NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS CNATRA P-819A (REV. 06-97) PAT

RADAR PLANNING AND NAVIGATION STRIKE

ADVANCED SNFO/SNAV

1997

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL AIR TRAINING
CNATRA
250 LEXINGTON BLVD SUITE 102
CORPUS CHRISTI TX 78419-5041

N3111
19 JUN 1997

1. CNATRA P-819A (Rev. 06-97) PAT, "Radar Planning and Navigation, is issued for information, standardization of instruction and guidance of instructors and students of the advanced phase of Navigation, in the Naval Air Training Command.

2. This publication will be used to supplement the curriculum of Training Squadron EIGHTY-SIX.

3. Recommendations for changes shall be submitted to the Commander Training Air Wing SIX, Naval Air Station, Pensacola FL 32508-5200.

4. CNATRA P-819A (Rev. 11-91) is hereby canceled and superseded.

GLENN J. PITTMAN
Assistant Chief of Staff for
Training and Operations

Distribution:
CNATRA (4)
COMTRAWING SIX (196)

RADAR PLANNING AND NAVIGATION
STRIKE

Table of Contents

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Radar Planning and Navigation
Course book

OVERVIEW

This course is designed to guide you through your study assignments in a logical manner. It is divided into six units of instruction contained in three books. This course will help prepare you to navigate using the APG-66NT Ground Mapping Radar system. Typically most of the learning objectives listed below can only be accomplished in the airborne environment. However, this course is a necessary prerequisite for upcoming trainers and flight events.

SCOPE

This course will familiarize you with the APG-66NT Ground Mapping Radar. You will be taught to plan radar navigation charts, navigate using a radarscope and prepare radar predictions. This is necessary for successful completion of the curriculum at VT-86 and is valuable in becoming a successful NFO. After satisfying the learning objectives of this course, you will be prepared to plan a route and navigate operating the APG-66NT radar in the synthetic trainer periods and in the aircraft.

TERMINAL OBJECTIVE A

Effectively navigate operating a ground mapping radar system. Standards are prescribed in learning objectives A.3 through A.6

LEARNING OBJECTIVES

A.3 Plan a radar mission to the accuracy of: Fuel, +/-100 lbs;Time, +/- 6 seconds; Course, +/- 2 degrees; DD-175, one error.

A.4 Construct accurate radar predictions using recommended procedures.

A.5 Execute navigation procedures and make recommendations to track a given course to the accuracy of 2 NM and 30 seconds.

A.6 Make recommendation to return to planned course and preflight time to an accuracy of 1 NM and 12 seconds.

MODE OF INSTRUCTION

The student shall read the programmed text prior to the respective lectures. The programmed text will serve as the lecture outline and study guide.

FINAL PERFORMANCE CHECK

Upon completion of the six units of instruction, you will receive a midphase examination. You must pass the midphase to continue in the program. Trainers, flights and a final exam will continue to evaluate your increased grasp of this material.

UNIT GUIDE

RP RADAR PLANNING

LEARNING OBJECTIVE: Plan a radar mission to the accuracy of: Fuel, +/-100 lbs; Time, +/-6 seconds; Course, +/-2 degrees; DD-175, one error. Interpret DD-175-1.

LEARNING STEPS:

1. Extract planning data from FLIP
2. Prepare a radar navigation chart
3. Prepare a jet log

SKILLS DEVELOPMENT UNIT: This academic unit of instruction is the primary reference for chart preparation for radar navigation missions. The primary reference for preparation of the jet log is the Trainee Guide for Instrument Navigation, Basic SNFO. The final performance check is RN-4X and midphase examination.

INSTRUCTIONAL AIDS:

1. Black and blue felt tip markers
2. TPC chart
3. Plotter
4. Dividers
5. Nickel/Dime
6. CR-2 computer
7. Jet log
8. DD-175
9. T-39 NATOPS Manual

References:

1. T-39 NATOPS Manual
2. Trainee Guide for Instrument Navigation, Basic SNFO
3. FLIP General Planning and FLIP AP/IB
4. Low Level Planning and Navigation, Intermediate SNFO
5. VT-86 STRIKE Planning Guide

RADAR PLANNING

INTRODUCTION

Virtually all tactical aircraft in the Navy and Marine Corps inventory have installed radar suitable for navigation. The skills learned in STRIKE training are applicable to any warfare specialty to which you may be assigned subsequent to VT-86.

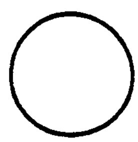
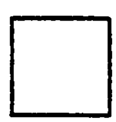
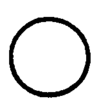
Effective radar planning is more than just constructing a chart. In addition to carefully plotting turnpoints, turn radii, courselines, and leg information, the professional NFO should also consider terrain features of the route and the radar significance of checkpoints. Without attentive, preflight planning, navigation situational awareness degrades.

CHART PLANNING

The planning guide contains descriptions of all routes flown in the STRIKE syllabus. The particular routes for your class can be found on your ground training schedule. Daily route assignments will be made via the STRIKE rough flight schedule. It is imperative that you check the planning guide and FLIP AP/IB for IR route changes and specific route restrictions.

Plot the turnpoints, turn radii, courselines, emergency and military diverts, and leg information (doghouses). Remember to round off leg time to the nearest 6 seconds (1/2 NM). The chart symbols used will be the same as for planning low level routes. CHUM information is not necessary for radar charts since these routes will be flown above 2000 feet AGL. Above each doghouse put the TACAN cut for the point you are going toward. The altitude block of the doghouse will have the expected IFR altitude for the direction of flight. All other doghouse information is exactly as planned for low levels.

Chart TPC (1:500,000)

TURNPOINT (TPT)		NICKEL CIRCLE
TARGET (TGT) EMERGENCY DIVERT		EQUILATERAL TRIANGLE
MILITARY DIVERT		SQUARE
RADIUS OF TURN (30° or more)		DIME CIRCLE

DOGHOUSE

Just as in low levels you will use total elapsed time in planning radar missions. The route will be time-ticked for 300 knots ground speed at one minute intervals with every third time tick numbered. In addition to numbering every third time tick, you will also note the distance remaining in parenthesis from that time tick to the next turnpoint. This will help you find the turnpoint by correlating time with distance to the turnpoint. Besides labeling your chart with the NPA number and your name, sign your name in the center of the chart in black ball point ink where it will not conflict with the route.

THIS PLAN IS WHAT YOU WILL FLY, WITH HEADING CHANGES TO MAINTAIN COURSE, AND SPEED CHANGES TO MAINTAIN PREFLIGHT TIME.

CHECKPOINTS

Next, you need to select your checkpoints, considering both terrain and the radar significance of the checkpoint. Look at the example on page 5. Is the town of Leakesville a good checkpoint? To answer this question fully, we need to look at several factors.

First, is there any terrain blocking our view of Leakesville? A close study of contour lines and spot elevations around the town indicates that Leakesville sits on a hill between two river drainage patterns. No ridge lines block our view, so we can assume that it should be visible.

Second, is the town radar significant? Another close study of the checkpoint shows several secondary roads leading into Leakesville. These indicate a fair amount of development and we can assume that Leaksville is reasonably radar significant.

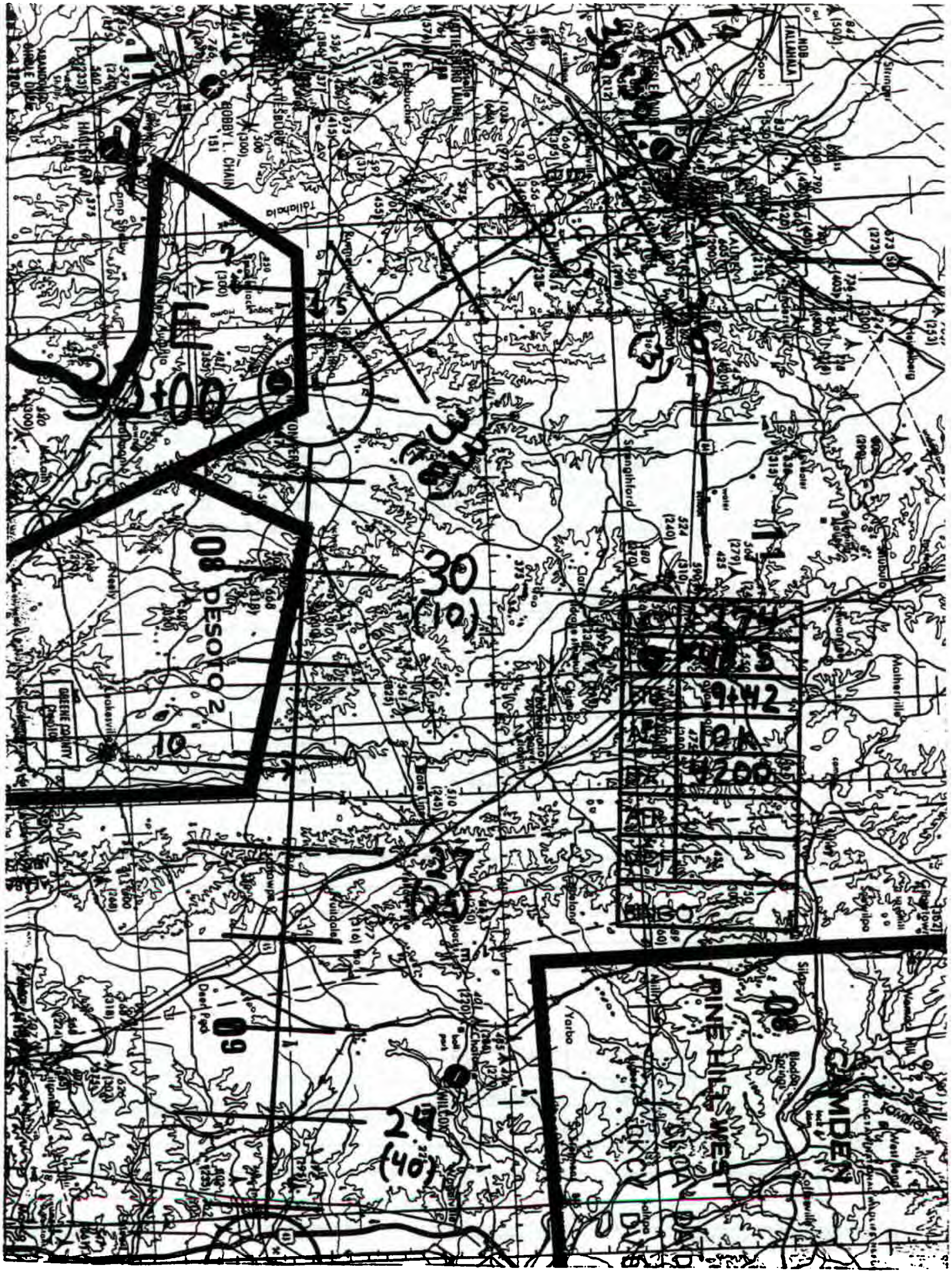
Finally, can Leakesville be used to determine course placement and/or ground speed. Since it is not on course, we cannot accurately update time. For course placement we can, by using angular math (1° @ 60NM = 1NM), determine our position relative to the preflight course. If we assume that it will take about 2 minutes to complete our wings level procedures, we will find ourselves 18 NM prior to a position abeam the town. Using angular math, we find that the town will disappear off the left side of the scope at about 10 NM. If we are able to devote our attention to the checkpoint at 2 minutes, that leaves only 8 NM, or one minute thirty-six seconds, in which to analyze our position, make a course correction and re-evaluate our position before Leakesville disappears from the screen. Therefore, even though the town of Leakesville is visible from line-of-sight and is radar significant, it is a marginally usable checkpoint since it will not be on the scope very long.

