NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS **CNATRA P-869 (Rev. 02-15)**

FLIGHT TRAINING INSTRUCTION

UMFO VISUAL NAVIGATION (VNAV) T-6A

2015

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL AIR TRAINING
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CNATRA P-869 (Rev. 02-15)

Subj: FLIGHT TRAINING INSTRUCTION, UMFO VISUAL NAVIGATION (VNAV) T-6A

1. CNATRA P-869 (Rev. 02-15) PAT, "FLIGHT TRAINING INSTRUCTION, UMFO VISUAL NAVIGATION (VNAV) T-6A" is issued for information, standardization of instruction, and guidance for all flight instructors and students within the Naval Air Training Command.

2. This publication shall be used as an explanatory aid to the T-6A Primary 1 and 2 Undergraduate Military Flight Officer Curriculum. It will be the authority for the execution of all flight procedures and maneuvers herein contained.

3. Recommendations for changes shall be submitted via CNATRA TCR form 1550/19 in accordance with CNATRAINST 1550.6E.

4. CNATRA P-869 (Rev. 03-10) PAT is hereby cancelled and superseded.

C. J. HAYDEN
By direction

Distribution:
CNATRA website

FLIGHT TRAINING INSTRUCTION

FOR

UMFO VISUAL NAVIGATION (VNAV)

T-6A

P-869

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INTERIM CHANGE SUMMARY

The following Changes have been previously incorporated in this manual:

CHANGE NUMBER	REMARKS/PURPOSE

The following interim Changes have been incorporated in this Change/Revision:

INTERIM CHANGE NUMBER	REMARKS/PURPOSE	ENTERED BY	DATE

SECURITY AWARENESS NOTICE

This course does not contain any classified material.

SAFETY/HAZARD AWARENESS NOTICE

There are no special safety precautions to be observed during this lesson.

HOW TO USE YOUR STUDENT GUIDE

This Student Guide provides the lesson objectives and information needed to augment the instructor presentations. Each classroom lecture corresponds to a chapter in this student guide. The chapter is to be read and the assignment sheet completed prior to class.

GENERAL COURSE OVERVIEW

Regardless of the type of aircraft you fly, at some point in your aviation career you will be called upon to fly a high speed, low altitude mission. Whether it is an F/A-18 striking multiple targets or a P-8 doing low altitude ingress on a surface surveillance mission, the success of any mission depends on the aircrew's confidence and abilities in the low level regime.

Flying the T-6A in the Visual Navigation Stage will be your initial introduction to the low level flight regime and the skills introduced in this course are essentially the same as those used in high performance aircraft flying at 500 Knots Indicated Airspeed (KIAS) and 200 feet. Your ability to properly prepare a navigation chart, study and interpret the information on the chart, and identify points on the ground while airborne determines the success of your mission.

This training highlights the importance of learning proper procedures and the ability to handle high task loads in the low level environment. These procedures and acquired abilities are the building blocks for your future low level procedures and skills. Additionally, this training enhances all forms of navigation through increased attention to detail and effective headwork.

Before you start to plan low level missions, you need to understand why we fly low level in the first place. The decision to fly a high or low level route is made by evaluating the following advantages and disadvantages.

WHY LOW LEVEL?

Advantages

1. Element of surprise. The element of surprise is a great asset to any striking force. A surprise attack requires flying low enough to avoid enemy radar detection. Irregular or rugged terrain features degrade early warning radar capability and provide cover for the low flying aircraft.

2. Reduced air-to-air threat. Rugged and irregular terrain complicates and degrades ground controlled intercept capability as well as air-to-air track and engagement weaponry. Surface-to-Air Missile (SAM) capabilities are reduced in the same manner.

3. Minimize time over target area defenses. Reduces time for acquisition, track, and engagement of aircraft in target area by both anti-aircraft artillery and missile systems.

Disadvantages

1. Comprehensive preflight planning. The margin for error is smaller because extensive and detailed flight planning is required, increasing aircrew task load both before and during the mission.

2. Reduced aircraft radar and visual range. Reduced ranges can lead to disorientation, loss of the target area, and possible collision with the ground.

3. Increased threat engagement. Low altitude flight can place aircraft within the range of anti-aircraft fire normally avoided by flying at higher altitudes.

4. Reduced aircraft range. Low level flight causes higher aircraft fuel flow, resulting in decreasing the combat radius for the mission.

5. Reduced time and altitude to assess and correct any type of aircraft malfunction.

Instructional Objectives

Upon completion of this course of instruction, you will:

1. Be familiar with the low altitude environment and specific hazards to low level operations.

2. Have the basic knowledge and skills needed to prepare for and execute flights in the low level environment.

A progress check requiring a minimum of 80% accuracy to pass will be administered at the end of the course. This examination is based on the enabling objectives stated in behavioral terms and identifies exactly what is expected of the students. The objectives also state the course training standards required to progress in your training.

Instructional Procedures

1. Each lesson topic contains the terminal objective, enabling objectives, description of the subject area, and sample questions.

2. This Flight Training Instruction (FTI) is designed to reinforce instructor lectures and demonstrations.

3. Study the FTI assignment and complete the end-of-chapter questions prior to going to class. Ask questions if any of the instructional material is not clearly understood.

Reference Materials

1. Flight Information Publication (FLIP) (Area Planning - 1A, 1B)
2. T-6A NATOPS
3. Tactical Pilotage Chart (TPC) and Operational Navigation Chart (ONC) Charts
4. Joint Mission Planning System (JMPS) Computer/User Generated Charts (Strip Charts)
5. Various Peculiar to Aviation Training (PAT) Publications for T-6A

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CHAPTER ONE
CHART LEGEND REVIEW

100. INTRODUCTION

Low altitude, high-speed flight affords a tactical aircraft the element of surprise and protection from enemy radar detection. These two factors greatly increase the probability of reaching your target, executing your mission, and returning to base. The Visual Navigation (VNAV) Stage of T-6A training introduces you to the basics of low level mission planning. You will be exposed to the basic building blocks of using a chart to visually navigate the terrain while assessing and compensating for winds.

The success of any low level mission depends on extensive preflight planning by the aircrew. The proper charts must be selected to cover the route of flight to the target and the course to be flown must be plotted on the chart. The Student Naval Flight Officer (SNFO) must be familiar with the symbols used on the chart to successfully plan, navigate, and execute a mission in the low level environment.

This chapter reviews several types of aeronautical charts used for visual navigation and the interpretation of the various chart symbols. Many charts share features and use similar symbology. During the VNAV stage of training charts will be digitally created using JMPS. However, basic chart knowledge is required to successfully use the program and it is possible that you may one day need to build a low level chart by hand. This section introduces the layout of aeronautical charts, the different items depicted, and how to interpret them.

101. VISUAL REFERENCE CHARTS

Lambert Conformal Projections

The most commonly used aeronautical chart, outside of polar regions, is the Lambert Conformal Projection. Some of the features making this chart type particularly useful are:

1. A straight line approximates a great circle. Therefore, courses and radial bearings can be plotted with a straight edge.

2. The scale about a point is the same in all directions throughout a single chart. Hence, the scales for nautical miles, statute miles, and kilometers printed on each chart can be used on any portion of that sheet and in any direction.

3. Since they are conformal, angles are correctly represented and small shapes are correctly proportioned. Consequently, land or water areas have substantially the same shape on the chart as they appear from the air.

Common Scales and Usage

The information contained on a chart is a function of the chart's scale. The scale is the ratio between the dimensions of the chart and actual dimensions represented. Thus, if the scale is 1:1,000,000, one inch of the chart represents 1,000,000 inches (about 14 miles) on the ground. If the scale is 1:500,000, one inch of the chart represents 500,000 inches (about 7 miles) on the ground.

NOTE

A scale of 1:500,000 is considered larger than a scale of 1:1,000,000 (a large-scale chart gives you a large amount of detail and covers a smaller amount of area).

The conflict between chart requirements for local and long distance flights has led to the development of numerous special purpose charts of different scales. The objective is to put as much information on the chart as possible without cluttering the chart to the degree that it is less useful. The scale of charts used in general long range planning is typically between 1:5,000,000 and 1:1,000,000. For detailed area planning, a scale ranging between 1:500,000 and 1:25,000 is effective. The coverage on a 1:25,000 scale chart is too small for convenient use in aircraft because the plane would rapidly "fly off" the chart or sorties of extended range would require numerous charts.

Some chart types and scales:

1. Global Navigation Chart (GNC), scale 1:5,000,000 (small scale)

2. Jet Navigation Chart (JNC), scale 1:2,000,000

3. Operational Navigation Chart (ONC), scale 1:1,000,000

4. Tactical Pilotage Chart (TPC), scale 1:500,000 (large scale)

The following comparison is provided to help you visualize the amount of surface area covered by each chart:

1. One GNC covers several thousand square nautical miles, typically an entire ocean or continent.

2. It takes approximately three JNCs to cover the area of one GNC.

3. It takes 25 ONCs to cover the same area as one GNC.

4. It takes four TPCs to cover the area of one ONC.

1-2 CHART LEGEND REVIEW

Other chart scales are available, depending on your mission requirements. Such charts may have scales to 1:25,000 (Air Target Chart) or may even be derived from satellite imagery.

Interchart Relationship Diagram

On the bottom portion of the chart legend is an interchart relationship diagram which identifies the charts adjacent to the one you are using. If your route of flight extends beyond the coverage of your chart, obtain the adjacent chart and affix the two together by matching latitude and longitude.

Example: Planning a flight from NAS New Orleans to NAS Corpus Christi requires the use of H-24A and H-24B (Figure 1-1).

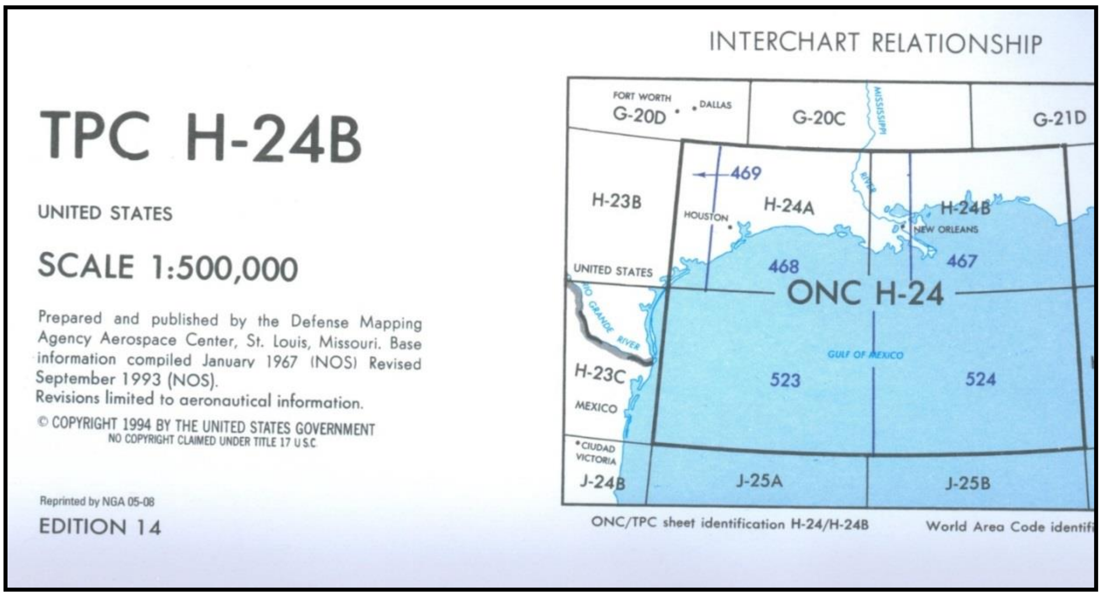


Figure 1-1 Interchart Relationship

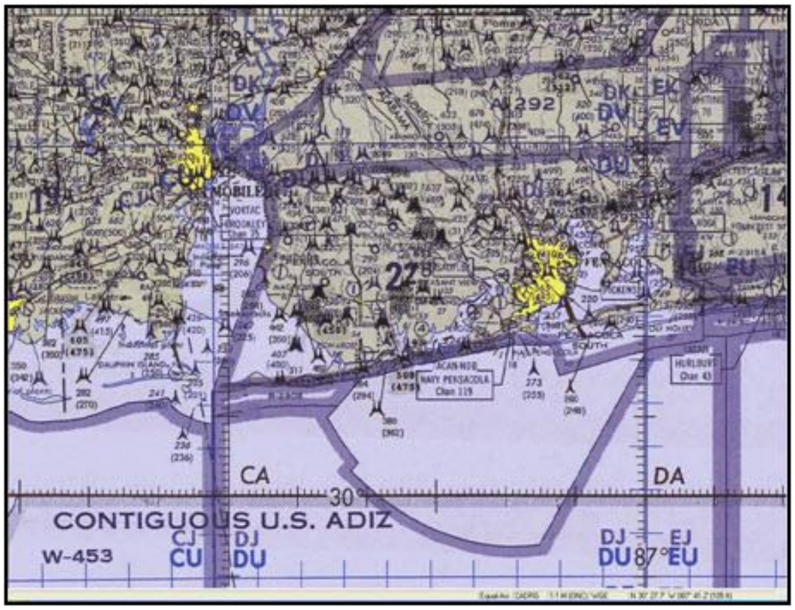


Figure 1-2 ONC H-24 (In the vicinity of Pensacola from JMPS)

Operational **N**avigation **C**hart (Figure 1-2) Published By National Geospatial-Intelligence Agency (NGA)

Code: ONC

Scale: 1:1,000,000 (1 inch = approximately 14 nautical or 16 statute miles)

Projection: Latitude 0 to 80^{o}. Lambert Conformal Conic.
Latitude 80 to 90^{o}. Polar Stereographic.

Size: 41 5/8 inches x 57 1/2 inches

Purpose: Designed primarily for preflight planning and high to medium altitude enroute navigation by dead reckoning, visual pilotage, celestial, radar, and/or other electronic techniques. The ONC is also used for operational planning, intelligence briefing, and plotting, as well as for flight planning wall displays.

Information Shown:

Relief: Contours (generally 200 or 250 feet to 1000 feet intervals), spot elevations, three dimensional relief shading, terrain characteristics tints, and maximum elevation data. Colors on this chart are functional. Green indicates flat or relatively level areas regardless of the altitude above sea level. Level areas at higher elevations (plateaus) are shown by yellow-green. Light buff and yellow color indicates hilly and rolling to mountainous terrain. Two bands of dark yellow at higher elevations identify major mountain ranges and/or critical mountaintops.

1-4 CHART LEGEND REVIEW

Culture: Extensive cities and towns, power transmission lines, principal roads, detailed railroad network, boundaries, and miscellaneous cultural features.

Hydrographic Features: Water tint, detailed drainage.

Vegetation: Stable vegetation pattern.

Aeronautical: Aerodromes and stable aeronautical facilities.

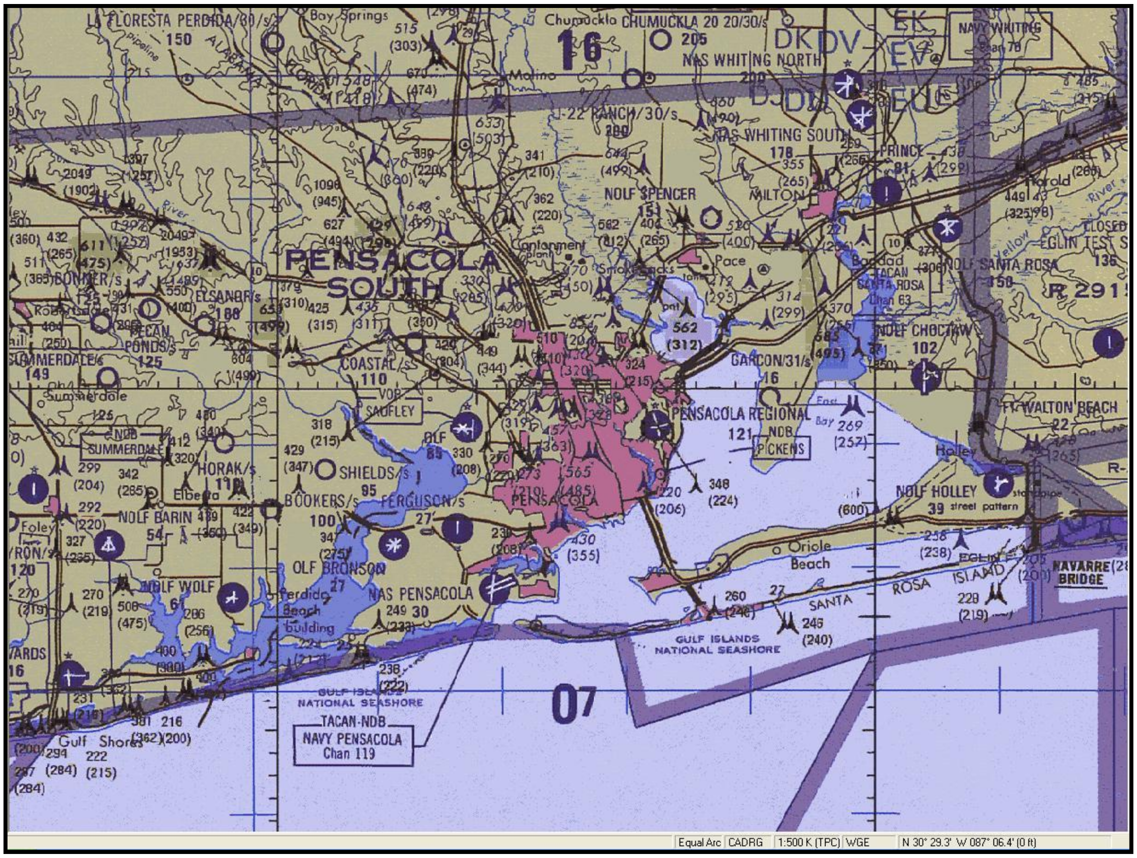


Figure 1-3 TPC H-24B (in the vicinity of Pensacola from JMPS)

Tactical **P**ilotage **C**hart (Figure 1-3) Published By National Geospatial-Intelligence Agency (NGA)

Code: TPC

Scale: 1:500,000 (1 inch = approximately 7 nautical or 8 statute miles)

Projection: Latitude 0 to 80^{o}. Lambert Conformal Conic.

Latitude 80 to 90^{o}. Polar Stereographic.

Size: 41 5/8 inches x 57 1/2 inches.

Purpose: Used for detailed preflight planning, mission analysis, and low to medium altitude navigation. Significant ground features are portrayed.

Information Shown:

Relief: Basic contour interval is 500 feet with 250 foot intermediate contours and 100 foot auxiliary contours in moderately level areas; spot elevations throughout the various elevation levels; three dimensional relief shading and/or, layer tints and land forms significant to low-altitude radar missions.

Culture: Extensive towns and cities, principal roads, detailed railroad network, power transmission lines, pipelines, boundaries, and cultural features selected for rapid visual recognition form a low perspective angle. Checkpoint features are portrayed by three-dimensional pictorial symbols.

Hydrographic Features: Detailed drainage, shoreline bordered in blue

Vegetation: Areas of perennial vegetation shown by symbol

Aeronautical: All aerodromes and stable aeronautical facilities

Interpretation of the Chart Legend

The chart is not a true picture of the real world, but rather a schematic diagram of certain characteristics of the world. It is a stylized, simplified, generalized, and codified presentation of selected characteristics of the earth's surface. These charts are annotated with various names, numbers, boundaries, and reference grids.

The discrepancies that exist between the real world and its representation on aeronautical charts are largely the result of limitations imposed by scale. To portray the world on the TPC, the cartographer must shrink the charted area to one half-millionth of its true size. If the cartographer were simply to reduce all features of the earth's surface equally to 1:500,000 scale, only the largest features would be visible. Roads, small towns, towers, power lines, streams, railroads, bridges, and many other features would be too small to see. The aeronautical chart would look like the familiar photographs of the earth taken from orbiting satellites. Consequently, the scale factor of an aeronautical chart refers primarily to the location of one object to another. For example, a tower one mile north of a primary road will have that distance accurately displayed on the chart.

Standard symbols are used for easy identification of information portrayed on aeronautical charts. The variance in symbols between various chart scales is slight. Chart legends explain the meaning of the relief, culture, hydrographic features, vegetation, and aeronautical symbols. You must be completely familiar with all symbols contained in the ONC and TPC legends (Figures 1-4 through 1-6).

Relief (Hypsography)

Chart relief shows the physical feature related to the differences in elevation of the land surface. These include features such as mountains, hills, plateaus, plains, depressions, etc. Standard symbols and shading techniques are used for relief portrayal on charts. These include contours, spot elevations, variations in tint, and shading to represent "shadows."

The highest terrain on each ONC/TPC chart is identified by location (latitude and longitude) and elevation above Mean Sea Level (MSL) in the chart legend.

The relief of the terrain is emphasized on charts by a system of gradient tints. They are used to designate areas within certain elevation ranges by different color tints. Green color indicates flat or relatively level terrain regardless of altitude above sea level. The green color does not indicate vegetation on either chart!

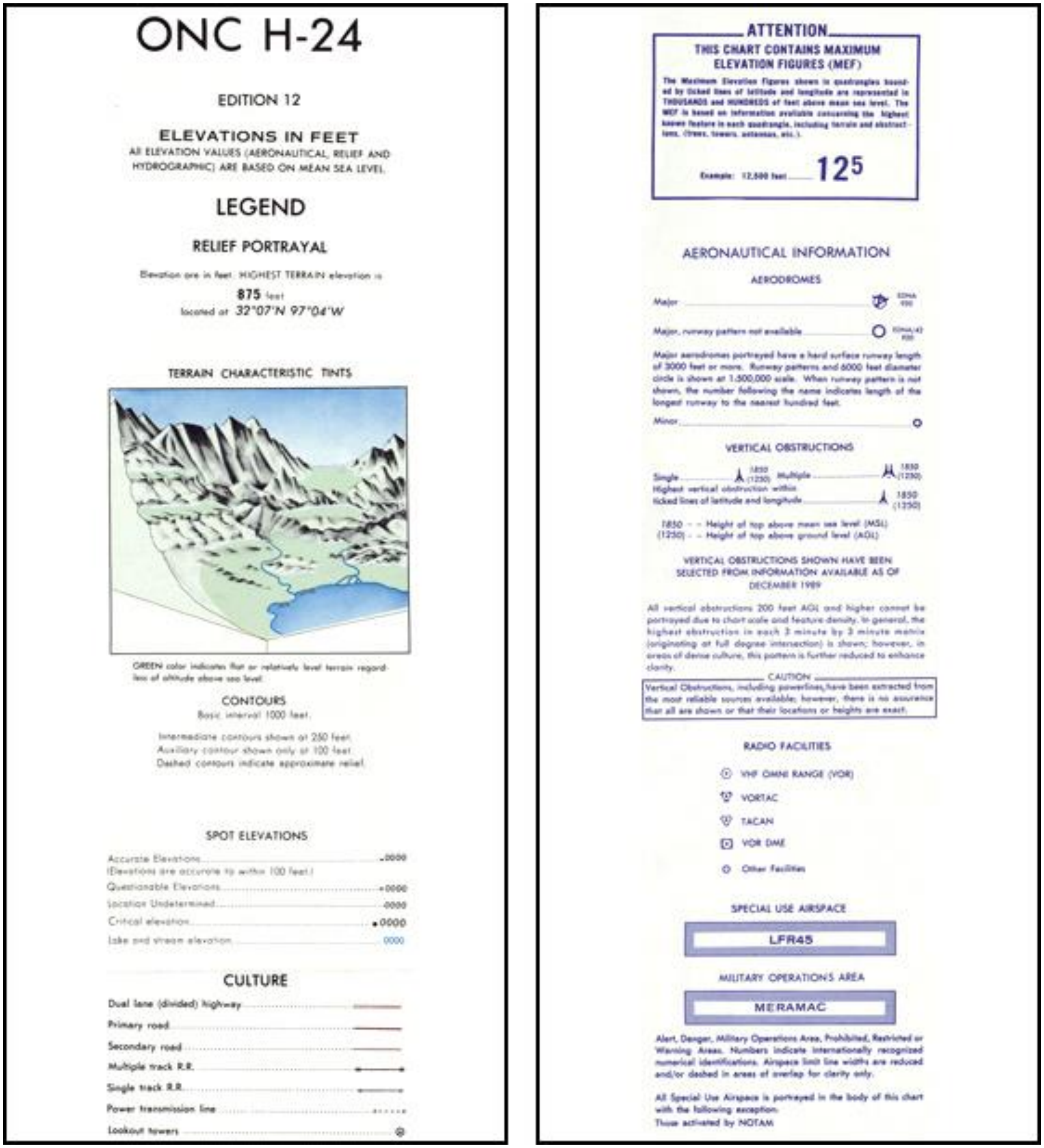


Figure 1-4 ONC Legend, Standard Symbols

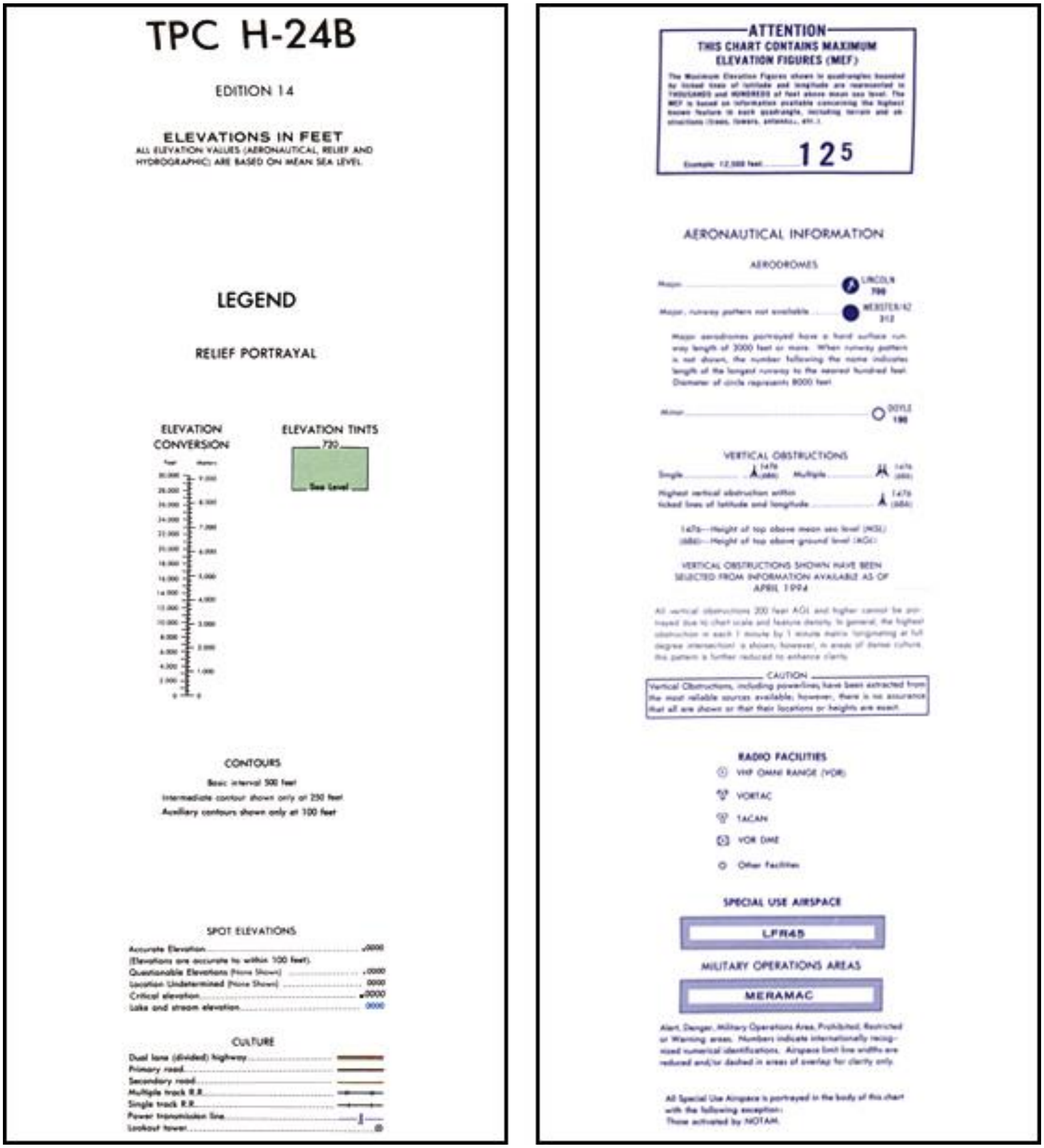


Figure 1-5 TPC Legend

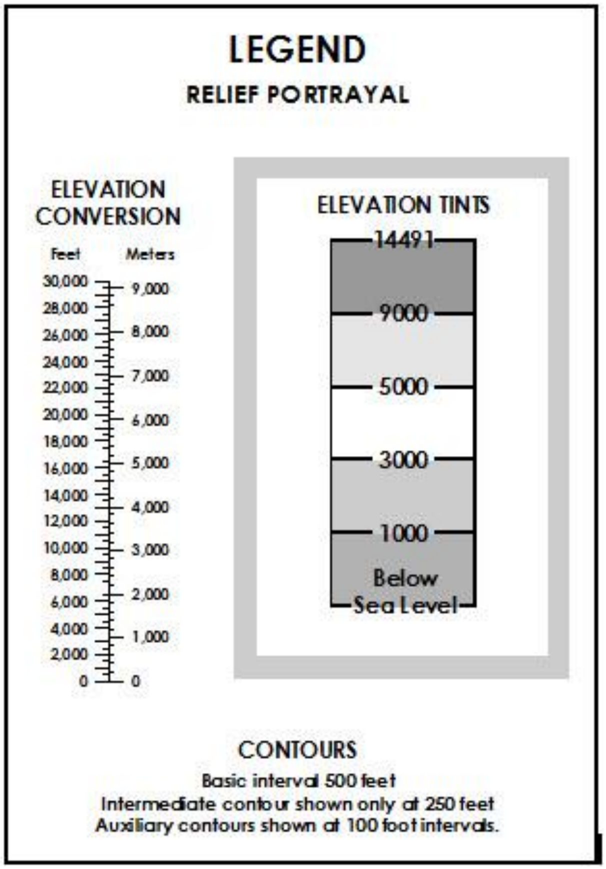


Figure 1-6 Relief Portrayal Legend

A contour line connects points of equal elevation. Figure 1-7 shows the relationship between contour lines and terrain. Notice the contours of steep slopes are close together and on gentle slopes they are farther apart. The interval of the contour lines usually depends upon the scale of the chart and terrain depicted. Depression contours are indicated with spurs or ticks added on the downslope side.

