacon must be positioned within a reliable reception distance of the en route course. Since reliable reception is desirable prior to reaching the planned

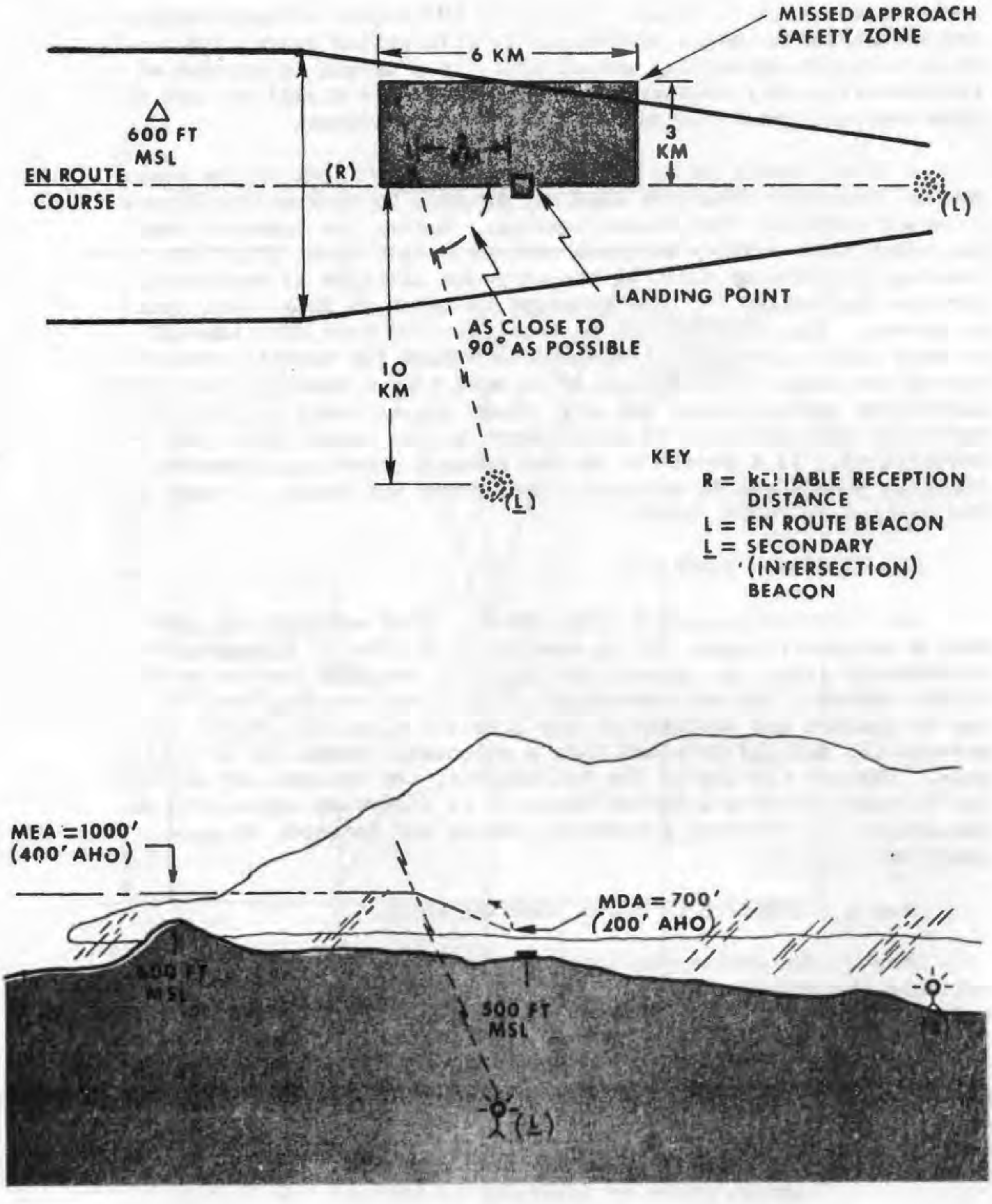


Figure 22-7. Corridor approach.

letdown point, the secondary beacon should be no more than approximately 10 km from the corridor letdown and approach point.

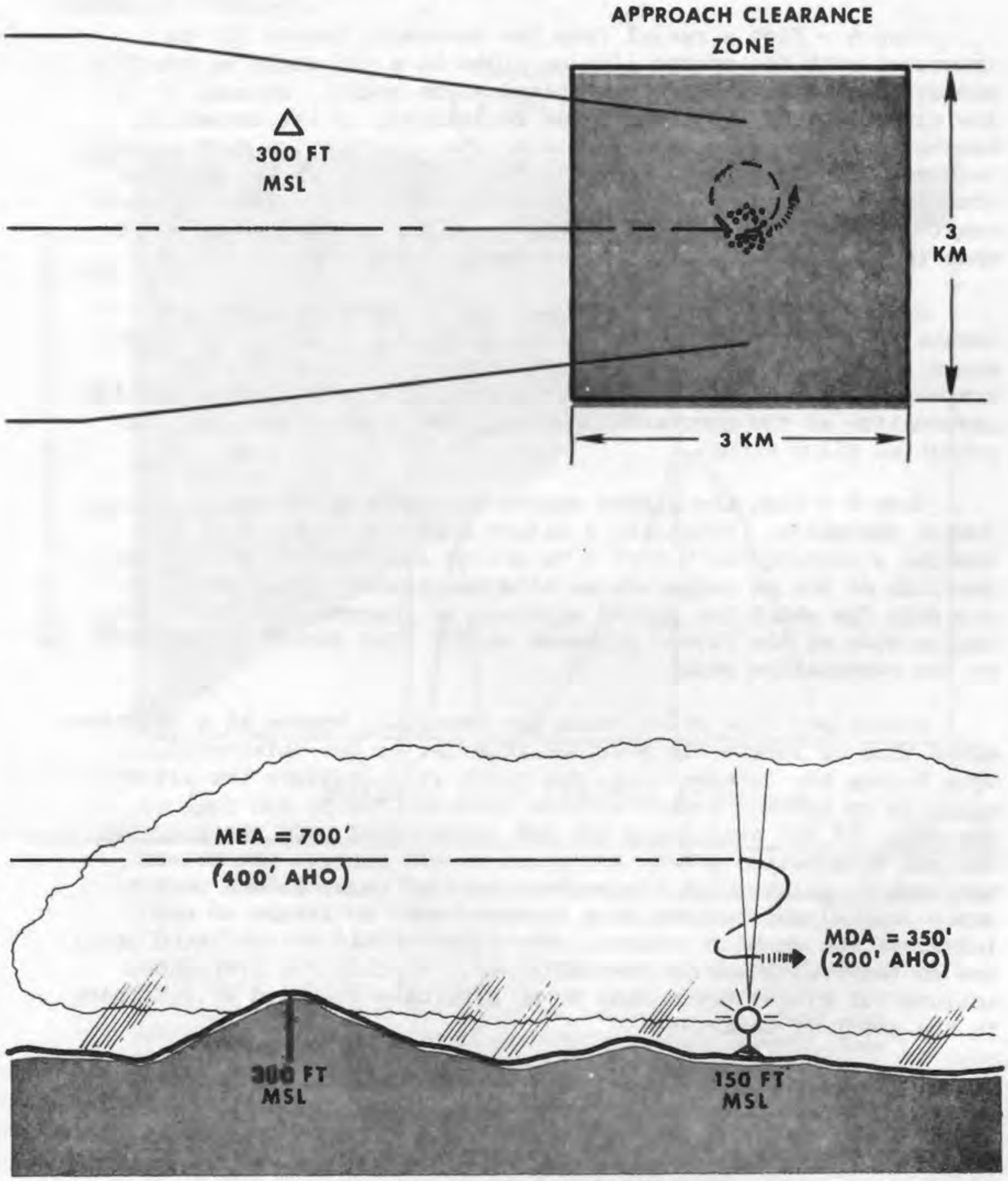
Step 4 - Plot a radial from the secondary beacon (L) to intersect with the course line as close to a 90° angle as possible and at least 2 km short of the termination point. Because of the low altitude and potentially weak reliability of the secondary beacon, a 90° angle will make fixing the intersection more accurate because of the smaller ADF needle fluctuations. At the approach airspeed of 60 kt and rate of descent of 200 to 300 fpm, the aircraft will arrive at the MDA after traveling approximately $1\frac{1}{2}$ km when the approach is initiated at the intersection.

Step 5 - Study the area around the termination point and locate the highest obstacle. Once the highest obstacle is determined, add 200 feet; this altitude becomes the MDA. The MDA compensates for altimeter error, lack of current altimeter setting information at the approach location, vegetation elevation, and potential pilot error.

Step 6 - Plan the missed approach to take advantage of the lowest obstacles. Establish a missed approach safety zone by drawing a rectangular 6 km x 3 km missed approach safety zone on the side of the en route course with the lowest obstacles or on the side for which the missed approach is planned. The en route course side of the missed approach safety zone should be centered on the termination point.

Execution: The pilot tunes the secondary beacon at a predetermined time to locate his position relative to the intersection. Upon fixing the intersection, the pilot will initiate the letdown using 60 kt IAS and a slow rate of descent (200 to 300 fpm) to the MDA. If VFR conditions are not encountered upon reaching the MDA and termination point, the pilot should execute the missed approach by climbing at the maximum rate of climb (check performance charts) and turning at a standard rate to return to and intercept the en route course. The climb should be continued until the en route altitude is reestablished. Execute the preplanned actions for either proceeding to an alternate location or returning to the point of departure.

(b) Spiraling approach (fig. 22-8). This approach uses a beacon at the letdown or approach point and requires a minimum of planning.



NOTE: INCREASE THE SIZE OF THE APPROACH CLEARANCE ZONE 1 KM FOR EACH ADDITIONAL 200 FEET OF ALTITUDE FROM WHICH THE APPROACH IS BEGUN.

Figure 22-8. Spiraling approach.

Step 1 - Complete necessary en route planning steps.

Step 2 - Plot an approach clearance zone with the terminal beacon at the center. The approach clearance zone should be a square with sides of 3 km x 3 km when en route altitude is 400 feet AHO. Thereafter, the size of the approach clearance zone should be increased by 1 km for each additional 200 feet of altitude to a maximum size of 6 km x 6 km.

Step 3 - Determine the MDA by studying the map for the highest obstacle within the approach clearance zone. After elevation of the highest obstacle has been determined, add an additional 200 feet and the resulting altitude will become the MDA. The lowest descent altitude (200 feet AHO) compensates for both altimeter error and lack of current altimeter setting (failing to determine current altimeter setting prior to takeoff). However, the study of the approach clearance zone should be accomplished with utmost care, since room for error is marginal.

Execution: The pilot will track inbound to the terminal beacon en route, taking care to compensate for even the smallest perceptible deviations from course line. Upon indication of station passage, the pilot will:

1. Immediately reduce power to approximately 10 lbs torque (preparatory to attaining a descent speed of 60 knots).

2. Simultaneously begin a turn (left or right) utilizing a 20° angle of bank and continue to decelerate to 60 kt indicated airspeed.

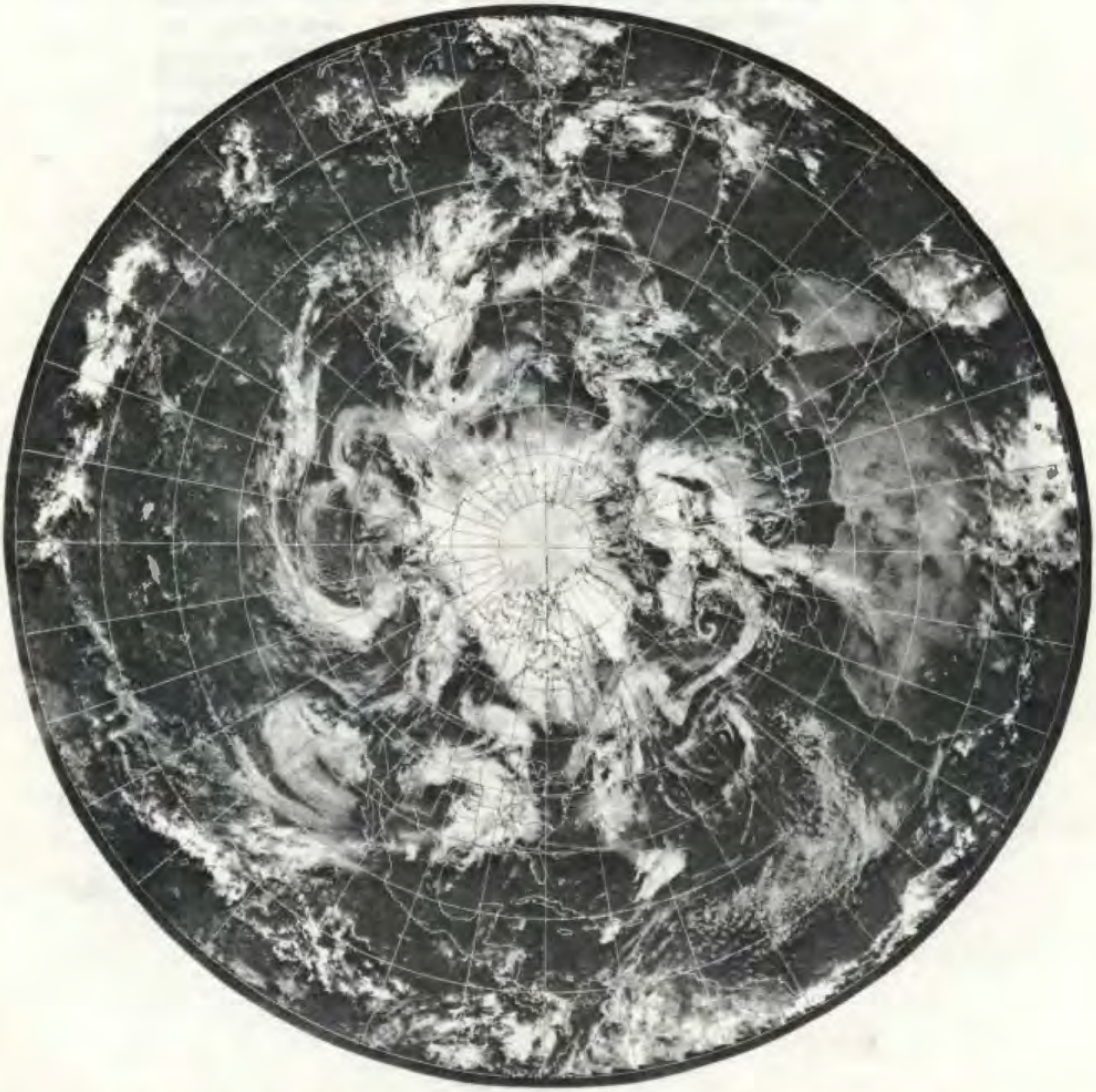
3. Establish descent at 300 fpm.

The copilot will perform a prelanding check and notify the pilot when approaching his MDA. The pilot will continue the descent and turn and, upon establishing VFR conditions, will immediately descend to NOE altitudes and adjust his airspeed as necessary. If VFR conditions are not established before or upon reaching the MDA, the pilot will continue the turn and apply power as necessary to achieve a 500 fpm rate in a spiraling climb. The climbing turn will be continued until reaching en route altitude at which time the pilot will roll out on the reciprocal of his en route heading and reestablish his course outbound.

The spiraling approach may be made using FM homing during an emergency situation when either the navaid or the onboard ADF becomes inoperative or unreliable. Using FM homing, the spiraling approach should be initiated whenever the pilot determines (as close as possible) that station passage has occurred. After station passage, the spiraling approach is executed as described previously. Missed approach procedures require that FM homing be used to return to a VFR condition or a rear location where a more reliable navigational aid is available.

Even in winds as adverse as 35 knots and descents from as much as 1,000 feet, the diameter of the spiral will not exceed 1,000 meters and the spiral will not be displaced from the beacon by an appreciable amount. However, the pilot should be aware that 60 kt and 20° angle of bank controls the radius of the spiral and should be strictly adhered to. Additionally, the pilot should perform the deceleration, turn, and reduction of power as simultaneously as possible.

FM 1-30
METEOROLOGY FOR ARMY AVIATORS



HEADQUARTERS, DEPARTMENT OF THE ARMY

Meteorolgy

INTENTIONALLY
LEFT
BLANK

FIELD MANUAL)
)
No. 1-30)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C., ____ 19__

METEROLOGY FOR ARMY AVIATORS

This manual supersedes TM 1-300, 10 June 1963, including all changes.

LOCATION IDENTIFIERS AND TYPE OF REPORT	SKY AND CEILING	VISIBILITY WEATHER AND OBSTRUCTION TO VISION	SEA LEVEL PRESSURE	TEMPERATURE AND DEW POINT	WIND	ALTIMETER SETTING	RUNWAY VISUAL RANGE	CODED PIREPS
MKC	15SCT M25OVC	1R-K	132	/58/56	/1817	/993/	R04LVR20V40	/OVC55

Figure 11-18. Key to aviation weather report.

11-11. Sky condition and ceiling.

a. Sky condition. The sky condition is transmitted after the station identifier. Standardized contractions (fig. 11-19) indicate the amount of sky covered by clouds or the amount obscured by surface-based phenomena.

CONTRACTION	NAME	AMOUNT COVERED OR OBSCURED
CLR	CLEAR	LESS THAN .1 COVERED
SCT	SCATTERED	.1 THRU .5 COVERED
BKN	BROKEN	.6 THRU .9 COVERED
OVC	OVERCAST	OVER .9 COVERED
-X	PARTIAL OBSCURATION	LESS THAN 1.Ø OBSCURED
X	SKY OBSCURED	1.Ø OBSCURED

A MINUS (-) SIGN PRECEDING A CONTRACTION (-SCT, -BKN, OR -OVC) INDICATES THE LAYER IS THIN.

Figure 11-19. Sky condition contractions.

(1) Heights with contractions. Sequence reports contain the height of the base of each cloud layer (measured in hundreds of feet AGL) that is indicated by a sky condition contraction. The cloud layers are encoded in ascending order. The base precedes the appropriate sky condition contraction. Various encoded sky conditions and interpretations are shown in figure 11-20.

REPORTED AS	INTERPRETED
2ØSCT	TWO THOUSAND SCATTERED
5-BKN	FIVE HUNDRED THIN BROKEN
12ØOVC	TWELVE THOUSAND OVERCAST
25ØSCT	TWO FIVE THOUSAND SCATTERED
5SCT 1Ø-OVC	FIVE HUNDRED SCATTERED, ONE THOUSAND THIN OVERCAST

aavn1229

Figure 11-20. Encoded sky conditions and interpretations.

(2) Amount of sky cover. The sky coverage is accumulative in the sequence reports; i.e., each sky coverage contraction (fig. 11-19) represents the total coverage at and below the reported cloud deck. (Only those clouds visible from the surface can be reported.) The amount of sky cover designated by successive contractions at a station will either remain the same or show an increase in ascending layers. The amount of sky coverage will never decrease vertically; i.e., a report may appear as 12SCT 25SCT 55-BKN 250-OVC, but never as 12-OVC 25-BKN 55SCT 250SCT.

(3) Obscuration (X) and partial obscuration (-X). When obscuring phenomena such as fog, haze, smoke, dust, and the several forms of precipitation exist at the surface, the sky may be either totally or partly obscured.

(a) An obscuration (X) is reported 10/10 of the sky is hidden by surface-based obscuring weather phenomena. In this situation, the limit of the observer's vertical visibility over the point of observation is reported as the ceiling height. The obscuration may be reported as 0X, 2X, 10X, etc. (interpreted as ceiling zero, sky obscured; ceiling 200 feet, sky obscured; ceiling 1,000 feet, sky obscured). Thus the altitude indicated with an obscuration is the vertical visibility into the obscuration, not the height to the base of the obscuration.

(b) When the sky is only partly obscured by surface-based weather phenomena (less than 10/10), a partial obscuration (-X) is reported. Since partial obscurations do not restrict the vertical visibility over the point of observation, any cloud layers observed above the partial obscuration are reported after the -X. The heights of the cloud bases and ceiling, if any, are reported, but the -X is not preceded by an altitude figure.

(c) Weather conditions producing partial and total obscurations are based on the surface and restrict the horizontal visibility, whereas cloud layers (SCT, BKN, AND OVC) have definite bases above 50 feet and do not directly affect the horizontal surface visibility.

b. Ceiling. The ceiling is the lowest condition reported as BKN, OVC, or X that is not prefixed by a minus (-). A thin cloud layer or a partial obscuration is never a ceiling. When a ceiling is reported in sequence reports, the method by which the ceiling was determined or classified must precede the height of the contraction (BKN, OVC, X) which appears as the ceiling layer. The letters used as ceiling classifiers are shown in figure 11-21.