However, the smokestack that lies 5NM beyond and 7NM left of the town of Richton is radar significant and can be used as a checkpoint for the remaining six minutes (30 NM) to the turnpoint.

A general rule of thumb: the closer a checkpoint is to the beginning of the leg, the closer to course it must be to be usable. A checkpoint over 10-12NM from course is usually not very good. Use your radar prediction template to locate good radar checkpoints within range of the scope boundaries. Annotate checkpoints on radar charts by writing the abeam distance in NM from courseline next to an identifying arrow.

The length of the leg is always a factor when deciding which checkpoints you should annotate. One or two checkpoints should be annotated per radar leg. other radar significant features should be noted when planning and anything on the chart may be used for navigation and correlation. See your personal advisor for information regarding proper checkpoint selection.

Correlation refers to the use of geometric relationships to determine course information. Checkpoints should be used for correlation and positive identification of the turnpoint.


08 DESOTO 2
BOBBY L. CHAIN
CAMDEN

Checkpoints beyond your turnpoint should be annotated with miles past turnpoint and miles abeam extended courseline.

FUEL PLANNING

Before launching on any flight you must do fuel planning. For most of your flights at VT-86, a simple climb schedule and a constant fuel flow for your fuel planning will do. The tables on the following pages should be consulted. You will start with a preflight fuel of 7200 pounds and round all fuels to the nearest 50 pounds.

FILING

Normally, local radar flights (NPA series) will be scheduled for you and a DD-175 will not be required for the flight. The STRIKE and Composite routes, on the other hand, require you to prepare a DD-175 with the scheduled route entry times in the remarks section and the planned route of flight filled in for filing at base operations. All out and in flights and some local flights will require this DD-175. A sample DD-175 prepared as per GP chapter 4 is provided. Ensure AP-1B entry and exit points are on your route of flight on either side of your IR route number. Routes without AP-1B IR numbers must be filed.point to point, i.e., NPA-14 and 18.

DATE	AIRCRAFT CALL SIGN	AIRCRAFT DESG AND TO CODE
	VV8F12C	T-~-/A

BASE OPERATIONS USE

	TYPE FLT PLAN	TRUE AIRSPEED	POINT OF DEPARTURE	PROPOSED DEPARTURE TIME (Z)	ALTITUDE	ROUTE OF FLIGHT	TO	ETE
	I	420	NPA	1800	330	MARDE - ___ NSE CEW330015 MCN AHN SOT149019		
						IR080 HNN046014 APE 185037 FFO140011	FFO	2-15
	I	300	FFO	2135	090	TARTO HNN048014 IR723 SUG051006 ELW MCN		
						CEW CANJE NPA NPA 213014 (3-30 VPS 0-15)	NPA	2-30

REMARKS

FFO - S, RV
IR080 E PT. A aaaa X PT. I bbbb L C AAA
IR723 E PT. A aaaa X PT. K bbbb L C AAA
Void 7-0C

RANK AND HONOR CODE

FUEL ON BD	ALTN AIRFIELD	ETE TO ALTN	NOTAMS	WEATHER	WT AND BALANCE	AIRCRAFT SERIAL NUMBER, UNIT, AND HOME STATION

SIGNATURE OF APPROVAL AUTHORITY	CREW/PASSENGER LIST: ATTACHED / SEE PSGR MANIFEST	ACTUAL DEP TIME (Z)	BASE OPERATIONS USE

DUTY	NAME AND INITIALS	RANK	SSN	ORGANIZATION AND LOCATION
PILOT IN COMMAND	aaaa/bbbb = Zulu times for entry and exit			
	on IR route			
	AAA = Lost Comm Altitude			

DD Form 175, MAY 86 MILITARY FLIGHT PLAN

UNIT GUIDE

RN RADARSCOPE NAVIGATION

LEARNING OBJECTIVE: Execute navigation procedures and make recommendations to track a given course to an accuracy of 2 NM and 30 seconds.

LEARNING OBJECTIVE: Make recommendations to return to planned course and preflight time to an accuracy of 1 NM and 12 seconds.

LEARNING STEPS:

1. Describe the components of DR navigation
2. Execute turnpoint procedures
3. Compute total wind and apply to maintain course and time
4. Determine aircraft position in relation to radar returns/planned course
5. Execute course corrections to within 1 NM of course
6. Execute speed corrections to remain within 12 seconds of preflight time

SKILLS DEVELOPMENT UNIT: This academic unit of instruction is the primary reference for radar navigation. The final performance checks are the midphase, final examination, and RN-4X flight.

REFERENCES:

1. Navigation Manual, VA-128

RADAR NAVIGATION

Radar navigation is 90% dead reckoning (DR) and 10% scope interpretation. To interpret the scope correctly you must know the approximate position of the aircraft. Dead reckoning procedures will allow you to maintain an approximate plot of the aircraft position. From this approximate position you will be able to use the radarscope to determine your actual position. On a good day your actual position will be on your plotted course, making scope interpretation relatively easy. In order to keep your aircraft on course, a good understanding of dead reckoning procedures is necessary.

According to Webster, dead reckoning is the determination of the position of an aircraft from the record of the courses flown, the distances made, and the known or estimated drift. The courses to fly and the times to make (based on 300 knots ground speed) will be your planned radar navigation routes. Your job is to correct your courses and airspeeds along the route in order to hit your turnpoints and target on time. In other words, you should strive to minimize drift from your planned route. How do you minimize drift? You can correct for the cause of it. WIND is one source of this drift and is one side of the navigation triangle.

The navigation problem can be completely defined in terms of three vectors, each having a magnitude and a direction. These three vectors combine to form the navigation triangle.

1. The TAS/MH vector describes the aircraft's movement with respect to the air mass. Its magnitude is determined by the aircraft's true airspeed (TAS) and its direction is determined by the aircraft's magnetic heading (MH). This is the side of the triangle you will change during flight.

2. The GS/MC vector describes the aircraft's movement with respect to the earth. Its magnitude is determined by the aircraft's ground speed (GS) and it's direction is determined by the aircraft's magnetic course (MC) or ground track. This side of the triangle is your planned route at 300 knots ground speed.

3. The WIND vector describes the movement of the air mass with respect to the earth. It consists of wind speed and wind direction. This is the side of the triangle <u>you</u> will correct for in-flight or else you will not maintain your preflight course and time.

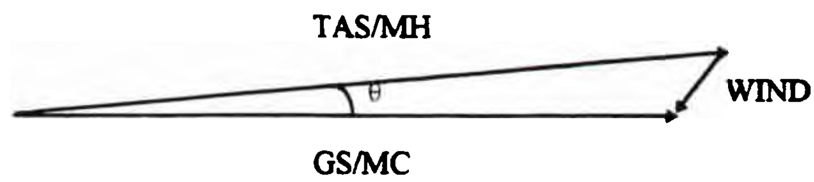
The relationship between these vectors is shown below:

THE NAVIGATION TRIANGLE

MC = 090° MH = 085°

GS = 300 kts TAS = 315 kts

Wind = 030°/30 kts



15 kts headwind

25 kts left crosswind

Notice that the angle (θ) between the TAS/MH vector and the GS/MC vector represents the aircraft's drift angle (crab or crosswind effects). The difference in the length of the TAS/MH vector and the GS/MC vector represents the head wind/tailwind effects, which will affect your timing.

With a thorough understanding and appreciation of the navigation triangle and DR procedures you will be ready to start radar interpretation and, finally, radar navigation. The radar navigation turnpoint procedures (TPP) are designed to aid you in accomplishing the required DR navigation.

The turnpoint procedures are:

<u>TWO MINUTES PRIOR (2MP)</u>
Outbound heading
Outbound airspeed

<u>MARK ON TOP (MOT)</u>
Turn aircraft
Note time
Set airspeed
Rebuild a rough scope
TACAN update

<u>WINGS LEVEL (WL)</u>
Heading
Airspeed
Altitude
Fuel analysis
Turnpoint analysis
Time/Wind analysis
Check crab
Check airspeed
Update ETA to next TPT

Turnpoint procedures are done aloud (The items following fuel analysis are relayed just to the NFO instructor when navigating from the cabin station on RN-1). Turnpoint procedures are not always your priority. For each leg a list of navigation priorities exists, including turnpoint procedures and the following items:

1. REMEMBER YOUR PRIORITIES. Aviate, navigate, communicate, briefs, checklists, turnpoint procedures. "Aviate" includes the first four items of the wings level turnpoint procedure. This allows you to keep the big picture. Turnpoint procedures should help you with your navigation; <u>however</u>, don't hesitate to interrupt the wings level call in an effort to keep your situational awareness.

2. Using time/chart/scope correlation, locate turnpoint or next checkpoint.

3. Refine scope picture.

4. Correct to course using standard course correction or BDHI.

5. Determine validity of your wind solution, paying attention to crab, turnpoint drift and course corrections.

Your priorities may change depending on the length of the leg. Remember, turnpoint procedures are designed to help you maintain your course and time by applying wind to your preflight route. The amount of time you allot to wind analysis will depend on wind velocity, length of the leg and your situational awareness. Once inside two minutes prior, it is your priority to mark on top the turnpoint.

Due to their complexity, turnpoint analysis and wind analysis require in depth discussion before pressing on to in-flight corrections.

TURNPOINT ANALYSIS

Turnpoint analysis is the physical position of the aircraft relative to the previous turnpoint at MOT and how that affects outbound course and ETA to the next turnpoint. It has nothing to do with the MOT time at the previous turnpoint.

Marking on top a turnpoint on heading is your first priority. Second priority is marking on top in a course correction. Third priority is marking abeam correcting to the turnpoint. Fourth priority is marking abeam. Marking on top on heading reduces your turnpoint analysis to a minimum (On Top On Heading-On Course OTOH-OC).

Marking abeam in a correction or marking on-top a turnpoint in a correction may significantly change the preflight turn radius, placing the aircraft off course and time. Being off course and time affects where and when the next turnpoint or checkpoint appears on the scope. This situation is sometimes erroneously interpreted as wind and should be carefully evaluated before attempting a wind analysis. A proper turnpoint analysis enables you to predict your position relative to course and provides an accurate update to your ETA. Know how to use the Turnpoint Analysis information provided in your low level course book to determine distances and times off.

WIND ANALYSIS

The first wind used will be preflight wind from the DD-175-1. In-flight you will determine how well the preflight winds are holding and use the formulas to refine or recalculate the wind. Wind calculations are the same as in low levels; however, the velocities are usually greater at higher altitudes. Upon marking on top a turnpoint, you will have three "times" associated with that point: preflight time, updated ETA, and actual MOT time all three in minutes and seconds. Wind analysis will be determined by comparing updated ETA to actual MOT (seconds early or late). It is important to have an accurate ETA if you must turn on time and is essential for computing head wind/tail wind (HW/TW) in your wind analysis. Crosswind (CW) can be computed by noting distance abeam course over time flown, as in low levels. However, how well crab holds the aircraft on course directly indicates crosswind and it is much easier to observe turnpoint drift on radar than it is to use the crosswind formula.

To perform successfully in radar navigation, you must be able to quickly and accurately utilize the following formulas for wind analysis.