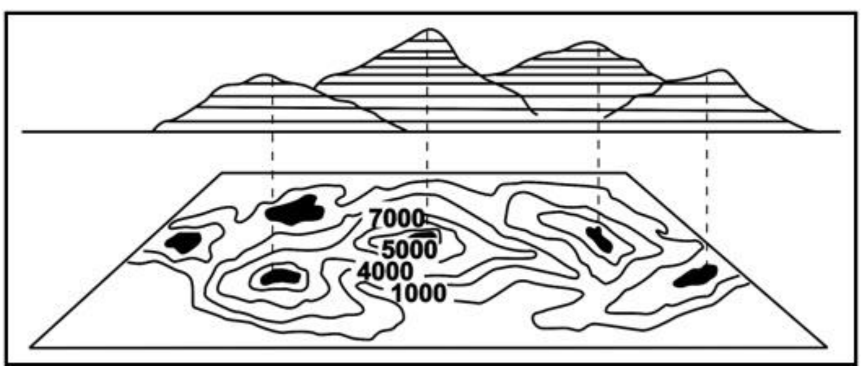


Figure 1-7 Contours

The basic contour interval is found in the chart legend and indicates distance between lines. In Figure 1-7, the basic contour interval is 1000 feet. In addition, intermediate and auxiliary contours may be indicated in the legend. Basic, intermediate, and auxiliary contour intervals will vary depending on the scale of the chart. Spot elevations are the heights of particular points of terrain above an established datum (usually MSL).

As depicted in the legend in Figure 1-5, Maximum Elevation Figures (MEF) are computed by the National Geospatial-Intelligence Agency (NGA) and take into account both terrain and obstacles.

If the highest feature within a latitude/longitude grid is terrain, NGA adds 200 feet to the terrain elevation, plus the vertical accuracy of the identified point. This value is then rounded up to the next 100 foot value. If the highest vertical obstruction (man-made) is higher than the highest terrain elevation plus 200 feet, then the MEF is computed using the elevation of the obstruction plus its vertical accuracy, then rounded to the next higher 100 foot value.

What is critical to keep in mind is that the MEF will give at least 100 feet of clearance but does not ensure absolute clearance of terrain or obstacles. The location of this highest feature within the grid is not identified on the chart, which means flight planned course may be up to 30 NM from this obstruction. The MEF is used as guidance for emergency situations on low level routes.

(Information above is collected from Defense Mapping Agency Aerospace Center (DMAAC) SOP 8440.2, 1 DEC 1989)

For example, $\mathbf{3^1}$ means the highest feature within that grid is between 2901 and 3000 feet.

Cultural Features

Man-made structures appearing on the chart are cultural features. Three main factors govern the amount of detail given to cultural features:

1. Scale of the chart.

2. Intended use of the chart.

3. Geographical area covered.

Additional points to remember when interpreting cultural features:

1. Populated places, roads, railroads, installations, dams, bridges, and mines are cultural features typically portrayed on aeronautical charts.

2. True representative size and shape of larger cities and towns are shown.

3. Standardized coded symbols and type sizes are used to represent the smaller population centers.

4. Some symbols denoting cultural features are keyed in a chart legend.

5. Some charts use pictorial symbols that are self-explanatory and require no explanation in the legend.

Roads

Transportation lines, consisting primarily of railroads and roads, are important features for use in obtaining time checks along your route. When used in conjunction with other features, they help determine aircraft position.

Dual lane highways are multiple-lane, hard-surfaced roads having a center median or divider. Highways are indicated by a double line and are easily identified from the air since they are large and few in numbers in most areas (e.g., Interstate 10, north of Pensacola).

Primary roads include hard-surfaced, all-weather roads that are two or more lanes in width and are portrayed as a single thick line. In sparsely populated areas almost all primary roads are portrayed, but in built-up areas they are shown only as space permits. Primary roads represent the characteristic configuration of the transportation network in the area.

Secondary roads include all other roads maintained for automobile traffic, including hard-surfaced and dirt roads. They are shown as a single thin line and are selected for portrayal when they do not cause clutter. Tracks and trails are generally dirt roads not necessarily maintained for automobile traffic. They are portrayed with a broken line and shown only in areas where few roads exist.

NOTE

Except for dual lane highways, the road classification shown on the chart may not be a reliable indication of the visual appearance of the road. This is particularly true of two-lane roads, which may be encoded as either primary or secondary. Therefore, specific roads may be difficult to identify. Roads may also be visible that do not even appear on the chart. Students should not attempt to count roads as an orientation technique.

Bridges

In uncongested areas, bridges over 500 feet long are portrayed with a bridge symbol (Pensacola Bay Bridge in Figure 1-8). Bridge length may be exaggerated on the chart since the minimum length to scale on a TPC is 2000 feet between abutment ticks. Typically, bridge symbols are shown where roads cross double line streams (streams at least 600 feet wide).

Many bridges along the flight path are not shown on the chart. Their presence is inferred by noting the road crosses a portrayed stream (the northernmost bridge in Figure 1-8). The bridges, one might infer from road crossings, may vary widely from minor culverts to significant spans because of wide disparities among the actual widths of single line streams. In addition, the vertical development of the bridge cannot be determined from the symbol. Though a tall bridge may appear on the same on a chart as a low bridge, it is easier to spot from a distance. Bridges are excellent fix points, but only when they are correctly identified.

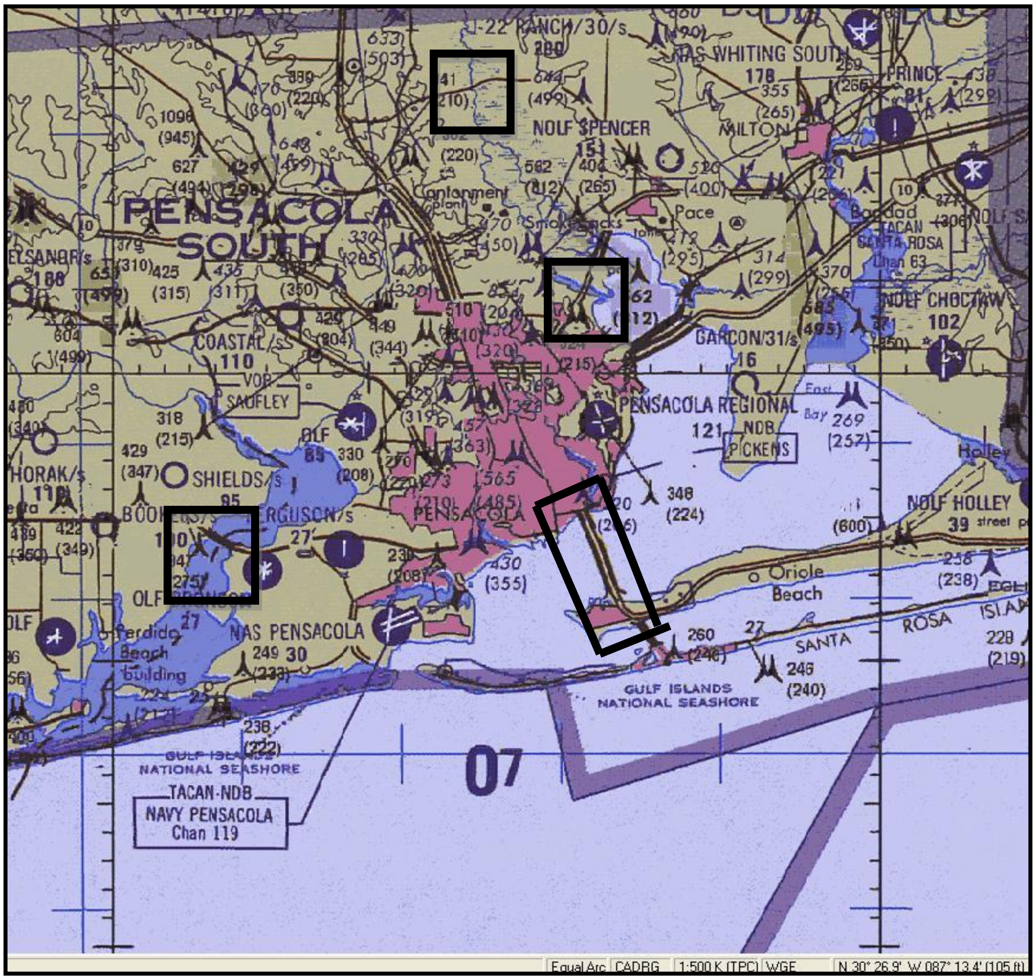


Figure 1-8 Bridge Symbols

Railroads

All multiple track railroads, most single-track railroads, and some abandoned railroads are portrayed on the charts. Typically, railroads are sufficiently sparse and can be readily identified and distinguished from each other. Railroads may make smaller fix points (small towns, intersections) more identifiable. Railroads are not always easy to see from low altitudes, even though they are portrayed boldly on the chart. The tree slash clearing for a railroad track is generally narrower than one for a primary road, thus reducing its visibility.

NOTES

1. As a rule, railroads are easier to detect in hilly or mountainous terrain than in flat populated areas. Since a locomotive must operate on gentle grades and turns, the track beds in mountainous regions are normally characterized by numerous cuts, fills, trestles, and tunnels. Thus, the features associated with the track bed lend visual significance to the railroad. Railroad yards are excellent radar checkpoints, and generally shown if they exceed 2000 feet in length and five tracks in width. Railroad stations have distinctive buildings, and are generally shown in areas of sparse culture.

2. With respect to the use of railroads for checkpoints, the student should adopt this attitude: "I might not see it, but if I do, I will very likely be able to identify it with respect to the chart."

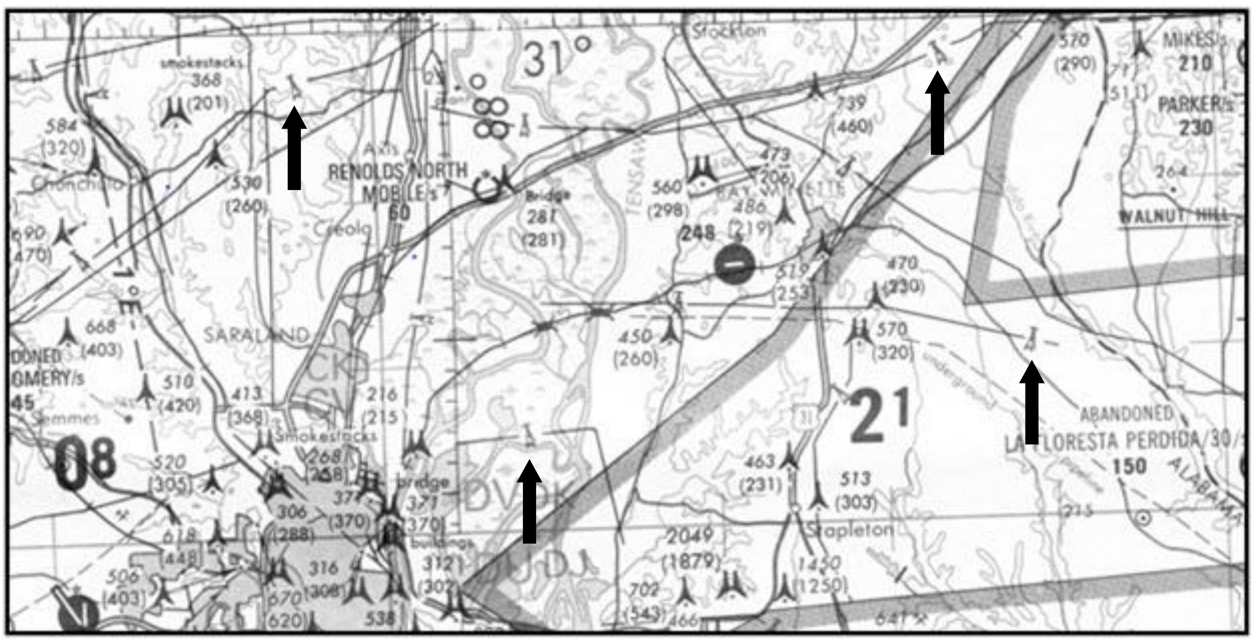


Figure 1-9 Power Transmission Lines

Power lines/Pipelines

Power transmission lines are generally difficult to see from the air. To install the power line network in a wooded area, a path is cut through the forest. Airborne, this path area may look similar to a dirt road. Power lines (Figures 1-9 and 1-10) generally are laid out in straight lines.

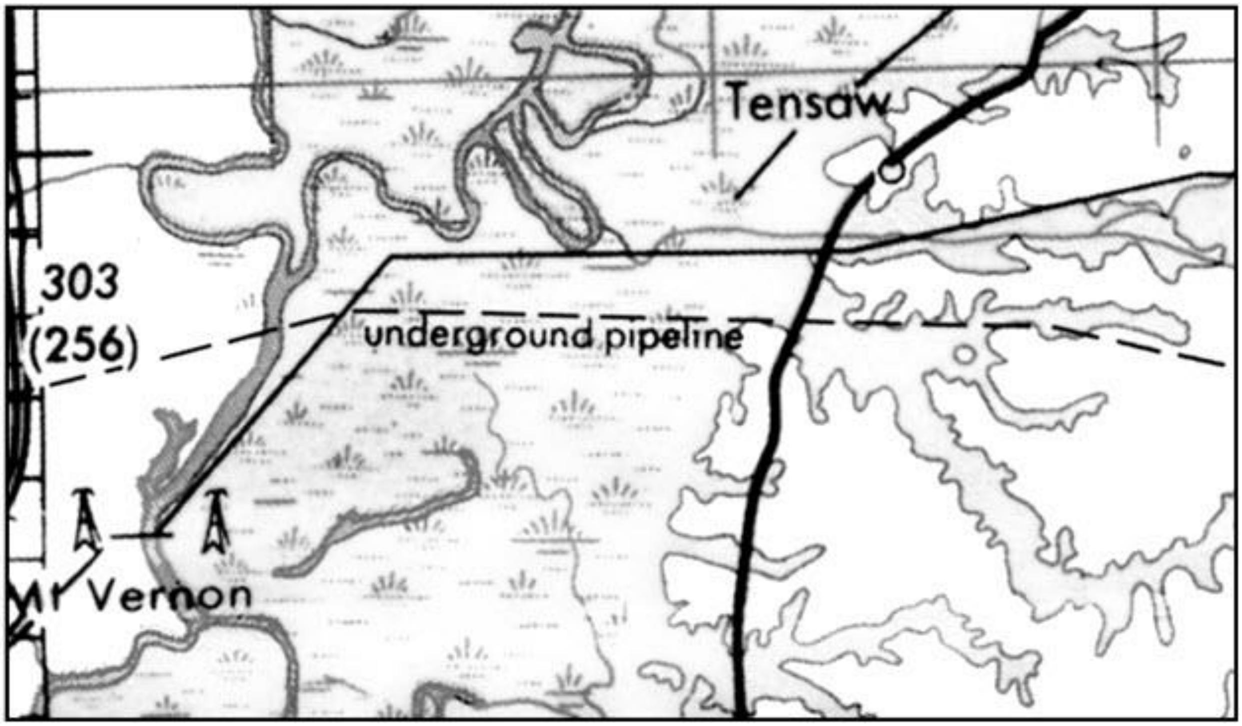


Figure 1-10 Pipelines

Figure 1-11 Satellite View of Figure 1-10

Pipelines are depicted on the chart by a broken line with the words "underground pipeline." Actual buried pipeline will not be visible from the air (no matter how low you fly). As with power transmission lines (Figures 1-10 and 1-11), the cut out area where trees were removed during installation is easily visible. It may appear as a dirt road in the air, but will typically be abnormally straight, where a dirt road has turns.

Cities/Towns

Populated areas are visibly prominent and easily identified (Figure 1-12). Distinguished cities are valuable checkpoints. Although the shape of the built-up area of the city is shown on the chart, do not attempt to identify a city on this basis alone. The portrayed built-up area is intended primarily to identify the location where the significant vertical development of the city exists.

1. Those of relatively large size (usually at least one mile square) and known shape are portrayed with city outlines designed to show areas of vertical development.

2. Isolated communities of small size or unknown shape are shown by means of a small circle.

Figure 1-12 Populated Areas

The shape of Mobile, as shown in Figure 1-12, relates to its area of vertical development and not to its visible outline.

Remember, prior to actually flying over a town, you can use products such as satellite imagery (i.e., Google Earth™) to observe how the town may actually appear. Do not be surprised if the town is much smaller or larger than you expected after looking at the chart. This holds especially true for small towns, which could be anything from one store and two houses to 100 or more buildings.

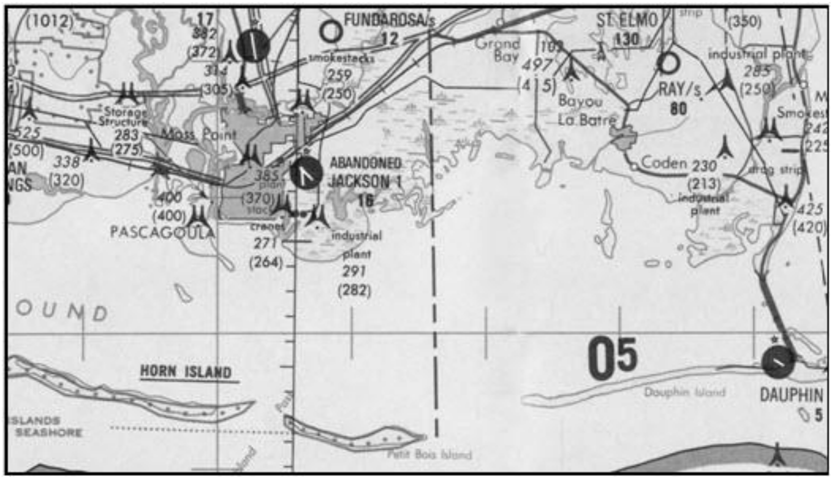


Figure 1-13 Coastal Hydrographic Features

Coastlines may be used in obtaining time checks inbound or outbound from the land mass and may be used for position determination if significant points or inlets are available (Figure 1-3). Coastal hydrographic features include: oceans, coastlines, lakes, rivers, canals, swamps, reefs, and numerous others. Open water may be portrayed by tinting, shading, or may be left blank. Vegetation is not shown on most small-scale charts.

Aeronautical information symbols on charts include: airfields, radio aids to navigation, commercial broadcasting stations, Air Defense Identification Zones (ADIZ), compulsory corridors, restricted airspace, warning notes, lines of magnetic variation, and special navigation grids. Some aeronautical information is subject to frequent change. Aeronautical type data subject to frequent change is provided by the DOD FLIP documents. Consult the FLIP, Chart Updating Manual (CHUM), Notices to Airmen (NOTAMs), and check your JMPS software for the most current information.

Aerodromes

Aerodromes are depicted on ONC and TPC charts with symbols as illustrated in Figure 1-14 through Figure 1-17:

A major aerodrome has at least 3,000 feet of hard-surfaced runway.

A solid dark blue circle depicts major aerodromes on a TPC chart. The diameter of the circle represents 8,000 feet. A runway pattern may be depicted and if so it will be to scale.

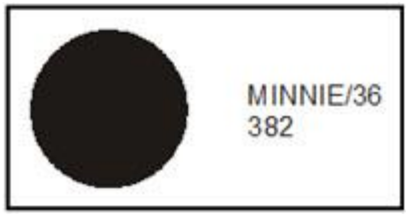


Figure 1-14 Major Aerodrome (TPC)

In Figure 1-14, the airport name is Minnie, elevation is 382 feet MSL, and the 36 indicates the longest runway is 3,600 feet long.

Figure 1-15 Major Aerodrome, Runway Greater than 8,000' (TPC)

In Figure 1-15, the runway pattern is shown, but the length of the longest runway is not included. Since the circle represents 8,000 feet in diameter, we can infer the longest runway in this case is at least 8,000 feet since the pattern is wider than the circle. The actual location of the airport is at the center of the circle.

An open circle depicts a major aerodrome on an ONC chart. The diameter of the circle represents 6,000 feet (1:500,000 scale). A runway pattern may or may not be shown. If no pattern is included, the length of the longest runway in hundreds of feet may be included.

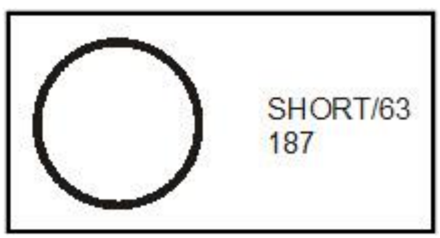


Figure 1-16 Major Aerodrome (ONC)

In Figure 1-16, the airport name is Short, length of longest runway is 6,300 feet, and field elevation is 187 feet MSL. The actual location of the airport is at the center of the circle.

Figure 1-17 Major Aerodrome with Runways Depicted (ONC)

In Figure 1-17, runway patterns are shown. Since the circle is 6,000 feet in diameter, the North-South runway is approximately 6,000 feet long; the East-West runway is approximately 4,000 feet long; and the runway aligned Northwest-Southeast is approximately 10,000 feet long. The only way to determine the exact length of any runway is by referring to the Instrument Flight Rules (IFR) Supplement, Visual Flight Rules (VFR) supplement, or the appropriate approach plate.

A hard-surfaced runway with less than 3,000 feet is a minor aerodrome.

An open blue circle representing a 4,000-foot diameter depicts minor aerodromes on TPC charts. The actual airport location is at the center of the circle. This circle will show the aerodrome name and elevation.

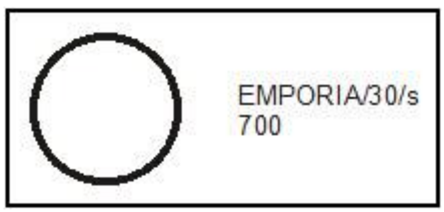


Figure 1-18 Minor Aerodrome (TPC)

In Figure 1-18, the airport name is Emporia, length of the longest runway is 3,000 feet, and the “s” indicates the runway is soft surface. Field elevation is 700 feet MSL.

A blue circle representing a 3,000 foot diameter at TPC scale, along with name and elevation depicts a minor aerodrome on an ONC chart. Runway patterns are not shown.

Towers

Man-made obstructions extending 200 feet or more Above Ground Level (AGL) are depicted on TPC and ONC charts.

Lookout towers are typically located on high terrain, such as hilltops. They are often difficult to locate due to their small size and coloring. Additionally, they may be “nested” in a wooded area such that only the top third of the tower is visible. They are represented by a circled small black triangle (Figure 1-19).

Figure 1-19 Lookout Tower

A radio-transmitting tower extending 236 feet AGL is depicted in Figure 1-20.

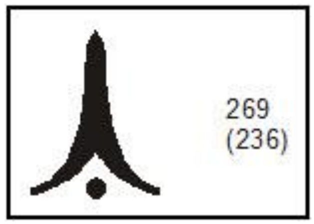


Figure 1-20 Single Tower

In Figure 1-20, the upper number is the altitude above MSL at the top of the tower, while the lower one in parenthesis is the tower height above the ground. The elevation of the ground below the tower can be determined by subtracting the lower number from the upper. In this case ground elevation is 33 feet MSL.

Multiple obstructions near each other are depicted in Figure 1-21.

In Figure 1-21, the numbers indicate the same information as with single obstructions. The highest of the multiple towers height is 1,050 feet MSL and the towers are 625 feet tall, thus the ground elevation is 425 feet MSL. Note the tower symbols are not to scale. If they were, the tower would be over a mile high.

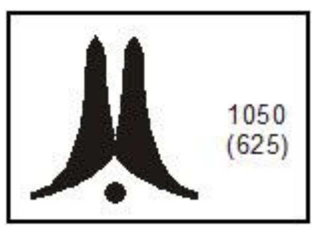


Figure 1-21 Multiple Towers

Often an obstruction will have some landmark significance, and if so, a pictorial symbol will be used along with the same MSL and AGL obstruction heights (Figure 1-22).

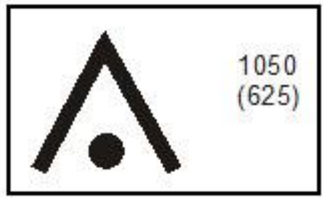


Figure 1-22 Factory with Tall Smokestack

Others

Standard symbols are used to depict radio aids to navigation. Refer to the chart legends and be completely familiar with the symbols for VHF Omnidirectional Range (VOR), VORTAC, Tactical Air Navigation (TACAN), VOR with Distance Measuring Equipment (DME), and other facilities.

Special Use Airspace has defined dimensions in which aircraft flight may be restricted or which contains danger to flight operations. Special use airspace is depicted on ONC and TPC charts unless it is activated only by NOTAM. Letters and numerals identify each area of special use airspace and are internationally recognized.

By referring to FLIP Area Planning AP-1A you can determine the coordinates (latitude and longitude) that define the special use airspace area, affected altitudes, times of activation, and controlling agency, if any. These areas are:

1. Prohibited area (P): Airspace through which aircraft are prohibited from flying. Permission to cross it will rarely, if ever, be given by the controlling agency.

2. Restricted area (R): Airspace through which flight of aircraft is restricted. Permission may be obtained to cross it from the controlling agency.

3. Warning area (W): International airspace which may contain hazards to non-participating aircraft. Aircraft may fly through warning areas in international airspace without permission from the controlling agency, but they do so at their own risk.

4. Military Operations Area (MOA): Airspace assignment of defined vertical and lateral dimensions established for the purpose of separating certain military activities from IFR traffic.

5. Alert area (A): Contains a high volume of pilot training or an unusual type of aerial activity. Both participating and non-participating pilots are responsible for collision avoidance.

102. CHARACTERISTICS OF GOOD CHECKPOINTS

In military flying, Dead Reckoning (DR) is your primary means of low altitude navigation. Low altitude DR navigation is based upon visually identifying a point and then traveling in a direction for a set time and airspeed in order to visually find the next point. In low altitude flying, visual fixing is the primary means of identifying aircraft position. Radar, Global Positioning System

(GPS), and Inertial Navigation System (INS) are all great "crutches," but it all starts with visual situational awareness. Your most important duty in this environment is to look outside the aircraft! Now you need to know what to look for. The focus of this section is on the qualities that make a checkpoint more easily identifiable and usable for position determination.

Several factors determine the most important quality of a visual checkpoint - our ability to see it! Size is important because a larger feature can generally be seen from greater distances and is easier to identify. Also, the more unique and distinctive a point is, the better. If you can find a feature that has something unique (color, shape, size), it will reduce errors in identifying your point.

Horizontal development refers to the "width" of the feature. Coastlines, lakes, roads, and rivers are examples of features with large horizontal development. Vertical development refers to towers, mountains, and other man-made structures.

The ideal checkpoint has both vertical and horizontal development. Such a point might be a tall bridge across a wide river or a large factory complex with tall smoke stacks. Unfortunately, such points are not always available.

For T-6A flights, horizontal development is generally more desirable than vertical development due to the altitude flown. Small towers can be difficult to see from 1,500-2,500 feet altitude due to their size and possibility of blending into a nearby tree line. In lower altitude flight (500 feet AGL), vertical development will prove more effective, as horizontally developed features become masked by trees and a shortened horizon. Further, as aircraft altitude decreases, vertical development tends to rise above the horizon due to the perspective change, making the vertical checkpoint more easily identifiable.

Also consider the information that a checkpoint provides. Linear features (e.g., roads, railroads, pipelines, power lines) running parallel to your planned track give information regarding course. Features running perpendicular to your track give information regarding time. An ideal checkpoint should give both course and time information (e.g., a road intersection, a distinctive bend of a river, or bridge). On the contrary, a linear feature crossing the planned track at a 45º angle does not provide either accurate course or time information if used alone.

The surrounding area of a checkpoint can also be helpful through the use of funneling and limiting features. A funneling feature is an aid that helps track your eyes onto the point for which you are looking. Flying parallel to a river that leads to the desired bridge, or visually tracking a power line that forms your desired road intersection, are great uses of funneling features to find an individual checkpoint. Roads, rivers, power lines, and railroad tracks can all be good funneling features. A limiting or catching feature, alerts you when you are at your checkpoint or have flown past it. This can be any feature that is prominent and located at or past your checkpoint. Availability of these features is a plus when selecting a checkpoint.

The ultimate goal when choosing checkpoints is to fix your position as accurately as possible. While an airfield is a good example of horizontal development and good for situational awareness, it may not provide the most accurate position unless a distinctive structure or runway pattern is used. The ideal checkpoint will not only have both vertical and horizontal development, but will have funneling and limiting features available as well. Figure 1-23 shows the chart depiction for the first turnpoint of VNAV 1 and figure 1-24 is the corresponding satellite imagery. The checkpoint is a group of large smokestacks located next to a distinct river bend. The river acts as a funneling feature and the distinctive bends act as a limiting feature to alert you to the checkpoint. Note that even if the checkpoint were a small feature such as a tower, the funneling and limiting features would help to narrow your visual search area, which greatly improves your chances of seeing the checkpoint.

As you build your proficiency in low altitude navigation, your preflight selection of checkpoints will become more discriminating, and your airborne ability to gain situational awareness from less than ideal checkpoints will improve.

Figure 1-23 Ideal Checkpoints – VNAV 1 Point A

Figure 1-24 Satellite Image of VNAV 1 Point A

Additional items to remember when selecting checkpoints:

1. Inferred bridges crossing double-lined rivers are a minimum of 600 feet in length.

2. Where primary roads cross interstate highways, an overpass, bridge, or access ramp is generally present.

3. Multiple tower annotations can represent two, three, or even twenty towers making accurate position fixing difficult.

4. Look for other nearby features to aide in identifying the checkpoint, such as terrain, river bends, roads, etc. In this manner, any checkpoint can be uniquely and positively identified. Note the road intersection prior to the bridge ensures you have the correct turnpoint/checkpoint (Figure 1-25).

