NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS **CNATRA P-821 (08-10)**

FLIGHT TRAINING INSTRUCTION

ADVANCED NAVAL FLIGHT OFFICER T–45C

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1. CNATRA P-1212 (Rev. 10-10) PAT, "Flight Training Instruction, Familiarization T-45 Strike" is issued for information, standardization of instruction and guidance to all flight instructors and student aviators within the Naval Air Training Command.

2. This publication shall be used as an explanatory aid to support the T-45 Combined Multi-Service Pilot Training System. 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 1550.6 series.

4. CNATRA P-1212 (01-00) PAT is hereby cancelled and superseded.

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FOR

ADVANCED NAVAL FLIGHT OFFICER

T-45C

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CHAPTER ONE
INSTRUMENT PROCEDURES

100. INTRODUCTION

The importance of a proficient basic instrument scan is paramount in military aviation. Day and night, all weather capability depends on instrument flight proficiency. For this reason, Basic Instruments (BI) is the cornerstone of the advanced syllabus. Actual and simulated flight into Instrument Meteorological Conditions (IMC) will start with SIM events and progress to Radio Instrument (RI) events. Later in the syllabus, section flight procedures in IMC conditions will be introduced.

Contact Instrument events are an important part of the Naval Flight Officer's training. During the course of flying BI events in the simulator, the student will learn to satisfactorily perform all basic transitions from the instrument takeoff to the final approach phase. BI events are intended to improve student knowledge and performance in the following areas:

CHECKLISTS: Improve student skills in accurate and efficient completion of aircraft checklists.

SCAN: Rapidly develop and improve student’s instrument scan.

AIRCRAFT KNOWLEDGE: Increase student’s knowledge of the T-45C aircraft through operation of the aircraft’s systems.

COMMUNICATIONS: Improve student’s radio communication skills by practice of local communication procedures.

COCKPIT RESOURCES: Improve student’s cockpit organizational skills through management of cockpit equipment and controls and kneeboard documents.

CREW COORDINATION: Improve integration of student tasks with pilot actions. Student will gain an appreciation of pilot responsibilities, tasks, and workload.

UNUSUAL ATTITUDES: Develop student’s capability to recognize different types of unusual attitudes as well as provide verbal instructions for correct T-45C unusual attitude recoveries.

SIMULATED FLIGHT: Enhance follow-on Emergency Procedures (EP) and Radio Instrument (RI) simulator instruction by gaining an understanding of the characteristics, capabilities, and limitations of the T-45C Flight Simulator.

101. PHYSIOLOGY OF INSTRUMENT FLIGHT

During flight, the sense of sight is used to determine the aircraft's attitude in relation to the earth's surface. In visual flight conditions, the aircraft’s attitude is determined by reference to the earth's horizon and flight instruments. During instrument flight conditions, when the earth's horizon is not visible, the aircraft’s attitude must be determined by reference to the attitude indicator and other flight instruments.

Under instrument flight conditions, the sense of sight may disagree and conflict with supporting senses, and equilibrium may be lost. When this happens, the pilot is susceptible to spatial disorientation and vertigo. The degree varies with the individual, his proficiency, and conditions that induced it. To recognize and successfully overcome the effects of false sensations that may cause spatial disorientation, it is important to understand the senses affecting a pilot's ability to remain oriented.

The ability to maintain equilibrium and orientation depends on various sensations, or signals, from three sources. These sensations come from the motion-sensing (vestibular) organs of the inner ear; the postural senses of touch, pressure, and tension; and the sense of sight. If one of these sensory sources is lost or impaired, the ability to maintain equilibrium and orientation is reduced. The need for adequate crew rest and proper hydration should never be overlooked; fatigue and dehydration will invariably induce sensory impairment.

Required periodic physiology training exposes the SNFO to the numerous spatial orientation influences essential in flight. A complete review of the sensations of instrument flight may also be found in the NATOPS Instrument Flight Manual.

Effective use of flight instruments to supplant the senses must be preceded by knowledge and confidence. Secondly, interpretation of the combined reports of various instruments is necessary. Attention must not be fixed on one instrument. The pilot must learn to scan the panel and gain an almost instantaneous picture of the situation. An NFO must also learn to develop an efficient scan pattern, which provides the pilot with descriptive information and, when required, enables switching to directive communication should the pilot become disoriented to the point of degrading performance.

Next, it must be recognized that instrument perception is slower than sensory perception. Tests show a visual interpretation of the actual horizon is one-fifth of a second faster than an interpretation using instruments. Recovery from a dive takes one and one-half seconds longer on instruments.

Finally, one must remember that in instrument flight, factors such as fatigue, boredom, and instrument fixation are more likely to occur. To counteract this, the crewmember may occasionally move about in the seat, shake his head, or change cockpit lighting.

102. AIRCRAFT INSTRUMENTATION

AIRCRAFT FLIGHT INSTRUMENTS

Aircraft flight instruments are divided into three categories according to their specific function: control instruments, performance instruments, and position instruments. Except for engine instruments, all primary instrument flight information is presented on either the ADI display or the HSI display. The engine instruments are on the right side of the instrument panel, and the standby instruments, airspeed indicator, altitude display, attitude indicator, and Vertical Speed Indicator (VSI) are located on the left side of the instrument panel. The magnetic compass is located on the canopy bow. Refer to the Forward and Aft Cockpit foldout in the T-45C NATOPS for specific instrument location.

CONTROL INSTRUMENTS

The control instruments enable you to provide a proper combination of pitch, roll, yaw (attitude), and power control to achieve the desired aircraft performance. These instruments include the ADI display, rpm gauge, fuel flow gauge, and the slip indicator.

PERFORMANCE INSTRUMENTS/DISPLAYS

The performance instruments indicate how the aircraft is performing as a result of control changes. These instruments include the airspeed indicator, various heading indicators (magnetic compass, HSI display, and ADI display), vertical speed indicator, angle of attack indicator, clock, and turn needle. Although the HSI is primarily used as a position instrument, in some maneuvers it can be used as a cross-check on aircraft performance.

POSITION INSTRUMENTS

The position instruments convey the aircraft's location in space and will determine what control changes are required to achieve the desired aircraft performance. These instruments include altitude and bearing pointers, TACAN and Waypoint data blocks, Planimetric or Course Deviation Indicator (CDI) course lines, and ILS azimuth and glideslope deviation bars. A course deviation situation steering arrow and the azimuth and glideslope deviation bars are also displayed on the HUD.

ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY

The ADI display is the primary control instrument. It replicates a conventional electromechanical ADI instrument. It provides your primary indication for the aircraft's attitude using the horizon bar, bank pointer, pitch reference scale, and the attitude display. Whenever a deviation from a desired performance is indicated on one of the performance instruments, the correction should be made by referencing the ADI display.

In addition to the typical ADI, the ADI display includes additional flight parameters (Figure 1-1). True airspeed, Angle of Attack (AOA), Mach, G, and peak G are shown digitally on the left-hand side of the display. Indicated airspeed and barometric altitude, trend indicators, and a heading scale are across the top of the display. The digital indicated airspeed has a resolution of one knot. The indicated airspeed trend indicator wiper blade rotates clockwise for increasing airspeeds and counterclockwise for decreasing airspeeds. The airspeed trend scale is graduated in 10-knot increments with multiples of 100 kts at the 12 o'clock position. The digital barometric altitude resolution is 20 ft. The barometric altitude trend indicator wiper blade rotates clockwise for increasing altitude and counterclockwise for decreasing altitude. The altitude trend scale is graduated in 100-ft. increments with multiples of 1,000 ft. at the 12 o'clock position. The heading scale, with heading numbers and scale tick marks, scrolls left or right above a fixed caret. The command heading bug, a vertical line, is referenced to the heading scale. The command heading is referenced to the selected navigational aid unless ILS or no steering is selected. With ILS or no steering selected, the command heading bug location is determined by the heading value set on the HSI display heading option. A digital radar altitude and a vertical

velocity trend indicator are to the right of the display. The vertical velocity scale limits are –2,000 ft./min and 1,500 ft./min.

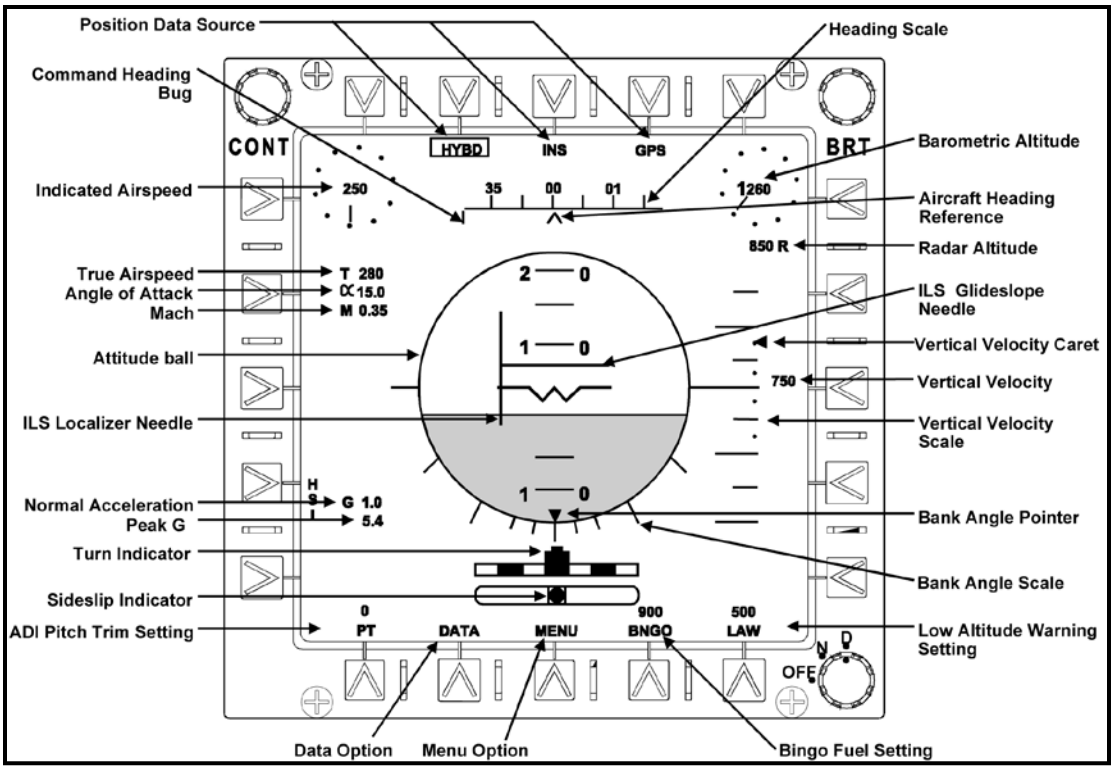


Figure 1-1 Attitude Director Indicator Display

Dashes are located at –2,000, –1,000 and 1,000 ft./min. Tics are located at –750, –250, 250, and 750 ft./min. The digital vertical velocity resolution is at 10 ft./min. The vertical velocity caret is open when vertical velocity exceeds –2,000 or +1,600 ft./min. The digital vertical velocity range is +/- 9,990 ft./min. A turn and slip indicator is at the bottom of the display. The shaded reference areas to the left and right of the shaded center marker represent a +/- 3 degree per second turn rate (standard-rate turn). BNGO fuel and Low Altitude Warning (LAW) height settings are also on the ADI display. The ADI display pitch can be adjusted +/- 5 degrees in relation to the waterline with the “PT” selection. With a valid ILS channel station selected and ILS steering selected, ILS needles are shown. The needles are referenced to the waterline. The localizer and glideslope needles range +/- 1/2 inch from the waterline. Full deflection represents +/- 2.5 degrees of azimuth deviation (with a 5-degree localizer signal) and +/- 0.7 degrees of glideslope deviation. The localizer or glideslope needle will flash when limited. The needles for an invalid input are removed, and an MFD advisory window, “GLIDESLOPE” (Figure 1-2), “LOCALIZER,” or “ILS” will flash on all MFDs. The advisory window will remain on the MFDs until either the REJ button is depressed or the failed data becomes valid again. The ADI display is normally placed on the left MFD to facilitate cross-checking the standby instruments on the left side of the main instrument panel.

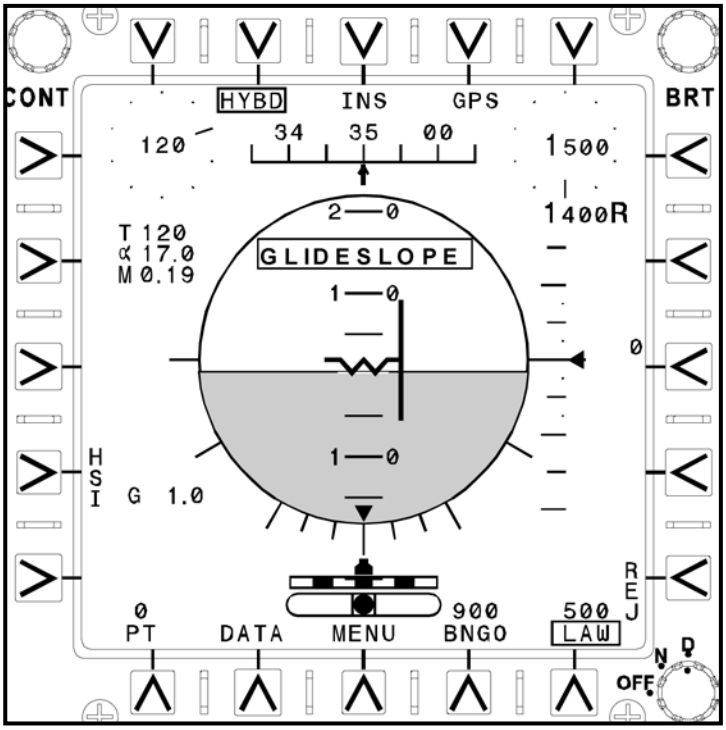


Figure 1-2 Failed ILS Glideslope

HORIZONTAL SITUATION INDICATOR (HSI) DISPLAY

The HSI display performs the course deviation indication function of a conventional electromechanical instrument. With the capabilities of the Global Positioning/Inertial Navigation Assembly (GINA) and display electronic unit (DEU), additional display options and navigation information are available on the HSI display (Figure 1-3).

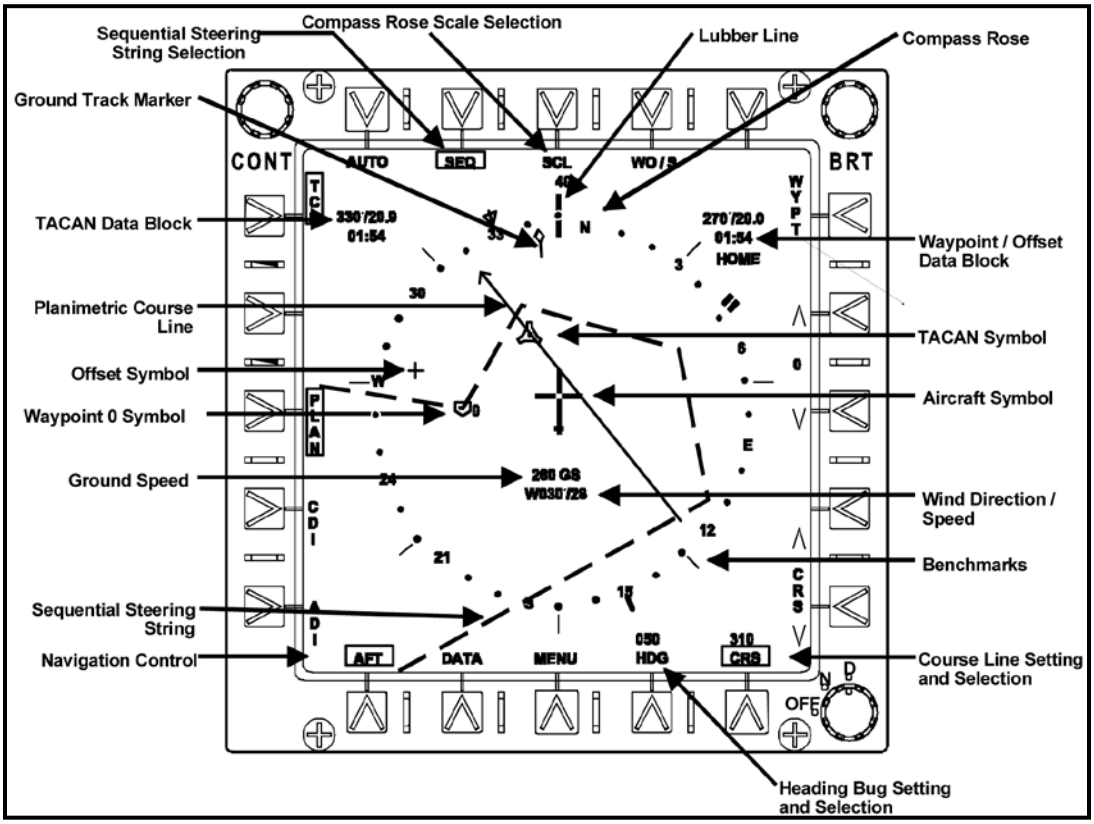


Figure 1-3 Horizontal Situation Display

The aircraft symbol is fixed in the center of the display, heading up. Ground speed and wind direction and speed are below the aircraft symbol. The compass rose rotates according to the aircraft's magnetic heading, referenced to a lubber line and the actual ground-track marker.

Reference benchmarks are spaced every 45 degrees around the periphery of the compass rose. A split heading bug is located on the periphery of the compass rose. The heading bug is positioned according to the heading set with the increment and decrement arrows on the HSI display or by selecting HDG on the HUD Data Entry Panel (DEP) (Figure 1-4) and entering the heading with the number keys. The head and tail of the TACAN bearing pointer are located on the outer edge of the compass rose. The head and tail of the VOR, or waypoint bearing pointer, are located on the inner edge of the compass rose. Only the bearing pointer for the selected steering reference is displayed. In the Course Deviation Indicator (CDI) mode, the inner bar represents deviation from the selected course. If TACAN or VOR is the selected steering, each dot represents 5 degrees of

course deviation. For waypoint or waypoint offset steering, the scale varies based on landing gear position. With the landing gear up, full scale deflection of the inner CDI bar represents a +/- 4.0-nm cross track deviation. With the landing gear down, a full scale deflection represents a +/- 0.3-nm cross track deviation. When ILS is the only steering selected, the CDI deviation scale is relative and must be interpreted by the pilot, depending on the width of the localizer course. If the localizer course is 5 degrees wide, a full scale deflection represents a 2.5-degree deviation. In addition to the typical CDI course line, a planimetric (PLAN) course line can be selected. The planimetric course line is only available for TACAN or waypoint steering. The planimetric course line is drawn through the selected steering symbol (TACAN, waypoint, or waypoint offset). Course intercept angle and deviation are shown by the relationship of the planimetric course line to the aircraft symbol. The course line is only shown when CRS is selected on the HSI display. The course is set with the increment and decrement arrows on the HSI display or by selecting CRS on the HUD data entry panel and entering the course with the number keys. The scale of the compass rose can be set to 10, 20, 40, 80, or 160 nautical miles. TACAN, waypoint, and waypoint offset symbols are shown within the compass rose, relative to their bearing and distance from the aircraft symbol and the selected scale of the compass rose. Digital bearing, slant range distance, and time-to-go are provided for waypoints and valid TACAN stations. Digital bearing is also shown for a valid VOR station. A sequential steering string of two or more waypoints can also be displayed as a dashed line on the HSI display. Navigation control selection is also made on the HSI display indicating either FWD or AFT.

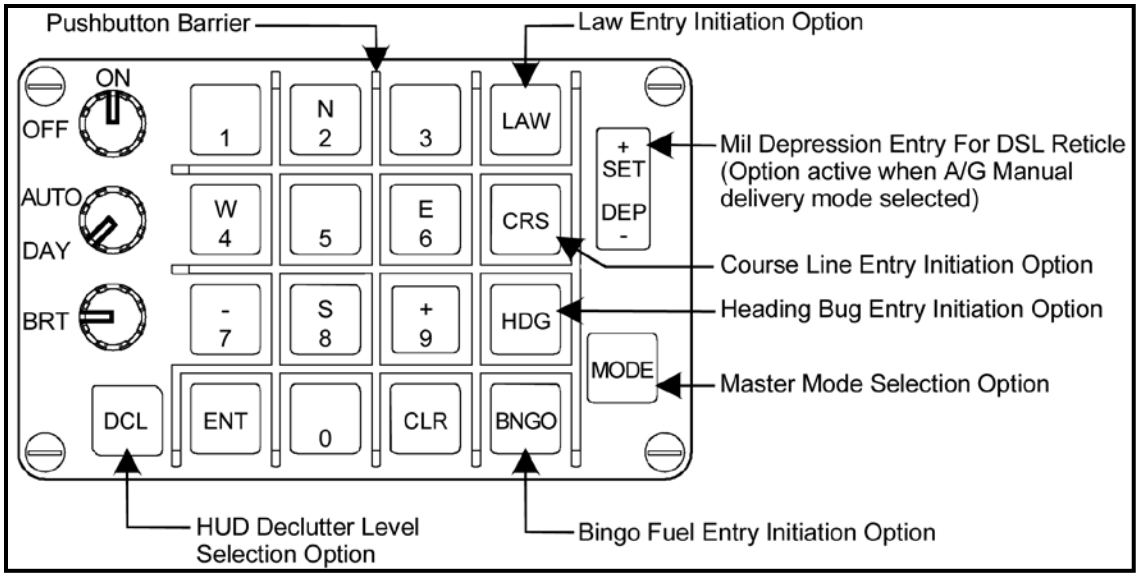


Figure 1-4 Data Entry Panel

FUEL FLOW AND RPM GAUGES

These instruments both provide a reference to the proper control of the aircraft's engine. In many of the different maneuvers, a specified rpm or fuel flow can be set to allow for the proper thrust to complete the maneuver. In some cases, a range can be used to allow for other possible variables. Fuel flow and rpm can also be monitored on the MFD ENGINE page (Figure 1-5).

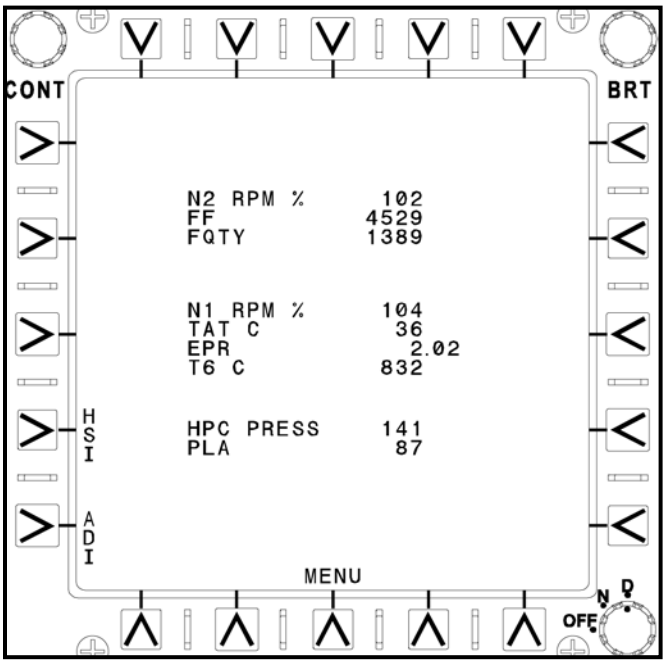


Figure 1-5 MFD Engine Page

STANDBY FLIGHT INSTRUMENTS

The standby instruments include airspeed, altimeter, VSI, turn and slip, and attitude indicators. These instruments are used as a cross-check of multi-function display (MFD) indications if there is a failure of the ADI display or a failure of one or both of the MFDs. The standby performance instruments, airspeed, altimeter, and VSI all have lag. This factor must be accepted as an inherent factor. When the attitude and power are smoothly controlled, the lag factor is negligible, and the indications on the performance instruments will stabilize or change smoothly.

HEAD-UP DISPLAY (HUD)

The head-up display (Figure 1-6) presents control, performance, and position information. The pitch ladder, AOA bracket, course deviation steering needle and dots, and ILS needles are referenced to the velocity vector. These symbols are referenced to the waterline of the aircraft if velocity vector information becomes invalid (velocity vector occulted). The pitch ladder attitude bars are in five-degree increments. Solid attitude bars represent a noseup pitch, and dashed attitude bars represent a nosedown pitch. The attitude bars are angled toward the horizon at one half the pitch attitude. Also, the tips of the attitude bars point toward the horizon. The bank scale

is located at the bottom of the HUD and indicates 0, 5, 15, 30, and 45 degrees of bank. The bank pointer limits and flashes at 47.5 degrees and is occulted at bank angles greater than 90 degrees (the bank scale on the ADI display is different than the bank scale on the HUD). The currently selected steering mode on the HSI display is displayed on the lower right side of the instantaneous field-of-view.

The displayed steering mode acronyms are:

TCN – TACAN

W## – Waypoint (waypoint number)

O## – Waypoint offset (waypoint number)

VOR – VOR

ILS – ILS only

TILS – TACAN and ILS

WILS – Waypoint and ILS

OILS – Waypoint offset and ILS

The distance and time-to-go to the selected steerpoint are displayed when applicable. When TACAN, waypoint, or waypoint offset steering is selected and course line (CRS) is selected on the HSI display, a situation steering arrow and two reference dots are displayed. Orientation of the situation arrow indicates the difference between the aircraft's ground track and the selected course. The position of the arrow in relation to the two dots represents course deviation, commensurate with the CDI scaling on the HSI display. The reference dots are removed when deviation from the selected course is within one degree of TACAN steering. With waypoint or waypoint offset steering selected, the dots are removed when course deviation is less than 0.4 nm and gear up or 0.03 nm and gear down. When ILS needles are shown on the ADI display, they are also displayed on the HUD. The ILS needle scaling is commensurate with the scaling on the ADI display. The needles will flash when limited.

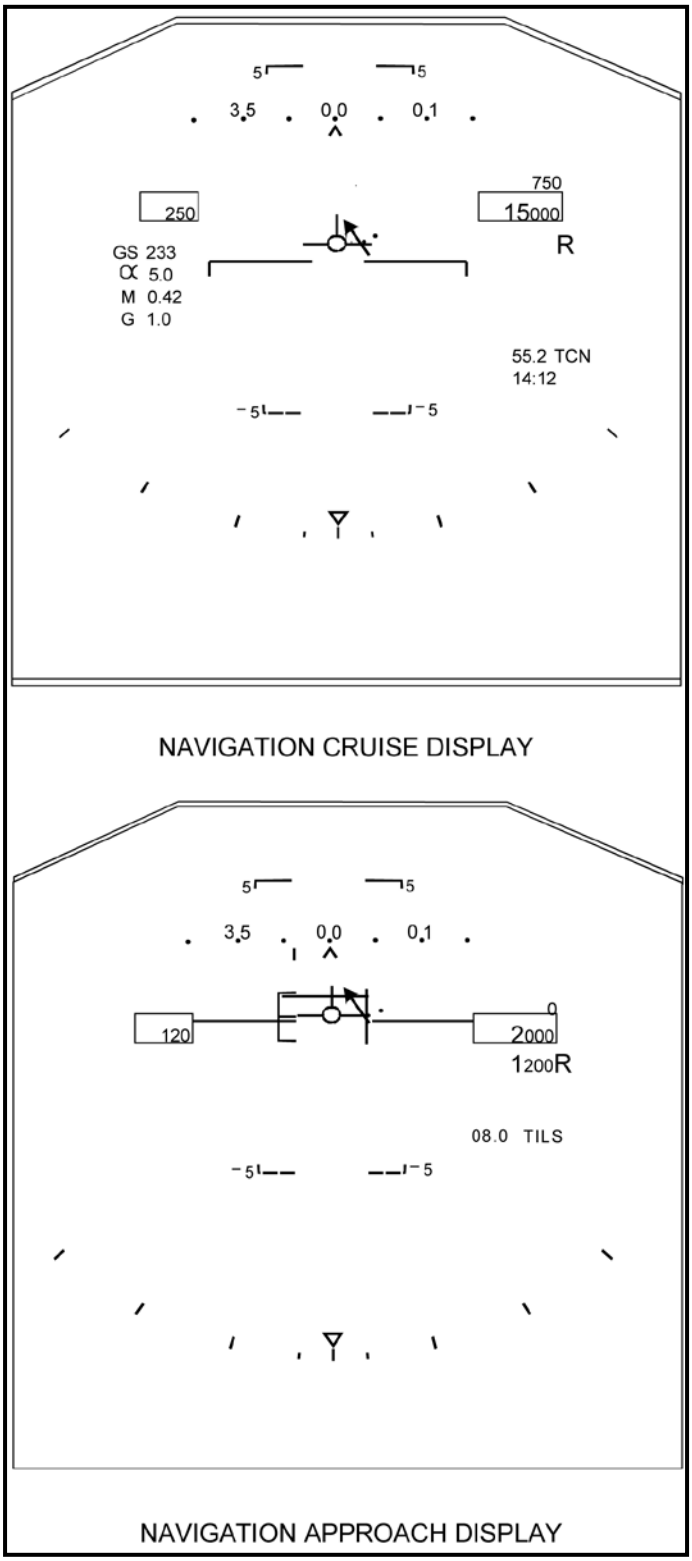


Figure 1-6 Heads-Up Display (HUD)

INSTRUMENT SCAN

During instrument flight, the pilot and NFO must divide their attention between the control, performance, and position instrument/displays. Proper division of attention and the sequence of checking the displays change throughout the various phases of flight. There is no one set order for scanning the instrument/displays; it depends on the type of maneuver to be executed as to which instruments are of prime importance. The NFO should become familiar with the factors to be considered when dividing his or her attention between instrument/displays. The NFO should know the indications that will enable him to identify the correct and incorrect scan techniques. The best way to improve proficiency is through practice. Some common errors in instrument scanning include the following: having no scan pattern plan, omitting a display entirely from the scan, fixating on a single or a few display indications, or misusing a display indication.

SCAN TECHNIQUE

A major factor influencing scan technique is the characteristic manner in which instruments respond to attitude and power changes. Because of signal filtering, raw data processing, and display time, there is an inherent lag in a digital display. The lag will not appreciably affect the tolerances within which the pilot controls the aircraft; however, at times, a slight unavoidable delay in knowing the results of attitude and/or power changes will occur.

For every maneuver, the ADI display is the primary reference that should be scanned most frequently. The majority of your pilot's time will be spent on the control of the aircraft attitude by referencing the ADI display, supported by the control instruments. The remainder of your pilot's time will be spent confirming the desired performance and position by quickly scanning those displays.

GROUND PROCEDURES

Prior to taking off on an instrument flight, you must ensure that the instruments/displays, navigation equipment, radios, aircraft lighting, and the hood are in proper operational condition.

INSTRUMENT CHECKLIST

Before each IFR flight, ensure that all the instruments/displays, communications gear, and navigation equipment are in proper operating order by completing the instrument checklist in NATOPS, Chapter 19, reprinted below. Check the following list of equipment while in the chocks, prior to taxi.

1. Check all communications and navigation equipment for correct operation.

2. Set navigation equipment to local station.

3. Check cockpit lighting, if necessary, and set as low as possible in order to retain night vision. Adjust the kneeboard lights for use in reading approach plates, charts, kneeboard cards, etc.

4. Vertical Speed Indicator (VSI) – The VSI on the ADI display is set to zero with weight-on-wheels. Check the standby VSI for ZERO (note error if not zero).

5. Airspeed indication – Minimum airspeed indication on the ADI display is 50 kts. Check standby airspeed indicator – ZERO.

6. ADI display – Adjust the ADI display pitch with the pitch trim selection on the ADI display (+/- 5 degrees); ensure waterline is on the horizon. Adjust the standby AI; ensure waterline is on the horizon.

7. Altimeter – Set the standby altimeter to field barometric pressure. Note the barometric altitude on the ADI display. (Note error if not equal to field height. The aircraft is down for IFR flight if the error exceeds +/- 75 ft.). ADI display altitude is based on the barometric altimeter setting on the standby altimeter.

8. Clock – Set and running.

9. Standby compass – Swings freely, fluid full.

10. HUD, HSI display, and ADI display heading indications – Check for proper operation while taxiing.

11. Check turn needle and ball for proper function during turns while taxiing.

LOW ALTITUDE WARNING (LAW)

Procedures for low altitude warning usage are outlined:

1. Takeoff - The LAW is set to 200-ft. for low altitude warning during climbout.

2. Enroute - The LAW is set at 5,000 ft. (platform), if above 5,000 ft. Once the LAW Tone is tested descending through 5000’ AGL, the LAW will be set for 1000’ AGL or 2000’ AGL if in mountainous terrain.

3. Penetration - During penetrations, the LAW advisory shall be set at 5,000 ft. (platform) so the LAW advisory will serve as a warning to break the rate of descent.

4. Approach - Set the LAW to Height-Above-Touchdown (HAT) for precision approaches and 10% below HAT for non-precision approaches. On the approach LAW should be reset at glideslope intercept for precision approaches and at the FAF for non-precision approaches.

5. Section Approach – Set the LAW to 10% below HAA (Height-Above-Airport).

6. VFR Pattern - At the initial, the LAW will be set to 380’ AGL to correspond to the 45º position in the VFR landing pattern.

NOTE

The only time the LAW should sound is at Platform and passing through HAT / "45". At intermediate altitudes, the LAW should be reset so as not to sound passing through the previous altitude setting. NFSs will report to IP any time the LAW setting is changed. In addition, any time the LAW sounds, the NFS will report the reason as to why and the subsequent LAW setting. In addition, NFSs will not utilize the REJ button to silence the LAW Warning.

Cockpit Lighting

When preparing for a night flight, set the cockpit lighting as low as possible to safeguard your night vision and reduce glare on the canopy while still enabling you to see your instruments. You should use a white lens in your flashlight for a night preflight (to detect hydraulic fluid leaks). Once in the cockpit, put a diffuser lens over the flashlight to reduce its intensity.

103. BASIC INSTRUMENT MANEUVERS

Unusual Attitudes

An unusual attitude is any aircraft attitude you encounter inadvertently. It may result from inattention to scan, instrument failure, pilot vertigo/temporary blindness, turbulence, or a combination of factors. A key skill for any NFO is to be able to verbalize to his or her pilot how to maneuver the jet to return to a safe flight regime.

There are several general rules that apply to all unusual attitude recoveries. First, the pilot must neutralize the flight controls (center the stick and rudder pedals). Second, you must be able to analyze and evaluate the situation before initiating a recovery. Third, if your aircraft is in a dive, you must tell your pilot to reduce power and, if required, extend the speedbrakes to aid in airspeed control, then roll the aircraft in the shortest direction to wings level. Fourth, when nose-high, hold your wing position while adding Military-Rated Thrust (MRT) and retracting the speedbrakes until the nose is below the horizon and airspeed reaches 150 (Knots Indicated Airspeed) KIAS.

General procedures:

- Controls: Neutralize
- Attitude: Analyze and evaluate to determine best recovery
- Airspeed: Limit in dives
- Bank: Eliminate when nose-low; hold constant when nose-high

Nose-High Recovery

Your primary concern when recovering from a nose-high unusual attitude is to maintain the AOA between 5 and 10 units. At slow speeds, very slight back stick pressure will cause a rapid increase in the AOA. Additionally, uncoordinated aileron and rudder inputs at slow speeds can introduce enough adverse yaw and increased AOA on the rising wing to cause a departure from controlled flight.

Voice procedures:

Upright

1. "Throttle – MRT; speedbrakes – IN"
2. "Maintain 5–10 Units"
3. Once nose falls through the horizon AND airspeed is above 150 knots…
4. "Roll right/left" (to nearest horizon)
5. "Stop roll"
6. "Pull not to exceed limits"
7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

Inverted

1. "Throttle – MRT; speedbrakes – IN"
2. "Slight Pull"
3. Once nose falls through the horizon AND airspeed is above 150 knots…
4. "Roll right/left" (to nearest horizon)
5. "Stop roll"
6. "Pull not to exceed limits"
7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

Nose Low Recovery

Recognize a nose-low unusual attitude by a nose-low indication on the ADI display and/or standby AI, accompanied by increasing airspeed and decreasing altitude. Once again, your pilot

should neutralize the controls and then you will analyze the performance and attitude instruments to determine the best recovery.

With your airspeed above 150 KIAS, retard the throttle to idle in order to control airspeed and to minimize the loss of altitude. If airspeed is rapidly increasing, extend the speedbrakes as necessary. Either or both of these procedures are used to control airspeed and altitude loss. Roll the aircraft to wings level in the shortest direction and smoothly pull the nose up to the horizon. Do not attempt to raise the nose and roll wings level at the same time (a “rolling pullout”) because this can overstress the aircraft. Complete the recovery by readjusting the throttle for level flight.

Nose-low recovery procedures:

1. Controls: Neutralize

2. Attitude: Analyze and evaluate

3. Throttle: Retard to idle with airspeed above 150 KIAS

4. Speedbrakes: Extend (as required) if airspeed is rapidly increasing

5. Wings: Roll level in shortest direction to horizon

6. Nose: Pull to horizon

7. Throttle: Adjust for level flight

Voice Procedures:

1. “Throttle – Idle”

2. “Speedbrakes – OUT”

3. “Roll right/left”

4. “Stop Roll”

5. “Pull not to exceed limits”

6. “Power up, Speedbrakes – IN”

7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

104. GENERAL COMMUNICATION PROCEDURES

You may have heard the old adage covering flight priorities, “aviate, navigate, communicate.” The message is, of course, that first you take care of flying the aircraft, then you attend to

keeping the airplane at the correct point in three-dimensional space, and finally, you worry about talking to others. There certainly is good sense in that set of priorities, but simply because communication is last on the list does not relegate it to insignificance.

When flying on an IFR flight plan, you will be in constant contact with various Air Traffic Control (ATC) facilities from before takeoff until after landing. To operate successfully within the traffic control system, you must be thoroughly familiar with the responsibilities and capabilities of these control facilities. Although you must comply with controller instructions, it is your responsibility to follow them intelligently, not blindly. Always be sure that you understand the controller's intentions and that he or she understands your needs.

General ATC procedures will be discussed later in this FTI, each addressed as it normally occurs in each phase of flight.

NAVIGATION AND COMMUNICATION COCKPIT MANAGEMENT

MULTIPLE NAVAID MANAGEMENT

Use TACAN, VOR/ILS, and waypoints to navigate airways and maintain orientation at airfields. Enroute, navigate primarily off the applicable TACAN or waypoint and set the other navigation resource(s) to the next station or waypoint ahead. During ILS vectors at the field, select TACAN and ILS steering. TACAN course deviation is displayed on the HSI display, and ILS steering is displayed on the ADI display. If required, change from TACAN to ILS DME frequency on the base leg. During the approach phase, consider selecting NAVAIDs so one backs up another in case of failure. For example, if on HI TACAN, penetration approach and TACAN bearing fails, have ILS in VOR to fly ILS or localizer as backup.

TWO-RADIO MANAGEMENT

Managed effectively, two radios can add convenience. However, avoid the confusion of listening to two radios at once. For example, if unable to listen to ATIS on COMM 2 (Aux) for the destination airfield while still monitoring ATC on COMM 1 (Pri) you may turn down COMM 1 or deselect it entirely. To do this you must inform the pilot he is responsible for COMM 1 communications. Once complete with ATIS, reselect or turn up COMM 1 and inform the pilot you have COMM 1.

Start by briefing the communication plan before the hop. To the max extent possible COMM 1 will be used exclusively for ATC (Clearance, Ground, Tower, Departure/Approach, and Center) communication. COMM 2 will be used for Base frequency, ATIS at the destination airfield, TAC Freq. (Section/Division), and/or any other necessary frequency unrelated to ATC.

IFR VOICE PROCEDURES

REPORTS THAT ARE MADE AT ALL TIMES (RADAR AND NON-RADAR)

- When vacating any previously assigned altitude or flight level for a newly assigned altitude or flight level

- When an altitude change will be made if operating on a clearance specifying "VFR ON TOP" (Below 18,000 ft. MSL or above FL600)

- When unable to descend or climb at a rate of at least 500 ft. per minute

- When an approach has been missed (Include a request for specific action, i.e., to alternate airport, another approach, etc.)

- Change in the average true airspeed (at cruising altitude) when it varies by 5 percent or 10 kts (whichever is greater) from that filed in the flight plan

- Time and altitude arriving at a holding fix or point which cleared

- When leaving any holding fix or point

NOTE

The reports in subparagraphs above may be omitted by pilots of aircraft involved in instrument training at military terminal area facilities when radar service is provided.

- Any loss of navigational capability such as VOR, TACAN, ADF, or INS; complete or partial loss of ILS capability; or impairment of air/ground communications capability. Reports should include aircraft (identification), (equipment effected), (degree to which the capability to operate under IFR in the ATC system is impaired), and (the nature/extent of assistance desired from ATC).

NOTE

Other equipment installed in an aircraft that may effectively impair safety and/or the ability to operate under IFR. If such equipment (e.g., airborne weather radar) malfunctions and in the pilots judgment either safety or IFR capabilities are affected, reports should be made.

- Any information relating to safety of flight

- When encountering weather conditions that have not been forecast or hazardous conditions that have been forecast, you are expected to forward a report of such weather to ATC and, time permitting, to FSS or METRO.

NOTE

The ATC controlling agency should be informed anytime weather conditions on an IFR approach differ from the latest observation or anytime a wind shear or (microburst) is encountered on departure or approach.

- Beginning and end of a direct route (off airway) between two navigational points or fixes regardless of altitude or flight level including when operating on an ATC clearance specifying VFR ON TOP. Additionally, if a pilot is handed off while in transit on a direct leg, state present position to new controller on initial contact.

- When unable to comply with an ATC clearance as given

REPORTS SPECIFIC TO RADAR ENVIRONMENT

When operating in a radar environment and no position is required, on initial contact, pilots should advise controllers of their altitudes preceded by the word “level,” “climbing,” or “descending” and provide the present vacating altitude, if applicable, and the final altitude. Also, when on other than published routes, pilots should include the present navigational position on initial contact with each air traffic controller.

NOTE

Pilots will comply with all specific ATC-requested reports during a given flight regardless of environment (radar or non-radar).

REPORTS SPECIFIC TO NON-RADAR ENVIRONMENT

When radar contact has not been established by initial handoff:

- Initial contact **not at a fix** – Report will include “ATC (name), aircraft (identification), estimating (to the next identifiable published fix or reporting point and time), (descending, climbing, or maintaining altitude or flight level).”

- Initial contact **at a fix** – Report will consist of a courtesy call only “ATC (name), aircraft (identification), and (position).”

NOTE

If ATC states "Roger" and does not state "Go ahead," then no additional information is required at this time. Another courtesy call shall be made once the aircraft has reached the next designated reporting point (solid triangles, low altitude structure). ***(There are no compulsory reporting points in the high altitude structure.)***

If ATC states "Go ahead," then a full position report is required.

- Position report includes (position), (time), (altitude), (next compulsory reporting point), (planned time to that point), and (next compulsory reporting point). (P.T.A.P.T.P.)

NOTE

If radar contact is established or has been reestablished once lost along the route, pilots should discontinue position reports over designated reporting points in the low altitude structure. Pilots should resume normal non-radar position reporting when ATC advises "Radar Contact Lost" or "Radar Service Terminated."

- When leaving a final approach fix inbound on final approach (non-precision approach) or when leaving the outer marker or fix used in lieu of the outer marker inbound on final approach (precision approach)

NOTE

OPNAVINST 3710.7 requires gear down report be made to the controlling agency by the final approach fix.

- When a corrected ETA at any time becomes apparent that an estimate, as previously submitted, is in error in excess of three minutes

CHANGE OF FLIGHT PLAN

Three voice procedures are used when changing your flight plan. Each procedure addresses a different change to your flight plan and contains different content to be delivered to ATC in a specific sequence. The categories are:

- Change of route or destination – 13 items
- Change from VFR to IFR only – 7 items
- Change of ETA by more than 30 minutes – 4 items

The specific items and sequence are found on the inside back cover of the IFR Supplement, which should be used when delivering an in-flight change of flight plan.

NOTE

Aircrew should request a frequency change for a change in flight plan from the ATC controlling agency. Normally, the change is given to an FSS facility. However, if the ATC controller handling you is not too busy, he will often copy the change.

105. INSTRUMENT FLIGHT PLANNING

Flight planning requires you to understand the planning process along with the associated documents needed to manage a cross-country flight. Before you can prepare a flight plan, you must gather accurate and complete weather and route information for your intended flight.

FACILITY REQUIREMENTS

When planning a flight, be sure to take into account the facilities and equipment available at your destination and alternates. Those airports must have an adequate runway and the equipment required for aircraft servicing. Especially, you need to determine before departing for an unfamiliar field that (1) the runway is of adequate length and properly surfaced, (2) fuel is available at the proper grade IAW NATOPS, and (3) if you are going to a civilian field that has contract fuel, it will accept a government fuel card. Additionally, you should always determine if your destination is PPR (prior permission required).

ROUTE AND ALTITUDE

You must give primary consideration to enroute weather and winds when planning a flight. You will normally want to use the most direct route at the most favorable altitude for your fuel requirements.

ALTERNATE

You are required to plan for an alternate anytime your destination is forecast to be below a 3,000-ft. ceiling and 3-mile visibility during the period from one hour prior to and one hour after your ETA. If your destination is forecast to be below published minimums, then your alternate must be above 3,000-3. If your destination is between published minimums and 3,000-3, your alternate must be forecast to be 300-1 above published minimums for a non-precision approach or 200-1/2 above published minimums for a precision approach. Check alternate weather for the time you would arrive there and not for the ETA at your destination. Refer to Figure 1-7 for single pilot restrictions.

NOTE

CNATRA regulations require that you always plan an alternate.

DESTINATION WEATHER ETA plus and minus one (1) hour	ALTERNATE WEATHER ETA plus and minus one (1) hour		
0-0 up to but not including published minimums	3,000-3 or better		
Published minimums up to but not including 3,000-3 (single-piloted absolute minimums 200-1/2)	NON-PRECISION	PRECISION	
		ILS	PAR
	*Published minimums plus 300-1	Published minimums plus 200-1/2	*Published minimums plus 200-1/2
3,000-3 or better	No alternate required		

*In the case of single-piloted or other aircraft with only one operable UHF/VHF transceiver, radar approach minimums may not be used as the basis for selection of an alternate airfield.

Figure 1-7 IFR Filing Criteria

FILING MINIMUMS

When filing an IFR flight plan, base your weather requirement on the existing weather at your point of departure and the forecast weather at your destination and alternate from one hour before to one hour after your ETA. Figure 1-7 outlines the weather criteria to follow when selecting an alternate for an IFR flight.

The following are filing criteria for your destination:

- Single-piloted aircraft (T-45C) absolute minimums are 200-1/2.
- Use minimums for instrument approach to probable runway based on forecast surface winds.
- Use the lowest minimums for any approach you and your aircraft are equipped to fly.

For single-piloted aircraft, you may not commence an instrument approach if the weather is below the minimums published for your planned approach unless you do not intend to land. However, if you have commenced the approach prior to the weather being reported below minimums, you have the option of continuing down to the published minimums for that approach.

FUEL REQUIREMENTS

Fuel requirements are a chief concern in planning for a flight. In addition to having enough fuel for the route, you must also account for all the fuel you will use from engine start to the approach at your destination. On top of this, you will have to include the required amount of reserve fuel

and the fuel you will need from destination to alternate (if required) under various circumstances, including a divert at enroute altitude, at the destination IAF altitude, or from a missed approach at the destination. Additionally, you must be prepared for unusual occurrences such as unforecasted weather enroute.

TAKEOFF MINIMUMS

Special Instrument Rating

- No takeoff ceiling or visibility limits apply.
- Takeoff dependent on judgment of pilot and urgency of flight.

Standard Instrument Rating

- Lowest non-precision minimums for runway in use but not lower than 300-1.
- If runway has a precision approach, takeoff is permitted to precision minimums or 200-1/2, whichever is higher.

Use the STANDARD T-45C FUEL PLANNING DATA chart (Figure 1-8) to determine your fuel requirements for a flight.

OPNAVINST 3710.7 and CNATRA cross-country instructions set policy for minimum fuel requirements. Local directives may impose further fuel requirements for your cross-country flights, and the situation may dictate that you need to plan for more reserve fuel than the minimum required in the event of higher winds, worse weather, increased distance to a suitable alternate, or other unusual circumstances.

STANDARD T-45C FUEL PLANNING DATA

Based on T-45C NATOPS flight manual. Actual performance will vary with nonstandard temperature, winds, and varying gross weights. For initial planning only.