CEILING CLASSIFIERS

E ESTIMATED

M MEASURED (NORMALLY WITH A CEILOMETER)

W INDEFINITE (USED WITH OBSCURED CONDITION)

FORM	INTERPRETATION
2ØSCT M5ØBKN	TWO THOUSAND SCATTERED, MEASURED CEILING FIVE THOUSAND BROKEN
-XE8OVC	SKY PARTIALLY OBSCURED, ESTIMATED CEILING EIGHT HUNDRED OVERCAST
W5X	INDEFINITE CEILING FIVE HUNDRED, SKY OBSCURED
28SCT 5Ø-BKN E25ØBKN	TWO THOUSAND EIGHT HUNDRED SCATTERED, FIVE THOUSAND THIN BROKEN, ESTIMATED CEILING TWO FIVE THOUSAND BROKEN
4ØSCT 1ØØSCT E25ØOVC	FOUR THOUSAND SCATTERED, ONE ZERO THOUSAND SCATTERED, ESTIMATED CEILING TWO FIVE THOUSAND OVERCAST

Figure 11-21. Ceiling classifiers and examples of their use.

11-12. Visibility. The visibility is reported in statute miles after the sky condition contraction (with one space separation) indicating the greatest horizontal distance than an object of specified characteristics can be seen and identified. When restricted or irregular, the visibility may be reported by one or more of the following refinements.

a. Prevailing visibility. The prevailing is the greatest visibility that exists over half or more than half of the horizon. When the visibility varies in different quadrants from the point of observation, the prevailing visibility is reported. Variations from the reported prevailing visibility value are included at the end of the report (remarks section). The visibility may be variable at a station; if the prevailing visibility is varying between reportable values (b below) and less than 3 miles, the reported visibility value is followed by the letter V.

b. Reportable values. When the visibility is less than 3 miles, it is reported in miles and fractions of a mile. When the visibility is between 3 and 15 miles, it is reported to the nearest mile. When visibility exceeds the most distant marker used, the symbol "+" indicates visibility is greater than that being reported.

c. Runway visual range (RVR). Although the visibility or prevailing visibility will normally determine the type of flight plan to file, an aviator landing at a terminal under instrument conditions will find the runway visual range (RVR) to be the most reliable guide to visibility along the selected runway. RVR is the horizontal distance an aviator will see down the runway from the approach end. It is based upon the sighting of high intensity runway lights or upon the visual contrast of other sighting targets - whichever yields the greater visual range. Runway visual range is determined by an instrument called a transmissometer mounted beside the instrumented runway near the touchdown point. RVR has an advantage over the prevailing visibility because the high intensity lights can often be seen on the approach path even though the actual runway is not visible. Under IFR conditions, the RVR provides a more realistic value of the actual visibility existing at an airfield and is used as the basis for approach minimums in many cases. RVR systems are planned for all fully instrumented runways in the United States. RVR is reported in the remarks section of the hourly sequence report when it is 6,000 feet or less, and is given in hundreds of feet. For example, R28VR38 indicates that on runway 28 the runway visual range is 3,800 feet. R23VR30V indicates that on runway 23 the runway visual range is 3,000 feet variable.

NOTE: The RVR value shown in aviation weather reports represents a mean value and is shown for information only. It is not to be used for flight planning minimums.

11-13. Weather and obstructions to vision. Weather phenomena and obstructions to vision are reported by the use of letter symbols after the reported visibility (no space separation).

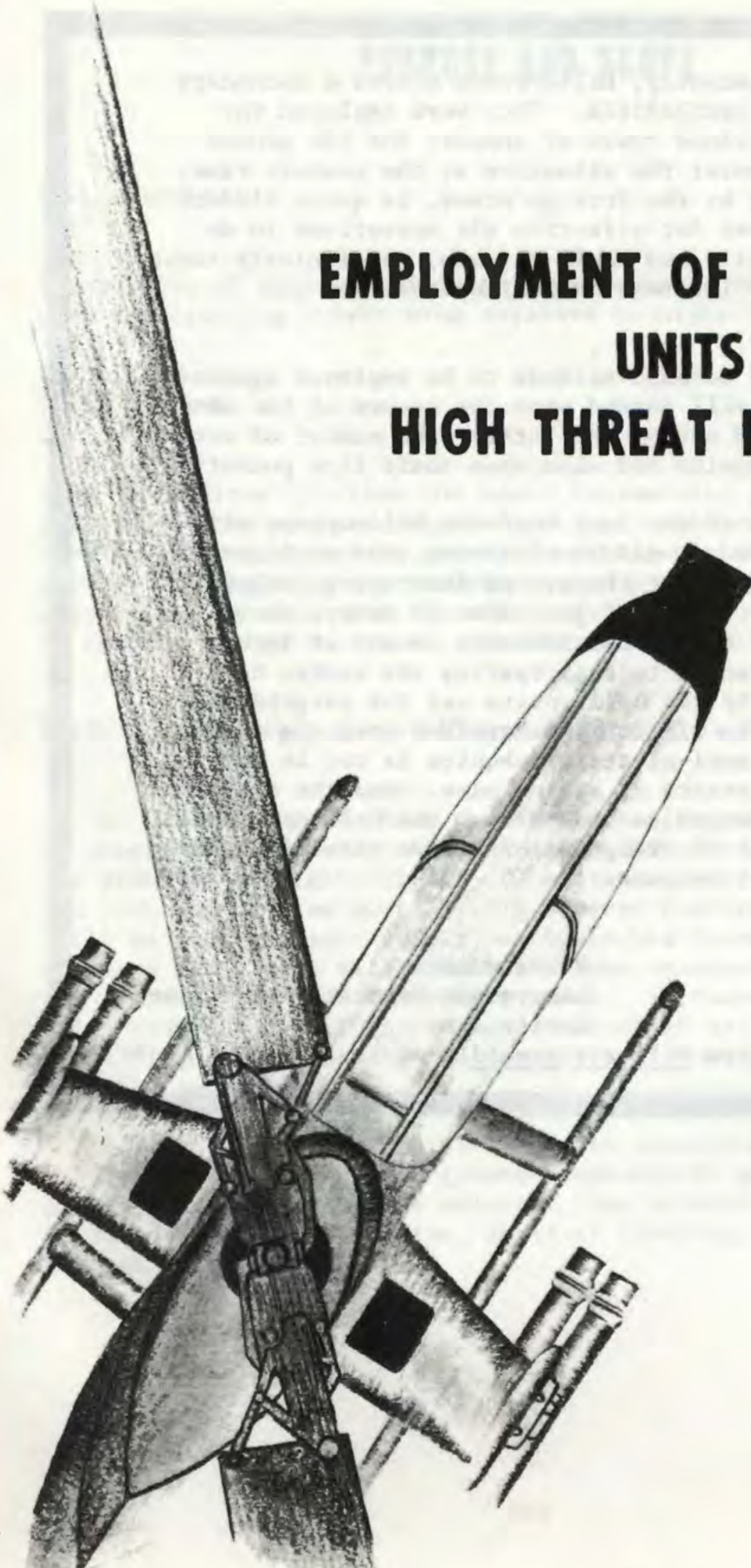
a. Weather elements. Atmospheric phenomena considered as weather elements in a report are tornadoes, waterspouts, funnel clouds, thunderstorms, and precipitation in any form. The letters used for reporting weather elements are shown in figure 11-22. These letters are used whenever the phenomena are occurring at observation time, regardless of their effect on visibility and ceiling.

NOTE: Intensities appear in the report as a suffix to the weather element. They are spoken as if they were a prefix (e.g., S- is light snow; R+ is heavy rain).

INTENTIONALLY
LEFT
BLANK

FM 90-1

EMPLOYMENT OF ARMY AVIATION UNITS IN A HIGH THREAT ENVIRONMENT



"Until recently, helicopters played a secondary role on the battlefield. They were employed for providing various types of support for the ground forces. However the situation at the present time, as borne out by the foreign press, is quite different. The need for effective air operations in destroying mobile and small targets, particularly tanks, has revived interest in helicopters. . . . .

. . . . .

"The air defense methods to be employed against helicopters will depend upon the nature of the actions carried out by the latter, the number of antiaircraft subunits and also upon their fire potential.

"In view of the fact that the helicopters will rarely be used at middle altitudes, the antiaircraft gunners must master the art of destroying targets flying at altitudes of just several meters above the ground. Here a considerable amount of importance is attached to anticipating the course to be followed by the helicopters and the targets of their strikes. If it is determined that the deployment of the anti-aircraft subunits is not in keeping with the interests of air defense, then the deployment should be changed to insure that the helicopters will appear within the range of effective fire of the PVO (air defense) weapons. . . . .

. . . . .

--V. Gatsolayev
Lieutenant General of Artillery
Soviet Army

"Extracted from Military Herald, No. 11, 1973, pp 65-70"

PREFACE

As its title indicates, this manual is intended to describe how Army aviation can make a major contribution to land combat in the high threat environment. In addition, it is designed to provide a broad doctrinal foundation for future publications which will be specifically oriented toward employment of type aviation units, operating as branch proponent elements. Even though certain units are singled out as examples, the concepts, tactics, and techniques discussed are generally applicable to all aviation units. To insure the applicability of our doctrine, the assistance of all Army aviation users was solicited, and representatives of the U. S. Army Armor School, Air Defense School, Artillery School, Transportation School, Intelligence School, and Aviation Center wrote the manual.

Because Army aviation is a member of the combined arms team, combined arms employment is stressed throughout this manual. Total integration of the broad spectrum of ground and aerial capabilities provides commanders a wide variety of tactical alternatives. The complexity of future battlefields indicates multiple solutions to demanding challenges will be required. In the final analysis the unique advantages aviation provides as part of the arms combination may well be the key to success.

To keep the manual unclassified, threat information contained in this publication is in some instances general, imprecise, and incomplete because of classification problems. By keeping the manual unclassified, we hope to promote dissemination and use at unit level. Where detailed, precise planning is required, authoritative threat sources should be consulted for actual, complete data.

You are encouraged to submit recommended changes and comments to improve the publication. Please key your comments to the specific page, paragraph, and line of text in which the change is recommended, and then explain each comment to insure understanding and complete evaluation. If possible, use a DA Form 2028 for your recommendations and forward them directly to Commander, U. S. Army Aviation Center, ATTN: ATZQ-D-CD, Fort Rucker, Alabama 36360.

INTENTIONALLY
LEFT
BLANK

TABLE OF CONTENTS

CHAPTER 3 CONCEPT OF OPERATIONS

Introduction

This chapter provides the combined arms commander with the principles of employing aviation units properly. Moreover, it describes what aviation units can do to increase the overall combat effectiveness of the combined arms team. A multiple approach is used. The principles are defined, the aircraft capabilities described, and mission profiles are provided. As a unifying concept, action-oriented scenarios provide the air and ground interface of major combat units in realistic combat situations on a future battlefield. Finally, an overview of aviation unit operations in a high threat environment are described for desert, tropic, mountain, and arctic warfare.

3-1 Principles of Employment

General

The principles of employment are basic guidelines for the tactical employment of Army aviation units to accomplish their objectives (CHAPTER 1) in a high threat environment (CHAPTER 2). The principles of employment are applicable to all aviation elements and units operating in the combat zone. They provide a guide for planning and executing tactical operations for not only air cavalry, attack, and assault units, but for combat support units as well. The principles of employment constitute a collection of commonsense ideas that must be understood in their entirety but that are not dogma to be rigidly applied. Their application must be carefully measured for each situation. More emphasis may be placed on one or more of the principles in any particular situation. The considered balance of these principles to meet successfully each specific situation is the aim of the military leader. BY FOLLOWING THE PRINCIPLES THE COMMANDER CAN ATTAIN OPTIMUM EFFECTIVENESS, MINIMIZE VULNERABILITY, AND MAXIMIZE SURVIVABILITY.

Figure 3-1. Building blocks for achieving aviation unit objectives.

In applying these principles, a continued awareness of the threat must be maintained. In fact, the particular threat existing in any given situation forms the base or foundation of knowledge necessary for the optimum application of the principles of aviation unit employment to achieve the commander's objective--tactical effectiveness 9fig 3-1).

Mere knowledge and understanding of the principles of employment will not provide the solution to every problem of war. The human elements - courage, morale, discipline, and leadership - have a direct bearing on the outcome of any operation and are so vital to success that they deserve constant attention. In the final analysis, sound judgment and commonsense are of vital importance to the successful application of the principles of employment.

Principles of Employment

- ★ **Fight integrated on the combined arms team**
- ★ **Exploit capabilities of other services**
- ★ **Capitalize on intelligence-gathering capabilities**
- ★ **Suppress enemy weapons and acquisition means**
- ★ **Exploit firepower**
- ★ **Exploit mobility**
- ★ **Integrate fire and maneuver**
- ★ **Employ surprise**
- ★ **Mass forces**
- ★ **Utilize terrain for survivability**
- ★ **Displace forward elements frequently**
- ★ **Maintain flexibility**
- ★ **Exercise staying power**

A discussion of important considerations to each principle of employment follows.

Fight Integrated on the Combined Arms Team

Aviation units must be an integral component of the combined arms team, for only through their full and continuous integration into the combined arms force will the helicopter's full combat potential be achieved. For the helicopter the density and sophistication of enemy air defense weapons systems will also require mutual support as offered by the separate capabilities of the various weapons systems. Furthermore, the firepower of one element reduces threats to the other, thus improving the survivability of all. The effectiveness of helicopters is improved by a closely knit teamwork of aviation and ground units that comes from training with each other. For the infantryman and tanker, the capabilities of aviation offer great assistance in achieving their portions of the overall mission. Thus the effectiveness of the total combined arms force is greater than the sum of its elements. Applying this principle to helicopter operations as a part of the combined arms team -- engaging at ranges which minimize their own vulnerability -- taking maximum advantage of terrain cover and concealment -- coordinating suppression with their movements -- operating around the clock and in adverse weather -- aviation units can contribute to the favorable outcome of the battle.

Additionally, aviation units must be closely integrated with air defense elements in the area of operation. This will help assure freedom of operation from enemy tactical aircraft, particularly those that may be equipped with new "look down - shoot down" radars and weapons.

Exploit Capabilities of the Other Services

The requirement for close air support has not diminished even though armed helicopters have become an integral part of the combined arms team. Attack helicopters perform traditional Army firepower tasks which in no way conflict or compete with tactical air support provided by other services. This support must be utilized to the maximum extent possible to aid in suppression, intelligence-gathering, reconnaissance, saturation of air defenses through jamming, electronic warfare and countermeasures, target location and acquisition, and in combined mutually supporting attacks. Just as the combined arms whole is strengthened by integrated combat action, increased survivability of Army aircraft and, thus, greater mission effectiveness of the combined arms team will be obtained by exploiting the capabilities of the other services.

Capitalize on Intelligence-Gathering Capabilities

Army aircraft have the ability to gather quantities of timely information of the enemy, weather, and terrain, and provide responsiveness equaled by no other intelligence-gathering means available to the ground commander. Observation helicopters can cover larger areas in less time than is possible by the use of ground means. If heavy vegetation negates aerial observation efforts, ground reconnaissance elements may be air-landed to collect the detailed information required. Aviation units use visual, photographic, and infrared means to conduct aerial reconnaissance and provide a battlefield capability through visual observation and radar coverage. Intelligence collection is enhanced by aerial deployment of ground surveillance, target acquisition, and night observation. Additionally, aircraft provide rapid evacuation of prisoners of war and captured documents from forward areas.

Radio direction-finding systems mounted on aircraft organic to Army Security Agency aviation units can provide a capability to detect and locate electronic emissions associated with enemy communications and noncommunications equipment.

Even individual aircraft not performing intelligence missions have the inherent capability of collecting intelligence information. This inherent capability of aviation can be exploited and the information collected as a byproduct of almost all flights over the battle area. Such information can be collected in post-flight crew debriefings and submitted to the proper intelligence agency. Therefore, continued emphasis is necessary to:

. . . Exploit the intelligence-gathering ability of organic and supporting aircraft which have high responsiveness, a wide ranging coverage of the battlefield, a unique point of view, equipment ideally suited for collection, and crewmembers who understand the enemy and the ground battle.

Suppress enemy weapons and acquisition means

The principle of suppression is to degrade the effectiveness of enemy combat power for a given period of time. Because of the forward employment of the ZSU-23-4, the ZSU-57-2, the SA-7's and SA-6's, aviation units cannot count on surviving on the battlefield if they expose themselves more than momentarily to weapons which are range effective and which have not been destroyed, suppressed, or obscured.

The principle of suppression requires that:

. . . Attacking elements are prepared to deliver overwatching suppressive fire at all times from carefully selected positions, and they move into and out of these positions with the least possible exposure.

. . . Supporting field artillery, overwatching Cobra TOW and AH-1G, assault helicopters and tanks, antitank-guided missiles and automatic weapons deliver suppressive fires to provide essential protection to those elements moving forward over the best covered routes.

. . . Maximum use is made of attack helicopters, friendly ground fire, artillery, and tactical air suppressive fire. This is mandatory in minimizing the effectiveness of the enemy's air defense.

. . . Unit commanders must be experts on the scope and nature of air defense suppression operations. They must plan and coordinate air defense suppression operations using all available assets or they will not receive effective support from aviation units or air elements of the other services.

. . . Enemy overwatch positions, direct and indirect fire weapons must be suppressed or obscured.

. . . The use of chaff and smoke will degrade the enemy's capability to optically or electronically acquire your aircraft.

. . . Use must be made of electronic countermeasures (ECM) to limit the effectiveness of enemy electronic warfare (EW) equipment.

Exploit Firepower

The commander is able to more fully exploit his firepower capabilities through the employment of Army aircraft to deliver area and point target fire, observe and adjust fires, position artillery and antitank teams, and provide timely ammunition resupply. The attack helicopter provides a standoff antitank, antibunker, antipersonnel weapon system which augments the commander's capability to deliver selective, responsive, accurate, and discriminating fires in the accomplishment of his mission. Through the use of the observation helicopter, the commander is provided with a highly mobile platform to acquire and designate targets and to adjust both his aerial and ground fires. By using the medium lift and utility helicopters to rapidly move towed artillery and to reposition ground antitank teams about the battlefield, the commander can maximize the efficiency of the employment of his ground firepower assets. Finally, Army aircraft provide the commander with the means to rapidly resupply ammunition throughout his area of responsibility to insure the continuous utilization of his firepower assets.

For the maximum firepower advantage the attack helicopter should:

. . . Fire fast and first in an attack helicopter-antitank battle. In such a duel - firing first with accuracy while minimizing exposure time is critical to avoiding destruction.

. . . Be integrated into the fire support and battle plans of the combined arms team.

. . . Be employed early as far forward in the battle area as possible.

. . . Fire weapons at maximum effective standoff range compatible with terrain.

. . . Engage the most eminent threat first.

Exploit Mobility

That quality or capability of military forces which permits them to move from place to place while retaining the ability to fulfill their primary mission is inherent in Army aviation units. Mobility is essential to apply maneuver to establish the concentration of forces or using the principle of mass. Because helicopters have a marked mobility differential over other members of the combined arms team, they provide the means for the commander to rapidly apply heavy, decisive combat power. The rapidity of helicopter movement over obstacles, the maneuver of helicopter firepower into position to engage the enemy, the rapid concentration and prompt dispersal of fire elements, and the ease of convergence on a single objective from several directions permit the employment of concentrated firepower on the objective as the maneuver element closes with the enemy. The inherent capability of the helicopter to overfly obstacles permits the assignment of multiple tasks to helicopter units and also permits their rapid redeployment to a more critical sector once committed.

Mobility through the use of aviation assets:

. . . Allows a gain of 5-to-1 equivalent force ratio over the enemy for an attack.

. . . Allows a gain of 20-to-1 equivalent force ratio over the enemy during exploitation.

Integrate Fire and Maneuver

This principle employs two common features of warfare -- a base of fire element and a maneuvering element. A base of fire is the element that restricts the enemy's ability to maneuver during the engagement. The maneuvering force is the element that attacks and destroys the enemy by fire. Their roles may be interchanged when the maneuvering force completes its task and becomes the new base of fire, while the old fire element becomes the new maneuvering force. Helicopters have both the firepower and the maneuverability to accomplish the mission. By maneuvering, the commander can dispose his force in such a manner as to place the enemy at a disadvantage and thus achieve results that would otherwise be more costly in men and materiel. By maneuvering, combat power is moved to provide the necessary mass at the proper time and place for mission accomplishment. Helicopters can also aid in positioning of military forces to accomplish the principle of fire and maneuver.

. . . One of the primary missions of the utility, medium and heavy lift helicopters is to give the ground force commander the ability to rapidly move both firepower and forces about the battlefield without regard to the tyranny of terrain. The firepower of the attack helicopter also offers the ground commander a capability of a system that exceeds any other at his disposal in maneuvering firepower quickly about the battlefield.

. . . Assault helicopter forces provide an excellent means for the commander to rapidly exploit assailable flanks before the enemy is able to reposition elements to fill the gap in his defenses.

. . . The unique fire and maneuver capability of attack helicopter units allows them to deny and dominate key terrain and major avenues of approach on the battlefield. The helicopter cannot hold ground but, with the heavy hitting power of its attack elements, can make the enemy pay too heavy a price to seize a given piece of ground. When driven from a terrain position by heavy enemy artillery fire, for example, the attack helicopter force still has the capability to rapidly shift to adjacent terrain and continue to cover by fire the ground it had previously occupied.