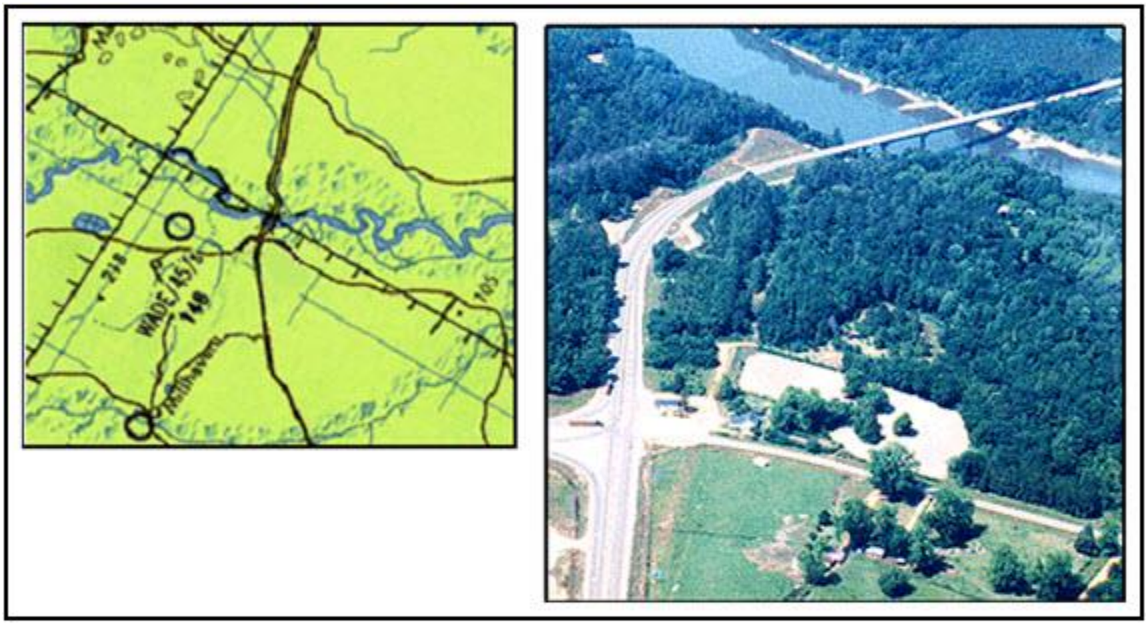


Figure 1-25 Road Intersection and Bridge

103. ADDITIONAL CONSIDERATIONS FOR CHOOSING CHECKPOINTS

It is important to anticipate what the checkpoint will look like from the cockpit and not just the ground level perspective. Until you gain more experience in the aircraft, utilizing all available resources is a great way to build your image of how the turnpoint should appear from the aircraft prior to actually getting there.

Use point Alpha of VNAV 1 as an example (Figure 1-26). While a power plant initially sounds like a good checkpoint, further investigation should be conducted. Satellite imagery from common, open source websites will provide you with a bird’s eye view for your turnpoints and intermediate checkpoints. In Figure 1-27, you can see that three tall smokestacks sit on top of a large rectangular factory.

For training purposes, aerial photos of the turnpoints are also provided in the squadron spaces. These will be found in the briefing spaces and student ready rooms. The photographs will have a perspective of a specific direction on the compass and may or may not be aligned with the course on your chart. Figure 1-28 shows the smokestacks from route centerline at 2,500 feet AGL.

Combining the image from the chart, aerial photographs (if available), and satellite imagery should give you a complete picture of your checkpoints and/or turnpoints. Learn to reconcile these images with your every day, ground-level sight picture to that of the actual low-altitude cockpit perspective.

Figure 1-26 Point A VNAV1

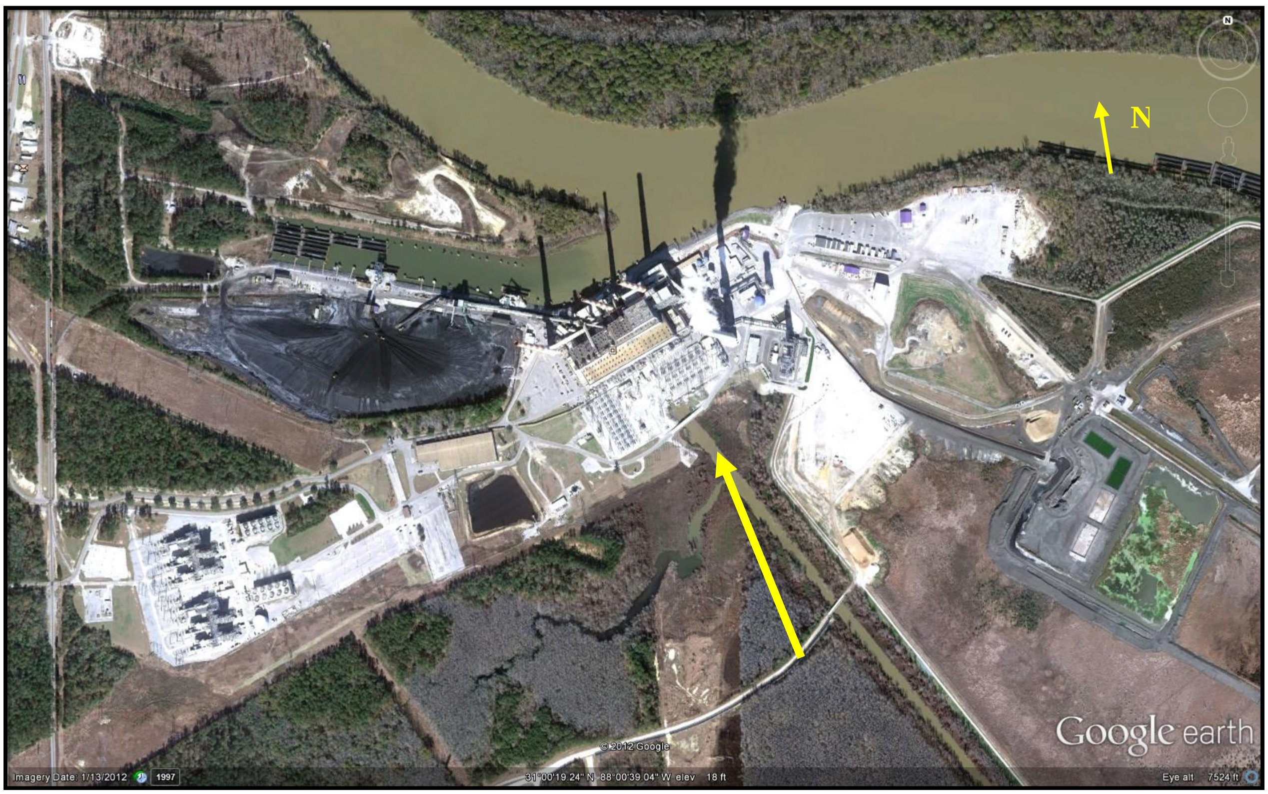


Figure 1-27 Satellite Image of Point A VNAV 1

Figure 1-28 Photo of Point A VNAV 1 from the Aircraft

104. MISSION RELATED CONSIDERATIONS FOR CHOOSING CHECKPOINTS

There are also important mission related factors that also must be considered in the selection of both turnpoints and checkpoints. These include the altitude to be flown, visibility, and mission pacing. The turnpoints for the T-6A VNAV missions have already been chosen for you with these aforementioned considerations in mind. However, since it is desirable to update our position more frequently than just at the turnpoints, SNFOs will make use of intermediate checkpoints (ICP).

Altitude is related to visibility, because it affects the visible distance to the horizon. At the altitudes flown in the T-6A, points greater than 3 NM left or right of course are difficult to identify and accurately judge position. Do not plan for ICPs more than 3 NM from the route centerline.

Mission pacing requires an appropriate amount of time (and distance) between checkpoints in order to accomplish our training objectives. Route legs were typically chosen to be greater than three minutes long to enable accurate wind analysis. For SNFOs, mission pacing influences ICP selection. Intermediate checkpoints within 2 minutes prior the turnpoint do not allow enough time for a correction (if needed) and become wasted effort. Conversely, ICPs chosen within a minute and a half following the turnpoint will not allow enough time to complete the turnpoint procedures discussed in Chapter 5.

So in T-6A VNAVs, choose one planned ICP per leg, outside of those windows, in order to focus your efforts. If the leg is short or if no prominent feature is available, then that leg does not require an intermediate checkpoint. In the future, any feature that can be positively identified along the route will be used to update your position.

105. SUMMARY

This chapter described the basic features found on aerial navigation charts. It is imperative that the aircrew becomes intimately familiar with all aspects of these charts because referencing a chart legend in flight is not only impractical but unsafe. Furthermore, as the name implies, visual navigation occurs via the use of visual checkpoints and success in the aircraft is directly impacted by their selection during preflight planning. Planned altitude, visibility, mission pacing, and terrain are some of the factors that affect the quality and selection of visual checkpoints. And finally, students should utilize all available resources to vet and study their turnpoints and/or checkpoints prior to seeing them in the aircraft.

STUDY QUESTIONS

1. An ONC is a ___________________________ projection.

2. Indicate the scale of each of the following type of charts:

   a. ONC _______________________

   b. TPC ________________________

3. Three desirable features of the Lambert Conformal projection are:

   a. ____

   b. ____

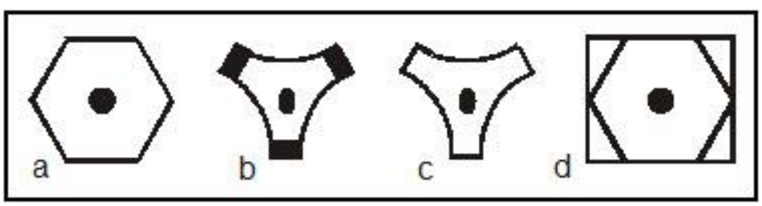
   c. ____

4. The decision whether to use a large or small scale chart is based on what two criteria?

   a. ____

   b. ____

5. Identify the following radio aids to navigation symbols.



   a. ____

   b. ____

   c. ____

   d. ____

6. The terrain elevation of the tower shown below is ____________ feet MSL. This obstruction is _____________ feet AGL.

7. Bridge symbols will be shown if bridge is at least ____________________ feet long.

8. Double line streams are at least _________________________ feet wide.

9.

a. On an ONC chart this runway is approximately _____________ feet long.

b. Airport elevation is _____________ feet MSL.

10.

a. This symbol on a chart indicates a _______ Area.

b. Before flying through this airspace you must refer to _______ to obtain additional information about this area.

CHAPTER TWO
LOW LEVEL CHART PREPARATION

200. INTRODUCTION

Now that we can properly interpret an aerial navigation chart, we need to learn how to build a format that is usable in the cockpit. This chapter will describe the general steps needed to build a proper low level chart, often referred to as a "route book" or "strip chart." In ground school, you will be taught how to use the Joint Mission Planning System (JMPS) to produce your charts via a computer. This is a great improvement over manual chart creation because it saves a tremendous amount of time. However, significant user input is still required to get the desired product from the program. Therefore, it is important to understand the fundamentals of chart preparation in order to create the desired product and double check the automated work of the computer. In the end, you are responsible for the accuracy of the products you bring to the cockpit, regardless of how you produce them.

The first chart will be produced with the assistance of the ground school instructor. If the remaining charts are not completed in the allotted class time, then the student must finish them on their own time. While this chapter provides the overview of how to build a generic low level chart, the VT-10 VNAV Planning Guide contains the detailed procedures for producing the required event products via JMPS.

201. BASIC CHART BUILDING

In the fleet, the planning process begins with the selection of a target. Once that is determined, a strike route is planned based on a variety of factors: availability of visual checkpoints, fuel, threats, terrain masking, radar horizon, etc. In training, the route and target will be provided in order to allow the student to focus on the mechanics of low level navigation. All of the figures in this chapter are based on a route to "strike" the target in Figure 2-1, a highway overpass.

Figure 2-1 Target

The next step in the process involves choosing the appropriate chart based on the route length and amount of detail necessary for the mission. In VT-10, an ONC is used as an overview chart (Figure 2-2); while TPCs are used to navigate each route leg (Figures 2-3 through 2-8).

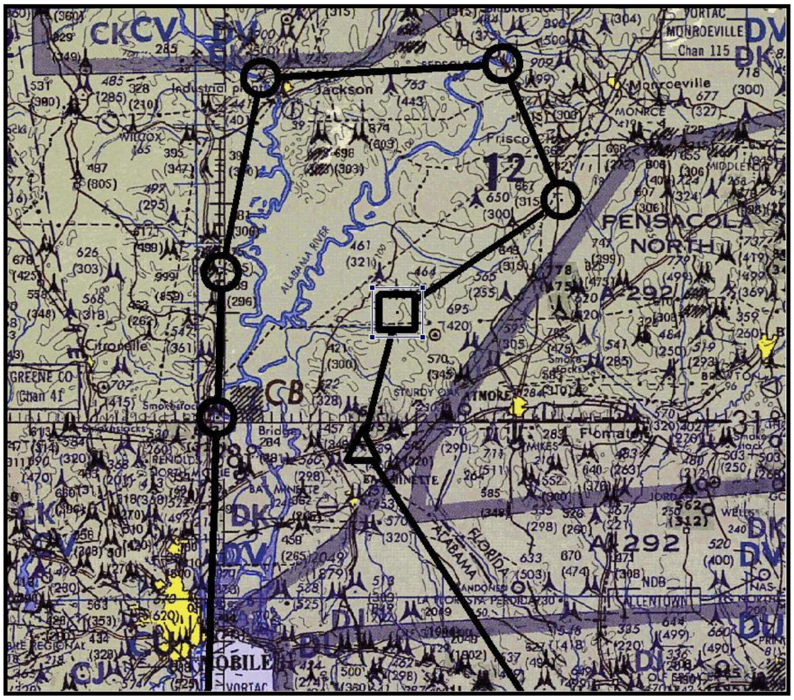


Figure 2-2 ONC Overview Chart of VNAV-1

Notice that the scale of the ONC is better suited for big picture situational awareness and area orientation, while the TPC scale provides better detail in order to navigate the route. A TPC route overview (Figure 2-3) is not normally used in the aircraft, but it does serve our instructional purposes for this chapter.

After the chart is selected, begin the process of selecting and plotting turnpoints on the chart (Figure 2-4). When simply given a Latitude/Longitude for a turnpoint (i.e., from the AP-1B for a Military Training Route [MTR]), it is important to choose a visually significant feature (within 1-2 NM) to use as the checkpoint.

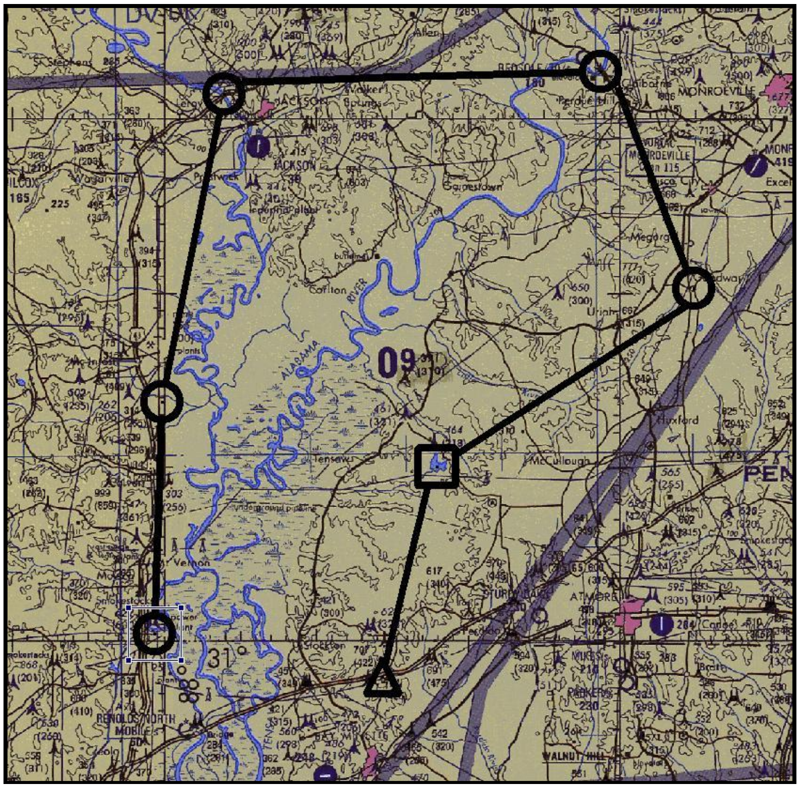


Figure 2-3 Route with Turnpoint Circles and Centerline

Next connect the turnpoints to create the course line (Figure 2-3). The target is designated using a triangle, while the point prior to it, called the initial point (IP) gets a square. Each leg then needs to be measured for distance and course. For distance, recall that 1 minute of latitude on a Lambert Conformal Projection Chart equals 1 NM. Use a plotter to measure course, but remember that Lambert Conformal Projection Charts produce true headings. To convert from a true course (TC) to a magnetic course (MC) for use in the aircraft, magnetic variation must be taken into account. Therefore:

MC = TC – East variations (+ Westerly variations)

Magnetic variation is depicted on the chart as a blue dashed line and actually changes over time. The annual rate of magnetic variation change is depicted in the chart legend. A VFR Sectional Chart often has the most up-to-date lines of variation. Note that JMPS automatically takes variation into account and will be setup to produce magnetic headings.

Next, draw time ticks along the course line at one minute intervals (Figure 2-4). Typically, every third time tick is made more distinct by drawing it a bit larger and labeling it. In the T-6A, VNAVs are flown at 180 knots groundspeed, where 1 minute equals 3 NM.

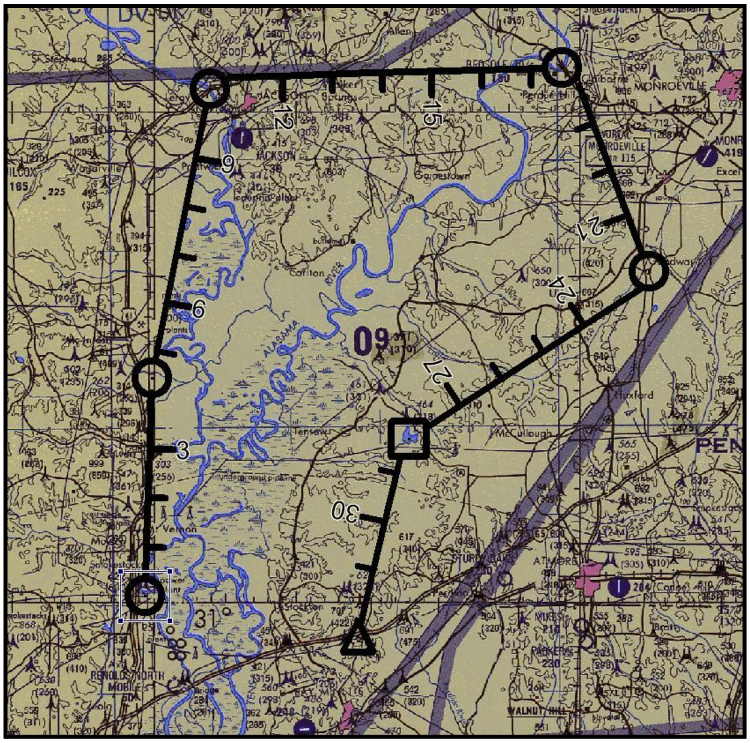


Figure 2-4 Add Time Ticks

A handy format has been developed for referencing the important information for each leg (MC, leg distance and time, fuel, etc.) called a "doghouse" (Figure 2-5). It is customizable for the needs of the aircraft or unit, but is always drawn parallel to the route leg.

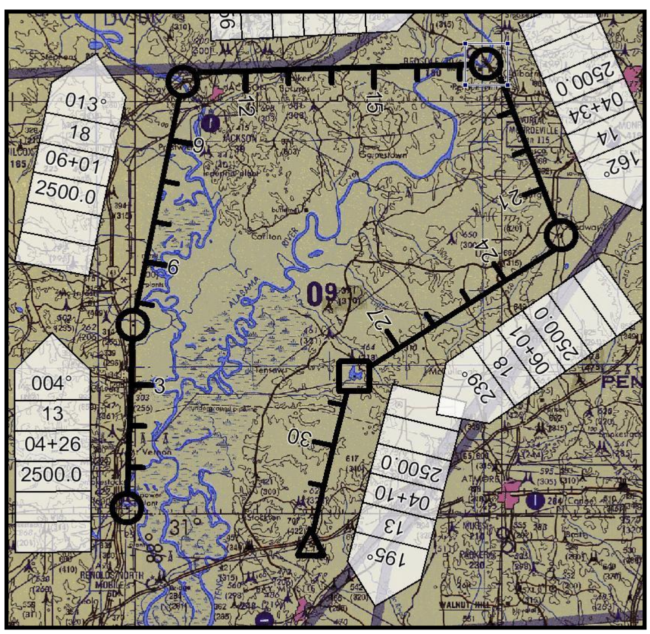


Figure 2-5 Add Doghouses

The route is then studied for hazards. Any hazards within +/- 4 NM of centerline should be annotated clearly on the chart. Since it is not practical to publish a new aerial navigation chart every time a charted feature changes or new obstacle goes up, a Chart Updating Manual (CHUM) is produced semi-annually with a supplement being produced monthly in between. Therefore, it is imperative that aircrew not only use the most recent chart edition, but also "CHUM" their low level charts monthly for any potential hazards along their route of flight. Fortunately, JMPS has an electronic CHUM (ECHUM) feature, shown as blue towers with white lettering (Figure 2-6), but it too requires monthly updates.

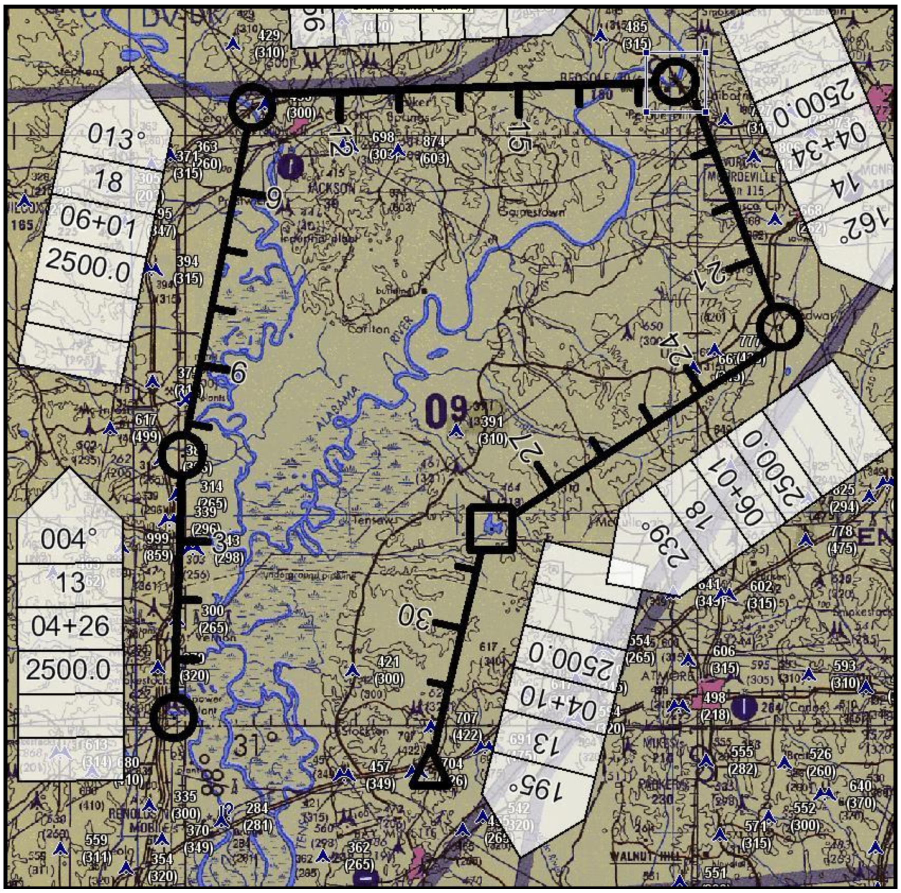


Figure 2-6 CHUM Added to the Chart

The previous steps accomplish the basic requirements needed to produce a low level chart for a visual navigation flight. However, it is often desirable to add additional information for quick reference and to improve situational awareness (SA). Some examples are: selecting emergency divert airfields, annotating conflicting low level routes, plotting controlled airspace, noting needed communications frequencies, and adding intermediate check points. Ensure that any added information does not obscure terrain feature within +/- 4 NM of route centerline.

202. USING THE LOW LEVEL CHART

The desired end-state of a low level chart is a product that not only contains all necessary information required to successfully navigate the route, but is also convenient for use in the cockpit. Therefore, it should be approximately kneeboard size and the writing in it must be clear, concise, and easy to read. At low altitude, our attention needs to be spent outside of the cockpit to the maximum extent possible. The route book, or strip chart, is designed with one leg per page (Figure 2-7), oriented with the magnetic course pointed "up." Notice that Figure 2-8 is oriented to the course line, which is a southerly direction. This is done so that the chart features match the flow of the ground features as they "appear" in the cockpit. The spine of the book is oriented horizontally so that as you pass each turnpoint, the page is flipped toward your body to reveal the next leg. As you progress through the route, the book should be flipped toward the front, or top, of the book. Typically, the outside covers of the route book contain important information such as route descriptions, CHUM dates, fuel plans, and the chart's creator. Example route books will be shown in ground school and created via the VT-10 VNAV Planning Guide.

Figure 2-7 Strip Chart for A-B Leg

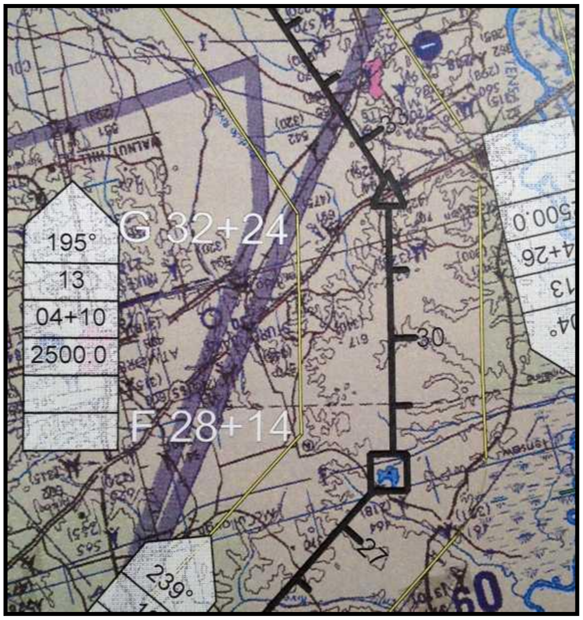


Figure 2-8 Strip Chart for Target Leg

203. SUMMARY

There is a dedicated Computer Assisted Instruction (CAI) class designed to teach the use of JMPS. In VNAV ground school, there is time allotted for chart preparation, but the student will be required to finish the charts outside of class time if they do not use their time wisely. Follow the instructions in the VT-10 VNAV Planning Guide to prepare your charts to the VT-10 standard. Without a proper chart, the event cannot be flown!

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STUDY QUESTIONS

1. What type of chart is used as an overview chart in VT-10? _________

2. What shape denotes a target on the chart? a._____ What about an initial point (IP)? b. __________

3. One degree of Longitude equals 1 NM on a Lambert Conformal Projection Chart. (T/F)

4. What type of heading is produced on a Lambert Conformal Projection Chart? ______

5. If the TC is 005 and the magnetic variation is 3 degrees west, what is the MC? _______

6. Name two methods of determining the current magnetic variation. ________

7. What is the purpose of CHUM? a. _____How often is it updated? b. _________

8. Doghouses should be aligned with route MC and located 3 NM from centerline. (T/F)

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CHAPTER THREE
FUEL PLANNING, JET LOGS, AND DD 175

300. INTRODUCTION

This section describes the profile used to fuel plan for the entire flight and the format for the jet log to represent that data. Additionally, for each flight you are required to have a DD 175 completed even though you will likely fly stereo (Pre-Filed) routes for all of your T-6A VNAV flights.

301. ROUTES

The squadron has created six routes for these low level events, referred to as VNAV 1 through 5 and VNAV Maxwell, found in the VT-10 VNAV Planning Guide. The N3001 and N3002 simulators will use the VNAV 1 and VNAV 4 routes, respectively, and the N4001 flight will use the VNAV 1. After N4001, all routes are eligible to be flown, in any order. Further, if the weather precludes flying the scheduled route, the student may be required to fly another route in an area where the weather is better. Check the remarks section of the flight schedule for your VNAV route, planned route entry time, and stereo route for the flight plan. The Operations Department plans the entry times to de-conflict aircraft using the same route. The stereo routes are defined in the TRAWING SIX In-Flight Guide (IFG) and may combine both IFR and VFR flight. If the stereo route does not specify a recovery routing following the VNAV route, develop your own recovery plan from the route target to the destination airfield's initial approach fix (IAF), but at 10,000 feet and 240 KIAS.

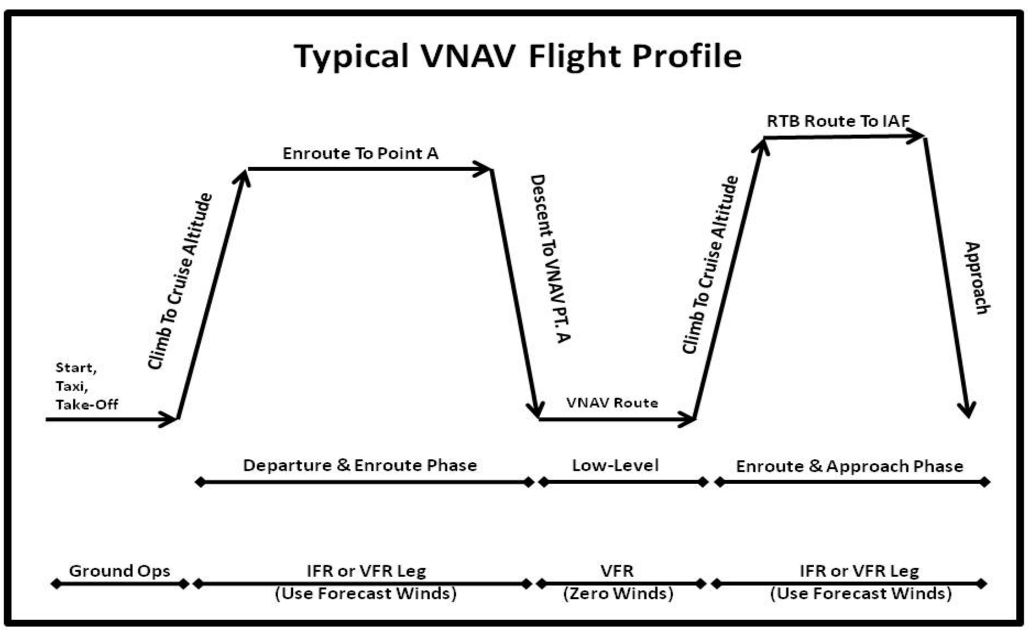

Figure 3-1 Flight Profile

302. BASIC FUEL PLANNING PROFILE

Figure 3-1 shows the basic flight profile for T-6A visual navigation flights. The profile has three basic segments:

1. Engine start to the low level route entry point.

2. The low level route.

3. Route exit to recovery at the field.

In this chapter, we'll work through a fuel planning example using a route similar to VNAV 1. The routing is KNPA – TEEZY – TRADR – VNAV 1 (A-G) then direct SIDNY. The enroute portions are flown 10,000' MSL and 240 KTAS, and the route at 2500' MSL and 180 groundspeed.