Total usable fuel	2938 lbs
Start/Taxi/Takeoff	200
Penetration approach	250
GCA	250
Reserve (20 min @ 10,000 FT MSL)	300

LOW LEVEL

360 KGS, 12K GW = 6.6 lbs/NM and 2,375 PPH
300 KGS, 12K GW = 5.0 lbs/NM and 1500 PPH

JP-4 = 6.5 lbs/Gal **JP-5 = 6.8 lbs/Gal** **JP-8 = 6.7 lbs/Gal**

CLIMB OUT (Using climb schedule: 250 KIAS to 10K, 300 KIAS to intercept .72 IMN)

ALTITUDE	KIAS	NM	TIME	FUEL USED
5,000	250	04	0+01	60 lbs
10,000	250	10	0+02	120
15,000	300	20	0+04	190
20,000	300	28	0+06	260
25,000	292/.72	38	0+08	360
30,000	263/.72	53	0+10	440
35,000	235/.72	70	0+12	540
40,000	209/.72	80	0+16	600

ENROUTE

ALTITUDE	#/NM	IMN	CAS	#/HR	TAS
5,000	5.21	.43	260	1460	280
10,000	4.72	.45	250	1345	285
15,000	4.08	.49	245	1245	305
20,000	3.69	.52	240	1180	320
25,000	3.46	.56	230	1160	335
30,000	3.24	.61	225	1165	360
35,000	2.90	.65	220	1090	375
40,000	2.84	.68	200	1110	390

DESCENT

ALTITUDE	KIAS	NM	TIME	FUEL USED
5,000	195	12	0+03	25 lbs
10,000	195	28	0+07	80
15,000	195	39	0+10	90
20,000	195	53	0+14	125
25,000	195	68	0+17	150
30,000	195	85	0+21	175
35,000	195	100	0+24	210
40,000	195	116	0+26	225

OPTIMUM ALTITUDE and SPEED

GROSS WEIGHT	IMN	ALT	#/NM
13,000	.68	36,800 ft	3.08
12,000	.68	38,400 ft	2.86
11,000	.68	39,600 ft	2.63

Figure 1-8 T-45C Fuel Card

106. FLIGHT PROCEDURES

This section of the FTI discusses contact instrument flight procedures in sequence by phase of flight.

DEPARTURE PHASE

The departure phase of instrument flight includes that portion of your flight occurring from takeoff to level off at your enroute altitude and requires specific communication and standard instrument departure procedures.

DEPARTURE COMMUNICATION PROCEDURES

In your initial communication with clearance delivery, you should state your aircraft's identification, location on the airport, type of operation planned (VFR or IFR), point of first intended landing, and request (i.e., clearance on request). If no delay is expected, you should receive your clearance within 30 minutes of filing your flight plan.

Your IFR clearance should contain the following information in order:

Aircraft identification
Clearance limit
Departure instructions or SID
Route of flight
Altitude
Special information, including departure frequency and IFF code

You should not accept a clearance if it has a clearance limit short of your destination, an altitude not in the filed route structure, or an altitude at which sufficient fuel reserves would not be available, unless you receive an expected further clearance (EFC) time or expected higher (suitable) altitude, as appropriate.

STANDARD INSTRUMENT DEPARTURE (SID)

The standard instrument departure is designed to expedite traffic from airfields and provide a set transition from takeoff to the enroute structure, while ensuring adequate vertical and horizontal aircraft separation. The two types of SIDs are pilot nav (Figure 1-9) and vector (Figure 1-10).

Procedures – SID preflight and pre-takeoff preparation:

1. Identify frequencies used by ATC and ensure compatibility with communication equipment.

2. Determine if your aircraft's performance is adequate to adhere to all restrictions.

3. Identify routes, altitude, and specific restrictions.

NOTE

When accepting a SID, you must comply with all requirements and restrictions unless ATC amends it.

Pilot Nav

For a pilot nav SID, you will use a pre-published route that supplies headings, altitudes, and reporting points for the transition from takeoff to the enroute structure. ATC can issue amendments to initial clearance anytime action is necessary to avoid conflict between aircraft. When a SID is changed, confirm what part of the SID is still in effect. If ATC desires to reinstate a canceled SID, departure control must state portion of routing that applies and restate altitude restrictions. The card is divided into two sections, with a pictorial representation on top and a textual description of the departure procedures on the bottom (Figure 1-9).

When performing a pilot nav SID, you must comply with the instructions published on the SID plate. Normally, you will be assigned the SID as part of your clearance and receive no further departure instructions. The pilot nav SID has distinct advantages: it requires a minimum of controller time and sorts departing aircraft by initial route. On the other hand, the pre-published format of the pilot nav SID cannot adapt to changing weather or traffic conditions.

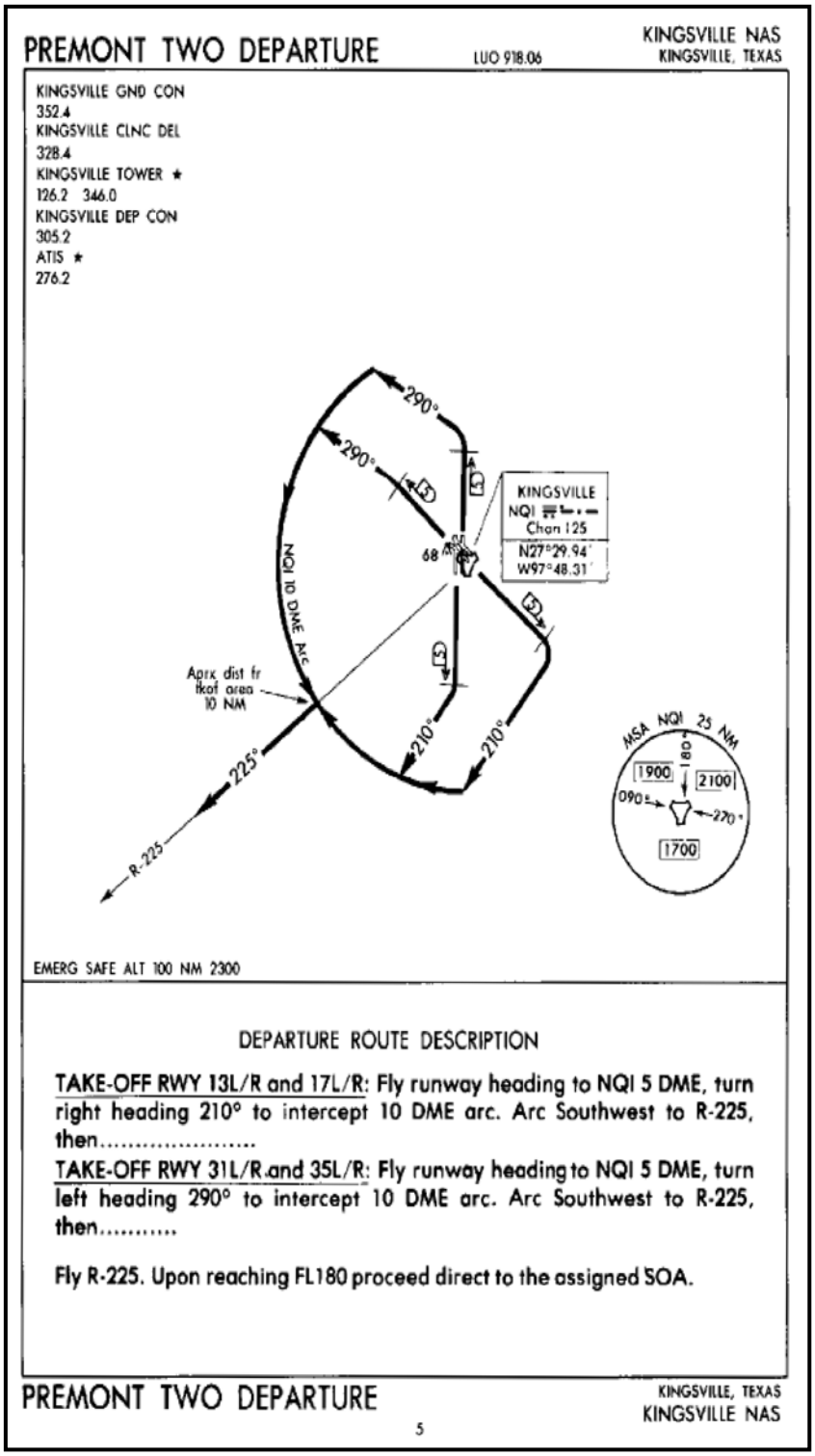


Figure 1-9 Standard Instrument Departure (SID)

Vector

A vector SID is more flexible than a pilot nav SID, but at the cost of being more labor-intensive for the controller. In this type of SID, you will be given radar vectors and altitudes by the controller, who will constantly monitor your position (Figure 1-10).

Because the vector SID requires the active participation of the controller, the amount of radio traffic between you and the controller will be significant. You must acknowledge all radio calls; repeat all headings, altitudes, and altimeter settings; and promptly comply with any instructions.

While a vector SID makes more demands on the controller than does a pilot nav SID, it also provides the controller more flexibility in dealing with changing weather or traffic conditions or with temporary restrictions. Consider the SID canceled if the aircraft is vectored or cleared off the SID (a specified heading), unless ATC adds “expect to resume the SID” or otherwise indicates the deviation is temporary.

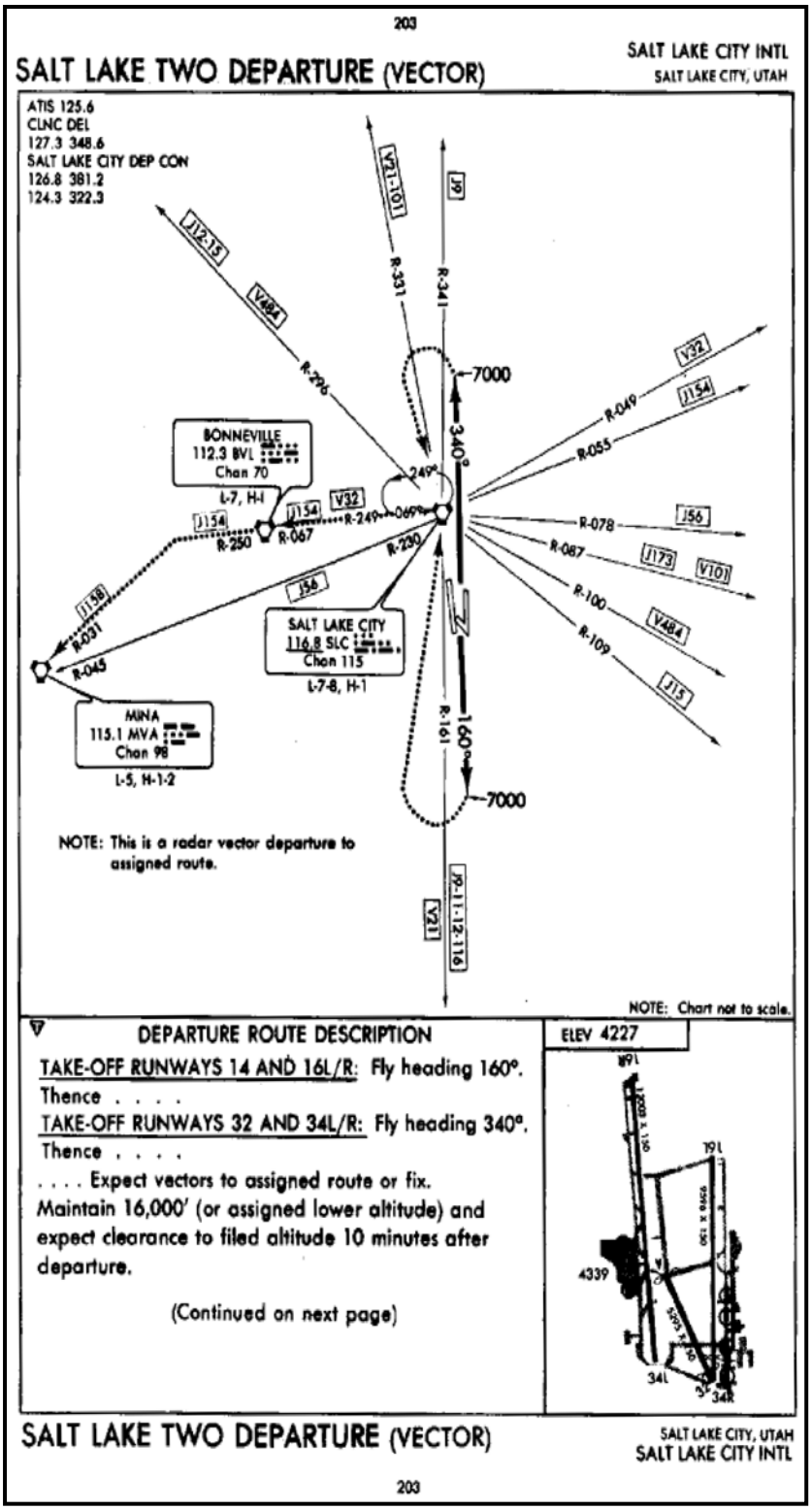


Figure 1-10 Vector SID

ENROUTE PHASE

The enroute phase of flight includes all your flight activities from the time you level off at enroute altitude until you initiate an approach at your destination.

ENROUTE CRUISE

Level off at enroute altitude at "optimum cruise," IMN for cruise altitude. Use the fuel chart found in Figure 1-8 for cruise settings.

ENROUTE COMMUNICATION PROCEDURES

Enroute communications will begin when you switch from departure control to ARTCC (hereafter referred to as "Center"). The phrasing of your initial contact with Center should be in one of the following three formats:

When operating in a radar environment and no position reporting is required: "[name] Center, [aircraft identification] at/climbing to/descending to/passing [altitude] for [altitude]."

When a position report is required: "[name] Center, [aircraft identification], [position], [altitude]."

When no position report is required, but you're not in radar contact: "[name] Center, [aircraft identification], estimating [reporting point] at [time] [altitude]."

When operating in a non-radar environment, you will give position reports to Center at designated compulsory reporting points along your route of flight. The report is always preceded by a courtesy call that includes "[name] Center, [aircraft identification], [position]." If Center's reply is "[Roger]," then no further information is required or wanted from the pilot. If Center states "[Go Ahead]," then the full position report is given. The report includes the following information:

Identification
Position
Time
Altitude/FL
Position – (Next reporting point)
Time
Position – (Name only of next succeeding reporting point)

When you are operating under an IFR clearance, you may not deviate from it unless you obtain an amended clearance or unless safety of flight considerations prohibits compliance.

When you are cleared to climb or descend at pilot's discretion, you may do so, leveling off at intermediate altitudes if desired, but you may not return to an altitude once you have vacated it. Don't forget to report leaving altitude.

When cleared to a point short of your destination, you should ask for an expected further clearance (EFC) time if it is not given or offered. When cleared to a point not on your route of flight, you must receive expected further routing (EFR). You should normally receive further clearance at least five minutes prior to reaching your clearance limit.

Request an amendment to your clearance as early as possible to avoid delays. Refer to the format for filing a flight plan while airborne and requesting a change of routing on the back of the FLIP IFR Enroute Supplement or in the Flight Information Handbook.

To file a change to your flight plan enroute, the pilot communicates five required items to the ARTCC. You can recall these items by using the acronym D-R-A-F-T: (D)estination, (R)oute, (A)ltitude, (F)uel, and (T)ime. This acronym may not be understood by ATC; it is only a memory aid for you to recall the items necessary in the request.

LOST COMMUNICATIONS

When dealing with a communications failure, you are expected to use good judgment in whatever action you take. Do not be reluctant to take emergency action to maintain safety of flight.

If your aircraft has a usable transponder when two-way radio communications are lost, squawk mode 3, code 7600. Using this code will bring immediate controller attention to your problem. Continue to squawk this code while you still have radio problems or until directed by ATC to change your squawk. In addition to the squawk, also make “in the blind” calls in case your transmitter is still operating.

If you lose communications enroute, first try to contact Center on the last assigned frequency, then on an appropriate frequency listed in the FLIP Enroute IFR Supplement. If you are unable to reestablish contact with Center, attempt to call the nearest FSS on 255.4 or 122.5, monitor the appropriate VOR frequency (as Center may issue instructions over this frequency), or as a last resort, transmit on guard.

If you have lost your transmitter but are still receiving, you can expect ATC to attempt to determine if you are receiving by requesting that you do one or more of the following: squawk ident on your IFF, change your IFF squawk, switch IFF squawk to standby, or request that you execute turns.

If you are in Visual Meteorological Conditions (VMC) when communications are lost, do not enter IFR conditions if it is possible to descend and land VFR at a suitable field.

If you are in Instrument Meteorological Conditions (IMC) or must reenter IMC when communications are lost, continue along your route and altitude in accordance with the following procedures in the order presented:

Route:

1. Route assigned in the last ATC clearance

2. If on a vector, direct to the point specified in the vector clearance

3. In absence of assigned route, by the route given in an expected further routing (EFR)

4. In absence of EFR or assigned route, by route filed in flight plan

Altitude (at the highest of the following):

1. Altitude or flight level last assigned

2. Minimum enroute altitude/flight level for the segment being flown

3. Altitude ATC says you may expect in a further clearance

As previously mentioned, if a climb is required, commence it as necessary to comply with the minimum altitude, as required in one through three above.

If you lose communications while on a vector off your planned route with no expected further routing (EFR), return to your filed route. If at all possible, do not accept a clearance off your filed route without an EFR.

PROCEEDING DIRECT TO A STATION

There are two ways to fly to a NAVAID: by homing and by proceeding direct. The difference between the two is that in the presence of a crosswind, a homing aircraft will fly an arcing route (therefore not maintaining a given course) to the station instead of flying in a straight line (Figure 1-11).

To proceed direct to a station, first tune and identify the station and then turn the aircraft in the shortest direction to place the VOR or TACAN bearing pointer under the lubber line (heading index) at the top of the HSI display. (If you were to stop at this point and fly to the station, keeping the bearing pointer at the top of the HSI display, you would be homing.) Once the bearing pointer is centered at the top of the HSI display, use the course selection option on the HSI display and increment or decrement the course until the CDI or Planimetric course line is centered with the course line arrow pointing to the lubber line. Note the position of the ground track marker. Turn the aircraft to place the ground track marker under the lubber line and maintain a wind-corrected heading that will track the selected course to the station by crabbing, as necessary, to keep the course line centered.

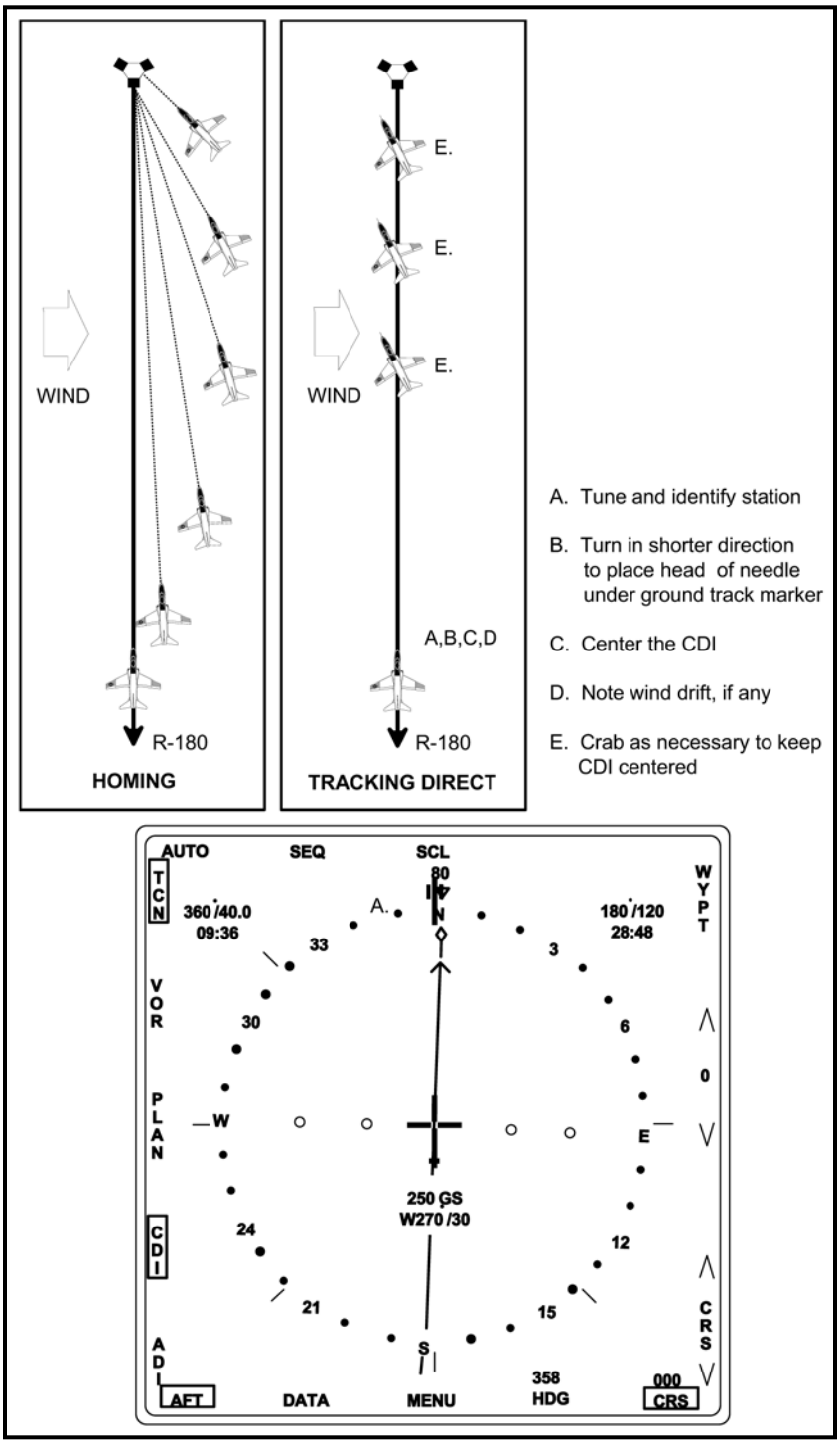


Figure 1-11 Proceeding Direct

Indications Of Station Passage

When flying VOR or VOR/DME, station passage is indicated when the bearing pointer falls past the 90-degree reference benchmark on the periphery of the compass rose. TACAN station passage, due to increased size of the cone of confusion associated with TACAN stations, is noted when minimum DME is reached.

WIND DRIFT CORRECTION

Determining wind-corrected heading (WCH) is the technique you will use to compensate for crosswinds when maintaining a course on a radial. To compensate for wind, use a WCH that stops drift from your course. The difference between WCH and desired course is called “crab angle” (Figure 1-12).

The difference between the lubber line and the ground track marker is your “crab angle.” To compensate for crosswinds using the ground track marker, first establish the aircraft on a radial tracking on course, course line centered, inbound or outbound from a station. Check the position of the ground track marker for an indication of drift. If the ground track marker indicates a drift, turn the aircraft to place the ground track marker under the bearing pointer. Maintain the heading under the lubber line. Continuously monitor the course line to ensure that you are maintaining the desired course. Adjust your heading to maintain a centered course line. The amount of crab angle required will vary with wind strength and direction and may change while the course is being tracked.

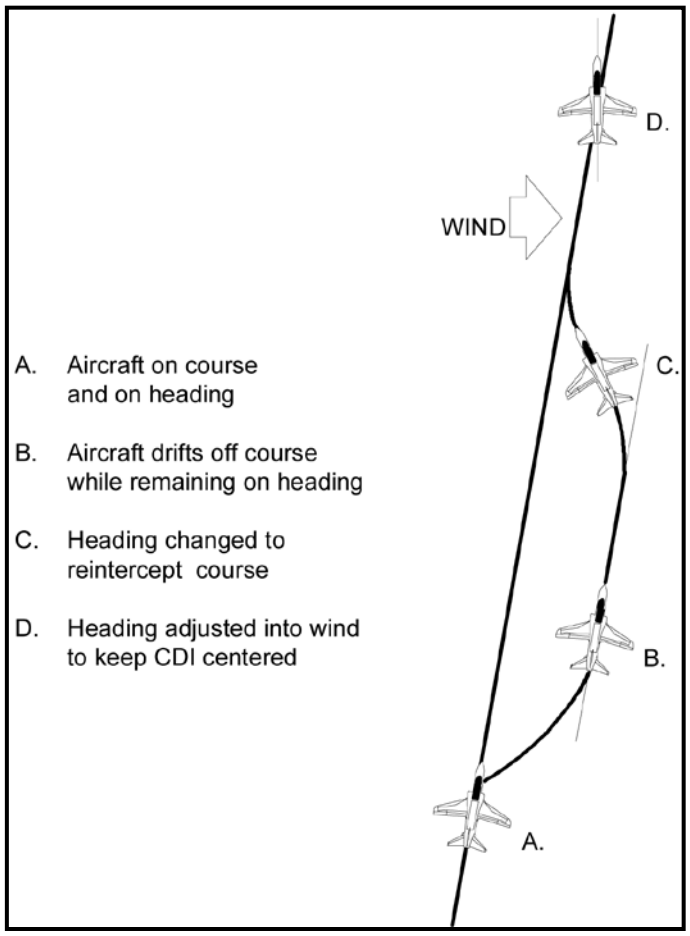


Figure 1-12 Wind Drift Correction

COURSE INTERCEPTS

It is sometimes necessary to change positions or radials inbound to or outbound from a facility. Both inbound and outbound course intercepts are basically the same in that you must determine the angle of intercept to achieve the most expeditious intercept and on heading of the desired radial. The angle of intercept is the angle between the heading of your aircraft and the desired course; it is normally greater than the number of degrees you are from your desired course, but it must not exceed 90 degrees. At 90 degrees, the rate of interception is the maximum possible. Within these two limits, you can adjust your intercept angle to achieve the most desirable rate of interception.

Lead point for course intercepts is calculated as one percent of your ground speed for an intercept angle of 90 degrees. For intercept angles of less than 90 degrees, use an applicable ratio of this formula (e.g., a 45-degree intercept would require one-third as much lead as a 90-degree intercept). See Figures 1-13 and 1-14. You will calculate lead point either in radials or DME, depending on the maneuver you are performing.

The HSI display provides two indications that will assist you in determining lead point. First, the bearing pointer will give you the relative speed at which you are approaching the desired course. By observing the rate at which the bearing pointer approaches the desired course, you can determine when to initiate your turn. Second, the course line provides the relative speed at which you are approaching the desired course. The CDI course line starts to move once you are within 10 degrees of that course. When you are 60 nm from the station, the radials are 1 nm apart, and at 30 nm, they are 0.5 nm apart. Therefore, the CDI will move rapidly when you are close to a station and more slowly when the station is distant. Use the HSI display scale selection and relative position of the aircraft symbol to the Planimetric course line to judge the distance and intercept angle from the desired course.

Inbound Intercepts

To perform a course intercept inbound to a station, first tune and identify the station (if you have not already done so) and then dial in the desired inbound course in the course select window. The two most used procedures for accomplishing an inbound intercept are the 30-degree and the double angle off the bow methods. When determining which intercept is most appropriate, consideration should be given to the aircraft's distance to the NAVAID (if known). A double angle off the bow intercept could be as little as one or two degrees or as much as 45 degrees. The 30-degree method is always 30 degrees. Consideration for radial spread and closure rate, determined by the distance from the NAVAID, as well as wind should always be a factor in the selection and application of an inbound intercept.

30-Degree Method

Once you have tuned the station and selected the desired course in the HSI display course select window, look from the desired course on the compass card to the head of the bearing pointer used and 30 degrees beyond. The heading located 30 degrees beyond the bearing pointer is the heading you will fly to the intercept. Turn the aircraft to this heading and maintain it until you reach the lead point and then complete the intercept (Figure 1-13). You look from the desired course to the bearing pointer.

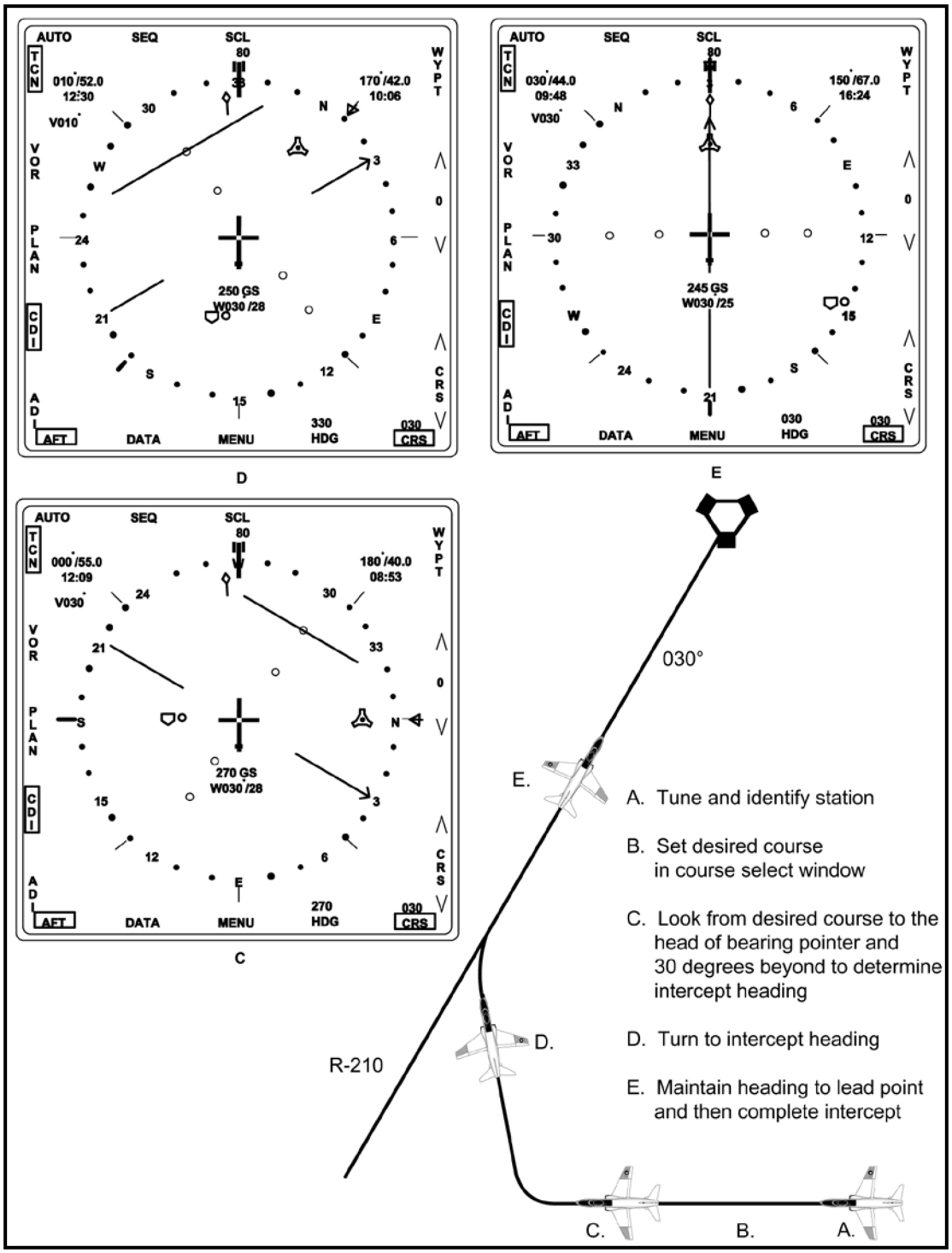


Figure 1-13 30-Degree Method

Double Angle Off The Bow Method

As with the 30-degree method, begin this intercept by tuning the station and setting the desired inbound course in the course select window. Now, look from the desired course on the compass card to the head of the bearing pointer used and an equal number of degrees beyond. The heading located an equal number of degrees beyond the head of the bearing pointer is the heading you will fly to the intercept (max 45 degrees). Turn the aircraft to this heading and maintain it until you reach the lead point and then complete the intercept (Figure 1-14). You look from the desired course to the head of the bearing pointer.

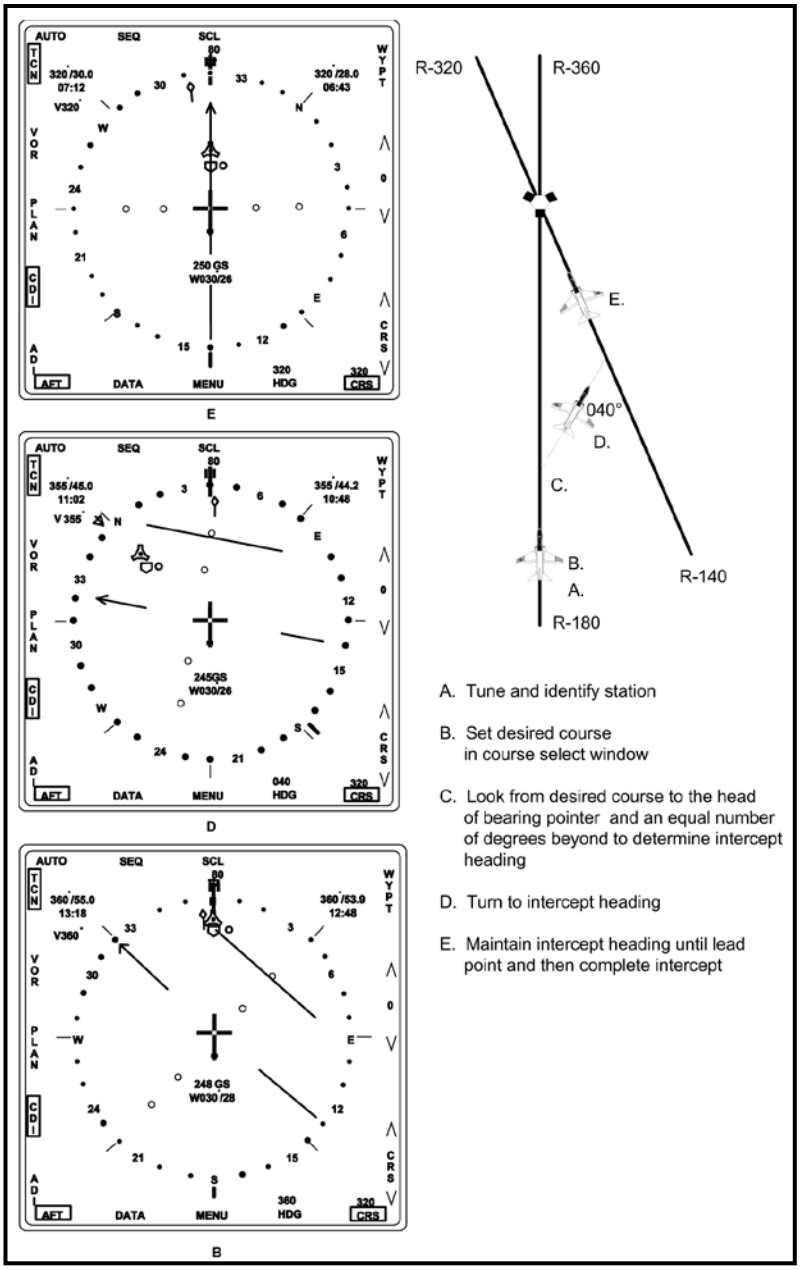


Figure 1-14 Double Angle-off Bow Method

Outbound Intercepts

You can intercept a radial outbound from a station either when you fly directly to a station and then pick up an outbound radial immediately after passing the station or when you intercept an outbound radial at some distance from the station. The two outbound intercept procedures discussed here will address each of these situations.

Course Intercept Immediately After Station Passage

First, tune and identify the station if you have not already done so. When station passage occurs, turn parallel to your desired course and then dial it in on the course select window. Now, look from the tail of the bearing pointer used to the desired course and an equal number of degrees beyond, but not more than 45 degrees, to determine the intercept heading. Turn to and maintain the intercept heading until you reach the lead point and then turn to intercept the desired course (Figure 1-15). You look from the tail of the bearing pointer to the desired course.

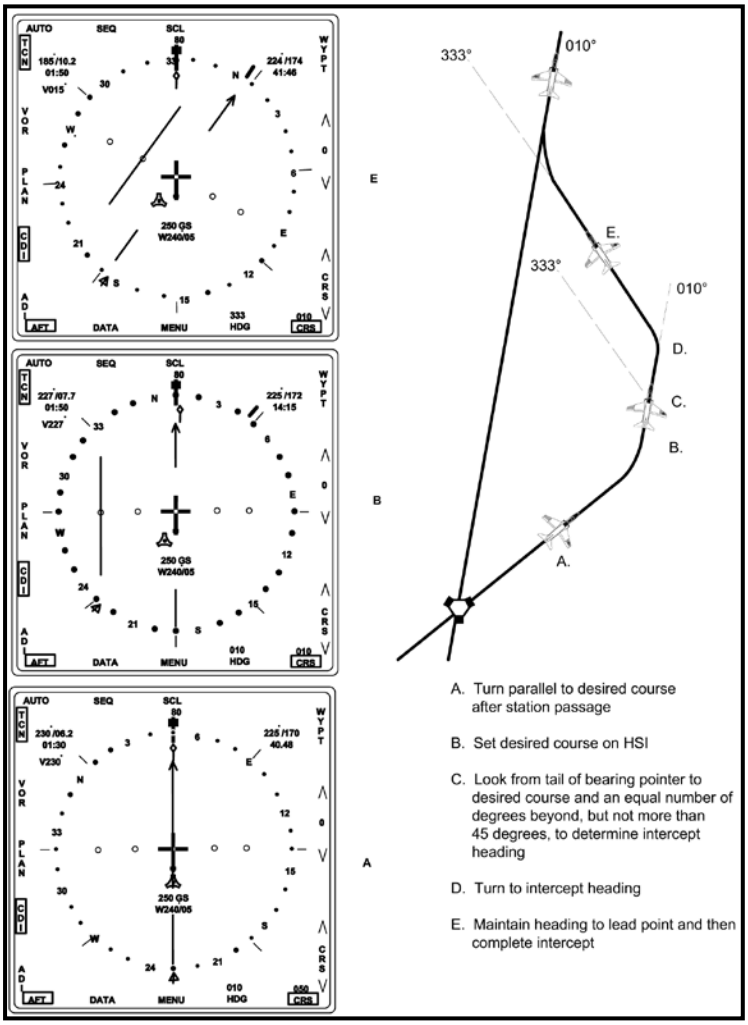


Figure 1-15 Course Intercept Immediately After Station Passage

45-Degree Method

You will find this procedure useful when intercepting an outbound radial of a VOR or TACAN station that is some distance away. As with the other intercept procedures, you must first ensure that the station is properly tuned and identified and then set the desired course (radial) on the HSI display or DEP. To determine the intercept heading, look from the tail of the bearing pointer used to the desired course and 45 degrees beyond. Now, turn to and maintain the intercept heading until you reach the lead point (Figure 1-16).

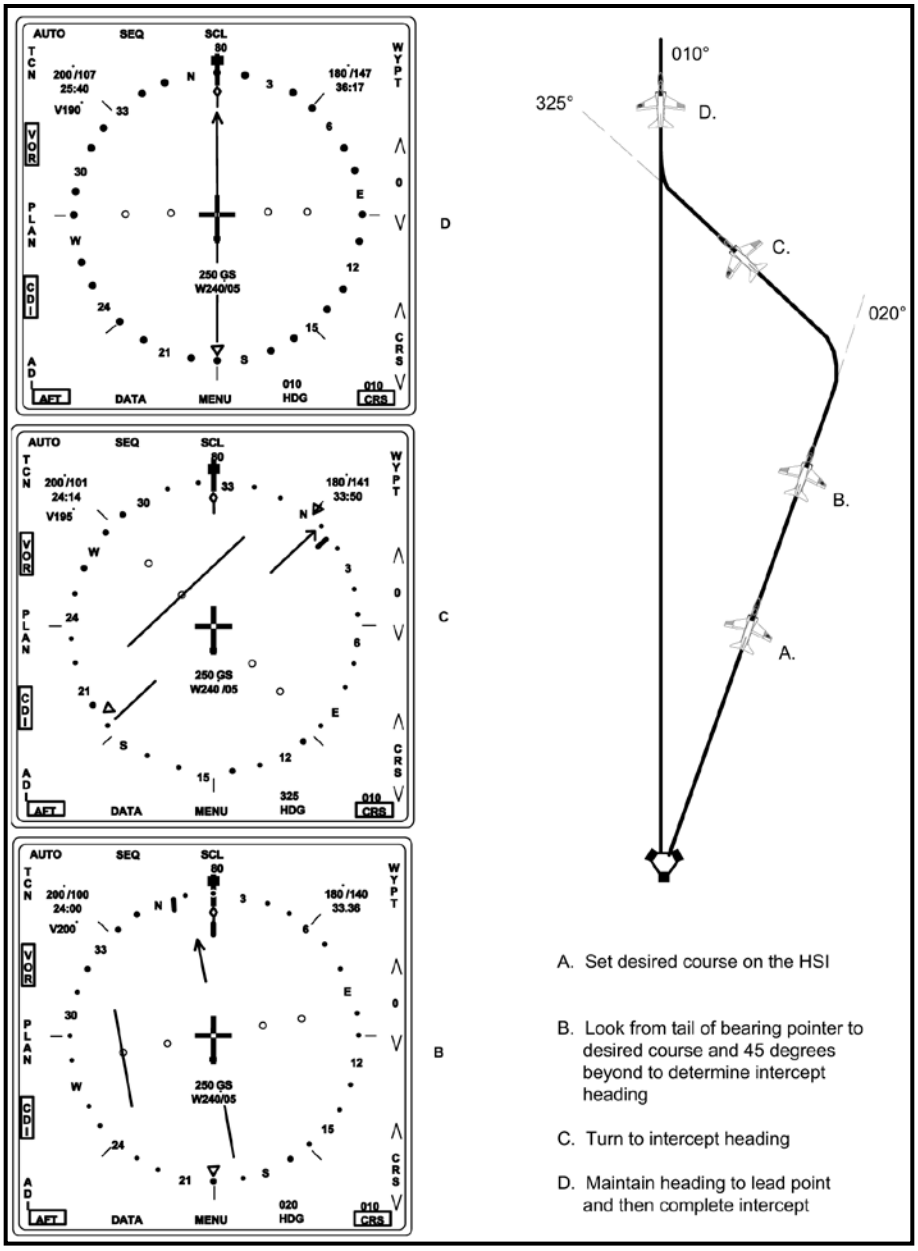


Figure 1-16 45-Degree Method (Outbound)

TACAN AND VOR/DME PROCEDURES

Adding range information to instrument navigation enables you to perform several other navigational procedures, including flying an arc around a station, proceeding point-to-point, or determining ground speed, if the ground speed indication on the HSI display does not display.

Ground Speed Checks

You must recall two facts to perform a TACAN ground speed check: first, your DME from the station must be greater than or equal to your altitude in thousands of feet (in order to limit the impact of slant range on your calculation); second, you must be flying either directly to or directly from a station to get an accurate ground speed check. If you are arcing or cutting across radials, your check will be inaccurate. The GINA also calculates ground speed. But unlike the ground speed check that you do, the aircraft does not have to proceed directly to or from the station for the system to calculate a valid ground speed. The time-to-go in the TACAN data block is computed from slant range to the station and computed ground speed. Therefore, the time-to-go displayed in the TACAN data block is only valid if the DME from the station is greater than or equal to your altitude in thousands of feet. The time-to-go in the waypoint data block is not based on slant range, so it is always valid.

To perform a ground speed check, start your timing when the DME displays a whole number. After a predetermined time (in minutes), record the DME that has elapsed.

To calculate your ground speed, divide the distance (in nautical miles) by the elapsed time (usually one or two minutes) and then multiply the quotient by 60. The product of this calculation will be your ground speed in knots.

For example: 12 nm/2 min = 6 X 60 = 360 kts

You can also time for a longer period of time to find the average miles per minute and then multiply by 60. This will increase the accuracy of your ground speed calculation.

For example: 12 nm in 3 minutes = 4 nm/min = 240 kts

NOTE

ATC can also provide you with ground speed from radar.

Intercepting an Arc from a Radial

The key to intercepting an arc precisely at the desired DME lies in performing an accurate lead point calculation (LPC) to determine the correct lead point DME to initiate the interception turn. For radial to arc intercepts, you will determine the lead point in miles (DME) instead of radials, which are used in arc-to-radial intercept calculations discussed later in this chapter.

The turn to intercept an arc from a radial will normally be at approximately 90 degrees (Figure 1-17). When intercepting an arc, you have to calculate the lead point at which you initiate the

turn in order to intercept it at the correct distance. To determine the lead point, use one percent of your ground speed. For example, whether flying inbound or outbound at a ground speed of 250 kts, your lead point will be 2.5 DME prior to the desired arc. When inbound to the arc, add the one percent to the arc DME, and when outbound, subtract one percent from the arc DME when calculating the lead point.

When you reach the lead point, initiate a one-half SRT turn in the proper direction and maintain it until the bearing pointer nears the 90-degree benchmark on the HSI display. You may have to modify your turn rate/AOB somewhat in order to arrive on the arc at the proper DME.

When intercepting an arc from a radial that is significantly more or less than a 90-degree turn, adjust the lead point by applying the following:

For turns of approximately 45 degrees, use one-third of the distance calculated for a 90-degree turn.

For turns of approximately 60 degrees, use two-thirds of the distance calculated for a 90-degree turn.

Turns of 30 degrees or less require very little lead.

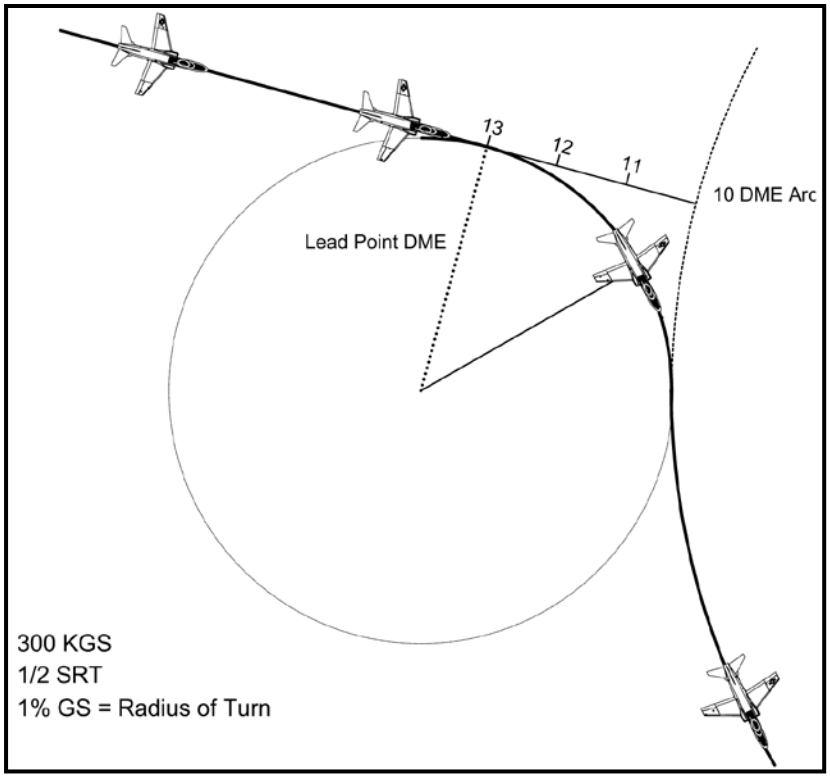


Figure 1-17 Radial-to-Arc Intercept

Maintaining an Arc Around a Station

Two ways of maintaining an arc around a station are the chord method and the angle of bank method. Either procedure (or a combination of the two) will work at any distance from a station. However, the chord method is generally more practical when you are flying a distant arc (usually more than 12 DME from a station), while the angle of bank method usually works better when you are flying an arc close in (12 DME or less). The chord method consists of a series of short, straight legs, connected by turns. The angle of bank method is flown as a shallow turn with variable AOB to maintain a constant arc.

Chord Method (Normally used for arcs of greater than 12 DME)

To maintain an arc using the chord method, fly a series of short, straight legs connected by small turns that take you slightly inside and outside the actual arc (Figure 1-18). To maintain an arc using the chord method, first ensure that the station is tuned and identified; then, determine the direction of turn and calculate lead point. Initiate the turn at the lead point (when DME equals the radius of arc, plus your correction according to the rate of deviation minus the LPC) using a one-half SRT Roll out from your interception, necessary according to the rate of turn when the bearing pointer correction is 5-10 degrees ahead of the 90-degree benchmark at the correct DME. Maintain your heading until the bearing pointer has moved to 5-10 degrees behind the 90-degree benchmark and then turn until the bearing pointer is once again positioned 5-10 degrees ahead of the 90-degree benchmark.