Employ Surprise

With their high mobility and ability to operate from front line locations, helicopters can strike the enemy when, where, and in a manner for which he is unprepared, thus using the principle of surprise. By using the speed, maneuverability, and firepower of the helicopter to aggressively attack the enemy at an unexpected time and from an unexpected direction, surprise is achieved. Terrain flying using concealment and cover, the maintenance of radio silence or deception, and around-the-clock capabilities are key factors in providing the element of surprise. Surprise is also accomplished through taking advantage of adverse weather.

Mass Forces

Combined arms forces must concentrate superior combat power at the critical time and place. This requires immediate, accurate intelligence, mobility, firepower, training, and effective decision making. Aviation units help achieve the principle of mass by being able to rapidly move combat power, by concentrating maneuver forces and firepower, and by rapid combat service support to gain an advantage over the enemy.

To accomplish the principle of mass, the following fundamentals must be observed:

. . . Early use of aeroscouts at the FEBA or area of contact to assist in rapid tactical commitment of attack helicopters upon decision by the commander.

. . . ATTACK HELICOPTERS SHOULD BE EMPLOYED IN LARGE NUMBERS AT CRITICAL POINTS. This means they will normally be committed by platoons, companies, and battalions in a series and recycled back into action as rapidly as they can be rearmed and refueled.

. . . Concentration of attack helicopters with antitank capability to destroy massed enemy tank forces.

Utilize Terrain for Survivability

Army combat aircraft in forward battle areas must use terrain flying in order to survive. Scout, attack, utility, and cargo helicopters must live and operate in an environment characterized by the enemy's use of sophisticated air defense weaponry. So effective are these systems that any target that can be seen or detected by the enemy can be engaged and destroyed. Aircraft must use the protection afforded by the terrain to conceal their movement to minimize exposure to direct fire weapons and air defense radar systems, and to deny the enemy intelligence concerning locations of friendly troops and installations. However, terrain flying is more than flying close to the ground. It involves utilizing the ground and vegetation for protection. Terrain flying down forward slopes will not necessarily afford protection against radars sensitive to moving targets or whirling rotors as in the case of the ZSU-23-4 radar. Normally, Army fixed-wing aircraft operate with a combination standoff range and minimum altitudes to insure survival and effectiveness; however, the situation may require over-the-hill reconnaissance capabilities peculiar to the OV-1. Such an effort would require a concerted operation involving electronic suppression, fire support, and air defense suppression.

Because of the threat:

. . . The first cardinal rule in minimizing vulnerability to enemy fire is proper use of concealment or cover.

. . . Exposed forces will be destroyed unless they effectively employ their weapons at maximum effective ranges and use terrain to reduce vulnerability.

> . . . Any part of the defense which can be seen by the enemy will be destroyed or suppressed. Every commander from squad to battalion must inspect his defenses from out front -- from the terrain from which the enemy's direct and indirect fire weapons will be brought to bear on his defenses. The same thought applies to the air. The commander must insure that his force is covered by air defenses so that every enemy tactical aircraft, especially those with "look down - fire down" capabilities are denied effective operations.

Displace Forward Elements Frequently

Because of the increased ability of potential enemies to acquire targets and the telltale signature of Army aircraft, such as their communication and navigation aids, commanders must expect that their aircraft will have only limited survivability if they remain static for extended periods of time. In fact, the closer to the FEBA a unit is located, the more vulnerable it is to early acquisition and destruction. The same probably will be true for forward area command posts frequented by aircraft - even those few used for command and control. Therefore, bivouac and refueling sites must be moved periodically and landing areas must be offset from unit locations and facilities to the maximum extent feasible. Hours rather than days will be the norm for how long such elements may remain in place.

In positioning aviation units on the high threat battlefield, commanders must not only displace elements frequently and properly utilize terrain but must also consider the maximum use of dispersion consistent with security and mutual support limitations. Because of the lucrative target presented by large aviation complexes, all aviation unit operations and trains facilities should be dispersed and positioned outside the range of enemy light and medium artillery when possible. Therefore, in most cases they will be located in the brigade rear area when functioning as part of the combined arms forces. Aircraft in static positions should be camouflaged to protect against detection by enemy aircraft.

In selecting positions for his aviation elements, the commander must consider factors such as command relationships, mutual support and security requirements, and mission, enemy, terrain, time and troops available.

Aviation units must generally be close enough to ground forces to permit rapid reaction and deployment with these units while receiving assistance in providing for local security. However, the principle of frequent displacement and wide dispersion in positioning aviation assets requires that:

. . . When requirements do not dictate that aviation units be positioned in the forward battle area, they should be located far enough to the rear to reduce the possibility of destruction by enemy artillery fire. Generally this should be beyond the reach of medium artillery fire.

. . . The size of aviation elements will also be a factor in determining the degree of dispersion needed to reduce the size of the target offered to enemy weapons. In addition, the farther forward elements are placed, the greater the degree of dispersion required consistent with the other factors of security and mutual support.

. . . Owing to the extended range of enemy weapons, forward area operations such as landing zones and forward refueling and rearming points (FARRP) must be dispersed and shifted frequently. Forward operational refueling and rearming between missions should be conducted in areas separate from bivouac areas and command posts. Frequency of use of any facility greatly increases the chance of detection and destruction.

. . . Consideration must be given to the use of dispersed, existing manmade structures such as tunnels, buildings, and bridges and natural terrain features to protect and camouflage aviation maintenance and other operations from enemy visual and electronic devices including satellites.

Maintain Flexibility

Mobile warfare requires flexibility in responding to rapidly changing situations on the battlefield. Helicopter units possess excellent means of communications, a high degree of mobility, and a variety of weapons that are ideally suited for operations in a mobile warfare environment. They can rapidly respond to changes in enemy attack formations and tactics. To fully exploit these capabilities, a commander must keep his troops, himself, and his superiors well-informed and must be able to rapidly adapt his plans to fit the overall combined arms mission. Use of mission-type orders provides the most flexible means of responding to rapidly developing situations and changing conditions that are characteristic of mobile warfare.

Exercise Staying Power

Staying power involves the capability to remain effective on the battlefield around the clock and in adverse weather conditions. While in the past aviators have been taught night flight and instrument flight, these capabilities generally have not been adapted to standard battlefield doctrine. True, night operations have been the exception, not the standard. Yet, hardware already exists for effective night flight and tactical instrument operations. Thus the intention and the requisite training are key for the establishment of true staying power. Once the intention is established, new hardware improvements will come along to enhance basic capabilities.

For example, while crewmembers, flying without the aid of night vision equipment, can perform many normal daytime duties with efficiency, they can gain marked increase in capabilities with night vision goggles and forward looking infrared (FLIR) equipment.

To exercise staying power there is a need for emphasis on:

. . . Individual crewmember and unit proficiency so as to be able to exploit the protection provided by flight during hours of darkness or limited-visibility conditions.

. . . Proper planning and maintenance procedures to sustain the vitality of tactical aviation operations providing quick-fix sites well forward of major maintenance facilities in rear areas. Modular part replacement expedites repair and return of aircraft to combat.

. . . Operations of aviation units on an around-the-clock basis to provide immediate response to requests for aerial fires and the movement of urgently needed troops and supplies.

. . . Operating in darkness or other conditions of reduced visibility in order to take advantage of the reduced range and accuracy of enemy observation and fire.

. . . The ability to fly during intermittent or sustained instrument flight conditions as required to remain combat effective longer.

. . . Control and distribution of antitank fires in order to kill targets rapidly, conserving ammunition to engage the next attacking echelon.

. . . Establishing mobile FARRP's within the forward battle area to reduce turn-around time and fuel consumption, thus increasing responsiveness, enhancing stamina, and reducing time spent away from the mission area.

. . . Insuring that all commanders and planners understand the requirements for maintenance, rearming, and refueling which have an impact on the helicopter's staying power. For example, if a given number of helicopters are required to defend a sector, it may take two to three times that number to insure continuous coverage while elements rotate through required maintenance, rearming, and refueling. Approximately one-third of the force will be committed at a given time with possibly a reduction in the size of the committed element when there is a lull in the action.

Summary

The principles of employment are designed to gain maximum tactical effectiveness and survivability as well as to get full measure from the capabilities of aircraft and personnel. Roles and missions of each Army aircraft will next be presented followed by realistic combat scenarios that portray the principles of employment.

The combined arms commander utilizes aviation resources to accomplish specific missions, thereby increasing the effectiveness of his force. Army aircraft are employed in a wide range of roles and operations. Listed below is a summary of those operations and the degree to which Army aircraft, as a part of the combined arms team, can contribute to the overall success of the mission (table 3-1). Also depicted are the major capabilities provided by Army aircraft and the significant limitations which impact on each individual type operation.

TABLE 3-1 AIRCRAFT EFFECTIVENESS CHART

OPERATIONS	EFFECTIVENESS				AIRCRAFT CAPABILITIES													AIRCRAFT LIMITING FACTORS									
TYPES OF OPERATIONS FOR ARMY AIRCRAFT PERFORMING MISSIONS IN COMBINED ARMS OPERATIONS	DEGREE OF AIRCRAFT EFFECTIVENESS: OPTIMUM	EFFECTIVE	MARGINALLY EFFECTIVE	NOT EFFECTIVE	RAPID MOBILITY	HIGH VOLUMES OF FIRE POWER	TANK KILLING AT STANDOFF RANGES	RECONNAISSANCE AND INTELLIGENCE	SECURITY	RESPONSIVE LOGISTICAL SUPPORT	ECONOMY OF FORCE	AIR DEFENSE SUPPRESSION	COMMAND AND CONTROL	DOMINATE, DENY, AND COVER KEY TERRAIN	BYPASS RESTRICTIVE TERRAIN & OBSTACLES	FIRE ADJUSTMENT	MEDICAL EVACUATION	REQUIRES TAC AIR AND AIR DEFENSE SUPPRESSION	RESTRICTED COMMO BECAUSE OF TERRAIN FLIGHT AND ENEMY EW	ADVERSE WEATHER	LACK OF NIGHT VISION DEVICES	LACK OF ENDURANCE	AIRCRAFT LOAD RESTRICTIONS	VULNERABILITY OF FORWARD ELEMENTS TO ARTILLERY	HIGH VOLUMES OF LOGISTICS SUPPORT	LACKS AIRCRAFT SURVIVABILITY EQUIPMENT	LACKS TARGET ACQUISITION AND DESIGNATION EQUIP
OFFENSE:																											
MOVEMENT TO CONTACT	X				3	3	3	3	3	3	3	2	3	3	3	3	3	1	0	0	0	0	1	1	0	0	0
RECONNAISSANCE IN FORCE	X				3	3	3	3	3	3	3	2	3	3	3	3	3	1	0	0	0	0	1	1	0	0	0
COORDINATED ATTACK		X			3	3	3	2	2	3	2	2	2	2	3	3	3	0	0	0	0	1	0	0	0	0	0
EXPLOITATION	X				3	3	3	3	3	3	3	2	3	3	3	3	2	1	0	0	0	0	0	1	0	0	0
PURSUIT	X				2	3	3	3	3	3	3	2	3	3	3	3	3	1	0	0	0	0	0	1	0	0	0
NIGHT ATTACK			X		3	2	1	1	1	1	1	1	1	1	3	1	3	0	0	0	0	1	1	0	0	0	0
INFILTRATION		X			3	3	3	2	2	2	3	2	2	3	3	3	3	0	0	1	0	0	0	1	0	0	0
COVERING FORCE		X			3	3	3	3	3	3	3	2	3	3	3	3	3	0	0	0	0	0	0	1	0	0	0
DEFENSE:																											
AREA DEFENSE		X			3	3	3	2	2	3	3	2	3	3	3	3	3	0	1	0	0	1	0	0	0	0	0
MOBILE DEFENSE		X			3	3	3	3	3	3	3	2	3	3	3	3	3	0	1	0	0	1	0	1	0	0	0
RETROGRADE:																											
WITHDRAWAL		X			3	3	3	3	2	3	3	2	3	3	3	3	3	1	1	0	1	2	1	1	1	0	0
DELAY		X			3	3	3	3	2	3	3	2	3	3	3	3	3	0	0	0	0	1	0	1	0	0	0
RETIREMENT	X				3	3	3	3	3	3	3	/	3	3	3	3	3	2	2	1	2	2	1	2	1	2	2
RELIEF OPERATIONS:																											
PASSAGE OF LINES		X			2	2	1	1	2	3	/	2	3	2	3	1	2	0	1	1	1	2	1	0	1	1	0
SPECIAL OPERATIONS:																											
AMPHIBIOUS OPERATIONS		X			3	3	3	2	2	3	3	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
LINK-UP OPERATIONS			X		3	3	3	2	2	3	3	2	3	3	3	3	3	0	0	0	0	0	0	1	0	0	0
RAIDS - SPOILING ATTACKS		X			3	3	3	3	2	2	3	2	2	3	3	3	3	1	1	1	1	2	2	1	1	1	1
DECEPTION, FEINTS, DEMONSTRATIONS AND RUSES		X			3	3	3	3	3	3	3	2	3	3	3	/	3	0	0	0	0	0	0	0	0	0	0
AIR ASSAULT OPERATIONS	X				3	3	3	3	3	3	3	2	3	3	3	3	3	0	0	0	0	1	0	0	0	0	0
COMBAT AT RIVERLINES		X			3	3	3	3	3	3	3	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
COMBAT AGAINST FORTIFIED AREAS				X	3	3	3	1	1	1	1	1	1	1	3	1	1	2	2	1	1	1	1	2	1	2	2
CIVIL DISTURBANCES/POPULACE CONTROL		X			3	/	/	3	3	3	3	/	3	/	3	/	3	1	1	1	0	1	1	1	1	1	1
STABILITY OPERATIONS		X			3	3	3	3	3	3	3	2	3	3	3	3	3	0	1	0	0	1	1	1	0	0	0
RIVERINE OPERATIONS		X			3	3	/	3	3	3	3	2	3	3	3	3	3	1	1	0	0	1	1	1	1	1	1
UNCONVENTIONAL WARFARE	X				3	3	3	3	3	2	3	2	3	3	3	3	3	1	1	1	0	1	0	2	1	0	1
ANTI-AIRBORNE OPERATIONS		X			3	3	3	3	3	3	3	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
HELICOPTER VERSUS ARMOR	X				3	3	3	3	3	3	3	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
HELICOPTER VERSUS INFANTRY	X				3	3	/	3	3	3	3	2	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
HELICOPTER VERSUS MODEST AIR DEFENSE		X			3	3	/	3	3	2	3	2	3	3	3	3	2	0	0	0	0	0	0	0	0	0	0
ATTACK OF BUILTUP AREAS			X		3	3	3	3	3	3	2	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0
OPERATIONS IN NBC ENVIRONMENT		X			3	3	3	3	3	3	3	2	3	3	3	3	2	1	1	0	1	0	1	0	0	0	0
SEARCH AND RESCUE OPERATIONS	X				3	3	3	3	3	/	3	2	3	3	3	3	2	0	0	0	0	0	0	1	2	0	1
PSYCHOLOGICAL OPERATIONS		X			3	3	/	3	3	/	3	2	/	3	3	3	2	1	1		1	1	1	2	1	1	1

(1) AIRCRAFT CAPABILITIES

3 - OPTIMUM

2 - EFFECTIVE

1 - MARGINALLY EFFECTIVE

0 - NOT EFFECTIVE

(2) AIRCRAFT LIMITING FACTORS

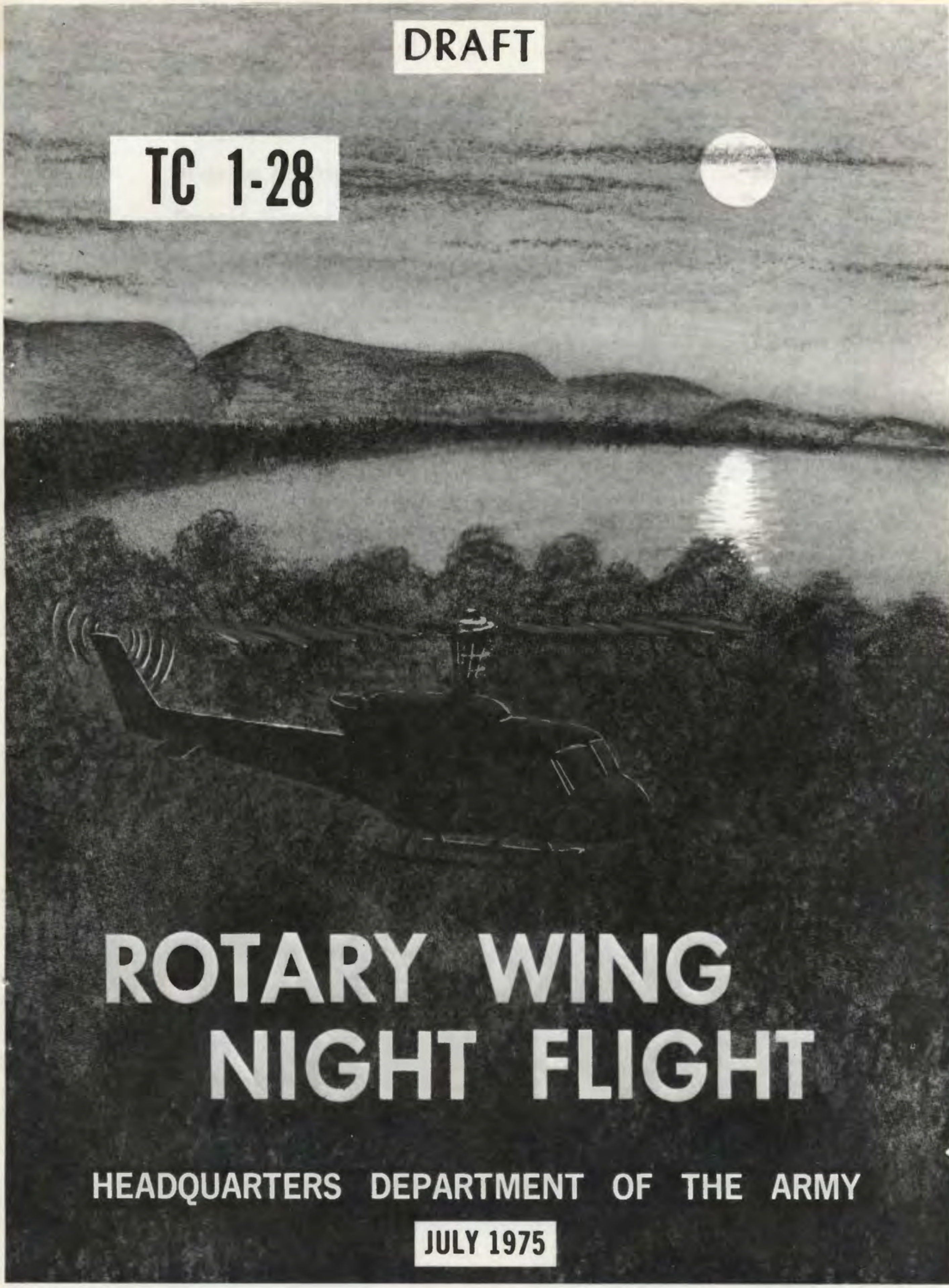
0 - MAJOR

1 - MINOR

2 - NONE

From the preceding table, it can be seen that the significant capabilities of Army aviation units outweigh the limitations. Even in those operations identified as not being ideal for employment of Army aviation units, Army aircraft can provide to the combined arms team commander an important segment of the firepower, mobility, and staying power available to him. Thorough planning, innovation, imaginative execution and comprehensive training in conjunction with proper utilization of the principles of employment outlined earlier will reduce the effects of these limitations. Equipment presently in the developmental process and future technological breakthroughs promise to reduce these limitations even further. However, threat changes and advancements in enemy capabilities will continue to make both the capabilities and limitations variables in the combat success equation.

INTENTIONALLY
LEFT
BLANK



DRAFT

TC 1-28

ROTARY WING NIGHT FLIGHT

HEADQUARTERS DEPARTMENT OF THE ARMY

JULY 1975

Night Flight

INTENTIONALLY
LEFT
BLANK

PREFACE

History reveals that discoveries made by world explorers have resulted from their perseverance in overcoming the fear of the unknown. Christopher Columbus is an example of such an explorer. Fear of what would be encountered on his journey to America dominated his subconscious; however, his vision of discovery and how it would affect the world compelled him to explore the unknown. This analogy describes the present thinking of many of our Army aviators relating to night nap-of-the-earth (NOE) flight. A new horizon confronts Army aviators and it must be explored. In past conflicts the ground commander has used his night airmobility sparingly; however, wars of the future will require extensive employment of night airmobile forces. To assist the commander in the accomplishment of his mission, the Army aviator must be prepared to conduct night tactical operations. Because the enemy has more sophisticated air defense weapons, the helicopter is forced to fly lower to the ground. This technique allows the aviator to take advantage of vegetation and terrain obstacles to mask the helicopter from the enemy's radar. Through training, the aviator can develop confidence in his ability to conduct night low-level operations and overcome the fear of the darkness. His imaginative and innovative solutions to solve problems which are created by the darkness will contribute to the success of night low-level operations. To stereotype the tactical employment of Army aviation assets is to court defeat, but to develop effective countermeasures against the air defense threat is to remove a principal obstacle to the commander's victory.