Actual fuel figures for your events can be determined from the charts found in NATOPS, Appendix A. The figures illustrated here are provided for convenience in studying the examples provided.

303. ENGINE START TO ROUTE ENTRY

Figure 3-2 shows the different phases of flight that are encountered before entering the low level route. As such, we must fuel plan for each different phase.

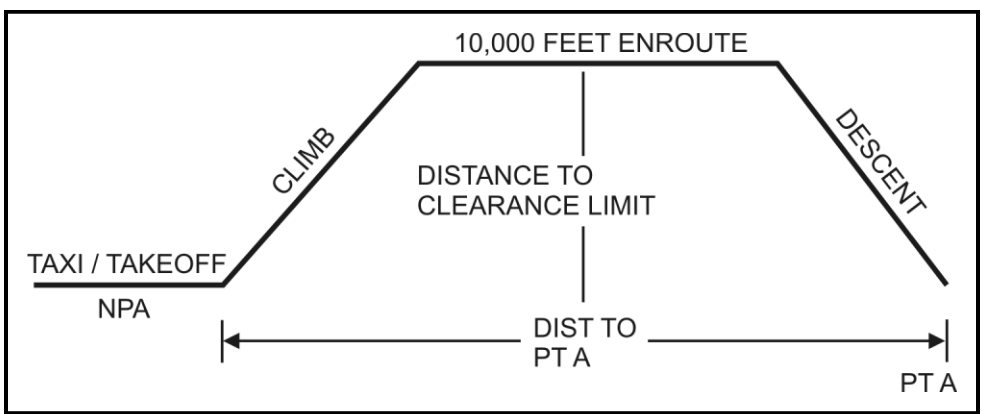

Figure 3-2 Flight Profile to Route Entry

Start/Taxi/Takeoff and Climb

Consider the initial total usable fuel to always be 1100 pounds. Plan the start, taxi, and takeoff as a 50 pound fuel requirement. The resulting fuel total is 1050 pounds.

Our example's initial filed enroute altitude is 10,000 feet prior to low level entry. Using Appendix A, Part 4 of the NATOPS, we find that a climb to 10,000 feet in a 6,500 pound aircraft covers 10 NM, takes 4 minutes and burns approximately 41 pounds, which rounds to 45 pounds. Round all fuel upward to the next 5 pound increment.

Enroute and Descent

For our example route we find the following distances:

KNPA to TEEZY	22 NM
TEEZY to TRADR	19 NM
TRADR to Pt A	42 NM
Total	83 NM

Subtracting the 10 NM used in the climb leaves us with 12 NM to TEEZY and 73 NM total. Up to this point, this should look very similar to your Instrument FTI procedures. But, since we will not enter the low level route at 10,000' MSL, we must take the descent into account.

For planning simplicity, use the assumption that the descent goes from the enroute cruising altitude to sea level. Using the Maximum Range Descent chart in Appendix A part 7 of the NATOPS, we determine that a 10,000' descent takes 7 minutes, results in 22 NM of travel, and requires 40 pounds of fuel. Knowing the climb and descent distances, the distance flown at enroute altitude is computed as follows:

  83 (Total distance from takeoff to Point A)
- 32 (10 + 22, Total distance in climb and descent)
  51 (Distance flown at enroute altitude)

Now we turn to Appendix A, Part 5 of the NATOPS to determine the cruise fuel numbers. Using the Specific Range chart with the assumptions of 10,000', Standard Day, 240 KTAS, and an average aircraft weight of 6000 lbs, we arrive at a specific range of 0.54 NM per pound of fuel. Taking that number to the Fuel Flow Conversion Chart in the same chapter produces a fuel flow of 450 pounds per hour (pph), or 7.5 pounds per minute (ppm), for the enroute cruise.

Level-off to TEEZY is 12 NM. At 240 KTAS (4.0 NM/min with no wind), it will take 3 minutes. At 7.5 ppm, this requires 22.5 pounds of fuel, which rounds to 25 pounds. Adding it up, we find the leg fuel from takeoff to TEEZY requires a total of 70 pounds (45 climb + 25 cruise).

Similarly calculated, TEEZY to TRADR is 19 NM, which rounds to 5 minutes and 40 pounds of fuel.

Since the descent from 10,000' to Point A requires 22 NM, there remains a 20 NM enroute transit from TRADR to the descent point. This 20 NM takes 5 minutes and 40 pounds of fuel for a total of 80 pounds (40 cruise + 40 descent) to get from TRADR to Point A.

NOTE

In the previous example, we assumed winds were light and variable. Remember, groundspeed (not true airspeed) is used to compute enroute times. Since winds affect enroute times and fuel, compute enroute portions of the jet log similar to the procedures from the Instrument FTI (i.e., "Wind your jet log").

304. THE LOW LEVEL ROUTE

Reference Appendix A, Part 5 of the NATOPS again to determine the low altitude fuel numbers. Since the specific range charts do not have the exact VNAV flight profile numbers, we must interpolate. Assume all VNAV route profiles are based on an airspeed of 180 KTAS, altitude of 2500' MSL, and an average temperature of 25 C (approximately 80 F). This then produces a specific range of 0.40 NM per pound of fuel. Using that number in the Fuel Flow Conversion chart results in a fuel flow of 450 pounds per hour (pph), or 7.5 pounds per minute (ppm), while on the low level route.

The VNAV route (i.e., A-G) shall be fuel planned for "no wind." Therefore, the times and fuels will not change due to forecast weather. Fuel plan the VNAV route (i.e., point A-G) using 450 pounds per hour (pph) fuel flow and round each leg fuel up to the next five pound increment (e.g., 51 pounds = 55 pounds).

In our example route, the distance from Point A to Point B is 16.3 NM. At 180 knots ground speed, it should take 5 minutes and 25 seconds (16.3 / 3 = 5.43 minutes). At 7.5 ppm, the leg fuel is 45 pounds (5.4 minutes x 7.5 ppm, rounded to the next 5 lbs.).

It is important to point out the difference between preflight and in-flight fuel planning here. While you have the time on the deck, you can use a calculator or CR-2 computer for accuracy. In flight, it is permissible to trade a little accuracy for expediency. As such, this calculation could become 6 minutes times 8 ppm for a total of 48 pounds. Even with the rounding error, the difference is a negligible 5 pounds. Get comfortable with these mental math manipulations because the CR-2 "whiz wheel" is not allowed while on the low level route.

The total fuel required for the entire VNAV route is simply the total of all the individual route legs.

305. ROUTE EXIT TO RECOVERY

Here we need to fuel plan for an IFR return leg, whether we expect to be IFR or not. If provided, follow the stereo routing to the destination IAF. If the stereo route directs VFR to the destination, then develop your own routing from the target to the destination IAF, and fuel plan it for 10,000' MSL, 240 KTAS, and 450 pph fuel flow. Note that if your routing takes you through any Special Use Airspace, then you need to know the associated procedures and frequencies in order to properly transit it (e.g., Area 1 or Area F).

Continuing with our example plan, let's say a straight line from our target to the IAF for NPA is an acceptable route and the distance is 52 NM.

For the climb computations post route, assume the climb begins at sea level and goes to the flight planned altitude. Appendix A, Part 4 of NATOPS shows us that a climb to 10,000' MSL, in a now 6000 pound aircraft, requires 3 minutes, 8 NM, and 35 pounds of fuel.

The remaining 44 NM takes 11 minutes at 240 KTAS. At a 450 pph cruise fuel flow, this requires 82.5 pounds of fuel, which rounds up to 85. The total fuel from route exit to the IAF is 35 + 85 = 120 pounds. Remember to account for winds during all enroute portions of your preflight planning. It is not necessary to take the descent into account here because it is factored into the approach fuel.

306. ESTIMATED FUEL REMAINING (EFR)

EFR is the amount of fuel expected at each point, if the mission is flown exactly as planned. In the previous sections you computed the fuel for each leg of the flight profile. Now, subtract the leg fuels from the initial starting fuel to get usable numbers for the aircraft (Figure 3-3).

Point	Leg Fuel	EFR
Initial Fuel		1100
STTO	50	1050
TEEZY	70	980
TRADR	40	940
A	80	860
B	45	815
C	70	745
D	40	705
E	35	670
F	55	615
G	35	580
SIDNY	120	460

Figure 3-3 Example EFRs

You are almost ready to make the jet log, but you must determine one last item.

307. MISSION COMPLETION FUELS (MCF)

Unfortunately, the mission does not always go as planned during preflight! Maintenance delays, stronger headwinds, and ATC routing delays are a few examples that could cause you to use more fuel than planned. When this occurs, the aviator needs to know if they can continue the mission as planned or if a change to the conduct is required. This is where a concept such as MCF is useful.

In accordance with CTW-6 guidance, MCF is the fuel required to complete planned mission conduct and return to planned destination via standard routing (including approaches for training or weather) to arrive with:

1. VMC: SOP minimum fuel on deck (200 pounds) or fuel to proceed to alternate and arrive above SOP emergency fuel (120 pounds), whichever is higher.

2. IMC: Divert Fuel.

In essence, MCF is the minimum acceptable fuel at a point that allows the crew to complete the event as planned and land with the SOP fuel requirements. It requires the crew to determine their minimum recovery fuel, and then work backwards through the flight conduct to determine the minimum fuel needed at each point. As you can see, the definition includes a number of variables that must be determined: what constitutes planned conduct, what is standard routing, is the recovery field forecast to be VMC or IMC, and what is my divert fuel?

Calculating MCF first requires determining the minimum landing fuel and is dependent on whether the destination and alternate airfields are forecast to be VMC or IMC. The airfield weather is considered VMC if it allows for a VFR recovery and the aircraft can maintain minimum visibility and cloud clearance requirements (3 statute miles visibility, 2000 ft horizontally from clouds, 1000 ft above, and 500 ft below). If the field is not VMC, then it is IMC. Divert fuel is defined as the fuel required to fly direct to the planned alternate and fly an approach (if required, based on weather) to land above SOP emergency fuel on deck. Notice that this is the same definition as the second half of the VMC recovery requirement. Therefore the minimum landing fuel is either 200 pounds or divert fuel.

The divert profile is defined as a climb from the destination airfield to 10,000’ MSL and then a 240 KTAS enroute cruise transit direct to the alternate airfield. Again, Appendix A of NATOPS shows us that a climb to 10,000’ MSL in a 6000 pound (half fuel) aircraft requires 3 minutes, 8 NM of travel, and 35 pounds of fuel and cruise fuel flow at 10,000’ MSL is 450 pph. To then calculate divert fuel, add the fuel to fly the divert profile, a 125 pound fuel reserve, and if the alternate is IMC, 50 pounds for an approach.

Divert Fuel = divert profile fuel + 125 pound reserve + 50 pound approach (if IMC)

Example: Destination airfield is KNPA and the alternate airfield, KBFM, is 43 nautical miles away. KNPA is VMC and KBFM is IMC. Calculate divert fuel.

If the climb requires 8 NM, then 35 NM remain for the cruise. At 240 kts ground speed (assuming no-wind), the transit requires 9 minutes and 70 pounds of fuel (35 / 4 and 9 x 7.5). The divert profile then requires 105 (35 + 70) pounds. Added to the 125 pound fuel reserve and 50 pounds for an approach because KBFM is IMC, the divert fuel is 280 (105 + 125 + 50) pounds. Since KNPA is VMC and the divert fuel is higher than 200 pounds, minimum recovery fuel is 280 pounds.

Now that the minimum fuel for recovery has been addressed, standard routing and planned mission conduct need to be discussed. For VT-10 purposes, standard routing means that you will flight plan to the destination IAF and avoid Military Operating Areas (MOAs) and restricted airspace. Planned mission conduct includes the main mission objective (e.g., low level route) and any additional objectives that need to be accomplished for that event (e.g., practice approaches, aerobatics, EP training). Due to the extra requirements for VNAV events, SNFOs shall contact their Instructor prior to the flight events to discuss the flight conduct and the plan to accomplish additional training objectives. For planning purposes, instrument approaches require 50 pounds, 10 minutes of aerobatics requires 100 pounds and assume a constant 50 pounds of fuel to get from destination IAF to landing if not recovering via an approach.

Knowing all of this, one can finally compute MCFs for each point along the route.

Example: Using the leg fuels from Figure 3-3, a VMC destination of KNPA, and a VMC alternate of KJKA, compute the MCF at Point F, Point A, and TRADR. Also assume that the Instructor wants to accomplish two instrument approaches in the Pensacola terminal area.

Divert fuel to Jack Edwards is 185 pounds (35 climb + 25 cruise + 125 reserve). Since this is less than 200 pounds, the min recovery fuel is 200 pounds. To get from the destination IAF, SIDNY, to landing requires 50 pounds. Because this accounts for one of the two instrument approaches, another 50 pounds of fuel must be added onto the desired fuel at the IAF. Therefore, the minimum fuel, or MCF, at the IAF is 300 pounds (200 + 50 + 50). Working backwards through the fuel plan shows that the MCF at Point F is 455 pounds (300 + 120 + 35). MCF at Point A will be 700 pounds and 780 Pounds at TRADR.

Notice the difference between the MCF and EFR is a constant 160 pounds in this example. Once the MCF at the IAF has been determined, you can subtract it from the planned EFR at the IAF to get your spare fuel for the mission. That difference can then be subtracted from each EFR in the fuel plan to get the MCF. You now have a definite way of knowing whether there is enough fuel to complete the mission or not at each point. If training objectives, such as aero, are going to be accomplished prior to the destination IAF, be sure to account for them in the fuel plan similar to drop-in approaches in INAV.

Example: How would the numbers change for the previous example if both KNPA and KJKA were IMC?

Divert fuel would require fuel for an instrument approach, bringing it to 235 pounds. The MCF at the IAF becomes 335 pounds to allow for the two training approaches. Therefore, spare fuel is 125 pounds and the MCF at Point F, A, and TRADR are 490, 735, and 815, respectively.

308. T-6A VNAV JET LOG

With this information, we are now ready to complete the jet log. The jet log is similar to the one from the Instrument FTI, but we need to add information to make it a more usable product for VNAVs. The basic format will be produced through JMPS while following the instructions in the VT-10 VNAV Planning Guide. JMPS will auto-populate much of the data (Figure 3-4), but you will be required to manually enter aircraft call sign, name, VNAV route, stereo flight plan route, pre-flight winds used, leg fuels, EFRs, MCFs, BINGO, and divert fuels, and your intermediate checkpoints with the route time and deviation from centerline (Figure 3-5).

T-6A VNAV Form 1.1	KATT	Flight Plan Date:	12/12/2012

	TOT DIST	TOT ETE	TOT FUEL
	247	01+22+29	641
	SNFO: V ROUTE: FP ROUTE: WINDS: *Planned for 450FF at 180GS		

TP DESCRIPTION IM CHECKPOINT DEVIATION		MC	ALT MSL ELEV	DIST TDIST	LEG ETE ETA	ATA	LEG FUEL EFR	AFR MCF
KNPA/A			28M					
			28 FT	0	23:32:13			
TEEZY/W		245	10000M	22	00+07+19			
			0 FT	22	23:39:32			
TRADR/W		295	10000M	19	00+06+20			
			0 FT	41	23:45:52			
.A		004	2500M	42	00+14+08			
			13 FT	83	00:00:00			
.B		004	2500M	13	00+04+26			
			20 FT	97	00:04:26			
.C		013	2500M	18	00+06+01			
			82 FT	115	00:10:27			
.D		090	2500M	22	00+07+12			
			30 FT	136	00:17:38			
.E		162	2500M	14	00+04+34			
			381 FT	150	00:22:13			
.F		239	2500M	18	00+06+01			
			184 FT	168	00:28:14			
.G		195	2500M	13	00+04+10			
			279 FT	181	00:32:24			
SIDNY/W		163	10000M	52	00+17+15			
			0 FT	232	00:49:40			
KNPA/A		022	28M	15	00+05+03			
			28 FT	247	00:54:42			

ALT / IAF								DIV FUEL
BINGO PROFILE								BINGO FL

Figure 3-4 Initial JMPS Jet Log

BINGO fuel is defined as the fuel required to fly from the farthest point of a working area or route point to your planned destination via standard routing to arrive with:

1. VMC: SOP minimum fuel on deck or fuel to proceed to alternate and arrive above SOP emergency fuel, whichever is higher.

2. IMC: Divert Fuel.

Plan this to the destination IAF at 10,000’ MSL, 240 KTAS, and 450 pph.

Example: Find the BINGO from VNAV 1 Point C, if the destination, KNPA, and alternate, KBFM are both IMC. Assume VNAV 1 Point C direct to SIDNY is a 90 NM transit and divert fuel to KBFM is 280 pounds.

After the climb to 10,000’, 82 NM remain, which takes 21 minutes and 160 pounds to fly. Therefore, it takes 24 minutes, 90 NM, and 195 pounds of fuel to get to SIDNY. With a divert fuel of 280 pounds and 50 pounds for the approach from SIDNY, the aircraft needs to arrive at the IAF with 330 pounds. The BINGO from Point C is then 525 pounds (330+195).

Enter the divert and BINGO fuels and profiles in the last two rows of the jet log as shown in Figure 3-5.

T-6A VNAV Form 1.1	KATT 690	Flight Plan Date:	12/12/2012
	TOT DIST	TOT ETE	TOT FUEL
	247	01+22+29	641

SNFO: 2ndLt Amos
V ROUTE: VNAV 0
FP ROUTE: NPA 632
WINDS: 260/10
*Planned for 450FF at 180GS

TP DESCRIPTION ICP DESC. DIST TIME		MC	ALT MSL ELEV	DIST TDIST	LEG ETE ETA	ATA	LEG FUEL EFR	AFR MCF
KNPA/A			28M					
			28 FT	0	23:32:13		1050	890
TEEZY/W		245	10000M	22	00+07+19		70	
			0 FT	22	23:39:32		980	820
TRADR/W		295	10000M	19	00+06+20		40	
			0 FT	41	23:45:52		940	780
.A		004	2500M	42	00+14+08		80	
Rd/Pipe X 0.5L 2+15			13 FT	83	00:00:00		860	700
.B		004	2500M	13	00+04+26		45	
River Bend 1.0R 7+20			20 FT	97	00:04:26		815	655
.C		013	2500M	18	00+06+01		70	
Road X 0.5L 12+45			82 FT	115	00:10:27		745	585
.D		090	2500M	22	00+07+12		40	
Road X 2.0R 20+20			30 FT	136	00:17:38		705	545
.E		162	2500M	14	00+04+34		35	
Rd/River X 1.5R 26+00			381 FT	150	00:22:13		670	510
.F		239	2500M	18	00+06+01		55	
N/A			184 FT	168	00:28:14		615	455
.G		195	2500M	13	00+04+10		35	
			279 FT	181	00:32:24		580	420
SIDNY/W		163	10000M	52	00+17+15		120	
			0 FT	232	00:49:40		460	300
KNPA/A		022	28M	15	00+05+03		50	
			28 FT	247	00:54:42		410	

KBFM		302	10K	51	12+45		105	280 DIV FUEL
Pt C D> SIDNY BINGO								525 BINGO FL

Figure 3-5 Completed JMPS VNAV Jet Log

NOTE

Placing the intermediate checkpoints on the jet log allows the Instructor to know your checkpoints for that day's event and is unique to VT-10. A copy SHALL be presented to the instructor at the brief.

Again, while JMPS is great at automating tasks, it is very easy to end up with a wrong input or calculation. You must "sanity check" the information. As with any computer system, you, as the operator, are ultimately responsible for the data and its accuracy.

NOTE

Until a T-6 fuel planning module is developed for JMPS, there is no way to guarantee the accuracy of the fuel numbers it generates without calculating the numbers by hand. SNFOs shall complete manual fuel calculations to enter into the jet log.

309. DD 175

Students shall prepare a DD 175 that matches the assigned stereo route from the flight schedule. Figure 3-6 is an example of a composite flight plan. Notice how this flight plan separates IFR and VFR flight routing. Since T-6A VNAV routes are local routes that are flown VFR (not under a route structure as in future Military Training Routes), the VFR portion should list the fix, radial, and DME for each point IAW FLIP General Planning guidelines. Information defining each point is listed in your VT-10 VNAV Planning Guide. Fuel on board will be listed as 2+30 due to the increased fuel flows during low altitude events.

PRIVACY ACT STATEMENT

AUTHORITY: 10 USC 8012 and EO 9397.
PRINCIPAL PURPOSE: To aid in accurate identification of personnel participating in the filed flight.
ROUTINE USES: To provide data required to process flight plans with appropriate air traffic service authorities. A file is retained by the agency processing the flight plan.
DISCLOSURE: Voluntary; however, failure to provide the SSN could result in denial of flight plan processing.

DATE	AIRCRAFT CALL SIGN	AIRCRAFT DESG AND TD CODE
Today's	KATT 603	TEX2/G

BASE OPERATIONS USE

	TYPE FLT PLAN	TRUE AIRSPEED	POINT OF DEPARTURE	PROPOSED DEPARTURE TIME (Z)	ALTITUDE	ROUTE OF FLIGHT	TO	ETE
	I	240	NPA	1300	100	TEEZY TRADR		0 + 10
	V	180	TRADR	1310	025	SJI040025 GVC062027 MVC298021 MVC345012 MVC229004		
						MVC221025 BFM032026	NPA	1 + 05

REMARKS

RANK AND HONOR CODE

FUEL ON BD	ALTN AIRFIELD	ETE TO ALTN	NOTAMS	WEATHER	WT AND BALANCE	AIRCRAFT SERIAL NUMBER, UNIT, AND HOME STATION
2 + 30	MOB	0+15	X	CR-1234	NPA/DDMMMYY	ON FILE / CTW-6 / NPA

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

DUTY	NAME AND INITIALS	RANK	SSN	ORGANIZATION AND LOCATION
PILOT IN COMMAND	PILOT, I.R.	CAPT	ON FILE	CTW-6 / NPA
SNFO	LEARNING, I.M.	ENS	ON FILE	VT-10 / NPA

DD Form 175, MAY 86 *Previous editions are obsolete.* MILITARY FLIGHT PLAN
Adobe Professional 7.0

Figure 3-6 Composite Flight Plan, DD 175

310. OTHER MISSION PLANNING CONSIDERATIONS

After computing the jet log with best known winds, preparing the DD 175, and making the final chart annotations, there are still a few items left to complete before walking to the aircraft.

As with every flight, be sure to check NOTAMS, Temporary Flight Restrictions (TFRs), and BASH. At the time of this publication, www.usahas.com lists the BASH condition for the VNAV routes by selecting “other units” and then VT-10. Also, ensure you brief and follow the most current version of TRAWINGSIX Low Altitude Training Rules found in the IFG. Weather requirements now include the conditions permitting low level flight, such as 3000’ ceilings and 5 miles visibility. Lastly, ensure you review your Wing and Squadron SOPs for items applicable to VNAV or low altitude flight. You are expected to know your Commander’s guidance!

311. SUMMARY

This chapter covered the requirements for the jet log and DD 175. The processes for figuring fuel computations from NATOPS were included in the event your flight profile does not fit the fuel planning assumptions (Figure 3-7) covered in this chapter. Even though many of the VNAV events will be flown with weather better than 3000/5 around the destination, we are always required to flight plan for enough fuel to proceed to an alternate. Planning for the IMC divert scenario ensures that we always will. Use MCFs to ensure you arrive above SOP requirements.

VNAV Fuel Planning Assumptions

Start to Route Entry:
Initial Fuel = 1100 lbs STTO = 50 lbs
Climb: takeoff to 10K’ = 10nm, 4 min, 45 lbs
Descent: 10K’ to sea level = 22nm, 7 min, 40 lbs at 180 kts

Enroute cruise fuel flow for 10K’ and 240 KTAS = 450 pph

VNAV route:
Fuel flow = 450 pph or 7.5 ppm.
Flown 180 knots GS, but planned for no wind.

Route Exit to Recovery:
Climb: target to 10K’ = 8 nm, 3 mins, 35lbs
Plan to destination IAF, no descent
Approaches, VFR recovery from IAF = 50 lbs
10 minutes of Aero = 100 lbs

Figure 3-7 Fuel Planning Assumptions

The low altitude training flights will be some of the most dynamic and enjoyable of your syllabus, but they require great attention to detail due to the increased risks. Proper planning will help mitigate some of these extra risks and can save precious seconds in the event of an emergency. The end goal of the pre-flight planning is that your route chart and jet log should provide all information necessary to fly the route. But know that your primary focus should be outside of the cockpit, so intimate familiarity with your VNAV chart and other planning documents are essential to a successful flight.

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STUDY QUESTIONS

1. Which of the following must be computed in order to obtain MCF for each low level point?

   a. AFR

   b. BINGO fuel

   c. EFR

   d. MCF at the low level exit point

2. The low level route is fuel planned without regard to winds. (T/F)

3. What is the divert fuel if it requires 80 pounds of fuel to get from the destination IAF to the alternate and weather is VMC? ___________

4. How much spare fuel does the crew have if the EFR at the IAF is 450 pounds, the weather is VMC and the instructor was to perform 2 approaches at the destination? ________________

5. If the EFR at Point A is 750 pounds, the EFR at the IAF is 380 pounds, and the MCF at the IAF is 300 pounds, what is the MCF at Point A? ___________________

6. You are only required to prepare a DD 175 when you expect to encounter IMC. (T/F)

7. What visibility is required for T-6A VNAV operations? _________________________

8. What is the definition of Mission Completion Fuel? ____________________________

9. What is the definition of BINGO fuel? _______________________________

10. Will your fuel plan (jet log) always match you the DD 175 for these events? Why or why not? ______________________________

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CHAPTER FOUR
CORRECTIONS FOR DEVIATIONS AND WIND COMPUTATIONS

400. INTRODUCTION

This chapter introduces the procedures and calculations associated with corrections and winds. The analysis that depends on these calculations is explained in the next chapter. For a general understanding of how this chapter fits into the bigger picture, it is recommended that the SNFO briefly skim Chapter 6 before returning to Chapters 4 and 5.

In the low level environment, we compare a chart to the features on the ground in order to navigate along a pre-determined route and arrive at the target at a specific time. In T-6 VNAVs, the goal is to stay on centerline and on time for the entire route, thus getting us to the target on time. Invariably, we will deviate from the perfect solution and must know how to correct and compensate. Dead Reckoning (DR) navigation is used with visual checkpoint updates and basic math to get us back on the correct course and timeline. In order to maintain the planned course and time, we need methods to determine the winds and then compensate appropriately for their effects. In general, it is important to first determine our position relative to course and time (Fix), then analyze our deviations and their causes (Assess), then input proper corrections to get back on course and time (Correct), and finally put in compensations for wind (Compensate). As you will soon discover, the pace of the flight is too fast to spend excess time “heads down” in the cockpit crunching numbers. The student must commit these basic corrections to memory and be practiced enough to perform this basic math mentally. After all, this is training for a low-altitude environment where the first priority is always to avoid terrain. You have to see it to avoid it!

NOTE

> There are three basic terms that the SNFO must understand before moving forward: ***base, compensated,*** and ***corrected***. First, the ***base*** heading is the charted magnetic course for the leg. ***Base*** airspeed is an indicated airspeed that must be adjusted for temperature in order to get the proper true airspeed. It does not account for winds. Second, a base heading or airspeed that has been adjusted for the effects of the wind in order to maintain the desired ground track or groundspeed is a ***compensated*** one. Third, a ***corrected*** heading or airspeed is a temporary change to the wind compensated value that expires when the correction times out.

401. COURSE CORRECTIONS

Standard corrections, Bearing Distance Horizontal Indicator (BDHI) corrections, and jungle rules are the three approved methods for correcting a course deviation. The deviation is determined by visually fixing your position relative to a known feature on the chart.

Standard Corrections

At 180 knots ground speed, a 10° heading change held for 1 minute corrects for approximately 0.5 NM of lateral deviation. A 20° heading change held for 1 minute corrects for approximately 1.0 NM of lateral deviation and a 30° heading change held for 1 minute corrects for approximately 1.5 NM of lateral deviation.

If the aircraft position was fixed 3 NM left of course, then the SNFO has the option to turn the aircraft right 10° for 6 minutes, 20° for 3 minutes, or 30° for 2 minutes (Figure 4-1). Attempt to use the smallest correction available that will return the aircraft to course prior the turnpoint. Corrections larger than 30° are not used because of their adverse effect on route timing. Corrections are always implemented in increments of 1 minute.

Round all course deviations to the nearest 1/2 NM. While not exact, the corrections are accurate enough approximations to place the aircraft within 1/4 NM of course, thus allowing one to see the next visual reference point.

STANDARD CORRECTIONS FOR 180 KNOTS GROUND SPEED			
DISTANCE OFF COURSE	CORRECTION		TIME (min)
1/2 mile	10°	for	1+00
1 mile	10°	for	2+00
1 mile	20°	for	1+00
1 1/2 mile	10°	for	3+00
1 1/2 mile	30°	for	1+00
2 miles	10°	for	4+00
2 miles	20°	for	2+00
3 miles	10°	for	6+00
3 miles	20°	for	3+00
3 miles	30°	for	2+00

Figure 4-1 Standard Course Corrections

Example

After turning at a turnpoint, or passing an ICP, you determine the aircraft is 1 1/2 NM right of track. Your choices for course correction, from Figure 4-1, are to call for a 10° heading change for 3 minutes or a 30° heading change for 1 minute. You are not permitted to use 20° for 1+30 to correct for 1 1/2 NM. The communication to the pilot for this correction (current heading 190°) would be "*We are 1 ½ NM right of course. Clear left, left one eight zero. Time in one one plus four five, time out one four plus four five.*"

While the amount of time is always in multiples of 1 minute, if a subsequent checkpoint/visual reference shows the aircraft back on track prior to the correction being completed, terminate the correction. Likewise, if during the correction it is determined (from a subsequent checkpoint/visual reference point) that the correction needs to be continued, leave the correction in and calculate a new time for the correction to come out.