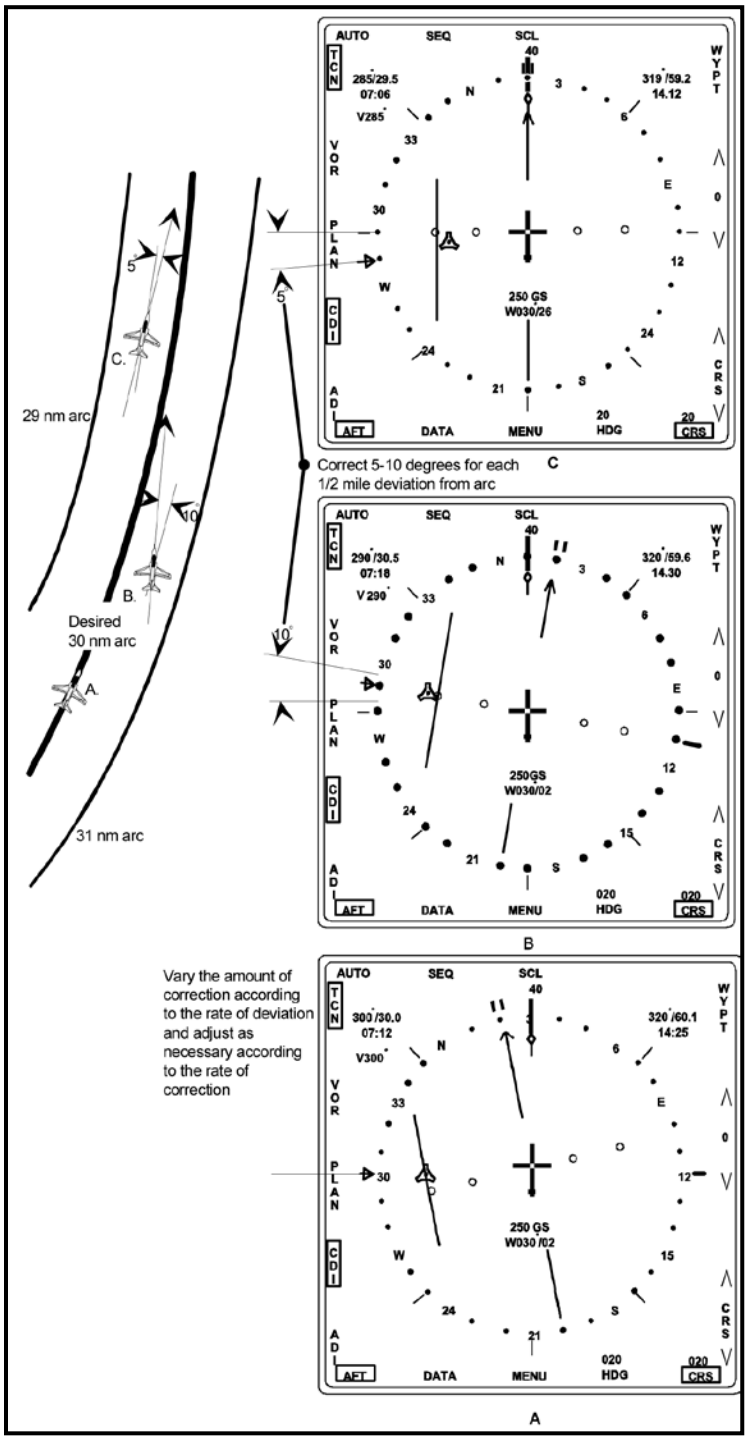


Figure 1-18 Maintaining an Arc (Chord Method)

Repeat this procedure as long as you are flying on the arc. The length of the legs will decrease as you fly arcs closer to a station until you reach a point where this method loses its advantage over the angle of bank method described below. If a crosswind makes holding your DME difficult,

you may need to increase or decrease the number of degrees you place the bearing pointer ahead of the 90-degree benchmark or the number of degrees that you allow it to move behind the 90-degree benchmark to avoid having to make heading changes too frequently to maintain the arc.

Angle of Bank Method

To maintain an arc using the angle of bank method, first ensure the station is tuned and identified. Next, determine the direction to turn and lead point. At the lead point, turn and position the bearing pointer on the 90-degree benchmark and keep it there by holding the aircraft in a shallow turn. The closer you are to a station, the greater your bank angle will be. The angle of bank method is normally used inside of 12 DME. Outside of 12 DME, the bank angle that is required to maintain an arc will probably be too small to hold accurately.

Adjustments to the position of the head of the bearing pointer, relative to the 90-degree benchmark, will have to be made to compensate for the position of the wind, relative to the aircraft, as it moves around the arc.

Intercepting a Radial from an Arc

When intercepting a radial from an arc, you must determine which way you have to turn to intercept and fly the radial in the correct direction (Figure 1-19). Since you will most often be performing an arc as part of an approach or departure procedure, you can obtain this information from the appropriate approach plate or SID. To turn from an arc to a radial, your main consideration is to determine the proper lead in radials. Radials diverge as you get further from a station and are 1 nm apart at 60 DME. Take this divergence into account when calculating your lead point for the turn.

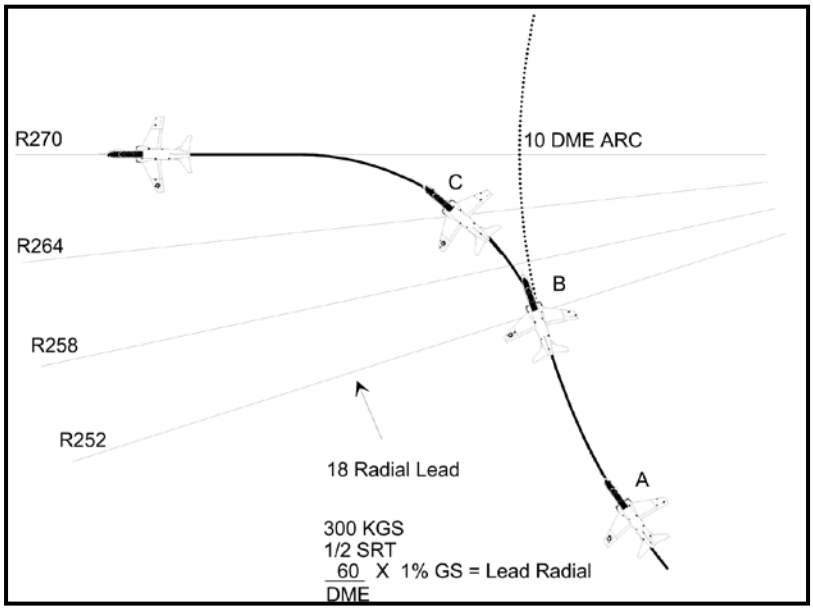


Figure 1-19 Arc-to-Radial Intercept (Method 1)

To calculate the lead point for intercepting a radial from an arc, first you must calculate or estimate the ground speed and then apply the following formula:

> Divide the arc DME into 60, then multiply the quotient by 1 percent of the ground speed.
>
> For example, if you are on a 15 DME arc at 250 kts ground speed, your lead point will be 10 radials (60 divided by 15 equals 4; 1 percent of 250 is 2.5; and 2.5 multiplied by 4 equals 10).

When making your intercept turn, you can also use the movement of the bearing pointer and course line as a guide to determine when to initiate the turn. Use the HSI display scale and relative position of the Planimetric course line to initiate and execute the radial intercept. When you are flying close to the station, you must initiate the intercept turn before the CDI course line begins to move. Therefore, the turn must be initiated at the calculated lead point. Figure 1-21 depicts the HSI display indications during the intercept procedure.

To intercept a radial from an arc, first set the desired course on the HSI display. Next, determine your lead and then turn using a one-half SRT when you reach the lead point. Finally, vary your AOB in the turn with the movement of the course line so that it is centered when the turn is complete. Do not exceed 30 degrees AOB.

For radial intercepts from arcs less than 10 DME, a correction factor must be applied to the arc-to-radial formula to account for the turn to the radial being more or less than 90 degrees. In the case of a turn inbound, the turn will actually be more than 90 degrees, and the correction factor will be added to the standard 90-degree arc-to-radial formula. In the case of an outbound turn, the turn will actually be less than 90 degrees, and the correction factor will be subtracted from the standard 90-degree arc-to-radial formula.

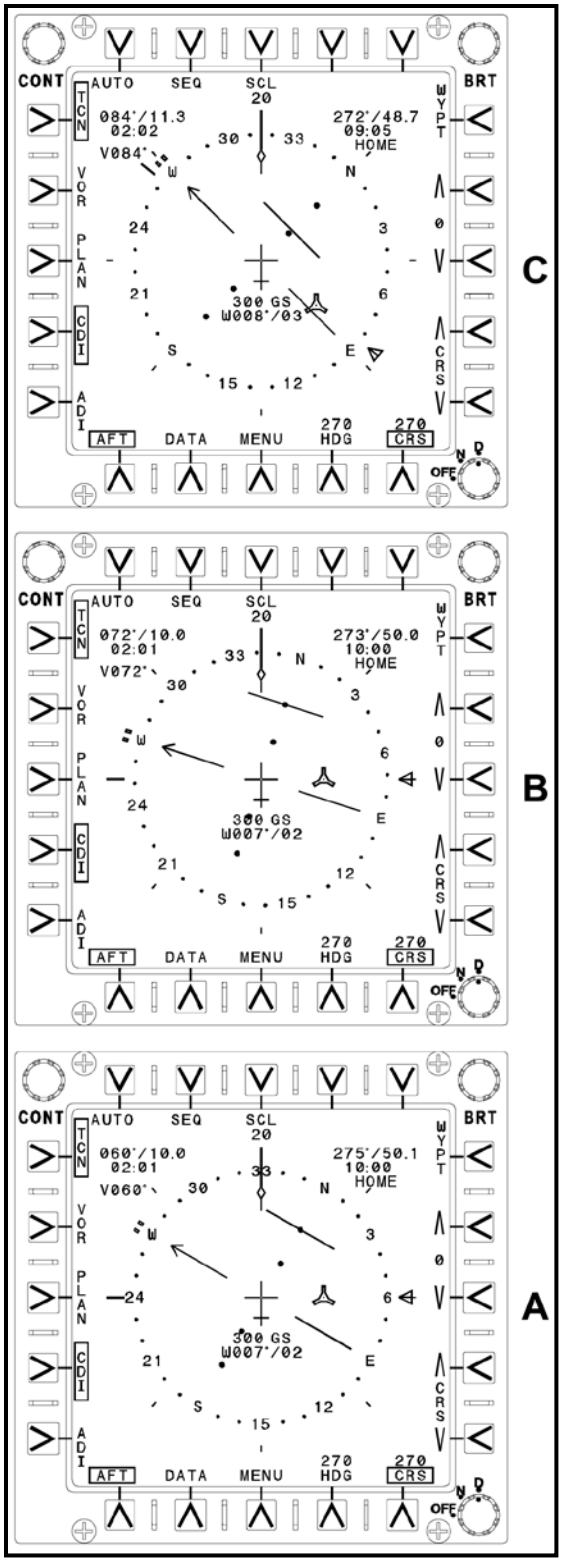


Figure 1-20 Arc-to-Radial Intercept (Method 2)

The correction factor is calculated as follows:

- Inbound turn correction factor = ([90 + Lead (radials)] / 90) x (Turn Radius)
- Outbound turn correction factor = ([90 - Lead (radials)] / 90) x (Turn Radius)

Examples:

An inbound turn of more than 90 degrees on a 10 DME arc at 250 KGS:

Correction Factor = ([90 + 15] / 90) x 2.5 = 2.9

Therefore, the correct lead for an inbound turn at 10 DME =

15 (lead for 90-degree turn on 10 DME arc) + 2.9 = 17.9 or approximately 18 radials. See Figure 1-22.

An outbound turn of less than 90 degrees on a 10 DME arc at 250 KGS:

Correction Factor = ([90 - 15] / 90) x 2.5 = 2.08

Therefore, the correct lead for an outbound turn at 10 DME =

15 (lead for 90-degree turn on 10 DME arc) – 2.1 = 12.9 or approximately 13 radials. See Figure 1-21.

ARC DME	90 DEGREE TURN	INBOUND TURN (>90 DEGREES)	OUTBOUND TURN (<90 DEGREES)
20	7.5	N/A	N/A
15	10	N/A	N/A
10	15	» 18	» 13
7	21	» 27	» 16
5	30	» 40	» 20

Figure 1-21 Approx. Lead Radials to Arc (250 KGS)

POINT-TO-POINT NAVIGATION

As you approach a terminal area, the controller may clear you either to a holding fix or to the IAF. When cleared direct to a fix, you will have to use radar vectors, traditional point-to-point navigation, or waypoint offset navigation to navigate to the fix.

TRADITIONAL POINT-TO-POINT NAVIGATION

The following steps (Figure 1-22) are used to accomplish the point-to-point procedure:

- First, tune and identify the appropriate TACAN or VOR/DME equipped station. The HSI display will function as a plotting board.
- Place the station at the center of the compass rose.
- Picture the fix with the greater distance on its radial at the edge of the HSI display compass rose. The HSI display scale and the scale you used for a point-to-point calculation do not have to be the same.
- Visualize the fix with the lesser distance (determined by the previous step), placed at a proportional distance from the center of the HSI display on its radial. The aircraft is placed on the tail side of the radial that the aircraft is on. The actual point on the radial is determined by which fix is greater. If the aircraft is farther away from the station than the point-to-point target fix, then the aircraft fix will be located where the tail of the bearing pointer crosses the compass card. If closer, then the aircraft is located at a proportional point along the tail of the bearing pointer.
- Once the fixes are determined, connect them with an imaginary line or with the aid of a straight instrument such as a pencil.
- Move the line to the center of the HSI display, paralleling the original imaginary line and read the course to the target fix where the line intersects the outside edge of the compass rose.
- Turn the aircraft to the new course and apply a WCH, if known.
- Repeat the point-to-point procedure periodically enroute and make corrections to the target fix as needed.

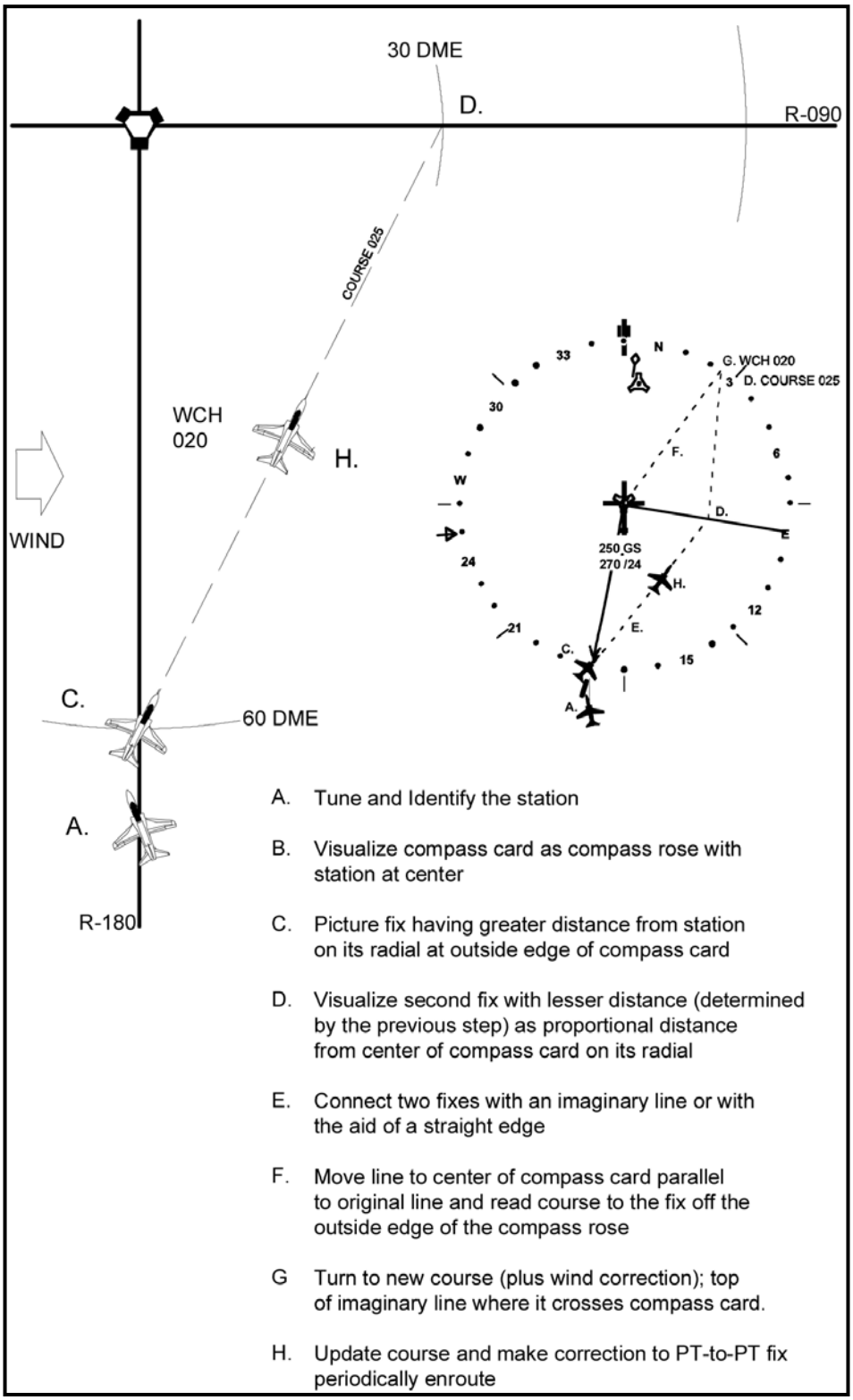


Figure 1-22 Point-to-Point Navigation

WAYPOINT OFFSET POINT-TO-POINT NAVIGATION

The following steps are used to set up steering to a waypoint offset. First, select a waypoint that represents the location of the appropriate navigational aid that defines the fix. If the waypoint is one of the active waypoints, select that waypoint number with the increment/decrement arrows on the HSI display. Second, from the HSI, ADI, or MENU display, select DATA. On initial selection of DATA, the system defaults to the waypoint selection; on subsequent selections of DATA, the display returns to the last selected sublevel format, WYPT, ACFT, or GPS. If required, select WYPT (Figure 1-23).

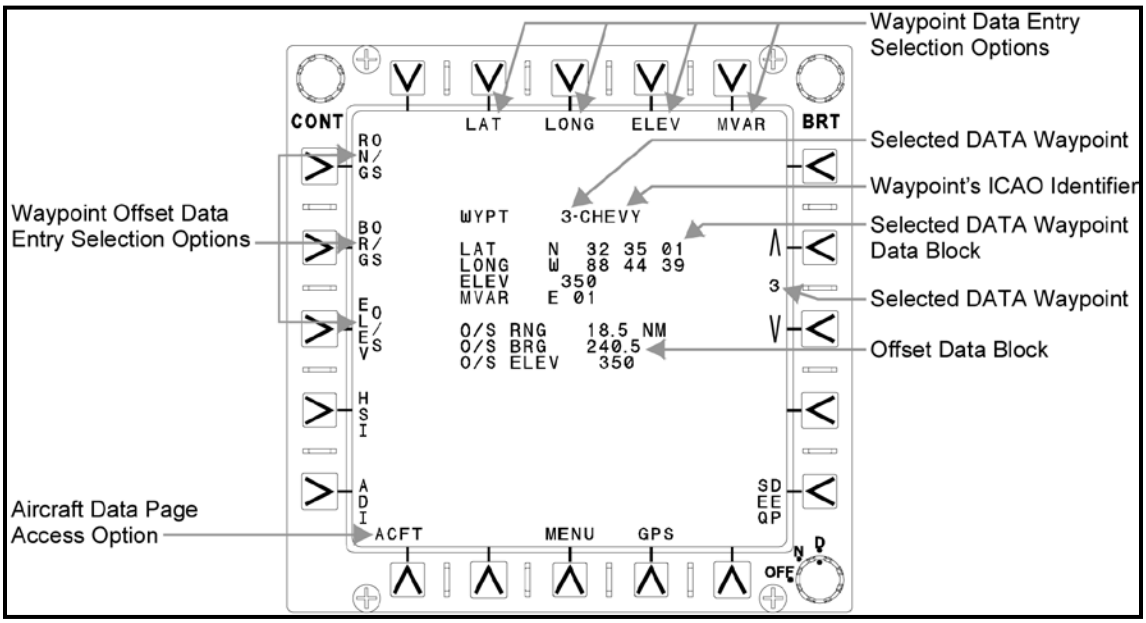


Figure 1-23 Waypoint Data Display

Third, enter the bearing and range of the fix for the waypoint that define the navigational aid. The offset entry options are located on the left bezel of the MFD (Figure 1-24): range (RNG O/S), magnetic bearing (BRG O/S), and elevation (ELEV O/S). Offset data entry, using the DEP and scratchpad, is enabled when one of the O/S options is selected. No offset data is displayed if range is set at 0.0 nm. Range is limited to 0.0-99.9 nm in one-tenth-of-a-mile increments. Bearing is 000-359.9 degrees in one-tenth-of-a-degree increments (360 may be entered for 000). The decimal is not displayed on the scratchpad, but is automatically entered before the last digit after the data is entered into the system. The decimal is displayed in the offset data block. Elevation initializes to the associated waypoint elevation and is limited from -999 to 9,999 ft. in one-foot increments. Do not change elevation; it is not used for waypoint offset steering. Changing the position of the waypoint after entering the offset data automatically sets the offset data for that waypoint to zero and blanks all offset data. Fourth, select HSI and WO/S. The waypoint bearing pointer and waypoint data block provide steering information to the fix.

If there is no active waypoint for the navigational aid, this waypoint data must be transferred from the Mission Data Loader (MDL), if the navigational aid is one of the 200 waypoints in the

MDL, or the latitude, longitude, and magnetic variation of the navigational aid can be manually entered.

To transfer data from the mission data loader, select DATA from the HSI, ADI, or MENU and then select GPS to bring up the Global Positioning System Data Display (Figure 1-24).

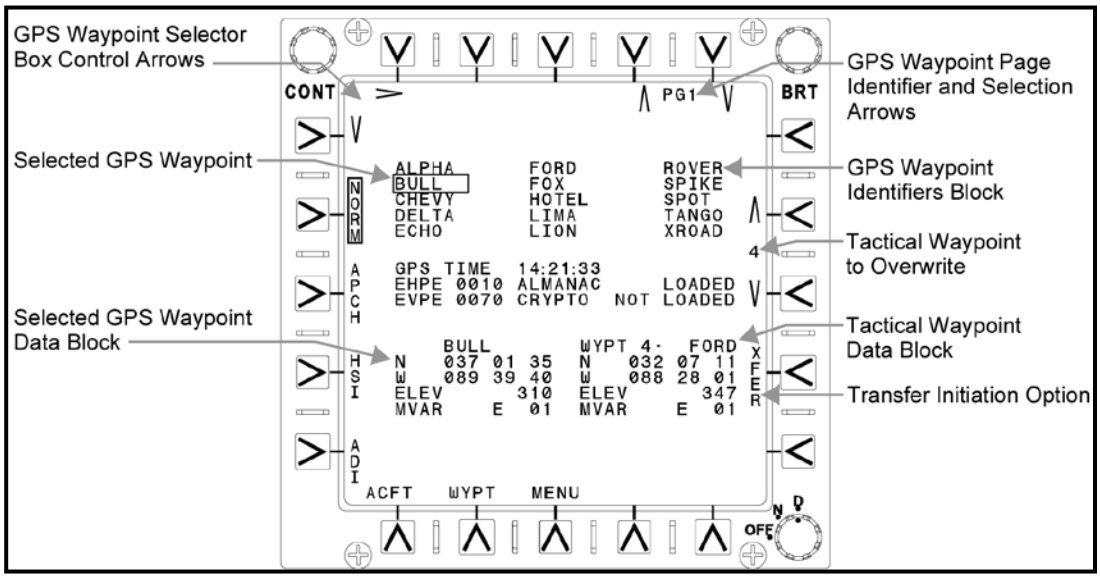


Figure 1-24 GPS Display

The first fifteen waypoints in the mission data loader are displayed at the top of the screen in the GPS waypoint identifiers block. The waypoints are in alphabetical order by column. The desired page of the GPS waypoint identifiers is selected with the increment/decrement arrows in the upper right of the display. Individual GPS waypoint information is selected by locating the selector box around the desired GPS waypoint with the selector box control arrows in the upper left corner of the display. The selected GPS waypoint data is shown in the selected GPS Waypoint Data Block. Using the increment/decrement arrows on the right side of the display, select the tactical waypoint that you want to overwrite; the tactical waypoint data is shown in the Tactical Waypoint Data Block. Press the pushbutton next to XFER to copy the waypoint data from the GPS mission data block into the Tactical Waypoint Data Block. Verification of a successful transfer of waypoint information is accomplished by comparing the two waypoint data blocks. They should be the same.

If the navigational aid is not one of the 200 waypoints in the MDL, you can manually enter the latitude, longitude, and magnetic variation for the navigational aid. To do this, select DATA from the HSI, ADI, or MENU and then select WYPT if required (Figure 1-24). Manual waypoint data entry starts by selecting the desired waypoint number with the increment/decrement arrows on the right of the display. When the desired waypoint is displayed, all parameters for that waypoint may then be changed by selecting data options at the top of the display: LAT (latitude), LONG (longitude), ELEV (elevation), or MVAR (magnetic variation).

Selecting a data option enables the scratchpad on the MFD and HUD; other data options are blanked. New data is entered with the pushbuttons on the data entry panel (DEP). When the ENT pushbutton on the DEP is pressed, the scratchpad is removed, waypoint data is updated with the new value, the option is unboxed, and the other blanked options are redisplayed. (Waypoint elevation is only used for CCIP bombing computations; not for waypoint steering or time-to-go computations.)

Once the latitude, longitude, and magnetic variation of the navigational aid are entered as an active waypoint, the bearing and range of the fix can be entered as previously described.

ARRIVAL PHASE

This phase consists of those activities occurring in the transition from enroute flight to approach and includes procedures for holding and performing enroute descents.

HOLDING

"Holding" refers to the maneuvering of an aircraft in relation to a navigational fix. Holding patterns are defined areas of airspace where aircraft could be required to hold enroute when awaiting clearance to commence an approach or after executing a missed approach. All aircraft given the same holding instructions must fly the same pattern, separated only by altitude. Holding is often required when weather conditions are poor in a terminal area and traffic congestion occurs.

Two basic holding categories are flown in the T-45C: VOR only and TACAN/VOR DME. The difference between the two is predicated on the use or availability of DME to identify the fixes and the limits of the holding pattern. There are also two different types of holding patterns, standard and nonstandard. Standard holding uses right turns in the pattern and nonstandard holding is flown using left turns in the pattern. Determination of which category and type of holding to be flown is dictated either by a depiction on a chart, the clearance the pilot receives from the controller, or equipment availability. The next several pages will discuss the clearances, holding communication, entries, pattern, and pattern corrections in detail.

TACAN/VOR DME Holding

When you are instructed to hold in relation to a TACAN or VOR DME station, the radial, DME of the holding fix, and DME limits of the pattern will be published (as on an approach plate) or will be assigned to you by the controller (Figure 1-25).

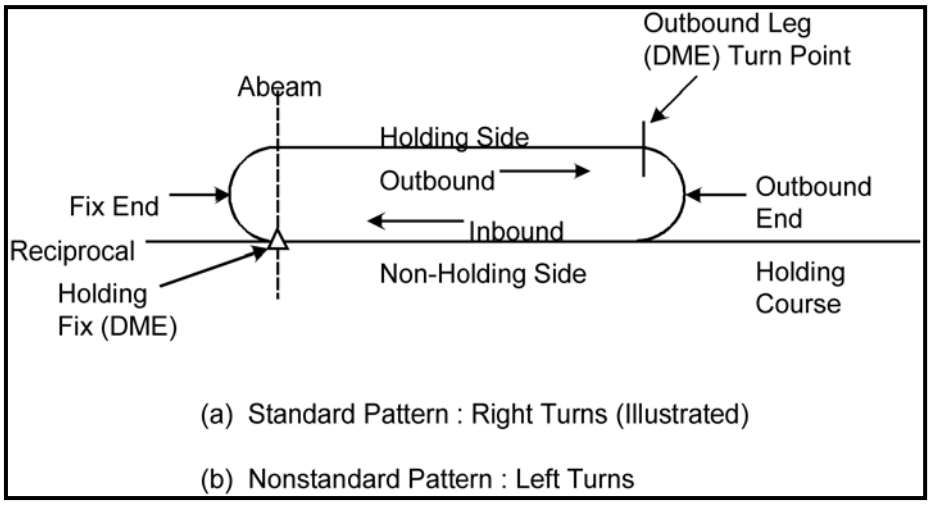


Figure 1-25 Standard Holding Pattern (TACAN)

A TACAN/VOR DME holding clearance will consist of the following instructions (if published holding instructions are not available):

1. Direction of holding from the fix (e.g., W, NE, East)

2. Radial and DME of the holding fix

3. Outbound leg length or the outer limit of the pattern in nautical miles (applicable DME)

4. Altitude

5. Direction of turns (if nonstandard, pilot request, or controller considers information necessary)

6. Expected further clearance (EFC) time

VOR Holding

The VOR holding clearance is essentially the same as that for TACAN/VOR DME except that VOR holding will not include leg lengths. Unlike DME-based patterns, VOR patterns are located over the station because there is no distance reference available to establish the holding fix (Figure 1-28). The difference between VOR holding and TACAN/VOR DME holding is that instead of measuring leg lengths with DME, you will have to time the legs. Leg times are 1-1/2 minutes above 14,000 ft. MSL and one minute at 14,000 ft. MSL and below. These times apply only to the initial outbound leg and all subsequent inbound legs. You may have to adjust your outbound time (due to head wind or tailwind components) to achieve the necessary inbound time. Outbound leg timing begins when you are abeam the fix or when you roll wings level out of the turn, whichever occurs last.

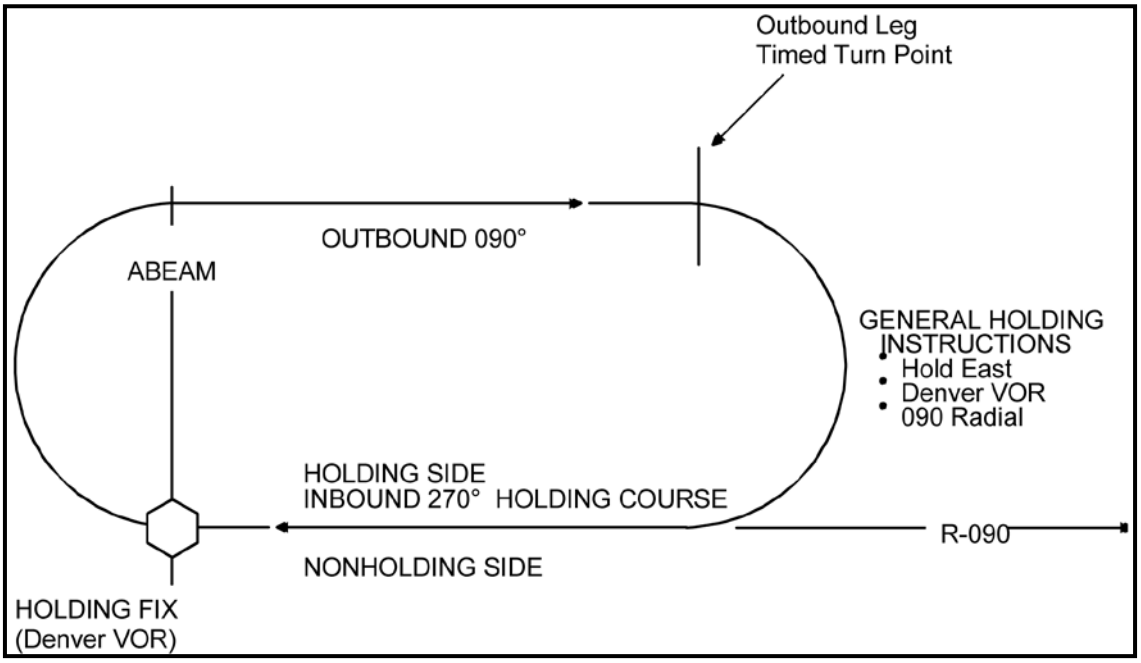


Figure 1-26 Non-DME Holding

General Holding Procedures

The basic procedures for flying a holding pattern (Figure 1-28) are as follows. First, begin slowing to holding airspeed no sooner than three minutes from the holding fix. Next, from your holding clearance, or published holding procedure, determine the type of holding to be used. From your heading, determine the appropriate entry procedure. Upon arrival at the holding fix, note the time and initiate the entry procedure. If timing is used for the pattern vice DME, note the time wings level or abeam the holding fix, whichever occurs last on the entry procedure heading outbound and on subsequent outbound orbits. Set inbound holding course on the HSI display or the DEP. Turn inbound when the appropriate time outbound has elapsed for the holding altitude and begin timing inbound wings level. All turns in holding are made at three degrees per second (standard rate), but do not exceed 30 degrees AOB. Communicate entering holding, if required, once established in the pattern. On subsequent orbits, adjust heading and/or timing, as required, for winds to maintain a holding pattern track and time.

Communication Procedures For Holding

For a normal holding pattern with a charted destination, the controller will not necessarily provide instructions unless they are requested by the aircrew or the controller deems it necessary. If the destination is not charted, the controller will provide fix, direction from fix, radial or bearing, leg length if DME, altitude if different than present assigned, and an EFC time or expected further routing (EFR). The controller will only indicate turn direction if holding is nonstandard by stating “Left Turns” in the clearance at the aircrew’s request or if the controller considers it necessary.

The pilot is required to report the time and altitude or flight level upon reaching a holding fix to which cleared and to report leaving the holding fix. However, these reports may be omitted by pilots involved in instrument training at military facilities when radar service is being provided. If the holding fix is the clearance limit (EFC assigned and not cleared for approach), then the fix is a compulsory reporting point.

Example:

> "ROKT TWO ZERO ONE, BIGFOOT, FLIGHT LEVEL TWO ONE ZERO, TIME ONE THREE FIVE ZERO ZULU."

Once cleared for the approach, penetrate upon arrival at the IAF (you need not make a complete turn in holding). See "Penetration from Holding" on page 1-60.

Holding Airspeeds

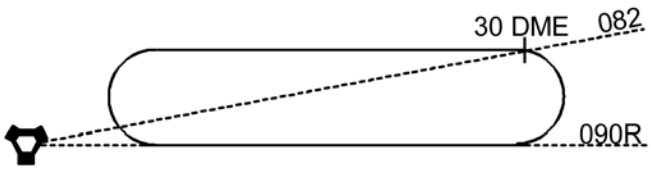
If you have been cleared to a holding fix or have not received further clearance while enroute, begin slowing to holding airspeed no sooner than three minutes prior to a holding fix. Since holding is a delaying or loitering maneuver until further clearance is received, it is flown at an airspeed approximating maximum endurance. Maximum holding airspeed for this aircraft, as published by the FAA, is 230 kts. Maximum endurance airspeed in the T-45C is 14 units; for simplicity, procedural holding airspeed for the T-45C is 200 KIAS regardless of altitude, not to exceed 14 units AOA. If turbulence is encountered, hold at 250 KIAS per NATOPS and notify ATC. The T-45C NATOPS recommended turbulence penetration airspeed is 250 KIAS. When higher speeds are no longer necessary, return to normal holding airspeed and notify ATC.

Entry Procedures

To enter holding, use one of three possible procedures, depending on your heading that is relative to the holding pattern when you arrive over the fix. (The discussions of entry procedures on the following pages assume a standard [right-hand] pattern; reverse the turns for a nonstandard [left-hand] pattern.) In each procedure, you cross the fix and turn outbound on the appropriate heading. At holding fixes that are not over NAVAIDs, an outbound offset should be determined prior to the entry (Figure 1-28). Turn inbound to intercept the holding course at the appropriate DME or time (Figures 1-27 and 1-28).

No Wind VOR/TACAN DME Entry Offset

Prior to reaching the holding fix on a teardrop or direct entry, based on the T-45C turn radius for 180 degrees at holding airspeed, the pilot should calculate the approximate offset required so that, at the inbound turn point, an SRT or 30-degree AOB burn for 180 degrees will place the aircraft on the holding course inbound. The actual offset required will vary with wind, true airspeed, altitude, and turn radius. For 200 KIAS at 15,000 ft., the T-45C turn radius is approximately 2 nm, or 4 nm for 180 degrees of turn. See Figure 1-27.



NO WIND

Offset 8 radials according to table:

DME (At turn inbound)	RADIAL OFFSET (Approximate)
10	24
20	12
30	8
40	6

Figure 1-27 No-wind Holding Offset

The quickest and most accurate method of determining which type of entry to perform is to use the HSI display compass rose as a plotting board (Figure 1-28). For a standard holding pattern, locate the holding radial on the compass rose. If the holding radial is located within an area of 70 degrees to the right of the aircraft's heading at the holding fix, perform a teardrop entry. If the holding radial is located within an area of 110 degrees to the left of the aircraft's heading, perform a parallel entry. If the holding radial is located outside an area of 110 degrees to the left and 70 degrees to the right of the aircraft's heading, perform a direct entry. For a nonstandard pattern (left turns), reverse the 70- and 110-degree lines. Additionally, most approach plates include a holding entry diagram to aid you in determining which type of entry to perform.

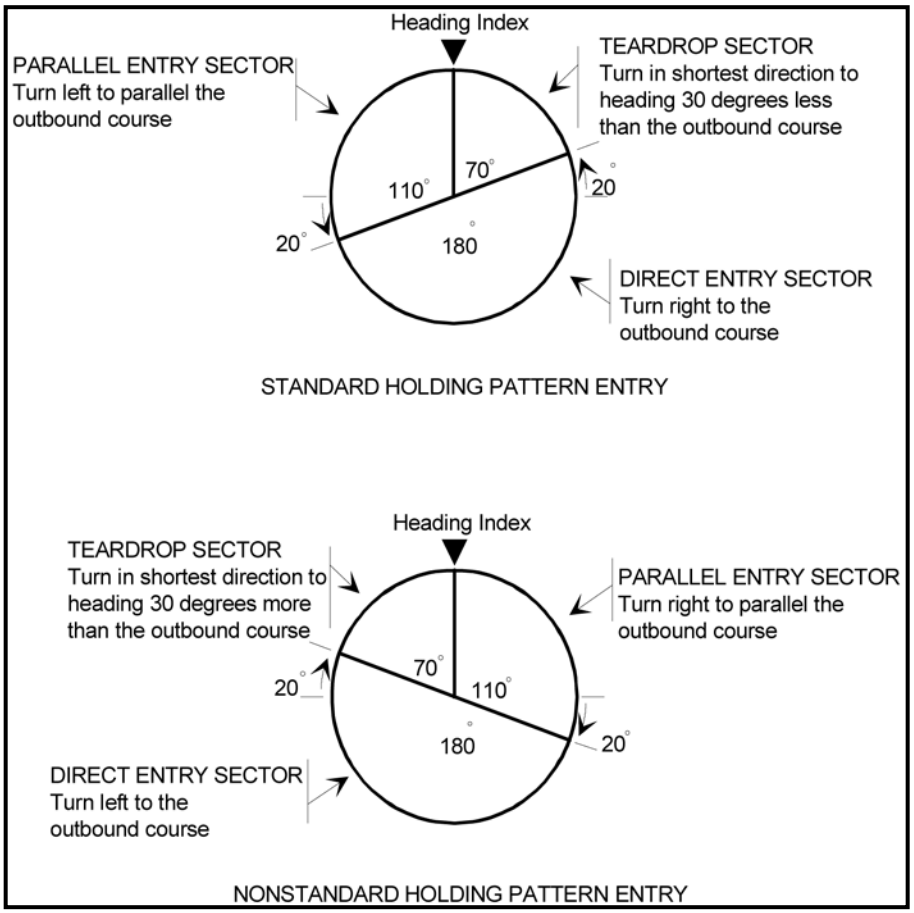


Figure 1-28 Holding Pattern Entry Sectors

NOTE

If the holding radial is within +/- 5 degrees of the entry plot quadrant division points, either entry procedure associated with the point may be used. The most appropriate entry is determined by consideration of known wind, holding airspace, etc.

1. Parallel Procedure: When approaching the holding fix from anywhere in sector (A), the parallel entry procedure would be to turn to a heading to parallel the holding course/radial outbound on the non-holding side (Figure 1-29). Wings level (VOR only) time for a period of one or one and one-half minutes (depending on the altitude). At end of timing (VOR) or outbound DME (TACAN), turn in the direction of the holding pattern through more than 180 degrees and return to the holding fix or intercept the holding course inbound.

2. Teardrop Procedure: When approaching the holding fix from anywhere in sector (B), the teardrop entry procedure would be to fly to the fix, turn outbound with a heading change of 30 degrees more than the outbound holding course/radial for a nonstandard holding pattern or 30

degrees less than the outbound holding course/radial for a standard holding pattern to initiate the teardrop entry within the pattern (on the holding side). Wings level outbound (VOR only), time for a period of one or one and one-half minutes (depending on the altitude). Turn to parallel holding radial at desired offset. At end of timing (VOR) or pattern outbound DME (TACAN), turn in the direction of the holding pattern to intercept the inbound holding course or proceed directly back to the fix.

3. Direct Entry Procedure: When approaching the holding fix from anywhere in sector (C), the direct entry procedure would be to fly directly to the fix and turn outbound to follow the holding pattern. Initial timing (VOR only) would begin wings level or abeam, whichever occurs last. Time for a period of one or one and one-half minutes (depending on the altitude). At end of timing (VOR) or pattern outbound DME (TACAN), turn in the direction of the holding pattern to intercept the inbound holding course or proceed directly back to the fix.

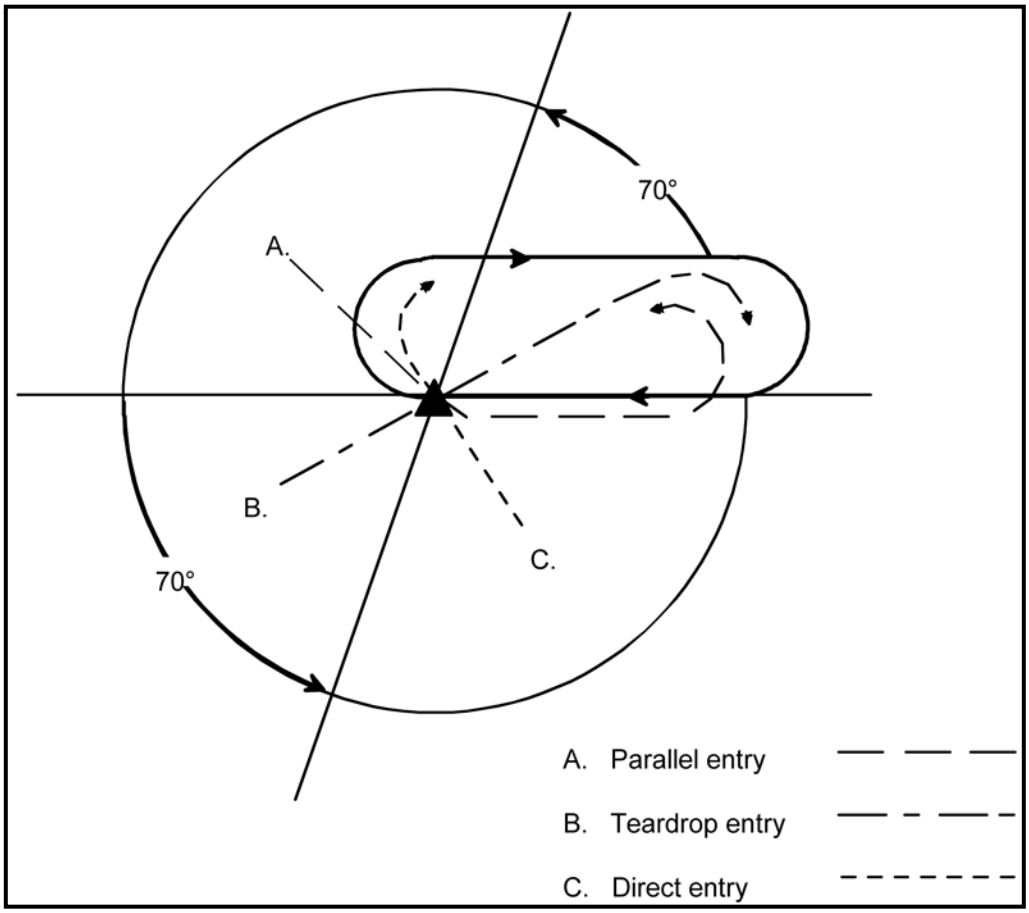


Figure 1-29 Holding Pattern Entry

Wind Drift Correction Techniques

You may have to compensate for two abeam different wind effects while flying a correct holding pattern – head winds or tailwinds, and crosswinds. Head winds or tailwinds will only be a factor

on non-DME patterns, for which you will have to adjust the outbound leg for a correct inbound time. Compensate for crosswinds in order to arrive at an outbound position from which a turn inbound will place the aircraft on the holding course. This is normally accomplished by using a larger drift correction (approximately two to three times) on the outbound leg. See Figure 1-30.

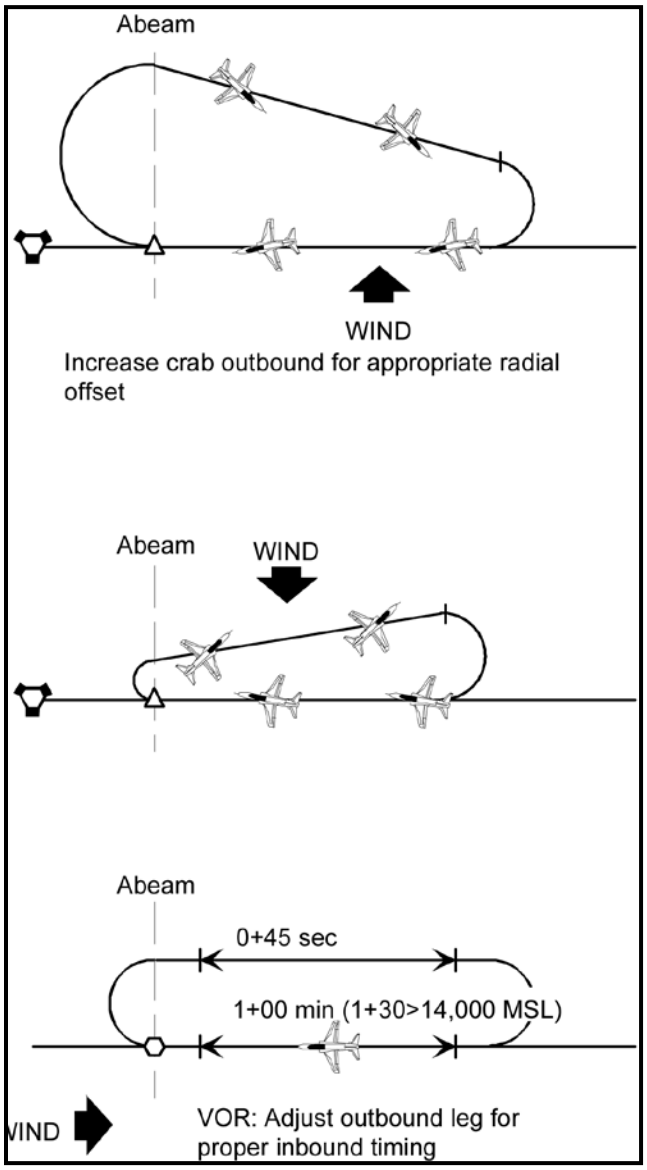


Figure 1-30 Holding Wind Correction

Lost Communication

If communication is lost and the pilot has received EFC time, and the holding fix and Initial Approach Fix (IAF) are the same, then leave the fix at EFC time. If, however, the holding fix and IAF are not the same, leave the holding fix at EFC time and proceed to initial approach fix. When EFC has not been received, continue on assigned route and do not hold.

Penetration from Holding

Depending on the goal, choose an appropriate method to accelerate from holding airspeed to 250 KIAS (TACAN penetration airspeed).

1. For fuel conservation, plan to intercept 250 KIAS as you descend out of altitude. At the fix, lower the nose and begin descent while accelerating to 250 KIAS. As airspeed approaches 250 KIAS, reduce power to IDLE and extend the speedbrakes if necessary.

2. For timing considerations (for example, CV approaches), accelerate to arrive at the IAF at 250 KIAS. Once cleared inbound and on course, perform a level speed change from 200 KIAS to 250 KIAS.

NOTE

To begin penetration, the aircraft must be established on initial approach course.

During approaches to airfields, retract boards when the profile allows and maintain 250 KIAS. During field approaches, call "Platform," and your IP may retract the speedbrakes if practical. Regardless, honor the minute-to-live rule.

ENROUTE DESCENT

Enroute descents are used to transition from an enroute altitude to the final portion of an instrument approach or visual approach in lieu of published penetrations. An enroute descent can also be flown to a GCA pickup. The routing on this descent may be via radar vectors or the NAVAIDs depicted on the high altitude charts.

You may request, or a controller may initiate, an enroute descent; however, the controller must advise you of his or her intention to provide this service, and you may refuse it in favor of a published instrument approach. Prior to issuing descent clearance below the highest published IAF for an airport, the controller must advise you of the type of approach to expect, current altimeter setting, and the current weather (if the ceiling is below 1,000 ft. AGL or the highest published circling minimums, whichever is greater, or if visibility is less than three miles).

ENROUTE DESCENT PLANNING

Cruise Descent

Goal: Reduce time to destination by descending at an IAS that is higher than the max range airspeed. This type of descent is used when saving fuel is less important than time-to-destination.

Procedure: To calculate VSI, divide altitude to lose by nm-to-go times ground speed. For example, you are cruising at FL300 and Center clears you to "descend and maintain 15,000 ft. in the next 50 miles." Substituting these numbers into our equation would look as follows: (–15,000 ft./50 nm) (5 nm/min) equals –1,500 ft. per min. Of course, the specific VSI depends on ground speed, but Figure 1-33 provides a rough approximation.

Fuel Flow (pph)	Airspeed (KIAS)	VSI (fpm)	DME to lose 1K
500 (idle)	250	-2,500	2
500 (idle), BDS	250	-6,000	1
500 (idle)	Max Range	-1,500	3-4
700 (75%)	250	-2,000	2.5

Figure 1-31 T-45C Enroute Descent Table

From cruise power and IAS at altitude, lower the nose to accelerate (if necessary) to the desired descent airspeed (usually 250 KIAS), then reduce power (if necessary) to maintain the desired VSI. At altitude, you will need to reduce fuel flow by approximately 50 pph for every –100 ft. of VSI. You must request permission to perform directed descents at rates less than 500 fpm.

Max Range Descent

Goal: Use less fuel while maximizing distance traveled. NATOPS lists the max range descent airspeed and descent point in the BINGO tables for various airspeeds and configurations. Max range descent AOA will be higher than the max range cruise AOA (triangle at 12–13 units). Center normally plans to descend you at your altitude plus ten, so you may need to ask for an earlier descent. For example, the letdown point for max range descent from FL350 is about 123 nm, but Center would not normally descend you until 45 nm. A rough approximation is to let down three and one-half times altitude plus the desired DME from field level off.

Delayed Descent

Goal: Minimize downrange travel if your descent is delayed by ATC or weather. Use this strategy when you are forced to stay higher than desired. At altitude, maintain max endurance AOA (“box” at 14 units) until cleared lower, then lower the nose and accelerate to 250 KIAS, reduce power to idle, and use boards as necessary. The idle-with-boards configuration gives the maximum altitude loss for distance over the ground.