A. For head/tail wind component: $\frac{\text{seconds off}}{\text{minutes flown}} \times k = \text{kts HW/TW}$

B. For crosswind component: $\text{degrees of crab} \times k = \text{kts CW}$

or

$$\frac{\text{NM L or R}}{\text{minutes flown}} \times 60 = \text{kts CW}$$

Where k is your TAS in NM/min (guide number, TAS/60). Use k=5 at VT-86 during 300 kts TAS radar routes.

HEAD WIND/TAIL WIND

Actual time of arrival is determined when the turnpoint disappears in the "altitude hole" of your radarscope. The head wind/tail wind component of your wind is determined as in low levels, comparing MOT to updated ETA.

CROSSWIND

The crosswind component in radar navigation is primarily determined by the amount of crab used to stay on course, known as the Crab Method. Angular math may also be used in conjunction with the crosswind formula in a method known as the Angular Math Method.

CRAB METHOD

The most common method for determining crosswind in radar navigation is observing turnpoint drift, followed by adjusting crab until the drift is arrested. After changing crab, it will be necessary to BDHI back to course before observing drift once again. The formula for crosswind using this method is:

$$\text{kts of crosswind} = \text{degrees of crab} \times k$$

ANGULAR MATH METHOD

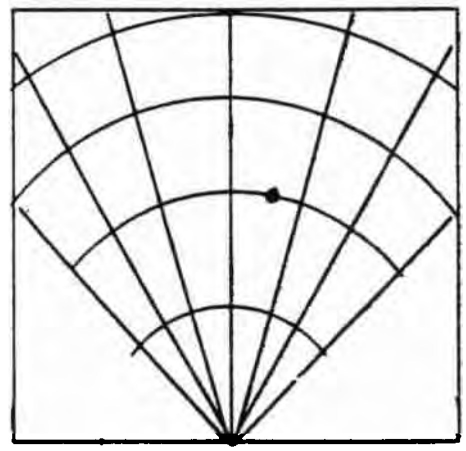
Distances traveled on a TACAN arc are determined by angular math. On a 30 DME arc, you travel one NM for every 2 radials crossed (On a 15 DME arc, one NM for every 4 radials crossed, etc.). Similarly, a return that is 2 degrees to the right of your course line at 30 NM is one NM right of course. The formula for calculating distance abeam, using angular math is:

For distances left or right from course: $\frac{\text{NM Away}}{60} \times$ Degrees L or R = NM L or R from course

Comparing the checkpoint's preflight abeam distance to the angular math distance determines if you are off course and by how much. Example: If you calculated a checkpoint to be 3 NM right of course line, but had preflight it to be 4 NM right- you would be 1 NM right of course. In the figure below, a checkpoint is seen 9 degrees right of course line, 20 NM away.

Scope range = 40 NM

$\frac{20 \text{ NM}}{60} \times 9 \text{ degrees} = 3 \text{ NM R}$



Remember, the number of degrees used must be from course line, not from scope centerline (crab must be considered).

Arriving abeam a turnpoint should not normally occur in radar navigation. If you do mark abeam, angular math can be used to compute crosswind effects.

TOTAL WIND

Once the HW/TW and CW components are determined, use ratio analysis, wind circle or best available method to determine the total wind vector. Most importantly, **apply it**! The next two items of the wings level call are check crab and airspeed.

When figuring total wind round your wind direction to the nearest 10 degrees and your wind velocity to the nearest 5 knots. Your corrections to airspeed will be in five knot increments and each degree of crab will correct for five knots of crosswind.

RATIOS

Determine the wind vector using ratios.

1:1 = 45 degrees
3:2 = 40 degrees
2:1 = 30 degrees
3:1 = 20 degrees
5:1 = 10 degrees

Direction is from the strongest source of wind.

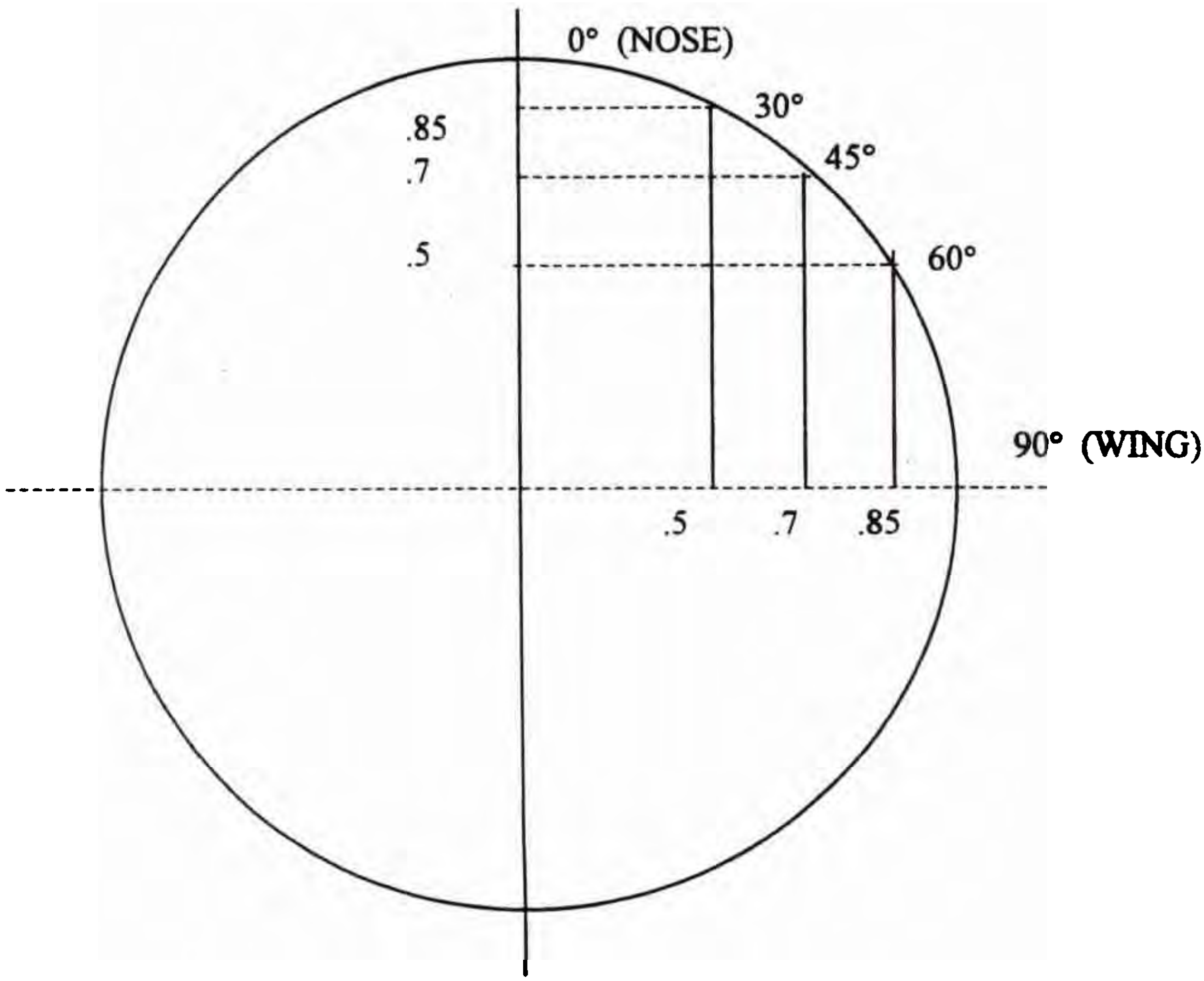
Determine velocity of the wind by adding the larger component to 1/2 the small component.

WIND CIRCLE

Component Wind Velocity = Total Wind Velocity X Wind Circle Factor

Course 360°. Total wind is 060/20. From the above formula: 10 kts head wind, 17 kts right crosswind (2:1 Ratio. Wind Circle Factor is .5 HW and .85 CW). To check, larger + 1/2 smaller wind components approximates total wind velocity. In this example, 17 + 1/2 (10) = 22 kts.

Course 360°. Total wind is 045/30. From the above formula: 21 kts head wind, 21 kts right crosswind (1:1 Ratio. Wind Circle Factor is .7 HW and .7 CW). To check, 21 + 1/2 (21) = 31.5.



Other factors to consider before blaming the wind for being off course are:

1. Your planning may be in error. If you were a little sloppy in planning, this can put you off course. (A 2 degree heading error will put you 1 mile off course after six minutes of flight).

2. The point you just left or the point you are going to may be misplotted. The only way to know this is to eliminate all other variables. Even with good turnpoint analysis and wind analysis you can still end up off course (Note that this is a rare occurrence).

3. If you turn early or late, your course and time on the next leg will be affected. Also, starting your watch early or late will affect your wind analysis on the next leg.

4. Pilot technique is also a consideration. Pay attention to the angle of bank in turns (greater than 30 degrees AOB will be inside the plotted turn radius, less than 30 degrees AOB will be outside the plotted turn radius). If airspeed and heading control are not accurate your course and/or time will be affected as well.

5. Any time you make a course correction you must update the ETA to the next turnpoint by adding time. As a general rule, a 30 degree correction for 1 min will add 9 sec to that leg time at 300 knots ground speed.

6. The track across the ground that the airplane flies in a turn may not be the same as your plotted turn radius. Generally, the difference between the two is negligible, but when you have turns of greater than 90 degrees your actual track is usually inside your plotted turn. Wind also affects your flight turn radius.

7. Equipment calibration errors may also cause some navigation errors. Typically, the pilot's compass is 2 to 3° different from your compass.

INFLIGHT CORRECTIONS

Airspeed Corrections:

1. Definitions:

a. Base Airspeed (BAS) - a calculated indicated airspeed for 300 KTAS (Temperature and altitude dependent; Using the CR-2, at 10,000 feet and a temperature of 25° Celsius, BAS = 250 KIAS).

b. Wind Adjusted Airspeed - An adjustment to the base airspeed compensating for the head/tail wind component in order to maintain 300 kts ground speed. For example, for a 20 knot tailwind component and base airspeed of 275 knots, the wind adjusted airspeed would be 255 knots indicated.

c. Corrected airspeed - an adjustment to the wind adjusted airspeed compensating for an early/late arrival at a turnpoint. Corrected airspeed is not required for less than 12 seconds of error. A 30 knot speed correction is applied to the wind. adjusted airspeed to return the aircraft to preflight time. Six seconds of time is made up for every one minute of a 30 knot speed correction. For example, if the wind adjusted airspeed is 255 knots and the aircraft arrives at the preflight turnpoint 14 seconds late, you should increase airspeed to 285 knots for 2 minutes and 20 seconds.

2. Employment of Corrections - Now that each airspeed is defined, a discussion of utilizing these airspeeds is necessary.

TWO MINUTES PRIOR

It is important to calculate a new wind adjusted airspeed at every two minute prior call since course changes will alter the head/tail wind component. Applying the wind incorrectly to airspeed will prevent the aircraft from maintaining preflight time.

MARK ON TOP

Note that the "on top" call immediately employs the wind adjusted airspeed given in the two minute prior call. If a speed correction is necessary you may put in your corrected airspeed during the "on top" call, but it is important to rebuild your scope and update the TACAN, too.

WINGS LEVEL

The wings level airspeed call is self-explanatory after understanding the aforementioned definitions. If a speed correction is needed the corrected airspeed "time in" is required. The corrected airspeed time out can be calculated now, but check your altitude and fuel prior to becoming involved in what can be a complicated "time out" calculation. A speed correction can be done at any time during the wings level call, it does not have to be done at the airspeed portion of the wings level call.