BDHI corrections

The BDHI was an instrument used in tactical aircraft prior to the development of an Electronic Horizontal Situation Indicator (EHSI). Through tradition, the name remains today and refers to a visual course intercept maneuver.

BDHI corrections follow this basic format:

1. Call for a 30^o turn from compensated heading toward the checkpoint.

2. Call "steady up" once the checkpoint drifts to the opposite side of the 12 o'clock position.

3. Call for a turn back to compensated heading when it is estimated that aircraft will roll out of the turn with the point at approximately the 12 o'clock position.

To perform a BDHI correction, the following conditions must exist:

1. A standard course correction is not practical prior to passing the point

2. The point must be in sight and within 30^o of compensated heading (11 to 1 o'clock).

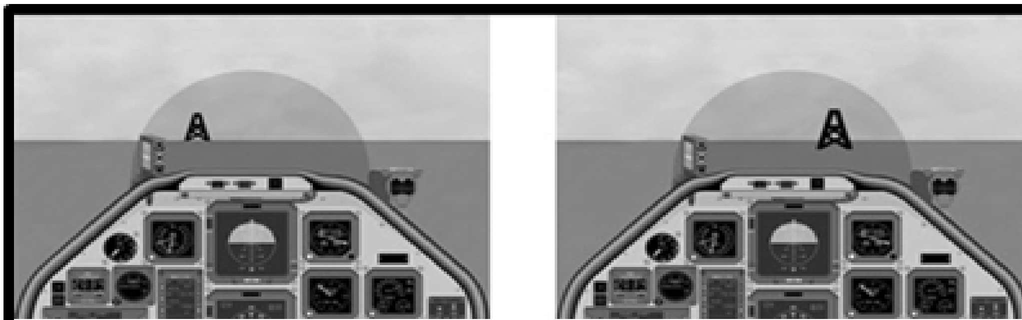
3. For intermediate checkpoints, the point must be closer to course than the aircraft.

4. The intermediate checkpoint shall not be on the opposite side of course from the aircraft (correcting to a known point on the other side of course will only put you off course again, just on the other side).

Example

The next turnpoint (a lock and dam) is visible 2 minutes prior to the turn. Unfortunately, instead of being at the 12 o'clock position, it is about 10º right of the aircraft track. It is obvious the aircraft is off course, but by exactly how much is unknown.

This is the situation where BDHI corrections are most helpful. The goal of this maneuver is to intercept the flight planned course inbound to the checkpoint on the correct heading. It is NOT a homing maneuver! It is similar to intercepting and maintaining a radial to a NAVAID, only the NAVAID is a visual checkpoint and the radial is our flight planned magnetic course.



Checkpoint in sight, within 30° of aircraft heading (180°). Unknown distance off course.

Checkpoint approx. 10° right of nose. Aircraft now heading 160° and proceeding back towards course. Tower will "drift" to the right.

Figure 4-2 Initiating a BDHI Correction

Example

The checkpoint (a tower) is visible on the horizon, but is 5º to 10º left of the nose (Figure 4-2).

The first step is to call for a 30° turn to the left. It is not always necessary to allow the aircraft to turn the full 30°, but the initial call is always for the full 30°. Have the pilot "steady up" after the tower has "moved" to the opposite side of the nose (Figure 4-2). The call for this turn with the aircraft heading 180° would sound as follows: "*Checkpoint in sight, clear left, left one five zero for BDHI*" as the point passes the opposite side of the 12 o'clock position call "*Steady up*."

The pilot stops the turn on the "steady up" call after 20° of turn. The aircraft is now heading 160° towards the flight planned course. As the aircraft gets closer to the tower (and planned course) the tower's position will drift to the right. Call for a turn back to the wind compensated heading when you think the aircraft will roll out of the turn with the tower on the nose (ignoring any significant crab). Lead the turn as you would a radial, and clear the turn for hazards. This should bring the aircraft back to the desired course with a proper crab heading to prevent future drift. Figure 4-3 shows the BDHI maneuver correctly completed with the aircraft back on course prior to the checkpoint.

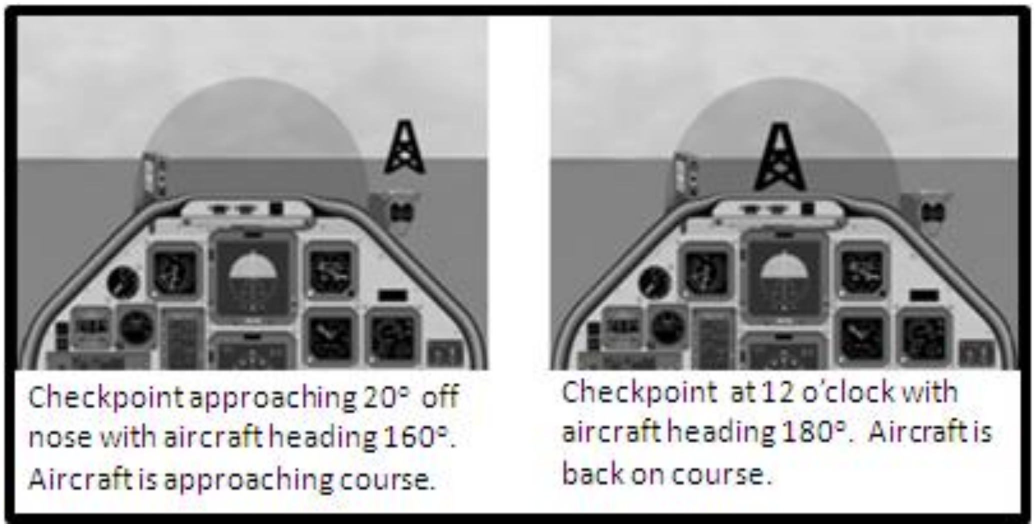


Figure 4-3 Completing a BDHI Correction

Example

In Figure 4-4, the checkpoint (a silo) is visible on the horizon; as in the previous example, a turn is initiated to the left, heading 150°. However, in this example, the silo never crosses the 12 o'clock position.

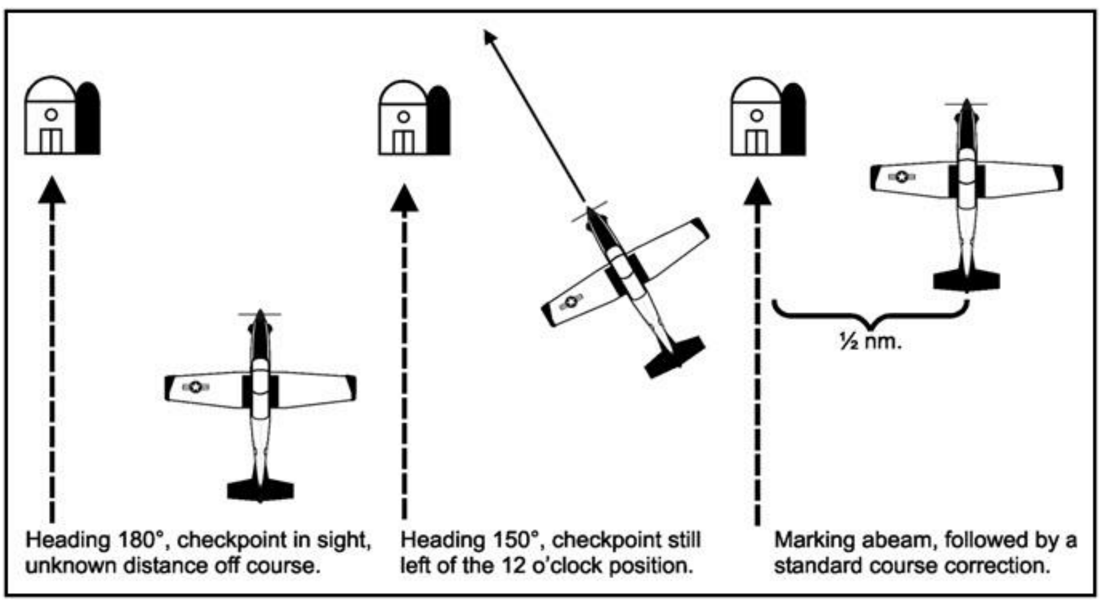


Figure 4-4 BDHI Corrections

The BDHI maneuver is not going to work in this situation because the silo was not within 30° of the compensated heading. The best course of action is to return to compensated heading, mark abeam of the checkpoint (noting the distance abeam), and perform a standard correction.

Jungle Rules

These corrections are used only on the target leg and as a last ditch effort to get the aircraft to the target. Unlike other legs, with the target in sight, the SNFO may "home" directly to the target. Directing this maneuver would sound as follows; *"Target in sight at 2 o'clock, clear right, hard right."* As the target approaches twelve o'clock call *"Steady up, target at 12 o'clock."* Headings are preferred, but not required.

If the SNFO has the ability to perform a standard course correction, they shall use it instead of jungle rules.

402. TIMING CORRECTIONS

There are two approved methods, standard corrections and jungle rules. Timing deviations are determined by comparing your actual time of arrival at a fix to the preflight or chart time of arrival at that fix.

Standard Corrections

In general, a 10% change in aircraft speed held for 1 minute will correct for 6 seconds (10% of a minute). In T-6A VNAVs, a 10 or 20 percent change equates to 18 or 36 knots respectively, so for ease we use a 20 or 40 knot speed change to correct for timing deviations.

To determine the length of time the 10% speed correction must remain in, divide the timing deviation by six. The whole number equals the number of minutes of correction and ten times the remainder yields the number of seconds. For example, a 19 second deviation requires a 3 minute and 10 second correction.

$$\frac{\text{Seconds off preflight time}}{6} = \text{Minutes needed of 10\% speed correction}$$

For T-6A VNAVs, only airspeed changes of 20 or 40 knots are permitted. The 40 knot correction is only allowed on the target leg or when the timing deviation is greater than one minute. The minimum airspeed on a VNAV route shall be 140 KIAS for safety reasons.

If using a 20% correction, apply it for half of the length of the 10% answer. Since you are correcting at twice the rate, it only needs to stay in half as long. In general, any time a correction is initiated it will be applied for an increment of either 10 seconds (at 20 knots) or 5 seconds (at 40 knots).

When applying timing corrections, it is very easy to get confused and apply the correction in the wrong direction. Talk through the calculations and learn to pair the words "late" with speeding up and "early" with slowing down. If you are early, you certainly don't want to speed up!

NOTE

> The time it takes for the aircraft to accelerate to the correction airspeed and the time to decelerate afterwards cancel each other. Timing starts when the pilot first advances/retards the PCL and ends when the PCL is moved back.

Example

To correct for 14 seconds late, increase speed 20 knots for 2 minutes and 20 seconds (140 seconds). For a base airspeed of 175, the SNFO student would instruct, *"Set airspeed one ninety-five for two minutes twenty seconds. Time in one zero plus one zero. Time out one two plus three zero."*

Another way to state this correction to the pilot would be *"Set airspeed one ninety-five. Time in one zero plus one zero. Correction is for two minutes twenty seconds. Time out is one two plus three zero."* This way you can get the correction started while you then calculate the correction and do the addition to come up with the time out.

Example

The time across a railroad bridge is 9+55, but the chart time is 10+10. The wind compensated speed is 175. What is the proper correction?

Time Analysis: "The aircraft is 15 seconds early. Set airspeed one hundred fifty-five for two minutes and thirty seconds. Time in eleven plus zero zero. Time out thirteen plus three zero."

Jungle Rules

On the target leg, directing airspeeds greater or less than standard timing corrections are acceptable to reach the target on time, however remember that the minimum airspeed on a VNAV route is 140 KIAS. This might sound as follows: *"Target in sight, 12 o'clock, we are at our TOT, PCL Max."* On the target leg, you may also use standard time corrections if less than 12 seconds off, and again, use a standard correction if able to do so.

403. WINDS

Winds can have a significant effect on the aircraft's track over the ground, even at low altitude. In your instrument training, you used the aircraft's ground speed and crab angle to determine the crosswind and headwind (or tailwind) components, which then allowed you to calculate the total winds. In VNAVs, we will similarly calculate the two wind components, but we will use timing and course deviations to respectively determine the headwind (or tailwind) and crosswind components. Note that this requires the aircraft to accurately fly the desired airspeeds and headings in order to attribute the deviations to the effects of wind.
There will be times in VNAVs where we need to break the total wind vector into the two components and other times when we need to convert the two components into the total wind

vector. The ability to go between these two representations of winds is critical for proper wind analysis in VNAVs. Typically, wind analysis is the area in which students struggle the most.

Crosswind Computation

The crosswind is the component of the wind that "pushes" the aircraft off course. It is nothing more than the velocity of the aircraft perpendicular to its ground track. The basic crosswind formula is independent of aircraft speed. Note both "distance off course" and "approximate time flown" are in respect to the last fix.

$$\frac{\text{Distance off course (NM)}}{\text{Approx. time flown (min)}} \times \frac{60 \text{ min}}{1 \text{ hr}} = \text{Crosswind (knots)}$$

What if the "approximate time flown" is equal to 6 minutes? Then the equation becomes:

Distance off course X 10 = Crosswind (knots)

And for 4 and 5 minutes, the equations become:

Distance off course X 15 = Crosswind (knots)
Distance off course X 12 = Crosswind (knots)

This "6 minute rule" may be used for time interval between 5 and 7 minutes (virtually every leg in T-6A VNAVs). For computing crosswind components over 5 to 7 minute intervals, you may simply multiply the distance off course by 10. To improve your accuracy, round up when using intervals closer to 5 minutes and round down if closer to 7 minutes. Always round to 5 knot increments.

Example

On the first leg of a low level you acquire a road/railroad intersection which should be 1/2 mile left of course at time 5+48. At time 5+50, the intersection passes down the right side of the aircraft at 1/2 mile. How much crosswind are you encountering assuming no prior compensations for the wind?

You are 1 NM left of course, and have been flying for about 6 minutes. Before working the numbers, realize you have a right crosswind because you are left of course, then:

1 NM X 10 = 10 knots of crosswind from the right

Check other intervals as well. What would the equation look like if the time was interval 10 minutes? What about three?

Headwind/Tailwind Computation

If wind is pushing the aircraft ahead or behind preflight time, the rate of error is proportional to the headwind/tailwind velocity. The following formula applies:

$$\frac{\text{Time gained or lost (sec)}}{\text{Approx. time since last update (min)}} \times \text{Planned Groundspeed} \left[\frac{\text{NM}}{\text{sec}}\right] \times \frac{60 \text{ min}}{\text{hr}} = \text{Head/Tailwind (knots)}$$

The equation basically converts the time deviation to a distance, which is then divided by time flown. At 180 knots (3 NM per minute), 1 NM equates to 20 seconds. After canceling terms, the simplified formula becomes:

$$\frac{\text{Time gained or lost (sec)}}{\text{Time since last update (min)}} \times \frac{1 \text{ NM}}{20 \text{ sec}} \times \frac{60 \text{ min}}{\text{hr}} = \text{Head/Tailwind (knots)}$$

Further reducing terms:

$$\frac{\text{Time gained or lost (sec)}}{\text{Time since last update (min)}} \times \frac{3 \text{ NM.min}}{\text{sec.hr}} = \text{Head/Tailwind (knots)}$$

Notice the equation is equivalent to time off divided by time flown multiplied by the groundspeed in nautical miles per minute.

For a time interval of 6 minutes at 180 GS, this equation becomes:

Time gained or lost (sec) / 2 = Head/Tailwind (knots)

Similar to crosswinds, this “6 minute rule” may be used for time interval between 5 and 7 minutes. For computing head/tailwind components over 5 to 7 minute intervals, simply use half of the time off in seconds. Again, it may be helpful to check other intervals as well. Round up when using intervals closer to 5 minutes and round down if closer to 7 minutes. Refine your computations as more information becomes available along the low level route and always round to 5 knot increments.

Below is an example of headwind/tailwind computation:

Example

At time 11+58 you pass abeam of a road bridge, anticipated crossing time of 11+46. You passed the previous turnpoint at 7+46. How much headwind/tailwind are you encountering?

You are 12 seconds late. Time flown was 11+48 – 7+46 = 4+12, approximately 4 minutes. Because we arrived later than expected, we note we have a headwind, then:

$$\frac{12 \text{ sec}}{4 \text{ min}} \times \frac{3 \text{ NM}}{\text{min}} = 9 \text{ knots } \underline{\text{Headwind}}$$

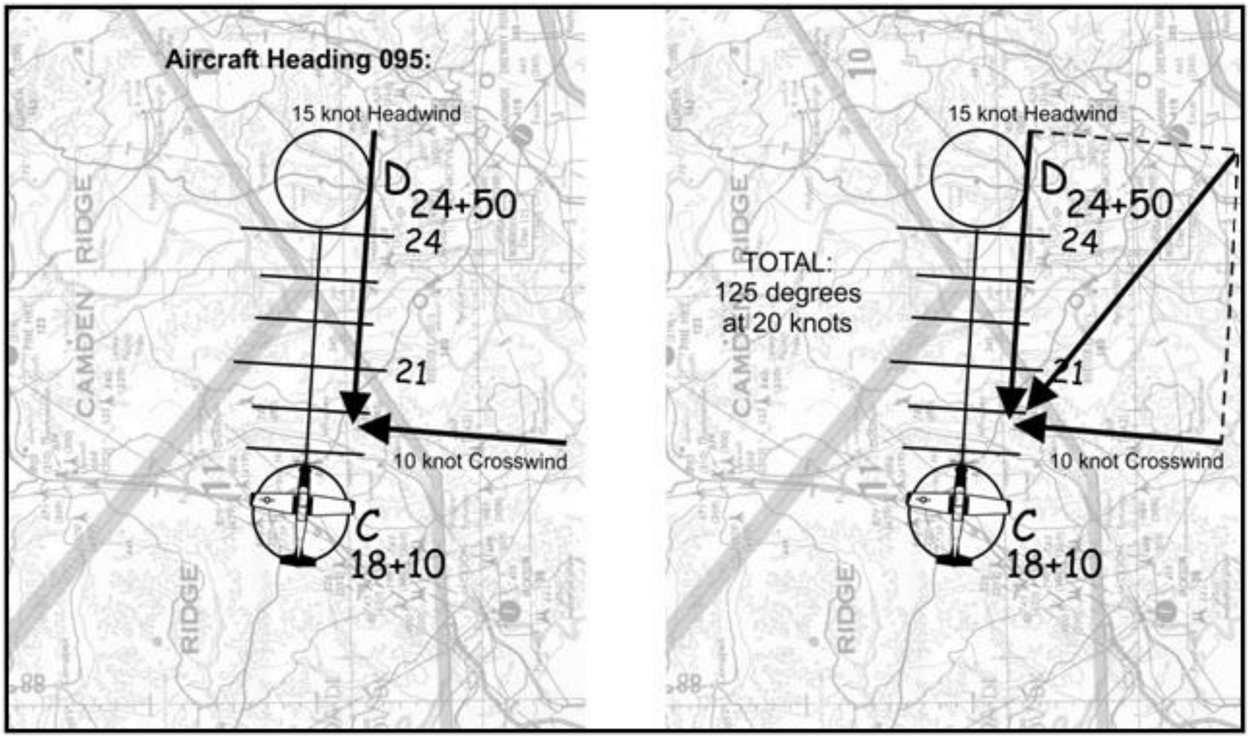


Figure 4-5 Wind vectors

Total Wind Computation

There are two methods to determine total winds, mathematically adding the components and wind estimation.

1. “All the big, half the small.”

LARGER WIND COMPONENT + 1/2 SMALLER WIND COMPONENT = TOTAL WIND

Recall that this method was taught in instrument training. It works because it is an approximation for finding the hypotenuse of the triangle formed by the crosswind and headwind/tailwind vectors (Figure 4-5). When complete, round to the nearest 5 knots. Adding all of the larger component to half of the smaller component gives you the magnitude (or strength) of the total wind, but what about the direction? If the two components are equal, then their forces are equal and the wind is coming at a 45° angle from that quadrant. If they are not equal, then the larger of the two components skews the overall wind direction toward its axis.

One technique is to draw a wind "T" to help visualize the total vector (Figure 4-6). This is merely a cross drawn in the margin of your chart, oriented with the magnetic course for the leg, and each 90° offset labeled with the magnetic heading as it would appear on the EHSI for that leg (rounded to the nearest 10°). A major advantage of this method is that it provides a visual aid allowing for quick orientation of the wind vector along the course leg. This provides a "sanity check" to prevent confusion between headwind and tailwinds and right and left crosswinds. As with any annotation, ensure that it is not drawn inside the route corridor and over important navigation information. Note that a "bullseye" is another representation of a wind "T."

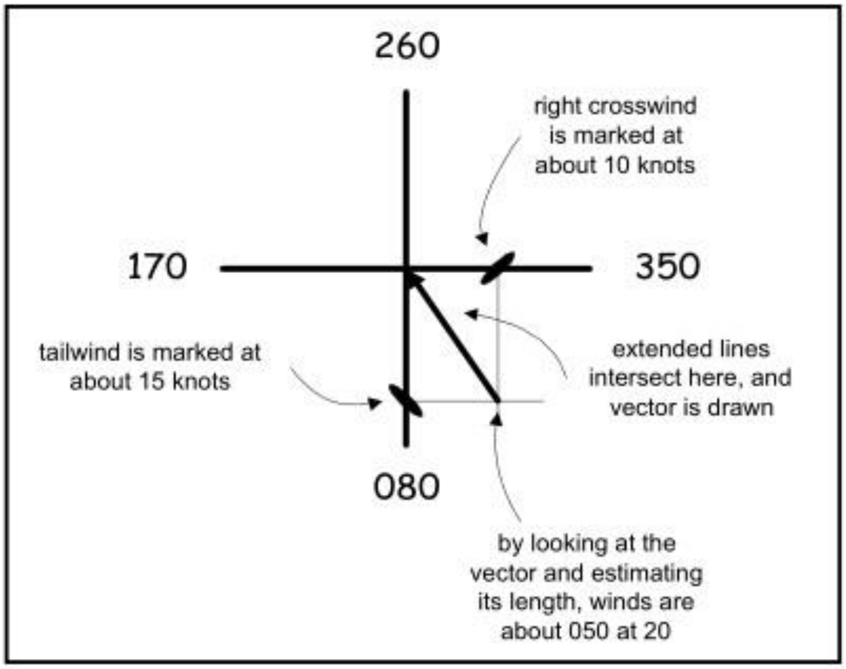


Figure 4-6 Wind "T"

Another technique is to use the EHSI for visualization instead of writing on the chart. Work through the calculation for the total wind strength and then use the CDI to twist in the wind direction based on the course of the previous leg. Equal components are 45° off from that quadrant, or the larger component pulls the CDI toward its axis.

If the wind components are known and "placed" on the EHSI, one can estimate the magnitude and direction of the wind by estimating the relative lengths of the horizontal and vertical axis, similar to the technique for point-to-point navigation. Figure 4-7 shows a wind of 210º and 20 knots on the CDI and the breakdown of the wind components using the dashed lines. The outside of the compass card is equal to the total wind velocity. Both wind components are about 3/4 of the radius of the compass card, thus equaling 15 knots (3/4 of 20). This technique can be used to generate a total wind from known components or vice versa it can generate the components from a known total wind.

Figure 4-7 EHSI

2. Wind Estimation

By now, you are no doubt wishing there was a way to figure out the total wind that did not require math. Luckily, there are two methods of wind estimation: *Visual estimation* and *forecast wind manipulation*. Both forms give wind in terms of a total vector. In general, you will take deviations from course, as well as visual cues and determine a total wind vector. These two estimation techniques allow for quicker calculations as well as allowing the pilot some deviations for heading/airspeed control.

Visual analysis has the advantage of being quick, though typically less accurate. The process is quite simple: Observe the effects of wind on smoke, waves, trees, etc., and determine the total wind from your observations.

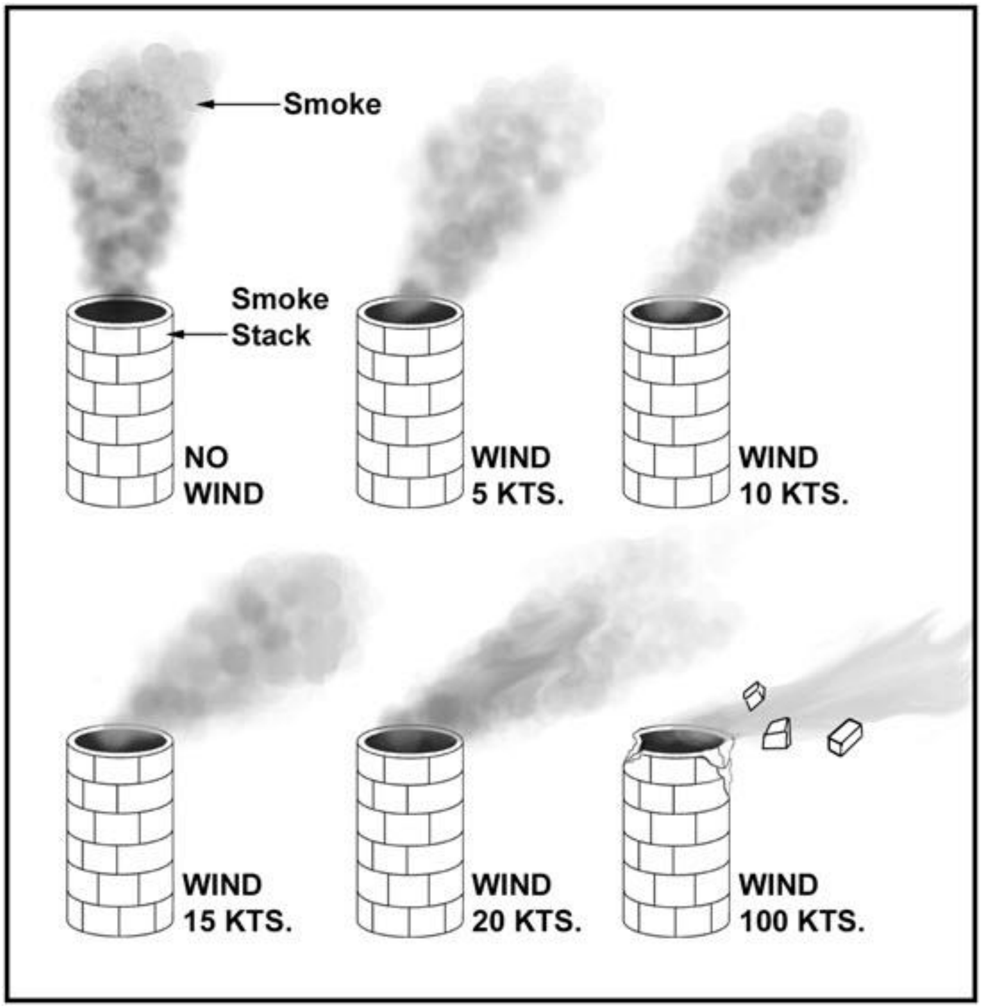


Figure 4-8 Visual Estimation of Wind

There are several visual cues available to determine wind speed and direction. Water (waves/spray – white caps at 15 knots of wind), windsocks, and even airport traffic patterns give clues to wind direction and magnitude. One of the easier cues, smoke (or steam), is fairly common and can serve as an excellent initial wind estimation or confirm an existing wind estimation because you can observe the smoke at your altitude.

Wind estimation using smoke is most effective when viewed from directly above. The further away the source of the smoke is from the track, the less accurate the estimation. If your track does not take you directly over the source of smoke, make your estimations from the closest point of approach. While direction is easy to determine, it requires practice to determine wind magnitude. Typically, this is easier when the smoke has a point source, such as a smokestack. Figure 4-8 gives a rough guide for estimating wind velocity based on its angle with a vertical axis. Be careful to visually follow the smoke path in its ascent, as this can provide visual cues to the existence of horizontal shear, in which either the wind magnitude or direction (or both) changes. At the altitudes flown in the T-6A, keep in mind that smoke from stacks are being affected by winds at the 200 – 500 foot level. Those winds may be different in speed and/or direction than the ones at 2000 feet.

Forecast wind manipulation involves imagining the forecast wind and updating based on course and/or time deviations. It is a more intuitive method of updating the wind that is best explained through examples.

Example

The aircraft is on the first leg of the route, headed 270^o, without a crab or wind compensated airspeed set. The aircraft arrives at point B, one half mile left of course and 10 seconds early. Intuitively, this means you have a right quartering tailwind (assuming the error is attributable to winds).

Example

Now, let's re-use that example with the aircraft entering with the route with a 272^o heading and flying 5 knots slower to compensate for a planned tailwind. What does it mean if the aircraft again arrives at B one half mile left of course and 10 seconds early? It means that the winds are actually stronger than planned for because your 2 degree crab to the right did not keep you on course and your 5 knot airspeed reduction still allowed you to arrive at the turnpoint early.

The estimates come in to play if the SNFO is not able to use the deviations to cumulatively update the winds. The correct answer in the second example is that there is an extra 5 knots of crosswind for a total of 10, and an extra 5 knots of tailwind for a total of 10. A 10 knot crosswind from the North, and a 10 knot tailwind from the East, results in approximately a 15 knot total wind (10 + ½ of 10) from 045^o.

This technique is very useful after you confirm the winds on the first couple of legs. If they stay constant, the forecast wind manipulation technique should have you adjusting the winds for a few degrees and 5 knots at most.

Total Winds to Components

The ability to break a total wind vector into its components is a necessary skill for wind analysis as well. How else can you plan for a crosswind or headwind/tailwind when given the "winds" from the weather brief or FSS? The good news is that it only requires memorization of a few ratios in order to do this with ease. Figure 4-9 breaks down a relative wind into its approximate components. While this is simplified into 5 distinct bearings for each quadrant, you really only need to memorize two rules and three fractions. If the wind is at a 45° angle to your ground track, then each component is equal to 2/3 of the total wind vector. And for a wind that is not 45° off, the larger component is 3/4 of the total wind and the smaller component is 1/2 of the wind. The larger component is determined by whichever axis the wind is closer to, headwind/tailwind if close to the nose, and crosswind if closer to the wing line. It should be obvious that if the total wind is directly down the nose or wing line, then there is not a "smaller" component.