INTENTIONALLY
LEFT
BLANK

TRAINING CIRCULAR)
)
No. 1-28)

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, D.C. ________ 19__

ROTARY WING NIGHT FLIGHT

INTENTIONNALY
LEFT
BLANK

CHAPTER 1

PURPOSE AND SCOPE

1—1. Purpose

The purpose of this manual is to provide basic information to be used for training rotary wing aviators in night flight.

1—2. Scope

This publication provides the basic fundamental principles required for night transition and related subject material which the aviator must have knowledge of in order to effectively develop his flying skills. It explains the techniques and procedures of night rotary wing flight in depth and of sufficient detail to train an aviator to conduct night, low-level, contour, and NOE flight.

1—3. Psychological and Physiological Conditioning

a. During the training phase, precautions should be undertaken to assure the psychological readiness of the aviator to cope with the problems of night flight. To achieve a positive mental state, the training program must instill aviator confidence in his own skill to conduct night flight, motivate his interest so as to increase his flying skill, and eliminate unnecessary items which may distract from the learning process. If these conditions are fully understood, the anxiety and fear which are associated with night flight are relieved and the aviator's learning rate will steadily increase.

b. Night flight is physically more demanding than flight in daylight and requires that greater emphasis be placed upon the physiological needs of the aviator. The aviator's night vision is affected by sleep, nutrition, physical training, and the use of alcohol or tobacco.

1—4. Threat

The mission of Army aviation units is to provide continuous, immediately responsive aviation assistance to the ground commander. The capability of Army aviators to accomplish this mission at night has been recognized by the commander in past conflicts; however, only limited use has been made of Army aircraft to conduct night operations. The doctrine of future wars confronts friendly forces with an enemy who possesses a high air defense threat. To counter this threat, greater emphasis must be placed upon night tactical air operations. The tactics which have proven effective in past conflicts can no longer be employed when conducting air operations in a high threat environment. In order to survive in this environment and remain an effective combat force, Army aircraft operating near the forward edge of the battle area (FEBA) must avoid detection by the enemy's sophisticated weaponry. This will require that Army aviators acquire the capability to conduct flight at night nap-of-the-earth altitudes. Not only does night NOE degrade the enemy's capability to detect friendly aircraft by electronic devices, it also restricts visual detection. In addition, a successful tactical night operation increases the shock effect and gives the advantages of increasing fear and confusion in the enemy's ranks.

1—5. Background

a. Minimal doctrine has been developed for the employment of helicopters in the night NOE role, as this concept is new to Army aviation. Numerous experiments and studies have been conducted which address the problems of day NOE to include both doctrinal concepts and flight techniques. In July 1972, the US Army Combat Developments Command Experimentation Command (USACDCEC) conducted the first in a series of the Attack Helicopter Clear Night Defense Experiments. These experiments were designed to evaluate the training requirements and the capabilities of the Army aviator to perform night NOE without the aid of artificial devices. Aviation units assigned to Modern Army Selected Systems Test, Evaluation, and Review (MASSTER) Board have also conducted tests relating to night NOE. Prior to the tests, there were no existing flight techniques relating to night NOE flight. As the tests progressed, techniques were developed which provided the best solutions to the problems. Limitations were identified which will restrict the aviator in the night NOE role; however, the capability to perform night NOE missions was demonstrated. The most recent testing, Operation Nighthawk, was conducted at the USAAVNC in early 1975. The purpose of the test was to determine how much and what type of night flight training should be added to the Initial Entry Rotary Wing and selected Graduate Flight Training Courses at the Aviation Center. Although this test was conducted in a training environment, the information obtained has direct application to developing skills for tactical night flying.

b. The techniques and procedures that are presented in chapter 6 of this manual represent the current thinking in night NOE flight. The solution to all the problems which may be encountered lies in the imaginative techniques which are developed by the aviators who are called upon to perform the night NOE mission.

1–6. Recommendations

Users of this publication are encouraged to recommend changes and submit comments for its improvement. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028, Recommended Changes to Publications and Blank Forms, and forwarded to the Commander, United States Army Aviation Center, ATTN: ATZQ-D-TL, Fort Rucker, Alabama 36362.

INTENTIONALLY
LEFT
BLANK

CHAPTER 2

NIGHT VISION

2–1. General

a. Of all the sensory means that an aviator uses in flight, his eyes are the most important. He needs good depth perception for safe landings and takeoffs, and good visual acuity for identifying terrain features and obstacles which lie along the flightpath. When flight is conducted during daylight hours, the eyes are capable of appreciating these visual cues; however, during hours of darkness, illumination is reduced and the unaided eyes are limited as to what can be seen. Flight personnel who have 20/20 day vision may not possess an adequate night vision capability. This may be caused by a physical deficiency or a self-imposed limitation (e.g., smoking). It is important that the aviator be aware of his deficiencies and limitations before conducting night flight. A thorough eye examination will normally reveal night vision deficiencies. Avoidance of self-imposed limitations will assist the aviator in achieving good night vision.

b. Laboratory tests have proven that having an aviator with good night vision does not automatically guarantee the most effective use of this capability. An untrained aviator may find it difficult to identify an object at night; however, the eye, like the mind and hand, can be trained. Although the limits of night vision vary from person to person, experience shows that most aviators have never learned to use their night vision to its fullest capacity. An aviator with an average night vision capability who knows techniques of night vision is far better off than an aviator with superior night vision who doesn't know "how to see."

c. Because of the technical medical nature of this chapter, it is annotated with superscript numerals. Commentary notes corresponding to these are found in appendix A. The notes are not essential to a practical understanding of the text, but are provided for personnel requiring an indepth explanation of specific technical terminology.

2—2. Anatomy and Physiology of the Eye

a. The eye functions similar to a camera and consists of two main parts (fig. 2-1).

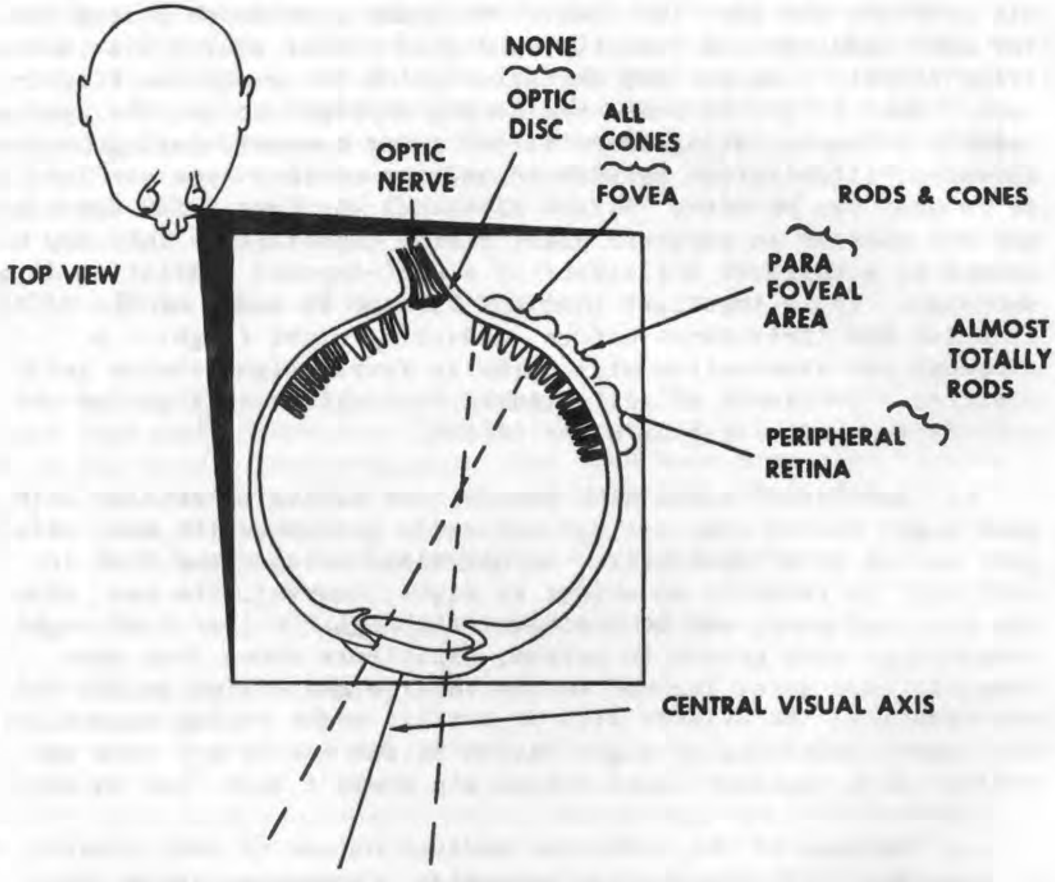


Figure 2-1. Anatomy of the eye.

(1) The cornea, lens, and iris combination gathers and controls the amount of light that is allowed to enter the retina.

(2) The retina can be compared to a photographic film. It is a sensitive layer upon which the light is focused to form an image.

b. The visual center of the retina is called the fovea centralis. It contains only cones which operate most efficiently at ordinary illumination such as those that prevail throughout the day and in normally lighted rooms at night. Cones provide for the perception of color and the ability for the normal individual to see clearly, sharply, and precisely with 20/20 or better visual acuity. Because the cones are more concentrated in the center of the retina, central vision is the most acute. As light levels are reduced, normal color vision becomes less reliable and finally disappears. Runway light colors can be identified because the light is of sufficient intensity for the cones to perceive color. If the color of an object or terrain feature is to be recognizable at night, it must be illuminated by a white light with sufficiently high intensity to permit cone perception of colors. During darkness or with low-level illumination, central vision becomes less effective and a relative blind spot (5^{o} to 10^{o} wide)[1] develops (fig. 2-2). This

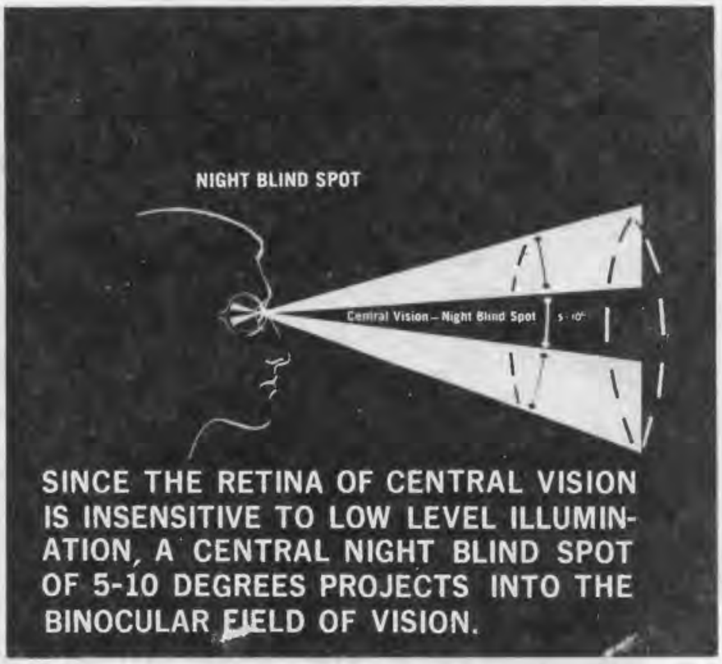


Figure 2-2. Night blind spot.

results from the relatively light insensitive elements concentrated in the area immediately surrounding the retina of the fovea centralis. Since the central fields of vision for each eye are superimposed for binocular vision, we can speak of a single night blind spot for the normal man.[2 3] If an object is viewed directly, it may not be detected due to the blind spot; if detected, it will fade more rapidly. As a result of the projected central blind spot,[4] larger and larger targets will be missed with increasing distance (fig. 2-3).

c. The remainder of the retina contains rods and cones with rods increasing in relative number toward the periphery. As previously stated, the central retina is capable of highly acute vision in high illumination due to the concentration of cones. This peripheral retina is almost exclusively associated with rods. Rods perceive only shades of gray. Because of the way they are connected to the brain, they only perceive form or shape; therefore, peripheral vision is less precise than central vision. However, rods are about 1,000 times as sensitive to light as cones. They are the primary visual receptor in dim illumination and thus mediate night vision. Greatest sensitivity of the rods is achieved after a total of 30 to 45 minutes. Exposure to light sources tends to bleach out the rods and reduces the night vision capability of the rods. Because visual acuity is reduced at night, object and target recognition is often limited to silhouette forms.

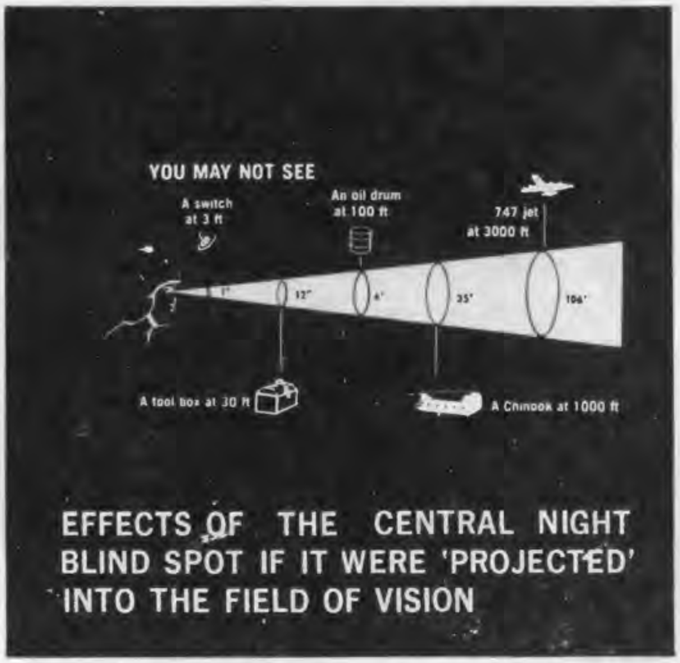


Figure 2-3. Effects of night blind spots.

2—3. Types of Vision

a. Photopic vision. Photopic vision is experienced during daylight hours or when a high level of artificial illumination[5] exists. Under these conditions, vision is achieved primarily by the cones, especially those concentrated in the fovea centralis. Due to the high light condition, rod cells are bleached out and become less effective. Sharp image interpretation (fine resolution of detail) and color vision are characteristic of photopic vision. The fovea centralis of the eye is directed toward an object by a visual fixation reflex which is inherent, subconscious, and automatic. Therefore, under photopic conditions, the eye views objects along the central visual axis of the eye and scans a field of view using primarily central vision.

b. Mesopic vision. Mesopic vision is experienced at dawn, dusk, and during clear nights with half to full moon illumination (mid light levels). Vision is achieved by a combination of both the rods and cones. The visual acuity steadily decreases as the available light declines. A reduction in color vision occurs as the cones become less effective. Descrimination of true colors becomes unreliable. Due to gradual loss of the cone sensitivity, greater emphasis should be placed upon off-center vision for detection of targets. It is this kind of vision that is utilized when a half to full moon exists.

c. Scotopic vision. Scotopic vision is experienced during darkness or when less than one-half moonlight down to starlight conditions exist (low light levels). Cone cells become ineffective. causing poor resolution of detail. Visual acuity decreases to 20/200 or less[6] and total loss of the color perception of otherwise unilluminated or nonluminous targets occurs. Peripheral vision is the only means of seeing; thus, central vision is no longer effective. A central blind spot occurs due to the loss of cone sensitivity. Viewing of objects must be accomplished by off-center viewing. Therefore, the natural reflex for looking directly at an object must be reoriented by night vision training. The use of scotopic vision demands searching movements of the eyes to locate an object and small eye movements to keep the object in sight. A further characteristic of scotopic vision is that image awareness fades away completely if the eyes are held stationary on a target for more than a few seconds.

2–4. Dark Adaptation

a. Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination. Rhodopsin (visual purple) is the substance in the rods responsible for light sensitivity. Dark adaptation occurs as the amount of visual purple in the rods increases through biochemical reactions. This may be accomplished to varying degrees and at different rates. In a darkened theater the eye adapts rather quickly to the prevailing level of illumination, which, compared to the characteristics of a moonless, starlit night, is rather high. Less time is required to adapt from the theater illumination level to complete darkness than from the high level of brightness in a hangar interior. Thus, the lower the starting level of illumination, the more rapidly complete dark adaptation is achieved. Dark adaptation for optimum night visual acuity approaches its maximum level in approximately 30 to 45 minutes under minimal lighting conditions. If the dark-adapted eye is carelessly or inadvertently exposed to a bright light while in flight, the sensitivity of that eye is temporarily impaired. The amount of impairment depends on the intensity and duration of the exposure. Brief flashes from a white (Xenon) strobe light of high intensity will have a minimum effect upon night vision because the pulses of energy are of such short duration (milliseconds); however, continuous exposure, particularly under undesirable conditions (haze, clouds), will cause a distraction that would reduce a pilot's ability to conduct night flight. Exposure to a flare or a searchlight beam which would normally be for a period in excess of 1 second could seriously impair the aviator's night vision. Depending upon the brightness and duration of such an exposure, the recovery of a previous maximum level of dark adaptation could take from 5 to the full 45 minutes in continued darkness.

b. Exposure to bright sunlight has a cumulative and adverse effect on dark adaptation. This condition is intensified by reflective surfaces such as sand and snow. Aviators exposed to intense sunlight for 2 to 5 hours will experience a definite decrease in photopic visual sensitivity which can persist for as long as 5 hours. In addition, the rate of dark adaptation and the degree of night visual capacity will be decreased. These effects are cumulative and may persist for several days.

c. The retinal rods are least affected by the wave length of a dark red light source (wave length longer than 620 millimicrons). Because the rods are stimulated so slightly, night vision is not significantly impaired when viewing red lights of the proper wave length. The intensity and duration of preexposure to this light source determines the degree to which night vision is affected.

2–5. Protection of Night Vision

a. Aviators who are required to conduct night missions should wear military neutral density (N-15) sunglasses or equivalent filter lenses when exposed to bright sunlight. This precaution will maximize the rate of dark adaptation at night and improve night visual sensitivity.

b. Red lights should be the only source of lighting in the cockpit. The intensity of the cockpit lights should be adjusted to the lowest level which will allow the pilot to interpret the instruments. Lights which are not mission essential may be extinguished. The duration and frequency of preexposure to the cockpit lights should be minimized if maximal dark adaptation is required.

c. Wearing approved red-lens goggles prior to the execution of a night operation allows the aviator to begin his dark adaptation in an artificially illuminated room and decreases the possibility of undesirable effects from accidental exposure to bright lights, especially when going from the briefing room to the flight line. The wearing of red-lens goggles, however, does not provide as good dark adaptation as does complete darkness for 30 to 45 minutes. When the mission permits, flight should be conducted in an area away from bright ground lights to allow sufficient time to achieve maximal dark adaptation prior to conducting an approach to minimal lights or low-level flight.

d. When conducting night operations from a fixed airfield, precaution should be taken to eliminate light sources which may impair the aircrew's dark adaptation. To insure a better operating environment for an aircrew performing night missions, the following precautionary measures should be implemented:

(1) Aircraft scheduled for night flight should be positioned on the airfield where the least amount of light exists.

(2) Light discipline should be practiced by maintenance and service crews.

(3) To permit hover operations without bright lighting, hover lanes cleared of obstacles should be established and marked with minimal lighting (preferably red).

(4) Airfield lighting should be reduced to the lowest intensity or turned off.

(5) Departure routes should be selected to avoid highways and residential areas where artificial illumination could reduce the aircrew's night vision.

e. During the conduct of a night tactical air mission, the aircrew can expect to experience battlefield and meteorological conditions (e.g., artillery flashes, flares, searchlights, lightning, etc.) which will cause total or partial loss of their night vision. When confronted with these conditions, the aircrew can apply the following techniques:

(1) If a flash of high intensity light is expected from a specific direction, crewmembers should turn the helicopter to minimize exposure to the light source. When such a condition occurs unexpectedly and direct view cannot be avoided (e.g., lightning), dark adaptation can be preserved by covering or shutting one eye while using the other to observe. Once the light source is no longer a factor, the eye which was covered will provide the night vision capability required to conduct flight. This is possible because dark adaptation occurs independently in each eye.

CAUTION: Difficulty will be experienced with depth perception or orientation outside the cockpit when viewing with the remaining dark-adapted eye, particularly when hovering near terrain obstacles or in the course of an approach to landing. Under such circumstances, altitude or distance should be maintained or increased until orientation is stabilized and assured.