All Descents

When descending through 5,000 ft. AGL, call “platform” and comply with the “minute-to-live” rule.

STAR

A STAR is a preplanned Instrument Flight Rule (IFR) air traffic control arrival procedure that is published for pilot use in graphical and/or textual form. STARs provide transition from the enroute structure to an outer fix or an instrument approach fix/arrival waypoint in the terminal area. Its purpose is to simplify clearance delivery procedures.

APPROACH PHASE

Instrument approaches enable you to transition from IMC to a visual landing while providing terrain clearance and separation from air traffic. As part of the FLIP series, instrument approach procedure charts are divided into two categories, high altitude (Figure 1-32) and low altitude.

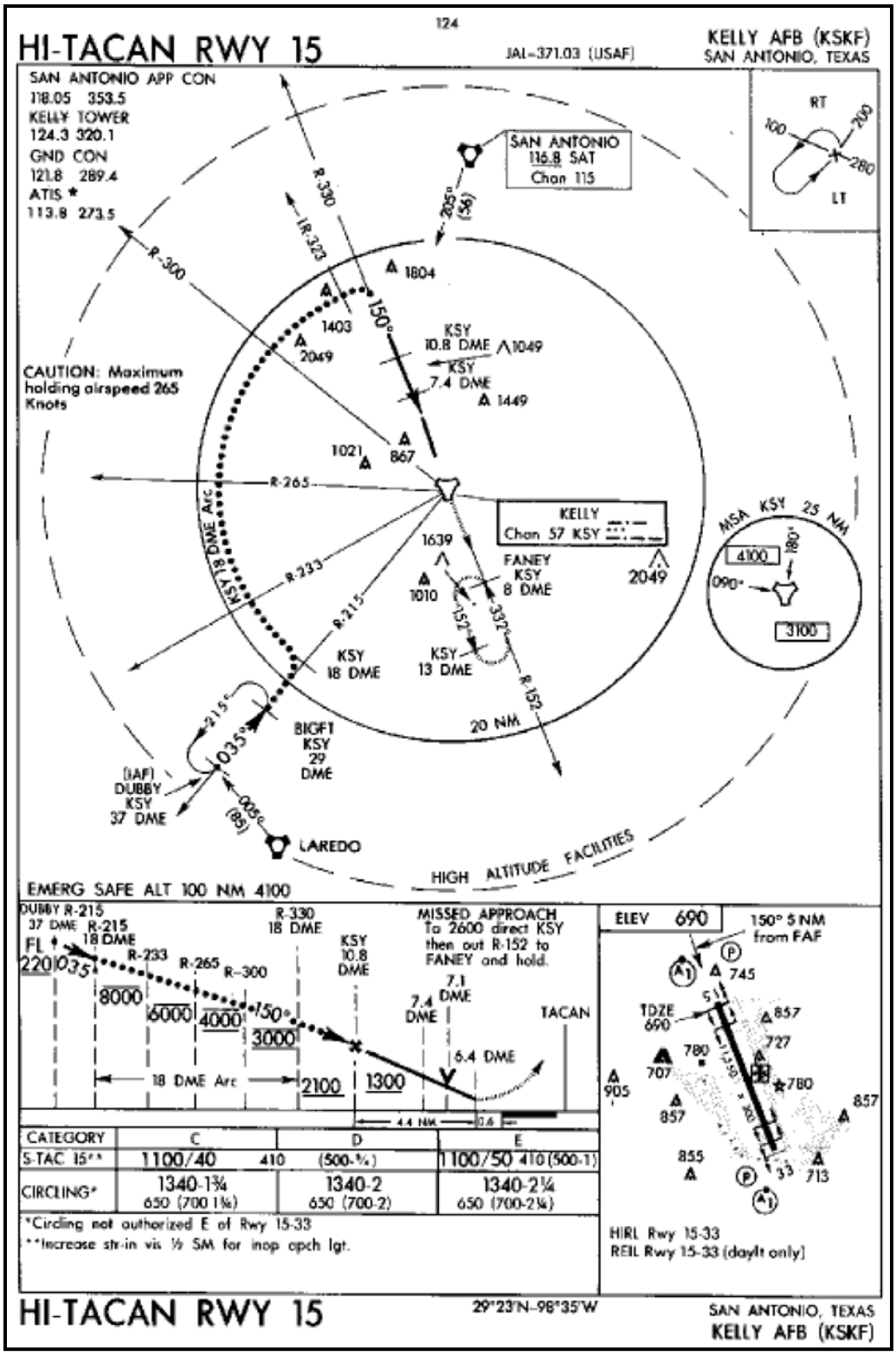


Figure 1-32 Instrument Approach Plate

Consider the following factors as you select an instrument approach:

- Altitude structure flown (high or low)
- Navigational equipment aboard aircraft
- Types of approaches available at your destination
- Published approach, pilot, and aircraft minimums
- Weather

In preparing to execute an instrument approach, you should thoroughly familiarize yourself with the following information:

- Minimum and emergency safe altitudes
- Initial approach altitude
- Penetration and final inbound course
- Altitude restrictions
- Approach weather minimums
- Approach minimums (minimum descent altitude (MDA) and/or decision height (DH)
- Field elevation plus any special notes on terrain or obstacles
- Missed approach procedures
- Communications procedures

In addition to approach procedures, instrument approach charts also provide a diagram of the airport (Figure 1-33) showing runway lengths, taxiways, obstructions, arresting gear and barrier locations, approach lighting configuration, buildings and structures, and ground tract from FAF to runway.

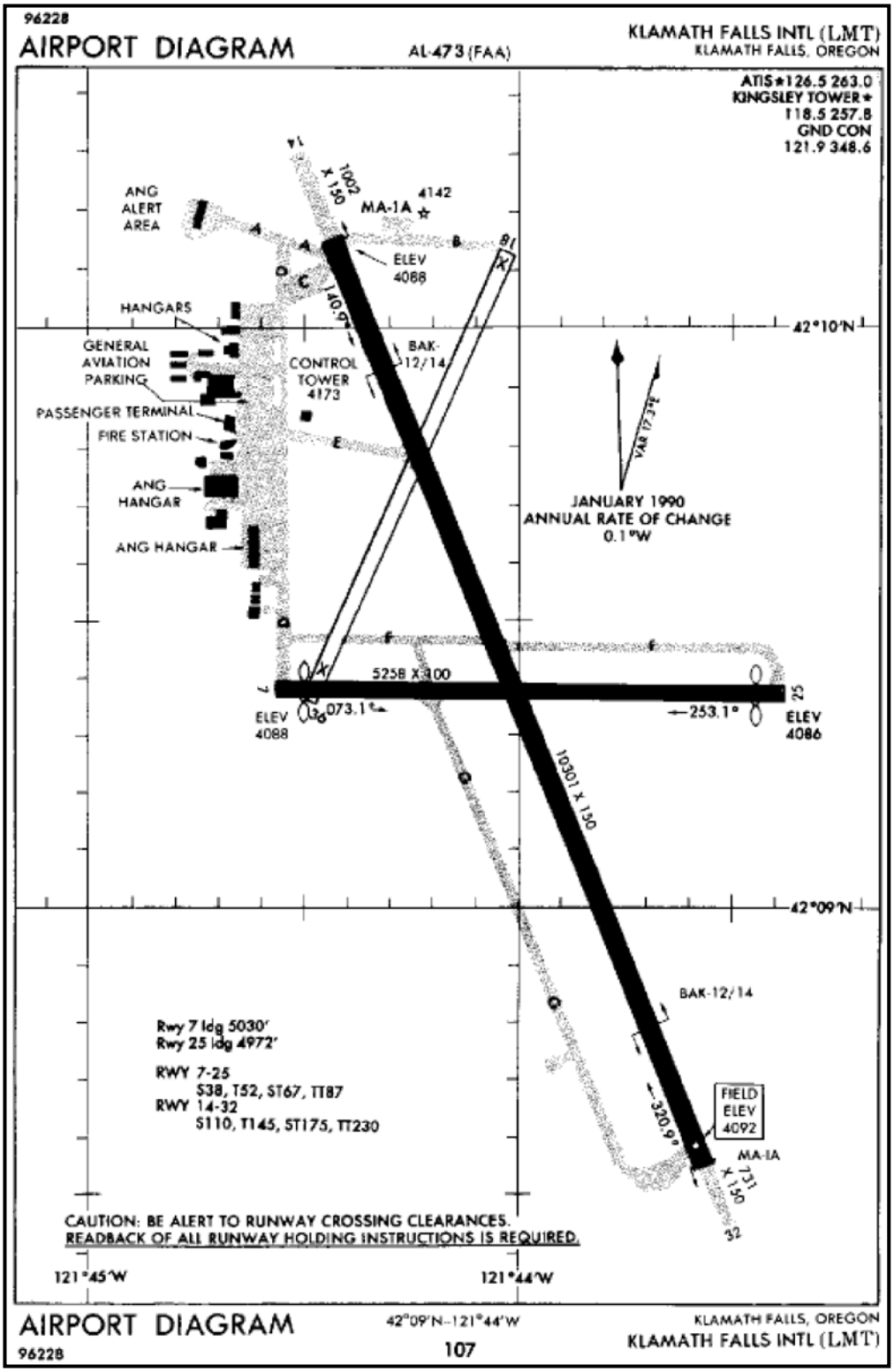


Figure 1-33 Airfield Diagram

Before commencing an instrument approach, you must know the approach procedure in use and complete the "WARP" checklist: confirm the Weather, Altimeter setting, Runway in use, and perform Penetration checks.

After determining which approach you desire to fly, request clearance to commence the approach. Clearance for an approach does not constitute clearance to land or give you priority over VFR traffic in the landing pattern; only the control tower may grant you clearance to land. However, the approach control facility (a radar controller) can relay landing clearance to you.

NOTE

> Selection of an approach other than the one identified by approach control as the approach in use may cause a delay in clearance. If not equipped for the approach in use, relay that information to the controller on initial contact with approach control.

You may not commence an instrument approach if weather is below minimums unless (1) you are dual-piloted or (2) you are performing a practice approach and do not intend to land. However, if the approach was above minimums when commenced, you may continue to the published minimums regardless of changes in the weather. An approach is considered to commence from an enroute descent when leaving the highest published IAF altitude. For penetration approaches, leaving the IAF is commencing. Before commencing an instrument approach, complete the penetration checklist, as follows:

Canopy defog and cockpit temperature:	AS REQUIRED
MASTER ARM switch:	SAFE
CONTROL AUG:	ALL
Standby Attitude/Altimeter:	ERECT/SET
Weather/field conditions:	CHECK
NAVAIDS:	TUNED/ID
LAW:	SET
MFDs/HUD/NAV Mode:	CHECK/SET
Fuel State:	CHECK

"Hold Brief"

"Approach Brief"

"Field Brief"

APPROACH COMMUNICATION PROCEDURES

In your initial communication with approach control, known as P-A-R format, give your Position (if required) and your Altitude and ATIS letter (information Alpha), and Request an approach. Most often you will be requesting a specific approach (e.g., High TACAN runway 13). In addition, you may also request current weather information, the altimeter setting, and the duty runway (WAR), if ATIS is not available. A prudent SNFO would have already tuned and copied ATIS and based his approach request on that information. If it is not included, then the controller is required to give you the weather. If the letter identifier is no longer current, the controller will automatically provide you with updated weather information. In response to your request, approach control will provide clearance, duty runway, surface wind, ceiling and visibility, current altimeter setting, and missed approach instructions. Whenever the controller gives you instructions containing headings, altitudes, or an altimeter setting, you are required to read that information back.

GROUND-CONTROLLED APPROACH (GCA)

There are two basic types of ground-controlled approaches: the precision radar approach (PAR) and the surveillance radar approach (ASR). A PAR provides you with the precise course, glidepath, and range information and is classified as a precision approach. An ASR (commonly referred to as a surveillance approach) provides lower resolution course and range information only (no glideslope) and is classified as a non-precision approach.

NOTE

> Glideslope is defined as the descent angle assigned to an approach to a given runway for obstacle clearance and/or signal reception. Glidepath is defined as the portion of a precision approach that intercepts the azimuth of an ILS approach or the FAC of a PAR approach.

Both the PAR and ASR approaches are divided into two segments: initial pattern and final approach. Refer to (Figure 1-34) for an illustration of the GCA pattern.

During the initial pattern of an ASR or PAR approach, you will be guided by surveillance radar. This segment includes all maneuvering up to the point at which your aircraft is inbound on the final approach course and at approximately 8 nm from touchdown. During the transition to final, the GCA controller will direct your headings and altitudes. All controller instructions to initiate turns and descents should be complied with immediately. In the pattern, maintain standard rate turns not to exceed 30 degrees AOB.

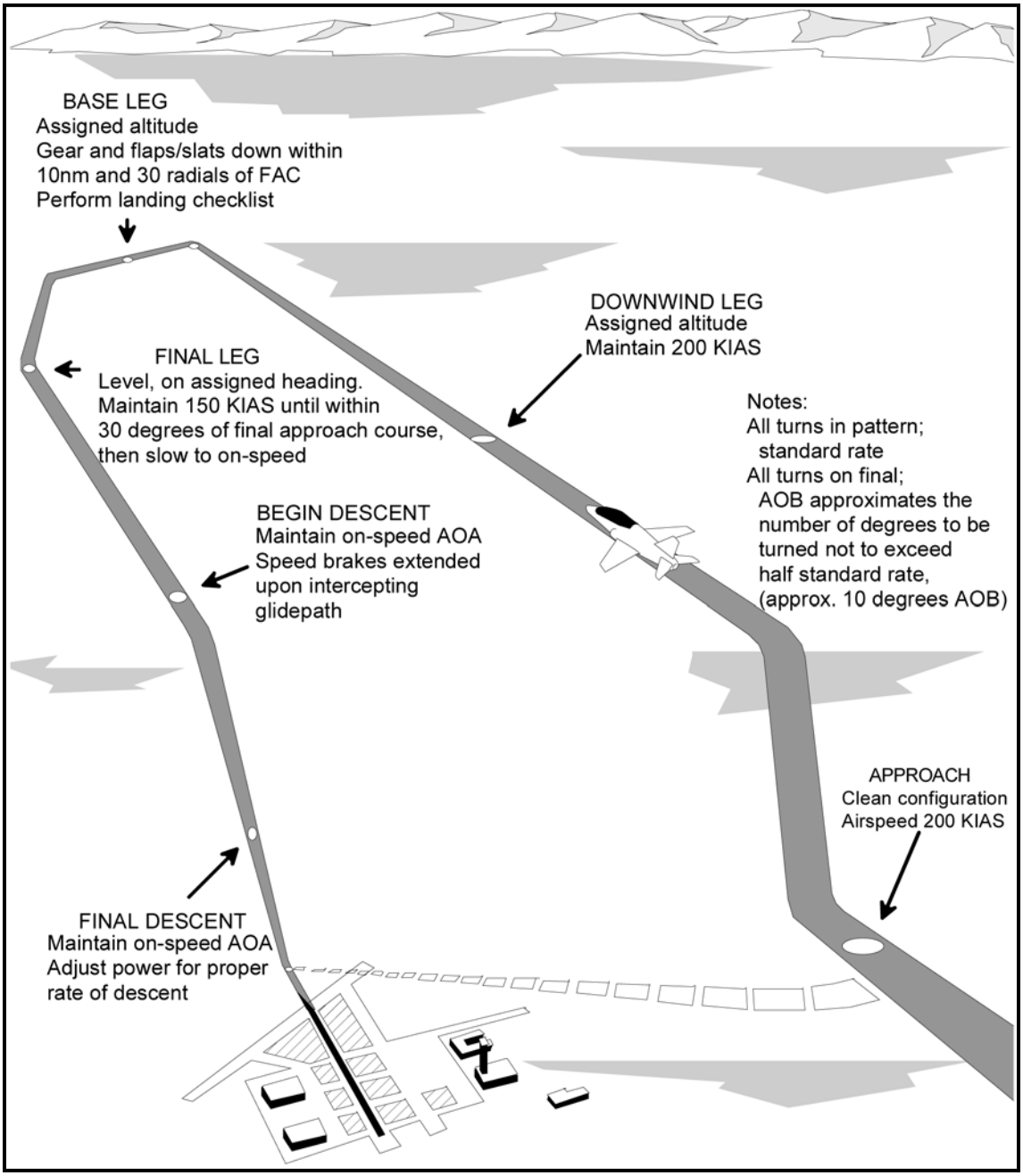


Figure 1-34 GCA Pattern

Radar approach minimums can be found in the FLIP instrument approach procedure publications, both on the approach plates and in the radar approach minimums section (Figure 1-35). Although some published approach minimums are lower than 200-1/2, you are limited to absolute minimums of 200-1/2 when single-piloted.

RADAR INSTRUMENT APPROACH MINIMUMS

GRAND FORKS AFB, ND (4 AUG 81 USAF) **ELEV 911**
RADAR – Ctc APP CON 118.1 318.1 371.2

	RWY	GS/TCH/RPI	CAT	DH/ MDA-VIS	HAT/ HAA	CEIL-VIS
ASR	17		CDE	**1200**/50	301	(300–1)
	35		CD	**1320**/40	409	(500–¾)
			E	**1320**/50	409	(500–1)
CIR ⓐ	17		C	**1380**–1½	469	(500–1½)
			DE	**1480**–2	569	(600–2)
	35		C	**1380**–1½	469	(500–1½)
			DE	**1480**–2	569	(600–2)

ⓐCir E Rwy 17–35 not auth.

GREAT FALLS INTL, MT (9 FEB 89 FAA) **ELEV 3674**
RADAR ⓐ – (E) 118.1 119.1 119.3 121.1 134.1 259.1 269.0 290.3 363.8

	RWY	GS/TCH/RPI	CAT	DH/ MDA-VIS	HAT/ HAA	CEIL-VIS
ASR	3		C	**4060**-½	386	(400-½)
			DE	**4060**-1	386	(400-1)
	34		C	**4060**-1	394	(400-1
			D	**4060**-1¼	394	(400-1¼)
			E	**4060**-1½	394	(400-1½)
	21		CD	**4000**-1	335	(400-1)
			E	**4000**-1¼	335	(400-1¼)
CIR	3-21, 34		C	**4140**-1½	466	(500-1½)
			D	**4240**-2	566	(600-2)
			E	**4420**-2¾	746	(800-2¾)

HILL AFB, UT (Ogden) (9 FEB 89 USAF) **ELEV 4788**
RADAR – Ctc Salt Lake City APP CON.

	RWY	GS/TCH/RPI	CAT	DH/ MDA-VIS	HAT/ HAA	CEIL-VIS
PAR ⓐⓑ ⓒⓓ	14	2.8°/57/1141	CDE	**4885**/16	100	(100–¼)
ASR ⓔⓕ	14		CDE	**5140**/40	355	(400–¾)
CIR ⓖ	14		C	**5240**–1½	452	(500–1½)
			DE	**5340**–2	552	(600–2)

ⓐOpr 1400–0600Z++. ⓑNo-NOTAM preventive maint sked: PAR–Sat–Sun 1800–2000Z++. ⓒWhen apch lgt inop, vis increases ¼ mile. ⓓWhen Salt Lake ASR O/S, PAR avbl to acft with opr TACAN and/or ILS. ⓔDescent blw 5700 on final not auth until 2.5 NM from Rwy (Step down fix). ⓕWhen apch lgt inop, vis increases ½ mile. ⓖCircling not auth E of Rwy 14–32.

RADAR INSTRUMENT APPROACH MINIMUMS

Figure 1-35 RADAR Instrument Approach Minimums

GCA Communication Procedures

During a GCA, your position in the pattern and on final will be directed by a controller who will continuously feed you course and heading information and, in the case of a PAR approach, glidepath information on final.

In the pattern, you are required to acknowledge all radio calls and read back all headings, altitudes, and altimeter settings. According to FAR 7110.65, the controller is required to give missed approach instructions, weather conditions (if less than VFR), altimeter, and lost comm instructions (if likely to encounter IMC).

In the pattern, the controller must communicate with you at least once a minute, and you are required to acknowledge the controller's calls. If you hear no transmissions for more than 60 seconds, attempt to contact the controller. If you are unable to reestablish contact, then comply with the lost communication instructions. While you are flying the pattern, the controller will furnish the following information:

Type of approach to expect (precision or surveillance)
Duty runway
Location of the missed approach point (MAP) (surveillance only)
Advisory to perform landing check (USN/USMC controllers only)
Missed approach and lost communication instructions

Additionally, the controller will give you position information and heading changes, as necessary, to keep you on course.

As you commence your final approach, the final controller will perform a radio check: "This is the Sherman final controller. How do you hear?" You should respond with "loud and clear, three down and locked" (or position of gear). The controller may also tell you that you need not acknowledge further transmissions. On final approach, the controller is required to make contact with you at least every five seconds on a PAR or 15 seconds on an ASR. If you lose contact with the controller for the respective amount of time for the approach being flown, attempt to recontact and, if not successful, execute the lost communication instructions.

GCA Pattern

The entry configuration for the GCA pattern is as follows:

Airspeed: 200 KIAS

Gear: Up

Speedbrakes: In

Flaps/slats: Up

Available NAVAIDS: Tuned

Normally, you will fly the first leg of the pattern (the downwind leg) straight and level at 200 KIAS and pattern altitude. At the end of the downwind leg, the controller will direct a turn to base leg. At the end of the base leg, the controller will direct a turn to either a dogleg or the final approach course. Once established on the downwind leg or on a dogleg to the FAC, unless directed by ATC, stay clean and at 200 KIAS until you are within 10 nm and 30 radials of the final approach course. When within those parameters, verbalize to your IP "slow to gear speed," wait for three green gear lights, and complete the landing checklist (speedbrakes retracted).

NOTES

1. USN/USMC controllers will state "perform landing checks" on the base leg; this is only a reminder and does not direct the pilot to dirty up. If the controller says "slow to approach speed," the controller is directing this for sequencing and the aircrew must comply or state that they are unable.

2. GCAs can be flown at full, one-half, and no-flap configurations.

Because the remaining PAR and ASR final approach procedures differ considerably, they will be discussed separately below.

PAR Final Approach

At the beginning of a PAR final approach, you will be straight and level, on-speed, and normally at approximately 1,500 ft. AGL. Verify gear down, flaps at half or full. When the controller informs you that you are "on glidepath," direct the IP to extend the speedbrakes and adjust power as required to establish a descent. Report "speedbrakes full, landing checklist complete" on the ICS.

The rate of descent will vary for different glideslope angles and ground speeds. The inside back cover of the approach plates contains a chart that will provide you with the rate of descent for a given glideslope and ground speed. Your IP will adjust power to maintain your rate of descent and keep the aircraft on-speed. When making heading corrections, keep the amount of bank angle small (5–10 degrees) so that you do not end up chasing the heading. If you get off heading, do not try to correct to course, return to your last assigned heading.

As you near the decision height, begin an "inside/outside" scan to visually acquire the runway environment. If you do not have the runway environment in sight when you reach the DH, direct the IP to execute a missed approach (make the mandatory missed approach call).

ASR Final Approach

On the ASR final approach, the controller cannot furnish glideslope information. It will be up to you to establish and maintain the correct rate of descent. The controller will identify the missed approach point (MAP) in nautical miles from the end of the runway and will direct the descent

by stating “begin descent.” On SNFO request, the controller will provide recommended altitudes each mile on final. Recommended altitudes decrease 300 ft. per mile (approximates a three-degree glideslope). In order to smoothly level at MDA prior to the MAP, your altitudes should be slightly lower than those recommended. Depending on your ground speed, a descent rate of 500–700 fpm will allow you to descend to the MDA prior to reaching the MAP. Upon reaching the MAP, if you do not have the runway in sight or are otherwise unable to perform a safe landing, direct the IP to execute the missed approach as instructed.

RADIO INSTRUMENT APPROACHES

Radio instrument approaches, unlike GCAs, employ onboard navigational equipment as a guide and can be flown, if necessary, without communication with the ground. In the T-45C, you will fly these approaches—VOR, TACAN, localizer, and ILS—in accordance with the published instructions found on high or low altitude approach plates.

Plan ahead by reviewing the procedures for the chosen approach before arriving at the IAF; stay ahead of the aircraft during the approach. Use all available NAVAIDs during the approach as backups in the event of equipment malfunction. If, for example, you are flying an ILS approach at a field that also has a TACAN, you should also tune the TACAN and select both TCN and ILS steering selected. TACAN course information is shown on the HSI display, and ILS information is shown on the ADI display.

VOR Penetration Approach

VOR navigational aids supply you with bearing information to the VOR station you have tuned. Instrument approaches flown to these facilities usually rely on direct overflight of the station during the approach (Figure 1-36).

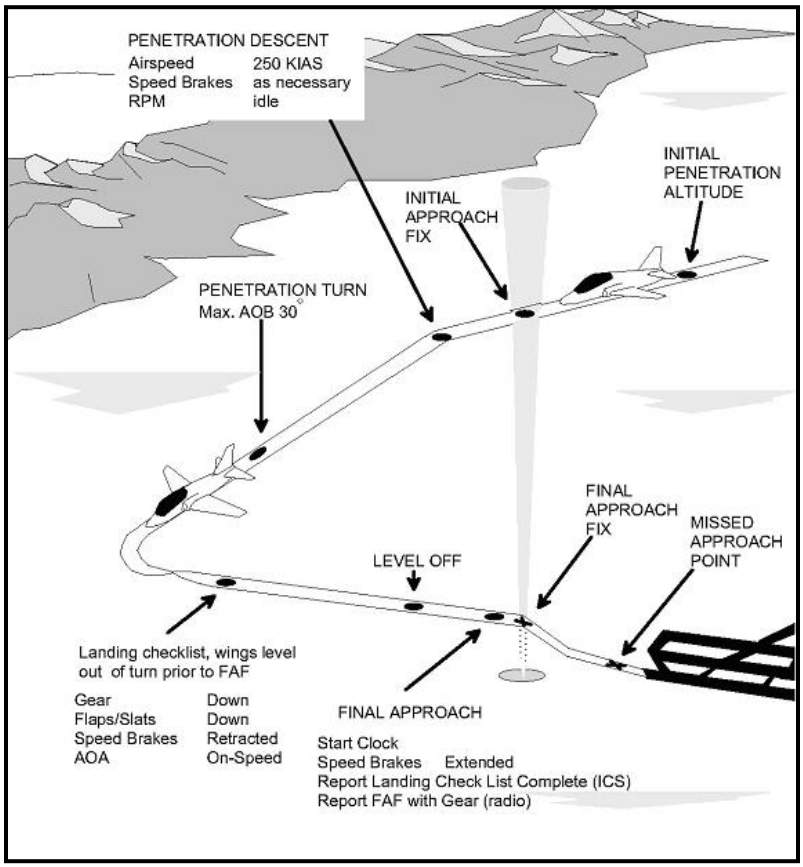


Figure 1-36 Non-DME Penetration

The VOR penetration approach is generally a procedure turn (i.e., 90/270, teardrop). Before beginning the approach, set the final approach course on the HSI display. The HSI must be in the CDI mode to get VOR information displayed. Begin the approach when you pass over the station on the altitude and heading prescribed by the approach plate.

At one half your initial altitude or at reaching the published penetration turn altitude, initiate the penetration turn (do not exceed 30 degrees AOB) to intercept the final approach course.

NOTE

Do not exceed the “minute-to-live” rule in the penetration descent.

At this point, the approach procedure can vary depending on whether the NAVAID is located at the field or not.

If the approach has an FAF (station located away from the field), station passage is normally the FAF, and timing will determine the MAP. After completing the penetration turn, transition to the landing configuration and check speedbrakes retracted prior to reaching the FAF. At station passage, start timing to the MAP, basing your timing on ground speed and the FAF to MAP table on the approach plate under the sketch. Extend speedbrakes, reduce power if necessary, and transition to descend on-speed to MDA. (Do not exceed 1,000 fpm.) Report FAF with gear to ATC and landing checklist complete on the ICS. Continue to a landing if you visually acquire the runway up to the MAP and you are in a position to land or maneuver to land safely. If you do not have the runway environment in sight when at the MAP (i.e., time expires), execute a missed approach.

If the approach does not have an FAF (station located at the field), transition to the landing configuration (on-speed and speedbrakes extended) as soon as you are wings level inbound to the station. Descend to the published MDA using the procedures in the paragraph above and start looking for the runway. Station passage is usually the missed approach point (MAP) for this type of approach.

If executing a low altitude TACAN and VOR approach that requires the aircraft to stay within 10 nm of the IAF/field, maintain 200 KIAS during the procedure turn and penetration.

NOTE

> Generally, you should not exceed the 1,000 fpm rate of descent during the final portion of the approach. If the approach requires a higher rate of descent, request clearance from the instructor prior to exceeding 1,000 fpm.

TACAN Approach

TACAN (and VOR/DME) navigational equipment supplies both range and distance information, making arcing approaches possible. Because range information is available, you can determine the fixes (IAF, FAF, and MAP) defined by DME (Figure 1-37).

The course line may be used for tracking all radials on the approach (e.g., initial inbound radial and final approach course).

When executing a TACAN/VOR DME approach and before reaching the IAF, set the final approach course on the HSI display and select the CDI mode. At the IAF, intercept and maintain the approach course as published. Direct the IP to lower the nose and accelerate to 250 KIAS. Report departing the IAF if requested. Start penetration turn 2.5 nm DME from the arc. At 5–7 nm prior to the FAF, direct the IP to “slow to gear speed.” Configure the aircraft for landing 3–5 nm prior to the FAF and perform landing checklist (speedbrakes retracted). Conform to all course, altitude, and DME instructions on the approach plate. Lead level off from penetration by 1,000 ft. if VSI pegged at 6,000 fpm.

At the FAF, start the clock, direct the IP to extend speedbrakes, report landing checklist complete on the ICS, and make gear down call to ATC. Descend to the MDA and start looking for the

runway while monitoring your DME for the MAP. Plan your descent to be in level flight at the MDA prior to reaching the MAP. From the FAF, maintain precise course, speed, and rate of descent control. Do not exceed 1,000 fpm. Keep heading changes small so you do not chase the final approach course on the HSI display or the course situation steering arrow on the HUD.

When you reach the MAP, if you do not have the runway environment in sight or determine that a safe landing is not possible, direct the IP to execute a missed approach.

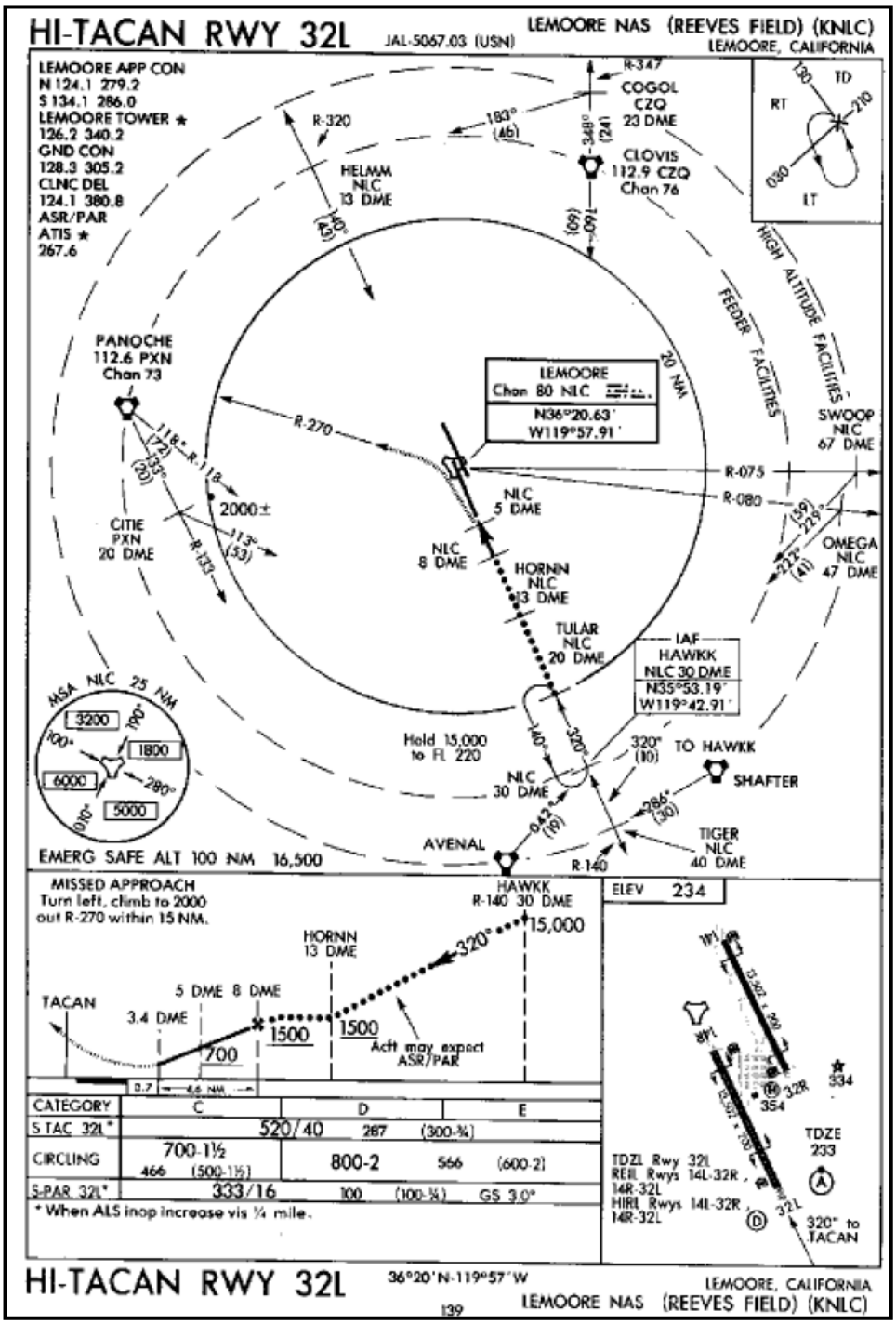


Figure 1-37 TACAN Approach

ILS Approach

Glideslope and localizer needles are displayed on the ADI display and HUD, and localizer deviation is displayed on the HSI when an ILS frequency is selected on the VOR control panel

and ILS is the only selected steering. TACAN or WYPT can be selected in conjunction with ILS steering. In this case, TACAN or waypoint course deviation is shown on the HSI, and ILS deviation is shown on the ADI. The HUD displays either the TACAN or the waypoint steering arrow and the ILS needles (Figure 1-38).

The ILS approach is a precision approach in which you are provided precise glideslope, azimuth (course), and range information. The ILS (Figure 1-39) is composed of three elements: the localizer transmitter, the glideslope transmitter, and marker beacons. As with any approach, you should back up the ILS approach with any other available NAVAIDs.

The localizer transmitter provides azimuth information to the HSI display course line (ILS selected as the only steering selection) and to the azimuth deviation bar on the ADI display and the HUD for maintaining alignment with the approach course. The localizer signal has a maximum range of 18 nm from the station, if you are within 10 degrees either side of the course centerline.

The glideslope transmitter provides glideslope information to the glideslope deviation bar on the ADI display and HUD. Glideslope transmitters have a normal range of approximately 10 nm, if you are on or near the localizer course. However, at some locations, the glideslope has been certified for an extended service volume that exceeds 10 nm.

When overflown, the three marker beacons (outer, middle, and inner) provide a distance (range) reference by sounding an aural tone and illuminating one of three marker beacon lights on the instrument panel. Although there are a maximum of three marker beacons, most ILS approaches do not have all three, and some do not use them at all. If beacons are not present, cross-radial fixes, DME, or radar is required. The outer beacon usually marks the FAF and will often indicate the point of glidepath intercept. The middle marker denotes the vicinity of the DH for category I approaches (the T-45C is equipped for Category I) and progress points for categories II and III. You will cross the middle marker approximately half a mile from the runway, at 200 ft. AGL (this may vary depending on local terrain and minimums). The inner marker denotes the DH for category II approaches and is a progress point for category III approaches. You will usually cross the inner marker at 100 ft. AGL. Fly the portion of the approach prior to intercepting the localizer using VOR or TACAN (depending on the published procedure) (Figure 1-40). If you are using VOR prior to localizer intercept, ensure that you have tuned and identified the ILS frequency. Upon selecting an ILS frequency, the VOR steering selection will automatically change to ILS steering. Set the ILS final approach course on the HSI display course selection so that the ILS azimuth deviation is correctly shown on the CDI. If you are using TACAN prior to localizer intercept, select TACAN and ILS steering. TACAN course information is shown on the HSI display, DME is shown on the HSI display and the HUD, and ILS information is shown on the ADI display and the HUD (Figure 1-40). Select MKR and VOR on the comm control panel to monitor the audio signals of the localizer signal and when passing the outer, middle, and inner marker beacons.

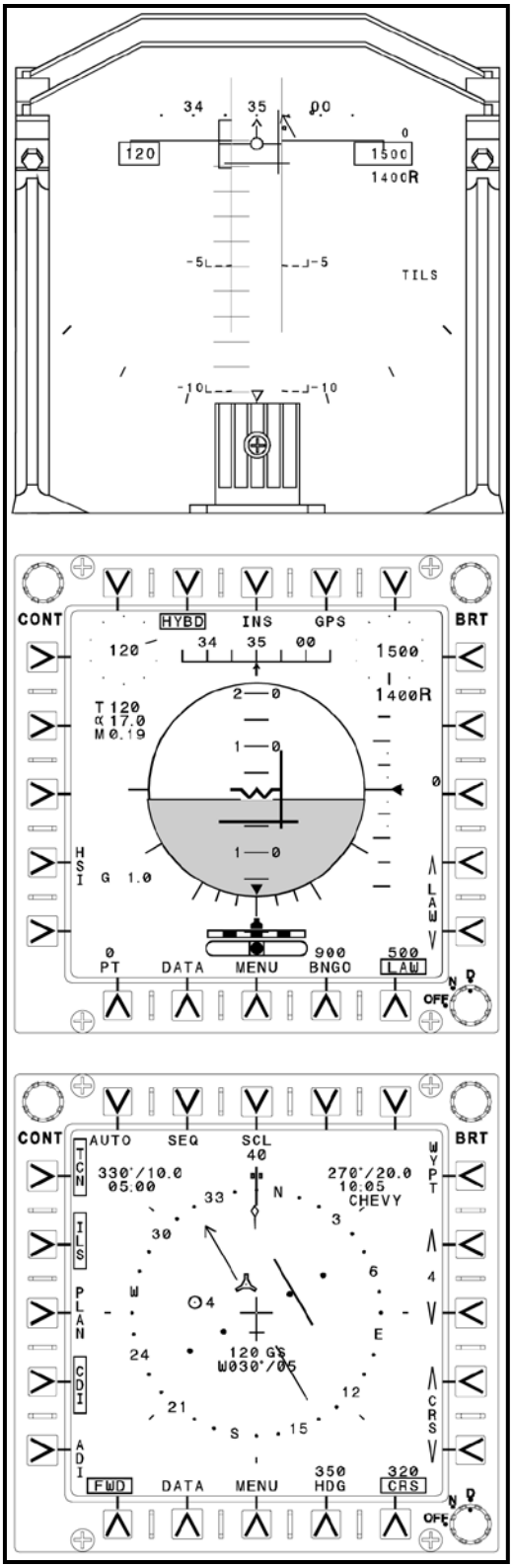


Figure 1-38 ILS Displays

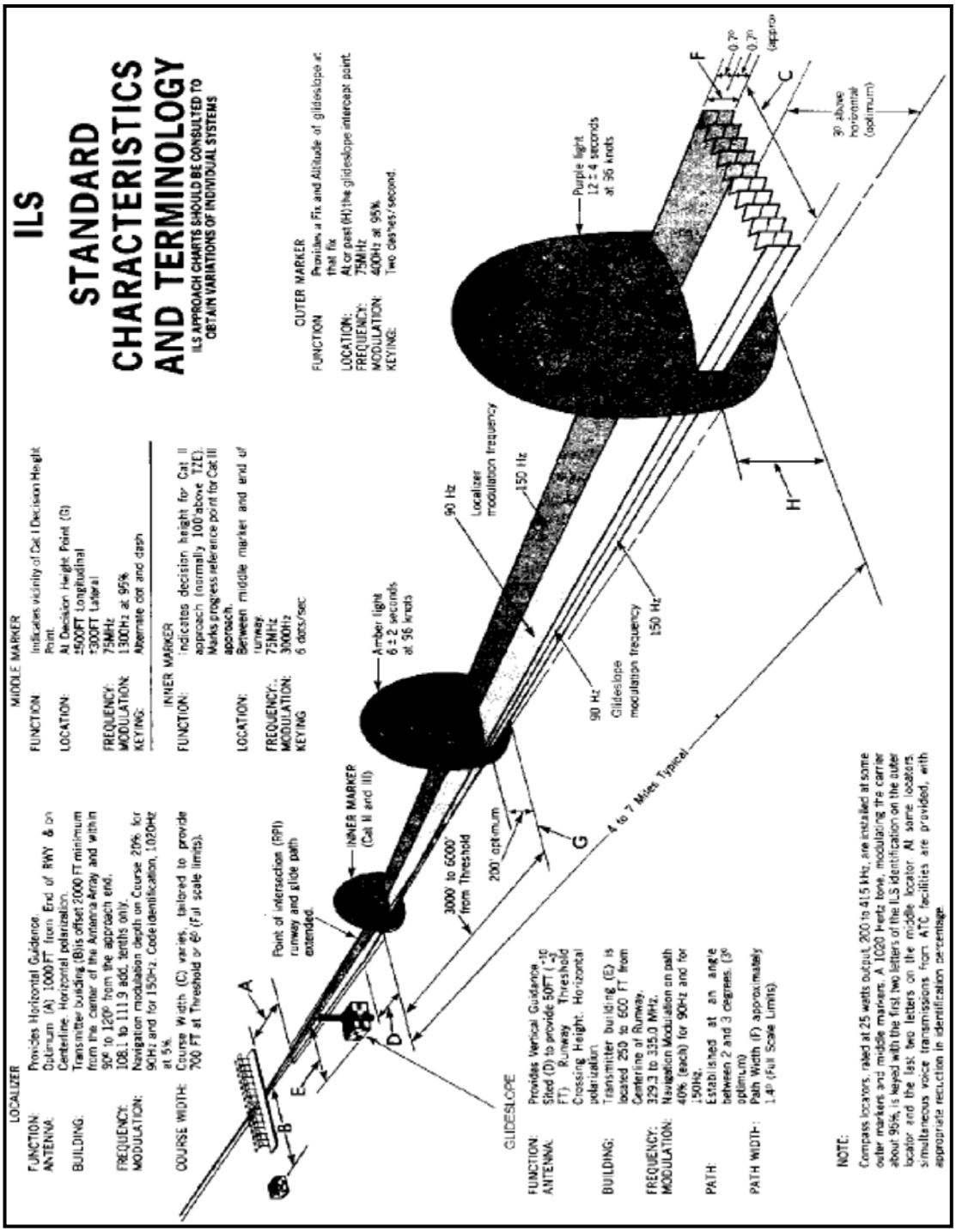


Figure 1-39 ILS Components

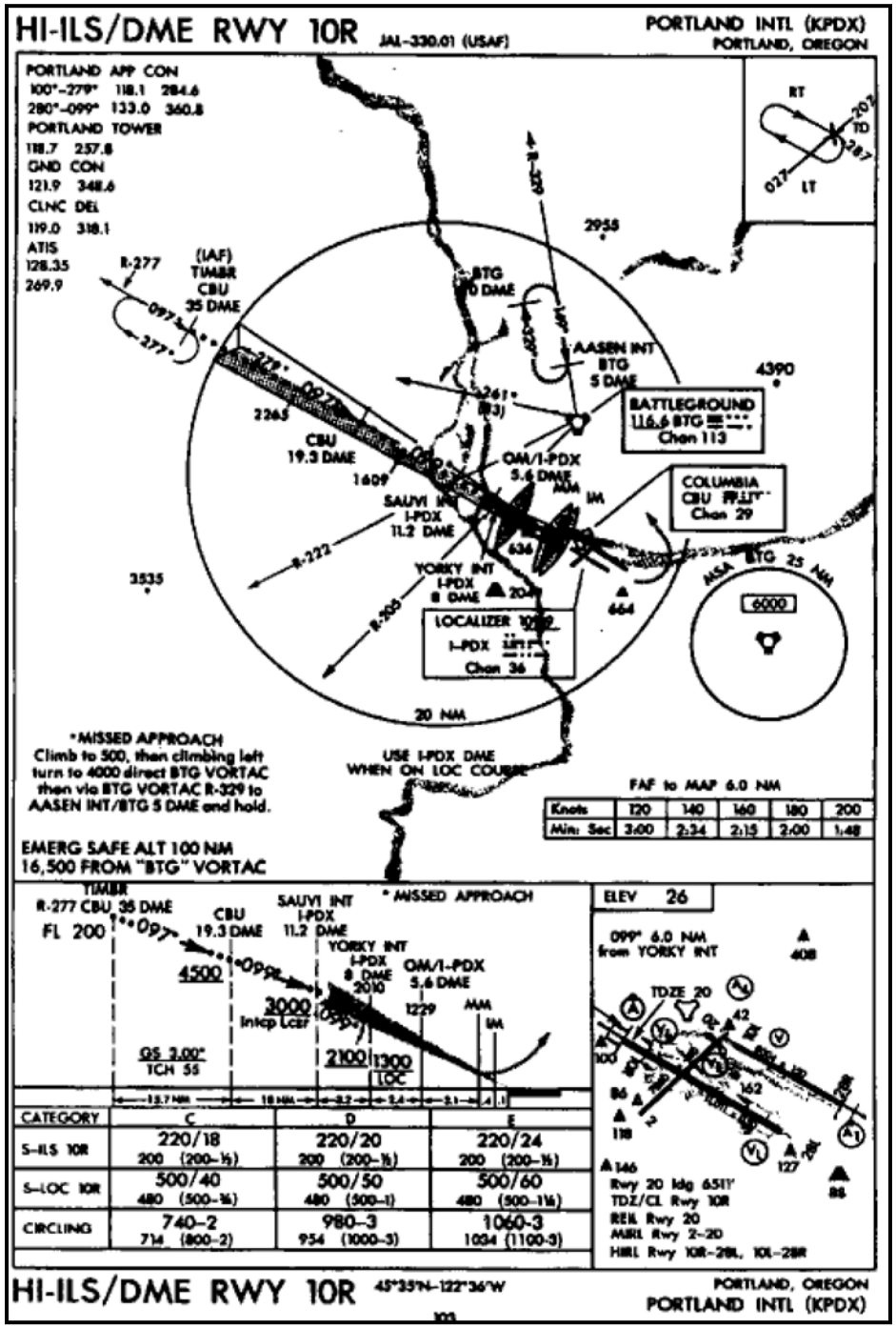


Figure 1-40 ILS Approach

If the penetration is performed on VOR, transition to landing configuration and on-speed, immediately after completing the penetration turn with the speedbrakes retracted, if used in the transition. If the penetration is performed on TACAN or VOR DME, direct the IP to “slow to gear speed,” 5–7 DME prior to the FAF. Speedbrakes should be retracted if used before the FAF.

NOTE

Transition to landing configuration and on-speed for an ILS approach with DME is performed using the same procedures as TACAN or VOR DME.

Radar vector to ILS final: Since a vector to an ILS final is a controlled, non-formalized procedure to a precision approach, aircrew should use logic and common sense when determining an appropriate time to transition from 250 KIAS to the landing configuration and 150 KIAS and then to on-speed. As a rule-of-thumb, it is appropriate to initiate the transition to the landing configuration anytime the aircraft is established on a base leg or within 10 nm of the FAF and on an intercept heading to the FAC, within 10 nm. It is important not to transition late.

By the time you intercept the glidepath, you should be flying on-speed with the landing checklist completed (speedbrakes retracted).

Immediately prior to glidepath intercept, as indicated by the glideslope deviation bar on the ADI display or HUD, verify on-speed with airspeed. As the glideslope deviation bar intercepts the glidepath, extend the speedbrakes and adjust pitch and power as required to maintain on-speed and stay on glidepath. Maintain course by making corrections using heading changes no greater than +/- 5 degrees from the WCH. At the FAF, start the clock and report FAF with gear, if necessary, to the ATC and landing checklist complete on the ICS. Descend to the DH. When approaching the DH, start looking for the runway while monitoring your range indications, marker beacons, and/or DME. Although you normally refer only to the barometric altimeter (using the current altimeter setting) to determine the DH, use radar altimeter as a backup, but be aware of extreme terrain features that could make the radar altimeter a dangerous alternative.

The elapsed time clock is started when passing the FAF in case the glideslope signal information is lost during the approach. If this happens, you can (depending on minimums) continue flying the localizer only, using time to determine the MAP.

If, upon reaching the DH on an ILS approach or the MDA on a localizer approach, you do not have the runway environment in sight or you determine that you cannot make a safe landing, execute a missed approach.

Localizer Approach

The localizer approach uses the ILS equipment, minus glideslope signal generation equipment. You may have to perform this approach because of equipment failures in your aircraft, on the ground, or because the runway lacks a glideslope transmitter. The localizer approach is non-precision with minimums higher (Figure 1-41) than a full ILS approach to the same runway. The MAP is determined by timing from the FAF, by DME, or by radar. As in the ASR, plan your descent so that you are leveled off and on speed prior to the MAP.