A speed correction "time out" is either a simple or complex calculation. Determining whether the calculation is simple or complex is dependent upon whether-or-not the full duration of the speed correction can be effected prior to the next turnpoint. A correction that can be employed prior to the next turnpoint is a simple correction. No updated turnpoint time is necessary (preflight time will be your updated time). If the correction cannot be fully effected prior to the next turnpoint, it is a complex correction. Study the following simple and complex sample problems. The complex problem illustrates the requirements to adjust the preflight turnpoint time.

Remember your Aviate, Navigate, Communicate, checklists/briefs, TPP priorities. Utilizing dead reckoning procedures and operating the radar for navigation is more important than doing turnpoint procedures and complex calculations.

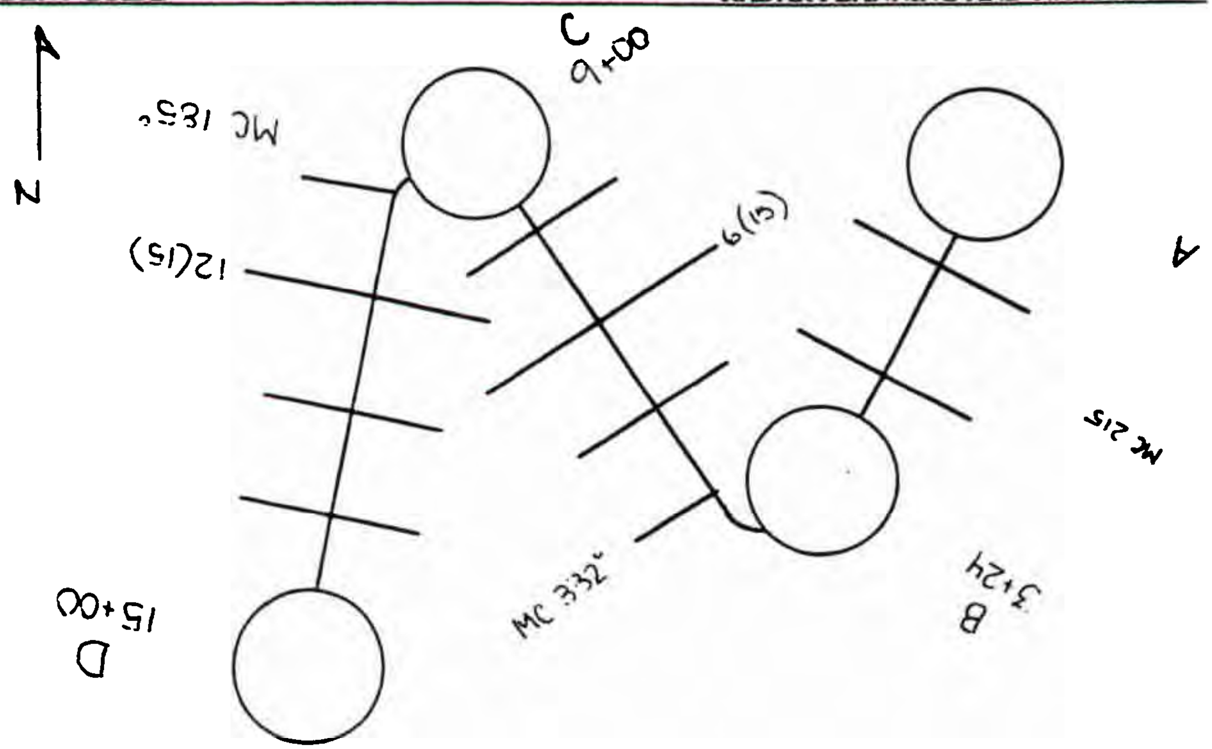
SIMPLE SPEED CORRECTION SAMPLE PROBLEM

GIVEN:
1. Aircraft arrives 18 seconds late at PT B
2. Wind 340°/20 kts
3. ALT = 5000 feet

From A to B, BAS = 280 KIAS (from CR-2). Applying the preflight wind to the leg, the wind adjusted IAS was 265 KIAS.

a. For the "Two minute prior" to PT B, you correctly calculate the new wind adjusted airspeed as 300 KIAS (B to C).

b. You are 18 sec late at PT B; time is 3+42. A speed correction is required since there is an error of 12 seconds or greater. At the "mark on top" you set a wind corrected airspeed of 300 knots.



c. The "wings level" call is as follows: "The wind adjusted airspeed is 300 knots; set corrected airspeed of 330 knots, time in is 5+00." Computation of speed corrected airspeed time out can be delayed until later.

d. Later: "Late 18 seconds. Speed corrected airspeed time in 5+00; for 18 seconds time out is 8+00. No updated turnpoint time necessary-"

COMPLEX SPEED CORRECTION SAMPLE PROBLEM

GIVEN:
1. Aircraft arrives 50 seconds early at PT. C.
2. Wind 340°/20 kts
3. 5000 Feet

BAS = 280 KIAS (FROM CR-2). Applying preflight wind to the leg from B to C, the wind adjusted IAS was 300 KIAS.

a. You are inbound to PT C utilizing the radar to mark on top. You turn at 8+10.

b. For the two minute prior call, you figure the wind adjusted airspeed to PT D. At the MOT you give the wind adjusted airspeed. The speed corrected airspeed can be postponed until the wings level airspeed call or even later.

c. You give the wings level airspeed call as follows: "Airspeed is 265, set airspeed 235 in a speed correction, time in is 9+30." Computation of time out for the correction can be delayed until later.

d. Later - "Early 50 seconds. Speed correction time in was 9+30, time out is 17+50. Updated ETA to PT D is 14+43". Since every one minute of a 30 knot speed correction generates 6 seconds of time made up, it would take 8 minutes and 20 seconds of 30 knot speed reduction to place the aircraft at the proper preflight point.

e. Now the complex portion of the problem surfaces. The calculated time the speed correction is to be taken out is beyond the preflight turnpoint time of 15+00. If an adjustment is not made to the preflight turnpoint time the aircraft could turn well beyond the preflight turnpoint position. In other words, you will still be early at PT D because the speed correction will not be complete. Consequently, preflight time at PT D must be updated to a more accurate ETA.

<u>Here is the solution:</u>

<u>METHOD 1</u>

1. Calculate the. total time the speed correction is employed. Subtract the time the speed correction was initiated from preflight turnpoint time.

15+00	(Preflight turnpoint time)
- 9+30	(Time the speed correction was initiated)
5+30	(Total elapsed time which the speed correction has been employed)

2. Convert the total elapsed time which the speed correction has been employed into seconds of time made up due to the speed correction. Since 6 seconds of time is recovered for every 1 minute of time the speed correction is employed, a speed correction employed for 5 minutes and 30 seconds would make up 33 seconds of time.

3. Now calculate the required seconds of time needed to be made up after the preflight turnpoint time. This is done by subtracting the seconds of time made up prior to the preflight turnpoint time (figured in the prior paragraph) from the total number of seconds required to be made up. In this example:

50 (Total seconds required to be made up)
- 33 (Seconds of time made up prior to upcoming turnpoint)
17 (Seconds of time required to be made up after upcoming turnpoint)

4. Finally, if the aircraft is early at the previous turnpoint, the number of seconds needed to be made up after the upcoming preflight turnpoint time must be subtracted from the upcoming preflight turnpoint time because you will still be early. On the other hand, if the aircraft had been late at the previous turnpoint, the number of seconds needed to be made up after the upcoming preflight turnpoint time would be added to the upcoming preflight turnpoint time. A condensed formula: Subtract if the aircraft is early, add if the aircraft is late. In this problem:

15+00 (Upcoming preflight turnpoint time)
- 17 (Seconds early still remaining to be made up after the turnpoint)
14+43 (Updated-turnpoint time)

METHOD 2

An alternate method to figuring the updated turnpoint time is very similar in theory to the calculation described above. All the given conditions remain the same.

1. Compare the time out for the correction to the preflight turnpoint time. In this example:

17+50 (Correction time out)
-15+00 (Preflight turnpoint time)
2+50 (Time correction must be in past the original turnpoint time)

2. Convert the excess correction time to number of seconds that are made up after the turn time:

Here, by reverse calculation: 2+50 X 6 sec/min = 17 seconds

OR

10% rule 2+50 = 170 seconds, so 10% is 17 seconds

3. Since these seconds are made up after the preflight turnpoint time, and we are early, in this case, at PT C, we will still be early at PT D (since the full correction has not been completed). In this case you are early 17 seconds. Therefore, the updated time at PT D is once again:

15+00 (Preflight)
- 17 (Seconds left to correct)
14+43 (Updated turnpoint time)

As before, if you are early you must subtract from preflight turnpoint time and add if you are late. Both methods are equally effective. Determine which works best for you.

STANDARD COURSE CORRECTIONS

Standard (timed) course corrections are utilized in radar navigation the same as in low levels. A 10 degree correction at 300 knots will correct for 1 NM for every minute. While correcting, remember, you are not heading directly to your turnpoint so your leg time will increase (a 10 degree correction for one minute will add 3 seconds to your time). On a radar navigation flight, you may be able to "see" your turnpoint (TPT) up to 30 NM before you get there. If your turnpoint is visible, you should correct back to course by putting the turnpoint on your courseline. Timed course corrections can help you correct back to course only if you know how far off course you are. However, BDHI corrections allow you to get back on course without having to analyze your distance from course.

BDHI CORRECTIONS

BDHI corrections on radar perform the same function and are accomplished as easily as they are in low levels. The radar allows you to see your check/turnpoints at much greater ranges than on a visual low level, giving you more time to make the correction and evaluate the results.

Rules of thumb governing radar BDHI corrections are:

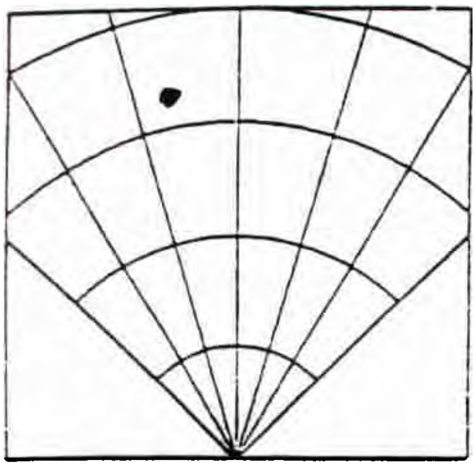
1. BDHI corrections are always commanded 30° from wind corrected heading (base heading).

2. Steady-up BDHIs are permissible, and recommended in close.

3. BDHIs may only be performed to checkpoints/turnpoints which are on course or closer to course than the aircraft. BDHIs are not allowed across the courseline!