In flight, this technique can be easily visualized on the EHSI by setting the CDI to the total wind direction. And once proficient, the CDI will no longer be needed.

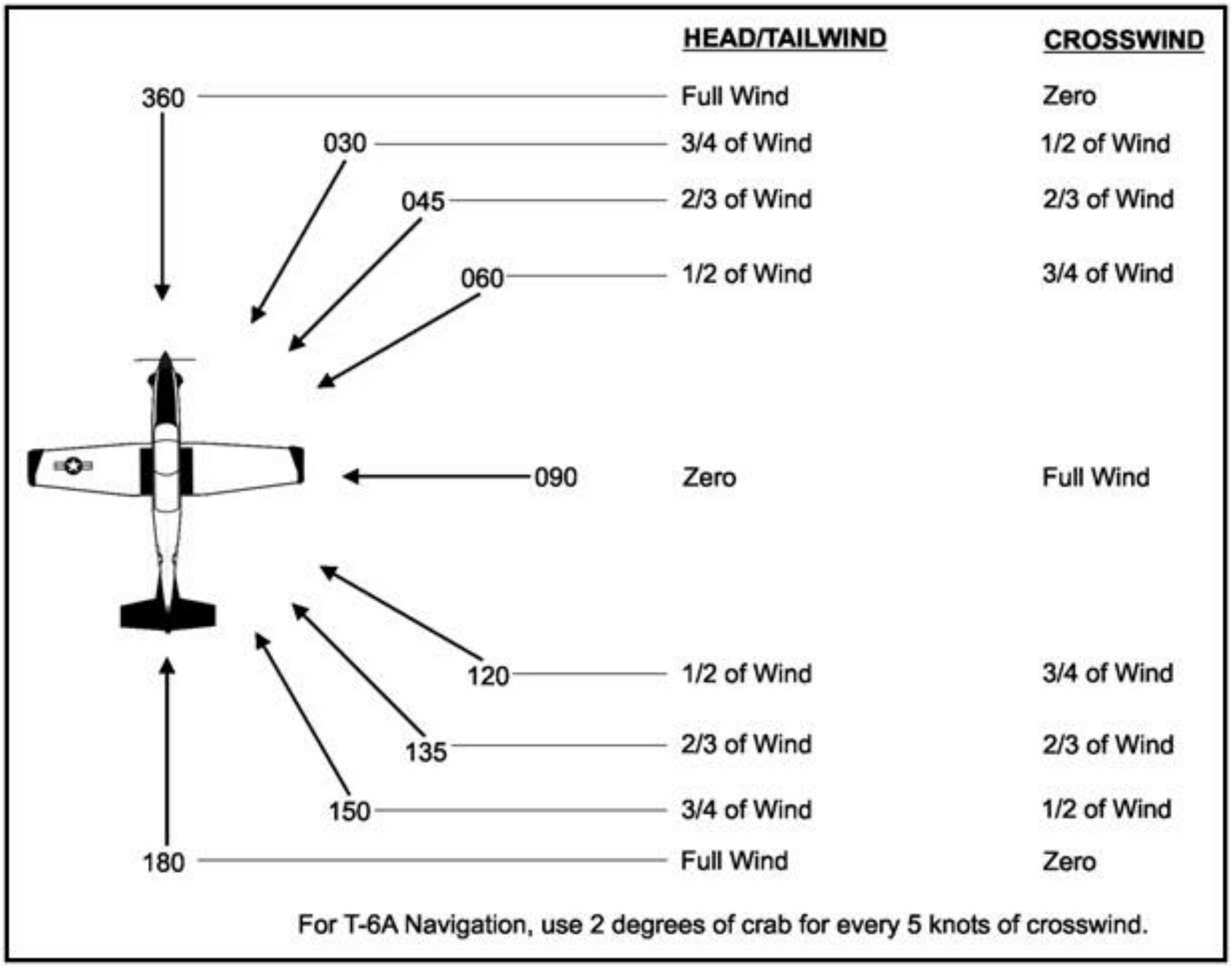


Figure 4-9 Wind Component Breakdown

Compensating For Wind

At this point, you may be wondering why we have spent so much time on learning the "math" to convert between wind components and the total wind vector. The reason is to adjust our base headings and airspeeds in order to compensate for the effects of the wind on our planned route. It would not make much sense to correct for the wind blowing us off course and time at each turnpoint only to allow it to happen all over again on the next leg.

1. Crosswind.

At 180 knots, crab 2º for each 5 knots of crosswind component because of the following formula. Round wind values to the nearest 5 knots so your adjustments to base-heading are always in 2º increments.

$$\frac{\text{Crosswind}}{\text{NM/min (TAS)}} = \text{Drift}$$

$$\frac{\text{5 knots}}{\text{3.0 NM/min}} = \sim 2^\circ \text{ crab}$$

Example

If base heading is 330° and the preflight winds are 020° at 15 knots, what is the compensated heading for the leg?

Since the winds are 50° off aircraft track, approximate the crosswind component by multiplying 15 knots by a factor of 2/3 to get 10 knots. 10 knots of crosswind requires 4° of crab to hold track, so the wind compensated heading is 334°.

2. Headwind/Tailwind.

You will also have to adjust for the headwind or tailwind to maintain the timing based on 180 knots groundspeed. Make adjustments to your base airspeed (the indicated airspeed you calculate to fly 180 KTAS) in 5 knot increments for the headwind/tailwind component you encounter. Ensure that you speed up for headwinds and slow down for tailwinds.

Example

Using the example above, what is the wind compensated airspeed if the base airspeed is 175 KIAS?

Since the winds are 50° from the front right quarter, the headwind component is 10 knots. Therefore, the wind compensated airspeed is 185 KIAS in order to maintain 180 knots groundspeed for that leg.

404. SUMMARY

A lot of information was presented in this chapter. The student must spend enough time practicing each of these corrections to be able to perform them from memory without reference to any formula in the cockpit. The formulas were presented for your understanding of why the relationships work, but in the end it is the relationships that you will use in the cockpit. There is no avoiding the mental math in visual navigation, but at least it is all simple math!

You may be able to tell where all of these corrections are leading. Inevitably, we will deviate from our charted course and time. When we do, we need a way to identify exactly how far and input a correction to get back on the plan. Then, we need to determine the cause of the deviations, if possible, and compensate for their future effects on our route. The procedures for how to execute this systematically are explained in Chapter 5.

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STUDY QUESTIONS

1. Determine appropriate standard course corrections for each situation. Assume no wind conditions, base airspeed of 175 knots and at least 6 minutes remaining on the leg.

	BASE HEADING	DISTANCE OFF COURSE (NM)	TURN TO HEADING	CORRECTION DURATION
a.	012	2 RIGHT	_________	___________
b.	327	1 1/2 LEFT	_________	___________
c.	154	1 RIGHT	_________	___________
d.	225	2 LEFT	_________	___________
e.	349	3 LEFT	_________	___________
f.	164	1/2 RIGHT	_________	___________
g.	048	1 LEFT	_________	___________
h.	273	2 1/2 RIGHT	_________	___________

2. Determine appropriate standard speed correction and the time the correction should be taken out. Assume no wind conditions and base airspeed of 175 knots.

	PREFLT TIME OF ARRIVAL	ACTUAL TIME OF ARRIVAL	TIME IN	RECOMMENDED AIRSPEED	TIME OUT
a.	5+10	5+26	5+50	_________	___________
b.	6+50	6+23	6+25	_________	___________
c.	7+50	8+07	8+20	_________	___________
d.	8+10	8+35	8+35	_________	___________
e.	9+15	9+39	10+00	_________	___________
f.	10+50	10+28	10+40	_________	___________
g.	11+35	11+25	11+40	_________	___________

h.	12+25	13+05	13+20	__________	____________

3. Determine appropriate wind compensations for each situation. Assume base airspeed is 180 knots.

	MAGNETIC COURSE	WIND	COMPENSATED HEADING	COMPENSATED AIRSPEED
a.	001	300/15	__________	___________
b.	232	200/15	__________	___________
c.	338	130/15	__________	___________
d.	185	270/20	__________	___________
e.	118	160/20	__________	___________
f.	151	100/30	__________	___________
g.	294	250/10	__________	___________
h.	127	310/10	__________	___________

4. Determine crosswind component and new compensated heading. The elapsed time shown is the time since the aircraft was last known to be on course. Assume no wind compensations during the leg duration and 180 knots base airspeed.

	BASE COURSE	ELAPSED TIME	DISTANCE OFF COURSE (NM)	CROSSWIND COMPONENT	COMPENSATED HEADING
a.	335	3+00	1/2 RIGHT	____________	______
b.	17	3+00	1 LEFT	____________	______
c.	121	6+00	1 1/2 RIGHT	____________	______
d.	242	6+00	3 LEFT	____________	______
e.	352	9+00	1 1/2 LEFT	____________	______
f.	154	4+00	1 LEFT	____________	______
g.	286	5+00	2 RIGHT	____________	______
h.	233	8+00	2 LEFT	____________	______

CHAPTER FIVE
TURNPOINT PROCEDURES AND ANALYSIS

500. INTRODUCTION

Due to the high task loading of the low altitude environment, it is important to standardize navigation and communication procedures to maximize aircrew efficiency and communication. Each turnpoint along the route requires 3 separate calls by the SNFO, the two minute prior call, the mark-on-top call, and the wings level call (Figure 5-1). The two minute prior call is made to provide situational awareness about the upcoming turnpoint and next leg of the route. The mark on top call is given at the point to transition the aircraft to the new leg and mark the aircraft position and time. Once outbound on the new leg, the wings level call is given to confirm that the aircraft is now flying the leg parameters and then analyze the aircraft's fuel state, position, timing and the effect of winds. From this analysis you will correct back to the charted course and timing, compensate for the effect of winds, and ultimately arrive at the target on time. Since terrain avoidance is always the primary concern in low altitude navigation, it is important to note that the format of these calls must be committed to memory and when performed, should require as little "heads down" time in the cockpit as possible. Each turnpoint call is designed with a specific purpose and therefore must be performed in the exact order shown in Figure 5-1.

2 Minute Prior Call	Outbound: Heading Airspeed Altitude Turn Point Description & Hazards
Mark On Top Call	Clear Turn Turn Time Set Airspeed Clear Turn
Wings Level Call	Heading Airspeed Altitude Fuel Turnpoint Analysis Time Analysis Update Wind Considerations Check Crab Check Airspeed

Figure 5-1 Turnpoint Procedures Format

This chapter uses Figure 5-2 to demonstrate the sample turnpoint calls. The information in quotation marks (“) is the ***exact format*** you will use to communicate with the instructor pilot. Presenting the information in this manner provides a better context for how and when to apply the various computation tools you will learn and standardizes the communication between the crew. The underlined items in each call below refer to an expanded explanation in the section following the sample dialogue.

The following turnpoint calls are based on an example (Figure 5-2) with an initial course of 360°, outbound course of 305°, winds 310°/15, base airspeed of 180 knots, and leg length of 5+30. Prior to turnpoint Delta, the aircraft was on a compensated heading of 356° and compensated airspeed of 190 KIAS.

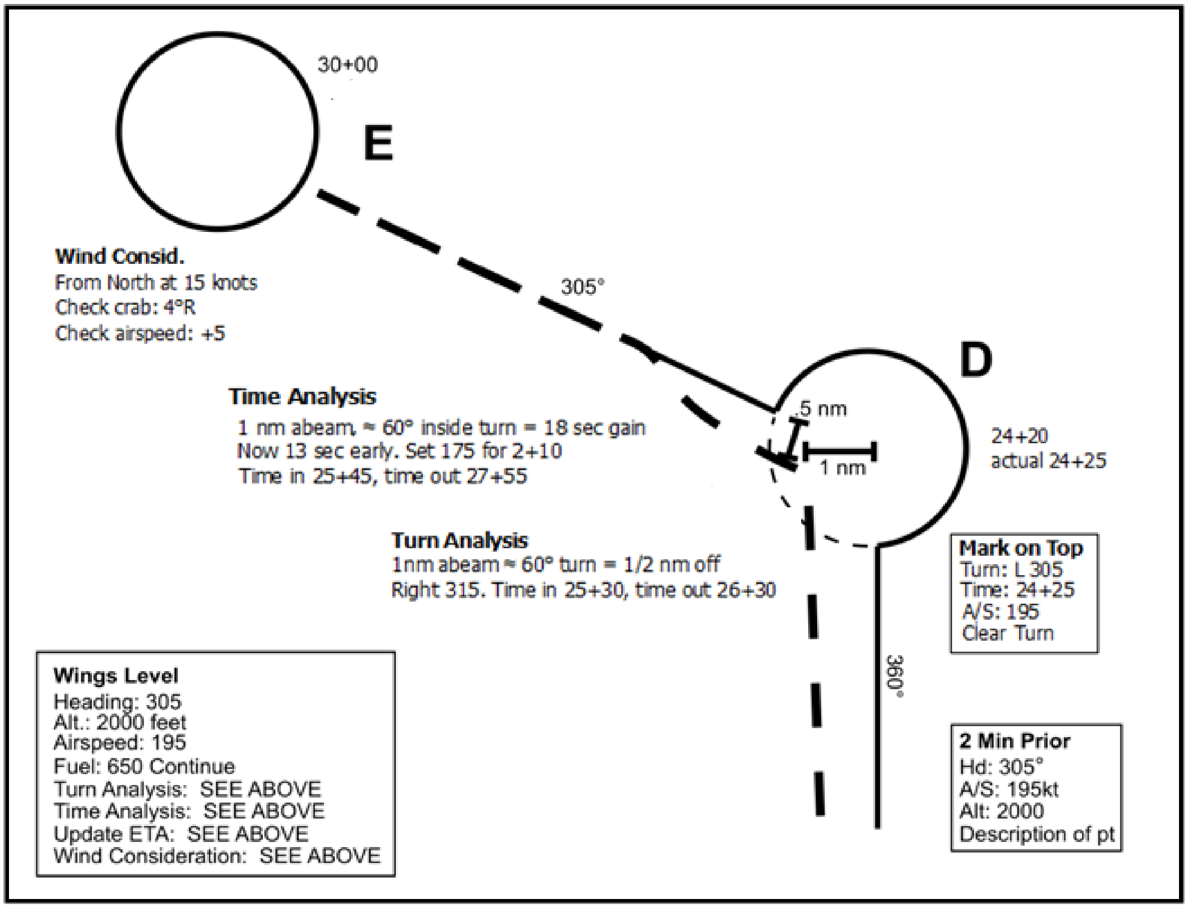

Figure 5-2 Turnpoint Procedures Example

501. TWO MINUTE PRIOR CALL

The Two Minute Prior (TMP) call is meant to inform the pilot about the parameters for the upcoming leg, as well as describe the turnpoint and any hazard in the vicinity.

Approximately two minutes prior to the turnpoint, the SNFO should reference the chart for the turnpoint name, outbound heading, airspeed, and altitude, and the turnpoint description. The outbound heading and airspeed should compensate for the winds. If the true winds match the pre-flight winds, then this is as simple as adding the preflight compensations placed in the margin of the route book to the leg MC and base airspeed.

1. *"**Two minutes** prior to **Delta**."*

Be accurate with time. If only one minute and 30 seconds away, then say *"one minute and thirty seconds prior."* The time allows the aircrew to judge how far in the distance to look for the point. State the name of the upcoming turnpoint (Alpha, Bravo, Charlie, etc.).

2. *"Outbound heading **three-zero-five.**"*

Headings are to be spoken in single digits and are wind-compensated. Add/subtract the crab from the course on the chart as appropriate. As a CRM technique, the outbound heading can be bugged during the two minute prior call, but discuss this with your pilot first.

3. *"Airspeed **one-ninety-five.**"*

Airspeeds are spoken using whole numbers, in order to differentiate from headings. The wind compensated airspeed should add/subtract the headwind/tailwind to maintain 180 knots groundspeed.

Wind-compensated headings and airspeeds will be calculated during preflight and penciled into the margins of your route book (T-6A only). It is still necessary to perform in-flight wind analysis, but as long as actual winds match the preflight winds, these numbers can be used. As you gain more experience, you will not need to record these numbers on your chart and will determine them purely based on mission progress.

4. *"Altitude **two thousand**" (or "climb to **two thousand five hundred**").*

If the next leg is flown at a higher altitude, direct the climb at the two minute prior call. For a descent, brief the altitude at the two minute prior call, but do not descend until wings level after the mark-on-top call.

5. *"Turnpoint (target) is a **primary road bridge left-to-right**, over a **river on course**, there is a town 2 miles left and a 450 foot tower one-half mile long. VR 1021 crosses right to left."*

Give a brief description of the turnpoint along with any hazards (covered in Chapter 6). Your description of the turnpoint will include 2-3 items from inside the turnpoint circle that positively identify the point. Brief any charted hazards located inside the turn circle. Hazards are described in detail in Chapter 6. The description should be referenced from the nose of the aircraft. Using standard terminology (on course, perpendicular, left-to-right, right-to-left, short, long, etc.) will build the picture for the pilot and give clues about which features will be visible first. Using the previous example, the pilot will surmise that the river on course should be visible first, followed by the road approaching diagonally from the left. Following these to their intersection you should find the bridge, and be able to verify it is the correct point by the presence of the town or tower, and the ETA. Practice the turnpoint and checkpoint descriptions ahead of time during your chart study to ensure they make sense and describe everything that will help you find the point and fix your position. After briefing the two minute prior call, you must scan outside in order to find the turnpoint and clear for hazards. There should be almost no reason to look back at your chart!

502. MARK-ON-TOP CALL

The primary purpose of the Mark-On-Top (MOT) call is to get the aircraft moving in the intended direction. The secondary purpose is to accurately determine when you were there.

Once at the turnpoint, the SNFO will initiate the MOT call. The heading and airspeed should be the wind compensated values given during the TMP call. While the aircraft position relative to the turnpoint is not included in this call, it is used in the wings level call, and the SNFO should note and record any deviation from course ***prior*** to initiating the MOT call.

1. "*Clear left, left three-zero five*."

The area for the turn must be cleared prior to giving this call as the pilot will begin turning the aircraft immediately upon its initiation. This call is ***not*** prefaced by "sir/ma'am" or the phrase "mark-on-top." The first words spoken, unless safety dictates otherwise, are "clear left/right/continue straight." Notice that it is not necessary to say "turn" either. Over time, the benefits of these standardized, and therefore expected, communications add up to real savings in workload and reduced confusion. Aircrew focus should always be outside the cockpit during a turn in the low altitude environment in order to clear for hazards and avoid descending in the turn.

2. *"Time is* ***twenty-four plus two five****."*

An accurate mark-on-top call is critical to future analysis, and delaying the reading of the clock will only induce error in your calculations. The time you read on the clock must be remembered and immediately recorded once the aircraft is wings level after the turn. If you attempt to note the time in the turn, you will draw your attention away from your duties of clearing and backing up the pilot. Another technique would be to note the time on the clock just prior to calling for the turn, add 3 to 5 seconds to it, and record that time on your kneeboard or chart.

3. *"Set airspeed* ***one ninety-five****."*

"Set airspeed" is used when the airspeed needs to change at the MOT. "Maintain airspeed" is used when an airspeed change is not required at the MOT. Continue to clear the remainder of the turn.

503. WINGS LEVEL CALL

The eight steps of the wings level call are designed to do two things. The first four steps are "aviate" items for the SNFO to confirm that the pilot is flying the necessary route parameters (heading, airspeed, altitude) and to ensure there is enough fuel to continue the mission. These four items are read directly from the flight instruments and should be checked against what you called for in the TMP and MOT calls. Allowing the pilot to fly off heading, airspeed, or altitude while you perform the last four steps will invalidate even the best analysis. Further, running out of fuel is a bigger problem than staying exactly on course through analyzing winds. The last four steps allow the SNFO to systematically analyze the progress of the low level mission and direct changes as necessary. This call is the largest of the turnpoint calls and requires a significant amount of analysis. The SNFO must be expeditious to perform all steps in order and return to visual navigation before the next checkpoint.

Heading, Airspeed, and Altitude

1. *"Heading* ***three-zero-five.****"*

Verify the heading on the EHSI and correct the pilot if off by more than 5°.

2. *"Airspeed* ***one-ninety-five.****"*

Verify the airspeed and correct the pilot if off by more than 10 knots.

3. *"Altitude* ***two thousand****."*

Point out altitude deviations if the pilot is off by more than 100 feet and not attempting to correct.

Fuel Analysis

4. *"Fuel* ***650 total, 40 pounds above MCF, and holding steady.****"*

State the total pounds of fuel on board and the number of pounds above or below MCF. Note any trends, and make your recommendation regarding the mission conduct. To do this, read the fuel quantity gauges and compare the actual fuel remaining (AFR) to the mission completion fuel written in your doghouse.

If the fuel state is above MCF, it is not required to state "continue" as your recommendation. Do note the difference between AFR and MCF for trend analysis. Ideally, if the actual fuel burn occurs as preflighted, you will see the same difference from MCF at each turnpoint. If the difference is getting consistently smaller, then it could indicate a fuel leak or malfunction that often will impact the remaining conduct of the mission. This is why it is important to do trend analysis. Whenever there is a deteriorating trend, attempt to diagnose the cause.

If the fuel state is below MCF, and you do not make a change to the mission conduct you will, at best, arrive at your destination below SOP minimums or worse, put yourself in a fuel critical divert situation. As the Mission Commander in training, it is your responsibility to come up with a new plan that both ensures the safe recovery of the aircraft and that attempts to prioritize and accomplish remaining mission objectives, if possible. Examples of recommendations are: "We are below MCF. Abort the route and proceed direct to the destination at 4,500 feet." "We are 20 pounds below MCF. We'll terminate the route early at Echo since it is the closest point to our destination," or "in order to reach the target and meet the EFR at the IAF, we can only execute one of the two practice approaches. All MCFs are now 50 pounds lower, continue."

Note that the last example is a change of the MCF because it is adjusting the mission objectives. Because the MCF is planned with extra fuel for mission, then it is permissible for that plan to change, provided that the crew is aware of the plan and that it still delivers you at your destination above the divert fuel. In this case, the MCF at the IAF would now change to the greater of either the divert fuel or 250 pounds. Discuss with your instructor during the brief which mission objectives are flexible and which are not.

NOTE

> Changing the preflight plan airborne requires a high degree of situational awareness and should not be done haphazardly. Delaying the decision to abort the route should not be borne out of hesitation, but out of a deliberate in-flight fuel estimation to make it back to the destination IAF with the minimum necessary fuel.

In summary:

AFR at or above MCF: Continue mission as planned.

AFR below MCF: Options are to abort the route, or continue, with a plan to leave the route early, or cut out a flexible mission objective such as an approach or aerobatics. Other possibilities are to climb and fly the route at a higher altitude or slow down. These last options are generally not feasible for the low level route due to timing and mission profile, but they can save a significant amount of fuel during an enroute transit. Max range and max endurance angles-of-attack are handy settings when fuel conservation becomes a priority.

The remaining four steps of the wings level call focus on analyzing the progress of the mission.

Turnpoint Analysis

5. *"Turn analysis – I marked **one** mile **left** of course and turned about 60° making me **one-half mile left** of course. **Right three-one-five for one minute. Time in two five plus three zero, time out two six plus three zero**."*

Execution of this call requires three pieces of information: the aircraft abeam distance position at the mark-on-top, the effect of the turn geometry, and the corresponding correction.

In the T-6A, the line formed from your eye to the wingtip to the ground is a 1:1 ratio of AGL altitude to distance in nautical miles (Figure 5-3). Knowing this fact allows aircrew to visually estimate the abeam distance based on where a point crosses the wingline. Recall that the fuel cap marks 2/3 of the wing and the point where the blue meets the white is 3/4. As the point approaches the wing, make a judgment as to what fraction of the wing it would intersect, and then multiply that by your altitude to get the abeam distance in nautical miles. For example if the aircraft is at 2000' AGL, and the checkpoint passes halfway down the right wingline, then the aircraft is 1 NM left of the checkpoint. Develop your accuracy with this method early (i.e., "calibrate your eyeball") and then be consistent in your judgments. As always, round all course deviations to the nearest 1/2 mile.

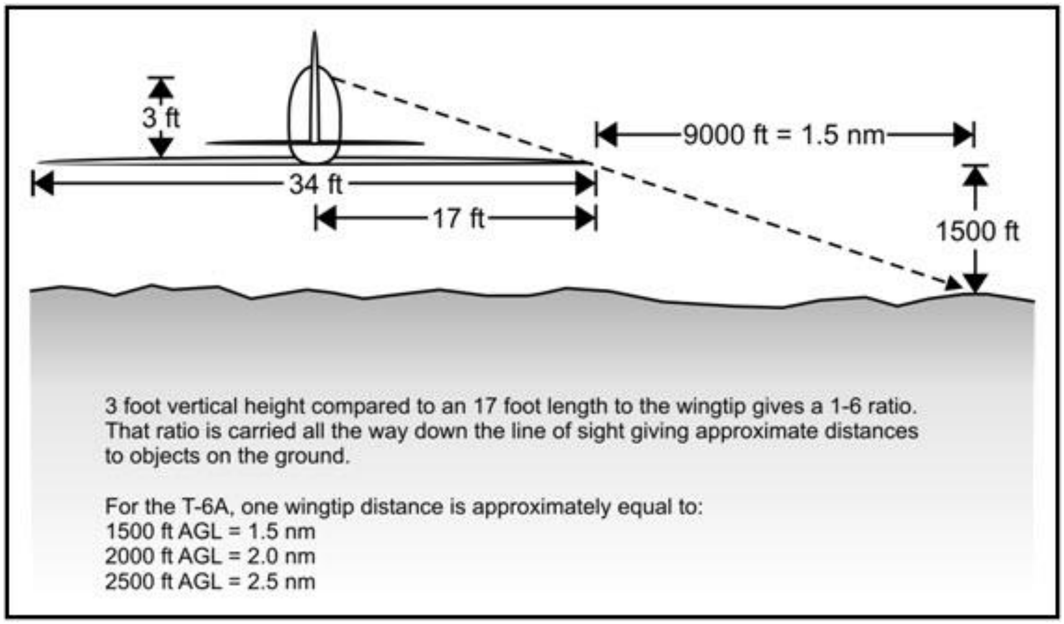

Figure 5-3 Judging Distance

Turnpoint Geometry

Next, we must understand how a turn affects our course. There are two things to account for: turn radius and turn geometry. Due to the tight turn performance of the T-6A, we assume that there is no effect to distance from the actual turning of the aircraft (i.e., a zero turn radius). However, turnpoint geometry is a phenomenon that occurs independent of aircraft type. Figure 5-4 shows that when off course, a turn induces course and timing errors that must be accounted for.

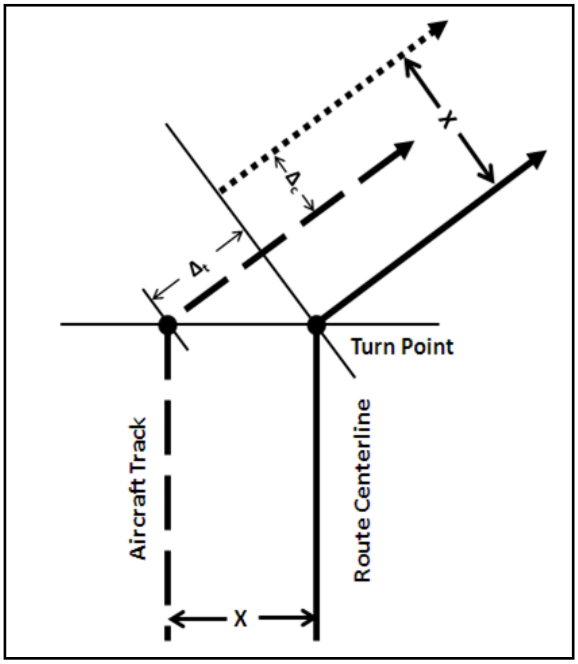

Figure 5-4 Effect of Turn

The turn angle affects your distance from route centerline by the factor, Δ_c. The turn also changes the effective length of the new leg, which causes the timing error, Δ_t. Note that the course error is independent of airspeed, but the timing error is not.

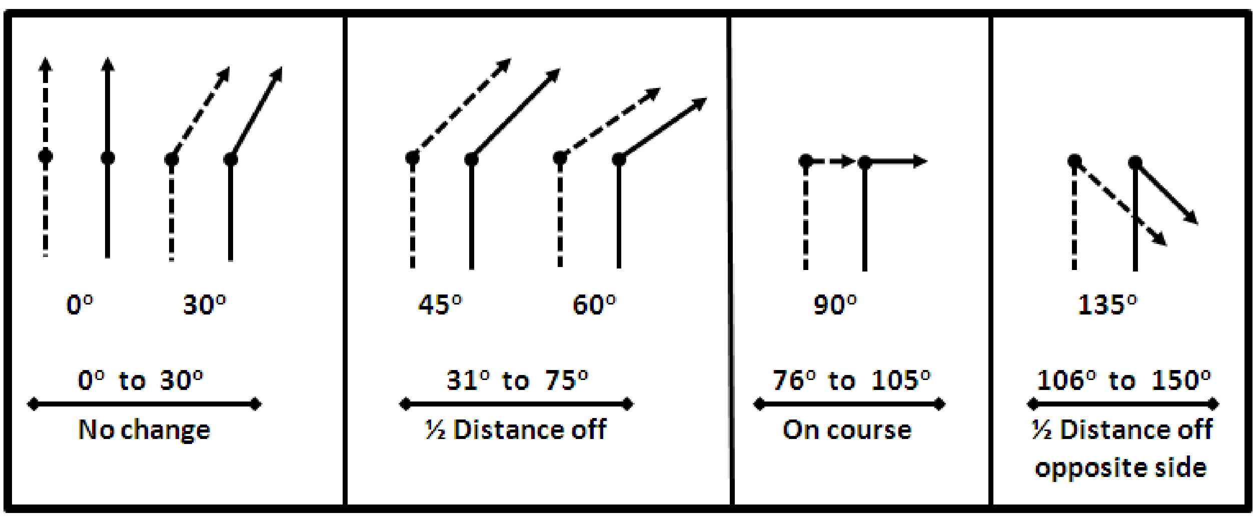

Figure 5-5 Turn Geometry's Effect on Course

Figure 5-5 shows how we will use this phenomenon in the aircraft. For course changes up to 30°, consider the change small enough to ignore. For turns of 31°-75°, geometry reduces the starting abeam distance by half. For 76°-105° turns, the turn places you back on course centerline. And for turns of 106°-150°, geometry reduces the abeam distance by half, but places you on the opposite side of the route.