CATEGORY	C	D	E
S-ILS 10R	220/18 200 (200-1/2)	220/20 200 (200-1/2)	220/24 200 (200-1/2)
S-LOC 10R	500/40 480 (500-3/4)	500/50 480 (500-1)	500/60 480 (500-1 1/4)
CIRCLING	740-2 714 (800-2)	980-3 954 (1000-3)	1060-3 1034 (1100-3)

Figure 1-41 ILS Minimums

Back Course Localizer Approach (BC LOC)

The back course localizer is established along the centerline of a runway in the opposite direction to the front course.

Caution should be taken when flying a back course LOC approach because of reverse sensing when the back course is selected in the HSI display. To center the CDI, it will be necessary to steer the aircraft in the direction opposite the CDI deflection. An alternate procedure is to set the front course into the HSI display. This will induce a normal sensing display in the HSI display. Again, caution should be taken because the azimuth deviation bar in the ADI display will continue to display reverse sensing.

Whichever procedure is used, a higher level of concentration is required from the SNFO to maintain orientation and fly the approach correctly.

No-Gyro Compass Approach

A no-gyro approach is ASR/PAR performed when you lose primary heading information. During this approach, the controller will transmit your turns using “turn right/turn left” and “stop turn.”

BINGO Profile

The BINGO profile for the T-45C is defined in NATOPS. During simulator flights, you may be asked to perform this maneuver. Refer to the NATOPS for all BINGO procedures.

NOTE

The BINGO profile does not include fuel that may be required for an instrument approach.

Simulated Minimum Fuel Approaches

On vectors for ILS or in the GCA box, remain in the clean configuration until 30 seconds before glidepath intercept. Direct the IP to “slow to gear speed.”

Simulated Minimum Fuel GCA

When a minimum fuel GCA is requested, ATC will give normal GCA box pattern vectors (intercept glidepath at approximately six miles from the end of the runway) and expect 200 KIAS until final. ATC should also provide a 30-second gear warning. The call "perform landing checks" is a required USN/USMC advisory call on the base leg and does not mean to dirty up or reduce airspeed.

Simulated Minimum Fuel ILS

Request vectors to ILS final and advise the ATC that you will maintain 200 KIAS until glidepath intercept. The glideslope needle starting to move down serves as a "30-second glidepath warning."

Simulated Emergency Fuel GCA

This GCA is designed to get you from altitude to the deck without any undue delay and is actually a practice procedure for dealing with emergency fuel situations. The controller will vector you direct to final approach with a glidepath intercept much closer to the runway than a normal GCA with a continuous turn from downwind to final. The controller will vector you to intercept a final at approximately four miles from the end of the runway at 800 ft. AGL. The controller may ask how much fuel you have remaining in minutes and will attempt to get you on the deck prior to simulated fuel exhaustion. Request a 30-second prior to glidepath intercept call from the controller. You will remain in a clean configuration until the 30-second call is heard. Then direct the IP to "slow to gear speed."

Simulated Emergency Oil/Precautionary Instrument Approach

The emergency oil/precautionary instrument approach, like the emergency fuel instrument approach, will get you on the deck without any delays. It sets the power at an appropriate setting for an impending engine failure.

When given the simulated emergency, set the power to 80–85 percent rpm (see NATOPS). Engine seizure is delayed by minimizing rpm, minimizing throttle movements, and maintaining one "G" flight. If extreme flight conditions warrant (i.e., high elevation or a hot summer day), power changes should be made with smooth, slow throttle movements. If given outside the GCA box pattern, monitor and control airspeed with speedbrakes, as necessary, to expedite landing without causing an unduly difficult transition to gear speed and glidepath. In the GCA box, use the speedbrakes to maintain 200 KIAS. When given the "up and on glidepath" call (approximately 6 nm from touchdown) on a PAR or as the needles center on the ILS, direct the IP to "slow to gear speed." The IP will lower the nose to maintain the glidepath at 175 KIAS.

The emergency oil instrument approach is a precautionary approach (PA) (see NATOPS), modified for actual instrument conditions or nighttime. On a day visual meteorological conditions PA, the "aimpoint" is short of the runway on a 10-degree (approximately) glideslope. However, the emergency oil approach "aimpoint" is the touchdown point for the PAR or ILS.

Also, the glideslope is more shallow, so the transition to half and full flaps is delayed to ensure that airspeed does not bleed too rapidly.

If during an actual emergency the landing environment is not in sight at decision height or a safe landing cannot be completed, direct the IP to execute a waveoff as follows: retract the speedbrakes, raise the gear, and slowly position the nose to a climb attitude. When above 300 ft. AGL and indicating a positive rate of climb, raise the flaps (140 KIAS minimum). Power should not be reset unless a positive rate of climb is not achieved. If unable to climb, a slow, smooth power addition to the minimum rpm required for climb should be made.

VISUAL MANEUVERS

Visual maneuvers, IFR procedures executed in VMC conditions, are included here because once you reach the MAP or are cleared by ATC for a visual approach, you will complete your approach and landing VFR. Non-precision approaches that have a visual descent point (VDP) require you to remain at the MDA until the visual descent point is passed.

Contact Approach

The contact approach is an IFR procedure that you can request when you are operating on an IFR flight plan in VMC conditions. To request a contact approach, you must be clear of the clouds with at least 1 sm of visibility and have an unobstructed view of the ground. In a contact approach, you may deviate from the published approach procedure and proceed to landing via visual references. You may not perform a contact approach to an airport that lacks an authorized instrument approach procedure or conduct an approach to one airport and then, when “in the clear,” discontinue that approach and proceed to another airport. The pilot must specifically request it and obtain clearance from approach control. During a contact approach, you are still operating under IFR, and ATC will ensure your separation from other aircraft. However, you are responsible for your own obstruction clearance. Radar service, if you are receiving it, will be terminated when you are told to contact the tower.

Visual Approach

In a visual approach, an aircraft on an IFR flight plan, operating in VMC conditions and having received an Air Traffic Control authorization, may deviate from the prescribed instrument approach procedures and proceed to the airport of destination by maintaining VFR conditions. ATC may initiate a visual approach, but you are never required to accept it.

Certain conditions must be met before you can fly a visual approach: (1) the field or a preceding aircraft must be in sight, (2) the ceiling must be at least 1,000 ft. AGL, and (3) there must be at least 3 sm of visibility.

Circling Approach

The circling approach is used to align aircraft with the proper runway at the end of an instrument approach. The runway is often not the same one to which the instrument approach was flown.

The minimums for a circling approach differ from the others published for a given runway. Circling minimums are higher than other instrument minimums and require you to remain VMC underneath while maneuvering to land.

Once you have elected to conduct a circling approach and have obtained clearance, descend to the circling minimums and visually acquire the runway. The applicable minimums are those published for the approach flown (not necessarily for the landing runway).

Once you descend to the MDA, determine if visibility is sufficient to safely complete the landing. If it is, choose the landing pattern (Figure 1-42) that is best suited to your situation or use the one directed by the controller. Stay at the MDA until you are in a position to execute a normal landing—ideally, the point at which you would intercept the normal glideslope to the runway. If weather permits, fly the circling maneuver at the normal VFR pattern altitude. Be sure to check the approach plate for any obstacles in the vicinity of the airport.

If you cannot safely complete the landing, execute a missed approach. The applicable missed approach procedures are those for the approach flown (not necessarily for the landing runway).

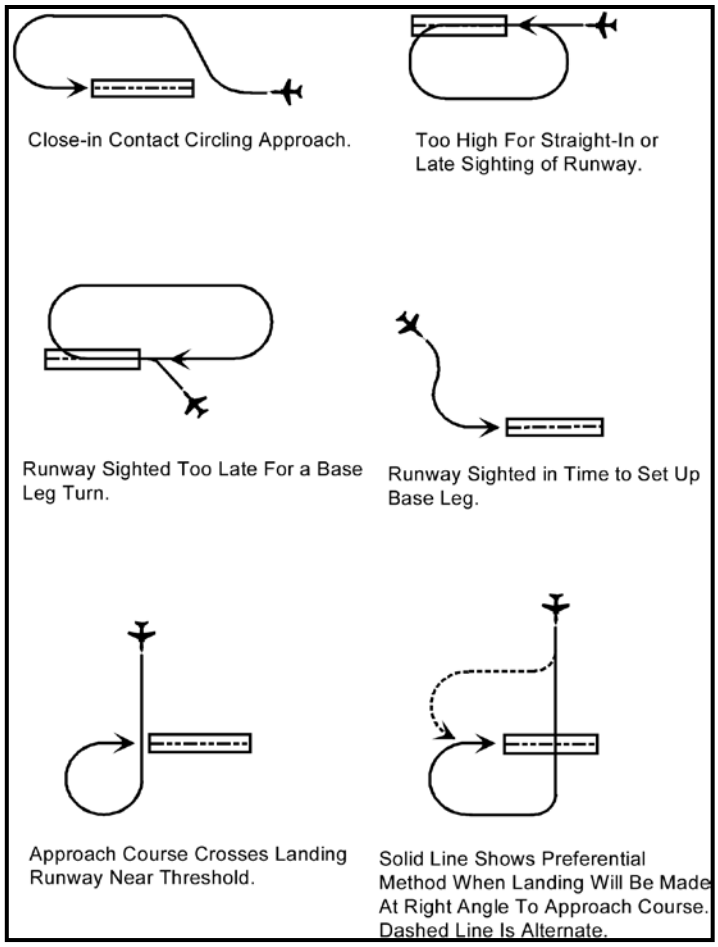


Figure 1-42 Circling Approach Options

Flap Setting

Due to the number of approaches required in a given instrument training sortie and the transit times to practice airfields, half flap approaches are normally performed. However, approach configuration for full stop landings should be full flaps.

MISSED APPROACH

You will execute a missed approach anytime you reach the MAP or DH on an approach and you do not have the runway environment in sight, you lose sight of the runway when circling, a safe landing is not possible, or when instructed by your controller to do so. If you execute a missed approach while circling to land, direct the IP to turn to fly over the airport center, then fly the published missed approach.

CHAPTER TWO
EMERGENCY PROCEDURES

200. INTRODUCTION

This chapter contains a description of ATM stage Emergency Procedures (EP) events, as conducted in 2F205/A Flight Simulators.

Simulator instruction during the contact block of training is intended to improve student knowledge and performance in the following areas:

1. **CHECKLISTS:** Accurate and efficient completion of aircraft checklists

2. **SCAN:** Instrument scan

3. **AIRCRAFT KNOWLEDGE:** Knowledge of the T-45C aircraft through normal operation of aircraft systems and the detection and correct execution of procedures for aircraft emergencies

4. **COMMUNICATIONS:** Radio communications

5. **COCKPIT RESOURCES:** Cockpit organizational skills: management of cockpit equipment and controls, kneeboard documents, and the NATOPS POCKET CHECKLIST (NPCL)

6. **CREW COORDINATION:** Development of an understanding and method for handling emergency procedures in a multi-crew aircraft

7. **SIMULATED FLIGHT:** Indications and characteristics of emergencies in the 2F205/A to enhance follow-on radio and SUA simulator instruction

201. EMERGENCY PROCEDURE STEPS DEFINED

Immediate Action Items (sometimes referred to as "bold-face" procedures): The NATOPS PILOT'S POCKET CHECKLIST states that "All EP steps with asterisks (*) within this section are immediate action items. These steps are required knowledge for all aircrew without reference to the NATOPS POCKET CHECKLIST."

Deferred Action Items: EP steps without asterisks are deferred action items. Students are expected to expeditiously locate, read aloud, and execute all deferred action items by reference to the NATOPS POCKET CHECKLIST.

202. EXECUTION OF EMERGENCY PROCEDURES

Emergency procedures requiring only Immediate Action Items (such as a HOT START):

The student will:

1. Identify the emergency by announcing the title (HOT START).
2. Simultaneously recite and execute the Immediate Action Items.
3. State the NPCL page number and the title of the emergency procedures.
4. Read aloud and confirm completion of all immediate actions.
5. Report when checklist is complete (i.e., “Hot Start Checklist Complete”).
6. Read aloud all notes, cautions, and warnings.

Emergency procedures requiring a mix of Immediate Action Items and Deferred Action Items (such as a CANOPY LIGHT IN FLIGHT):

The student will:

1. Identify the emergency by announcing the title (CANOPY LIGHT IN FLIGHT).
2. Simultaneously, recite and execute the Immediate Action Items.
3. State the NPCL page number of the emergency procedure.
4. Read aloud and confirm completion of all immediate actions.
5. Read aloud and execute the Deferred Action Items.
6. Report when checklist is complete (i.e., “Canopy Light In Flight Checklist Complete”).
7. Read aloud all notes, cautions, and warnings.

Emergency procedures requiring only Deferred Action Items (i.e., OIL PA Warning Light):

The student will:

1. Identify the emergency by announcing the title (OIL PA Warning Light).
2. State the NPCL page number and title of the emergency procedure.
3. Read aloud and execute the Deferred Action Items.
4. Report when checklist is complete (i.e., “Checklist Complete”).
5. Read aloud all notes, cautions, and warnings.

2-2 EMERGENCY PROCEDURES

CHAPTER THREE
CONTACT FLIGHT PROCEDURES

300. INTRODUCTION

The four T-45C contact flights are designed to transition the student from the simulator phase to the T-45C aircraft. The T-45C is a modern Navy jet trainer. Its performance and handling characteristics serve as an excellent transition to the tactical jets in the fleet.

During the contact flights, the student will be reintroduced to advanced tactical flight equipment such as a G-suit system, O_2 mask, and ejection seat. With the solid procedural foundation of contacts, the student will progress to the best tactical applications of weapons delivery and Basic Fighter Maneuvers (BFM).

301. FLIGHT PLANNING/SORTIE COMPOSITION

Contacts may be flown as single events locally, as out-and-ins, or completed in series during extended cross-countries. If the flight schedule does not delineate a local stereo route, the NFS should coordinate with the assigned IP the evening prior to the scheduled contact. Flight data (e.g., climb airspeeds, fuel data, etc.) may be found in NATOPS as well as in the "T-45C Inflight Guide" and PFPS.

The composition of a contact flight resembles a T-45C contact simulator event. Each contact should include at least one instrument approach (PAR, ASR, TACAN, or ILS). Additionally, unusual attitudes, VFR arrival procedures, and the VFR landing pattern will be emphasized during contacts.

302. COMMUNICATIONS

Excellent ICS and UHF radio communications are the hallmark of a professional Naval Flight Officer. Solid comms are essential to the efficient employment of tactical aircraft in a dynamic environment. For these reasons, radio comms are a high priority during the entire Contact Flight block. The radio skills previously learned in the Training Command will be polished while in T-45s.

Checklists will be challenge and reply if indicated in the T-45C Inflight Guide. Care shall always be made to avoid stepping on UHF transmissions while conducting challenge and reply checklists on the ICS.

303. BRIEF/DEBRIEF

All students and observers shall be in the briefing room with all appropriate briefing materials no later than 5 minutes prior to the scheduled brief time. Unless coordinated otherwise, the IP will meet the student in the VT-86 briefing spaces at the scheduled brief time.

Briefing Board

A briefing board will be completed to include the following:

1. Type flight (i.e., C5001)

2. Aircraft call sign (i.e., ROKT 403)

3. Instructor and student names

4. Brief, T/O, and land times

5. Route of flight (i.e., NPA 802 or DD-175). Students will utilize PFPS for route depictions /mission overviews instead of hand drawn depictions. PFPS depictions will be taped to the briefing board IAW the briefing board examples in the Briefing Guide. Exception: BFM area depiction and gun envelopes shall be drawn on the board by hand.

6. Fuel Planning Data

7. Takeoff and Landing Data (TOLD)

Takeoff and Landing Data (TOLD) is temperature specific. These numbers will be computed from the appropriate charts found in the NATOPS Pocket Checklist (PCL) and NATOPS. The student will make calculations based on actual forecasted temperatures and winds.

1. Communication plan (local channelization may be used)

2. Weather

3. NOTAMS

4. VT-86 questions of the day. In addition to reciting boldface items, NFS will generate a scenario, using worst case fuel and weather, and describe in detail how to recover the aircraft (type of approach, configuration, etc).

Additionally, the student will have the following available for the brief:

1. Students shall have a copy of the Master Curriculum Guide (MCG), In-Flight Guide (IFG), VT-86 T-45C Briefing Guide, FTI and Standards in addition to their ATJ for all briefs.

2. T-45C model

3. Aviation training jacket

4. Briefing cards (one for each leg for the IP and NFS)

5. A completed DD-175 for the route of flight, if required

3-2 CONTACT FLIGHT PROCEDURES

6. Students will obtain a (–1) weather brief (FSS weather brief if conducting ops at civilian field) prior to briefing and include the VOID TIME on the briefing board IAW the briefing board examples in the Briefing Guide.

7. A completed jet card and a copy for the instructor

8. At a minimum, the student is responsible for the following:

   a. Familiarity with T-45 flight procedures and checklists, as outlined in this FTI

   b. The emergency, instrument, safety, and tactics questions of the day

   c. Verbatim knowledge of all boldface items in the T-45 Emergency Procedures

   d. Aircraft systems knowledge and limitations

   e. The Unusual Attitude Recovery Procedures, as outlined in chapter 1

   f. The Course Rules for the local operating area to include local MOA procedures

   g. Information applicable to T-45 procedures in the VT-86 SOP

9. Ensure flight gear is ready and appropriate pubs are available, including:

   a. PCL

   b. T-45C Inflight Guide

   c. Approach Plates and High/Low Altitude Charts

   d. IFR Supplement

   e. Flight Information Handbook

Fuel Planning

Mission Completion Fuel (MCF): Fuel required to complete planned mission conduct (route of flight, low-level or tactical maneuvering) and return to planned destination via standard routing (including approaches for training or weather) to arrive with:

VMC: SOP minimum fuel (500 lbs) on deck or fuel to proceed to alternate and arrive above SOP emergency fuel (400 lbs), whichever is higher

IMC: Divert Fuel

Joker: Pre-briefed fuel state that allows for one more tactical run/set, or 1 minute at MRT (whichever is higher), prior to reaching Bingo fuel.

Bingo: Fuel required to fly from the farthest point of a working area or route point to your planned destination using standard routing to arrive with:

VMC: SOP minimum fuel (500 lbs) on deck or fuel to proceed to alternate and arrive above SOP emergency fuel (400 lbs), whichever is higher

IMC: Divert Fuel

Divert: Fuel required to fly direct to the planned alternate and shoot an approach (if required, based on weather) to land above SOP emergency fuel (400 lbs) on deck.

Emergency Divert: Emergency fuel required to fly a Bingo profile from present position and make it to the nearest suitable divert with the published NATOPS reserve fuel (300 lbs).

NOTE

During CV/CVN operations, BINGO fuel is defined as the specified fuel state that requires declaring an emergency and immediately intercepting the NATOPS BINGO profile to the nearest suitable divert.

Other considerations should be taken into account for additional fuel that may be necessary for contingencies such as weather, single usable runways, etc.

NOTE

Depending on the type of flight, weather, etc. some fuel definitions may not be applicable. For example, on a BFM flight MCF would not apply but Joker and Bingo would. Conversely, on a Cross Country flight, Joker and Bingo would not apply but MCF would.

BINGO Caution setting: For the tactical/mission portion of the flight, the Bingo fuel setting will be set in the BINGO Caution Setting. Upon completion of the tactical/mission conduct (normally during fence out checks), the Divert fuel setting will be set in the BINGO Caution Setting for RTB. Mission Completion Fuel and Joker fuel settings will be calculated during mission planning and will be referenced during the appropriate stages of the flight but will not be set in the BINGO Caution Setting. In addition, NFSs will not utilize the REJ button to silence the BINGO Caution.

Brief

Students will be prepared to brief all administrative portions of all syllabus flights. Contact 1, Weapons 1, and BFM-1 Conduct of Flight are at the discretion of the Instructor Pilot. Students should be prepared to discuss Conduct of Flight specifics on these flights. For all flights not listed above, the student shall be prepared to brief the entire flight(s). Students MAY utilize the briefing guide during the brief to enhance briefing effectiveness.

3-4 CONTACT FLIGHT PROCEDURES

The Briefing Guide is meant to be an aid to briefing. The published briefing flow shall be used to standardize the delivery order of information during all ATM/T-45C briefs. Specific information given during briefs is at the discretion of the briefer and may include more, or less, than is provided in this Briefing Guide.

While typically the Admin portion of a brief should only take about 10 to 15 minutes, in the Contact stage, the entire flight is Admin. NFSs should take the time in the Contact brief to "Chair Fly" the event one more time, talking through each procedure that they are to accomplish during the flight. For the Mission Conduct portion of the brief, the route of flight and approaches for that flight should be briefed in depth just as one might brief a low-level route. Charts/Approach plates should be available for the brief with the NFS briefing the particulars of the route/approach just as they expect it to occur airborne.

Debrief

The debrief is where most of the learning occurs during a training event. To ensure that all the learning points are addressed, the fleet uses a standard format when conducting debriefs. In VT-86, the following format will be utilized for <u>all</u> ATM debriefs:

<u>Safety-of-Flight/Training Rule Violations</u>: It is important to address any safety issues right off the bat so as to "clear the air" and allow for attention to be later focused on addressing learning points. A common mistake is too often make the leap to "that could have been a safety," usually items that fall into that category can just be addressed later.

<u>Questions from the Brief</u>: The debriefer should cover anything that was unclear or not addressed in the brief.

<u>Admin</u>: Conduct of the flight to and from the tactical portion of the flight. A common mistake is for aircrew to reconstruct the entire Admin portion of the flight during this stage of the debrief. That is not the intent. Only deviations from the brief or standard execution should be addressed (what went wrong); everyone already knows what happened on the flight. However, in the Contact phase of training, typically the entire flight is admin and may be covered more in-depth.

<u>TAC Admin</u>: Tactical Admin generally involves those areas that revolve around the facilitation of the tactical conduct of the hop: G-warm, fencing in/out, setup parameters, area management, fuel management, knock-it-off flow, etc… Like Admin, it should only be a discussion of those items that were not standard and not a rehash of the entire TAC Admin portion of the flight.

<u>Mission Conduct</u>: This is the portion of the debrief where we can go into more detail as to the particulars of the tactical portion of the flight. A common mistake is for aircrew to dive right into the Mission Conduct portion of the debrief before covering the four previous items.

<u>Training Objectives</u>: After covering the pertinent learning points in the Mission Conduct portion of the debrief, a final review of the Mission/Training Objectives generally tells us is we have accomplished the intended training. Often utilized in a "Good/Other" format, the review of Training Objectives gives us a "gradesheet" as to how we executed on any particular flight.

304. CONTACT FLIGHT CONDUCT

NOTE

The "flight conduct" sections of this FTI serve to provide the student with a standard flow of events and tasking during a typical syllabus flight. While this section may appear "canned" or "scripted," it must be emphasized that flights rarely evolve exactly as planned. Flexibility will be the one constant in your military flying career. Treat these sections as a guideline and always be prepared to flex to the basic priorities (aviate, navigate, communicate, then checklists) as required.

305. PREFLIGHT

The student is responsible for conducting a thorough preflight of the aircraft and rear cockpit seat in accordance with NATOPS. An aircraft and seat preflight will be demonstrated prior to or on C5001. On all subsequent flights, the student and IP perform individual preflight. A thorough ramp FOD check will be conducted prior to entering the cockpit. Prior to engine start, the student will be strapped in with gloves on, sleeves and visor down, and the Prestart Checklist complete, and seat and MDC handle pins removed and stowed in the map case.

306. PRESTART CHECKS

The student completes the Prestart Checks.

IP places battery switch on.

IP (ICS): "ICS check."

NFS (ICS): "Loud and clear, switches set, FCS Norm (Fuel Control Switch), Eject select FWD-Both."

NOTE

The student must ensure the anti-skid switch is on, engine switch is on, and the fuel control switch (FCS) MUST be in Normal or a hot start may occur during engine start.

IP (ICS): "Lights and tones."

The student will then test his/her lights in the aft cockpit by pressing the lights test switch and listening for four good tones. If the NFS is still testing his lights while the IP initiates the tone test only three tones will be audible. If this happens do not report a successful tone test.

NFS (ICS): "Good lights and tones rear."

IP (ICS): "Good lights and tones front."

307. GTS START/POSTSTART

GTS Start

IP signals PC to start the GTS.

IP (ICS): "Fuel - 3.0, GTS."

During the start sequence, the student monitors the caution/advisory panel to ensure a GTS light displays within 20 seconds. The IP will then engage the engine start switch, and you will both monitor the engine instruments and look for a ready light within 15 seconds. At 15 to 20 percent RPM, the IP will move the throttle to idle, and you will monitor the start. If you note an abnormal start, call it out and the IP will go through the appropriate procedures.

Poststart

With a good start and a thumbs up signal from the plane captain (PC), student reports:

NFS (ICS): "Thumbs up from PC."

The student will then turn on his/her MFDs and Data entry pad, radios, TACAN, and VOR. He/she will select AFT on the right MFD and AFT on the Comm 1 and 2 selector panel. The student will then tune ATIS in Comm 1 and tune base in Comm 2, with both switches set in the up position on the comm/nav selector panel.

After receiving ATIS, the student will switch the Comm 1 radio to clearance delivery.

As the student obtains ATIS, the IP will signal to the PC to run the engine up to 70% and initiate the run-up in order to reset HYD 2. You should be looking for the HYD caution light to extinguish and all HYD gauges to read 3,000 PSI. The IP will then select MAN/TEST on the fuel control switch and both crew members shall note the resultant rise or drop in RPM and illumination of M-FUEL advisory light. Once tested, the fuel control switch will be placed back to Normal and the IP will pull the power back to idle. Bleed valve closure should occur and shall be verified by checking that the ground IDLE RPM settles at 55% +/- 2% and the M FUEL advisory light goes out.

At the completion of these checks, the student will check the BIT/MAINT page on the MFD to check for any exceedances or overflows and report actual indications:

NFS (ICS): "No exceedances or overflows."

The student will then check the DATA/Aircraft page looking for four satellites and the alignment counting down.

NFS (ICS): "GPS 4 SATs, alignment count down."

Now, the student will contact clearance delivery.

NFS (COMM 1): "Clearance, ROKT 403, NPA-802 on request, ready to copy."

NOTE

The student will read back the entire clearance to Clearance Delivery.

After receiving clearance, the NFS will switch Comm 1 to GROUND frequency.

As the IP goes through the trim checks and Control AUG IBIT, the NFS will accomplish the following tasks per the TRAWING 6 standardized checklist bold items:

- LAW set to 200 ft.
- Bingo set as briefed
- BIT display – Check
- RADALT – BIT

  NFS (ICS): "Good tone back."

  IP (ICS): "Good tone front."
- Waypoints – set **(Do not overwrite waypoint zero)**
- NAV source – HYBD (If both the GPS and INS functions of the GINA are working properly the nav source defaults to HYBD.)

Once the system is set and/or the Control AUG IBIT is complete (noted by the C AUG caution light – OUT after 120 sec), the student will report:

NFS (ICS): "Ready for PC checks."

308. PLANE CAPTAIN CHECKS/FINAL CHECKS

The IP will signal the PC to initiate PC checks:

1. Full throw of flight controls
2. Lower the flaps (full down)
3. Extend the speedbrakes
4. Lower the tailhook
5. Lower the launch bar

Once these four items are extended, both crewmembers will place hands out of the cockpit. While the crew is "hands out," the PC will check the appropriate control surfaces, tailhook, and launch bar. **It is acceptable to input information via the DEP and MFDs while PC checks are taking place, BUT you must still ensure that your arms/elbows DO NOT come down below the canopy rail and you must keep SA on the PC's position during the check. This will avoid any confusion from the PC regarding your clearance from any control surface switches/controls and prevent inadvertent actuation.**

Once complete with this portion of the PC checks, the PC will signal the pilot to retract the speedbrakes, raise the tailhook and launch bar, and place flaps to HALF. The final step of the PC checks is a brake check. It is at this time, during the brake check, the NFS will report, "Ready for final checks."

NFS (ICS): "Ready for final checks"

When the brake check is complete the PC will hand off control to a final checker. The final checker, like the PC, will look to the aircrew for a hands up signal. As during PC checks the student may input data via the DEP and MFD only, keeping his arms/elbows above the rail. This is an ideal time to review the Instrument Checklist since most of the items can be checked visually. (Needle/ball movement cannot be determined until taxiing to check L/R turns and the TACAN may or may not be received at this point). Once final checks are complete the IP will lower the canopy, the last step before taxi.

A verbal confirmation from the rear cockpit crewmember that he or she is "clear" is required before the pilot in the front cockpit initiates any movement of the canopy, either open or closed.

The canopy shall be closed upon completion of final checks and prior to any aircraft taxi movement in the line.

IP (ICS): "Canopy"

NFS (ICS): "Clear"

NOTE

Weather dependent, the IP may elect to close the canopy at an earlier time in the checklist.

309. TAXI PROCEDURES

When the IP starts to taxi, the student will call "outbound" to Base then request for taxi from ground:

NFS (COMM 2): "Base, ROKT 403 outbound."

NFS (COMM 1): "Ground, ROKT 403, taxi with Delta."

GROUND (COMM 1): "ROKT 403, taxi to RWY 7R via Foxtrot–Delta–Alpha, altimeter 3002."

NFS (COMM 1): "ROKT 403, taxi RWY 7R via Foxtrot–Delta–Alpha, 3002."

The NFS will then give the taxi instructions on the ICS:

NFS (ICS): "Make a left on Foxtrot, a right on Delta, a left on Alpha, and taxi to the hold short for 7R."

Followed by the "Taxi Report" in its entirety and expect a respective reply from the IP:

NFS (ICS): "Taxi Report: squawk 1020, altimeter 2995, showing 20 ft. in STBY altimeter/ 40 ft. in MFD."

IP (ICS): "Squawking 1020, altimeter 2995, showing 20 ft. in STBY altimeter / 30 ft. in MFD." (Max altimeter deviation is 75 ft. between cockpits and from field elevation.)

NFS (ICS): "Departure brief: At 1 DME turn right 150, climb and maintain 3,000 feet."

After verifying the turn needle and ball are working during taxi (both L and R turns) and all other items on the Instrument Checklist are operating properly (i.e., TACAN), the NFS will report the Instrument Checks complete:

NFS (ICS): "Instrument Checks complete."

Once all these checklists are completed, the student will initiate the Takeoff Checklist by challenging the IP on each item in the checklist. The IP will "reply" to each student "challenge." If the student notes NO disparity, he will proceed to the next item. Always remember to CHALLENGE, REPLY, and VERIFY.

STUDENT (Challenge)	**IP (Reply)**
"Control AUG."	"All, light out."
"Anti-skid."	"On, light on."
"Flaps/Slats."	"Half, slats out."
"Trim."	"0, 0, 2–3 nose up."
"Canopy."	"Closed, locked, light out, arrows aligned."
"Harness – I'm attached 8 points, pins removed, select in Fwd/Both, ready to arm in back."	"I'm attached 8 points, pins removed, ready to arm in front."
Seats	Arm
"Armed in back."	"Armed in front."
"Takeoff checks complete."	

NOTE

Note that the *Seats* and *Arm* challenge and reply are not in quotation. These shall be treated as a silent command to arm up immediately after the IP replies he is "Ready to arm in front."

Before calling takeoff checks complete, NFSs should make it a habit to always double check ALL indications and instruments (in addition to the checklist items) by doing a complete sweep of the cockpit. This will ensure the aircraft is completely ready for takeoff.

310. TAKEOFF PROCEDURES

Approaching the hold short area (normally after crossing the last taxiway or 1000' prior), the NFS will switch the UHF radio to Tower and call for takeoff when both crews are ready.

NFS (COMM 1): "Tower, ROKT 403, takeoff."

TOWER (COMM 1): "ROKT 403, winds 040 at 10, cleared for takeoff runway 7R, change to departure."

NFS (COMM 1): "ROKT 403, cleared for takeoff 7R, switching departure."

The groove will be cleared during this time, and the IFF/strobes moved to their appropriate position for takeoff.

NFS (ICS): "Groove clear, check strobes on, squawk normal, pitot heat on, landing light on. Hot Mike."

IP (ICS): "Pitot heat, Strobes on, squawking normal."

Once the aircraft is positioned on the runway centerline and cleared for takeoff, the IP will run the power up to MRT. At military power, the student will verify all instruments are operating within limits and all warning and caution lights are extinguished.

NFS (ICS): "No warnings or cautions, good engine instruments. Ready. Line speed—94."

During T/O roll, the student will monitor airspeed, engine instruments, warning and caution lights, and the flap and trim indicators and check the 1,000-foot line speed.

NFS (ICS): "Good line speed."

After rotation, the IP will initiate the raising of the gear and flaps without any student input. It is the student's responsibility, though, to ensure that both the gear and flaps are safely retracted prior to 200 KIAS and report it.

NFS (ICS): "Aircraft clean at 190 KIAS, going Cold mic."
(Report airspeed at which the gear and flaps indicated up.)

IP (ICS): "Good gear handle, going Cold mic."
(After checking handle is up and locked.)

Once the aircraft is verified clean, the student will contact departure.

NFS (ICS): "Departure, RKT 403, airborne, passing 500 for 3,000."

DEPARTURE (ICS): "RKT 403, Pensacola Departure, radar contact."

311. DEPARTURE/ENROUTE

The student is responsible for all navigation and UHF communication throughout the flight. Additionally, the student is encouraged to be aggressive and drive the conduct of the flight as though he or she were the assigned MC.

Checklists

All Climbout Checklists should be completed within 500 ft. of the prescribed altitude (i.e., 9,500 to 10,500 ft. for 10,000-foot Checklist). Realize this is a guideline. If more pressing demands require the student's attention, it is important to recall the general hierarchy of priorities: aviate, navigate, communicate, then checklists.

5K' (AGL)

Reset LAW to 5000

10K'

Complete all items on the 10,000-foot Checklist, but only report the following:

NFS (ICS): "10K checks complete LAW set at 5,000."

18K'

Climbing through 18,000 ft., the altimeter is set to 2992.

NFS (ICS): "Altimeter 2992 in back."

IP (ICS): "Roger, 2992 in front."

Descending through 18,000 ft., set the altimeter to the local setting.

NFS (ICS): "Altimeter 3004 in back."

IP (ICS): "Roger, 3004 in front."

312. CRUISE

Cruise Checks

Cruise checks will be conducted throughout the flight as time permits. Cruise checks should be reported approximately every 10-15 minutes. The student will report all four items in accordance with the T-45C student in-flight guide on the first Cruise Check. During subsequent Cruise Checks, complete all items and only report the fuel status, its relation to Estimated Fuel Remaining (EFR) and Mission Completion Fuel (MCF), and aircraft position (divert info as required).

NFS (ICS): "Fuel - 2.0. 100 below EFR and 300 above MCF. Nearest divert - Mobile Regional at our 10 o'clock / 15 miles."

Low Altitude Warning (LAW) Usage

Students will set the Low Altitude Warning to 5,000' any time the aircraft is above platform, and below platform (once the LAW tone has sounded) step it down to an intermediate altitude, using 1000' AGL, or 2000' AGL in mountainous terrain, for terrain avoidance. On all subsequent descents, the LAW will be reset so as not go off descending through the previous setting.

- Approaches

  On precision approaches, once the aircraft is past the final descent point on the approach (glideslope intercept), the student will set the LAW to the HAT at the missed approach point.

  On non-precision approaches, students will step down the LAW using the 10% rule of thumb when able, and set the LAW to 10% below HAT after crossing the final descent point on the approach.

- VFR Pattern

  For the overhead, LAW will be set to 380 (to alert pilot to confirm a ball on the lens at the 45) inside the initial. If course rules apply, the LAW will be set to 380 once past the entry point of the appropriate course rules (X-Ray, Pickens Gate, etc.).

NOTE

The only time the LAW should sound is at Platform and passing through HAT / "45". NFSs will report to IP any time the LAW setting is changed. In addition, any time the LAW sounds, the NFS will report the reason as to why and the subsequent LAW setting. In addition, NFSs will not utilize the REJ button to silence the LAW Warning.

313. SUA ENTRY/EXIT PROCEDURES

During Contact flights, unusual attitudes will be practiced and evaluated in at least one of the flights as fuel, time, and airspace permits. During local round robins or out-and-ins, the students shall plan to enter the Gator South MOA to the max extent possible. If weather precludes the MOA, the W155A serves as a viable alternative to execute any necessary requirements. It is up to the students to properly and proactively plan any area contingencies and execute it accordingly.

Gator South MOA

The Gator South MOA is the primary choice during Contact events due to its proximity to the field allowing for better route and fuel planning. Since the MOA is a common area, it is very important to know the entry and exit procedures in order to enable the safe de-confliction between operating aircraft in the area. The confines and procedures for the MOA use are detailed in the T-45C Student In-flight Guide. What follows is a brief overview and does not relieve any student from thoroughly familiarizing themselves with all pertinent procedures.

The Gator South MOA's standard confines are 11,000 – 17,500 feet. If necessary, utilization of the MOA "high-block" up to 23,000 feet (areas 1-4 only) may be coordinated upon initial check-in with departure or approach to enable ample time to clear any commercial traffic at those altitudes.

NFS (COMM 1): "Departure, ROKT 403, 500 for 3000, request high block."

or

NFS (COMM 1): "Approach, ROKT 403, 9000', request vectors to GATOR MOA, high block on request."

When vectored and cleared into the MOA, students shall direct the IP to climb/descend to the VFR entry altitude of 10,500' (or 17,500' if coming from a round robin at high altitudes) and switch to the area common frequency when cleared to check in to the area.

NFS (COMM 1): "99, GATOR MOA, ROKT 403, Single T-45 entering from the South (at 10.5'/17.5'K), who's working?"

As everyone in the area replies, students shall note it and reply with intentions. The transit through any occupied areas will occur at 10.5'K (or 17.5'K) until established within the lateral confines of the area selected, after which, the students shall direct the appropriate climb or descent into the area. Once established, the students will transmit so over the common frequency to notify everyone of the de-confliction.

NFS (COMM 1): "GATOR MOA, ROKT 403, will work in areas 1 and 2."

NFS (COMM 1): "GATOR MOA, ROKT 403 established areas 1 and 2."

While in the area, it will be the student's responsibility to manage the area and direct the IP accordingly in order to remain within the altitude and lateral confines. Additionally, the students shall monitor the common frequency and respond accordingly to any incoming or exiting traffic for de-confliction.

Once complete in the area, ATIS shall be obtained on COMM 2 (while still monitoring AREA common). As this is done, students shall direct the IP to the appropriate altitude and heading to prepare for area exit (11'K and the 271/340 radial inbound to NPA until directed otherwise by ATC). When ready to exit, the NFS shall inform everyone over area common prior to switching to approach on COMM 1.

NFS (COMM 1):	"99-GATOR MOA, ROKT 403 exiting area X to the South, East in 1-mike, 11'K…Switching."
NFS (COMM 1):	"Pensacola Approach, ROKT 403, one-one thousand with delta, request course rules."

Note that while you are checking out of the area on the common frequency and you intend to RTB on an IFR clearance, you are still restricted to the confines of the area until you are in contact with approach and they clear you out of the area. Once checked in with approach, they should direct you accordingly depending on your request for the course rules or GCA. Until then, it is the student's responsibility to maintain area management and follow all navigation rules.

W155-A

To enter the W155 area, students shall ensure that the working area is scheduled for the expected entry time, exit time, and filed accordingly. Like all other tasks, the students will be responsible for all navigation and UHF communication to and from the operating area. Once ready to proceed and enter the area, the student will request direct to the desired entry point (ROZIE, STARR, or BEARD). Once headed toward the area, ATC will direct the flight to contact Seabreeze (the controlling agency for W155). The student should proactively request a frequency change if it has not been received by 20 DME to minimize any delay.

All communication should be performed on COMM 1 (unless otherwise required):

DEPARTURE:	"ROKT 403, contact Seabreeze on 353.775."
NFS:	"ROKT 403, switching 353.775"

On initial contact with Seabreeze, the student will request one, two, or all three of the W155-A operating areas (as de-conflicted with other flights with concurrent times):

NFS:	"Seabreeze, ROKT 403, one four thousand, request W155-Alpha 1, 2, and (or) 3."
SEABREEZE:	"ROKT 403, proceed direct Rozie, expect Alpha 1, 2, & 3."

If unable to comply with the request (i.e., the requested areas are occupied), Seabreeze will assign the available working area(s). Since more than one section or flight can be scheduled into the W155 areas simultaneously, all students are responsible for area and COMM de-confliction prior to the brief. This will enable expeditious coordination with Seabreeze for entry and exit out of the area.

Upon receiving clearance to a working area, the student will navigate to the applicable entry point for the assigned area. If Seabreeze delays the clearance, or is slow in providing it, the NFS is expected to be proactive and assertive to expedite the coordination without undue delay.

SEABREEZE:	"ROKT 403, upon reaching Rozie, you are cleared operational W155-A3, maintain block seven thousand to flight level four zero zero."
NFS:	"ROKT 403, at Rozie, cleared in W155-A3, seven thousand to flight level four zero zero."

As the flight approaches the entry point, Seabreeze will assign a discrete frequency:

SEABREEZE:	"ROKT 403, Seabreeze, switch to discrete frequency on 275.6."
NFS:	"ROKT 403, switching 275.6."
NFS:	"Seabreeze, ROKT 403 checking in on 275.6."

Once Seabreeze checks the aircraft in on the discrete frequency and verifies you are established in the area, it will terminate IFR control.

SEABREEZE:	"ROKT 403, loud and clear, radar services terminated, maintain VFR, contact me 10 minutes prior to RTB on my primary."
NFS:	"ROKT 403, Wilco."

<u>W-155A 10 Minute Prior RTB Call</u>

Approximately 10 minutes prior to RTB, the NFS will switch COMM 2 to get ATIS for the intended destination and determine what type of recovery will be available. Once obtained, NFS will switch COMM 1 to Seabreeze's PRI frequency to notify the 10 minute prior with recovery intentions (Course Rules, GCA, etc…).

NFS (COMM 2):	Switch BTN 1 – Get ATIS.
NFS (COMM 1):	"Seabreeze, ROKT 403, RTB ten minutes, course rules."
SEABREEZE:	"ROKT 403, Roger, Sherman Field landing RWY 7, weather is VFR, altimeter 3002."
NFS (COMM 1):	"ROKT 403, 3002."

W-155A RTB

Like the GATOR MOA, area management is the responsibility of the NFS. When ready to exit, students will switch COMM 1 to Seabreeze's primary frequency and notify the intent to RTB. Seabreeze will acknowledge and provide further direction for your exit, having already coordinated with ATC for your IFR clearance based on your 10 min prior request. If the student anticipates to arrive at the exit point before further clearance is received, the student will direct his pilot to orbit or navigate within the confines of the assigned area until Seabreeze is able to coordinate the hand off to Pensacola Approach.

NFS:	"Seabreeze, ROKT 403, RTB."
SEABREEZE:	"ROKT 403, roger, squawk 0627 and IDENT."
NFS:	"ROKT 403, squawking 0627 with a flash."
SEABREEZE:	"ROKT 403, radar contact 5 nm SE of Rozie, descend and maintain 7000 feet, proceed direct Rozie then NPA."
NFS:	"ROKT 403, passing 9,000 for 7,000, direct Rozie, NPA."

The student will direct the IP to descend to 7000 feet (the W155A exit altitude), and will provide an initial heading towards the applicable exit point (Beard, Starr, or Rozie for Area 1, 2, and 3, respectively). The switch to Pensacola Approach should follow shortly thereafter for the remainder of the event as briefed.

SEABREEZE:	"ROKT 403, Seabreeze, contact Pensacola Approach on 270.8."
NFS:	"ROKT 403 switching 270.8."
NFS:	"Pensacola Approach, ROKT 403, 7000, RTB, Course Rules."

314. UNUSUAL ATTITUDES

Unusual attitudes may be conducted on at least one contact flight. Prior to commencing, the student will complete the "Stall/Aero Checklist" in accordance with the PCL and report it complete. Like the simulator, the student will call the appropriate recovery commands and the IP will fly the recovery.

An unusual attitude is any aircraft attitude you encounter inadvertently. It may result from inattention to scan, instrument failure, pilot vertigo/temporary blindness, turbulence, or a combination of factors. A key skill for any NFO is to be able to verbalize to his or her pilot how to maneuver the jet to return to a safe flight regime.

There are several general rules that apply to all unusual attitude recoveries. First, the pilot must neutralize the flight controls (center the stick and rudder pedals). Second, you must be able to analyze and evaluate the situation before initiating a recovery. Third, if your aircraft is in a dive, you must tell your pilot to reduce power and, if required, extend the speedbrakes to aid in airspeed control, then roll the aircraft in the shortest direction to wings level. Fourth, when nose-

high, hold your wing position while adding Military-Rated Thrust (MRT) and retracting the speedbrakes until the nose is below the horizon and airspeed reaches 150 (Knots Indicated Airspeed) KIAS.

General procedures:

- Controls: Neutralize
- Attitude: Analyze and evaluate to determine best recovery
- Airspeed: Limit in dives
- Bank: Eliminate when nose-low; hold constant when nose-high

Nose-High Recovery

Your primary concern when recovering from a nose-high unusual attitude is to maintain the AOA between 5 and 10 units. At slow speeds, very slight back stick pressure will cause a rapid increase in the AOA. Additionally, uncoordinated aileron and rudder inputs at slow speeds can introduce enough adverse yaw and increased AOA on the rising wing to cause a departure from controlled flight.

Voice procedures:

Upright

1. "Throttle – MRT; speedbrakes – IN"
2. "Maintain 5–10 Units"
3. Once nose falls through the horizon AND airspeed is above 150 knots…
4. "Roll right/left" (to nearest horizon)
5. "Stop roll"
6. "Pull not to exceed limits"
7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

Inverted

1. "Throttle – MRT; speedbrakes – IN"
2. "Slight Pull"
3. Once nose falls through the horizon AND airspeed is above 150 knots…

4. “Roll right/left” (to nearest horizon)

5. “Stop roll”

6. “Pull not to exceed limits”

7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

Nose Low Recovery

Recognize a nose-low unusual attitude by a nose-low indication on the ADI display and/or standby AI, accompanied by increasing airspeed and decreasing altitude. Once again, your pilot should neutralize the controls and then you will analyze the performance and attitude instruments to determine the best recovery.

With your airspeed above 150 KIAS, retard the throttle to idle in order to control airspeed and to minimize the loss of altitude. If airspeed is rapidly increasing, extend the speedbrakes as necessary. Either or both of these procedures are used to control airspeed and altitude loss. Roll the aircraft to wings level in the shortest direction and smoothly pull the nose up to the horizon. Do not attempt to raise the nose and roll wings level at the same time (a “rolling pullout”) because this can overstress the aircraft. Complete the recovery by readjusting the throttle for level flight.

Nose-low recovery procedures:

1. Controls: Neutralize

2. Attitude: Analyze and evaluate

3. Throttle: Retard to idle with airspeed above 150 KIAS

4. Speedbrakes: Extend (as required) if airspeed is rapidly increasing

5. Wings: Roll level in shortest direction to horizon

6. Nose: Pull to horizon

7. Throttle: Adjust for level flight

Voice Procedures:

1. “Throttle – Idle”

2. “Speedbrakes – OUT”

3. “Roll right/left”

4. “Stop Roll”

5. “Pull not to exceed limits”

6. “Power up, Speedbrakes – IN”

7. The maneuver is complete when the aircraft is wings level with level/positive VSI.

315. PREDESCENT

During climbs and descents, good crew coordination dictates that the student will make “1,000 ft. prior” (to level off) calls on the ICS as appropriate. At 5,000 ft. AGL, an ICS “Platform,” call will be made. (The history and theory of this call was detailed in the Contact Instrument Procedures chapter.) It is important to note that the “Platform” call is made at 5,000ft. AGL, not MSL. When operating at areas other than sea level elevations the call will be made at something greater than 5,000ft. Do not wait for the tone to sound to make the call. Once Platform has been reached the instructor should comply with the “minute-to-live rule,” shallowing his rate of descent to approximately 2000 fpm. The “minute-to-live rule” dictates that the aircraft’s negative VSI will not exceed the aircrafts AGL altitude once below 5,000ft.

Prior to commencing an approach, the student will initiate the Penetration Checklist. Every item on this checklist needs to be reported. The checklist should be initiated after obtaining ATIS. If ATIS or WX information not available or out of range, the student can initiate the penetration checks but will NOT call complete until WX information is gathered or not able to be obtained. All comms are made on ICS. When stating the fuel it is necessary to estimate the fuel you will have on deck, not just the aircraft’s current fuel state.

NFS:	“Defog/Temp.” (Challenge)
IP:	“Set.” (Reply)
NFS:	“Master Arm.” (Challenge)
IP:	“Safe.” (Reply)
NFS:	“Control Aug.” (Challenge)
IP:	“All.” (Reply)
NFS:	“STBY Attitude/Altimeter – Erect and Set”.
IP:	“Erect and Set in front”.
NFS:	“Weather is VFR, altimeter 2992, overhead to runway 7.”
NFS:	“TACAN set NPA-119X, VOR/ILS – 109.3, Course 069”
NFS:	“LAW set 5,000’ until Platform”
NFS:	“MFD’s/HUD set as required, NAV mode set”
NFS:	“Fuel - 1.5. Estimated fuel on deck – 1.2”

The remaining three items (Hold, Approach, Field Briefs) in the Penetration Checklist are at the IP's discretion. For example, the student asks the IP if he or she requires an approach brief. Good crew coordination dictates that the student is prepared to provide a hold, approach, and field brief, regardless of the field and type of approach selected. A holding brief is only applicable if holding is expected.

316. APPROACH/LANDING

Visual Overhead

Weather permitting, the visual overhead (break) is the recovery of choice for most flights, thus, it is important that students become very familiar with local operating procedures (i.e. course rules).