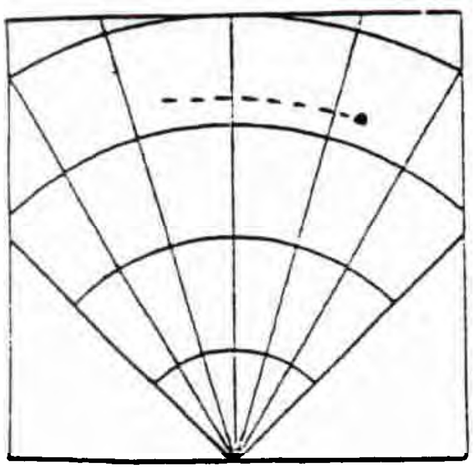
No Wind BDHI Correction

150°



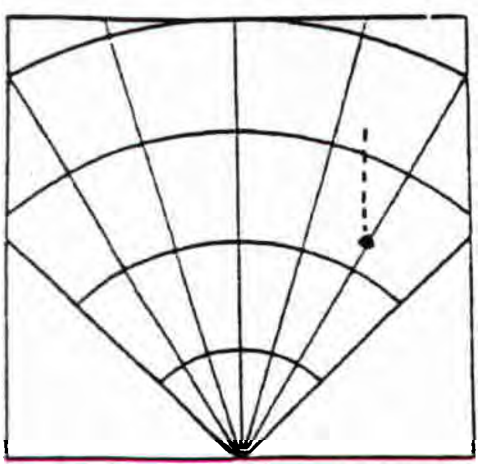
Heading 150° to maintain a course of 150°. You see your turnpoint (correctly identified) to the left of your courseline. You are right of course. A left BDHI is commanded from the base heading. "Left 120, BDHI."

120°

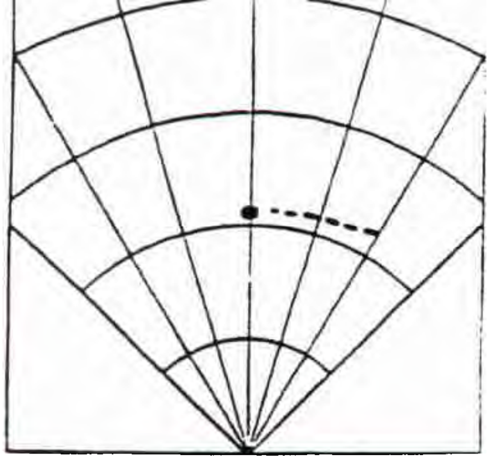


As you turn left, the turnpoint moves to right of the aircraft's nose. You are now correcting back to course. Wait until the turnpoint drifts down the scope (forward motion of the aircraft) and approaches 30° azimuth line (which, prior to the turn, was your courseline).

120°



Depending on the range to the point, you will want to lead the turn back to base heading as turn radius must also be considered. At long ranges less lead turn; and at short ranges, greater lead turn is needed.

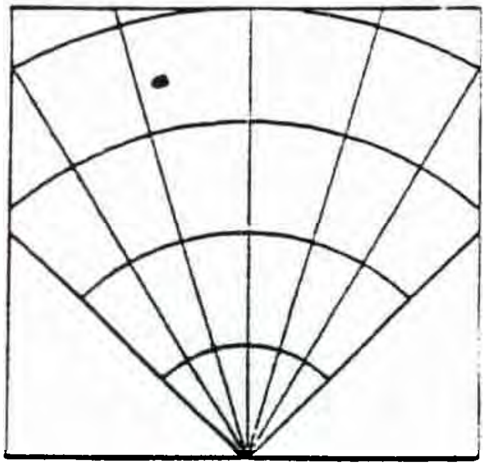


At the appopriate time, return to base heading; "Right 150;" and if the BDHI was performed accurately, the turnpoint should be on your courseline, ready to mark on top on heading.

<u>Wind Corrected BDHI</u>

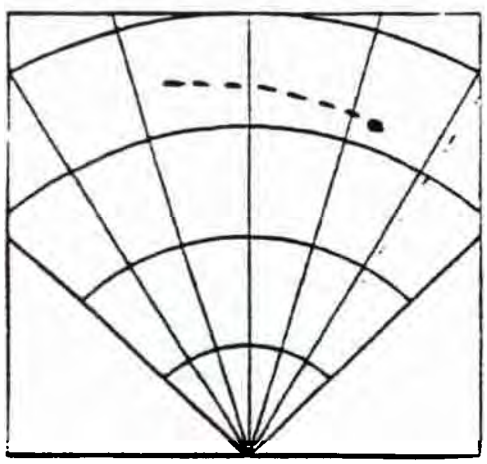
<u>Wind 175/15</u>

262MH



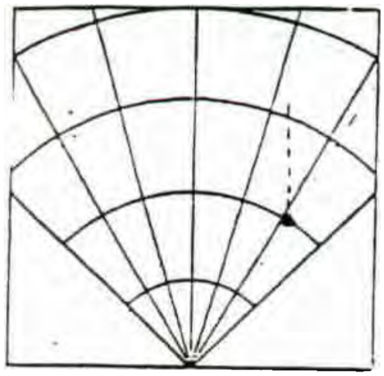
Heading 262° to maintain a course 265°;three degrees of left crab. You see your turnpoint (correctly identified) to the left of our courseline (which is three degrees to the right of the scope centerline, also known as aircraft heading). You are right of course. A left BDHI is commanded <u>from the base heading</u>, "Left 232; BDHI".

232MH



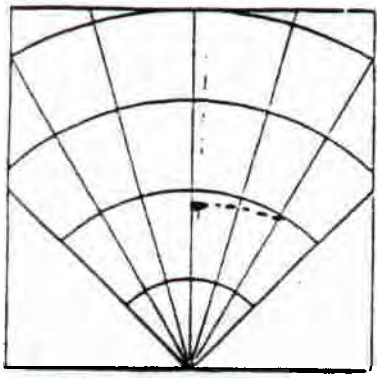
As you turn left, the turnpoint moves to the right of the aircraft nose. You are now correcting back to course.

232MH



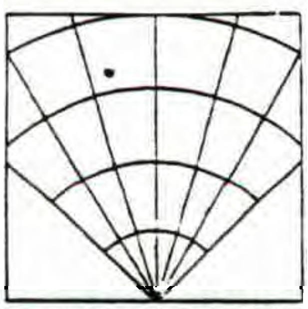
Wait until the TPT drifts down the scope (forward motion of the aircraft) and approaches the courseline (which is three degrees to the right of the 30° azimuth line). Again, you may lead the turn slightly to return to base heading. Note that the TPT drifts to the courseline vice the scope centerline with wind corrected BDHIs because you want to correct the aircraft back to course, not heading.

262MH

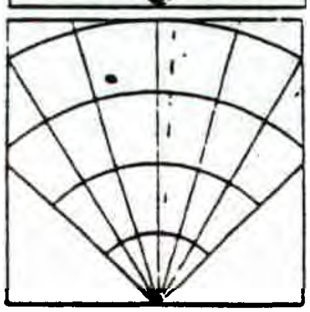


At the appropriate time, return to base heading; "Right 262." If the BDHI was performed accurately, the turnpoint should be on your courseline, ready to mark on top on heading.

The previous wind-corrected BDHI is an example of a left crab, left BDHI. A right-crab, left BDHI would allow the turnpoint to drift three degrees short of the 30° azimuth line. Right BDHI's are similarly executed. These situations may be summed up by the following statements:



Crabbing right and correcting left:-allow the BDHI to drift 30° from the centerline minus the crab angle.



Crabbing left and correcting left:-allow the BDHI to drift 30° from the centerline plus the crab angle.

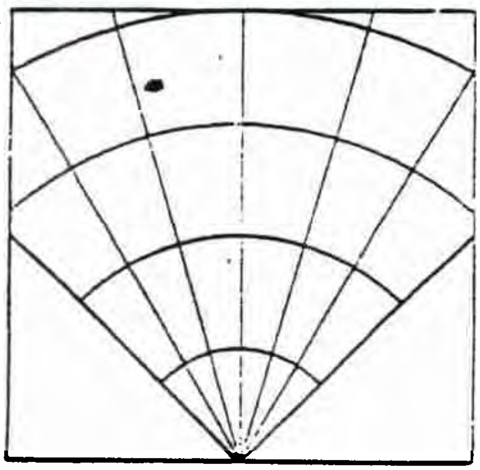
It is important to remember that in BDHI corrections, all 30° heading changes are applied to base heading, and all corrections are done in relation to courseline. If you know the aircraft is drifting prior to performing a BDHI, change base heading to account for the new crosswind and then execute a BDHI to return to course.

Steady-up BDHI corrections may be advantageous in-close to a turnpoint or when you are very close to course. It allows you to correct small distances with a minimum amount of turn radius, thus reducing the possibility of over-correcting at the turnpoint. As in low levels, you must ensure the point to which you are correcting crosses your courseline on the scope during your turn to assure a course correction.

Wind Corrected Steady-Up BDHI

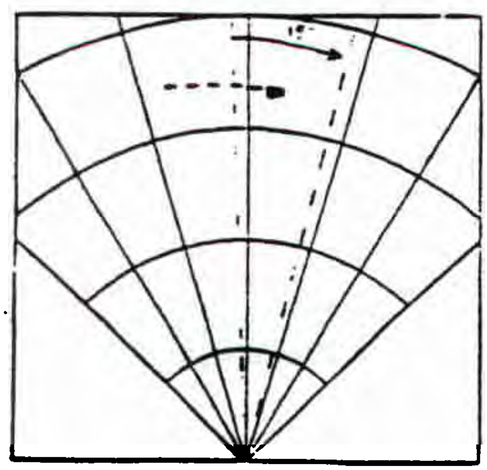
Wind 100/15

013 MH



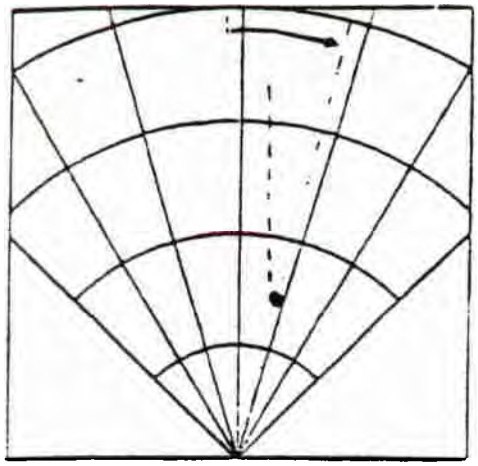
Heading 013° to maintain a course of 010°; three degrees right crab. You see your turnpoint (correctly identified) to the left of your courseline. You are right of course. A left BDHI is commanded from the base heading: "Left 343, BDHI."

358 MH



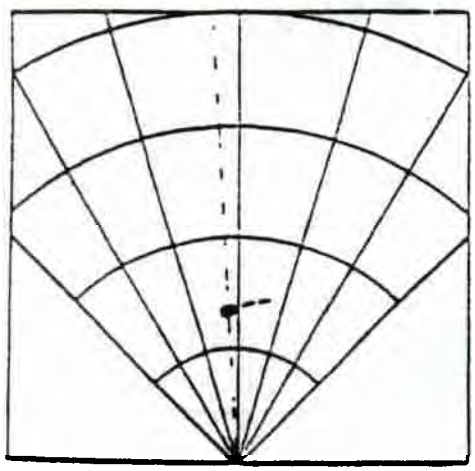
As you turn left, you decide a steady-up BDHI would benefit your nav situation. After the turnpoint crosses your courseline, you command, "Steady-up." Note the number of degrees you have turned on the BDHI, in this case 15°.