After applying the effect of the turn geometry, you now know the new distance from centerline. Call for a standard course correction from Chapter 4 to get back to route centerline.

Example

You mark 1.0 NM left of the turnpoint and turn 45°. What course correction is needed?

After the turn you are now 1/2 mile left of course, so correct 10° right for 1 minute.

Example

The aircraft is at 2000’. The point passes down the left wing and crosses where the blue meets the white. The MOT calls for a 60 ° turn to the left. What is the course correction needed?

Where the blue meets the white is 3/4 of the wingline so the aircraft marked 1.5 NM to the right of the point. The 60° turn makes the aircraft 3/4 NM right of course. Since we round to 1/2 NM increments, we’ll choose to round up to 1 NM right of course in this case, and correct 10° left for 2 minutes.

Example

The aircraft marks on top of the point and turns 75° to the right. Is a course correction needed?

No, there is no effect from turn geometry when the aircraft is on the planned course.

Example

The aircraft is severely off course with the turnpoint outside of the wingline. The MOT calls for an 80° turn. What is the necessary course correction?

A turn of roughly 90° actually places back on course, so a correction is not needed. However, you now have a significant timing error to deal with.

Time Analysis

6. “*Time Analysis – I was* ***five seconds late*** *and* ***one mile left*** *of course. I turned about 60° inside the turn, gaining* ***18 seconds****, which makes me* ***13*** *seconds* ***early*** *now.* ***Set airspeed one seventy-five*** **(assuming current compensated airspeed of 195 knots)** ***for two minutes and ten seconds. Time in twenty five plus forty-five. Time out twenty-seven plus five five.****”*

Execution of this call requires three pieces of information as well: the time the aircraft marked-on-top, the effect of the turn geometry, and the corresponding correction.

First, compare the mark-on-top time to the preflighted arrival time on the chart to find the timing error at the turnpoint. Then apply the effects of the turn geometry (using Figure 5-5) to find the total timing deviation. Purely for reference, the equation for the timing deviation based on groundspeed is:

$$\Delta t = (\text{Abeam distance}) \times \sin(\text{turn angle}) \times (60 / \text{GS [NM/min]})$$

Figure 5-6 has the timing deviations for 180 knots ground speed tabulated for use in the aircraft. A very slight rounding of the numbers was performed in order to make the deviations multiples of the 0.5 NM value. Therefore, the deviation for a 45° turn when 2.5 NM abeam is equal to 35 seconds because it is 5 times the 7 second error for 0.5 NM abeam.

Turn effect on timing at 180 GS (in seconds)				
NM abeam	30°	45°	60°	90°
0.5	5	7	9	10
1.0	10	14	18	20
1.5	15	21	27	30
2.0	20	28	36	40

Figure 5-6 Turn Angle and Abeam Distance's Effect on Timing

When turning outside of the route centerline, the turn creates extra distance to travel, thereby adding to the time deviation and making the aircraft later, whereas turns inside the route centerline subtract the time deviation and make the aircraft earlier.

After figuring out how far you are off from planned route timing, use a standard correction from Chapter 4 to get back to preflight timing. The SNFO will make many corrections throughout the route and keeping track of all of the time-outs will be very difficult if the student does not develop a consistent method of bookkeeping.

Example

The aircraft marks 1 NM abeam and 10 seconds late. The MOT calls for 45° turn outside of route centerline. What is the timing correction needed?

A 1.0 NM abeam distance equals a 14 second deviation. Since we were outside of the turn it makes the aircraft later, resulting in a total 24 seconds late. The correction is to speed up 20 knots for 4 minutes (24 divided by 6 is 4 with no remainder).

Example

The aircraft marks 1.5 NM abeam the point and five seconds early. The MOT calls for a 60° turn inside of route centerline. What is the timing correction needed?

1.5 NM requires three times the 0.5 NM deviation, so the turn inside the point makes us 27 (3 x 9) seconds earlier, for a total of 32 seconds early. Direct the aircraft to slow 20 knots for 5 minutes and 20 seconds (32 becomes 320, which divided by 60 is 5+20).

Example

The aircraft is at 2000', the initial point (IP) passes down the left wingtip, and we mark 10 seconds late. The turn is a 90^o turn to the right and the outbound wind compensated airspeed is 190 knots because of a headwind. What is proper voice call for the timing correction?

The point was 2.0 NM to left and we turned "inside" of the turn. The turn makes the aircraft 40 seconds earlier for a total of 30 seconds early (10 late minus 40 early). A 10% correction for 5 minutes would work, but since it is now the target leg, we'll choose to slow 40 knots for half of that time (30 seconds / 6 = 5+00, further divided by 2). The proper call is, *"Time analysis – I was 10 seconds late and 2.0 NM right of course. I turned* 90^o *right, gaining 40 seconds, which makes me 30 seconds early now. Set airspeed one fifty for two minutes and thirty seconds. Time in: three-one plus one- five. Time out: three-three plus four-five."*

Update the ETA

During this step we update the estimated time of arrival (ETA) to the next checkpoints. If you initiated a time correction that will be complete prior to crossing the subsequent turnpoint, there is no need to update the ETA. In the event that the timing deviation, after accounting for turn geometry, is less than 12 seconds, do not initiate a timing correction, but simply update the ETA to the next turnpoint and intermediate checkpoint.

7. Example call: *"We are three seconds off. Updated ETA is* ***thirty plus zero three****."*

If the calculated "time out" for the correction lasts past the preflight ETA for the next point, calculate a new ETA by adding or subtracting 6 seconds for each minute (for 20 knot corrections) that the correction lasts past the point. For a 40 knot correction, it is 12 seconds for each minute past the point. An example call is, "*The correction lasts* ***two minutes*** *past the turnpoint, so we will still be approximately* ***12 seconds early,*** *updated ETA is* ***twenty-nine plus forty-eight.****"*

Wind Consideration

If the compensated heading and airspeed keep the aircraft on course and on time then the assumed winds are considered confirmed and the SNFO can simply acknowledge this fact for the wings level call; however, when they do not, then the winds effects must be analyzed in order to compensate for them.

This step involves the computational efforts of analyzing the past effects of the wind on your deviations and then applying the proper compensations to your future base airspeed and heading to maintain desired track and timing.

Bookkeeping becomes very important in this step because the aircraft will already be flying a corrected heading or airspeed based off of a (potentially) old wind compensated adjustment. If this is not confusing yet, it will be after looking at a few examples. Practice and methodical application are the keys to keeping things straight.

Note that there are three types of "wind" – true, perceived, and apparent. The wind that is really there is the true wind. The perceived wind is the one we compensated for, and the apparent wind is indirectly determined by measuring the effectiveness of our compensations at maintaining preflight course and time. Note that if our perceived wind was accurate, then it would equal the true wind and there would be no offset from the apparent wind. But by now, you know that is generally not the case. So in order to establish a habit pattern for the wind consideration, the following framework should be used:

1. Calculate apparent crosswind from the abeam point deviation

2. Compare to the perceived crosswind

3. Combine for the true crosswind

4. Repeat steps 1-3 for the headwind/tailwind component

5. Determine new true total wind

6. Break the new total wind into components for the current (i.e., outbound) leg to determine new heading and airspeed compensations

Because there are many procedures (e.g., component calculations, estimation, forecast wind manipulation) and many techniques (e.g., wind T, EHSI, mental math) involved in this process, determining the wind is an art, as much as a science. Therefore, this process is best illustrated through the use of more example problems. It will probably help to draw out the course lines and wind vectors as you work through them.

Example

The preflight forecast says the winds are calm. Thus, the first leg of the route is flown with no crab and at the base airspeed. Assume that the pilot holds a constant heading airspeed and for the entire six minute leg. The route MC is 315°. Arriving at point B, the SNFO marks one NM left of course and eight seconds late. What is the true wind?

The apparent wind is the wind that pushed us one NM left of course. For a six minute leg, each half mile of deviation is equal to five knots, so there is an apparent 10 knot crosswind from the northeast. Since there was no heading compensation because we did not have a perceived crosswind, the true crosswind is 10 knots from the northeast.

Let's repeat this for the headwind/tailwind. The apparent wind also made us eight seconds late. For a six minute leg, eight seconds equals four knots (Time off divided by 2 = HW/TW) and since we arrived late, it is a headwind. Since we did not use any compensations from A to B, there is no perceived wind for step 2. Therefore, step 3 tells us the true headwind is four knots, which we round up to five knots from the northwest.

In step 5, we use "all the big, half the small" to determine the total wind vector. Ten is bigger than five, so the total magnitude is 12.5 knots, which we will round back up to 15 knots. For the direction, the wind is stronger from the northeast (XW) than the northwest (HW), so the total wind direction is not 45° off the track, but closer toward the XW side. Thus, the total wind is estimated as coming from 015° at 15 knots.

Example

Continuing with the previous example, what are the proper compensated heading and airspeed for the next leg if the MC from B to C is 000°?

First we have to account for the corrected headings from the turnpoint and timing analysis steps of the wings level call. One NM left of course with a 45° turn to the right places us 1/2 mile left of course. The course correction is then *"right 010 for one minute. Time in six plus thirty, time out seven plus thirty."* One NM abeam, eight seconds late, and a 45° turn make us a total of 22 seconds late (8+14) once wings level. If the base airspeed is 170 knots, the timing correction is then *"set airspeed one ninety for three minutes and forty seconds. Time in six plus five zero, time out ten plus three zero."* So as we move into the wind consideration, the aircraft is flying heading 010 at 190 knots.

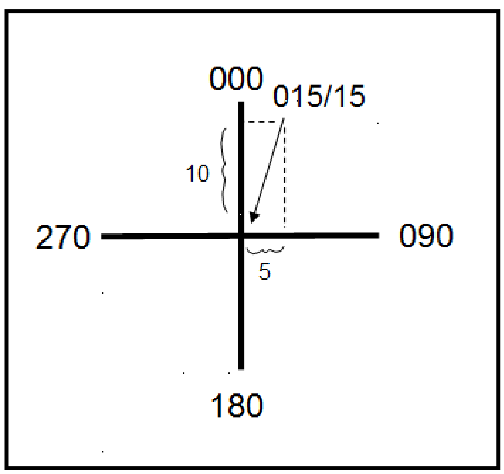

Figure 5-7 Wind "T" for Example

Now we must break the total wind into new crosswind and HW/TW components. Using the wind T method, draw the total wind vector as in Figure 5-7. Since we don't have a calculation for 15° off course, we'll approximate with the 30° ratio from Figure 5-6. The crosswind component is equal to half of the total wind for a value of 7.5 (15/2). Since it wasn't fully a 30° offset we will round down to five knots of right crosswind. For the HW/TW, the 30° ratio from Figure 5-6 tells us to multiply the total wind by 3/4 for a value of 11 (15 * 3/4), which we round to 10 knots of headwind.

Now we can finally accomplish the last two steps of the wings level call: check crab and check airspeed. Using 2° of crab for every five knots, direct a crab 2° to the right for wind compensated heading of 012°. And since we want to go faster because we are now facing a headwind, increase airspeed by 10 knots to 200.
What happens now when the course and timing corrections expire?

The answer is that you return to the wind compensated values of 002° (000° + 2° crab) and 180 (170 base + 10 knot headwind).

Compound Wind Problems

The most confusing aspect of wind consideration occurs when perceived winds do not match the true winds, resulting in compensations that do not hold desired track or timing. A compound wind problem requires you to calculate the apparent wind, compare it to the perceived wind, and then sum them for the total wind. You then apply new compensations based off that total wind to the current route leg.

Analysis, compensations, corrections, and updates may become confusing as these functions overlap. Students must be ready for these compound problems that are the nature of low level flight. Let's work through the compound wind calculations in the example from Figure 5-2 below.

Remember that prior to the turnpoint the perceived winds were 310°/15, the inbound heading was 356°, the inbound compensated airspeed was 190 knots, and the base airspeed was 180 knots. At the turnpoint the aircraft turned 55° to the left, marked 1.0 NM left and 5 seconds late. The turnpoint geometry placed the aircraft 1/2 NM from course and 13 seconds early, so the aircraft is now flying a corrected heading of 315° and corrected airspeed of 175 because the compensated airspeed is 195 knots for the perceived 15 knot headwind.

"We were a mile left so the apparent wind is 10 knots from the right, but I compensated for 10 knots from the left so there is no crosswind. We were five seconds late which means there is another five knots of headwind I didn't compensate for, so the new winds are from the north around 15 knots. That now gives us about 10 knots right crosswind so we need to crab right 4°. New heading three one nine (until the correction times out). *We have a five knot headwind so the new compensated airspeed is 185, which means the timing correction should now be at 165. Set airspeed one sixty five"* (until the correction times out).

"We were one mile left so the apparent wind is 10 knots from the right." For a six minute leg, every half mile of deviation is due to five knots of crosswind.

"… but I compensated for 10 knots from the left so there is no crosswind." The inbound compensated heading was 356°. For a six minute leg, multiply your deviation by 10 to get the crosswind. Note that a half mile of deviation equals five knots of wind in this case too. Another way of thinking about this case is "*I aimed left and ended up left, so there must be less crosswind than I anticipated."*

"We were five seconds late which means there is another five knots of headwind I didn't compensate for." This is the apparent headwind. Five seconds divided by 2 equals 2.5 so round up to 5.

"... so the new winds are from the north around 15 knots." Add the apparent wind, +5, to the perceived wind, +10, using "all the big plus half the small." Since we found there to be no crosswind, it is all headwind.

"That now gives us about 10 knots right crosswind." After twisting the CDI to 000 (or 180), we see that the winds are now offset 60° to the right of course. Sixty degrees is 3/4 of total wind, so 15 times 3/4 is rounded to 10 knots.

"So we need to crab right four degrees." Each five knots of crosswind requires two degrees of crab using the six minute rule.

"New heading three one nine" (until the 1/2 NM correction times out). Now apply the crab to the current heading. Since we are in the middle of the course correction, the heading is 315 + 4. Once it times out, the heading will return to the new wind compensated value of 309°.

"*We have a five knot headwind."* The headwind component of a 60° offset wind is equal to 1/2 the total wind. Half of 15 is 7.5, which we rounded down to five knots in this case.

"So the new compensated airspeed is 185, which means the timing correction should now be at 165. S*et airspeed one sixty five."* The current corrected airspeed is 175. To keep it simple, find the new compensated airspeed and then adjust by any correction that is currently inputted.
180 knots + 5 knots HW = 185 knots – 20 knot correction = 165 knots.

It should be extremely clear at this point that proficiency with the basic corrections is critical. The bad news is that you do not have all day to crunch these numbers because the aircraft is constantly moving forward along the route. The good news is that because the aircraft is still progressing along the route, the next fix provides new updates that will correct for any previous errors. Low level flying is a continual process of updating your position and making corrections all the way to the target.

504. SUMMARY

This chapter introduced the format for the turnpoint calls and the procedures needed to accomplish them. It is important to understand the concepts of base, compensated, and corrected headings and airspeeds, as well as apparent, perceived, and true winds, in order to keep the calculations straight. Practice with the small calculations (e.g., 2° crab for every 5 knots, 1/2 NM deviation equals five knots of wind) until they are second nature. Always think about the big picture of what is happening with the aircraft as well. Crosscheck your numbers with the big picture to see if they make sense.

You are almost ready to execute your first low level event! It's definitely worth all the mental math. Chapter 6 will cover the remaining flight procedures.

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CHAPTER SIX
FLIGHT PROCEDURES AND EXECUTION

600. INTRODUCTION

This chapter switches the focus from mission planning to mission execution. Your job is to ensure that we get the aircraft to the target on time. In this block, the time starts at the route entry point and the goal is to cross the target at the planned elapsed time. Later in training, that time will be an actual time of day at which you'll need to arrive over the target.

With the knowledge you have gained from Chapters 4 and 5 in computing wind compensations, performing corrections, and executing turn point procedures, you are prepared for this section which teaches the standard procedures and techniques for a basic visual low level navigation event.

601. BASICS OF T-6A VISUAL NAVIGATION

Thus far in the FTI we have covered many of the individual components required for a VNAV event, but have only alluded to the physical actions of visual navigation. This section will describe in detail the process of using a chart to find features on the ground to determine your position and then what to do once you have that information.

FACCU

Flying a low level route is a process of constantly discerning where you are in relation to mission course and time, correcting back to the charted course and time, and then assessing what caused the deviation. The process is succinctly described by the term FACCU: FIX, ASSESS, CORRECT and COMPENSATE, and then UPDATE. If you look closely, you will see that your turnpoint calls follow this format. Note that compensation can be performed before correction with the same end result. But in order to match the flow of the wings level call, "correct" is placed before "compensate" here. As stated above, this process is done ***CONSTANTLY***, not just at the turnpoints. The continual use of intermediate checkpoints and other visual features on the ground throughout the route is essential. The only step of FACCU that has not yet been described in the FTI is the one that gets the entire process started, fixing your position. That is the focus of the remainder of this section.

Clock, Chart, Ground

Again, the basis for visual navigation is Dead Reckoning (DR). DR consists of predicting where the aircraft will be based on flying a constant heading for a length of time from a previously known position. The predictions are fairly accurate, and if you fly the entire route based on time and heading alone, you should end up relatively close to the target environment. However, your goal is not to just "get close" and arrive at any random time. Due to winds, chart error, computational approximations, and the dynamic environment of aviation, you need a process to update your DR navigation.

In the low level environment, your new navigation scan is based on the mantra ***CLOCK, CHART, GROUND***. This is the order you must follow to properly use your chart. First, look at the clock that is keeping track of your route timing. Your aircraft should be in the vicinity of where that time is labeled on your chart, just by the basics of DR navigation. Then, look 30 seconds to 2 minutes ahead on the ***CHART*** in order to visualize the environment the aircraft is about to pass through. At 180 knots, 2 minutes of flight time is equal to 6 miles, well within visual range. Critical to this step was having an accurate clock start at the entry point of the mission.

Then, and only then, do you look outside at the features on the ***GROUND*** in order to see if they match up to the features from the chart. When they do, you have determined your general position over the ground. Next, determine how far away you are from the feature using the wingtip estimations from Chapter 5. Doing so specifically fixes your position and timing in relation to a known object on the chart.

It is a common, initial tendency to reverse the scan by first looking at the features on the ground, then the clock, and finally at the chart. Because not all ground features are represented on the chart, it is very easy to “fit” what you are seeing to the chart depiction, thereby erroneously fixing your position. If accomplished backwards, you run the risk of convincing yourself the surrounding sight picture is revealing a different position on the chart (e.g., “I see an inferred bridge, I have an inferred bridge on the chart, I must be 20 seconds late.” Even though there are actually two bridges present).

Another tendency is to look aft of the aircraft for checkpoints that may have been missed. This is a very bad habit to get into. Remember that we are ultimately training towards altitudes as low as 200’ AGL and airspeeds near 500 knots! Attention needs to be focused on what’s ahead of the aircraft at all times. If you miss a checkpoint, move on, and attempt to find the next one.

Finding and Deriving Information from Visual Checkpoints

Checkpoints on a low level chart can only help us if we know how to find and use them. By keeping the chart oriented with the track of the aircraft, landmarks on the ground appear in the same relative position as the features on the chart. After referencing the clock, look at the chart for that time frame and tell yourself “what you should be seeing” before looking out over the ground. Techniques that help narrow, and therefore expedite, your visual search are to work “big to small” and to find features that “lead” or “point” to the checkpoint. Examples of working big to small are: looking for a town before looking for the tower that borders it, or looking for the lake before looking for the dam that resides on it. Can you think of an example of a feature that “leads” or “points” you to a checkpoint? These were discussed in Chapter 1 as funneling features. Examples of their use are: visually following a river in order to find the bridge that sits on it, or using one of the roads that forms an intersection to lead up to the point where the other road crosses. What are the funneling features in Figure 6-1? Be sure to take into account your actual time and track position relative to the centerline on the chart. For example, if you are a little early and possibly left of course, then a checkpoint that is on centerline should appear earlier than the charted time and to the right of the aircraft.

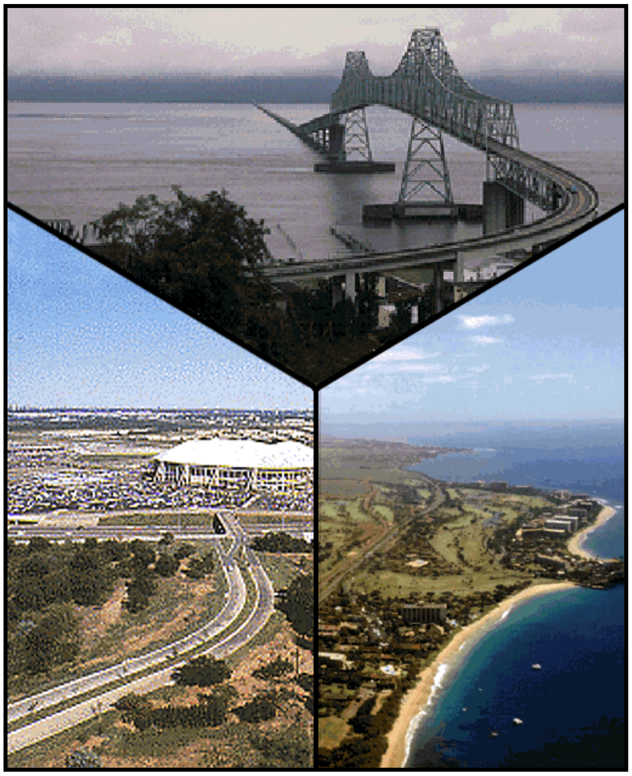

Figure 6-1 Funneling Features

But what will the feature look like? Geography, climate, altitude, and season are just some of the factors affecting the appearance of checkpoints. As your flight experience increases, so will your ability to predict how a particular feature will appear from the air. Preparation for the flight by viewing the turnpoint photos and satellite imagery will also aid your development. Below are some points to consider when searching for specific features:

1. Trees may mask roads running perpendicular to course. Look for traffic, particularly trucks.

2. Rivers may be masked just as roads are. Look for changes in forest color. Typically, deciduous (leafy) trees will grow next to the rivers, while pines will grow everywhere else. Also look for the lower terrain associated with the riverbed. Winter/Summer will change the appearance of these areas.

3. Pay close attention to the contour lines on your chart. They may indicate terrain trends useful for navigation or terrain that may hide other checkpoints.

4. Observation towers (generally placed in forested areas) may only appear as a small building sitting on the tree line.

5. Remember, a bridge is where "a river and road meet," the river and road are likely to be visible long before the bridge.

6. Underground pipelines may look similar to dirt roads, but generally they are unnaturally straight and have few turns.

7. Lakes in low-lying areas (marsh/swamp) can change shape with the tide or with heavy rains or drought.

With any checkpoint in sight, the next question to ask is, “What is it telling me?” Ideally, it tells us if we are early or late and if we are left or right of planned track. Unfortunately, not all types of checkpoints give the same information. Recall the discussion on linear features from Chapter 1. Regardless of whether you do something with the information or not (such as initiating a correction), it can help you “cage” your eyes to where subsequent turnpoints are located. For example, a tower might be used to determine that you are one mile left of course. With this information, you now know to look to the right for the turnpoint. Although you are required to scan all sectors for hazards, you can concentrate on the right, as this is the direction of the turnpoint. This reduces your workload significantly.

Perhaps the most common reason students fail to see an intermediate checkpoint is actually quite simple: They are not looking in the right place at the right time! Prevent this problem with an effective CLOCK, CHART, GROUND scan. Always reference the clock! It should be considered a primary instrument in this stage. It is often the deciding factor when visual checkpoints look the same or when confused as to whether “that” feature is “your” feature.

602. PREFLIGHT PLANNING

Preflight planning has so far consisted of creating a low level chart and the necessary mission products. Performing a detailed study of the low level chart and developing a game plan to get to and from the route are also critical. Prior to the brief, the SNFO should be very familiar with each turnpoint’s identification, the basic layout of the route, and any major hazard along it.

No earlier than the night before the event, check the anticipated winds for your route through winds aloft, a qualified forecaster, or FSS. For your T-6A training, write this wind value on your jet log, and then compute and record the compensated heading and airspeed for each leg in the margin of your chart (in pencil). This will allow a rough estimation of the required airspeeds and headings to maintain course. In subsequent phases of your SNFO training, this “winding” of the chart will not be accomplished and all heading and airspeed adjustments will be managed while airborne. For the simulator events, no winds will be introduced into the scenario; therefore, “winding” of the chart is not required.

The mission products that shall be prepared for the event, all IAW the VT-10 VNAV Planning Guide, are:

1. Route chart – with preflight wind compensations

2. VNAV jet log – fully annotated. Provide an extra copy for the Instructor.

3. DD 175

Chair-fly the mission as realistically as possible using winds and random deviations. Use a stop watch to not only time yourself, but to get an idea of the pacing of the low level route.

The brief will be covered at the end of the chapter.

603. THE DEPARTURE

For the VNAV events you will be scheduled for a Pre-filed (stereo) route, either IFR or VFR, or simply a "VFR West (East)" departure.

IFR Departure

If taking off on an IFR flight plan, you will execute the departure using the same procedures you did during the INAV flights. In order to execute the low level though, you will have to transition to VFR at some point. To do so, contact the controlling Air Traffic Control (ATC) agency, at or before reaching your IFR clearance limit, and cancel your IFR flight plan. ATC needs to hear the words "cancel IFR" in order to make this happen. A simple call such as, "Pensacola Departure, KATT 6XX, cancel IFR" is sufficient. In response, you should hear something similar to, "Roger KATT 6XX, cancelation received, squawk VFR, frequency change approved."

The decision to transition to VFR is based on many factors. In general, you need to be clear of the Pensacola Class "C", able to maintain VMC, and no longer desiring radar services providing traffic separation. Discuss this decision point in the brief.

As described in the AIM, maintain VFR visibility and cloud clearance separation requirements at all times while operating under VFR. At a minimum, you must be 2000 feet horizontally away from any cloud, 500 feet below and 1000 feet above any cloud or cloud layer, and have 3 statute miles visibility (VBAH – 3512). You must also comply with any minimum weather requirements directed by the TRAWING SIX and VT-10 Standard Operating Procedures (SOP). What about the case where the aircraft is still IMC approaching the clearance limit? An option is to request a descent, to as low as the controller's minimum vectoring altitude (the lowest ATC can legally take you IFR). The voice communication procedures are: "ATC Agency name, KATT 6XX, request descent to **_____** (a known VMC altitude below the cloud layer or "minimum vectoring altitude"). Another option is to request an extension beyond your IFR clearance limit (e.g., TRADR). Using your IFR chart, pick a point beyond the clearance limit that gets you closer to the route entry point (e.g., RAZLE, BRATT, AXSIS). A sample call is, "ATC Agency, KATT 6XX, request clearance to Brookley VOR." Approval makes this your new clearance limit. After acknowledging instructions, comply with the assigned altitude and/or continue to your new clearance limit, as appropriate. Upon reaching VMC, cancel IFR as described above.

VFR Departure

If you are assigned to depart with a VFR flight plan (via the flight schedule) you must prepare for a slightly different execution. First, you will need to consult the TW6 In-flight Guide and brush up on the VFR departure procedures for all four runways. Second, you need to understand

VFR operations in class "C" airspace. You will be assigned a discrete squawk because you are operating under "radar services" as described in the AIM. Therefore, you will follow ATC instructions while in class "C" airspace, but will eventually need to cancel these services once clear of the airspace.

When you depart Sherman Field and climb to altitude (typically 4,500' or 6,500'), you clear the class Charlie airspace when above it at 4200' or beyond the 10 NM ring. Once clear, communicate to ATC that you are clear of the class Charlie, you intend to proceed without their "radar services," and you desire to switch to another frequency (like button 15 for Area 1). In this case, ATC is expecting to hear one of the following phrases: cancel, cancel advisories, cancel radar services, or cancel flight following. An example call to accomplish this is, "*Pensacola departure, KATT 6XX, clear of class Charlie, cancel advisories.*"

Upon canceling IFR or radar services, proceed to your route entry point VFR as briefed. You immediately need to pick up a solid VFR navigational scan, keep track of where you are on your chart, and direct your pilot to point Alpha. As a technique and with time permitting, orient yourself to your visual navigation chart prior to canceling with ATC.

604. PRIOR TO ROUTE ENTRY

There are a number of steps that need to be accomplished before entering the route. The following is a general flow of how the events should unfold, but most of it is not set in stone. Therefore, it is up to the SNFO to accomplish the following steps in whatever order necessary.

HATT Brief

Any time after "canceling" IFR or radar services, immediately provide the IP with a HATT brief. Direct the IP to the desired ***H***eading, an appropriate VFR ***A***ltitude, set the ***T***ransponder (1200), and change the radio to the appropriate ***T***actical frequency (Area Common or VNAV Route Common).

Use descriptive communication to clarify where you would like the IP to fly the aircraft and give some visual cues for use in navigation. The route can follow prominent features (e.g., roads) or DR Nav in straight lines from feature to feature. Keep in mind that you have to be well aware of aircraft position to properly proceed through or around Special Use Airspace (SUAS) and/or class Bravo, Charlie, and Delta airspace. Also, keep in mind where other VFR training aircraft are operating. Continue to navigate visually to the entry point and pass instructions to the IP as you accomplish the remaining tasks.

Contact FSS

Now is a good time to contact the local Flight Service Station (FSS) to get an update of current winds and altimeter settings for the geographical region where you will conduct the flight. As learned during INAVs, be specific as to ***exactly*** what information you are requesting from FSS. Many times, they may ask you for a PIREP. Give one only if you have time in your mission and are prepared to do so. The format for a PIREP is located in the Flight Information Handbook.

Once the weather information has been updated, change the VHF radio frequency to the next one needed for your route of flight. If the new weather information is different from the wind data you gathered before the brief, update your compensations on your chart. The stereo VNAV routes are generally close to many of the airports from where you may be departing. As such, you will not have a great deal of extra time. If time is limited, at least adjust the compensations for the first leg.