Approaching the initial for the runway in use (i.e., X-ray for RWY 7), the student will report the initial in sight to the Approach Controller.

NFS (COMM1):	"Pensacola Approach, ROKT 403, X-ray in sight."
APPROACH (COMM 1):	"Roger ROKT 403, contact Tower."
NFS (COMM 1):	"ROKT 403, switching Tower."
NFS (COMM 1):	"Tower, ROKT 403, two miles south of X-ray for the break."
TOWER (COMM 1):	"Roger ROKT 403, report numbers runway 7R."
NFS (COMM 1):	"ROKT 403, WILCO."

When approaching or overhead the numbers:

NFS (COMM 1):	"Tower, ROKT 403, numbers (or approaching numbers)."
TOWER (COMM 1):	"ROKT 403, Right break approved (at the numbers – L/R break approved)."

NOTE

There is no need to report the numbers if clearance to break has already been received.

The IP will break appropriately to slow the aircraft down below 200 KIAS. The IP should lower the gear and flaps automatically when airspeed below 200 KIAS is confirmed. The student shall verify that this occurs and challenge the IP over the ICS if the configuration change is not initiated promptly. The student will then initiate the Landing Checklist only after visually confirming the gear is down-and-locked on the landing gear indicator and challenging the IP with a "GEAR" call on ICS.

Landing Checklist

STUDENT	IP
"Gear."	"Gear, three down-and-locked."
	"Flaps full/half/up."
	"Hook up/down."
	"Harness locked."
	"Speedbrakes out/in."
	"Anti-skid on/off."
	"Fuel – X.X."
	"On Speed - ____knots."

The student will confirm the On-Speed calculated by the IP. If NFS determines that IP calculated on-speed is incorrect, NFS will announce it on the ICS: "On-Speed is 116." After confirming all items are set as required, NFS will report checklist complete over ICS.

NFS (ICS): "Landing Checklist complete."

The student will state intentions to Tower at the abeam position.

NFS (COMM 1): "Tower, ROKT 403, abeam, three down-and-locked, full stop."

TOWER (COMM 1): "ROKT 403, Sherman Tower, winds 060 at 8 knots, RWY 7R, cleared to land."

NFS (COMM 1): "ROKT 403, cleared to land, 7R."

With clearance to land or touch and go, the student will visually re-confirm the aircraft's landing configuration and report full clearance to land/option on ICS.

NFS (ICS): "Gear down, Landing checklist complete, cleared to land/touch and go on RWY…"

Often, the landing gear has not yet been lowered as the abeam call is being made. If this is the case, no reference to the landing gear occurs during this transmission. A separate UHF transmission is required once the gear is lowered and the Landing Checklist is completed.

NFS (COMM 1): "Tower, ROKT 403, three down-and-locked."

TOWER (COMM 1): "ROKT 403, Roger."

NOTE

Do not interrupt the Landing Checklist to make the three down-and-locked transmissions.

During the APPROACH turn, students shall monitor the approach and be able to recall and discuss all observed parameters with regard to altitude, position, and on-speed (refer to Chapter 7 of the NATOPS manual for field landing pattern, figure 7-4). Reference altitudes in the NATOPS manual are pertinent to every field, except for the break altitude which is dependent on local field procedures. RADALT for the pattern should be set at 380'. This setting approximates the 45 degree position in the pattern. Unless intending to depart the pattern, this setting should be set at the initial and kept through the VFR pattern.

If a touch and go is requested in the VFR pattern, on climb out, the student will request clearance to turn downwind from Tower.

NFS (COMM 1): "Tower, ROKT 403, downwind."

TOWER (COMM 1): "ROKT 403, right downwind approved."

NOTE

A separate Landing Checklist is required for every approach and/or landing.

During rollout, after a full stop landing, the student will report airspeeds and boards to the IP on the ICS. These calls occur every 1,000 ft. until the aircraft has slowed to less than 60 KIAS or the IP acknowledges control of the aircraft. A "good brakes" call by the IP also negates the requirement for boards/airspeed calls.

NFS (ICS): "6 board, 80 knots; 5 Board 60 knots" etc.

317. APPROACH PROCEDURES

HSI Usage on Instrument Approaches:

For ILS approaches, the student will remain in planimetric mode until intercepting final approach course (no later than 10 DME) then switch to CDI and deselect the previous steering source.

For non-precision approaches, the student has the option to switch to CDI mode when the aircraft is within 30 radials of the final approach course (no later than within 10 radials) and no later than 10 DME.

Precision Approaches

On any instrument approach, it is the student's responsibility to inform the IP when it is appropriate to transition to the landing configuration. On a precision or surveillance approach (PAR/ASR) or ILS, this occurs when the aircraft is within 5-7 nm of the FAF or 10 nm of the field and 30° from runway heading when there is no defined FAF.

NFS (ICS): "Slow to gear speed."

The IP will ensure the gear and flaps are lowered as the aircraft decelerates through 200 KIAS (NFS will backup the IP). The student will initiate the Landing Checklist after three down-and-locked is observed on the landing gear indicator.

LANDING CHECKLIST

STUDENT	IP
"Gear."	"Gear, three down-and-locked."
	"Flaps full/half/up."
	"Hook up/down."
	"Harness locked."
	"Speedbrakes out/in."
	"Anti-skid on/off."
	"Fuel – X.X."
	"On-speed - _____knots

On a radar approach (PAR or ASR), the speedbrakes will remain retracted until the aircraft begins its final descent. During an ILS, the speedbrakes will remain retracted until glideslope intercept. The student will proceed through the entire Landing Checklist, but will not call the checklist complete until the speedbrakes are extended and flaps are set as intended for landing. Once final descent is commenced, the speedbrakes will be extended and, at this point, the Landing Checklist may be completed:

NFS (ICS): "Speedbrakes."

IP (ICS): "Out."

NFS will report checklist complete whether he/she has clearance to land or touch and go, since clearance to land/option is separate from the internal landing checklist.

NFS (ICS): "Landing Checklist complete."

When clearance to either land or execute the option has been received, the NFS will verbalize the full Clearance to Land/Option report which re-confirms the landing checklist is complete for landing.

NFS (ICS): "Gear down, Landing checklist complete, cleared to land/touch and go on rwy…"

TACAN APPROACHES

On a TACAN approach, transition to the landing configuration will be initiated when the aircraft is within 5-7 nm from the FAF. As with a radar approach, the speedbrakes may remain retracted until the aircraft begins its final descent at the FAF. Therefore, the student will treat the Landing Checklist in a manner similar to a GCA.

318. POST LANDING

Once clear of the runway and prior to accomplishing any other task the student will initiate the disarming of the ejection seats.

NFS (ICS): "Ready to safe in the back."

IP (ICS): "Safe in the front."

NFS (ICS): "Safe in the back."

IP (ICS): "Cleared to unstrap."

After the seats have been confirmed safe by both aircrew the student may call Ground:

NFS (COMM 1): "Ground, ROKT 403, clear of the duty, taxi to my line."

GROUND (COMM 1): "ROKT 403, taxi to your line."

Additionally, once clear of the runway, the student and IP will check for any exceedances or overflows (on MFD – MENU/ BIT / MANT) and complete the Post-Landing Checklist:

NFS (ICS): "No exceedances or overflows."

NFS (ICS): "Check pitot heat, strobes, squawk, landing light, speedbrakes, flaps, and trim."

While no further communication is required regarding the Post-Landing Checklist, it is the student's responsibility to ensure the IP complies with all items in this checklist. The student, meanwhile, will complete his/her portion of the checklist. When completed and verified the student will report it complete.

NFS (ICS): "Post Landing checks complete."

After exiting the taxiway into the CTW-6 line area, the student will call Maintenance Control on the Base Frequency and report the status of the aircraft (use side numbers when communicating with Maintenance). Following a response from Maintenance the student will call Base and report the status of the event (use ROKT call sign when communicating with Base).

NFS (COMM 2):	"Maintenance, 607 in and up/down (state reason)."
MAINT (COMM 2):	"Roger 607."
NFS (COMM 2):	"Base, ROKT 403, complete/incomplete, 1.5 (hrs)."
BASE (COMM 2):	"Roger 403."

Before engine shutdown, NFS will secure all pertinent items in the rear cockpit (navaids, MFDs, DEP, radios, etc…) and report clear for opening of the canopy after shutdown.

NFS (ICS):	"All my equipment is off, I'm clear of the canopy after shutdown."

After the IP shuts down the engine and a thumbs-up is signaled from the PC, the student will exit the aircraft. Always ensure there is no loose gear or FOD left in the aircraft. Ejection seat etiquette forbids stepping on an ejection seat while getting in or out of an aircraft.

319. CONCLUSION

While the Contact phase is meant to familiarize the NFS with the T-45 aircraft and systems, it also provides the baseline procedures and habit patterns that will be built on in follow-on stages of the ATM Syllabus. NFSs will be held accountable for all the procedures learned in the Contact phase in all subsequent stages. Therefore, it is incumbent upon all students to establish solid procedural execution early, through solid preflight preparation and practice, so as to have a solid foundation to build upon as the ATM missions get more complex and tasking.

CHAPTER FOUR
STANDARD SECTION FORMATION PROCEDURES

400. INTRODUCTION

Formation flying is essential to tactical military flying. It serves many purposes, from the expeditious recovery of aircraft at the carrier to tactical mutual support in a high-threat environment. Good formation flying requires solid procedural knowledge and attention to detail and is the mark of a superior aviator. A Naval Flight Officer's role in formation flying is critical to the safe completion of the mission. It is for this reason that we introduce and practice formation procedures in VT-86.

There are two basic types of tactical flight formations: sections and divisions. A section is the smallest formation unit and is composed of two aircraft, a lead and a wingman. Next in size is a division, which is composed of two sections. Adding sections or divisions, as required, makes larger formations. Both section and division formation procedures will be covered in the advanced syllabus.

401. BASIC FORMATION DEFINITIONS

Parade formation is the standard multi-plane formation. Parade is a close aboard formation that is utilized when the flight can be critically viewed from the ground. This is most common during section takeoffs and section breaks. Parade formation is also utilized when a flight encounters IMC conditions. The close proximity of aircraft in parade formation allows the penetration of instrument conditions while maintaining section integrity. The limitation of the parade formation is the lack of dynamic flight maneuverability allowed. Smooth, coordinated control inputs are vital for safe parade formation.

To improve maneuverability and when conditions permit, cruise formation is utilized. Cruise formation is a looser version of parade formation. The increased distance between aircraft in the cruise formation permits greater maneuverability for the flight and allows for an increased "inside scan" for the wingman. Additionally, the cruise formation is less fatiguing, and provides greater fuel efficiency for the wingman by eliminating the need for excessive power corrections normally required to maintain the parade formation. Cruise formation is the standard formation used enroute from one point to another by fleet formations when there is no potential enemy threat.

While parade and cruise formations are the basic building blocks of formation flying, there are many other variants of tactical formations. Procedures for formations, such as combat spread, battle box, etc., will be introduced in the advanced syllabus as well.

402. FLIGHT DISCIPLINE

Discipline, in reference to formation flying, involves the conduct of the flight members as individuals and as part of a team. This includes individual operations such as taxi, takeoff, downwind procedures, landing, observance of course rules, and radio procedures. As a member

of a team where individual errors affect the overall performance of the flight, each member of the flight must do his utmost to make the flight function as a unit.

The Formation Leader: The formation leader, or lead, carries the primary responsibility of conducting the sequence of maneuvers in an orderly manner. He has the primary responsibility for communications. He must always keep the following in mind:

1. Keep the flight clear of other aircraft.

2. Keep the flight clear of clouds, if possible.

3. Keep the flight within the proper operating areas and comply with local course rules.

4. Be considerate of wingmen by giving ample time for acknowledgement of signals before execution.

The Wingman: The wingman is responsible for flight integrity. It is his duty to:

1. Maintain position and avoid collision with the lead.

2. Promptly answer all hand signals and radio calls from the lead.

3. Back up the lead's navigation and maintain situational awareness so that he could assume the flight lead's responsibilities at any point, if required.

403. FORMATION COMMUNICATION PROCEDURES

Formation communications include verbal and nonverbal (i.e., hand signals) comms. Clear communications within a formation is essential for mission accomplishment.

Verbal Communication

The section will always have two call signs, your "ROKT" admin call sign (from the flight schedule) and your "TACTICAL" call sign. The admin call sign will be used whenever talking to controllers while the tactical call sign will be used whenever communicating within the section.

<u>Frequency Pushes</u>

Flight lead will positively "push" wingman (on UHF2) to frequencies when ATC does not assign a specific frequency:

ATC: "ROCKET 409, switch approach."

LEAD NFS (UHF1): "ROCKET 409."

LEAD NFS (UHF2): "Hammers, switch button 6."

WING NFS (UHF2): "2"

Positive Check-ins

Positive check-ins will be executed as follows:

- On deck, once both aircraft have been final checked, lead NFS will verify the thumbs-up from -2 and initiate a check-in on Tac freq:

  LEAD NFS (UHF2): "Hammers, check TAC…Hammer 11."

  WING NFS (UHF2): "Hammer 12."

  LEAD NFS (UHF2): "ROKT 403 is cleared on the NPA-13…(clearance)…No questions, button 3."

  WING NFS (UHF2): "2"

- On any safety of flight/common frequency:
  - Low Levels: Btn 29 (FSS)
  - PNSS MOA: Btn 18
  - W-155A: SEABREEZE assigned discrete frequency
  - R4401: Btn 23/24

  LEAD NFS (UHF2): "Vipers, check Pri…"

  LEAD NFS (UHF1): "Viper 21."

  WING NFS (UHF1): "Viper 22."

Pri/Aux Usage

When operating on a discrete frequency (i.e. W-155A, R4401) all section tactical comm will be performed over PRI. When operating on a common frequency (i.e. PNSS MOA, Low Levels), all tactical comm will be performed on AUX.

Hand Signals

Good formation discipline depends upon the proper use and execution of visual signals. The hand signals cover most maneuvers encountered and lessen the need for airborne radio transmissions. The lead must give the signal in such a manner as to be easily seen and understood. A wingman must fly in a position so that the lead's signals may always be visible. Typically, front and back seat crews signal each other respectively, unless there are an odd number of crews in the flight. The following table (Figure 4-1) and pictures (Figures 4-2 and 4-3) describe and illustrate the typical hand signals utilized in formation.

SIGNAL	MEANING
Thumbs-up/down	Self-explanatory
Forearm vertical, 1 through 5 fingers extended	Numbers 1 through 5
Forearm horizontal, 1 through 5 fingers extended	Numbers 6 through 9
Clenched fist	Zero
Arm raised in circular cranking motion	Preparatory gear signal
Exaggerated head	Execute signal
Head nod left or right	Turn in that direction
Hand raised palm down, left to right motion	Level off
Hand raised palm down, fore and aft motion	Climb
Two fingers raised in turn-up signal	Break up signal
Kiss off	I'm breaking
Forearm raised vertically with clenched fist	Wingman cross under
Forearm raised vertically with clenched fist and pumping motion	Section cross under
Hand raised in chopping motion	Roll out
Hand raised palm down, patting glare shield	Cleared to land
Forearm raised, fingers facing aft in opening and closing motion	Speed brake preparatory signal
Forearm raised palm down, pointing down	Descent
Thumbs-up pointing over alternating shoulders	Wingman take cruise position
Lead holds hand with thumb and little finger extended in front of face as if drinking	Fuel check
Lead pats shoulder or porpoises aircraft	Wingman join in parade
Frequency changes; Lead taps earphone followed by new freq. with finger signals	Wingman switch to appropriate frequency

Figure 4-1 Formation Visual Signals

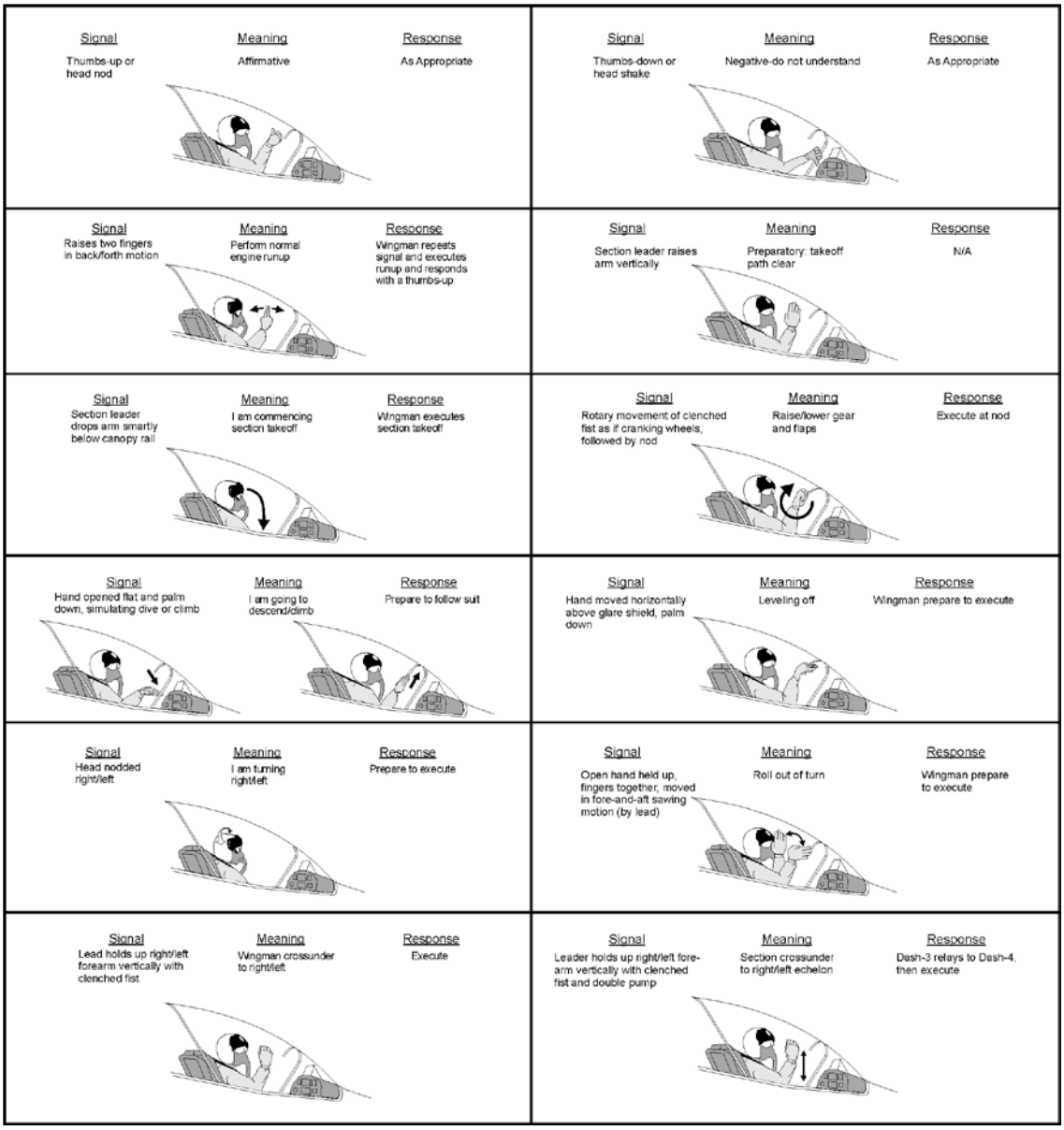


Figure 4-2 Hand Signals

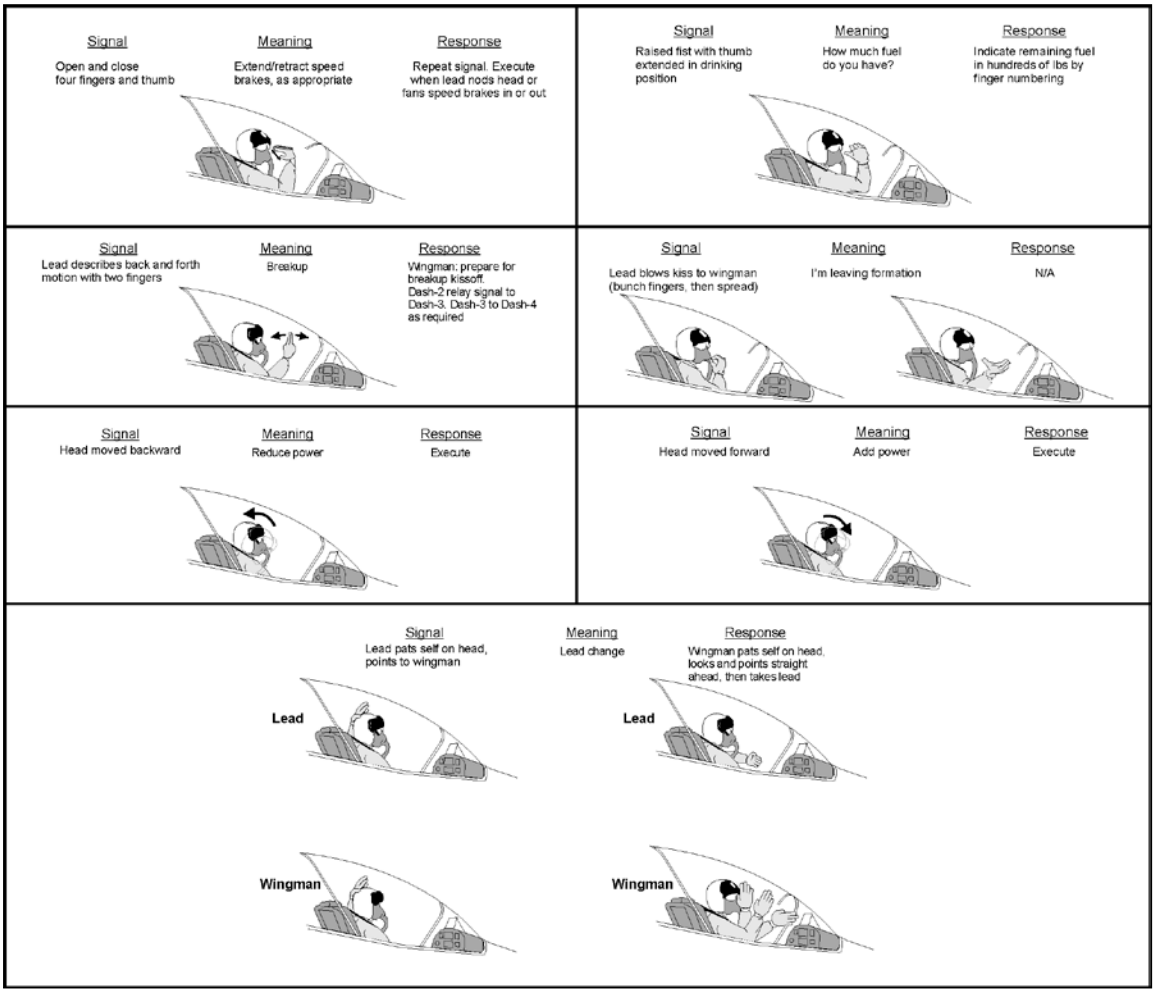


Figure 4-3 Hand Signals (cont.)

Another standard set of hand signals is the HEFOE signals, as represented below in Figure 4-4. Each letter in HEFOE corresponds to a major aircraft system. For example, the third letter in HEFOE is F, which would represent a fuel system problem.

HEFOE SIGNALS	
Forearm covering face followed by:	
One Finger	Hydraulic
Two Fingers	Electrical
Three Fingers	Fuel
Four Fingers	Oxygen
Five Fingers	Engine

Figure 4-4 HEFOE Signals

NOTE

On all radio frequency switches, the wingman must ensure to signal the thumbs-up after switching the appropriate radio to the new frequency. This signal must be given high up on the canopy and with a back and forth motion in order to facilitate its visibility to the lead. Maintain this hand signal until you are positively checked-in on the new frequency, noting that you can still tend to other minor tasks while signaling.

404. GROUND/DEPARTURE PROCEDURES

Section Line Procedures

Start up and line procedures are identical to those used in the contact stage. Once your aircraft is complete with final checks, a thumbs-up will be passed to the lead. It is important to note the side number of your wingman so a "thumbs-up" can be passed to the correct jet at the appropriate time.

Radios shall be set to the pre-briefed frequencies for each radio. On start up, COMM 1 will normally be set to BASE frequency, while COMM 2 is set to the pre-briefed TAC FREQ. This set up will ensure the ability to be reached by BASE, lead, or wingman as necessary prior to switching for taxiing. As always, take care of your aircraft first and then attend to formation responsibilities on the deck.

Section Taxi

The lead NFS is responsible for obtaining flight clearance for the entire flight. The clearance is normally obtained before leaving the line area and then passed to the flight after all aircraft pass a "thumbs-up", which signals completion of their respective final checks and readiness to proceed as a section or a division. Flight lead will then initiate a positive check-in on TAC and pass the clearance. If no questions or clarifications are requested by the wing NFS, the lead aircraft will then check out with base on COMM 1 (if departing from NPA), then switch the flight to GND frequency on PRI (COMM 1). The lead NFS will call for taxi clearance.

LEAD: "Ground, RKT 407, flight of two, taxi with Bravo."

Jet aircraft, taxiing in close interval, increase the risk of "foreign object damage" (FOD). To minimize this risk, squadron Standard Operating Procedure (SOP) will define the approved taxi interval. Additionally, it is customary to taxi formations on opposite sides of the taxiway centerline (when adequate taxiway width is available). While taxiing a prudent distance apart is important for FOD prevention, it is also essential that formation integrity be maintained. Every effort should be made to prevent other aircraft from taxiing between the formation's elements. Checklists, taxi reports, and radio frequency switches will be conducted in accordance with the "Student In-flight Guide."

Passing the last active taxiway, NFS may AUTO switch to tower (i.e. NO positive check-in on tower freq at the hold-short). At the hold short, the crewmember of each aircraft will check the other aircraft for integrity. Wing NFS will give lead a thumbs-up when the lead aircraft has been checked and tower freq is dialed in COMM 1. Lead NFS will check the wing aircraft in return and pass a thumbs-up indicating that the section is ready to call for takeoff.

LEAD: "Tower, RKT 407, flight of two, takeoff."

After cleared to take the duty runway to position and hold or to takeoff, students will clear the groove, check the strobes/squawk/pitot-heat/landing lights. Flight will switch to departure after takeoff clearance has been issued or as directed.

LEAD: "RKT 407, cleared for takeoff 7R, switching departure."

Crossing the hold short to take the runway, each NFS will report on ICS:

NFS: "Groove clear, check strobe on, squawk normal, pitot heat and landing light on".

When both aircraft are set in position on the runway and cleared for take-off, wing will give a thumbs-up to lead, whereupon the lead IP will signal to run-up the engines. Both IP's will initiate a run-up for the MRT check. Like in Contact Flight Procedures, each NFS will ensure their aircraft is ready for takeoff and make the appropriate report on ICS. Additionally, each NFS will give one last check to the other aircraft and look for any obvious damage, un-secure panels, leaks, etc that might prevent a safe departure. The IP's will be doing the same. Upon their mutual thumbs-up, the "chopping" hand signal will be given by the lead IP to initiate the Section take-off roll or the "kiss-off" signal if a section interval go is executed.

Section Takeoff

The purpose of a section takeoff is to get the formation airborne in the safest and most expeditious manner. Many factors go into determining the best method for getting a section airborne. Weather, standing water on the duty runway, crosswind limitations, and like-aircraft configurations (e.g., flap settings and fuel states) are a few of the deciding factors. To takeoff as a section weather must be above circling mins (or in the absence of an approach with circling mins, 1000'/3). If the weather is below circling mins, the flight cannot take off as a section and must get individual clearances to launch as singles. A plan for rendezvousing the section airborne in the working area should be covered in the brief.

Section takeoffs may be done three different ways:

1. Section Go: Both aircraft roll and rotate in formation.

2. Interval Go: Wing aircraft initiates takeoff roll after a mandated time delay (SOP defined).

3. Individual Go

Section Go

The wing aircraft will take a normal parade position for departure. There should be no wing overlap when positioned. During the takeoff roll, it is important that the NFS keep his head out of the cockpit as much as possible. Both aircraft will proceed down the runway together during a section go. The wingman will “fly form” on the runway. The lead and wing students will have different responsibilities during a section go.

The lead student's primary responsibility is to monitor the position of the wing aircraft in relation to the lead. If sucked (aft of the initial bearing line) or acute (forward of the initial bearing line), verbalize the deviations to the lead pilot. If in position, state so. No more than two position calls should be necessary during the takeoff roll; the IP will make the ICS calls as described in Contact Flight Procedures.

The wing student will monitor trim and flap position and airspeeds and will make the same ICS calls as described in Contact Flight Procedures.

When safely airborne, the lead student will report “2’s airborne” to his pilot on the ICS. The lead pilot will then signal the section to raise the landing gear with an exaggerated head nod. The wing pilot will raise his gear simultaneously. At 140 KIAS, another head nod from the lead pilot will prompt raising the flaps. The students should scan for a clean aircraft prior to gear speed and ensure the other aircraft in the flight is clean. When both aircraft are clean, the lead student will call “flight clean at 195 (or as indicated)” on the ICS and then check in with departure control.

Interval Go

Relative position between aircraft on the runway is the same as for a section go. After run-up checks are completed and the thumbs-up is passed, the lead will “kiss off” the wing with a hand signal and release the brakes. The wing will wait the SOP-mandated interval (approximately 8 seconds) and initiate the takeoff roll. Procedures during the lead and wing takeoff rolls are the same as for a contact takeoff. Once the wing aircraft is clean, the wing NFS will call “2's airborne” on TAC FREQ (Unlike a section go, this call must be made on the AUX radio since the wing may not be in the lead’s field of view). Once the “2’s airborne” call is made, the lead student can check in with departure control. The wing student’s primary responsibility is to **monitor the rendezvous and report airspeeds** to the pilot over the ICS until within two wingspans of lead, stabilized in parade, or the IP reports “I got it”.

Individual Go

If weather precludes either a section go or an interval go (i.e. the weather at the departure field is less than circling minimums), a third option is to split the section and perform individual go’s. Lead NFS will request separate clearances for both aircraft. The flight will taxi as a section and follow section procedures to the hold short. Takeoff procedures are identical to contact flight procedures. Both aircraft will follow ATC directions until able to proceed to a predetermined TACAN position or waypoint to join.

405. ENROUTE/SECTION RECOVERIES

Enroute

During the enroute portion of the flight, the section will fly in cruise position. As previously stated, with clear weather, cruise is the best position to travel from point to point for both lead and wing. The formation may “tighten up” into parade formation if hand signals need to be passed or weather dictates. As a rule, the wingman should fly in a position so that he is clearly visible to the lead at all times.

Section Recovery

Upon completion of the tactical portion of the flight (Break-up & Rendezvous (B&R), section low-level or BFM), the flight will rejoin and return to base (RTB). The type of recovery conducted is dependent upon the weather and fuel states. The lowest fuel state in the section becomes the fuel state of the flight. Weather may preclude the break or even a section PAR. Individual PARs may be necessary if the ceiling is too low (below circling mins or 1000/3 in the absence of a circling approach) to allow safe separation of the aircraft after the landing environment is in sight.

VFR Recovery

A VFR course rules recovery for a section is almost identical to a single aircraft recovery. Wing will most likely be in cruise until just short of the initial. Approximately 3-5 miles prior to the initial, both students should inform their pilots which side of the formation the wing should be on for the break. At this point, the wing will close to parade position.

Upon initial check-in with the tower, the lead NFS will give the flight’s position relative to the initial in the same manner as a contact flight. Approaching the numbers for the break, it is a good idea to report the numbers just a little bit early to preclude being interrupted on the radio and not delaying clearance to break until four miles upwind. When cleared to break, and with proper interval on other aircraft in the pattern, the lead IP will initiate the break with the appropriate hand signal, as briefed. There are several different types of breaks (fan break, 2 or 4-second interval break, reaction break, etc.).

Lead student will report the abeam position and obtain clearance to land for the flight. Upon completion of the landing checklists, the formation elements will report “three down and locked" in order to the tower. The wing student will wait until the lead has either made his “three down and locked” call or touched down before making the “Dash-2 three down and locked” call. The aircraft will land on centerline and drift inboard to provide a clear lane for the aircraft behind (wingman).

Sample Course Rules COMM 1:

LEAD: “Tower, ROKT 407 flight of two, 3 miles south of X-ray, for the break.”

TOWER: “ROKT 407, report the numbers 7R.”

LEAD: “ROKT 407, numbers.”

TOWER: “ROKT 407, right break approved.”

LEAD: “ROKT 407, abeam, full stop.”

TOWER: “ROKT 407, cleared to land 7R.”

LEAD: “ROKT 407, cleared to land 7R.”

LEAD: “ROKT 407, three down and locked.”

TOWER: “Roger.”

WING: “Dash 2, three down and locked.”

TOWER: “Roger.”

IFR Recovery

A section recovery in IMC conditions is a valuable tool for a few reasons. First, a section recovery in IMC conditions is utilized to expedite the recovery of a formation. Another reason to execute a section instrument approach is to recover a NORDO aircraft in the formation.

Weather is the most important consideration for a section recovery. Landing field weather must be circling minimums or better to attempt a section GCA. If the weather is below circling minimums, individual instrument approaches will be performed. LAW should be set for HAT (for circling mins) IAW the Contact Procedures chapter.

Procedures are basically the same for all possible types of section recoveries: PAR, ASR, TACAN, and Visual Straight-in. Primary consideration is to comply with either the controller's directions or the printed approach plate. All contact flight procedures for an individual approach apply (e.g., navigation, altitude calls, penetration checks, etc.). The wing student will continuously back up the navigation while complying with his own checklists.

On a precision approach, the lead NFS should call to slow the section to gear speed within 10 nm and 30º heading of the final approach course. On a non-precision approach, this call will be initiated 5-7 nm from the Final Approach Fix. Although these procedures are identical to the instrument procedures previously covered in the Contact Flight Procedures chapter, special emphasis must be made on the above ranges due to the limited maneuverability inherent in a formation.

At this point, the lead pilot will slow the formation to configure. After passing the preparatory gear and flap signal to the wingman (at or below gear speed), the lead will give a head nod for execution and place the gear handle down, flaps to one half, and speedbrakes in (if extended). The lead NFS will ensure the pilot stabilizes the approach speed at 150 KIAS to allow ample room for the wingman to maintain parade position without sacrificing maneuverability or safety of flight.

When each aircraft has three down and locked, the wing NFS will pass a thumbs-up to the lead NFS. With the Landing Checklist complete, the lead NFS will report "SIX down and locked" to the controller. On a PAR or ASR, the "down and locked" call to ATC is permitted before the Landing Checklist is complete. The speedbrakes will be extended at the final approach fix, or glidepath, via hand signal and head nod to initiate the final descent to MDA/DH/touchdown while still maintaining 150 KIAS until separation occurs.

When executing a section approach, ATC controllers will expect the formation to take its own separation on final. At the discretion of the lead IP, and with the runway environment in sight, the lead pilot will detach the wing with the "kiss-off" signal. Once detached, the wingman will immediately slow to on-speed by lowering flaps to FULL and decelerating accordingly. The lead will maintain his airspeed until the appropriate point to slow down to on-speed for the touchdown. At fields where parallel runways are available, the lead student may request to "split the duals," if briefed.

If "splitting the duals," lead will ensure the wing is on the side of the formation the approach runway is on (i.e., if the approach is to 25 right, the wing should be on the right side). This allows an easy transition from formation flying to landing for the wing pilot.

Post Landing

During rollout, each student will make the appropriate "board and speed" ICS calls as in contact flights. The **wing IP** will make a "-2 slow" call on TAC FREQ once the wing's brakes have been checked, wing has slowed to a controllable speed, and de-confliction with lead is assured. When cleared of the runway, the lead student will <u>auto</u> switch to GROUND and request clearance to taxi (while waiting for wing to clear the runway):

LEAD (COMM 1): "Ground ROKT 403, taxi to my line."

Unlike a contact flight, "cleared of the duty" will not be part of the call above since the wingman may not have cleared the runway at this point. Once the wingman is clear of the duty runway, the wingman will *automatically* switch to ground frequency. The section will proceed to the line area and complete the required cockpit checklists. Once in the line/hot brake area, the lead student will positively switch the flight's COMM 1 to BASE via the TAC frequency. Each aircraft will then call Maintenance Control, **in order**, to notify aircraft status using the side number (i.e., "Maintenance, 604 In and Up"). Once the wing student completes his maintenance call, the lead student will then call the Duty Officer with the status of the flight using the ROKT call sign (i.e., "Base, ROKT 407, Back, complete 1.2").

406. FUEL MANAGEMENT

Fuel Checks

Both students are responsible for fuel management within their own cockpits. Additionally, the lead must always be aware of the fuel state of other jets in the flight. The lowest fuel state in the flight becomes the flight's fuel state. For example, if one aircraft in the section reaches Bingo fuel, the section is considered at Bingo state and will RTB accordingly. Due to the "jockeying"

of the throttles required to maintain position in formation, the wingman will tend to be less efficient with fuel than the lead. The lead NFS will be responsible for initiating all fuel checks on the TAC FREQ.

Example:

LEAD: "Turbo One, 2.0."

WING: "Turbo Two, 1.9"

Keep track of all fuel checks in your notes so that you may refer to them at any time to analyze any trends. As "mission commander" for the flight, the lead student must analyze fuel states and determine when it is appropriate to RTB. As wingman, it is the same responsibility to maintain the same situational awareness to always be ready to take the lead or backup the lead at any moment.

407. COMBAT CHECKS - FENCE IN/OUT

G-Warm

CNATRA Low Altitude Training Rules require the performance of a G Awareness Maneuver prior to section low altitude training. The G-Warm will be conducted for a minimum of 4 G's for180 degrees of turn (90 each direction) at a minimum of 300 KIAS. To facilitate introduction of the G Awareness maneuver, it will be demonstrated by the IP's during the WEPS-1. G Awareness maneuvers will be implemented as follows:

WEPS-1: Upon entering the working area, the G-Warm will be conducted by accelerating the flight to 300 KIAS and conducting two 90º turns of 4 G's in each direction. Upon completion of the G-Warm, the flight will report fenced in.

Lead IP (UHF2): "VIPERs accel G-Warm, 180."

Wing IP (UHF2): "2"

Lead IP (UHF2): "VIPERs, 90 right, go."

"VIPERs, 90 left, go."

Lead NFS (UHF2): "VIPER 1, fenced in, 2.5, negative yardstick."

Wing NFS (UHF2): "VIPER 2, fenced in, 2.5."

After fencing in, the lead will initiate the 250 KIAS rendezvous by directing the flight to take a check turn into the wingman 45 degrees and calling the wing to reverse his turn as lead pulls nose on, thus establishing himself on the 45 degree bearing line.

WEPS-2/3X: The G-Warm maneuver will be conducted prior to route entry. NFSs will query ATC as to whether there is any traffic between the flight's current position and Point A. With no traffic and flight VMC below 17.5K' MSL, the lead NFS will cancel IFR, switch the flight to FSS, initiate fencing in and initiate a descent for the G-Warm. The G-Warm will be conducted

above 5000' AGL whenever practical, but in no case will it be conducted below 2000' AGL. After completion of the G-Warm, Lead NFS will initiate fence checks with alibis.

Fence In / Fence Out

A strike fighter aircraft's role is to be employed tactically in order to execute an Air-to-Air or an Air-to-Ground mission objective. Since these objectives are more than likely to be executed away from home base (ship or airfield), a section of aircraft will need to administratively transit from their point of departure to the area of operation and back to home base. Since these are ADMIN legs that do not entail a tactical objective, there must be a way to change this administrative mindset to one that will enable us to carry out the mission.

"Fence In / Fence Out" calls serve this purpose. They enable the flight lead (lead NFS in VT-86) to plan and brief predetermined points at which the flight will transition to a tactical mindset and back to an administrative one when the conduct is complete. During the Weapon and BFM flights in VT-86, all NFS's will be responsible to fence in and out at an appropriate time as briefed and directed by the assigned lead NFS and IP. In the training command, these checks are covered by the Combat checks found in the Student In-Flight Guide: A/A and A/G Combat Checks.

This section will cover the fence checks for Section weapons hops, while the Division and BFM fence checks are covered in the respective chapters. In WEP-1, the fence in checks will consist of an abbreviated A/A combat checklist while WEP-2/3X will encompass both A/A and A/G combat checks.

WEP-1 Fence Checks

WEP-1, being a section coordination introductory flight in a working area, will only require the A/A TACAN set up and MFD display management for area control. The reason for this abbreviated check is because the conduct consists mainly of Break Up and Rendezvous, Engaging Turns and a Tail Chase exercise that will require the use of A/A TACAN to be able to maintain distance SA between aircraft.

<u>Fencing In</u>

Lead NFS will direct the flight to "fence in" along with the switch to Seabreeze (or MOA freq as appropriate). For example:

Lead NFS (UHF2):	"VIPERs, switch button 15, fence in."
Wing NFS (UHF2):	"2"

Both NFS's will setup their appropriate TACAN as briefed and displays for proper area management. After completion of the G-Warm, students will report the completion of the checklist (with the fuel state and alibis) to establish the section as ready for tactical maneuvering.

Lead IP (UHF2):	"VIPERs accel G-Warm, 180."
Wing IP (UHF2):	"2"
Lead IP (UHF2):	"VIPERs, 90 right, go."
	"VIPERs, 90 left, go."
Lead NFS (UHF2):	"VIPER 1, fenced in, 2.5, negative yardstick."
Wing NFS (UHF2):	"VIPER 2, fenced in, 2.5."

Fencing Out

Once complete in the area and the section is joined up for the RTB, the lead NFS will direct the flight to fence out on TAC FREQ, usually in conjunction with the frequency switch for RTB:

Lead NFS (UHF2):	"VIPERs, switch button 15 Pri, Fence Out"
Wing NFS (UHF2):	"2"

Reversing the fence in, each student will set the TACAN back to the appropriate navaid and the MFD set up as required to execute the administrative return leg to home field. When complete with the checks and the flight is safely rejoined, NFS's will report themselves as fenced out with a fuel state, automatically signaling the clearance to perform Battle Damage Checks (BDC) executed by the IP's (through hand signals) with NFS direction and verification.

Lead NFS (UHF2):	"VIPER 1, fenced out, 1.0"
Wing NFS (UHF2):	"VIPER 2, fenced out, 0.9"

WEP-2/3X Fence Checks

Since WEP-2 and 3X are flights that simulate the ingress of a low level route to execute pre-planned attacks on targets, they will require the more complete A/G combat checks to execute the mission successfully. But in order to prosecute targets into "enemy" territory through a low level environment, the flight must make its way to the target while sanitizing the airspace in front and around them to detect any opposition to their attack through the use of an A/A radar. Since the T-45C does not have radar to simulate this scenario, the fence checks are executed in a particular way in order to facilitate this training.

Upon cancellation of IFR the lead NFS will direct the flight, on TAC FREQ, to fence in and switch the primary radio to the appropriate FSS frequency to prepare for route entry. The checks will initially consist of switching to the briefed A/A TACAN game-plan, directing IP to squawk appropriate code (4000 for the route), verifying VCR on, LAW set as required, verifying initial A/G setup on the stores page, setting up the MFD as necessary, and setting the ***NAV mode*** as

simulation for the A/A radar. It is a combination of the A/A and A/G Combat checks found in the in-flight guide.

Lead NFS (UHF1):	"Mobile Approach, Rocket 410, is there any traffic on my nose for the next 15 miles?"
ATC:	"Rocket 410, Mobile Approach, negative."
Lead NFS (UHF1):	"Mobile Approach, Rocket 410, cancel IFR."
Approach:	"Rocket 410, cancellation received, squawk VFR, frequency change approved."
Lead NFS (UHF2):	"HAMMERs switch button 29, fence in."
Wing NFS (UHF2):	"2"

NFS will ensure the completion of:

1. **A/A TACAN – AS BRIEFED**
2. SQUAWK Appropriate Code – 4000 (1200 – VFR prior to entry point)
3. **VCR – ON**
4. **LAW – SET as Required**
5. **A/G Stores Page – SET UP**
6. MFD's – SET UP as Required
7. NAV Mode – SET

NOTE

Notice the items in bold correspond with items in either the A/A or A/G combat checklist. Those not in bold are additional items particular to these events and must be ensured for safe and effective mission accomplishment.

Like WEP-1, after the G-Warm, the students will report the completion of the checklist, with the fuel state, to establish the section as ready for tactical maneuvering into the low level route.

Lead IP (UHF2):	"HAMMERs, accel G-Warm."
Wing IP (UHF2):	"2"
Lead IP (UHF2):	"HAMMERs, 90 left, go."
	"HAMMERs, 90 right, go."

Lead NFS (UHF2): "HAMMER 11, fenced, 2.5."

Wing NFS (UHF2): "HAMMER 12, fenced, 2.5, negative yardstick."

Battle Damage Checks (BDC)

After all tactical flights, the potential exist for aircraft damage or hung bombs. For these reasons, upon conclusion of the tactical conduct, the section shall conduct a battle damage check by visually inspecting each aircraft for hung bombs and any damage such as loose panels, leaks, or any other discrepancy that may alter the RTB. The BDC is normally executed after the fence out checks to ensure that the master arm switch is safe and prevent the inadvertent activation of the weapons release button or the gun trigger.

When fence out checks are reported complete, the lead IP will pass the BDC signal at an appropriate time by extending the index finger and the thumb straight up in the shape of a pistol and simulating the cocking of the hammer. On this signal, the wing IP will visually inspect the lead's aircraft by elevating to check the top portion on the current side the wingman is on. The wingman will then lower the aircraft to cross under the lead, while inspecting the bottom of lead's aircraft, and elevating again to inspect the opposite top portion. If anything is noted, wing IP will notify on TAC FREQ, otherwise, a thumbs-up will be passed to the lead. The lead IP will then "pass the lead" to the wing IP so that his aircraft can be inspected after passing the appropriate hand signal. Upon completion, the lead is passed back to the lead IP as the flight continues on its RTB. If anything out of the ordinary is noted, the crew will take appropriate action to recover the aircraft safely by following standard and NATOPS procedures.

Although this is a check that is coordinated and executed by the IPs, it is the NFS's responsibility to ensure that BDCs are executed before the initial to provide ample time for coordination should some damage or hung ordnance occur. Weather and time permitting, it should be conducted promptly after the fence out checks. NFSs shall back up the IPs in their execution and completion after all Weapons (section and division) and BFM flights.

408. SECTION WEAPONS INTRODUCTION (WEP-1)

To introduce these section procedures, section WEP-1 will be flown out to a suitable working area (W155 or Gator MOA). The premise of this first section flight is to expose the student to the basic section coordination, introduce Breakup and Rendezvous (B&R) join up procedures, Engaging Turns and demonstrate a tail chase. Additionally, two section approaches will be performed. A lead change will performed between the two GCAs in order to provide a lead opportunity to each NFS during an approach.

The conduct of the flight will consist of all the ground and enroute procedures discussed thus far. All standard W-155 and Gator MOA entry and exit procedures will be followed with area and section management responsibility resting with the lead NFS and backed-up by the wingman. Once established in the working area, the lead IP will initiate the first of two B&R's, followed by a set of Engaging Turns and a tail chase exercise. The flight will then execute a lead change whereupon the sequence will be repeated for the new Lead NFS. Upon completion, the flight

will join up and the new Lead NFS (original wing) will lead the RTB to execute two section approaches.

Breakup & Rendezvous (B&R)

A minimum of four B&Rs will be executed, two at 250 KIAS and two at 300 KIAS, to introduce and practice airspeed calls and monitoring the rendezvous. This will allow each student to see two B&Rs as the joining aircraft. Additionally, on one of these runs for each NFS, the joining IP will demonstrate an excessive closure rate that will result in an under-run.

The lead NFS will direct the flight toward the center of the working area at 250 KIAS to set up the first breakup of the flight. The wingman will be established in parade position and await the preparatory hand signals for the B&R. When the lead IP is ready, he/she will pass the "breakup and kiss off" signals and break away from the wingman in an energy sustaining turn (13-14 units AOA) for 180 degrees. The wing IP will wait 7-8 seconds before executing the same turn to establish the aircraft 1nm on the lead's six o'clock position. Once established, the wing IP will call "Established" on TAC FREQ to notify the lead IP that he is clear to maneuver.

The lead IP, at this point, will start a 30 deg AOB turn in either direction, left or right, while maintaining the respective airspeed. The wing aircraft will wait several seconds until the lead transitions from the 12 o'clock position to the 1 or 11 o'clock position (approaching the canopy bow) to begin the turn to establish the aircraft on lead's 45 degree bearing line. The lead NFS will monitor the joining aircraft, taking note of the closure rate. Meanwhile, the joining NFS will monitor the same as he/she calls airspeeds every 2-3 seconds over the ICS until safely established in parade or the IP indicates "I got it".

The lead IP, at his discretion or as briefed, will accelerate to 300 KIAS to execute the second B&R or may pass the lead to the wing IP to perform the second 250 KIAS B&R. After completion of the B&Rs, another breakup will be initiated to begin a tail chase exercise to demonstrate part of the basic maneuvering characteristics of the T-45C. Upon completion of this exercise, seen from both perspectives, the flight will join up and RTB for section approaches as described later in this chapter.

If an excessive closure rate is observed in any of the rendezvous, an "Under-run" shall be called on TAC FREQ. Either NFS can make this call and shall be honored by the joining aircraft regardless of who makes it. The joining aircraft will immediately and simultaneously unload the aircraft, level its wings, set the throttle to idle, and extend the speedbrakes to cross under and behind the lead aircraft until safely clear to the outside and above the lead's turn. The lead IP will then clear the joining aircraft to the inside of the turn to re-join.