358 MH

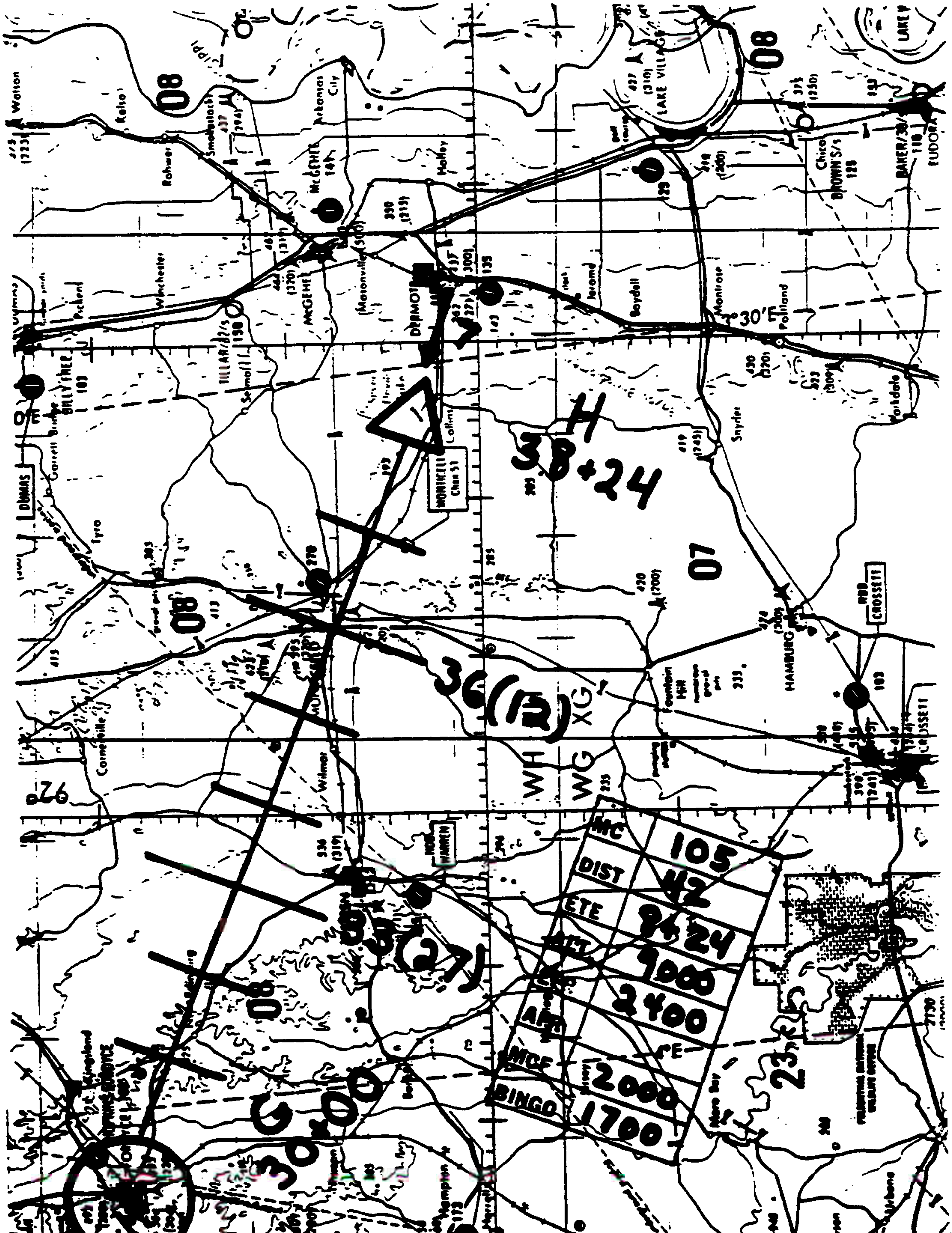


A steady-up BDHI turn of 15° will require the turnpoint to drift 15° from the original courseline. You may imagine this 15° as indicated by the arrow on the drawing at left, or you may compute the drift to be 12° to the right of the scope centerline (crab considered).

013 MH



As the TPT approaches the courseline, return to base heading: "Right 013." With an accurate steady-up BDHI, the turnpoint should appear on your ourseline ready to mark on top on heading.


MC
105
DIST
ETE
BINGO
1700
MCF
2000
DERMOTT
CROSSETT
EUDORA
LAKE VILLAGE
McGEHEE
HAMBURG
Montrose
DUMAS

IN-FLIGHT INTERPRETATION AND NAVIGATION

Base airspeed is 260. The leg time from F to G is 6+00. Inbound heading to PT G is 040° and wind corrected airspeed is 245. The following procedures occur in order:

1. Two Minutes Prior

You determine that based on the last known wind, there will be 20 kts of crosswind and 20kts of head wind on the next leg. Your two minute prior call will be:

> "Two Minutes-Prior to PT. G
> Outbound heading is 109
> Outbound airspeed is 280."

2. Mark on Top

You arrive 1NM left abeam PT. G at 30+05. Your mark on top call will be:

> "Right 109
> Time is 30+05
> Set Airspeed 280
> (Rebuild scope)
> Tacan changes to channel 53, going to the Monticello 092 at 7."

3. Wings Level

As soon as wings level, begin your wings level call. Since they relate to aviate, the first four items should come very quickly.

> "Wings Level Heading 109
> Airspeed is 280
> Altitude is 10,000 ft
> Fuel is 2,500 lbs, preflight 2,400 lbs, 100 lbs over, steady trend"
> (from past analysis)

The rest of the WL call can be delayed at this point for other aviate or navigate priorities. If you are comfortable with the nav situation, press immediately to the turnpoint analysis and the remainder of the wings level call.

Turnpoint analysis

Using the same principles as in low levels, you analyze and state; "1 NM left abeam Fordyce (PT G), on heading. Should be 1/2 NM left of course and 10 seconds slow on the next leg." Since you were 5 seconds slower than preflight at the turnpoint and turnpoint analysis shows you will be 10 seconds later, you are a total of 15 seconds late and need a speed correction. Note time in and time out.

Wind Analysis

This is probably the most difficult part of the wings level call and definitely the most time consuming. Therefore, it is important to develop a method by which you can quickly and accurately determine the new wind components. This example is merely one way of accomplishing this task. There are many others, so it is best to find one that works for you and perfect it.

Starting with the crosswind:

You were correcting for 25 kts of right crosswind and were blown 1 NM left of course over a 6+00 leg.. Therefore, the wind amount is stronger from the right than you were expecting. The amount is determined by the following:

$$\frac{1\text{NM}}{6\text{ mins}} \times 60 = 10\text{ kts}$$

You were already correcting for 25 kts of right crosswind and this analysis shows that you have an additional 10 kts of wind. Therefore, the total crosswind component is 35 kts from the right.

Figuring the head wind/tail wind component, you arrived at the turnpoint 5 seconds later than preflight. This gives you an apparent head wind, but you were correcting for a tail wind of 15 kts so you must be careful when analyzing this situation. The apparent head wind component is computed as follows:

$$\frac{5\text{ sec late}}{6\text{ mins}} \times 5 = 5\text{ kts apparent head wind}$$

Since you were correcting for 15 kts of tail wind, you were overcompensating for the tail wind on that leg. Therefore, the net wind component is 10 kts of tail wind.

To find the total wind component, compare the two components using ratio analysis. In this case, 35 kts right crosswind and 10 kts of tailwind result in a wind aft of the right wing. Ratio analysis of approximately 3:1 indicates the total wind was 20° aft of the right wing line; therefore, the wind direction was 145°. The wind speed is determined by adding the larger component to one-half the smaller. Wind velocity is 35 kts + 1/2 X 10 = 40 kts. Total wind is 145° at 40 kts.

An essential part of wind analysis is application. The first step is to break the total wind into crosswind and head/tail wind components. The wind is approximately 45° to the right of the nose of the A/C. Using the wind circle, we see that 70% (.7) of the total wind is right crosswind and 70% of the total wind is head wind, therefore:

Crosswind	40 X .7 = 28 kts
Head wind	40 X .7 = 28 kts

Since the wind vector is actually 40° vice 45° off the nose, it will result in a slightly greater headwind component than crosswind component. Therefore rounding the wind to the nearest "5" or "0," the crosswind component can be rounded down to 25 kts right crosswind and the headwind component up to 30 kts. Applying that: "Change crab 110° and change airspeed to 290 kts."

The last step of the wings level call is to update the ETA, if required. In this case, we will be out of our speed correction prior to arriving at the target; updated ETA to the target is preflight, 38+24.

4. Clock/Chart/Scope Correlation

As soon as the wings level call is complete, navigation is the priority. The easiest way to find any turnpoint is to note the time, determine distance from the turnpoint (based on DR), then look on the scope at that distance. As long as you properly computed where you should be, the turnpoint should be relatively easy to find.

Your clock now reads 33+00. According to your chart, the target (a dam) should be 27 NM away. Beam width error, however, prevents you from seeing it. Using annotated checkpoints for correlation, Monticello should be 15 NM ahead and Dermott should be 34 NM away. Additionally, you see a cultural return approximately 12° left of Dermott. You identify this as the town of McGehee.

Dermott is on your extended courseline. You want it 6° left of scope centerline since you are crabbing 6° to the right. However, it is 5° left of centerline indicating you are left of course. Through angular math at this distance, you find you are one-half mile left of course. This confirms your turnpoint analysis.

You decide to do a right 30° BDHI to get back on course. You command: "Right 140°, BHDI". Dermott drifts towards 360 to the left of scope centerline. Leading to keep from overshooting, you command, "Left 110°," returning to base heading. Now you are back on course and can observe drift by noting any movement of Dermott left or right of courseline.

As you get closer to the target, continue using the checkpoints to help look in the proper area for the dam (correlate).

What if you still cannot see the dam? There are basically three choices:

A. If you see the lake, go for the straight shore line. Nature rarely makes long straight lines, so it must be the dam.

B. If you cannot even see the lake, stay in a 10 NM scope and keep Dermott on the courseline. When the town closes to seven miles, you are on top of the target. Turn the aircraft.

C. If you have no other information, turn on updated ETA.

The key to successful radar navigation is having a game plan for accomplishing all the tasks, and then sticking to it. Practice your turnpoint procedures, scope/chart correlation and scope control in the GMRT. By RST-1, you should have a well-practiced game plan and be thoroughly familiar with radar procedures. Pay special attention to turnpoint procedures. They are the framework that will firmly support your effort to successfully navigate around the route, if they are quick, accurate, and thorough. To build speed while maintaining accuracy, you must build strong habit patterns. Once again, PRACTICE, PRACTICE, PRACTICE.

RADAR PROBLEMS

1. Preflight leg time: 9+48
   Actual time of arrival: 10+19

   ____________ KTS Head/Tail Wind

2. Preflight leg time: 6+12
   Actual time of arrival: 5+47

   ____________ KTS Head/Tail Wind,

3. MC=MH=010°
   You mark 2 NM left of turnpoint B at 10+05 ETE was 9+42. What are the wind components?
   ____________ KTS Head/Tail Wind
   ____________ KTS Left/Right Crosswind

4. MC=003° Wind is 045/20. BAS is 250. What is the wind corrected airspeed?

   ____

5. During a radar flight, aircraft magnetic heading is 085° for a magnetic course of 090°. A 30° BDHI correction is made to the right when the target (a factory) appears on the scope. The proper time to resume the 085° magnetic heading is:

   a. When the target has moved 25° off to the left of scope centerline.
   b. When the target has moved 35° off to the left of scope centerline.
   c. When the target has moved 25° off to the right of scope centerline.
   d. When the target has moved 30° off to the right of scope centerline.
   e. When the target has moved 20° off to the right of scope centerline.

6. During a radar flight, aircraft magnetic heading is 270° for a magnetic course of 279°. A 30° BDHI correction is made to the right when the target (a shipyard) appears on the scope. The proper time to resume the 270° magnetic heading is:

   a. When the target has moved 30° off to the right of scope centerline.
   b. When the target has moved 21° off to the left of scope centerline.
   c. When the target has moved 39° off to the right of scope centerline.
   d. When the target has moved 21° off to the right of scope centerline.
   e. When the target "touches" the centerline of the scope.