(2) Flight routes should be selected to avoid built-up areas where a heavy concentration of lights would be encountered. If these conditions are inadvertently encountered, the flight route should be altered to avoid overflight of the brightly illuminated area. Loss of dark adaptation from a single light source such as a farmhouse or an automobile can be avoided by turning the head and eyes away from the light.

(3) When flares are being used to assist in a night tactical operation or if they are inadvertently detonated above your position, the helicopter should be flown as close to the periphery of the illuminated area as possible. Also, the pilot should maneuver the helicopter so that his position will be on the opposite side of the light source. This procedure prevents direct observation of the flare by the pilot.

(4) Aircrews who are exposed to weapon flashes fired from the helicopter can avoid loss of night vision by limiting the duration of time during which the ordnance is expended. Rockets can be fired in almost any combination without serious impairment of night vision so long as the weapon flash is of short duration and the aircrew avoids looking directly at the flash.

f. Night vision is dependent upon optimum function and sensitivity of the rods of the retina. Lack of oxygen to the rods (hypoxia) significantly reduces their sensitivity and causes an increase in the time required for dark adaptation and a decrease in the ability to see at night. Without supplemental oxygen, a measurable decline in night vision is evident at all pressure altitudes in excess of 4,000 feet. For this reason, it is recommended that oxygen be used when operating above a pressure altitude of 4,000 feet (i.e., nap-of-the-earth mountain operations where the mean elevations exceed 4,000 feet).

2–6. Self–Imposed Stresses

There are limitations to night vision which are self-imposed by aviation personnel. An awareness of these self-imposed restrictions is essential to insure that each is avoided before participating in night flight.

a. Smoking and night vision. Cigarette smoking significantly increases the amount of carbon monoxide carried by the hemoglobin of red blood cells, thus reducing the blood's capacity to combine with oxygen. Hypoxia from carbon monoxide poisoning affects night visual sensitivity and dark adaptation in the identical way and to the same extent as hypoxia resulting from high altitude. Smoking three cigarettes in rapid succession or 20 to 30 cigarettes per day may saturate from 8 to 10 percent of the capacity of the hemoglobin of the red blood cells in the body. The physiological effect of this condition is that the smoker has effectively lost 20 percent of his night vision capability at sea level.

b. Alcohol and night vision. Alcohol has the effect of creating sedation, thus causing lack of coordination and impairment of judgment. As a result, the aviator fails to apply the proper techniques of night vision. He begins to stare at objects and his scanning techniques become disorganized. Alcohol, like cigarette smoking, impairs night vision, but to a greater extent. The two in combination are probably cumulative. The degree to which night vision is affected is determined by the amount of alcohol consumed. Hangover aftereffects will also impair visual scanning efficiency.

c. Fatigue and night vision. An aviator who is fatigued when performing night missions lacks mental alertness and fails to apply the proper techniques of night vision. He responds slowly to situations which require immediate reaction. He tends to concentrate his attention in one area without consideration for the total requirement. Depending on the degree of fatigue, his performance may become a safety hazard.

d. Sickness and night vision. Normally associated with sickness is an increased temperature and a feeling of unpleasantness. High body temperatures consume a higher rate of oxygen than is normally required. As a result, relative hypoxia is induced and degradation in night vision may occur. In addition, the unpleasant feeling that is associated with sickness distracts the aviator's attention and restricts his ability to concentrate on night flying requirements.

e. Nutrition and night vision. Failure to eat foods that provide sufficient vitamin A could cause impairment of night vision. Foods that are high in vitamin A content are eggs, butter, cheese, liver, apricots, peaches, carrots, squash, spinach, peas, and all types of greens. An adequate intake of vitamin A is normally provided by a balanced diet. Note that excess quantities of vitamin A will be of no additional help and may be harmful. Stomach contractions (hunger sensations) from missed or postponed meals appear to exert a most unpleasant effect and could conceivably cause distraction, breakdown in habit pattern, shortened attention span, and other psychological trait changes.

f. Physical conditioning and night vision. Because of the physiological stresses of night flight, the aviator becomes more easily fatigued. To overcome this limitation, aircrewmembers should participate daily in organized athletic programs. Good physical fitness may help the aviator conduct night flight with less fatigue and might improve his night scanning efficiency.

2–7. Night Vision Techniques

a. Successful dark adaptation is only the first step toward maximizing one's ability to see at night. In order to see effectively in the dark, an individual must apply night vision techniques which will enable him to overcome the previously discussed physiological limitations of the eyes. During daylight hours, objects can be perceived at a great distance with useful detail. At night the range is limited and detail is poor. A sound basic principle of visual scanning, day or night, is to view the predetermined field of vision moving the head and eyes together as a unit. Movement of the eyes, independent of the head - sideways or vertically - will in some cases reduce the protective overlap provided by binocular vision or tend to break the stimuli that encourage fusion of the images reaching each eye. Thus, it prevents a tendency or condition in which the eyes might operate independently and cause confusion. Because of these limiting factors and the inability to perceive objects while rapidly sweeping a field of view, a systematic method of scanning must be used.

b. The technique used by the aviator to view the terrain along the flightpath becomes an important consideration if he is to perceive obstacles and identify terrain features which will insure safety of flight, accurate navigation, and target acquisition. To scan effectively, the aviator must scan from right to left, and from top to bottom of the field of view in 10° overlapping movements. This procedure is repeated continuously throughout the flight. Figure 2-4 depicts the correct scanning technique and pattern. While eye movements will be directed along the central visual axis, it is the peripheral field of vision that will permit detection of an object coming into the field of view. The scanning technique can be compared to a series of aerial photographs. All the pictures make up a "composite" of the terrain being viewed. Once the aviator has developed this scanning technique, he must incorporate one additional factor - the rate at which he will scan.

c. Due to the inability of the light sensitive elements of the retina to perceive images while in motion, the aviator must develop a stop-turn-stop-turn type motion. The time required in the stop portion of the scanning procedure is determined by the degree of detail that is required but should be no longer than 2 to 3 seconds. This is because the rhodopsin (visual purple) in the rods will bleach out momentarily unless the stimulation is variable in light energy. (Remember that head movements must be limited during turning maneuvers to avoid vestibular illusions such as Coriolis.)

d. Viewing a target using central vision during daylight poses no limitation; however, this same technique at night will result in a loss in the visual acquisition of the target. To compensate for this limitation, "off-center vision" must be used. This technique requires that an object be viewed by looking 10° above, below, or to either side rather than directly at the object. This allows the peripheral vision of the eyes to maintain surveillance of a detected target.[7] Figure 2-5 depicts the correct viewing technique.

e. Even though off-center vision is practiced, if an object is viewed for a period of time in excess of 2 to 3 seconds, the images tend to bleach out and become one solid tone. As a result, the object can no longer be seen, thus inducing a potentially unsafe operating condition. To overcome this limitation of night vision, the aviator must be aware of the phenomena and avoid viewing an object "off-center" longer than 2 or 3 seconds per scan. By shifting the eyes from one "off-center" point to another, the object will continue to be acquired in the peripheral field of vision.

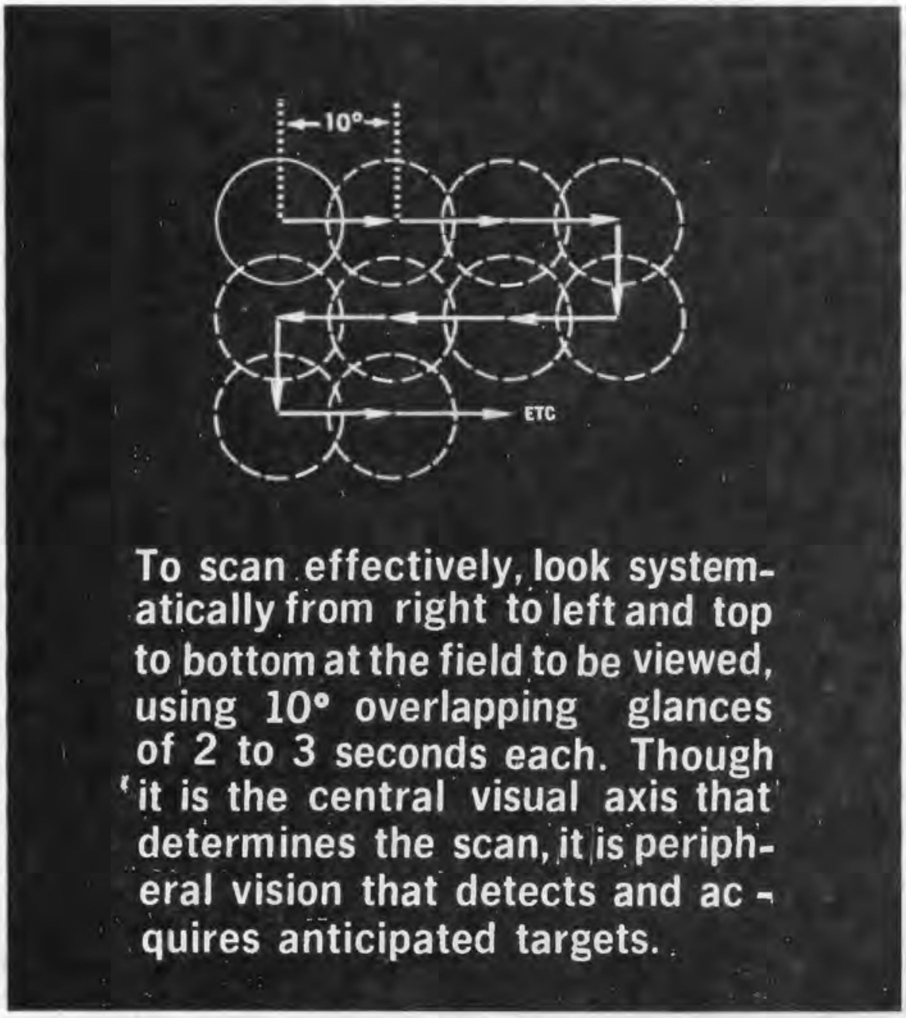
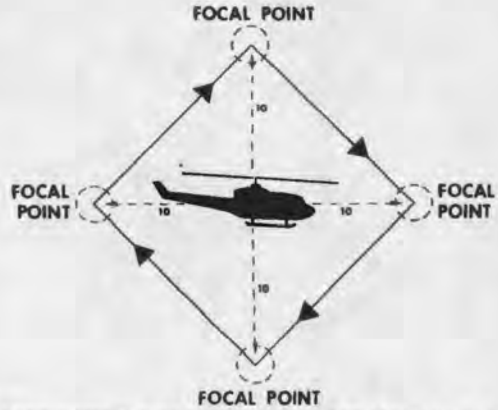


Figure 2-4. Scanning pattern.

f. Visual acuity will be significantly reduced at night. Because of this limitation, objects must be identified by their silhouettes. The ability of the aviator to recognize objects using this technique will be determined by the aviator's familiarity with the architectural design of the structures which are common to the area in which the mission is being flown. A silhouette of a building with a high roof and a steeple can be easily recognized as a church in America; however, churches in other parts of the world may have a low-pitched roof with no distinguishing features. Man-made features depicted on the map will also assist in recognition of silhouettes observed while in flight.



ONCE A TARGET IS DETECTED IN THE PERIPHERAL FIELD OF DARK ADAPTED VISION, CONTINUED SURVEILLANCE IS MAINTAINED BY USE OF "OFF-CENTER" VISION.... LOOKING 10 DEGREES RIGHT OR LEFT AND ABOVE AND BELOW THE TARGET, VIEWING NO LONGER THAN 2 TO 3 SECONDS AT EACH POSITION.

Figure 2-5. Off-center vision.

2—8. Depth Perception With Night Vision

The cues to depth perception are most apparent using central vision under good illumination. As night falls, judgment of depth perception decreases. One night seeing eye is less precise as a distance measuring device and can be subject to illusions as well. A knowledge of the mechanisms and cues to depth perception will assist the aircrewman in making a better judgment of distance at night.

a. Estimation of distance.

(1) There are numbers of mechanisms and cues that are used to judge distance. An estimation of distance in a situation can be derived by using only one mechanism or by using a combination of several mechanisms and cues. These estimations are usually derived on a subconscious level; that is, without the individual being aware of the evidence on which he bases his decision as to distance.

By understanding these mechanisms or cues to estimation of distance, an individual in a given situation may look for, or be aware of, additional cues beyond those which he would habitually use, and thus form a more accurate estimation of distance. These cues to distance or depth perception are monocular or binocular. Monocular means that only one eye is required for judgment. The binocular cues depend on the slightly different view each eye has of the object. Consequently, binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of the two eyes.

(2) In flying, most of the distances exterior to the cockpit are so great that the binocular cues are of little if any value. In addition, these cues operate on a more subconscious level than the monocular cues, and are thus not as capable of being improved by study and training. Therefore, binocular cues will not be discussed.

b. Depth perception - monocular cues.

(1) Geometric perspective. An object has an apparent different shape depending on the distance and angle from which it is being viewed. Types of geometric perspective are:

(a) Linear perspective. Parallel lines such as railroad tracks (A, fig. 2-6) tend to converge as distance increases from the observer.

(b) Apparent foreshortening. The true shape of an object or terrain feature appears elliptical when viewed from a distance. As the distance to the object or terrain feature decreases, the apparent perspective changes to its true shape or form. B, figure 2-6 illustrates how the shape of a body of water changes when viewed at different distances.

(c) Vertical position in the field. Objects or terrain features which are farther away from the observer appear higher on the horizon than objects or terrain features that are closer to the observer. The highest vehicle in C, figure 2-6 appears to be closest to the top, thus is judged as being the greatest distance from the observer.

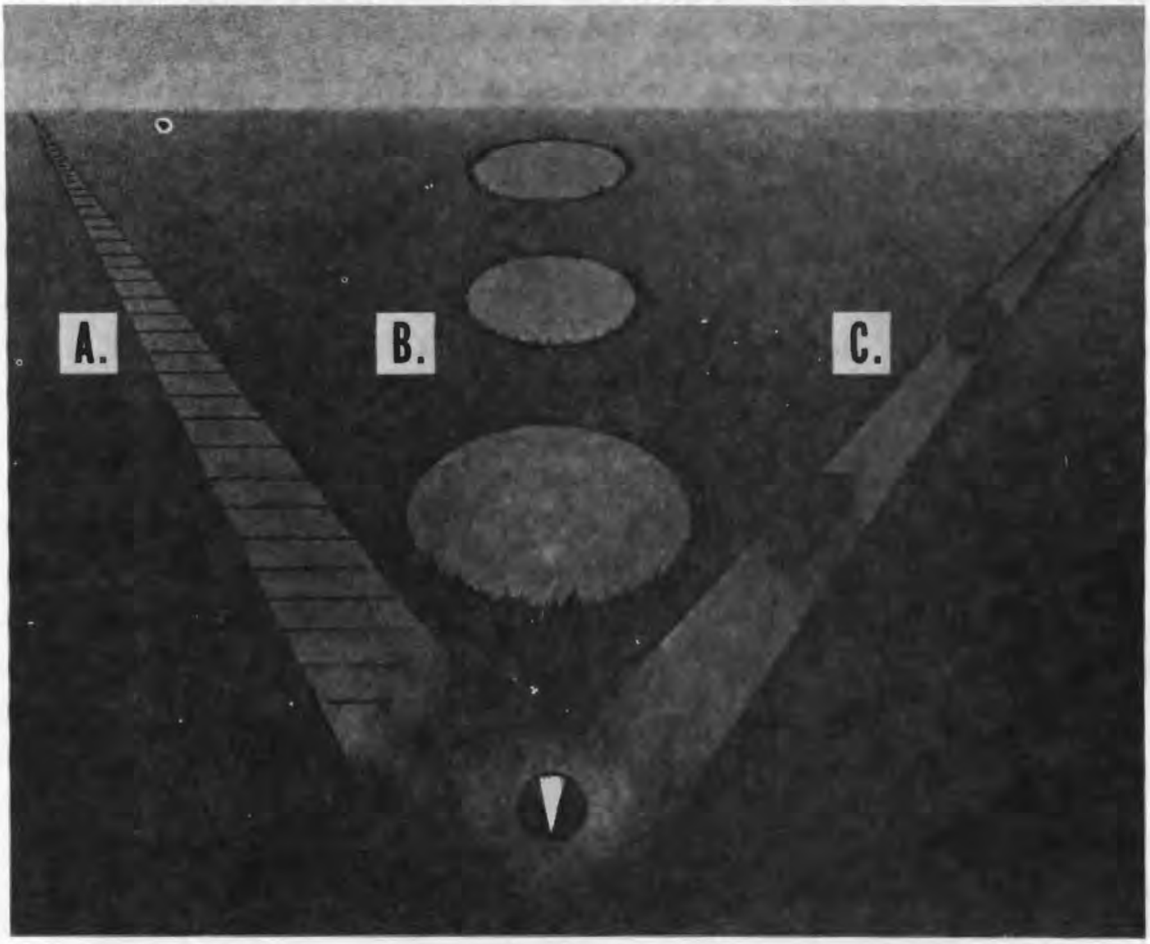


Figure 2-6. Geometric perspective.

(2) Motion parallax.

(a) This cue to depth perception is often considered the most important. Motion parallax refers to the apparent relative motion of stationary objects as an observer moves across the landscape. Near objects appear to move backward, past, or opposite the path of motion and far ones seem to move with it or remain fixed. When one fixes upon near objects, distant objects tend to move in the same direction as the observer. The rates of apparent movement depend on distance from the observer - objects near the aircraft move most rapidly, while distant objects appear to be almost stationary. Thus, objects that appear to be moving rapidly are judged to be near and those moving slowly are judged to be distant.

(b) This can be readily appreciated from the reader's position if he looks at his surroundings. When the line-of-sight is fixed and maintained on one object while the position of the head is changing, other objects which appear to move in the same direction as the movement of the head are judged more distant while objects moving in the opposite direction are nearer than the object on which the line-of-sight is fixed.

(c) While an individual drives along a road, the fence pickets near the roadside rapidly whiz by. A tree not far from the roadside passes more slowly. Mountains in the distance and the moon appear to be fixed or moving with the vehicle and its occupant.

(d) In figure 2-7, boundary light A appears to move in an opposite direction to the airborne observer as he moves from Position 1 to Position 2, because the apparent distance between the boundary light and the tower appears to increase. The distance between the control tower and boundary light B appears to decrease as it is viewed while moving from Position 1 to Position 2; therefore, light B appears to move in the same direction as the helicopter. From this, the observer has the impression that light A is nearer and light B is more distant than the control tower.

(3) Retinal image size. The size of an image focused on the retina is perceived by the brain to be of a given size.

(a) Known size of objects. The nearer an object is to us, the larger is its retinal image. By experience, the brain learns to associate the distance of familiar objects by the size of their retinal image. A church building is seen at an unknown distance. It may be 30 to 40 feet tall. If its height subtends a small angle on the retina, the observer judges, usually subconsciously, that the building is at a great distance. A large angle would be judged by the observer as the building being close in to the helicopter (fig. 2-8). To utilize this cue, one must know the actual size of the object and have prior visual experience with it. If no experience exists, an object's distance would be determined primarily by motion parallax.

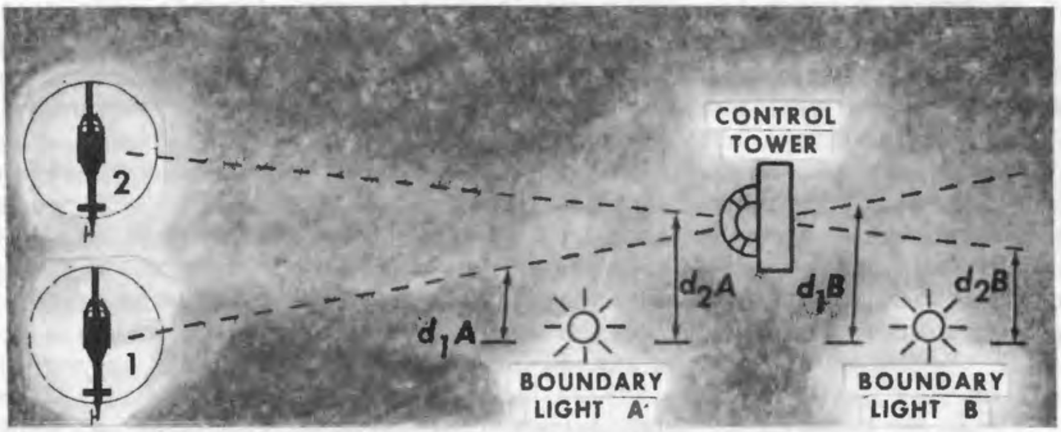


Figure 2-7. Motion parallax.