The intent of these maneuvers is not to make you an expert in joining up but rather to make you aware of the importance of maintaining situational awareness, through airspeed calls and monitoring, when two aircraft are intending to come in close proximity of each other. Each NFS will be responsible for these items considered critical for safety of flight.

Engaging Turns

Overview

After the second Breakup and Rendezvous and after initiating fuel checks, the Lead IP will begin directing the engaging turns on a cardinal heading and work toward the center of the area. As this is conducted, the NFSs shall review/direct their respective IP's to establish the engaging turn PADS on ICS:

(P) Position – Abeam

(A) Altitude – Lead: 14K', Wing: 15K'

(D) Distance – 1 NM

(S) Speed – 300 KIAS

Engaging turns are energy sustaining turns flown at 300 KIAS and 13-14 units AOA. There are three types of engaging turns flown in a combat spread formation:

1. TAC Turn. This turn is used for a 90° heading change.

2. INPLACE Turn. This turn is used for a 180° heading change laterally offset.

3. CROSS Turn. This is used to turn the section 180° without an offset.

Direction of Engaging Turns

The TAC and INPLACE Turns can be further defined as Into or Away, based on the direction of lead's turn relative to the wingman. For example, if the wingman were on the left side of the formation, a TAC Left would be defined as a TAC Into, while a TAC Right would be considered a TAC Away. This same principle applies to the INPLACE Turns as well.

TAC Turns

TAC Turns will change the section's heading 90°. The TAC Turn is initiated with a TAC FREQ transmission from the Lead IP and replied to accordingly by the Wing IP:

LEAD IP: "Turbo, TAC LEFT."

WING IP: "Two."

The aircraft on the outside of the turn then commences a level, energy sustaining (13-14 unit AOA) turn for 90°. As this aircraft approaches the extended six of the other aircraft, the inside aircraft begins its 90° turn. At the completion of this turn, the two aircraft are again in combat spread. As a result of this turn, the two aircraft will switch sides of the formation.

The turn depicted in Figure 4-5 is a "TAC Left Away." In this case, the wingman is responsible for clearing the airspace at the section's new six o'clock. To do this, the wing student will clear

the airspace to the inside and aft of the turn. Once the aircraft (the wing aircraft in this case) completes its 90° turn, the student will shift his lookout back to the inside of the section (right in this case) and scans the airspace aft of the wing-line (the new six o'clock). The student must physically rotate his body to facilitate this lookout. Merely turning the head from side to side is insufficient to appropriately clear the section's six o'clock. While "checking six," it is important the student scans in the vertical, both high and low. Once the airspace is sufficiently cleared, the student (wing in this case) will make the following call on TAC FREQ:

WING NFS: "Six clear."

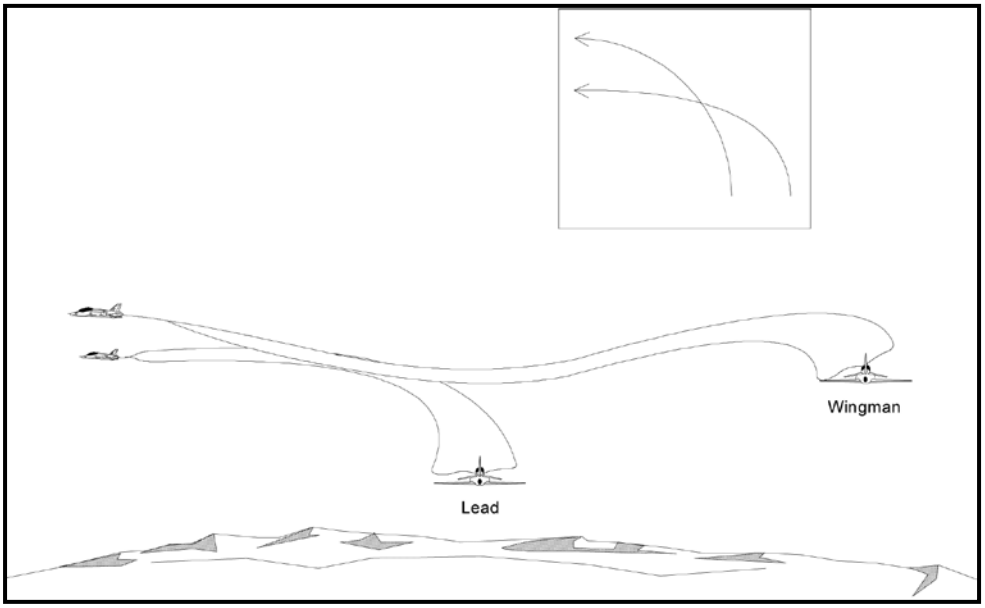


Figure 4-5 TAC Turn Away

Figure 4-6 illustrates a "TAC Right Into". The mechanics of a "TAC Into" are identical to a "TAC Away" with the exception the lead will cross the wingman's six and therefore it is the responsibility for the Lead NFS to "check six" and making the "six clear" call.

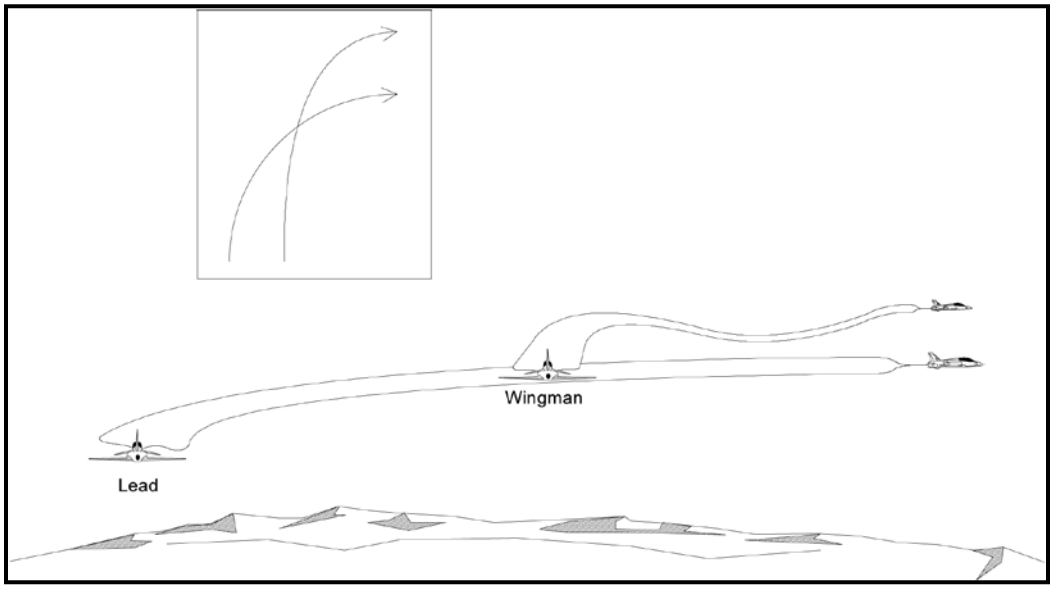


Figure 4-6 TAC Turn Into

<u>In-Place Turns</u>

INPLACE turns will maneuver a section for 180° of turn and will offset the section laterally in the direction of the turn. The INPLACE Turn will be initiated with a transmission from the Lead IP on the TAC FREQ:

LEAD IP: "Turbo, INPLACE Left."

WING IP: "Two."

Both aircraft will simultaneously commence a level, energy sustaining turn (13-14 unit AOA) in the same direction for 180° of heading change.

The turn depicted in Figure 4-7 is an "INPLACE Right Into." Both students are responsible for clearing the airspace to the inside and aft of the turn. After 90° of turn, the aircraft on the outside of the turn calls "six clear." During the turn, the aircraft to the inside of the turn (wing in the above example) will lose sight of the other aircraft temporarily. When the turn is an INPLACE Into (as depicted) the wingman, he will be the one to temporarily lose sight of his lead. This being the case, it is the wing student's responsibility to ensure the lead is aware sight has been regained by calling "visual." This "visual" call should occur approximately 135° through the turn as the wing student is scanning inside and aft and visually reacquires the lead.

LEAD NFS: “Six clear.” (after 90° of turn)

WING NFS: “Visual.”(after approximately 135° of turn and lead is reacquired)

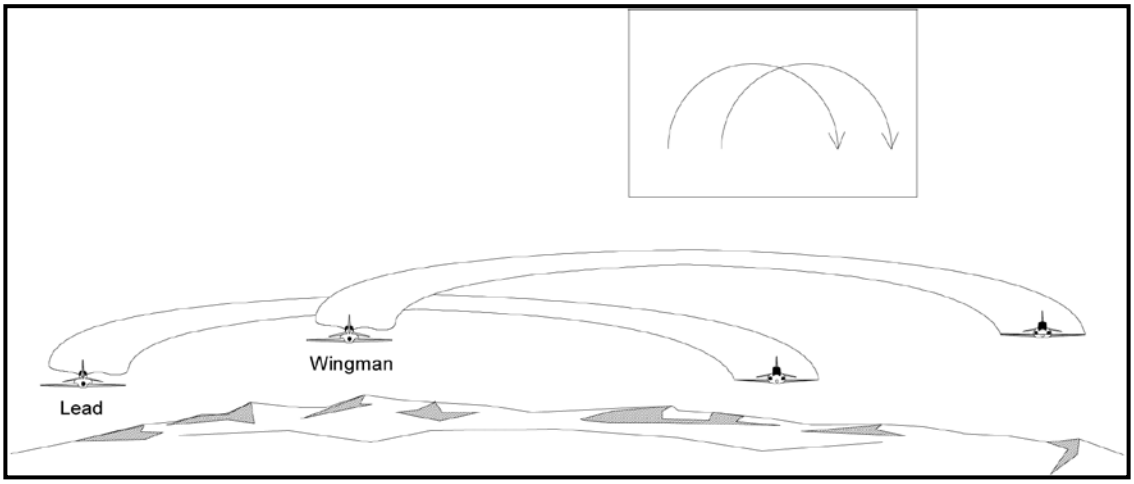


Figure 4-7 Inplace Turn Into

The second type of INPLACE turn is the "INPLACE Away." The turn illustrated in Figure 4-8 is an INPLACE Left Away. The mechanics of the "INPLACE Away" turn are identical to the "INPLACE Into". Once again, the aircraft on the outside of the turn will call "Six clear" after 90° of turn. When the turn is an INPLACE Away, the lead will temporarily lose sight of the wingman. Maintaining sight in a section however is the wingman’s responsibility, and for this reason, the lead student will not make a "visual" call when sight is regained.

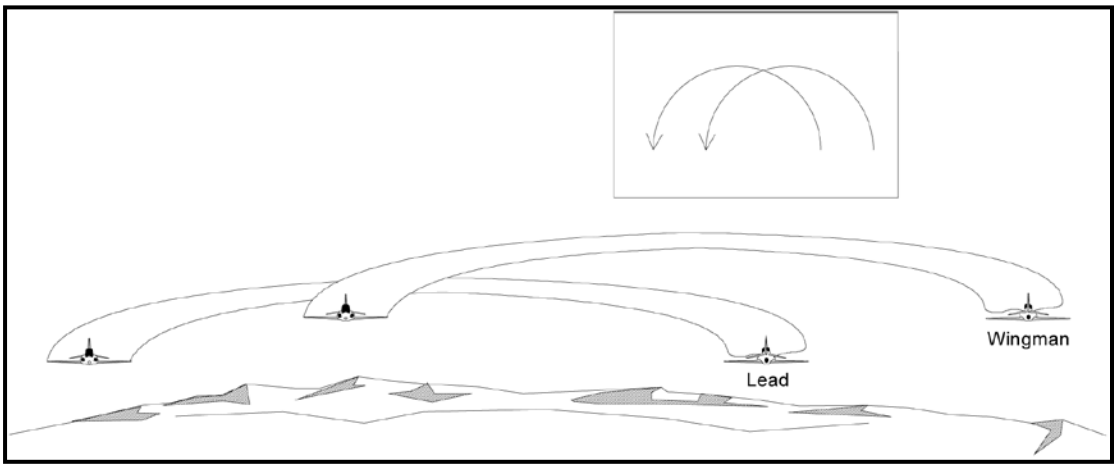


Figure 4-8 Inplace Turn Away

Cross Turn

The final engaging turn is the CROSS Turn. A cross turn will change a section's heading 180 degrees without any lateral displacement. A cross turn would be utilized to counter a threat directly aft of the section.

A CROSS turn will be initiated by the lead student. To conduct a this turn, both aircraft will turn into the section (i.e. towards each other) (Figure 4-9). The flight lead will deconflict the flight with an altitude separation call. Since in combat spread, the wingman is always stepped-up (approx 1000 ft) during engaging turns and the lead is always low, the lead will always initiate the turn and identify himself as the "low aircraft":

LEAD IP: "Turbo, CROSS Turn, Lead low."

WING IP: "Two."

During the 180 degree energy sustaining turns, both students are responsible for clearing the airspace to the inside and aft of the turn. Since each aircraft has equal responsibility for lookout doctrine during this turn, no "Six clear" call is required.

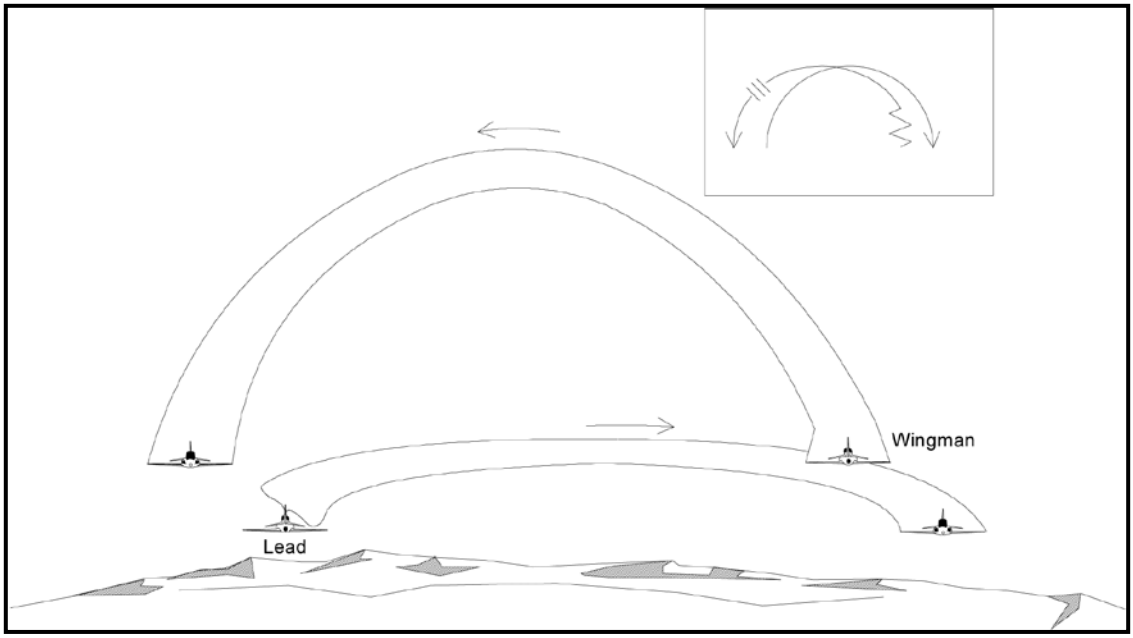


Figure 4-9 Cross Turn

Turn Sequence

On WEP-1 the instructors will demonstrate one sequence of five engaging turns (Figure 4-10), consisting of one of each of the five turns: TAC Into, TAC Away, INPLACE Into, INPLACE Away, and CROSS Turn. On subsequent section flights, turns will be executed as necessary for

route or area management. In all turns, students shall execute and verbalize their appropriate lookout doctrine and “six clear/visual” calls respectively.

NOTE

> While engaging turns are a standard in tactical aviation, you will not find such a sequence used tactically. The objective of this sequence in VT-86 is to expose students to the different aspects of tactical turns and visual lookout doctrine while maintaining mutual support. Thus, the above turn sequence is a training tool unique to VT-86.

The following table is an example of an Engaging Turn sequence:

TURN	AIRCREW	COMM
TAC Left, Into (TLI)	LEAD IP:	“Turbo, TAC Left.”
	WING IP:	“Two.”
	LEAD NFS:	“Six clear.”
TAC Left, Away (TLA)	LEAD IP:	“Turbo, TAC Left.”
	WING IP:	“Two.”
	WING NFS:	“Six clear.”
INPLACE Left, Into (ILI)	LEAD IP:	“Turbo, INPLACE Left.”
	WING IP:	“Two.”
	LEAD NFS:	“Six clear.”
	WING NFS:	“Visual.”
INPLACE Left, Away (ILA)	LEAD IP:	“Turbo, INPLACE Left.”
	WING IP:	“Two.”
	WING NFS:	“Six clear.”
CROSS Turn (C)	LEAD IP:	“Turbo, CROSS Turn, Lead low.”
	WING IP:	“Two.”

Figure 4-10 Engaging Turn Sequence

Tail Chase

The purpose of the tail chase exercise is to introduce the NFS to some basic maneuvering flight and to demonstrate the concept of pursuit curves to manage relative position to another aircraft. The exercise will begin, after conclusion of the Engaging Turns Exercise, by the flight lead checking the flight 45° from the wingman. From a 45° AOT position and 1000’ above the lead, the wingman will roll in and "chase" the lead aircraft as it begins some benign maneuvering. The trail aircraft will “chase” the defensive aircraft through a wide range of random maneuvers, demonstrating how pursuit curves can be used to maintain position. Meanwhile, the defensive student will strive to maintain sight of the attacking aircraft by using proper body positioning.

Upon completion of this chase, the flight will "knock-it-off" and either execute a lead change or coordinate for the section to RTB.

Section Approaches

On RTB, the new Lead NFS will request vectors for a section approach from ATC for a minimum of two approaches. NFS can request this by asking for vectors to the "GCA Box," "multiple approaches," or, simply, two approaches of choice or available (ILS, PAR, ASR, TACAN). Once vectored to the approach, the section approach procedures will be conducted as previously discussed in this chapter.

On the first practice approach (unless fuel does not permit), the section will execute a low approach at MDA or DH of the approach being executed. This will be reported accordingly to ATC or tower respectively. Once over the landing threshold, the lead IP will automatically start to increase power, elevate the nose, and retract the speedbrakes to fly away following ATC instructions. As the section climbs to assigned altitude, the lead IP will give the appropriate signals to raise the landing gear and flaps (above 140 KIAS for flaps).

As you establish the section on GCA downwind, following ATC vectors, the Lead IP will pass the lead to the wingman (original flight lead) for the second approach via hand signal or over the TAC FREQ. The second approach will mimic the first one except on final. At circling or better, the wingman will be signaled to get a visual of the runway by a pat of the dash and pointing toward the runway by the lead IP. When the wingman acknowledges sight of the runway environment, the lead IP will kiss off the wingman to execute a touch-and-go. As the wingman continues to the runway, the lead IP will maintain his position at the wingman's 10 or 2 o'clock position and continue to fly at 150 KIAS. Upon execution of the option, both IPs will automatically clean up their aircraft and effect a joinup at a pre-briefed airspeed, normally 250 KIAS.

Prior to this second approach, unless any more approaches are necessary or desired and fuel permits, the lead NFS can request a "Depart and Re-Enter following this approach" to conduct a section break via course rules or within tower's airspace, if specified with ATC and tower accordingly. If briefed, the lead may be passed back to the original flight lead; otherwise, the lead will remain with the wingman. If fuel does NOT permit the break, the NFSs are expected to be proactive and plan to land the aircraft at the appropriate time on a briefed game plan of separation on final or splitting the duals as necessary.

NOTE

Take note that these approaches can be changed at the discretion of the IP or as the mission dictates. Ensure that a thorough brief is provided and understood by all parties prior to walking to your aircraft.

409. EMERGENCIES

Aborts

Sympathetic aborts may be used during interval takeoffs if the wingmen are at low speed and can safely stop behind the lead. The eight-second delay on an interval takeoff will normally result in the wing being at a slow speed (< 50 knots) if lead aborts. Wing will then be able to safely stop the aircraft in a short distance. This statement, though, is not meant to override common sense and good headwork, only to maintain section integrity when practicable.

When a Section takeoff is executed, sympathetic aborts DO NOT apply. Instead, both aircraft shall maintain their takeoff lane. The non-aborting aircraft shall continue the takeoff roll and get clear of the runway. Once the good aircraft is clear, the aborting aircraft can move to the centerline of the runway and engage the long field gear as necessary.

In a dual high-speed abort scenario, the first aircraft to the arresting gear has to pass it up unless he hears “clear” on the radio from his wingman. The “clear” call tells the downrange aircraft that the aircraft behind is under control and deconflicted, and that we can now take centerline and take an arrestment. For that reason, an “Aborting” call is pivotal so that the wingman knows we are aborting. After that, only good news (i.e. clear) will be transmitted over the radio to preclude the downrange aircraft mistaking the intent of the transmission.

Aircraft Emergencies in Flight

When any member of a flight develops an emergency that requires him to land, the instructional portion of the flight will be terminated. The aircraft with the emergency will proceed directly to its point of intended landing, escorted by the other aircraft if possible. The aircraft with the problem has the option of being lead or wing, as the situation warrants. The escort will provide assistance wherever possible (or as requested) such as reading off emergency procedures or making radio reports, etc.

IMC Lost Sight: Two Plane Procedures

In the event that dash two loses sight of the lead, he will transition to instrument flight, turn away from the lead (or roll wings level if the turn is away from the wingman), and transmit that he has lost sight. The objective is to establish a 30° heading differential for one minute, then turn so that both aircraft are on a parallel heading. If in a climb or descent, the wingman shall level off momentarily while the lead continues his climb or descent to the assigned altitude; the goal being to establish a 1,000-foot altitude buffer between the aircraft until VMC or an ATC clearance can be attained. All headings and altitudes should be coordinated over the radio so as to expedite a join-up once VMC and to avoid a collision/ground contact. All aircraft should do their best to maintain sight and formation integrity with the aircraft ahead of them to minimize these lost-sight situations.

Communication Failure (NORDO)

The aircraft with the communication failure will become the wingman. This is a minor emergency when flying in formation. The aircraft with the good radio will be given the lead via standard hand signals and perform a standard recovery in accordance with the weather conditions.

If in VMC, stay VFR and bring the NORDO aircraft into the break. Perform a normal break and request clearance for yourself and the NORDO wingman. A touch-and-go executed by the lead will signify clearance to land for the wingman. Additionally, the lead may request the ALDIS lamp for the NORDO aircraft to provide visual indication of landing clearance. The reason for the leads' touch-and-go is in the event that the NORDO aircraft is unable to touch down, or goes around for any reason, the NORDO aircraft will follow. The lead will continue to coordinate with tower until fuel permits or landing is executed. Once on deck, the first aircraft to land will wait for the second to join up, clear of the duty runway, and allow lead to obtain clearance for the flight to taxi to the line.

If in IMC, the lead will have to recover the NORDO plane with a 150 KIAS, half-flap section instrument approach. Standard section approach procedures will be utilized. At approximately 500 ft. AGL, with a centered ball and in a position for a safe landing, the lead will pat the dash (meaning the wing is cleared to land), point at the runway the wingman is cleared to land on, and "kiss" the wingman off. The wingman should then make a normal approach and landing. The lead will continue at 500 ft. AGL and 150 KIAS to be in position for the wingman to rejoin if required. If the wingman does a touch-and-go or goes missed approach, he should find his lead at 10-11 o'clock or 1-2 o'clock at pattern altitude or below the ceiling. The wing may rejoin the lead for another approach. After the aircraft are rejoined, the aircraft will clean,up together prior to reentering IMC conditions. With the wingman safely on deck, the lead may circle to land or proceed with another instrument approach.

If you lose comm and sight of your wingman, flight deconfliction will be in accordance with the preceding paragraph. A standard lost-sight/lost-comm point will always be briefed so you can affect an expeditious join-up for RTB.

Down Aircraft (SAR)

In the event one aircraft in a flight of two or more develops difficulties to the point that the aircrew is forced to eject, the responsibility of coordinating Search and Rescue (SAR) will be the responsibility of the senior aircrew in the flight. He will coordinate remaining aircraft de-confliction.

On the local appropriate frequency or 282.8, the location will be passed (TACAN cut and latitude/longitude geographical). Assistance will be requested and a brief explanation of what has happened will be passed. It is essential that names are not given.

Although getting aid to the downed crew is important, the safe conduct of the remaining members of the flight is equally important. The Mission Commander may designate a high and

low orbit. The low orbit will check on the condition of the downed crew and crash scene. He will advise the high orbit, which will then relay the information. When any aircraft reaches a predetermined low fuel state, the Mission Commander will RTB or divert as appropriate.

Mid-Air Collision

The first consideration after a mid-air collision is naturally to regain control of the aircraft if it can be flown, or eject if the aircraft is out of control. The elements of the formation will separate and not rejoin.

Each crew will slow flight the damaged aircraft close to the landing field above 10,000 ft. AGL by dropping the gear (flaps may be lowered if wing damage is not suspected) at 200 kts or below and check slow flight characteristics. The pilot will make shallow turns in both directions to determine landing characteristics. In the final analysis, the pilot of the damaged aircraft must decide whether or not he has ample angle of bank and pitch authority to land the aircraft safely. Proceed directly to either the nearest suitable field or home field.

CHAPTER FIVE
SECTION LOW ALTITUDE TACTICS AND PROCEDURES

500. INTRODUCTION

Tactical strike aircraft are designed to be the proverbial “tip of the spear.” The ability to put ordnance on an enemy target anywhere in the world at any time is the primary “power projection” mission of carrier aviation.

In a hostile environment, modern-day strike tactics generally entail precision ordnance delivery from a high-altitude sanctuary. Technology provides strike aircraft with the capability for long-range accuracy from high altitude. Often, however, low altitude tactics and ordnance delivery are required due to system degradations or tactical requirements such as “close air support” (CAS). It is this type of scenario that we will train for in VT-86. This chapter presents the basic principles and procedures for a low-level section ingress and coordinated target attack.

The purpose of the weapons portion of the advanced syllabus is to demonstrate the low altitude tactical environment in a multi-plane scenario. The T-45C weapons flights are composed of one section formation, two section low-levels, and two division sorties.

Basic, Intermediate, and Advanced SNFO training provided the basic knowledge and skills necessary for the successful planning and execution of low-level navigation missions. The T-45C weapons syllabus flights will advance these skills with the introduction and practice of section procedures and coordinated tactical target attacks with simulated or inert ordnance delivery. This chapter furnishes additional information needed for the conduct of the T-45C tactical low-level flights. Emphasis during the Weapons phase will be on turnpoint procedures, target acquisition, situational awareness, wind analysis/correction application, air-to-ground timeline awareness, and crew coordination. As with any syllabus flight, basic contact flight procedures will be the bedrock of every successful event. The student’s proficiency in the operation of communication and navigation equipment will be emphasized.

501. ENABLING OBJECTIVES

Plan a low-level mission under visual meteorological conditions using recommended procedures and FLIP to an accuracy of (1) fuel: +/- 100 lbs; (2) time: +/- 15 secs; (3) course: +/- 2º; and (4) DD-175 (if required) with no errors.

1. Arrive at route entry point during low-level flight evolution +/-4 min. of scheduled entry time.

2. Execute standard turnpoint procedures during flight evolution without error.

3. Make recommendations, working with your pilot, to intercept and track a planned course during low-level flight utilizing a chart and visual reference to the ground to the accuracy of 1 nm and 12 seconds.

4. Visually identify and arrive on target during low-level flight within +/-1 nm and +/-15 seconds.

5. Make the appropriate ICS and UHF COMMS during the target attacks.

6. Compute and apply winds, as required, to maintain course and time.

7. Successfully get the flight to and from the low-level route in accordance with standard section and contact flight procedures.

502. LOW-LEVEL ROUTE PLANNING

The success of any low-level mission is directly dependent on quality preflight planning. The T-45C Advanced student is generally well versed in the skills of low-level planning and chart stripping. Students are required to prepare original low-level charts for VR-1021 A-E and VR-1024H-M.

NOTE

> While VR-1021A-E and VR-1024H-M are the routes most often flown during the WEPS-2 and WEPS-3 sorties, other routes published in the DoD AP-1B may be planned and briefed in the event of a cross-country or squadron detachment.

The T-45C low-levels will be flown at 360 kts ground speed, 500 ft. AGL. At the discretion of the instructor pilot and fuel permitting, the students may brief and plan to fly the last leg, “target leg”, of the route at 420 kts ground speed. Timing corrections should be made respectively for the acceleration and briefed accordingly. Construction of strip charts and divert charts will be in accordance with the following standards.

CHARTS

The chart planning room is located in the VT-86 academic building. You should find all of the charts necessary to prepare any and all routes required in WEPS. Currently we do not use either JNC or GNC charts in VT-86. These are for long-range planning and, therefore, are not required for VT-86 flights. The charts required for planning your events are as follows:

ONC – 1:1,000,000 (Used for the divert chart)

TPC – 1:500,000 (Used for strip chart production)

The final product, a route strip chart, should be approximately **kneeboard size** when closed. Larger strip charts (T-39 size) are difficult to manage in the tight confines of a T-45C cockpit. The divert chart should be of sufficient size to cover the operating area of the route. For the 1021A-E and 1024, all routes may be placed on one divert chart due to the close proximity of the routes.

CHART UPDATING MANUAL (CHUM)

Issued charts are not necessarily up to date. The CHUM manual is the best source for new hazards and obstructions such as recently erected towers and power lines. **THE MANUAL IS THE FINAL WORD** in updating charts. The use of such items as E-CHUM is not adequate for route planning purposes. Inadequate CHUMming will result in a below average for preflight planning. Students will CHUM all low-level charts within 10 nm of course.

MILITARY TRAINING ROUTES AP-1/B

Military training routes are designed to give military aircraft an area in which to practice navigation procedures. There are several different types of routes, but we are concerned with only two, VR and IR routes. Utilization of these routes enables military aircraft to waive the 250 KIAS airspeed limitation below 10,000 ft. in US airspace. To exercise this privilege safely, it is crucial to always squawk the appropriate transponder codes and not exceed the 250 KIAS speed limit until established on a route.

The routes listed in AP-1B are the official DoD/FAA approved routes. The route description includes the following:

- Latitude/Longitude
- TACAN cut
- Altitude blocks
- Avoidance areas
- Special Operating Procedures
- Originating and Scheduling Activities

All routes must be scheduled at least <u>two hours</u> prior to the desired entry time. This is an FAA requirement and should be coordinated appropriately.

CHART LAYOUT AND ANNOTATION

Chart preparation will be similar to the standards already set forth in Intermediate and Advanced training through the use of PFPS:

1. Plot the official AP-1/B points.

2. Clearly annotate in black ink the exact AP-1/B points (A, B, C, etc.).

3. Draw the corridor. Look in the special operating procedures to help you determine the route structure. PFPS should allow you to easily depict these corridors.

4. Plot the geographically significant points given below.

5. Highlight the corridor.

6. Leave the official AP-1/B points on the chart in ink so that it is an easy reference in case we need to report our position to ATC.

7. Plot each turn point with the 360-knot circle.

8. Plot a turn radius for every turn greater than 30 degrees.

9. The target triangle is a 5-nm equilateral triangle.

10. Do time ticks every minute based on 6 nm per minute at a speed of 360 kts to the target. For every time tick, draw a line 3 nm on either side of the centerline; on every third time tick, draw a 5 nm tick either side of the centerline and label the corresponding time.

11. Assume no wind for planning purposes. The NFS will obtain forecast winds prior to takeoff. If route winds are forecast to be 20 kts or greater, adjust no-wind headings and base airspeed, as necessary, to maintain preplanned course and time. If winds are less than 20 kts, fly pre-planned headings and airspeed.

12. The strip chart should encompass the area 10 nm on either side of the route centerline. This allows adequate chart reference in the event the flight is off course. (Remember: Flight outside the route is not authorized.)

13. Label each turn point or target with the appropriate LETTER and time. Orient the information parallel to the inbound course. Measure distances to each turn point to the nearest ½ mile. This means your times will be labeled in six-second intervals.

14. Special use airspace such as Restricted Areas and MOAs shall be highlighted and annotated on your chart. Annotate all areas within 20 nm of course. They shall also include altitudes, operating times, and any frequencies that require transmission. In addition, annotate all class “C” airspace by drawing a 10 nm circle around the airfield.

15. Hazards to flight shall be annotated on all charts. Hazards include the following:

    a. All towers and obstructions within 5 nm of course whose altitude is **300 ft. AGL or greater.** These must be verbalized on the route as a hazard as well.

    b. Hard surfaced airports within 5 nm of course. These should be avoided by 3 nm or 1,500 ft.

A photocopy of the AP-1B route description will be glued to the strip chart cover. "Z" diagrams (to be addressed later in this chapter) will be adjusted for terrain elevation, depicted in the margin near the target, and annotated in MSL altitudes.

There are several noise sensitive areas on the local routes. The NFS will annotate these and avoid them as necessary as per the instructions in the AP-1B or CHUM. Crossing routes are not required on VT-86 charts, but solid situational awareness will require familiarity of such potential hazards.

The following geographically significant points will be used for turn points on the VR-1021 A-E and VR-1024 routes:

VR 1021	
Point	**Description**
A	Tip of peninsula
B	Highway bridge over small river
C	Power plant (south end)
D	Abandoned mine on river
E	RR trestle over creek

VR 1024	
Point	**Dew**
H	RR / Road X – Section north of Bay Springs / Grain Elevators
I	Town of DeSoto
J	Road bridge over river
K	Fire tower (burned down ironically, so turn on time)
L	Town of Deer Park
M	RR bridge over river

Figure 5-1 VT-86 Low-Levels

DOGHOUSES (LOW-LEVEL)

Low-level "doghouses" filled in with the appropriate data will be used on every chart made in VT-86 (Figure 5-2). Required doghouse data will include:

MC: Mag Course to next turn point

DIST: The total leg distance to the next turn point to the nearest 1/2 nm

ETE: Leg time to the next turn point to the nearest six seconds

ESA: Emergency Safe Altitude. This is an MSL altitude specific to each leg that will provide at least 500 ft. vertical clearance from the highest obstruction within 10 nm. Minimum altitude to climb to in the event of disorientation or entry into inadvertent IMC conditions on the route. Calculate the leg's ESA as follows:

1. Take the highest MEF (block altitude) along the leg and add 500 ft.
2. If there is any CHUM tower within 10 nm of leg course line, round its altitude up to the next 100 ft. and add 500 ft.
3. Pick the higher of the two figures. This is the ESA for that leg.

EFR: Estimated Fuel Remaining. Derived from mission planning.

MCF: Fuel required to complete planned mission conduct (route of flight, low-level or tactical maneuvering) and return to planned destination via standard routing (including approaches for training or weather) to arrive with:

- VMC: SOP minimum fuel (500 lbs) on deck or fuel to proceed to alternate and arrive above SOP emergency fuel (400 lbs), whichever is higher
- IMC: Divert Fuel

BINGO: Fuel required to fly from that point of the route to your planned destination using standard routing to arrive with:

- VMC: SOP minimum fuel (500 lbs) on deck or fuel to proceed to alternate and arrive above SOP emergency fuel (400 lbs), whichever is higher
- IMC: Divert Fuel

EMERGENCY DIVERT: Emergency fuel required to fly a Bingo profile from present position and make it to the nearest suitable divert with the published NATOPS reserve fuel (300 lbs). NFS will have Emergency Divert fuels annotated for each point on their divert chart.

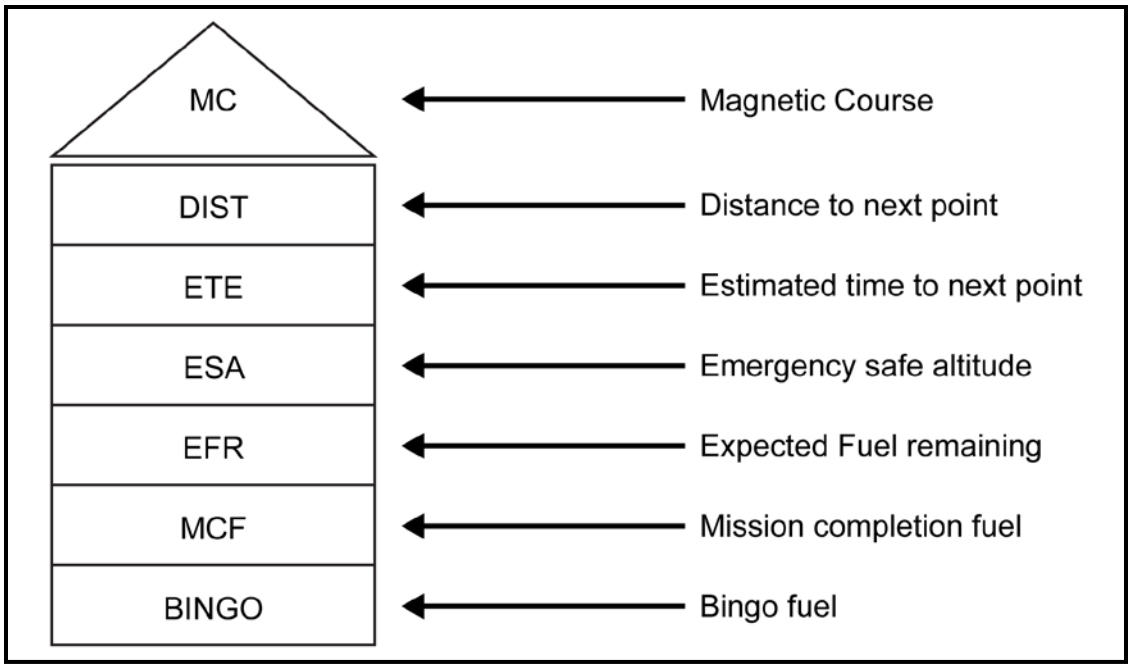


Figure 5-2 Low-Level Doghouses

STANDARD T-45C FUEL PLANNING DATA

Based on T-45C NATOPS flight manual. Actual performance will vary with nonstandard temperature, winds, and varying gross weights. For initial planning only.

Total usable fuel	2938 lbs
Start/Taxi/Takeoff	200
Penetration approach	250
GCA	250
Reserve (20 min @ 10,000 FT MSL)	300

LOW LEVEL

360 KGS, 12K GW = 6.6 lbs/NM and 2,375 PPH
300 KGS, 12K GW = 5.0 lbs/NM and 1500 PPH

JP-4 = 6.5 lbs/Gal **JP-5 = 6.8 lbs/Gal** **JP-8 = 6.7 lbs/Gal**

CLIMB OUT (Using climb schedule: 250 KIAS to 10K, 300 KIAS to intercept .72 IMN)

ALTITUDE	KIAS	NM	TIME	FUEL USED
5,000	250	04	0+01	60 lbs
10,000	250	10	0+02	120
15,000	300	20	0+04	190
20,000	300	28	0+06	260
25,000	292/.72	38	0+08	360
30,000	263/.72	53	0+10	440
35,000	235/.72	70	0+12	540
40,000	209/.72	80	0+16	600

ENROUTE

ALTITUDE	#/NM	IMN	CAS	#/HR	TAS
5,000	5.21	.43	260	1460	280
10,000	4.72	.45	250	1345	285
15,000	4.08	.49	245	1245	305
20,000	3.69	.52	240	1180	320
25,000	3.46	.56	230	1160	335
30,000	3.24	.61	225	1165	360
35,000	2.90	.65	220	1090	375
40,000	2.84	.68	200	1110	390

DESCENT

ALTITUDE	KIAS	NM	TIME	FUEL USED
5,000	195	12	0+03	25 lbs
10,000	195	28	0+07	80
15,000	195	39	0+10	90
20,000	195	53	0+14	125
25,000	195	68	0+17	150
30,000	195	85	0+21	175
35,000	195	100	0+24	210
40,000	195	116	0+26	225

OPTIMUM ALTITUDE and SPEED

GROSS WEIGHT	IMN	ALT	#/NM
13,000	.68	36,800 ft	3.08
12,000	.68	38,400 ft	2.86
11,000	.68	39,600 ft	2.63

Figure 5-3 T-45C Fuel Planning Card

503. LOW ALTITUDE "POP ATTACK" - Z DIAGRAM

Pop Z diagrams are useful presentations of pattern and weaponeering information included on briefing boards and kneeboard cards (Figure 5-4). The diagrams will be labeled with altitudes in AGL/MSL (i.e. 1.0A/1.1M release point for a target elevation of 100'MSL) as follows:

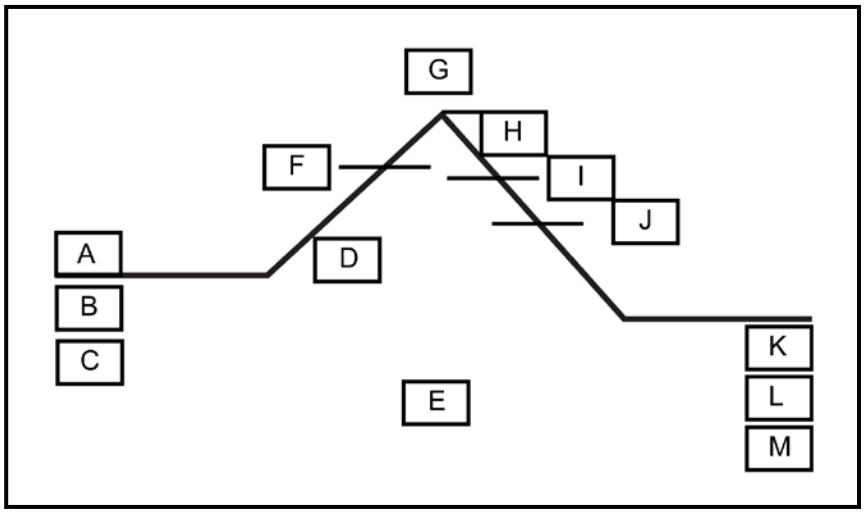


Figure 5-4 Pop Diagram

A = INGRESS ALT (AGL)/AIRSPEED (KGS) – Must remain at or above 500' AGL at all times.

B = POP POINT DISTANCE (NM) – Distance from waypoint

C = MANUAL MIL SETTING (MILS)

D = POP ANGLE – Double the attack angle (20° for a 10° Dive angle).

E = DELIVERY AIRSPEED (KTAS) – Planned Delivery Airspeed at Release

F = ROLL OVER ALT (AGL) – Point to start the pull to attack angle (APEX – 300').

G = ROLL IN (APEX) ALT (AGL) – Highest point of the attack.

H = DIVE ANGLE – Planned Dive Angle

I = PLANNED RELEASE ALT (AGL) – "MARK" call on ICS.

J = NO LATER THAN RELEASE (NLT) ALT (AGL) – "PULL" call on ICS.

K = MINIMUM ALTITUDE (MINALT) – Must stay above this altitude.

L = DIVE RECOVERY (DR) – Displacement traveled during recovery pull.

M = LAW SETTING (AGL) – Should equal 10% below ingress altitude

504. ARMAMENT SYSTEM GENERAL

The armament system provides for the carriage, jettison, sighting, gun firing simulation, and controlled release of external stores. The air-to-ground (A/G) HUD master mode provides both manual and Continuously Computed Impact Point (CCIP) sighting for bombs, rockets, and simulated guns. Armament system controls consist of the jettison button, Master Arm switch (forward cockpit), Master Arm switch/MSTR ARM light (aft cockpit), weapons release button and GUN trigger, HUD Data Entry Panel, and MFD stores display. There is no data interface between the weapons station and the A/G stores display. Weapon quantity and rocket firing mode must be set in by the pilot to match the weapons load.

Armament System Controls and Indicators

Emergency Jettison Button

The jettison button (Figure 5-5) in the forward and aft cockpit will jettison stores on the wing pylons simultaneously with weight off wheels. Stores jettison occurs regardless of the selected weapon or Master Arm switch position. Centerline external stores will not jettison.

Master Arm and Master Arm Override Switch/Master Arm Light

The Master Arm switch (Figure 5-5) is located in the front cockpit. All armament circuits, except for jettison, are controlled by the Master Arm switch. With the Master Arm switch in SAFE, the armament circuits are deenergized. In ARM, the armament circuits are energized and the MSTR ARM light (Figure 5-5) is illuminated in the aft cockpit. The Master Arm override switch (Figure 5-5) in the aft cockpit can disable the armament system when placed in the SAFE position. When in the FORWARD position, the forward cockpit controls the armament system.

Weapons Release Button and Gun Trigger

The A/G weapon release button or pickle button (Figure 5-5) is used to release weapons from the wing stations. With the Master Arm switch in ARM and a wing station selected on the stores display, pressing the button releases a bomb or fires a rocket. The GUN trigger (Figure 5-5) is used to fire the simulated gun. With the Master Arm switch in ARM and GUN selected on the stores display, squeezing the trigger simulates gun firing.

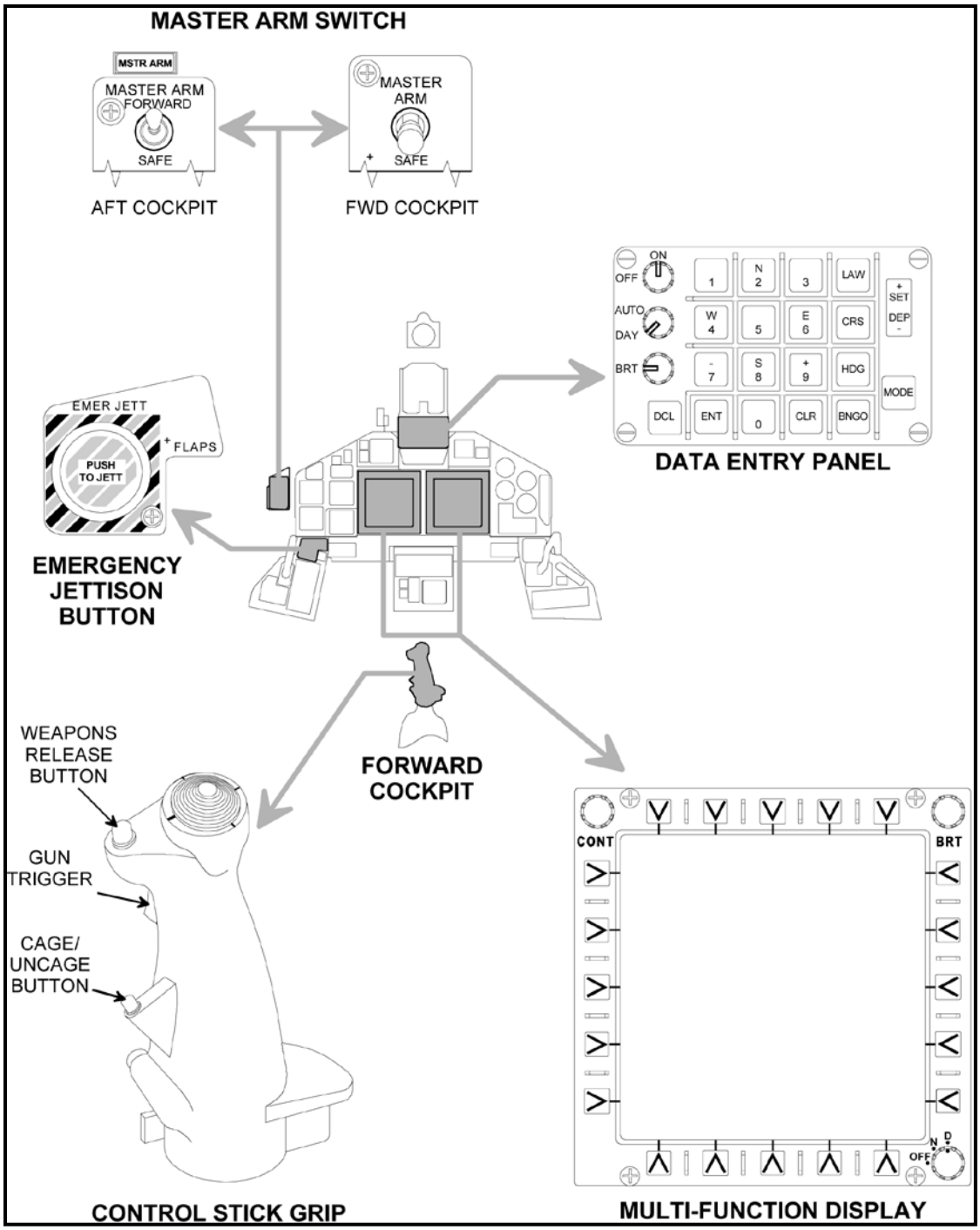


Figure 5-5 Armament Control System

HUD DATA ENTRY PANEL (DEP)

The DEP (Figure 5-5) is used to adjust the MIL depression setting, select the HUD master mode, and enter target height. The MIL depression setting of the depressed sight line is adjusted with

the SET DEP +/- rocker switch; HUD master modes, navigation, air-to-air, and air-to-ground are selected with the MODE button, and target height is entered with the DEP buttons.

MFD Air-to-Ground (A/G) Stores Display

The A/G stores display (Figure 5-6) options include submode selection, weapon and station selection, weapon quantity selection, weapon quantity, target height option selection, Master Arm switch status (SAFE or ARM), and rocket delivery options.