7. During a radar flight aircraft magnetic heading is 173° for a magnetic course of 180°. A 30° BDHI correction is made to the right when the target appears on the scope. The proper time to resume the 173° magnetic heading is:

a. When the target has moved 30° off to the right of scope centerline.
b. When the target has moved 23° off to the right of scope centerline.
c. When the target has moved 23° off to the left of scope centerline.
d. When the target has moved 37° off to the left of scope centerline.
e. No Correction Required.

8. During a radar flight, aircraft magnetic heading is 320° for a magnetic course of 330°. A strong return appears on the scope 15° left of scope centerline at 20 NM. The return is ____________NM left/right of course.

9. During a radar flight aircraft magnetic heading is 127° for a magnetic course of 1200. A strong return appears on the scope 20° right of scope centerline at 20 NM. The return is ____________ NM left/right of course.

10. MH=156° MC=151° You discover you have drifted 2 NM left of course after 5 minutes. Your most appropriate correction would be to:

Come left/right degrees for ________ min ________ secs, then return to base heading of _______ degrees.

11. MH=MC=270°. You mark 2 NM left abeam point B. ETE is 6+24 and ATA is 6+10. Outbound course is 360°, BAS is 250.

__________ HDG on next leg degrees
__________ Wind corrected airspeed

12. MH=153° MC=157°. You arrive on top point B at 8+00 for a preflight 8+30 leg. BAS=250, wind corrected was 260 KIAS.

What is total wind? _______

13. MH=151° MC=142°. You see a checkpoint 5° left of scope centerline at 30 NM. The return is _________ NM left/right of course.

14. MH=192° MC=204°. You see a checkpoint 10° right of scope centerline at 15 NM. The return is ______ NM left/right of course. Time is 10+00. What is the crosswind component if the checkpoint should be 5 NM left of course? _________KTS left/right crosswind. What should the HDG be? _______degrees

RADARSCOPE PREDICTIONS

LEARNING OBJECTIVE: Construct accurate radar predictions using recommended procedures.

LEARNING STEPS:

1. Interpret a tactical pilotage chart (TPC).
2. Recall radar prediction procedures.
3. Recall basic radar principles.

SKILLS DEVELOPMENT UNIT: This academic unit of instruction is the primary reference for the preparation of basic and mountain radar predictions. This unit should be read prior to the associated classroom lecture and practical application. Performance checks are the midphase and final examinations and every radar navigation event in VT-86.

INSTRUCTIONAL AIDS:

1. #2 wooden pencil
2. Radar prediction template
3. Tracing paper
4. TPC chart H24-B and G21-D
5. Graph paper
6. Masking tape

REFERENCES:

None.

BASIC RADAR PREDICTIONS

Radar predictions are required for all radar trainers and flights to aid in anticipating the airborne radar presentation. Radar predictions are study tools which increase your knowledge of the turnpoint and target areas and key indicators necessary for correlation.

Radar predictions are not ever going to be 100% accurate (that's why they are called predictions). However, by following general guidelines and adhering to basic radar principles and rules of interpretation, your predictions will appear similar with only minor variations. Radar predictions are your best guess of the signal potential of a given area of the earth based on the information appearing on a TPC or other chart. A prediction will always be drawn realistically, but may exhibit optimistic features within reason.

Predictions at VT-86 will be drawn from TPC data (Joint Operations Graphics (JOGs) are available and provide greater detail than TPCs). TPCs may contain data that is several years old. Cultural information, obviously, is much more apt to change than terrain features as charts age. Check with your personal advisor for current air intelligence.

You should strive to make neat, accurate predictions, but never forget that it is the information contained on the prediction that is most important. Radar predictions are not for art competition; they are study guides. Completed predictions should be taken into the aircraft and/or the GMRT to be checked and updated.

Required Predictions

At VT-86, you are expected to be familiar with each turnpoint and target by virtue of your extensive preflight planning. Radar predictions, obviously, are an integral part of your preflight planning. Below is a list of the required predictions for each pipeline. See planning guide for specific details.

STRIKE

For all radar navigation (RN) routes, prepare a radar prediction for each target.

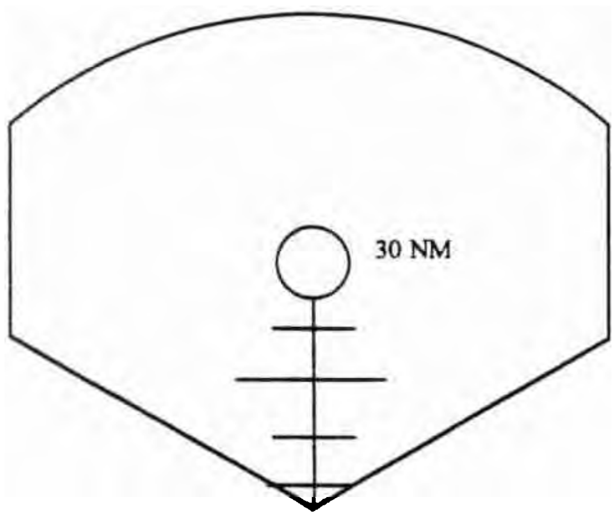
*Prior to RSTs, respective routes and predictions must be completed and should be checked by your personal advisor.

Drawing Basic Radar Predictions

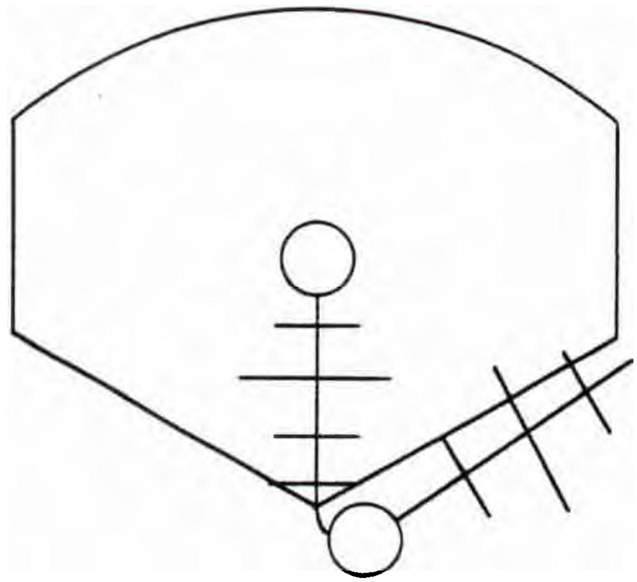
Radar predictions drawn at VT-86 are "negatives" of the presentation on the radarscope. What is bright on the scope (reflected radar energy) will be represented by dark marks on the prediction made by a No. 2 pencil. Dark areas on the radarscope (water and shadows) will appear as white paper on the prediction. See Figure 3.

Using the acetate template furnished in ground school, trace the large radarscope figure onto a piece of tracing paper. By using opposite corners of the paper, two predictions can be made on one sheet. The large radarscope figure is a 40 NM radar presentation and all predictions at VT-86 will be made using the 40 NM template.

An important consideration prior to actually drawing the prediction is the placement of the turnpoint or target within the template. The turnpoint or target will appear on the centerline of the prediction as shown below. The apex is the antenna location.



If the leg is 30 NM or longer in length, make a 40 NM prediction placing the turnpoint or target 30 NM on centerline at 30 NM from the apex.



If the leg is less than 30 NM in length, make a 40 NM prediction with the apex of the template at the wings level point and the turnpoint or target on centerline short of 30 NM

When drawing radar predictions, you should strive for three intensities of darkness with a No. 2 wooden pencil (Mechanical pencils do not allow for shading techniques). The very darkest marks are for major cultural returns (plants, factories), the front side of steep ridges, and far shore brightening. The medium intensity should be used for minor cultural returns, such as small cities or residential areas of larger cities. The lowest intensity is used for ground return. No pencil marks indicate an area of no radar returns, i.e., water and shadows.

Radar Prediction Mechanics

Now we are ready to produce a radar prediction. This example covers a typical flatland prediction like you will see in RN stage.

1. Place the apex of the tracing paper prediction on the courseline so that the turnpoint or target falls on the prediction at the proper range. Use a small piece of masking tape to hold down one side of the paper. Take care that the tape will not tear off an important portion of your chart.

2. Very lightly, draw in the land/water boundary (i.e., shoreline, large rivers, and lakes). This boundary line must not show in the final prediction. To determine which rivers will be visible, consider:

   a. Rivers with names (larger than unnamed)
   b. Rivers with contour lines along the banks. No show from the river valley or depression will make it more visible.

3. Darken the far shore of all lakes, rivers, bays and oceans. Far shore brightening occurs on those portions of the shore which are perpendicular to the radar antenna sweep. At long ranges, far shore brightening may be the first visible clue to rivers and lakes.

4. Next put in the major cultural returns (heaviest intensity pencil marks). The major cultural areas are represented on TPCs by *a magenta* color. Within the magenta, major cultural returns congregate near or along lines of communication (highways, rivers, railroads, port facilities), and will be heavily concentrated near areas of parallel or intersecting lines of communication.
Cultural returns, rectangular in dimension, are oriented perpendicular to the antenna sweep. At a distance, cities will appear as a cluster of cultural returns or blend into one large return because of BWE and PLE. In-close, the town will appear to spread out and more returns will be displayed because BWE and PLE decrease and the lower signal potential returns will begin to show.

5. Annotate minor cultural returns (medium intensity):

   a. Small towns
   b. Intersections of primary roads
   c. Residential areas
   d. Airport buildings, hangars.

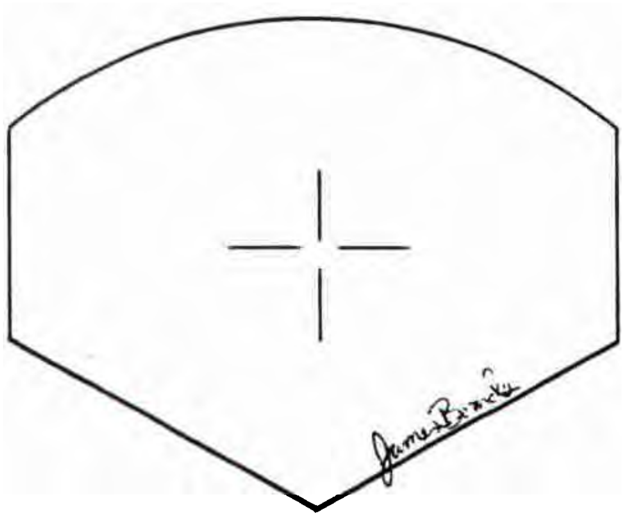
6. Using the side of the pencil, lightly (lowest intensity)shade all ground exposed to the radar beam. Ensure that you shade the prediction in an arcing motion centered from the apex. An object with a lightly roughened texture (cardboard from legal tablet, cinder block or simulated leather-covered books) placed under the tracing paper during the shading process will produce realistic results. The roughness of the terrain as depicted on the TPC will govern your choice of surfaces. Rubbing the completed ground return shading with tissue will smooth out its appearance.

> NOTE: Shading over a fold or crease in the TPC or textured surface will transfer an undesirable line or pattern onto the prediction.

7. Now erase the ground return shading which covered rivers, lakes, and inlets. Remember to consider BWE and PLE to prevent your prediction from being too optimistic.

8. Label the prediction somewhere outside the boundary with the turnpoint identification and route number. Sign your name, in ink, inside one of the two straight boundaries forming the apex.