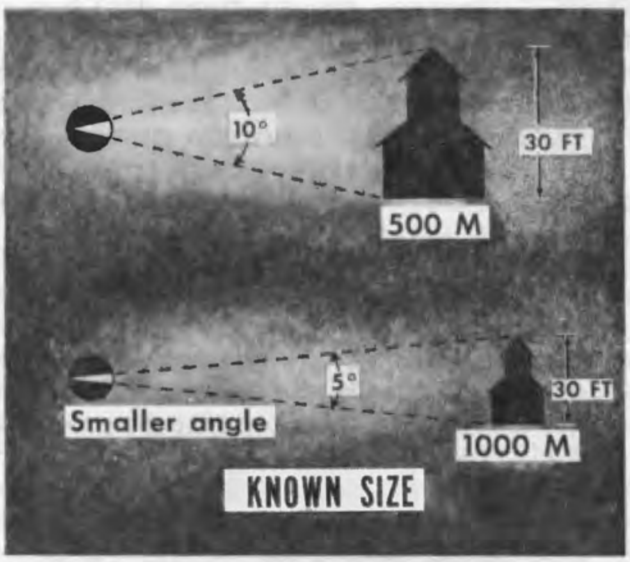


Figure 2-8. Known size.

(b) Increasing/decreasing size of objects. If the retinal image size of an object increases, it is approaching or moving nearer; if it decreases, it is retreating or moving farther away; if constant, it is at a fixed distance.

(c) Terrestrial associations. Comparison of an object such as an airfield in the distance with an object of known size, configuration, and alinement such as a helicopter, will help to determine its relative size and apparent distance. Objects ordinarily associated together are judged to be at approximately the same distance. A helicopter is seen at a great distance making a slow turn. An airport is seen in approximately the same direction. The helicopter is judged to be in the traffic pattern and therefore at approximately the same distance to the field (fig. 2-9).

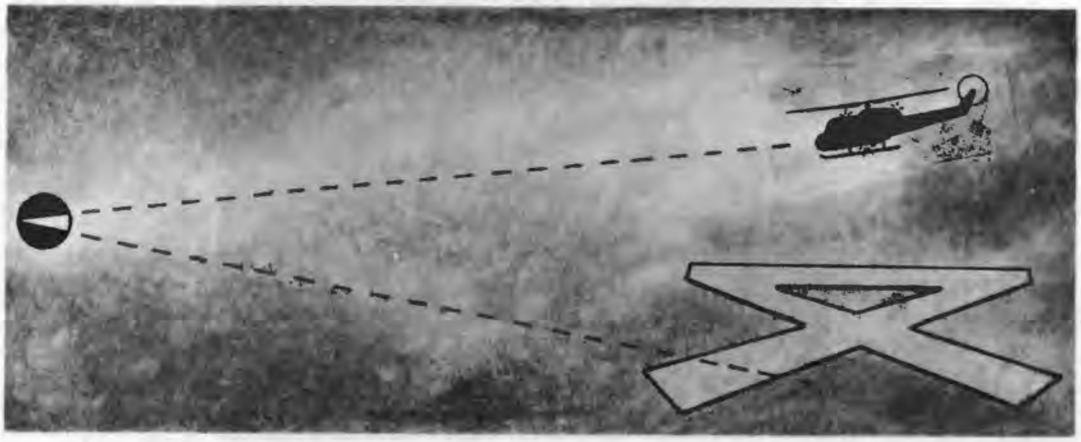


Figure 2-9. Terrestrial association.

(4) Overlapping of contours or interposition of objects. When one object is seen to overlap another, the object which is being overlapped is farther away. Otherwise stated, an object partly concealed by another object is behind it (fig. 2-10).

(5) Aerial perspective.

(a) Fading of colors or shades with distance. Large objects seen indistinctly are judged to have a considerable amount of haze, fog, or smoke intervening, and therefore appear to be at a great distance. If atmospheric transmission of light is less than expected, the distance is overestimated; if greater than expected, the distance is underestimated. The cargo helicopter is larger than the observation helicopter but, because of the difference in viewing distance and size, they both subtend the same angle on the observer's retina (their retinal image sizes are equal) (fig. 2-11). Therefore, from this cue alone, assuming no previous experience with the appearances, they appear the same size. However, if the cargo helicopter is seen less distinctly because of visibility restrictions, it would be judged to be a greater distance away and larger than the observation helicopter.

Figure 2-10. Overlapping contour.

(b) Loss of discrimination or texture. As one gets near to an object, more discrete details become apparent; e.g., a green field develops blades of grass, a tree develops leaves and branches, and an animal becomes a steer rather than a cow.

(6) Light and shadows. If a shadow is seen nearer the observer than an object, the object is nearer than the source of light (fig. 2-12).

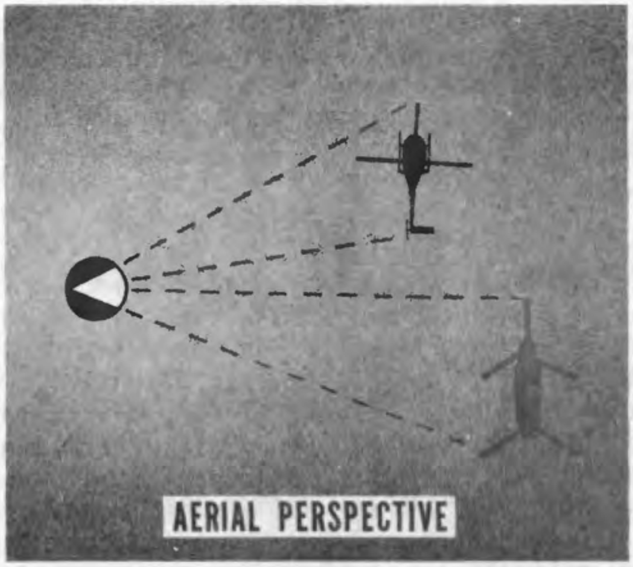


Figure 2-11. Aerial perspective.

Figure 2-12. Light and shadows.

2–9. Visual Illusions

With decreasing visual information, there is an increased probability of spatial disorientation. The cause for spatial disorientation due to the loss of visual reference may be a composite of several illusions. A few important visual illusions occurring in the aviation environment are:

a. Autokinesis. Autokinesis, or the autokinetic illusion (fig. 2-13), is the illusory phenomenon of movement which a static light exhibits when stared at for a long time in the dark. This phenomenon can be readily observed by taking a lighted cigarette into a completely dark room and staring at it until it appears to move. The apparent movement will begin after approximately 8 to 10 seconds. The cause is not known for certain, but appears to be related to the loss of surrounding structural references which normally serve to stabilize or anchor our visual perceptions. This illusion can be eliminated or reduced by visual scanning, by increasing the number of lights on aircraft, or by continuously varying the light intensity. The most important of the three is visual scanning technique. A target of light or lights should be fixated for periods no longer than 10 seconds. A fixed object, such as an instrument panel top, should be used as a reference from which an observer may scan. This illusion is not exclusively limited to lights in darkness. It can occur whenever a small, bright, still object is stared at against a dull, dark, or indescript background. Similarly, it can occur when viewing a small, dark, still object against a light, structureless environment. Place a pink-colored dot about 3 inches in diameter on a large chalkboard. Stare at the dot. Eventually it will move. Flying over still water toward a raft could produce such an illusion. Fixing on a marker in the snow day or night could produce similar results. Landing to an unlighted dark panel over an expanse of clay or dirt at night could cause the observer to experience autokinesis as well.

b. Confusion of ground lights with stars. Many aviators have put their helicopters into very unusual attitudes in order to keep some ground lights above them, having mistaken them for stars. Some aviators, for example, have misinterpreted the lights along a seashore as being the horizon, and maneuvered their helicopter dangerously close to the sea while under the impression of flying straight and level (A, fig. 2-14). Aviators have also confused certain geometric patterns of ground lights (e.g., moving trains) with a runway or identified ground lights as airborne targets (B, fig. 2-14).

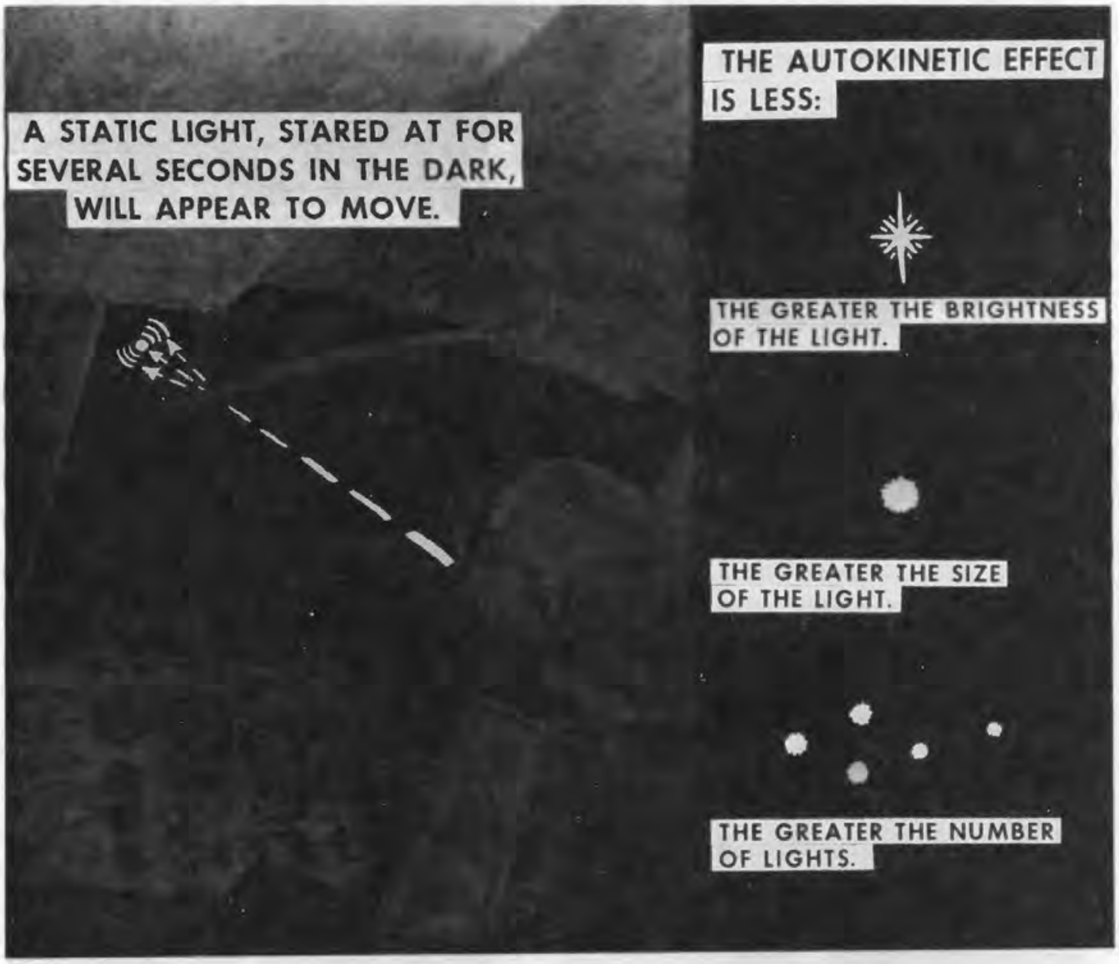


Figure 2-13. Autokinetic illusion.

c. Relative motion. The illusion of relative motion is similar to a person sitting in a car at a railroad crossing waiting for a train to pass - though the train is actually moving, the person in the car has the sensation that he is moving. This is often encountered by the aviator during formation flying. He sees motion of his wingman or leader and interprets it as motion of his own. The only way to manage this illusion is for the aviator to have sufficient experience to understand that such illusions do occur and not to react to them on the controls.

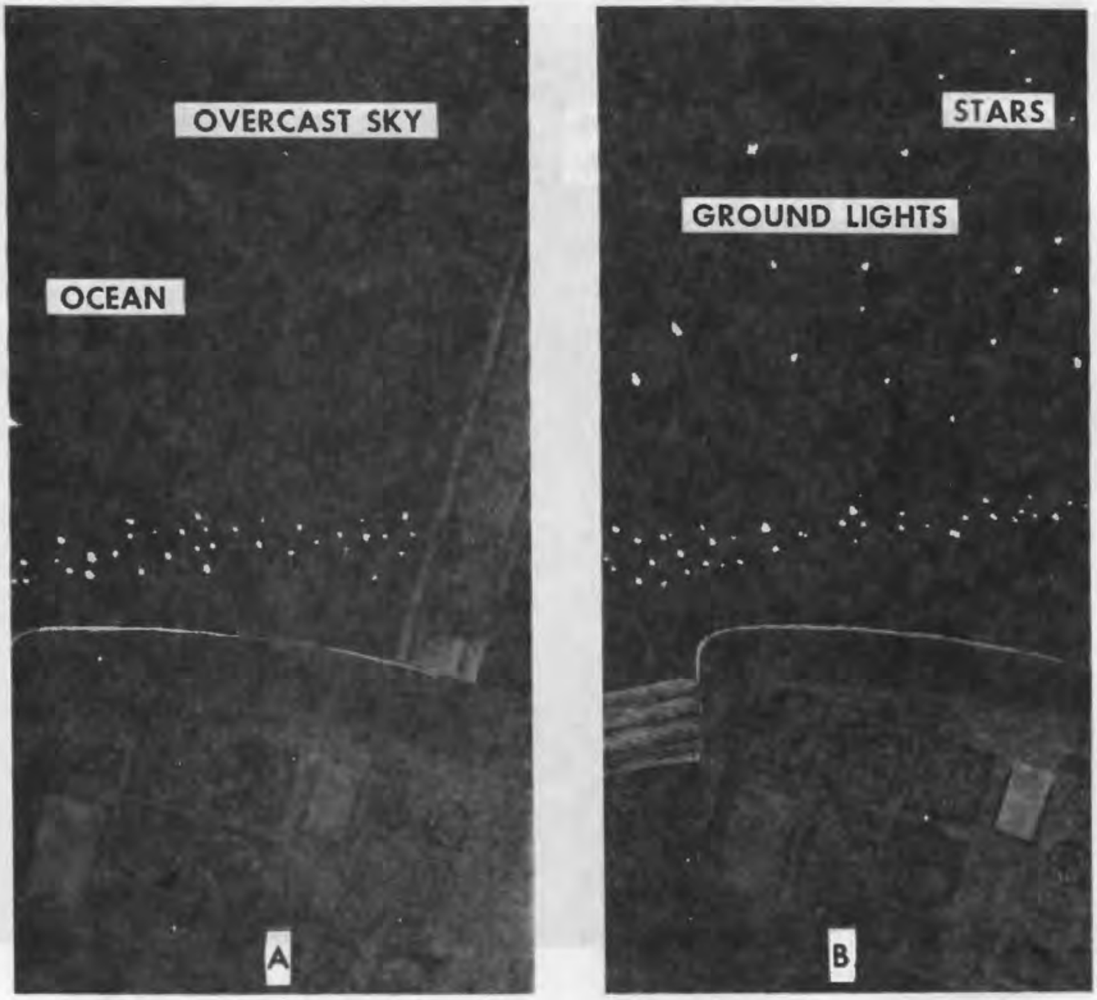


Figure 2-14. Ground and sky light illusion.

d. Reversible perspective illusion. An aircraft may appear to be departing when it is in fact approaching. This illusion is often experienced when a visually acquired aircraft is turning toward or away from your path of flight. Part of this phenomenon may be due to relative motion.

e. False horizons. The illusion of false horizons is experienced when an object other than the actual horizon is interpreted to be horizontal to the horizon. For example, a helicopter flying between two cloud banks may be flown in relationship to the lower cloud bank because the aviator feels that the lower cloud bank is horizontal to the horizon. In actuality the lower cloud may be at an angle to the horizon. The aviator tends to level the helicopter in reference to the cloud which puts the helicopter in a turn (fig. 2-15).

Figure 2-15. False horizon illusion.

f. Altered planes of reference. The pilot of an aircraft approaching a line of mountains or clouds sees the illusion of a need to climb even though altitude to clear is adequate. The reverse is true when leaving such a line. In flying parallel to a line of clouds, there is a tendency to tilt away.

g. Depth perception illusion. Day and night flying over desert, snow, or water are characterized by a lack of adequate depth cues. This results in poor or diminished depth perception and, consequently, potentially dangerous situations. This is a special hazard to helicopter pilots during night autorotations. Flying into haze or fog at night can produce the same illusion of depth perception.

h. Flicker vertigo. Much time and research have been devoted to the study of flicker vertigo. It has been demonstrated that a light flickering at a rate of between 4 and 20 cycles per second can produce unpleasant and dangerous reactions. These include nausea, vomiting, vertigo, and on rare occasions, convulsions and unconsciousness. Fatigue, frustration, and boredom tend to intensify these reactions. The problem can be caused by the flickering of the rotating beacons as reflected against an overcast sky.

i. Fascination (fixation) in flying. Fascination is said to occur when a pilot for one reason or another ignores orientation cues while his attention is focused on some other object or goal. Target hypnosis is a common type of fascination and is characterized by an incident that occurs when a pilot becomes so intent upon hitting his target during a gunnery run that he neglects to pull up in time to prevent crashing into the target.

j. Structural illusions. Structural illusions are caused by heat waves, rain, snow, sleet, or other disturbances of the air media through which we see. For example, a straight line may appear curved as seen through the heat wave of the desert. As seen through slanting rain or sleet, a single wingtip light may appear to the pilot as a double light or in a different location.

k. Size-distance illusion. The size-distance illusion results from staring at a point of light which approaches and recedes from the observer. In the absence of additional distance cues, accurate depth perception is extremely difficult. Instead of seeing the light advancing or receding, the pilot has the illusion that it is expanding and contracting at a fixed distance from him. This illusion may also be dispelled by continually shifting the gaze.

2–10. Meteorological Conditions and Night Vision

Although a flight originates during conditions of clear skies and unrestricted visibility, meteorological conditions may deteriorate during flight. Due to the reduced vision at night, the gradual encounter of clouds can easily go undetected. During the initial buildup of cloud formations, difficulty will be encountered in detecting airborne targets due to the lack of contrast between the cloud and aircraft. Inadvertent entry into clouds may occur without warning. At low altitudes the encounter of ground fog and haze can be expected. The loss of visibility can be a gradual deterioration or a sudden encounter. Because detection of adverse weather is difficult at night, the aviator should maintain a constant awareness of changing conditions. The following conditions serve as indicators in the detection of adverse weather conditions at night:

a. A gradual reduction in the available ambient light will occur as cloud coverage increases, resulting in a loss of visual acuity and contrast of terrain features.

b. Loss of visual contact with the moon and stars indicates that clouds are present. The degree to which the stars and moon are obscured determines the amount of cloud coverage.

c. Shadows caused by clouds obscuring the moon's illumination can be detected by observing the varying ambient light along the flight route.

d. The halo effect that is observed around artificial lights indicates the presence of moisture or other small particles. As the intensity of these lights decreases, the moisture or particle content increases.

e. The presence of water vapor suspended over water surfaces indicates that the temperature has reached the dew point and that this condition will spread over the ground area.

2–11. Equipment Limitations on Night Vision

a. Since less light is available at night, the aviator's ability to see through the windscreen of an aircraft is more easily impaired under this condition than in daylight. The light absorbed and reflected by the windscreen becomes an important factor since the available illumination is at a low level. Also, distortion occurs when viewing through the windscreen. Dirt, grease, and scratches on canopies and windscreens are a serious handicap at night. Inasmuch as the windscreen is indispensable, these factors must be reduced to a minimum. To insure optimum visibility, all transparent panels must be kept scrupulously clean.

b. The purpose of instrument lighting is to make the instruments easily readable to the pilot or other crewmembers. Because visual acuity increases with illumination, this is best accomplished with a high level of instrument illumination. However, the level of illumination needed for optimum reading is not practical because it interferes with maximum dark adaptation for the perception of dim objects outside the aircraft, lights are reflected off the interior windscreen reducing outward visibility, and lights which might be visible to the enemy must be avoided.

2–12. Principles of Night Vision

A thorough understanding of the anatomy of the eye and the techniques employed to overcome limitations are necessary in order to see in the dark. The principles that have been discussed in this chapter are summarized in the ten commandments of night vision.

a. Dark-adapt before attempting any night duties.

b. Avoid bright lights after dark adapting.

c. Identify objects by total form.

d. Practice blindfold cockpit drill.

e. Keep your windscreen clean, unscarred, and unscratched.

f. Use off-center vision when viewing an object.

g. Do not stare; scan constantly and systematically.

h. Use oxygen when conducting night flight above 4,000 feet MSL.

i. Avoid self-imposed stresses.

j. Keep physically fit.

INTENTIONALLY
LEFT
BLANK

SECTION II. PREFLIGHT PLANNING

5–4. Flight Briefing

a. Thorough flight planning and briefing procedures are extremely important in conducting training or tactical operations at night. The following are the minimum subjects that should be discussed during a night preflight briefing.

(1) In-depth weather briefing for the entire flight period to include winds aloft, sunset, moonrise, and percent moon available/ambient light level.

(2) Effects of visibility restrictions (e.g., smoke, haze, fog) prior to and during a flight.

(3) Thorough map reconnaissance of the field to be used and surrounding area of operation.

(4) A discussion of the type traffic to be flown, maneuvers to be performed, lighting that will illuminate the airfield or tactical site, and aircraft lighting for the training periods.