Descend

During preflight planning, identify a point over the ground that is approximately 4 minutes, or 12 NM prior to the route entry point to initiate your descent from 10,000' to route altitude. You should have a "no later than" point in mind where you will make your final descent to the route altitude, perform a descent checklist, and an operations checklist prior to your two minute prior call. An example is shown in Figure 6-3.

Set Base Airspeed

Once established at the route altitude, look at the IOAT gauge and decide what ***base airspeed*** to set (Figure 6-2) based on temperature. This is the same process as setting an IAS for a desired TAS in INAVs. Then, apply your wind ***compensation*** to your base airspeed in order to maintain 180 knots groundspeed. At the 2 minute prior call, direct the pilot to set that wind compensated airspeed (unless you are entering the route "un-winded.")

IOAT RANGE	**IAS**
+29ºC and higher	170
+28 ºC and below	175

Figure 6-2 T-6A Airspeed/Temperature Chart for 180 KTAS

2 Minutes Prior

On this pace, it should be time for the 2 minute prior call for Point A. The format for the entry point call will be covered shortly. Through good preflight planning, a visual point on the ground can be chosen to back up the 2 minute prior point (Example in Figure 6-3). Also, 2 minutes prior to any route entry, a call shall be made on VNAV Common (333.3 / UHF Button 18) announcing, *"99, KATT XXX, 2 minutes prior to VNAV X."*

Mach, Squawk, Clock

Approaching the entry point after the 2-minute prior call, double check that the pilot is flying temperature compensated airspeed (***MACH***) with wind compensations applied (if required), cross-check the ***Squawk*** (1200), and give the ***Clock Brief*** (*"at the abeam point of the road intersection at 11 o'clock, 2 miles, we will start the clock with ready, ready, hack")* prior to entering the route.

NOTE

> The Mach, Squawk, and Clock are the items you will review in future training aircraft to develop proper habit patterns and ensure all flight parameters are set for the route entry. This is the same concept as the HATT brief, only jet aircraft will be flying at much greater speeds. MACH is used to accelerate the aircraft to route speed (300, 360, 420 KIAS and higher) which is faster than the allowable speed below 10,000 feet. They can do this, because they will be entering a Military Training Route (MTR) where it is allowed. Squawk will be changed to 4000 on an MTR telling ATC that the aircraft is on an MTR and allowed to exceed the speed limit. The Clock Brief is good crew coordination to get both aircrew clocks started at the same time. The clock brief should include the “when” and “how” you intend to hack the clock.

Entry Method

Begin scanning the area for funneling features that will aid in finding the entry point. Using good descriptive communication, tell the IP exactly what you are looking for and have him help you find it. Be concise! Once you identify the point, give a reference using the clock code method, with 12 o’clock aligned with the nose of the aircraft; “Entry point of painted smoke stacks at 1 o’clock, 5 miles, just on the horizon.” Now you must decide how to enter the route. Weather may have caused a deviation in getting to the route, or you may have to delay getting on the route due to other VNAV traffic. Use either the Direct, Outbound Parallel, or Teardrop methods to get on.

There are three approved methods to enter the low level route:

1. **Direct Entry**. Visually extend the course line backward from the entry point to establish a point a minimum of 3 NM (1 minute) prior. Maneuver to cross that point on course, on airspeed, and on altitude. If necessary, make course corrections (such as the BDHI) inbound to the entry point. With solid preflight planning you may be able to establish yourself on outbound course as early as 6-12 NM prior to your entry point. You should choose a 2 minute prior checkpoint and ensure you fly over (or abeam) it if you can.

2. **Outbound Parallel**. This method is useful when your flight path makes the direct entry impractical. Fly abeam the entry point at a distance approximately equal to one standard rate turn diameter (approximately 2 NM at 180 knots) and fly the reciprocal of the first course for one minute outbound and then turn inbound. At the completion of the turn, the aircraft should be on course and 1 minute prior to the entry point.

3. **Teardrop**. The same thing can be accomplished by tear dropping over the entry point on a heading 30° off the reciprocal heading of the first leg for one minute outbound.

Make course adjustments as necessary. It is recommended, during the outbound portion of maneuvers two and three to maintain 500 feet above the entry altitude with a descent initiated after the inbound turn. Be vigilant for other aircraft attempting to enter the route at the same time, clear over the radio, and give yourself altitude separation as needed.

Because the entry point will be directly underneath the aircraft, you will need to pick a reference point abeam the entry point to start the clock (you can pre-plan this point; however, when you fly the event look outside the aircraft and find the point to use on the ground).

NOTE

Use this abeam point technique anytime a checkpoint is likely to disappear under the nose of the aircraft.

Start the clock when abeam the reference point you briefed, a simple but critical step. Hack the aircraft clock and a personal watch or clock as a backup. Refer to the T-6A NATOPS for the clock’s operating instructions.

605. FLYING THE ROUTE

The basic flow of the route involves a 2 minute prior, mark-on-top, and wings level call at every turnpoint. In between turnpoints, the SNFO will attempt to find their intermediate checkpoints and work through the FACCU process to stay on route centerline and timing.

Figure 6-3 will be used as our example for the rest of this chapter. Assume IOAT reads 31°C and the winds are 045° at 15 knots.

Figure 6-3 Example Route Leg A-B

2 Minutes Prior to Route Entry Call

The format for the call is the same as discussed in Chapter 5. Ensure you are using compensated headings and airspeeds. Work through the example calls using what you have learned in Chapters 4 and 5 (figure 6-3).

"Two minutes prior to Alpha."

"Outbound heading 008."

"Set one eighty."

"Altitude two thousand five hundred."

"The turnpoint is a group of large smokestacks near a westerly bend in the river."

"99, KATT 6XX, 2 minutes prior to VNAV X."

Abbreviated MOT call at the entry point

The priority for this MOT call is the hacking of the clock. A good MOT call for this entry point would be:

SNFO: *"Ready, ready, hack. One, two, three…"*

IP: *"Good hack."*

SNFO: *"Heading zero zero eight. Maintain one eighty."*

Wings Level Call upon Route Entry

As soon as you have completed the entry point MOT call, it is time for the first wings level call. You need to go over the first four items to ensure the pilot is flying the proper heading, airspeed, and altitude, and do your first AFR vs. MCF check:

"Heading zero, zero, eight. Airspeed one eighty. Altitude two thousand five hundred. Fuel, eight hundred and forty total. One hundred and sixty above MCF."

Then, you will need to go over the next four steps. If you got yourself off to a good start, all four items (Turn Analysis, Time Analysis, Update ETA, and Wind Considerations) should all be "not applicable." State this as one fact, then move on to the clock, chart, ground visual scan.

Execution of the Clock, Chart, Ground Scan

Now that you are on the route, begin the continual process of clock, chart, ground to fix your position. Once you do, work through FACCU to get back to the planned course and time.

Use the following format to tell the pilot what to expect on the route. In particular, always include a description guiding the pilot to the point as well as any hazards that might affect safety of the flight.

"In _____ seconds or minutes, there is a ***(brief description)****, _____NM left/right/on course."*

Example

Using Figure 6-3, assume your clock now reads 1+15. Based on the planned ICP at 2+15, you would say:

"In one minute, there is a highway and pipeline intersection one half mile left of course. The road is directly beneath us and the pipeline runs from right to left."

Do not give your IP the preplanned time you expect to see the point. Do the clock math and give him the time "out in front of the aircraft" based on the clock. This way they can be looking at the proper distance out towards the horizon (your IP's eyes are calibrated in time which equals distance to look).

Example

The SNFO sights the underground pipeline off in the distance and follows it toward the aircraft's flight path to see the intersection with the highway off the left side of the aircraft, about halfway down the wing. The aircraft passes directly abeam the intersection at 2+15. What does this tell us?

The aircraft marked 1.0 mile to the right of the ICP, which makes it a half mile right of course. Because the aircraft is now 2 minutes prior to B, the SNFO elects not to make a correction. See if you can compute the proper correction and wind estimate from this information.

2 Minute Prior Call

All TMP calls are now IAW Chapter 5 until the target. Again using figure 6-3, the call would be:

"Two minutes prior to B. Outbound heading zero one five. Airspeed one eighty-five. Altitude two thousand five hundred. Turnpoint is an inferred bridge on course. A limiting feature is a sharp bend in the large river to our right. VR 1021 crosses from right to left."

MOT Call

All MOT calls are fully IAW Chapter 5 until the target.

Example

As our aircraft approaches point B, the SNFO tracks the river from the right across the nose of the aircraft to find the inferred bridge at 11 o'clock. It appears that it will pass down the middle of the left wing, meaning the aircraft will be 1.25 miles right of course at the turnpoint. Since it looks slightly closer to the aircraft than the wingtip, it gets rounded down to 1.0 NM. As the bridge approaches the wingline, the SNFO checks the clock to see 04+19. Adding 3 seconds to it, he records the time at B as 04+22. The SNFO takes one last look at the chart to check the wind compensated heading and airspeed for B to C and then calls:

"Clear right, right zero one five. Time is zero four plus two two. Set airspeed one eighty-five."

Now what would happen had the SNFO not acquired the turnpoint? In this case, there are two options. Since there was a limiting feature available, as the aircraft passed it, the SNFO would MOT at that point. In the absence of a limiting feature, the answer is to ***turn on time***. That means that at 04+26 if the checkpoint was not in sight, the SNFO should have called for the MOT. Remember that DR navigation will get you close, so trust the chart timing, stay close to the route centerline and update your position again as soon as possible.

Here is another option at the MOT. For an aircraft with a zero turn radius assumption such as the T-6A, there exists a possibility to bypass the timing and turn analysis through the use of a second or "double mark-on-top." When turning ***outside*** of the route centerline, the aircraft passes abeam the turnpoint a second time. If the student is proficient enough, a second MOT can be made to note the current time and abeam distance. These numbers can then be corrected for directly, as they already include the deviations due to turnpoint geometry.

Wings Level Call

All remaining wings level calls are IAW Chapter 5.

Example

Continuing with our example, the SNFO checks the instruments as he calls,

"Heading zero-one-five. Airspeed one eighty-five. Altitude two thousand seven hundred. Descend to two thousand five hundred. Fuel is 800 total, 140 above MCF. There is a slight negative trend we need to keep an eye on."

Continuing now with the analysis:

"Turn analysis – I marked one mile right of course and turned 15°. I am still 1 mile right of course so turn right zero-two-five for two minutes. Time in four plus four five, time out six plus four five."

"Time analysis – I was 4 seconds early and one mile to the inside of course. I turned 15°, gaining about 10 seconds. I am now 14 seconds early so slow down for 2+20. Set one sixty-five. Time in five plus zero zero. Time out seven plus two zero."

"ETA stays the same." Refer to Figure 6-4 to see that the corrections will time out prior to the ICP and turnpoint.

"Wind consideration – I was one mile right of course so the apparent wind was 15 knots from the left (Distance X 15 for the 4+22 leg). *However, I was crabbing for 10 from the right so the crosswind is only 5 knots from the left. I was 4 seconds early, so the apparent wind is a 2 knot tailwind. I compensated for a 10 knot headwind, so it will remain 10 knots. The total wind is 330 at 10 knots."*

At this point, the SNFO takes a glance at the clock which says 5+30. Since he has enough time before his corrections time out and his next ICP, he continues the analysis. The SNFO then twists in 330 to the CDI and begins to figure out new compensations.

"New crab is 2° left. Left zero two one (removed the old crab and put in the new one). *New headwind is 5 knots, so set airspeed one fifty-five"* (base airspeed 170, 5 knot headwind, 20 knot correction).

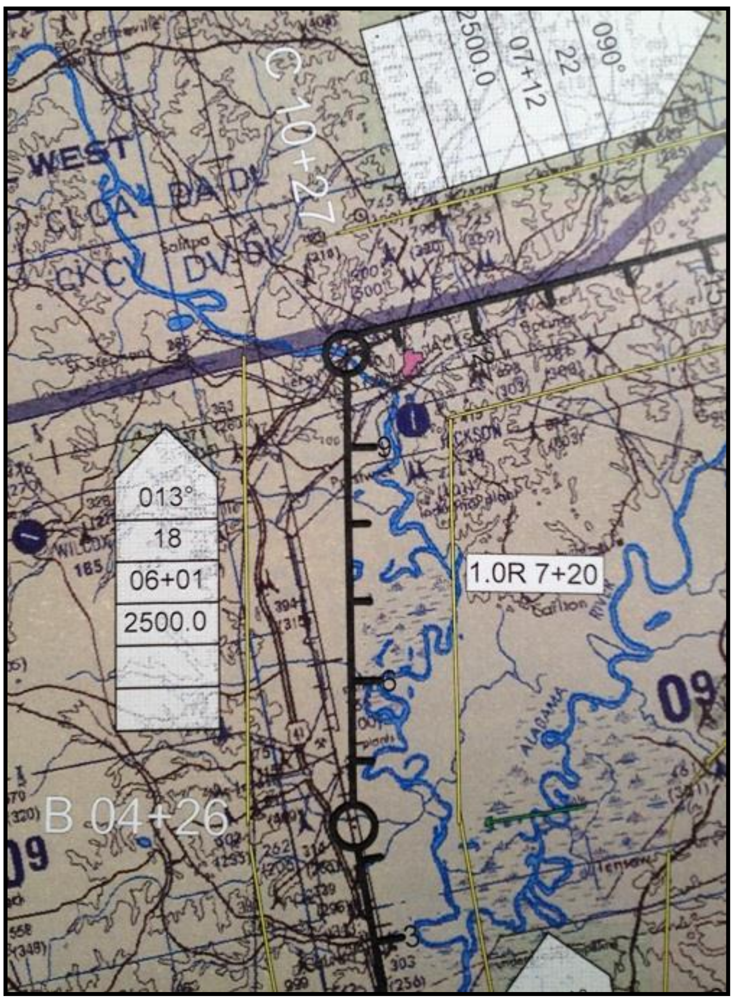

Figure 6-4 Example Route Leg B-C

The SNFO rechecks the clock to see 06+10. He knows the course correction ends soon, but remembers that he has an ICP at 7+20 so he quickly briefs it.

"In one minute there is sharp river bend oriented westerly one mile right of course."

At this time, it is time for the course correction to end.

"New heading zero one one."

The SNFO begins looking out the right half of the cockpit and see the large river. He follows it forward of the aircraft and sees the split that ultimately leads to his sharp river bend. He notices the bend is going to pass directly beneath the aircraft. Since there are no good abeam points available, he asks the IP for a right "wing dip" in order to see the point. As he flies over the ICP he marks the time at 07+15. From here,

"Set speed one seventy-five" (because the timing correction ended).

"I am a mile right of course. Left zero zero one for two minutes. Time in seven plus thirty, time out nine plus thirty. New ETA ten plus two two." (See figure 6-4)

NOTE

> As the SNFO gets more proficient with the procedures, or on long legs, it is acceptable to use unplanned ICPs as well to fix position.

Since the aircraft is nearing a briefed hazard of Jackson Airfield, the SNFO places the Common Traffic Advisory Frequency (CTAF) into the VHF radio to listen for any traffic and then briefs the pilot of the upcoming hazard.

"We are one and a half minutes from Jackson Airfield, which is two miles right of course. The CTAF is in the VHF."

And then at two minutes prior the whole process starts again until we get to the target leg. Practice the TMP, MOT, and wings level calls for turnpoint C.

Hazards

The SNFO should be on the lookout for hazards to flight at all times. These hazards include vertical obstructions, other aircraft in the low altitude environment, crossing low level routes, birds, and charted aerodromes. The consequences of a problem such as a bird strike in the low altitude environment can be very severe due to the potential inability to glide to an emergency field.

You are required at this stage to inform the pilot of hazards to flight following these guidelines:

1. Vertical obstructions within 3 NM and 500 feet of aircraft altitude.

2. All aerodromes within 5 NM of the aircraft's flight path.

3. All birds and aircraft.

4. Crossing/Conflicting low level routes.

For standardization and clarity of description, hazards are described in terms of time ahead of the aircraft and distance. Avoid giving hazards further than two minutes away.

SNFOs should find the CTAF or Tower frequency for any airfield that poses a hazard to the route of flight. The frequency will be put into the VHF no later than the hazard call for that airfield in order to monitor for traffic. If traffic at that airfield sounds like it will cross within 3 NM or 1000' of your position, then the SNFO should make a call announcing the aircraft position relative to the field, altitude, and heading.

Birds on the horizon, in the 11:30-12:30 range, pose the greatest threat of impact. A bird in this zone should be properly called out as "*Bird, right/left/on the nose, level or high*).

Examples

"*In one minute, there is a 1600 foot tower two miles left of course*."

"*In 45 seconds, there will be a small airfield 2 NM left of course*."

"*Bird, 12 o'clock, high"* or *"Bird, on the nose, level*."

"*In two minutes, NAV-3 will be crossing from right to left 500 feet below us*."

Target Leg

At the Initial Point, the call *"99, KATT 6XX, IP Inbound, VNAV X"* shall be made on the VNAV common frequency.

Remember that jungle rules corrections are allowed on the target leg. Once the target is in sight, it is acceptable to home toward it. However, you still want to "hit" the target on time, so don't make unnecessary adjustments.

2 Minutes Prior to the Target

This call is to prepare the crew for the heading, airspeed, and altitude following the route. The call should sound like:

"2 minutes prior to the target. Outbound heading two-two-five, airspeed two forty, altitude four thousand five hundred. The target is a highway overpass with the highway from the left to the right."

MOT at the Target

At the target, first mark the time. Then go right into the required post-route HATT brief to transition the aircraft from the low level route to the recovery portion of the flight. Brief the initial heading, airspeed, and altitude for the recovery. Check the transponder setting for accuracy and then make a radio call on VNAV Common, *"99, KATT 6XX, Off Target, VNAV X."*

There is no wings level call following the target.

606. ROUTE EXIT TO RECOVERY

After hitting the target, initiate the HATT brief. Depending on the requirements of the remainder of the flight, choose a direction that will set the aircraft up for that plan. Maintain VMC, and plan to initially navigate VFR to the destination airfield or briefed area for Aerobatics. This will require the use of your ONC overview chart, or an optional VFR sectional if it is available.

The same rules that applied to navigating to the route VFR apply when navigating from it. In the event that a return to IFR is necessary due to weather or desired for training, the SNFO has a couple options. One is to activate an IFR flight plan that has already been filed and the other is to make a request for IFR from ATC. The latter is known as an "IFR pickup" and differentiation needs to be made between this and *"activating my flight plan on file"* when contacting ATC.

If requesting an IFR pickup, have a game plan for your desired routing all the way to your final destination or until you plan to return to VFR. Plan to coordinate an "IFR pickup" for the arrival routing and approaches required to complete the event. In a busy environment, ATC may deny your request and send you to FSS to file a flight plan airborne.

If weather is a factor, maintain VMC until receiving your IFR clearance. Once IFR, transition to an instrument scan and follow all normal INAV procedures to prepare for and fly the approaches. Make sure to remain clear of any class A, B, C, or D airspace until you have the appropriate clearances to enter.

If you do plan to go back IFR, realize that your distances from the airfields are much closer than they were in INAVs. You are typically within 30-40 NM of the destination airfield, and sometimes much closer! In INAVs, you were retrieving ATIS at 100 NM out. Post-route, there is no time to waste. Get off the route, fully transition over to the recovery game plan and work hard to get ahead of the aircraft.

607. THE BRIEF

Now that all of the procedures have been covered, it is easier to talk about the requirements of the brief. You must have detailed knowledge of the flight plan, the route, all turnpoints and intermediate check points along that route. When arriving at the brief, all of your preflight planning materials need to be filled in completely with the most recent wind information that you can obtain.

Brief according to the VNAV Briefing Guide in each briefing room. Weather, NOTAMS, TFRs, and BASH must still be checked. Remember to specifically check the BASH for the route on www.usahas.com.

When you get to the conduct portion of the brief, explain in detail your plan to depart the airfield and navigate to the route entry point. This should include the point you expect to cancel IFR or radar services, your IFR routing, and VFR navigation game plan to include altitudes, airspeeds, headings, expected visual cues, and any hazards you may fly near (airports, special use airspaces, high traffic areas, etc.). If you plan to fly through a particular airspace, whether a special use or a standard Class C or D, know the frequencies and procedures required to transit it properly. Be sure to base your game plan on the prevailing weather for the day (don’t direct a climb to 6500’ if the weather is overcast at 5200’). Also, brief when you expect to accomplish the remaining procedures before route entry (e.g., contacting FSS, initiating the descent, the 2 minute prior call).

Now you are ready to brief the route. For each leg you must brief the name (i.e., A to B), heading, airspeed, altitude, all hazards, the intermediate checkpoint, and the turnpoint description. Repeat this process for each leg until you reach the target. Attempt to develop a rhythm or cadence and stick to it for each leg. Expect to brief example TMP, MOT, and wings level calls for the route until the instructor is confident in your knowledge and directs you to stop them. At some point, expect the instructor to give you sample deviations to correct and wind problems to work though.

Once you have completed describing the route, you will need to give clear instructions to the IP for your plan to recover the aircraft. Similar to the first portion of the route, brief the expected heading, altitude, airspeed, visual cues, and hazards. If planning to shoot practice approaches and/or fly IFR, brief when you plan to get ATIS and when and how you will call Approach. If the event will require Precision Aerobatics, discuss where and how the maneuvers will be performed. Review the procedures for the approach or the maneuvers you plan to accomplish in aerobatics and be prepared to discuss fuel requirements for each.

608. SUMMARY

This section includes all the actual mechanics of visual low level flight. The next “step” is to put it all together in the T-6A during the actual Navigation sorties! Using the fundamental method explained in this chapter, you will be able to keep the aircraft on time and on course to the target.

For course corrections, if you are a known distance off course, use the standard course correction. This consists of a 10, 20, or 30º change from heading held for intervals of one minute. However, if at an unknown distance from course with a known point in sight (on or closer to course), a BDHI correction is ideal.

To correct back to mission timing, remember, a 20 knot change (10%) corrects six seconds for each minute of correction and a 40 knot change (20%) corrects 12 seconds for each minute. Only a 20 knot (when at least 12 seconds off in time) or a 40 knot (when more than one minute off in time) adjustment is permitted along the route. For the target leg, a 20 knot adjustment for less than 12 seconds, or a 40 knot adjustment for less than one minute are permitted. For Jungle Rules any airspeed correction is permitted with the target in sight (considering minimum acceptable airspeed).

The key to successful low level navigation is planning. The best way to ensure success is to understand the factors which affect the aircraft, and to know the procedures cold. Turnpoint procedures and standard corrections should be second nature before you walk into the brief.

Here are some hints for successful completion of low levels:

Time between your first Navigation flight and this course is deceiving. Spend the night prior "chair-flying" the mission, not drawing the chart. Work all of the exercise problems provided in this chapter. ***STUDY! STUDY! STUDY!***

Fly the route several times from an armchair with a stopwatch running. Come up with a scenario at each checkpoint (e.g., 1/2 NM left of course and 5 seconds late). Practice performing track analysis and applying the appropriate corrections. The UTDs in the simulator building can also be used for practice. The VNAV-1 and VNAV-4 routes can be displayed on the ***Area Map*** screen by activating ***Lines*** and ***Text*** within the ***Symbol Display*** function tab in the right column.

Know the area inside each turnpoint circle well enough to describe it without reference to your chart.

Set up a game plan. Determine beforehand how to set up the low level route entry, where and when to start the descent, where to make required voice communications calls, when to complete checklists, etc. Have a game plan for exiting the route as well. Remember you will be going back to INAV procedures and doing point to points as well as instrument approaches. Pay attention to your Master Curriculum Guide requirements as well.

CR-2 computers are not allowed in the low level environment. After you leave the IFR environment put it away. A CR-2 computer may again be used again on the return leg of the flight.

Use well organized processes CLOCK, CHART, GROUND and FIX, ASSESS, CORRECT, COMPENSATE, AND UPDATE. VNAV flight will tax your brain power. It is easy to get behind, confused by the winds or a correction, or to be “heads down” too much. Your IP can see your helmet and knows when you are working math instead of looking for your point. Be organized and prepared, it will help your visual scan.

Visual navigation combines procedures and art. The more tools you learn and the better the scan you develop, the better you will be able to fly low level routes. Constantly try to learn more and challenge yourself to higher faster standards. Force yourself to look outside!

APPENDIX A
GLOSSARY

A100. NOT APPLICABLE

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APPENDIX B
MISSION EVENT TIMELINE

B100. SAMPLE MISSION PACING DIAGRAM

Figure B-1 provides a visual representation of the flow of events for a typical VNAV mission. Actual flight events may require slight changes to the order to accomplish mission objectives.

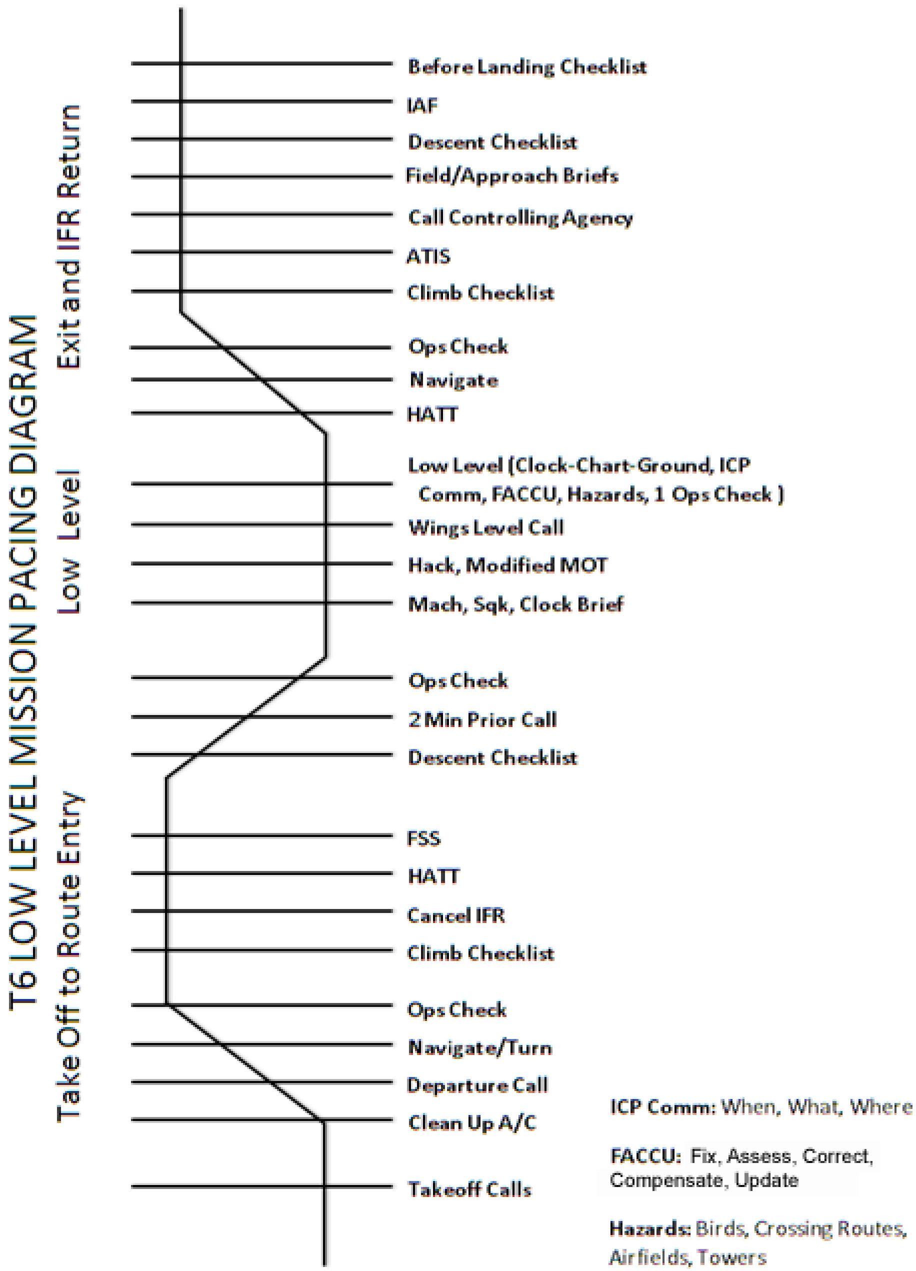

Figure B-1 Sample Mission Pacing Diagram

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APPENDIX C
ACRONYMS

C100. ACRONYMS

1.	A	Alert Area
2.	ADIZ	Air Defense Identification Zones
3.	AGL	Above Ground Level
4.	BDHI	Bearing Distance Heading Indicator
5.	CAI	Computer Assisted Instruction
6.	CHUM	Chart Updating Manual
7.	DME	Distance Measuring Equipment
8.	DR	Dead Reckoning
9.	ECHUM	Electronic CHUM
10.	EHSI	Electronic Horizontal Situation Indicator
11.	DMAAC	Defense Mapping Agency Aerospace Center
12.	EFR	Estimated Fuel Remaining
13.	FLIP	Flight Information Publication
14.	FTI	Flight Training Instruction
15.	GNC	Global Navigation Chart
16.	GPS	Global Positioning System
17.	ICP	Intermediate Checkpoints
18.	IFR	Instrument Flight Rules
19.	INS	Inertial Navigation System
20.	IP	Initial Point
21.	JMPS	Joint Mission Planning System

22.	JNC	Jet Navigation Chart
23.	KIAS	Knots Indicated Airspeed
24.	MC	Magnetic Course
25.	MCF	Mission Completion Fuel
26.	MEF	Maximum Elevation Figure
27.	MOA	Military Operations Area
28.	MSL	Mean Sea Level
29.	MTR	Military Training Route
30.	NGA	National Geospatial-Intelligence Agency
31.	NOTAM	Notice to Airman
32.	ONC	Operational Navigation Chart
33.	P	Prohibited Area
34.	PAT	Peculiar to Aviation Training
35.	R	Restricted Area
36.	SA	Situational Awareness
37.	SAM	Surface-to-Air Missile
38.	SNFO	Student Naval Flight Officer
39.	TACAN	Tactical Air Navigation
40.	TC	True Course
41.	TPC	Tactical Pilotage Chart
42.	UMFO	Undergraduate Military Flight Officer
43.	VFR	Visual Flight Rules
44.	VNAV	Visual Navigation

45.	VOR	VHF Omnidirectional Range
46.	W	Warning Areas

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