9. Place "crosshairs" around the actual turnpoint or target on each prediction. The four lines should be about one inch long, oriented vertically and horizontally, with an opening in the center about nickel size so as not to obscure turnpoint details.



10. After being checked by your personal advisor, the prediction should be mounted on white paper for preservation, organization, and enhanced-viewing. Spray your mounted prediction with a non-sticking hairspray or art fixing agent to prevent smearing.

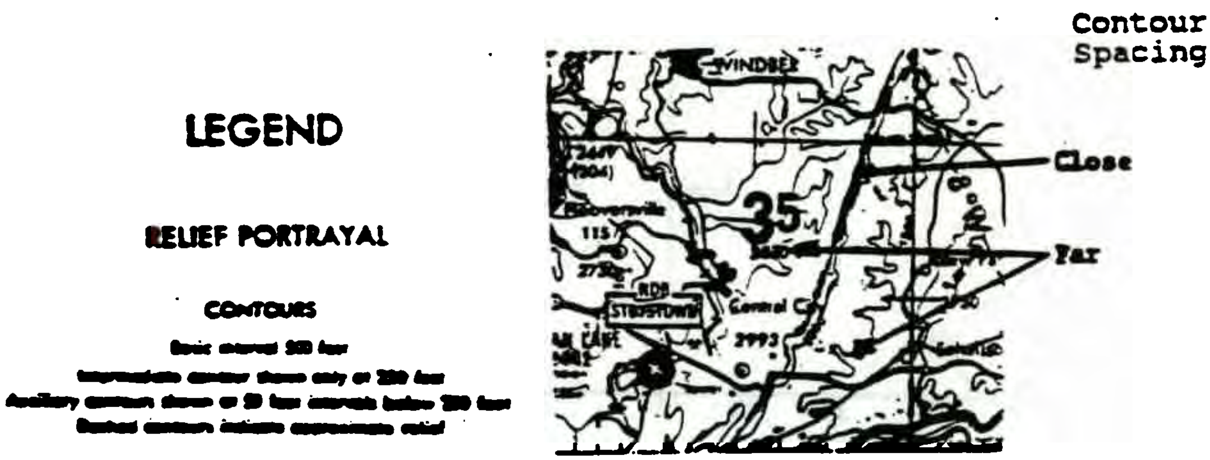
MOUNTAIN RADAR PREDICTIONS

Flatland predictions are relatively easy. Mountian predictions will require extensive TPC study and additional time to prepare. They are not easy. Time spent in preparation will pay off airborne with easier turnpoint correlation and acquisition.

Before drawing a mountain radar prediction, there are two subjects to consider: 1. Interpretation of contour lines, and 2. Shadow graphs.

CONTOUR LINES

A contour line is a line which connects points of equal MSL higher elevations, but not necessarily mountainous terrain, i.e., a flat top mesa or the high plains of the Texas panhandle. Contour line spacing denotes the rise and fall of terrain (gradient). If the contour lines are close together, the terrain elevation is rapidly changing (steep gradient).



At the altitudes flown in VT-86, if the terrain rises or falls more than 500 feet Per NM, the radar will display it as bright return (rising terrain) or a no-show (falling terrain). As in flatland predictions, only ridgelines which are perpendicular to the radar sweep will be highlighted.

The interpretation of contour lines is one of the more difficult techniques to master in radar navigation training. Be sure you understand what contour lines represent and what they mean to you as a radar operator/interpreter.

SHADOWGRAPHS

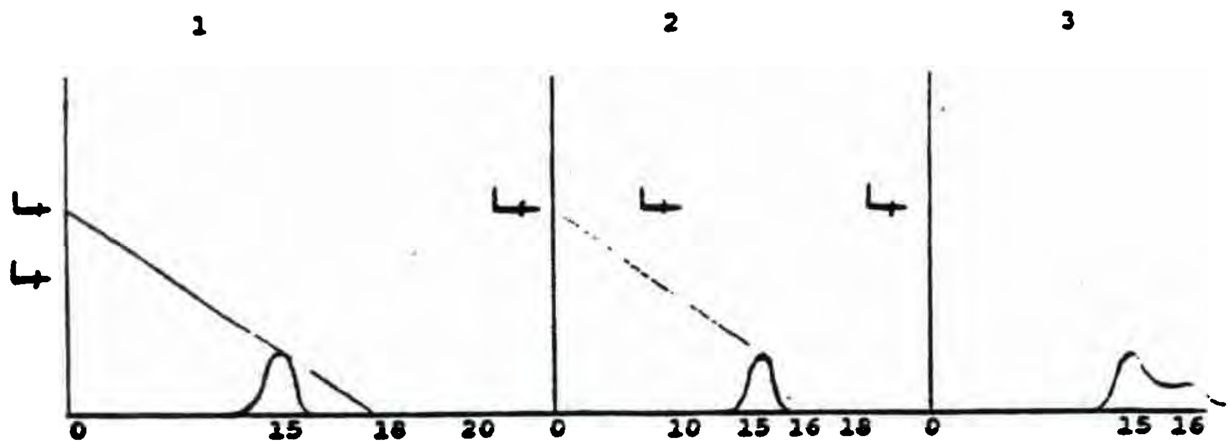
The shadow graph is used determine shadow lengths and distances at which objects will be seen emerging from shadows on a specific azimuth. The length of a shadow is a function of three variables: (Fig. 1)

1. The vertical separation between the aircraft and the ridge

2. The range between the aircraft and the ridge

3. The elevation of the terrain behind the-ridge

Figure 1



Figures 2a and 2b depict a typical mountain radar leg and its associated shadowgraph along the courseline. Since a shadowgraph is only drawn on a particular azimuth, you may need to do several in order to produce a single mountain radar prediction. Usually, three are sufficient: one on course and one 30° either side of courseline.

In the example shadowgraph, the aircraft is 26 -1/2 NM from the turnpoint (the template apex is located at the wings level point as this leg is less than 30 NM). Plot the aircraft MSL altitude on the vertical axis. Then plot the contour lines along the chosen azimuth from the template apex to 40 NM. When finished, you should have an accurate cross-section of the terrain along that azimuth.

(Figure 2a) Mountain Radar Prediction

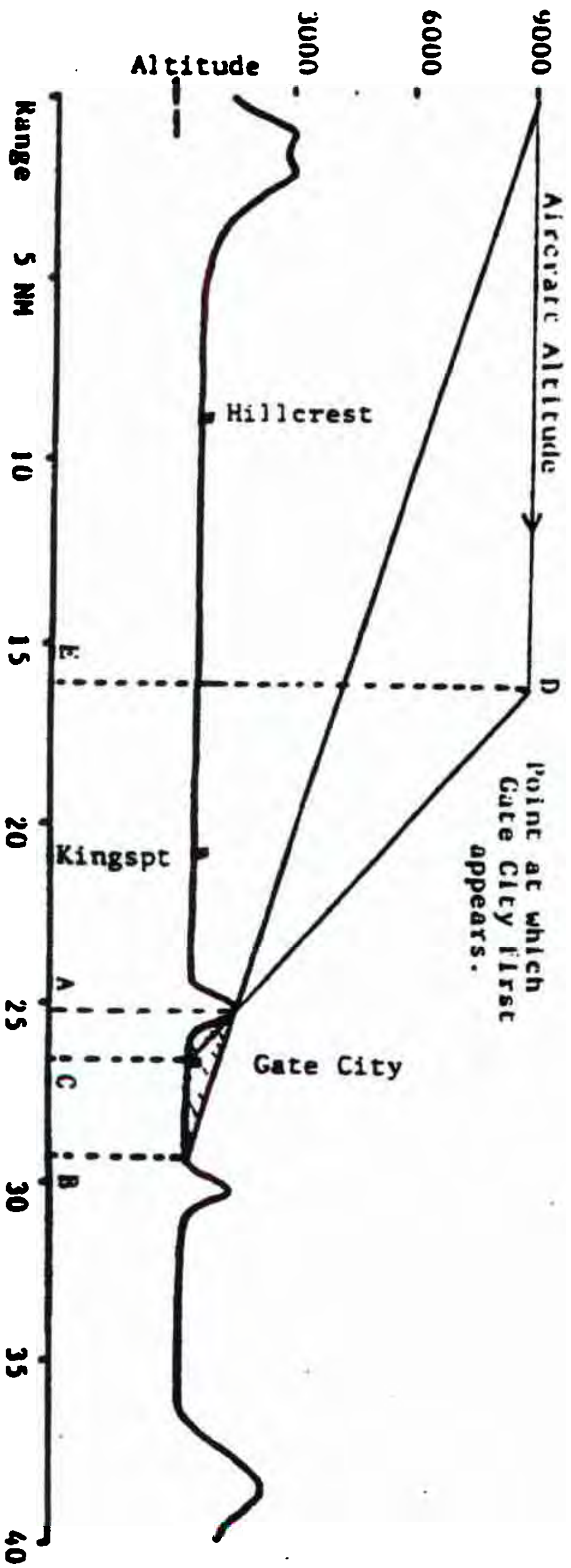


Fig. 2-b
Example Shadowgraph

Annotate the position of towns and plants along the azimuth (important checkpoints and the turnpoint). Draw lines from the aircraft through the terrain peaks to intercept the surface. These lines represent the radar line-of-sight. Terrain and cultural features falling behind the peaks and below the radar line-of-sight will be obscured by shadow. Drop vertical lines from the shadow start (peak) and the shadow end (point of ground intercept) to the range scale to obtain shadow length in NM (A-B in Fig. 2b).

Another use of the shadowgraph is to determine at the distance at which an object (such as Gate City), shielded by a ridge, will finally be visible to the radar operator. To perform this, draw a line from the object in question through the top of the shielding terrain to the aircraft MSL altitude (C-D in Fig 2b). Drop a vertical line to the range scale and measure the distance from the object to the vertical line (E-C). This is the ground range at which the point in question will appear. It is physically impossible for that point to show prior to this distance.

With time and experience, you may need to only do shadowgraphs for specific points on a particular azimuth.

Drawing Mountain Radar Predictions

1. Follow the same rules as basic predictions for the turnpoint placement on the template.

2. Shade in the front side of all mountains and ridges. With an unobstructed view, the entire front side will show from the base of the mountain to the crest. Avoid drawing just the crest of the ridge, and remember, the back side will not show. Observe contour lines to determine the intensity of the radar return.

3. Using shadowgraph principles, determine radar shadow locations. One technique in drawing shadows is to very lightly draw a line around the shadowed area so as not to inadvertently shade or draw within the shadow.

4. The rest of the mountain prediction is drawn as a flatland prediction. Draw in the land/water boundary, far shore brightening, major/minor cultural returns, and ground return. DO NOT draw returns which are hidden from view by a shadow. The prediction should be realistic in this sense. Erase stray marks in the shadow and no show (water) areas.

5. Label the prediction and sign it in ink, as before.

6. Draw "crosshairs".

Your first predictions will not be outstanding, but your technique will improve with practice. The GMRT is especially helpful in depicting ridge and shadow patterns. Also, compare your predictions with the actual radarscope. Once again, your personal advisor is an invaluable source of knowledge.

Some common pitfalls to avoid in making mountain predictions are:

a. Drawing straight line ridges. Ridges have depth and shape. They are not straight lines.
b. Using TPC colors to determine terrain elevation changes instead of using contour lines.
c. Not looking for large, distinctive patterns, known as the **BIG PICTURE**.