(5) Crew duties, night vision methods, scan techniques, and differences between the day execution and night execution of the same maneuver.

(6) Due to the reduced reaction time, limited visual clues, and mental and physical stress during night operations, there is little if any margin for error while conducting night training. This is especially true during autorotative and nonstandard maneuvers. Because of this reduced margin for errors, crews should be briefed to make a go-around anytime the approach feels uncomfortable. The reason for the uncomfortable approach should be discussed. If the crewmembers notice the effects of fatigue, the flight period should be terminated.

b. At the conclusion of the mission, a thorough debriefing should be conducted. Included in the debriefing should be lessons learned, problems which arose during the flight, recommended solutions to these problems, and the individual's exact feelings about the mission or maneuvers being performed at night.

5—5. Crew Duties

Specific crew duties are designed for coordinated crew teamwork necessary to safely conduct any type of flight. In a training environment, this sharing of duties should not relieve the instructor from his overall responsibilities. The following examples do not limit the duties which can be assigned to crewmembers but insure that crew duties are designated during the preflight briefing and understood by each member.

	Person Flying	Person Not Flying
a. Before takeoff check		X
b. Before landing check		X
c. Aircraft control	X	
d. Outside orientation	X	X
e. Radio calls	X	
f. Perform checks (airspeed, altitude, rpm, rate of descent, engine and transmission instruments, etc.)		X
g. Approach angle, rate of closure, etc.	X	X
h. Tuning radios		X

5—6. Common Phraseology

Along with crew duties, common phraseology (terminology) is vitally important. Very limited margin for error and reduced visual references during night operations make it necessary that crewmembers develop a common language to enhance the overall safety and effectiveness of training periods or tactical missions. This phraseology can vary and will be dependent upon the type aircraft flown, the type of terrain, and the type of mission flown. As a result of these variables, the need arises for common phrases to be developed and thoroughly explained during the preflight briefings. Unit SOP should be developed identifying standard terms to be used by the aircrews during flight.

SECTION III. BEFORE TAKEOFF PROCEDURES

5–7. Preflight

a. A night preflight inspection must be very thorough since defects which are easily detected in daylight will be difficult to identify at night. If practical, preflight inspection should be conducted during daylight hours. When circumstances require that the preflight inspection be conducted at night, a flashlight should be used to supplement the available lighting (e.g., helicopter lights, flood lights, vehicle lights, etc.). However, preflight with flashlight should be conducted in advance of takeoff time to allow for dark adaptation. Night inspection is identical to daylight inspection except that the position lights, landing light, searchlight, and cockpit lights must be checked to determine if they are operational.

b. During the preflight, the windscreens should be checked to insure that each one is thoroughly cleaned and free of scratches. Windscreens which are satisfactory for day flight may not be acceptable for night flight.

c. Prior to conducting the preflight, an evaluation of write-ups on the DA Form 2408-series should be made to determine if there are any discrepancies which would restrict night flight. Discrepancies which would make the helicopter nonoperationally ready for night flight may be acceptable for day flight (e.g., windscreens scratched, inoperative light, generator inoperative).

5–8. Use of Lights (Nontactical)

a. Position lights.

(1) Position lights should be turned on to the STEADY BRIGHT mode before takeoff.

(2) Helicopters performing advanced maneuvers (e.g., autorotations) in the same traffic pattern with helicopters performing normal approaches may operate in the FLASH BRIGHT mode. This readily distinguishes for other pilots and ground controllers the maneuvers which the helicopter will be performing.

(3) During formation flights, position lights will be operated in the STEADY DIM position.

(4) The position lights should be turned OFF during covert single helicopter tactical operations.

(5) If the anticollision light is inoperative when in flight, position lights should be operated in the FLASH BRIGHT mode.

(6) During shutdown, the position lights should be operated in the FLASH BRIGHT mode. Lights should remain on until the rotor blade is stopped and tied down.

b. Cockpit lights.

(1) During prestart checks, cockpit lights should be adjusted to an intensity level that will allow ease of reading the instruments. The dome light may be used to assist in illuminating the cockpit and the cabin area. When using this light, the RED mode should be used to protect against the loss of night vision. The dome light should be turned off before hovering the helicopter.

(2) For nontactical flights above 500 feet, all instrument and panel lights should be illuminated. As the ambient light level decreases from a twilight condition to darkness, the intensity of the cockpit lights must be reduced. The intensity should be adjusted to the lowest readable level. Although reflection off the windscreen will occur, restriction to night vision is minimized by reducing the level of intensity of the cockpit lights.

(3) When conducting night flight by reference to instruments, the cockpit lights will be adjusted to a higher intensity. Impairment of night vision will occur under these conditions. Prior to landings, cockpit lights should be dimmed to enhance the pilot's night vision capabilities for outside references during the landing.

(4) During the conduct of tactical low-level operations, only those flight instruments that are required for safety of flight will be illuminated. The intensity will be adjusted to the lowest readable level. These conditions minimize reflection off the windscreen, preserve night vision, and aid in covert operations.

(5) For helicopters equipped with a BRIGHT-DIM switch which controls the intensity of the caution panel warning lights, the DIM mode should be selected for night flight.

(6) The map light may be used to supplement the available light in the cockpit. Normally, it is used by the navigator/copilot to view maps. During the preflight, these lights should be checked to insure that the red lens mode has been selected. Also, the variable rheostat should be checked to insure that it is turned to the lowest intensity which is the OFF position.

c. Anticollision light.

(1) For nontactical operations, the anticollision light should be turned on just prior to starting the engine. This light will remain on until the rotor blade stops turning during shutdown.

(2) During the conduct of tactical operations, the anticollision light will be turned to the OFF position.

(3) When conducting nontactical flight formations, the anticollision light will be turned OFF with the exception of the one on the trail helicopter.

(4) Upon entry into meteorological conditions, the anticollision light should be turned OFF. Operation of the anticollision light during these conditions tends to induce distraction and disorientation.

d. Landing light/searchlight.

(1) The landing light or searchlight is normally turned on during all takeoffs and landings from established airfields when conducting nontactical training. The landing light or searchlight may be used when hovering to and from the parking spot. Caution must be taken to protect against the loss of night vision when flight is to be continued after the lights are turned off.

(2) When conducting practice night touchdown autorotations, the landing light or searchlight will be turned ON while on final prior to executing the maneuver and left ON until termination of the maneuver or the execution of a go-around.

CAUTION: The landing light or searchlight may reduce visibility light under certain atmospheric conditions when used prematurely.

(3) The landing light or searchlight may be used to identify the helicopter position when entering the traffic pattern.

e. Auxiliary power unit. Operation of aircraft lights during the preflight drains electrical power from the battery and thus reduces the available voltage. To insure that sufficient voltage is available to start the engine, an auxiliary power unit should be used to start the helicopter.

SECTION IV. IN-FLIGHT PROCEDURES

5–9. Hover

a. General. Difficulty is experienced when hovering at night. Because visual references are not available, the pilot will make control inputs which cause the helicopter to move both laterally and vertically without realizing movement of the helicopter. The type of terrain over which the helicopter is hovered affects the pilot's ability to judge movement.

(1) Asphalt/concrete. When hovering over asphalt (e.g., runways, helipads), depth perception is difficult because there are no terrain features on the ground which will allow the pilot to estimate height. Horizontal movement can be detected by observing the markings (e.g., runway centerlines, taxi lines, Maltese cross, and the lateral boundaries of the hard surface area). Horizontal movement is easier to judge when hard surface areas are light in color and provide a greater contrast between the darker grass areas along the lateral boundaries.

(2) Grass. When hovering over an open area which is covered by grass, difficulty is experienced in maintaining altitude and a constant position over the ground. There are no ground references that can be used to estimate vertical or horizontal movement. This condition is further intensified when tall grass is encountered. The wavy motion of the grass gives an illusion of hovering over water. A normal tendency when hovering over tall grass is to hover at a higher altitude than what is judged by the pilot and to inadvertently move laterally with the waves of the grass.

(3) Water. Water is the most difficult of all surfaces to judge movement from a hover. If possible, the helicopter should be hovered near objects (e.g., tree stumps, buoys, shorelines) or a reference marker should be thrown into the water (e.g., life preserver, water flare). A tendency of the pilot when hovering over water is to move laterally with the waves. Accurate depth perception is difficult if not impossible without a radar altimeter.

b. Hovering with position lights.

(1) The illumination provided by the helicopter position lights aids the pilot in both height perception and detection of lateral movement. When operating in the BRIGHT STEADY mode, illumination from the lights is first detected at approximately 25 feet. Effective use of the lights to detect movement of the helicopter can be accomplished at 15 feet. Illumination from the position lights when operating in the DIM STEADY mode is first detected at approximately 10 feet. At 5 feet sufficient light is available to detect movement of the helicopter. Both conditions vary according to the ambient light level and atmospheric conditions. The best effect is achieved from the position light during low light levels and low relative humidity.

(2) When hovering with the aid of position lights, a common error is to stare at a single reference on the ground which tends to induce autokinesis or disorientation. Reference points should be selected both to the front and to the sides of the helicopter. These references should be selected at varying distances from the helicopter. Continuous scanning by the pilot is required to insure that all available references are used to detect movement of the helicopter.

(3) On some helicopters, the shadow formed by the skid from the illumination of the position lights provides a good indicator for identifying the altitude of the hover. As the helicopter ascends, the size of the shadow will become larger; and as it descends, the shadow will become smaller. Upon establishing a 3-foot hover, the pilot should form a mental image of the size of the shadow for future reference. The intensity of the light on the ground and the distance the light is reflected from the helicopter are other techniques for gaging hover height using the position lights as an aid.

(4) When operating with minimum lights at night, a normal tendency is to hover too fast. This situation is difficult to overcome where recognizable features are not available on the ground. Continuous reference must be made to the side of the helicopter to observe objects that will give an indication of forward speed. If hovering on a runway or taxiway, evenly spaced lights provide a good reference for estimating forward speed.

CAUTION: Avoid fixation on runway center line or taxi line during takeoff. This may cause spatial disorientation.

c. Hovering with searchlight/landing light.

(1) When hovering with the landing light or searchlight ON, ground references which enable the pilot to detect movement of the helicopter over the ground and to estimate the height of the hover are visible. The primary difference from a daylight hover is that references will be limited to the arc of illumination created by the light. To develop proficiency when hovering with the aid of a landing light/searchlight, the pilot must incorporate the techniques learned when hovering during daylight and minimum lighting conditions.

(2) The positioning of the beam of light created by the landing light/searchlight will significantly affect the night vision of the pilot. When this beam of light is viewed directly by the pilot, as much as 30 minutes may be required to night adapt after the light is extinguished. To avoid this condition, the pilot should position the light so that he is receiving only reflected illumination. For those helicopters that are equipped with an adjustable landing light, extension of the landing light to a position approximately 45° below the stowed position will cause the beam of light to strike the ground aft of the nose of the helicopter at a 3-foot hover resulting in only reflected light for the pilot. If equipped with a searchlight, the beam can be directed approximately 45° to the left and slightly forward of the helicopter. Because the light beam is obscured by the instrument panel in side-by-side configured helicopters, only reflected light is being viewed by the pilot.

5–10. Takeoff

a. Night takeoff procedures differ from daylight takeoff in that sufficient power must be applied to assure that an immediate climb is established as the helicopter begins to accelerate forward. The takeoff can be executed from a hover or the ground. Before takeoff, the pilot should conduct a visual reconnaissance to determine if any obstacles are in the takeoff path. The night takeoff should be an altitude over airspeed type takeoff until passing through an altitude which will assure obstacle clearance (fig. 5-1). Because difficulty is experienced at night in determining if a climb has been established, cross-check of the vertical speed indicator (VSI) should be made to insure a positive climb. Upon ascending to an altitude clear of obstacles, the helicopter should be accelerated to the normal climb airspeed and rate of climb reduced to normal. The ascent is continued until arriving at the desired altitude at which time the leveloff is accomplished.

Figure 5-1. Night takeoff.

b. Takeoffs which are made with the landing light/searchlight ON aid in detection of obstacles during the ascent. As the helicopter ascends, the illuminated area increases. The high intensity light beam, which is beneath the helicopter while at a hover, is now dissipated over a larger area. As a result, the degree to which the pilot's night vision is affected is reduced. For helicopters with adjustable controls, the most benefit from the landing light/searchlight is achieved by adjusting it far enough in front of the helicopter to assure that obstacles along the flightpath will be illuminated. As the helicopter ascends above the obstacles, the light should be turned OFF. Upon extinguishing the landing light/searchlight, the pilot should be be prepared to experience a sudden reduction of night vision outside the helicopter. To assure positive control of the helicopter during the transition period, the pilot should rely more on his flight instruments. As the pilot's night vision improves, outside references will be used to determine the helicopter's altitude.

c. Because of the lack of visual references during takeoff and throughout the ascent, difficulty will be experienced in maintaining desired ground track. Knowledge of wind velocity and direction will assist in establishing a crab angle which will result in a constant track. Where ground lights exist, the best procedure is to select two distant lights to guide on. During the ascent, alinement of the lights should be maintained, thus assuring a desired ground track.

5–11. Flight at Altitude

Upon ascending to the desired flight altitude, the pilot should allow adequate time to adjust to the conditions of flight. This includes readjustment of the instrument lights, familiarization with the cockpit in the dark, and orientation of outside references. During this adjustment period, the pilot's night vision will continue to improve until total dark adaptation is achieved. Landings to minimum lighting conditions should not be attempted until dark adaptation is complete.

5–12. Night Vision

To see effectively at night, the pilot must learn new techniques for viewing objects and terrain features. A thorough knowledge of principles of night vision (discussed in chapter 2, Night Vision) will assist the pilot in his ability to see at night.

5–13. Terrain Interpretation

Even though the pilot can see effectively at night, if objects or terrain features cannot be identified, disorientation may occur. A thorough knowledge of the principles of terrain interpretation (discussed in chapter 4) will assist the pilot in his ability to identify objects and terrain features at night.

5–14. Landing

a. Nontactical.

(1) Prior to reaching the entry point on an approach, the landing point should be selected. When landing to a lighted helipad, this option is not available; however, if landing to a lighted runway or taxiway, a specific grouping of lights should be selected.

(2) The normal approach should be used at night when conditions allow. The angle of descent during the approach should be on the high side of the normal approach. This technique provides a steeper angle of descent, thus assuring greater obstacle clearance. Because rate of closure and height are difficult to estimate at night, airspeed and rate of descent during the last 100 feet of the approach should be slightly slower.

(3) Normally the helicopter will be decelerated to a slow airspeed above 100 feet to avoid abrupt attitude changes at low altitudes. Misjudgments of the helicopter's airspeed and altitude may occur which result in too fast an airspeed when at a low altitude. Rapid deceleration to correct for pilot error should be avoided due to the danger of the tail rotor of the helicopter striking the ground. When these conditions exist, a go-around should be executed.

(4) During the approach, the pilot may inadvertently decelerate the helicopter resulting in a critical flight condition. Visual detection of slow airspeeds may be unrecognizable because difficulty is experienced in detecting rate of closure. To avoid this condition, the airspeed indicator, although in error at low speeds, can be used in the cross-check of airspeeds above 20 knots

to insure that normal approach airspeed is maintained. Abrupt recovery from slow airspeeds may result in rapid loss of altitude when forward cyclic is applied. Coordinated control movement of both cyclic and collective is required to accelerate the helicopter along the desired approach path.

(5) When landings are made without the aid of the landing light/searchlight, the position lights in the BRIGHT STEADY mode provide effective illumination of the landing area when passing through an altitude of approximately 15 feet. This illumination significantly aids the pilot in estimating the altitude of the helicopter during the termination phase of the approach. This condition is also experienced when operating the position lights in the DIM STEADY mode at altitudes below 5 feet.

(6) The approach can be made to the ground or terminated at a hover. Approaches to the ground require the greatest degree of proficiency. Because the condition of the landing surface is difficult to ascertain at night, approaches are normally planned to terminate at a hover. If it is determined during the approach that the landing area is suitable for landing, the approach may be continued to the ground. A normal tendency when executing an approach to the ground is to stop forward motion before contacting the ground. Forward cyclic is required after passing through effective translational lift to assure that the helicopter continues in forward motion. As the helicopter nears the ground, difficulty is experienced in estimating when contact will occur. A tendency is to "milk" the helicopter down. This technique requires more time to get the helicopter on the ground and usually results in overcontrol of the helicopter. This may cause the landing gear on one side of the helicopter to contact the ground followed by a ricocheting action of both landing gears. To avoid this situation, a gradual but continuous reduction in collective pitch should be made when terminating the approach. Initially, the touchdown may be abrupt; however, contact will be in a level attitude.

(7) Approaches made using the landing light/searchlight are similar to daylight approaches. Depth perception and rate of closure can be detected by viewing the illuminated area below the helicopter. Effective illumination will occur at approximately 300 feet above the ground. Employment of the landing light/searchlight above this altitude tends to detract from the usefulness of the light. The landing light/searchlight should not be used during conditions when restrictions to visibility exist

(e.g., fog, haze) because light is reflected back into the cockpit which might induce a safety hazard.

(8) When making an approach to a landing zone that is lighted by a single light, difficulty will be experienced in interpreting the relative position of the light. Because of the physical limitations of the eyes, an illusion occurs when viewing a single light that causes an apparent motion of the light. To avoid this unsafe environment, a minimum of two lights should be used to identify landing areas. Two hand-held lights may not be separated far enough for the pilot to interpret as two lights when viewed on approach. Minimum separation of 15 feet between lights should be used. When more than two lights are used to mark the landing zone, spacing between lights can be reduced.

b. Tactical (T).

(1) When making an approach to a lighted T, the landing should be planned to terminate the approach in the upper left portion of the T. During the approach, the apparent distance between the lights in the stem of the T provides a cue for determining depth perception and serves as an indicator of the approach angle that is being maintained.

(2) Prior to entry on the final approach leg, the lights forming the stem of the T appear to merge as a single light (A, fig. 5-2). This sight picture occurs when the helicopter is below the desired angle of descent. For the normal approach angle, the stem of the T appears approximately as at B, figure 5-2. If the distance between the lights appears to increase, the approach is steepening or overarcing the desired angle of descent (C, fig. 5-2). The lights would appear as in D, figure 5-2, when viewed from directly overhead.

(3) Alinement of the helicopter with the desired direction of landing can be determined by observing the stem of the T. If the stem points to the left of your position (E, fig. 5-2), you are too far to the right of course and should correct to the left. If the stem points to the right of your position (F, fig. 5-2), you are too far to the left of course and should correct to the right.

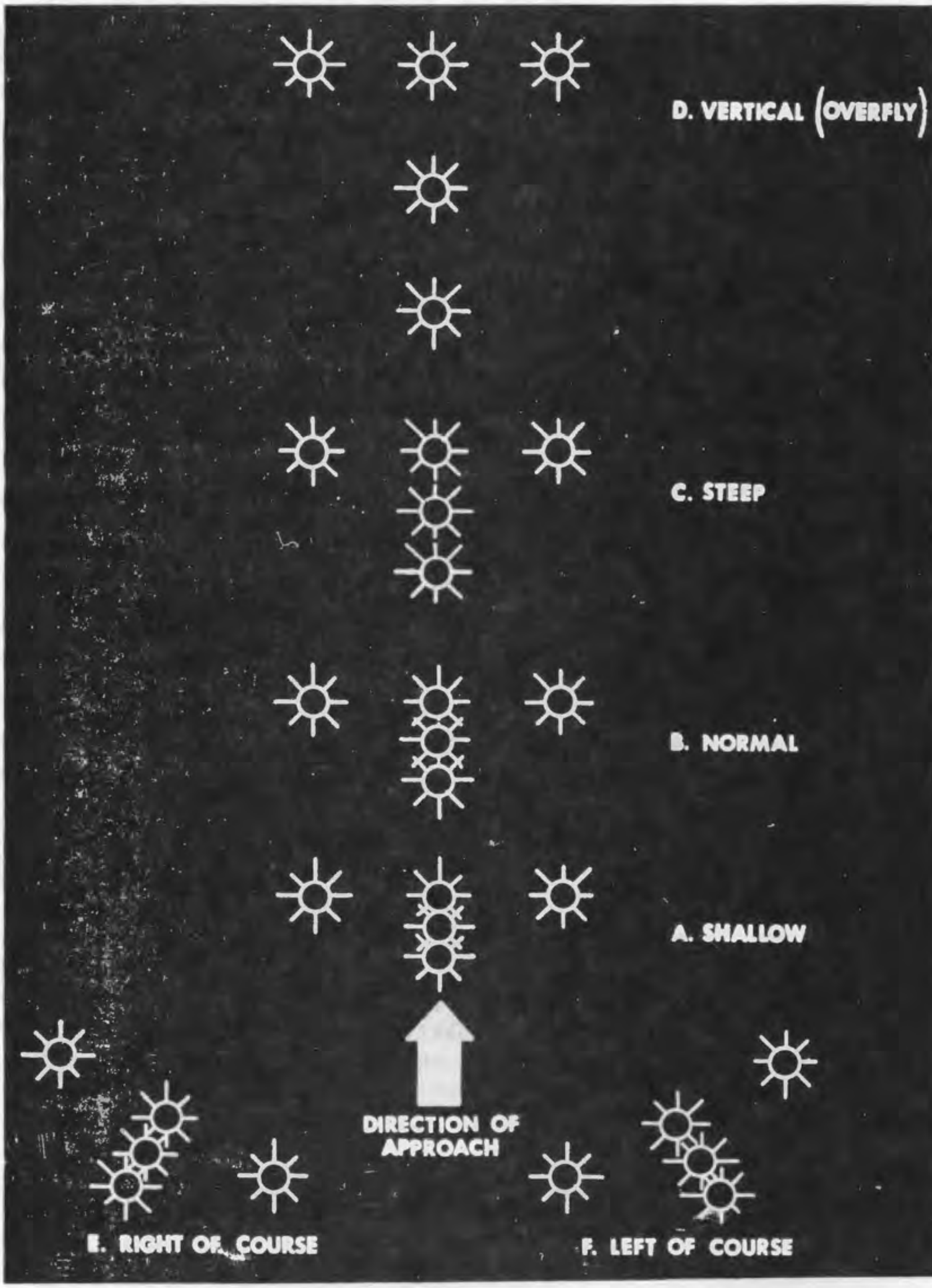


Figure 5-2. Approach to lighted T.

c. Tactical (λ).

(1) Another tactical lighting system that can be used in a confined area or pinnacle is the inverted Y. This arrangement gives the same information that the T provides but allows for better alinement information on final approach (fig. 5-3).

Figure 5-3. Approach to lighted λ.

(2) Prior to entry on final approach, the lights appear to merge as a single light (A, fig. 5-3). This sight picture occurs when the helicopter is below the desired angle of descent. For the normal approach angle, the λ appears as at B, fig. 5-3. If the distance between the lights appears to increase, the approach is steepening or overarcing the desired angle of descent (C, fig. 5-3). The light would appear as in D, fig. 5-3, when viewed from directly overhead.

(3) Alinement of the helicopter with the desired direction of landing can be determined by relative position of the front two lights in relation to the stem. If the spacing between the front two lights and the stem is shifted to the left, you are too far to the right of course and should correct to the left (E, fig. 5-3). If the spacing between the front two lights and the stem is shifted to the right, you are too far to the left of course and should correct to the right (F, fig. 5-3).

5—15. Landing to a Glideslope Indicator

The glideslope indicator is mounted on a universal joint which permits adjustment from zero to 15^{o} above the horizontal. When approaching in the center of any one of the three beams, a brilliant shade of the light is seen (fig. 5-4). The green beam represents the desired angle of descent and assures the pilot obstacle clearance if he stays within the beam. Also, obstacle clearance is assured by flying on the amber beam; however, the approach will be steeper than desired requiring a greater rate of descent. Flight within the red beam indicates that the helicopter is too low and may be in danger. If the helicopter is allowed to drift to the extreme edge of the approach beams, the light intensity may be reduced so much that all beams appear amber in color. The pilot, thinking he is high (in the amber beam), may reduce collective pitch to lose altitude; and, if the error is not corrected in time, premature ground contact will occur.

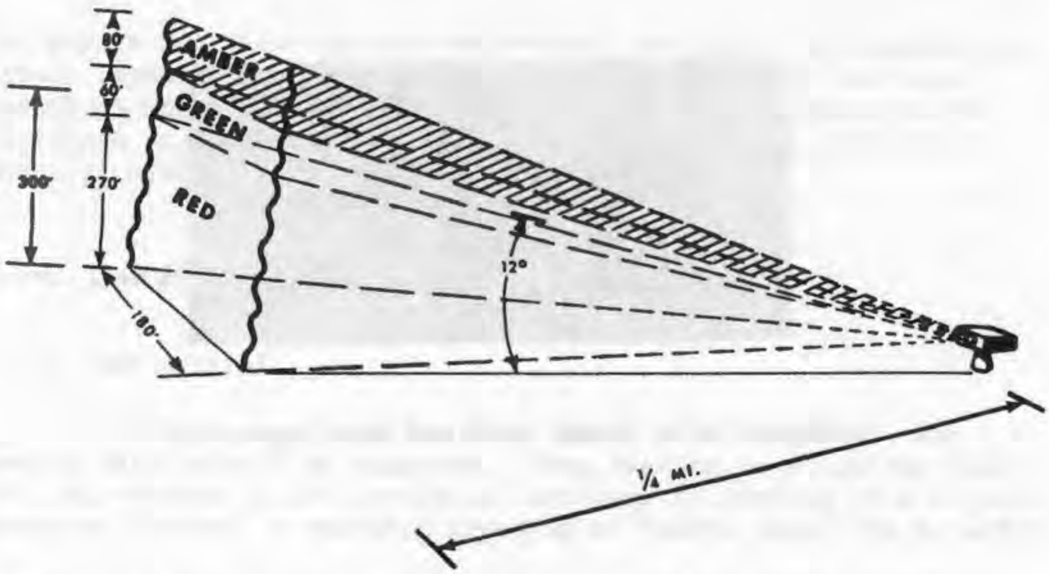


Figure 5-4. Approach light colors and effective distances.

5–16 Confined Area/Pinnacle Operations

The approach into a confined area/pinnacle is the same as discussed in paragraph 5-14 (Landing) except the approach to a confined area may be steeper depending on the terrain obstacles along the flightpath. During the initial stages of training, a high reconnaissance of the landing area should be performed at a maximum altitude of 300 feet to 400 feet above the highest obstacle (AHO) and at 60 knots to 70 knots with navigation lights on STEADY DIM. This enables the flight crew to acquire terrain definition and maintain sight of the area throughout the reconnaissance. It is important at night that sight of the landing area is not lost, especially if it is unlighted. Steady dim lighting configuration is much better because of the reduced halo effect which is emitted from the navigation lights. However, this lighting configuration does not produce enough light to successfully accomplish a landing if the ambient light level is low (figs. 5-5, 5-6).

Figure 5-5. Night confined area approach.

Figure 5-6. Night pinnacle approach.

5-17. Standard Autorotations

a. Night autorotations are performed in the same manner as in daylight conditions; however, techniques must be developed which will compensate for the reduced visibility that is experienced at night. Difficulty is experienced in estimating height at which the different phases of the maneuver will be performed. As a result, there is a tendency to apply collective pitch too soon or too late. To overcome this deficiency, the pilot will be required to make frequent observations out the side window observing cues which will help in judging height above the ground. A tendency is to concentrate on applying pitch and failing to correct for drift and for yaw effect when collective pitch is applied. Initial deceleration should be started in time to avoid an excessive nose-high attitude at the termination of the maneuver. Conditions which require an excessive nose-high deceleration attitude, may render the landing light/searchlight ineffective and create an unsafe condition.

b. When conducting touchdown autorotations in the training area, the landing light/searchlight is turned ON when on final approach and will be left ON until termination of the maneuver or the execution of a go-around. During an actual engine failure, the use of the light may be delayed until passing an altitude between 300 feet to 500 feet above the ground depending on atmospheric conditions. If the landing light/searchlight is turned ON before descending below this altitude, a halo effect appears which restricts the pilot's ability to identify a forced landing area on the ground. Use of the lights below this altitude aids in recognition of terrain features on the ground.

c. Upon entry into this maneuver, attitude control is critical. The lack of visual references reduces the pilot's ability to estimate airspeed. As a result, a normal tendency is to decelerate the helicopter which further aggravates the problem. To avoid this unsafe condition, reference must be made to the flight instruments to attain desired airspeed in the descent.

d. Regardless of the lighting condition of the aircraft or airfield a safe landing is assured in a UH-1, if a hovering attitude is established during the deceleration with initial and cushioning pitch being properly utilized (fig. 5-7).

Note. <u>The length of the ground slide will be dependent upon factors such as wind, landing area, and density altitude. To</u>

prevent steep descents and sudden decelerations, a longer ground slide may have to be accepted than in day standard autorotations.

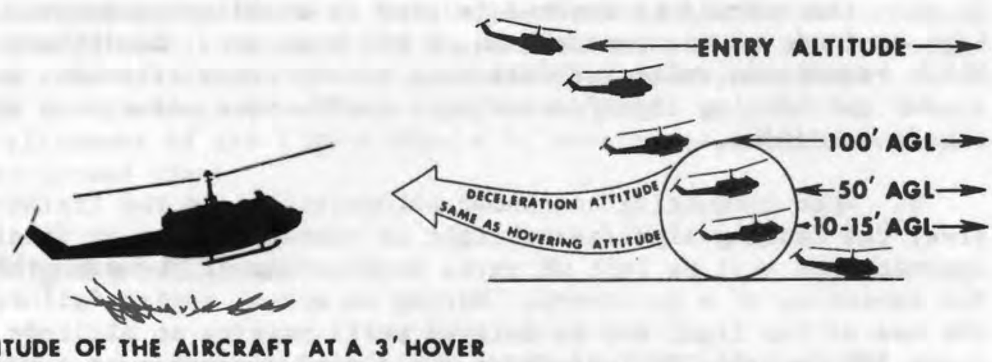


Figure 5-7. Standard autorotation.

5-18. Low-Level Autorotation

A minimum descent altitude should be established (to avoid contact with obstacles) and flown on final until the aviator can observe absolute terrain definition. At this point, a descent to entry altitude can be initiated. Upon entry of the maneuver, a partial flare attitude should be established initially until approximately 10 feet to 15 feet skid height. At this point, a hovering attitude is assumed while applying initial collective pitch. Because altitudes and rate of descent become very difficult or impossible to gauge, the aircraft should not be put into a vertical descent during the partial flare portion of the maneuver.

5–19. Hovering Autorotation

Determination of an engine failure while at a hover will not be immediate and in most cases will probably not be discovered until after the aircraft is on the ground. Because it is difficult to determine the aircraft skid height, the crewmember not performing the maneuver should advise the pilot of the approximate height of the helicopter. As the helicopter approaches the ground, collective pitch is increased to cushion the touchdown. This technique is necessary to protect against the helicopter striking the ground prior to the normal pitch pull at 1 foot due to poor depth perception.

5–20. Servos Off/Running Landing

To reduce the control problem that is associated with this maneuver, airspeed should be maintained above effective translational lift (16 - 24 kts). When terrain definition is acquired and the rate of closure begins to increase, the helicopter should be placed in a hovering attitude. The rate of descent should not be allowed to exceed 300 feet per minute upon touchdown. It must be understood that acquiring terrain definition during the final portion of the approach will be dependent upon the light level.

5–21. External Load Operations

External load operations can be extremely difficult during hours of darkness. To successfully accomplish this maneuver, a triangular set of lights with a spacing of 15 feet should be positioned approximately 75 feet in front of the hookup area for use as a reference marker (fig. 5-8). This lighting configuration aids the flight crew during hookup, release, and takeoff. Upon takeoff the aviator should vertically ascend until the load is clear of the ground. As the helicopter begins forward movement, sufficient power must be applied to begin a climb (fig. 5-9). Climb power should be maintained until the load is clear of terrain obstacles. The shorter the sling, the less power required to become airborne and clear obstacles.

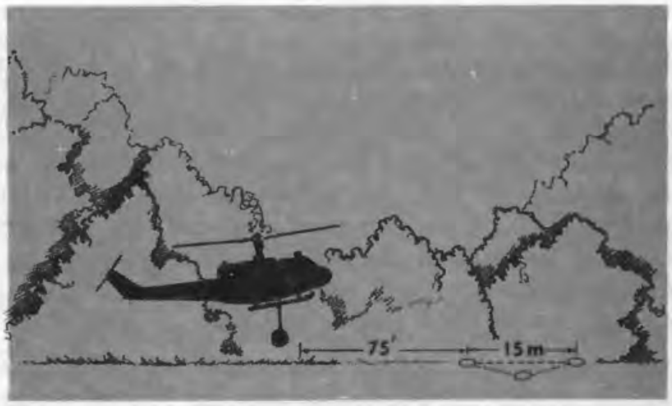


Figure 5-8. Ground lighting, slingload operations.

Figure 5-9. Night slingload takeoff.

SECTION V. EMERGENCY PROCEDURES

5–22. General

Emergency procedures for day flight and night flight are the same; however, the time required to respond to an emergency condition will normally be longer at night. This is due to the increase in psychological stresses and reduced vision within the cockpit at night. To minimize time delays in executing the required emergency procedures at night, the pilot must become familiar with the cockpit and emergency procedures.

5–23. Radio Failure

a. When failure occurs on the primary radio, secondary systems should be checked to determine if communication can be established with the controlling agencies. If communication cannot be achieved while in the traffic pattern at a field training site, a go-around should be executed, followed by a normal departure from the traffic pattern and return to the base field. Upon entering the traffic at the base field, the pilot of the distressed helicopter flies along the side of the landing runway 1,000 feet above field elevation (with landing light on) until it reaches the end of the runway. Then he turns downwind and checks mobile control and/or tower for green light on base leg and final approach.

b. If radio failure occurs during a training formation flight, the pilot should use the visual signals discussed in paragraph 5-26. Formation flight should be discontinued for the helicopter experiencing radio communications failure.

5–24. Electrical Failure

In the event of a total electrical failure, nonessential systems requiring power should be turned off. This procedure preserves existing power in the battery. The flashlight should be used to assist in reading instruments, and landing made at the nearest facility that affords a safe landing. If in the traffic pattern at a field training site, training should be terminated and the helicopter returned to the base field. Upon entering the traffic pattern, an attempt should be made to contact the tower. If battery power is insufficient to operate the radio, the pilot should initiate the electrical failure emergency procedure for entering an airport/heliport. The pilot of the distressed helicopter should fly 500 feet over mobile control or tower, thoroughly checking for other aircraft in the area. The pilot should then fly normal entry procedure while watching the mobile or tower for signals and remain clear of other aircraft. The control tower should clear the area of other aircraft and control the distressed helicopter with light signals.

5–25. Airport Traffic Control Light Signals

A helicopter that has experienced radio failure should observe the tower for light signals which will identify the required action by the pilot. Acknowledgment of the tower light signal at night is accomplished by flashing the helicopter lights (landing light or searchlight). Airport traffic control tower signals are identified in table 5-1.

Table 5-1. Airport Traffic Control Tower Signals.

Color and Type of Signal	On the Ground	In Flight
Steady Green	Cleared for takeoff	Cleared to land
Flashing Green	Cleared to taxi	Return for landing (to be followed by steady green at proper time).
Steady Red	Stop	Give way to other aircraft and continue circling.
Flashing Red	Taxi clear of landing area (runway) in use.	Airport unsafe -- do not land.
Flashing White	Return to starting point on airport.	
Alternating Red and Green	General Warning Signal - Exercise Extreme Caution	
Red Pyrotechnic (Red Flare)		Notwithstanding any previous instructions, do not land for the time being.

5—26. Visual Night Signals

Visual night signals are used by the pilot at night when the radio is inoperative. They may be used to signal an escort helicopter or the control tower of the distress. A unit SOP should be developed which identifies the visual night signal to be used during emergency situations. The following visual night signals are a guide for development of a more complete unit SOP.

a. Helicopter emergency (must land as soon as possible). If the nature of the emergency allows, the distressed pilot signals the escort helicopter by describing a circle on the side window with a flashlight, then he maneuvers to the escort helicopter wing position. The escort pilot leads to the nearest suitable field, declares an emergency with the controlling agency, and then flies a straight-in approach with the distressed helicopter on his wing. The distressed helicopter lands and the escort executes a go-around. While en route, the escort helicopter plans to fly the normal cruise airspeed of the distressed helicopter. If this airspeed is too fast, the pilot of the distressed helicopter signals by blinking his flashlight once for each 10-knot decrease desired.

b. Aircraft having minor difficulty. The distressed helicopter signals another helicopter in the formation by a series of flashes from a flashlight, then maneuvers to the wing position of the escort helicopter. The airspeed and flight procedures are the same as specified in a above except that the escort helicopter leads to the intended landing field but does not declare an emergency in doing so.

c. Signal acknowledgment. The pilot of the escort helicopter points a steady light from the flashlight at the signaling helicopter. If the message is not understood, the pilot in the escort helicopter will respond by blinking his flashlight.

5—27. Airfield and Heliport Lighting

To insure a safe operating environment, the pilot should know the standard colors for airfield and heliport lighting.

a. The aviation colors for Army airfield marker lights will be as follows:

(1) Lateral limits of runways (airfield) - white (clear).

(2) Lateral limits of runway (heliport) - alternating white (clear) and blue.

(3) Threshold lights defining ends of usable landing area - green.

(4) Taxiway lights - blue.

(5) Entrance or exit taxi - guidance lights at intersections (throat) of taxiways with runways or aprons - blue.

(6) Approach lights for instrument approach facilities and IFR procedures if directed - white and red.

(7) Obstruction lights - red.

(8) Wind-direction indicator - white (clear).

(9) Lighted entrance - exit signs will emit aviation - yellow light.

(10) Obstruction - red.

b. The aviation colors for Army airfield and heliport beacon lights are as follows:

(1) Station or airport at attended land airfield - white (double or split beam) - green.

(2) Station or heliport beacon at attended land heliport - white (flashing clear light, 60 to 80 flashes per minute).

(3) Hazard beacon - red.

5-28. Forced Landing

a. With power. If a system failure occurs which requires that a precautionary landing be executed, the pilot should first analyze the problem and apply the emergency procedure to see if the difficulty can be corrected. If the emergency continues to exist, the pilot should select an open area that is large enough to facilitate a normal approach. Descent to a lower altitude will assist in locating and identifying a suitable landing zone. As the helicopter descends below an altitude of approximately 500 feet, the landing light/searchlight should be turned on to assist in locating a landing zone and identifying obstacles. A normal approach should be made using as much power as necessary to execute a safe landing. Prior to touchdown, an attempt should be made to contact the controlling agency to advise of the circumstances and the approximate location. After touchdown, the helicopter should be shut down. The crew should remain with the helicopter and upon hearing an aircraft approaching, should turn on the anti-collision light and the position lights (BRIGHT FLASH) to assist in identification of the distressed helicopter.

b. Without power. Upon experiencing a power failure, emergency procedures should be executed. During the descent, a landing area should be selected which appears to be lighter in color as compared to the surrounding terrain. This area will provide the most suitable landing zone. As the helicopter continues to descend, the landing light/searchlight should be turned on when passing through an altitude of approximately 500 feet depending on atmospheric conditions. Upon selecting the desired touchdown point, the helicopter will be maneuvered into position. Deceleration should be performed at an altitude that is high enough to assure tail rotor clearance. Prior to ground contact, the helicopter should be decelerated to zero forward airspeed and sufficient collective pitch applied to cushion the helicopter onto the ground. If time permits, an emergency call should be made to advise of the situation and the approximate location of the helicopter.

SECTION VI. SAFETY PROCEDURES

5-29. Ground Safety

a. As the pilot walks to and from the helicopter during hours of darkness, obstacles along the ground are difficult to detect. Also, the pilot hovering a helicopter may not see ground personnel who are standing along the taxiway and unintentionally hover so close as to cause injury by blowing dust and foreign objects into them. To avoid these conditions, aircrew members should always carry a flashlight to illuminate the path so the pilot of a hovering helicopter can recognize their position.

b. Whenever possible, preflight should be conducted during daylight. This procedure allows for a more comprehensive inspection of the helicopter and avoids the loss of night vision when conducting the preflight with a flashlight.

c. During the preflight at night, the aircrew should pay particular attention to structural components of the helicopter which are difficult to see at night. Before moving forward to check another component of the helicopter, the flashlight should be shown forward to insure that no obstructions lie in the crewmembers' path. An example of a structural component which has caused serious injury to the aviator preflighting a UH-1 helicopter is the synchronized elevator. This component is at about the same level as the head and can cause serious injury if caution is not exercised when preflighting this area of the helicopter.

d. When climbing upon the helicopter at night, extreme care must be exercised to insure that surfaces are clear of oil and hydraulic fluid. These conditions are common in and around the transmission and rotor head. Extreme care must be exercised to insure that crewmembers do not lose their balance and fall during preflight of the rotor assembly.

5–30. Air Safety

a. The pilot must be aware of the limitations of night vision and must not overestimate his ability to conduct night flight. After initial qualification, continuous training is required to remain proficient. If night flight has not been conducted for a lengthy period of time, simple maneuvers should be performed before attempting more advanced maneuvers.

b. Because references are limited at night, vertigo is easily induced. The pilot must be aware of this condition and rely on his instruments to assure a normal flight attitude. When hovering without the aid of the landing light/searchlight, vertigo is a common occurrence. To avoid this condition, lights should be turned on whenever tactically feasible.

c. To assure immediate and positive response to an in-flight emergency, each crewmember should become familiar with the location of controls and switches within the cockpit.

d. Continuous observation outside the helicopter is required to insure avoidance of flight in the close proximity of another helicopter which could result in a mid-air collision. This condition becomes increasingly hazardous when conducting flight in and around field training sites.