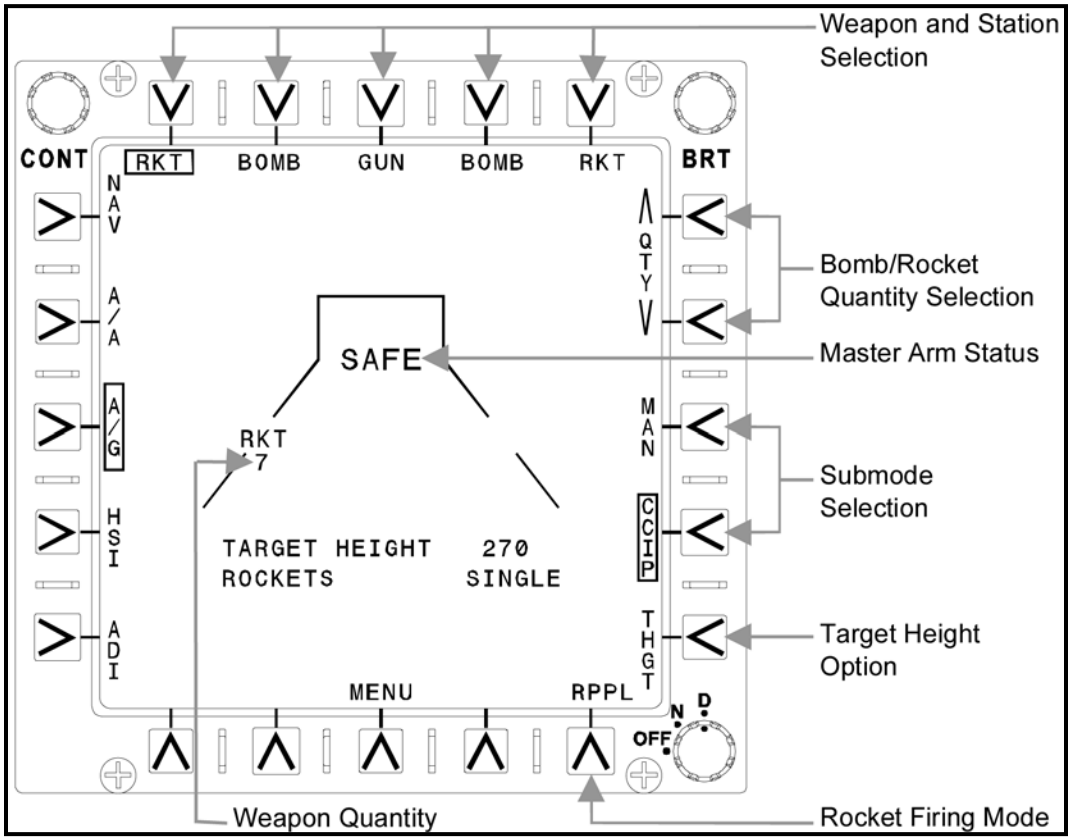


Figure 5-6 A/G Stores Display

The T-45C navigation and weapons delivery system defaults to various displays. Before air-to-ground sorties, you must assure that the STORES system is programmed to support your mission plan (Figure 5-7). Target data is stored in the system memory, retained for application in flight.

The T-45C carries MK 76 bombs and/or 2.75 FFARs. The gun is “always available”, simulated on the centerline station, and presumed to have unlimited ammo (no ammo countdown is provided). The DEU/mission computer does not monitor status of the simulated gun, bomb racks, rocket launchers, or weapons. Upon command to release a weapon (pickle button or trigger), the T-45C system counts down according to the number of times the release button/trigger is depressed. There is not a mechanical or electrical interface to wing stations; therefore, it is possible for the system to count down even though a weapon is not released or is “hung.”

WAYPOINT AND OFFSET DATA: Mission profiles determine in what manner you may employ waypoints and offsets. Remember that each offset (0-359.9° and 0-99.9 nm) is associated with an active waypoint; changing waypoint coordinates deletes offset data associated with that waypoint. Also, an offset causes replacement of CCIP target height with that height set in the offset.

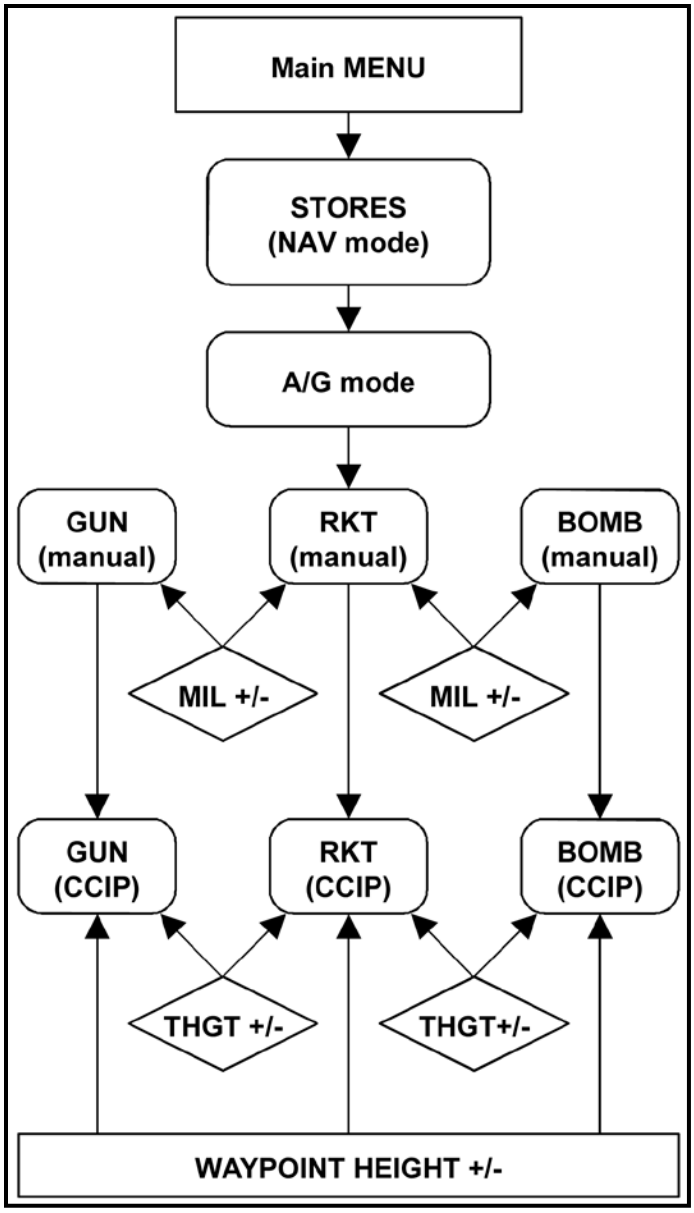


Figure 5-7 Weapons Data Entry

After completing the poststart checks and entering waypoint data, select the air-to-ground stores display by selecting MENU, then STRS, and then A/G. The air-to-ground display initializes to GUN and manual delivery (Figure 5-8). Select the appropriate station and weapon according to your weapons load. If RKT (rockets) (Figure 5-9) is selected, ensure that RPPL (ripple) is not selected, and the rocket quantity reflects the weapons load.

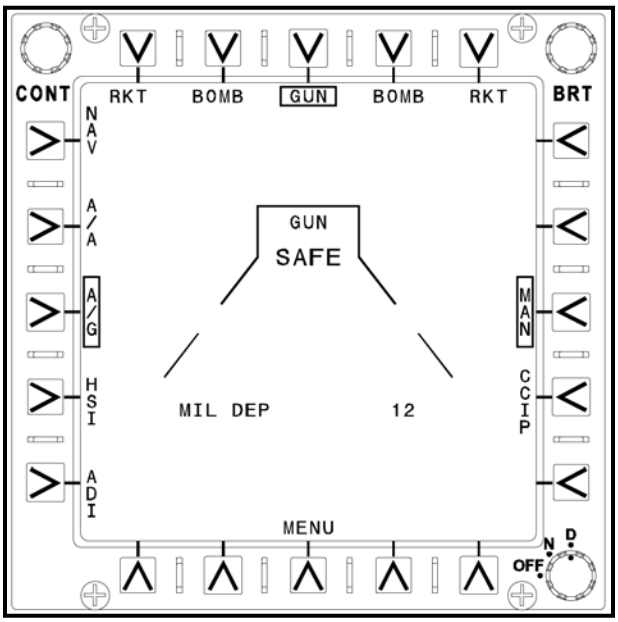


Figure 5-8 A/G Stores Display (GUN)

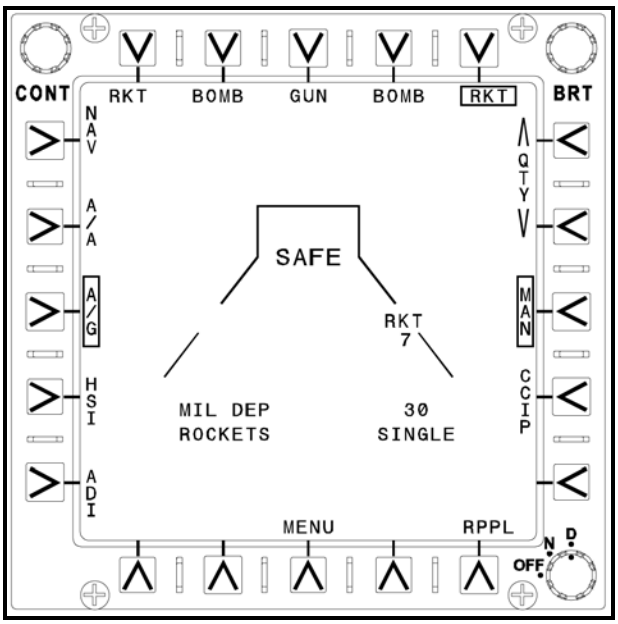


Figure 5-9 A/G Stores Display (RKT)

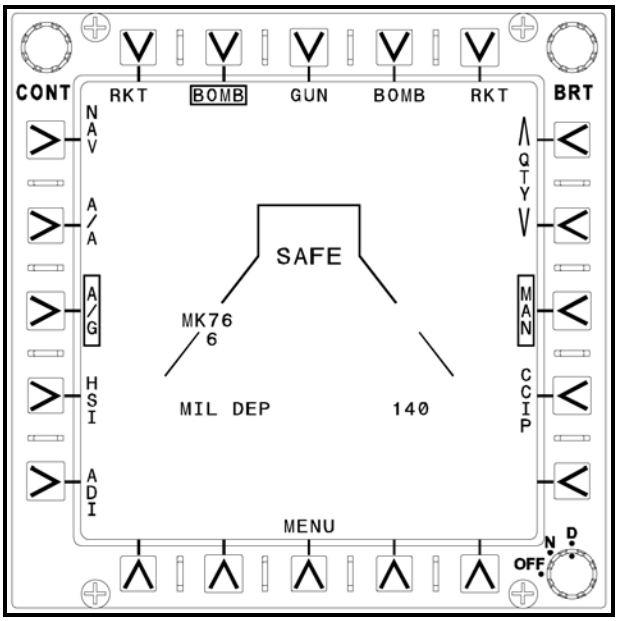


Figure 5-10 A/G Stores Display (MAN BOMB)

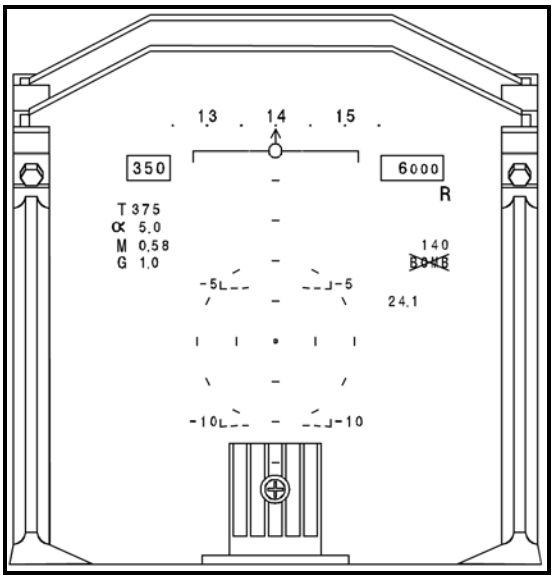


Figure 5-11 A/G HUD (MAN BOMB)

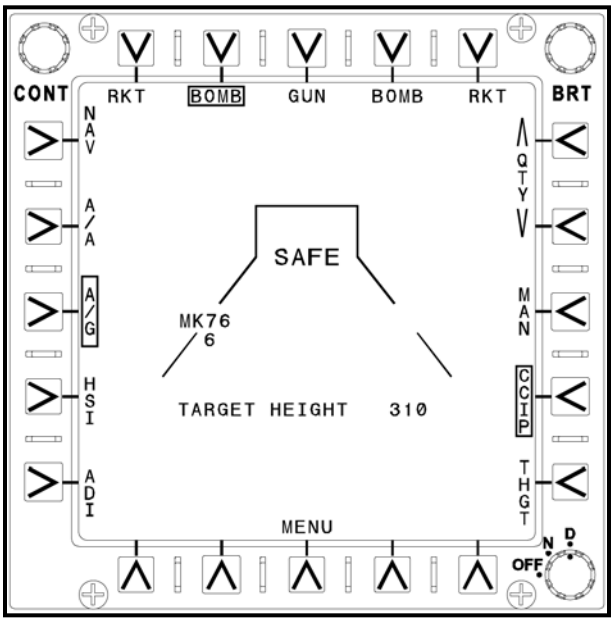


Figure 5-12 A/G Stores (CCIP BOMB)

If BOMB (Figure 5-10) is selected, ensure that the bomb quantity reflects the weapons load. If a manual delivery is planned, the MIL setting may need to be changed for the planned dive angle and release altitude. On start, the system default mil setting is 12 for guns, 30 for rockets, and 140 for bombs (Figure 5-11). The MIL setting is changed by pressing the SET DEP + to increase or SET DEP - to decrease the MIL setting on the DEP (Figure 5-5) for the selected weapon.

If CCIP is the planned delivery mode, select CCIP on the stores display. Normally, the target height does not need to be set (Figure 5-12). The entered target height is only retained as long as the waypoint does not change. As soon as a new waypoint is selected, manually or automatically, the target height reverts to the waypoint elevation. In addition, the system uses the radar altimeter for AGL altitude for CCIP computations. Target height is only used if the radar altimeter is off or inoperative.

When the desired weapon, MIL setting, and delivery mode are entered for all your planned delivery profiles, select the A/G display you plan on using first. Then, return to the ADI and HSI display on the MFDs and the navigation mode on the HUD.

Systems In-Flight Procedures

Approaching the target area, select the A/G stores display on the right MFD by selecting MENU, STRS, then A/G. Selecting the A/G stores display also selects the HUD A/G master mode. The last entered weapon and station, submode, weapon quantity, rocket firing mode (if RKT selected), and MIL setting (if MAN selected) entered during preflight are displayed. Verify HUD weapons delivery symbology is correct, or modify it using the stores display and/or the DEP. If CCIP submode is selected and the target height for the active waypoint is not correct, enter a new

target height. Set the VCR switch to the briefed position. Setting the Master Arm switch to ARM is all that remains to be done (Figure 5-13 and Figure 5-14). When changing delivery patterns, select the desired submode, weapon and station on the A/G stores display and, if required, adjust the MIL setting using the SET DEP +/- rocker switch on the DEP.

Though the weapon quantity indication may indicate zero, it is not an indication that all weapons were released from the aircraft. You must still perform a hung ordnance check. Following the weapons mission, select HSI on the right MFD and press MODE on the DEP once to return to the HUD navigation master mode.

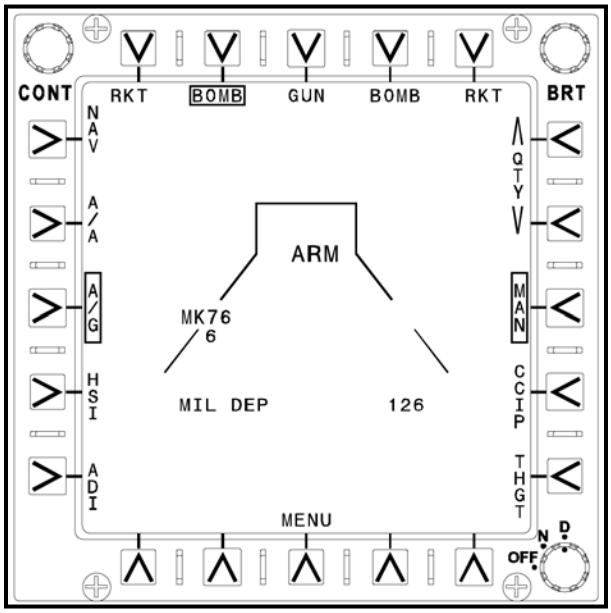


Figure 5-13 A/G Stores (MAN BOMB)

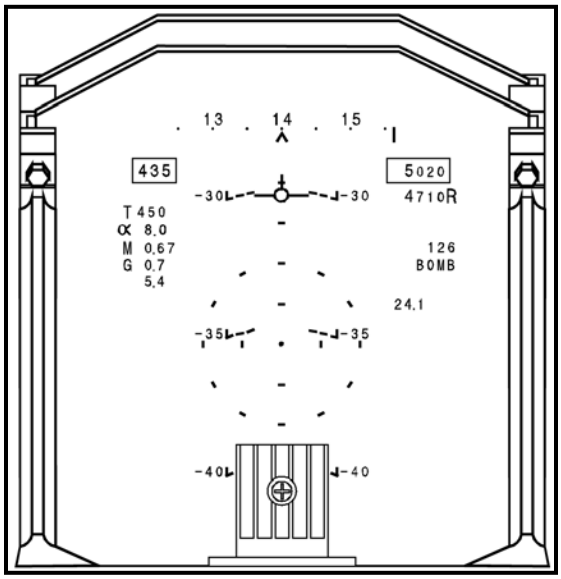


Figure 5-14 A/G HUD (MAN BOMB)

HUD

Aircraft weapons delivery requires maneuvering to a roll-in position in order to achieve a desired dive angle, then making corrections during the dive to compensate for wind and deviations from optimum delivery parameters. The T-45C system can also be flown in either a relatively automated Continuously Computed Impact Point (CCIP) mode or Manual (MAN) mode, which requires the pilot to make all required calculations. When using CCIP, the system automatically computes a predicted weapon impact point, adjusted for wind, dive angle, and airspeed.

As a proficient Naval aviator, one must learn how to make fundamental calculations and perform adjustments during bombing runs. As one becomes competent in delivery, one's understanding of various parameters and how to manage them from the cockpit will mature.

A HUD is a valuable asset for Naval attack pilots. It allows them to perform air-to-ground weapons delivery, while keeping attention focused outside the cockpit.

HUD Air-to-Ground Symbology

The velocity vector is always displayed, providing the GINA is on-line. The velocity vector indicates where the aircraft is actually going, as opposed to where the nose is pointed (waterline). That information proves very helpful during weapons delivery. In A/G modes, the HUD does not display bank angle.

When wings level, the T-45C waterline (pitch attitude) can be approximated by the point of intersection of an imaginary line tangent to the tops of the KIAS and BARO altitude boxes with the centerline of the pitch ladder (see Figure 5-15). Interpolation is less accurate as the aircraft banks and the pitch ladder displaces with the velocity vector.

An “X” overwriting BOMB or CCIP indicates that the Master Arm switch on the Armament Control Panel is in the SAFE position. The “X” is removed when ARM is selected.

A breakaway cross appears on the HUD when you must initiate an immediate dive recovery. The cross remains until the aircraft begins to climb. The cross is displayed when the system determines that a normal 4 G recovery, plus normal reaction time, will result in the aircraft bottoming out with 1,000 ft. AGL. This warning feature is disabled for dive angles of less than 15 degrees.

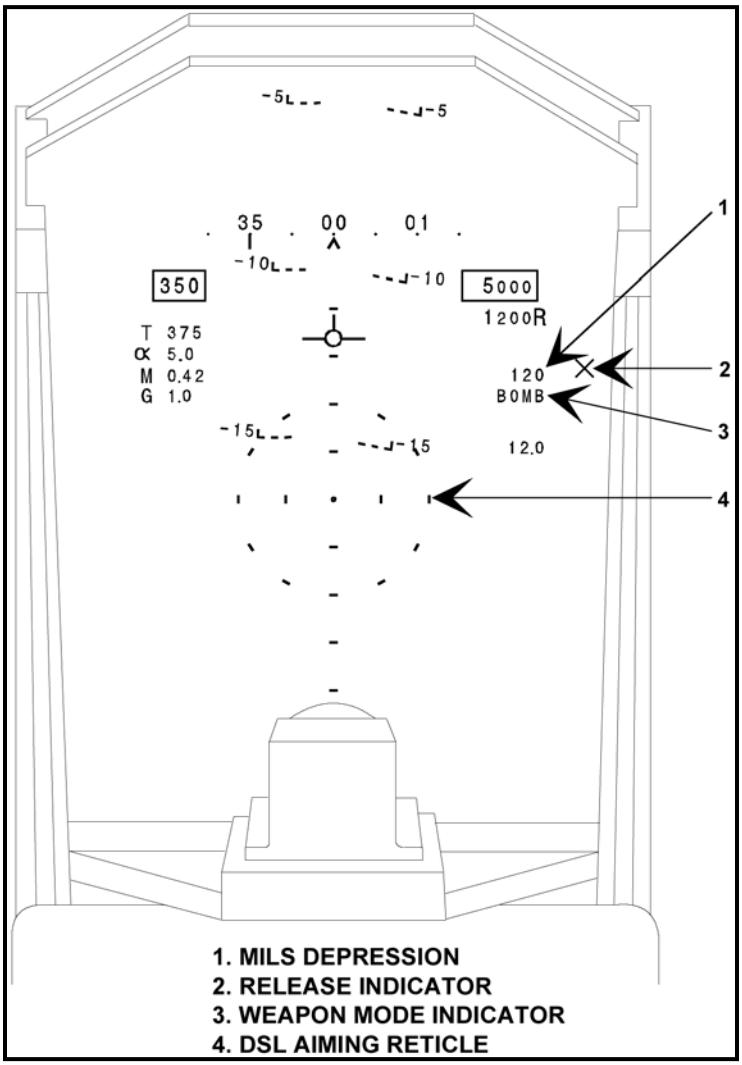


Figure 5-15 A/G HUD DSL Display

- **Manual (MAN) Mode**

  MAN incorporates a Depressed Sight Line (DSL) aiming reticle, for which mil depression angles set using the ± SET DEP rocker switch on the DEP (Figure 5-4). DSL defaults to 12 mils for gun, 30 mils for rockets, and 140 mils for bombs. Specific mil numbers are stored for each type weapon. The reticle indicates where the selected weapon will strike, given the weapon ballistic characteristics, aircraft airspeed, altitude, angle-of-attack, and direction of flight at the required release parameters. The reticle inner ring is 25 mils, and outer ring is 50 mils. Outside the rings are two additional mil marks along the pitch ladder centerline: 75 and 100 mils. (Figure 5-14).

- **Continuously Computed Impact Point (CCIP) Mode**

  In the CCIP mode, the HUD displays the same flight parameters as in MAN mode (compare Figures 5-14 and 5-15). CCIP compensates for dive angle, bank angle, airspeed, altitude, and target wind to display a continuously computed impact point for a selected weapon.

  When using the CCIP mode, target elevation should be entered into the system. The purpose is to have accurate BARO altitude available should the radar altimeter data input or instrument fail. During a bomb run in rugged terrain, the pipper may jump around as the aircraft passes over terrain of varying heights. To force the system to use BARO altitude versus radar altitude, the radar altimeter must be turned off.

  In the CCIP mode, the HUD displays a continuously predicted impact point under the pipper, a cruciform symbol. A bomb fall line is drawn from the pipper to the velocity vector, sometimes called a display impact line. It is only available in A/G BOMB mode, not in RKTS or GUN. The bomb fall line is an azimuth reference between the pipper and the velocity vector that indicates wind and speed effects on the weapon. When the target and CCIP pipper are coincident, you will command bomb release.

  The HUD can be used in A/G either caged or uncaged. The system defaults to uncaged. Should you have occasion to employ the HUD in the caged mode, be aware that the bomb fall line is displayed between the caged (solid) velocity vector and the pipper, not between the true (uncaged ghost) velocity vector and pipper. Correspondingly, your target may not track down the bomb fall line, as during uncaged mode of operation.

  The proper technique for using CCIP on a bombing run begins with a normal roll-in at the correct point to establish the desired dive angle. Once in the dive maneuver to place the bomb fall line over the target, proper position for the target along the line will depend upon specific parameters. With experience, your judgment regarding initial target placement will develop. As the dive progresses, the target will move down the bomb fall line until it is coincident with the pipper. That is the point of weapon release.

CCIP RKTS and GUN pipper flash when the computed slant range to the target exceeds 12,000 ft. for RKTS and 8,000 ft. for GUN, indicating that you are outside normal parameters for those weapons. Not only must weapons be released inside their max/min envelopes (fusing, fuel, range), releasing under optimum parameters will improve total system accuracy. This system only senses winds at aircraft altitude. Variance between release and impact winds has an unperfected, minor effect on CCIP.

- **Declutter**

  NORMAL, Declutter 1, and Declutter 2 HUD A/G displays (Figure 5-16) are available in MAN and CCIP weapon delivery modes. Declutter 1 removes AOA, MACH number, instantaneous-G, and peak-G legends. Declutter 2 additionally removes the heading scale, command heading bug, and TAS from both the MAN and CCIP. The peak-G legend will reappear once the peak-G threshold (4.0 G) is exceeded. IMPORTANT: Since reference to instantaneous-G loading is needed for safe recovery, declutter functions are not used in the air-to-ground mode in the Training Command.

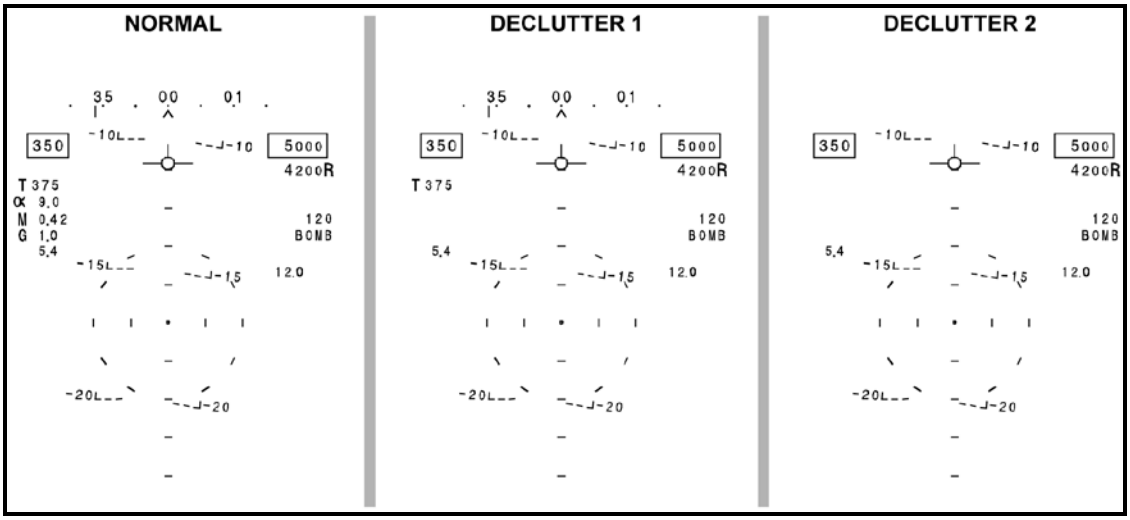


Figure 5-16 A/G HUD Declutter

Video Camera System (VCS)

The video camera recorder (VCR) is loaded and unloaded from the right console, rear cockpit. It must be done properly, or the VCR tape may malfunction. IMPORTANT: The VCR must be shut off at least 10 seconds prior to engine shutdown, allowing the tape to unthread to avoid a likely tape jam. Following flight, never remove a still threaded cassette from the sealed video module (SVM). Tape damage will result. Tapes must first be unthreaded.

The rear cockpit VCS panel has a three-position toggle switch: OFF/STBY/RECORD. If in OFF or STBY, the front cockpit VCS panel controls the VCS. When the aft switch is in STBY, the VCR tape is prethreaded and ready to instantaneously record; in OFF, there will be an initial delay as the tape threads. If the rear cockpit switch is in RECORD, imagery will be recorded as soon as power is applied to the aircraft; the front VCS switch is disabled. Video recording is initiated from the front cockpit using the VCR AUTO/OFF/ON switch on the main instrument panel, provided the rear cockpit VCR switch is in STBY or OFF. Selecting AUTO on the front cockpit panel commands the VCR to record HUD imagery whenever the Master Arm switch is in ARM. Selecting ON starts the VCR recording as per the latest MFD VREC entry and rear cockpit VCS switchology. Selecting OFF in front diverts VCS control to the rear cockpit; VCR is deenergized if the rear cockpit VCS switch is also OFF. Checking the BIT page for a VCR DEGD indication will confirm the tape is unthreaded.

Selecting VREC from MENU allows choosing what imagery the VCR will record. Options include the HUD (initial power-on default), LFWD, RFWD, LAFT, and RAFT MFD displays. Only one display can be selected at a time.

If the front cockpit VCS switch is in AUTO, the VCR records when the Master Arm switch is in ARM, and the rear cockpit Master Arm override switch is in FORWARD, provided the rear cockpit VCR panel switches are appropriately set. If the front cockpit selects ON, VCR recording is continuous from that moment. The system also records intercom/audio signals whenever the VCS is operating. Sounds recorded are the same as received by the rear cockpit headset at time of recording.

VCR Setup

1. Place the entire sealed video module in the VCR receptacle, located in the aft cockpit, right console, and secure it with the locking bar. Then, place the aft cockpit VCR switch in STBY or OFF as briefed.

2. Check that the forward cockpit VCR switch is set according to instructions: ON, VCR starts recording; OFF, VCR operation is controlled by the aft cockpit; or AUTO, VCR starts recording when the Master Arm switch is set to ARM.

3. Verify that HUD is selected on the Video Recording Source Display (VREC) record page prior to taxi.

505. LOW ALTITUDE FORMATIONS AND MANEUVERING

Formations

Low altitude tactical formations are designed to optimize terrain masking, facilitate threat detection and avoidance, and minimize terrain hazards. The two basic section formations utilized in the low altitude environment are “combat spread” and “tac wing.” How T-45C formations maneuver in the low altitude regime will be discussed in this section.

Combat Spread

Combat spread is a defensive formation (Figure 5-17) designed to provide:

1. Increased enemy detection through visual cross coverage against both air-to-air and surface-to-air threats.

2. Separation between aircraft to allow each aircraft to seek lines of least resistance and best concealment.

3. Commitment by air enemy threat early in an engagement to one aircraft.

4. Less exposure of a section of aircraft to a given defensive threat than a trail type formation.

5. Visual acquisition problems of both aircraft by an enemy.

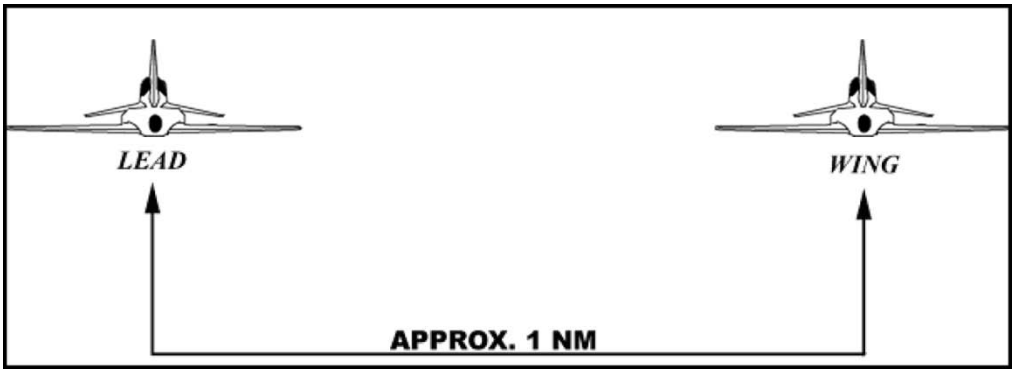


Figure 5-17 Low-Altitude Combat Spread

Combat spread formation in the low altitude environment is defined as follows:

1. Zero degree bearing line

2. Approximately 1 nm lateral separation (dependent on threat status and weather)

3. Co-altitude (terrain permitting)

Tac Wing

1. Tac Wing (Figure 5-18) is an extremely fluid formation designed to provide:

2. Reduced workload on the wingman (ease in position keeping).

3. Ease in maneuvering a section through rough terrain.

4. Aircraft in close formation can mass firepower while at the same time avoiding the “frag” of the other aircraft (i.e., during air-to-ground weapons delivery).

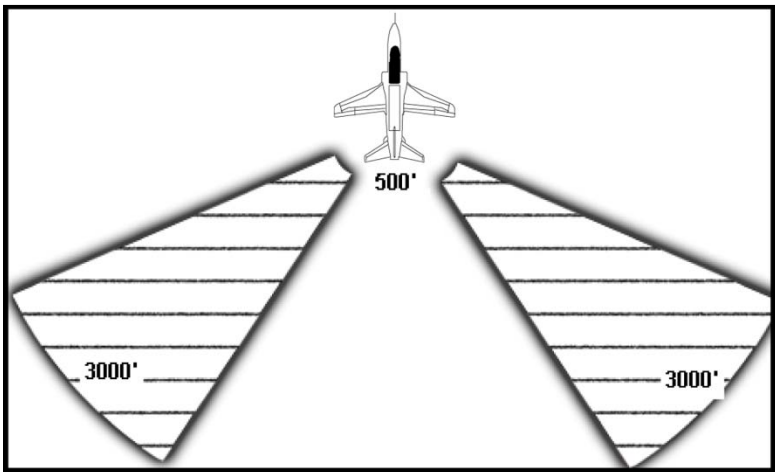


Figure 5-18 TAC-Wing Formation

Tac Wing formation is defined as:

1. The wing will fly in the depicted “cone” 20 to 60 degrees off the lead's tail.

2. Wing will maintain 500-3,000 ft. of nose to tail separation.

3. Wing will maintain a position level to slightly above lead’s altitude.

The wingman has the primary responsibility for lookout in the Tac Wing formation, more so than in combat spread. Wing should remain at least 20º off lead's tail for wingtip vortex avoidance and to allow easy visual acquisition. In a hostile environment, the wingman should cross the lead’s tail approximately every 60 seconds to ensure the 6 o'clock position of the section is clear.

Low Altitude Section Maneuvering

The benefits of combat spread in the low-level environment have been discussed. Now we address how to maneuver a section in combat spread in order to meet the ever-changing tactical scenario. Four distinct section turns are used in the low altitude environment while flying in combat spread. These turns are:

- Check turns – 0-30 degrees
- Nav Turns – 30-60 degrees
- Tac Turns – 60-120 degrees
- Shackle Turns

Other turns possible in the low-level environment include cross turns and in-place turns; however, these will not be covered in detail due to their specificity to a hostile environment. Because the goal during low altitude ingress is to avoid detection, turns will be pre-briefed and executed at the point, initiated by a wing-flash from the lead. (If there is doubt as to what turn the section is trying to execute, the lead will call it over the TAC FREQ. Safety is paramount.)

All turns during section maneuvering are considered level turns and should be executed with precision. The workload will be higher than normal due to the close proximity of another aircraft. The main priority during the turns is to track the turn and avoid the ground. Crewmembers should not spend more than one second mission critical time (MCT) on other tasks at this time.

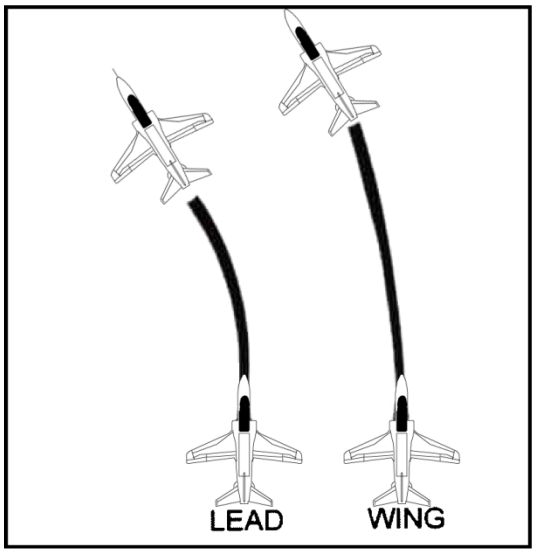


Figure 5-19 Check Turns (0-30 Degrees)

Check Turns (0–30 Degrees)

The check turn is a turn of less than 30 degrees that is designed to slightly change the heading of the formation, reposition the formation, or aid in visually checking the section's 6 o'clock (Figure 5-19). During Check Turns, the lead will generally use small angle-of-bank turns to affect the heading change desired. This will prevent the wingman from misinterpreting the turn as a wing flash. The wingman will use power to maintain proper formation. No communication is required for this turn.

NAV Turns (30–60 Degrees)

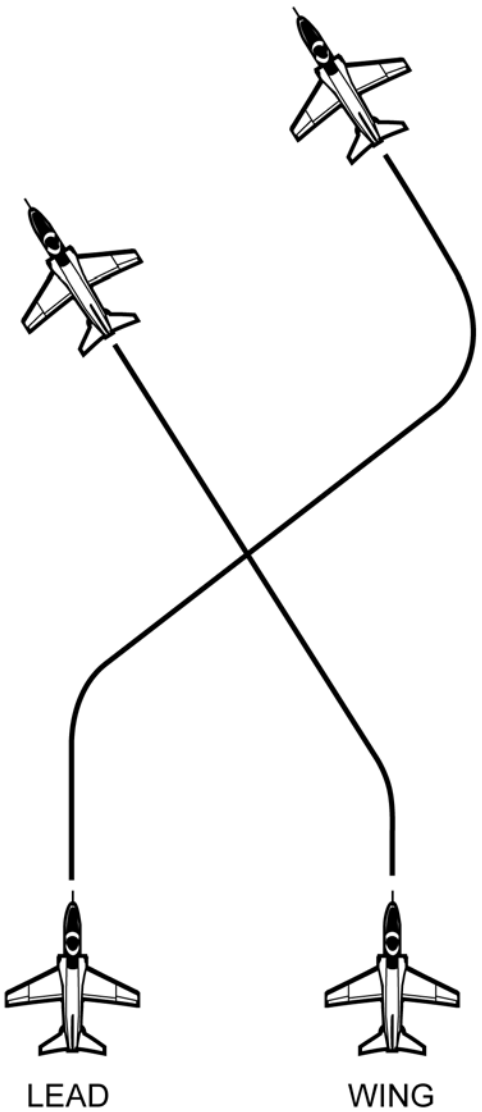
Nav Turns are designed to maneuver the section in heading changes of 30–60 degrees. They are a compromise between the lesser "check turns" and are more aggressive Tac Turns. Similar to Tac Turns, there are two types of Nav Turns:

1. Nav Turns Away from the wingman

2. Nav Turns Into the wingman

NAV Turn Away

A Nav Turn Away from the wingman will provide the section with 30-60 degrees of heading change away from the wingman while maintaining the tactical formation position (Figure 5-20).



Nav Turns Away from the wingman will be executed as follows:

1. Lead will initiate a Nav Turn Away with a UHF call with heading.

2. The wingman then starts a turn into lead.

3. Once the wingman is established in his turn and has completed the desired heading change, lead will commence a turn into the wingman.

4. Seeing the lead commence a turn into him after only 30–60 degrees of heading change, the wingman rolls out commensurate with a cruise turn.

5. Lead continues his turn into the wingman until a track-crossing angle of 90º is established and then rolls out. As the wingman's aircraft passes through lead's 4–5 or 7–8 o'clock position, lead will clear the section's 6 o'clock visually and then execute a turn to the new desired course.

6. The wingman ensures deconfliction.

Figure 5-20 NAV Turn Away

NAV Turn Into

A Nav Turn Into the wingman will provide the section with 30-60 degrees of heading change toward the wingman while maintaining the tactical formation position (Figure 5-21).

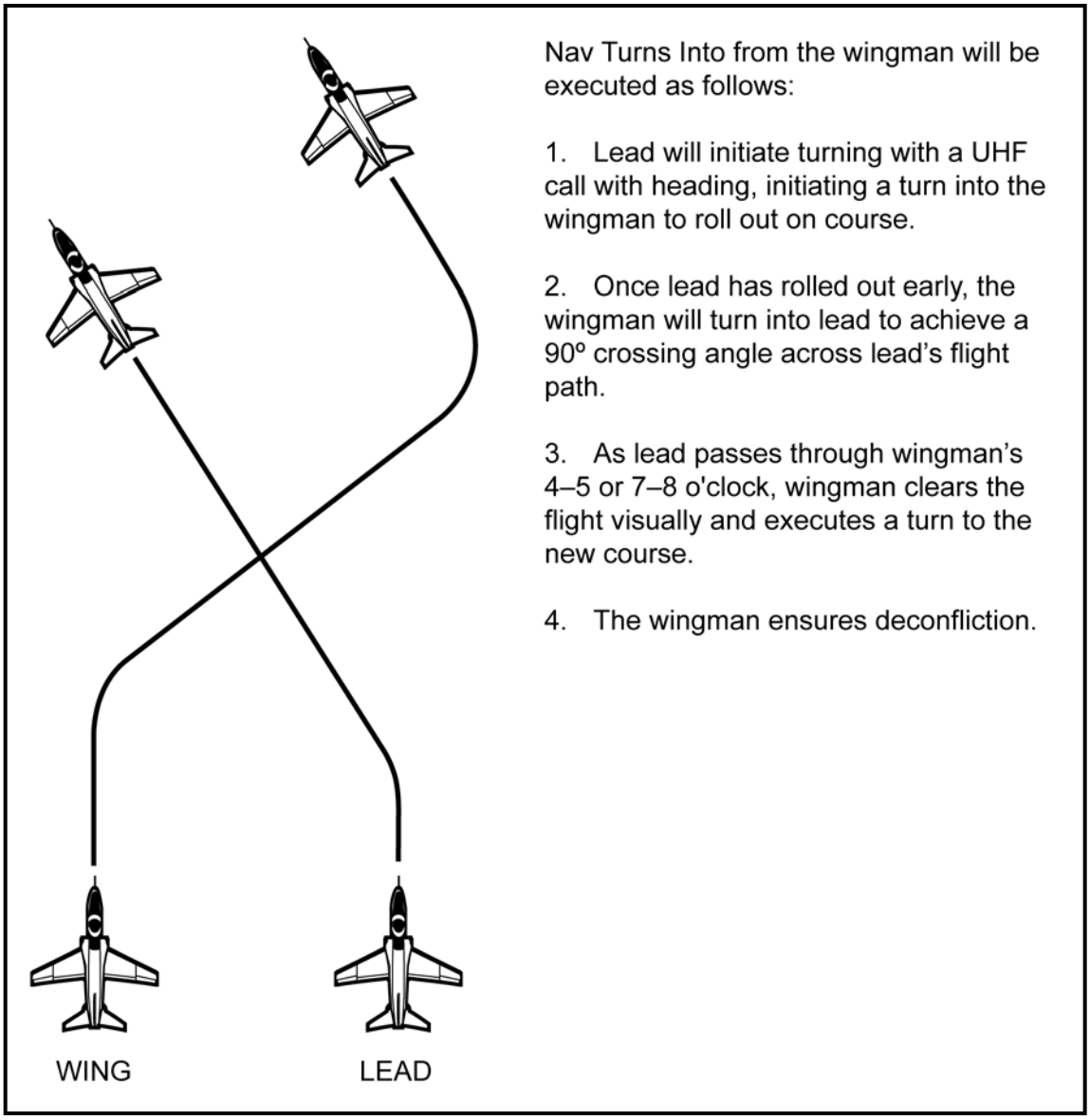


Figure 5-21 NAV Turn Into

TAC Turns (60–120 Degrees)

The Tac Turn is designed to turn the section approximately 90º for navigation or threat engagement. There are two types of Tac Turns:

1. Tac Turns Away from the wingman

2. Tac Turns Into the wingman

TAC Turn Away (Figure 5-22)

1. Lead will initiate with a UHF call.

2. Wingman initiates the turn into the lead for 90º of heading change and then rolls out.

3. As the wingman approaches lead's 4 or 8 o'clock (extended wingline), wing will visually clear the lead's six o'clock, then execute a turn to the new heading and roll out.

4. The wingman may need to execute a small repositioning turn to reacquire the bearing.

Primary lookout doctrine should be to track the turn with an occasional scan for any obstructions. Once wings level, each aircraft should check the new 6 o'clock position of the section.

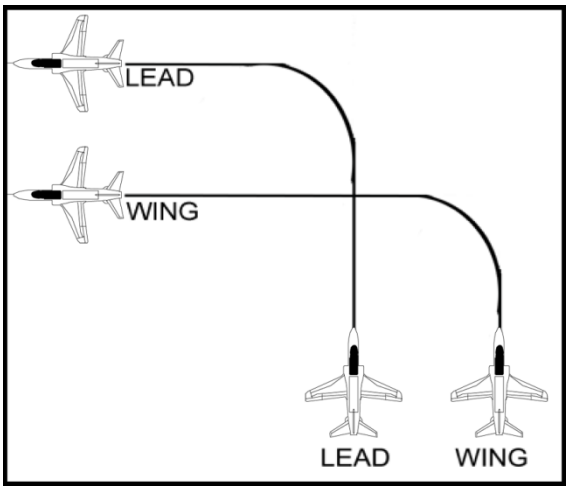


Figure 5-22 TAC Turn Away

TAC Turn Into (Figure 5-23)

1. Lead will initiate the appropriate UHF call, turning into the wingman to roll out on course.

2. As lead approaches the wingman's 4 or 8 o'clock (extended wingline), the wingman visually clears the flight's 6 o'clock and executes a turn to the new heading.

3. The wingman may need to execute a repositioning turn to reacquire the bearing.

4. Primary lookout doctrine should be to track the turn with an occasional scan for any obstructions. Once wings level, each aircraft should check the new 6 o'clock position of the section.

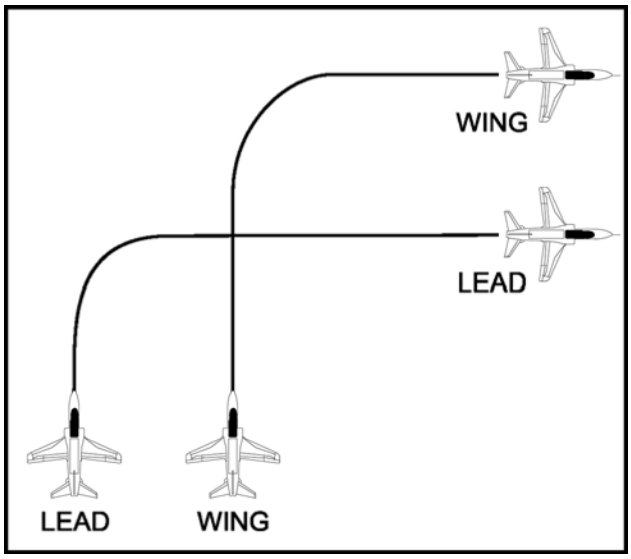
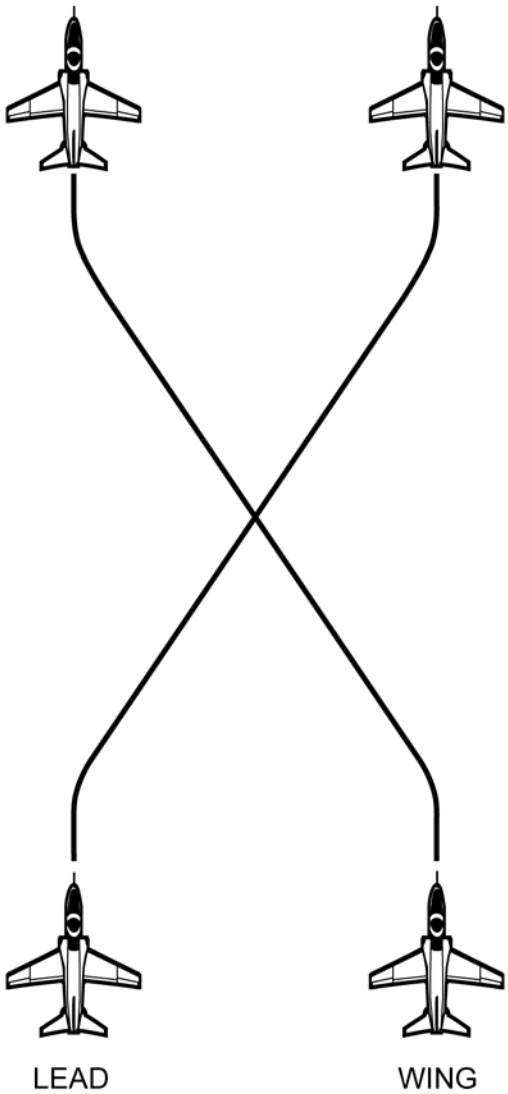


Figure 5-23 TAC Turn Into

Shackle Turn (Figure 5-24)



Shackle turns will be executed as follows:

1. Lead will initiate a shackle turn with a UHF radio call.

2. The wingman will respond by starting a turn into the lead.

3. As lead sees the wingman start his turn, lead will then commence a turn into wingman for 45º and then roll wings level.

4. As the wingman observes lead roll wings level, the wingman will stop his turn. As the aircraft cross, the wingman will always pass above the lead. (Wingman ensures deconfliction.)

5. The 45º headings are maintained until the two aircraft are nearing the 5,000 ft. abeam position. Both aircraft then perform a turn toward each other until the initial heading is reached and an appropriate combat spread formation is attained.

The above shackle turn procedures will result in proper formation bearing if both aircraft were in proper formation initially.

Figure 5-24 Standard Shackle Turn

Shackle turn to "Redress" the section

In cases where a shackle turn is used to redress a section out of position, the aircraft will be maneuvered so that the sucked aircraft will be able to regain proper bearing (Figure 5-25).

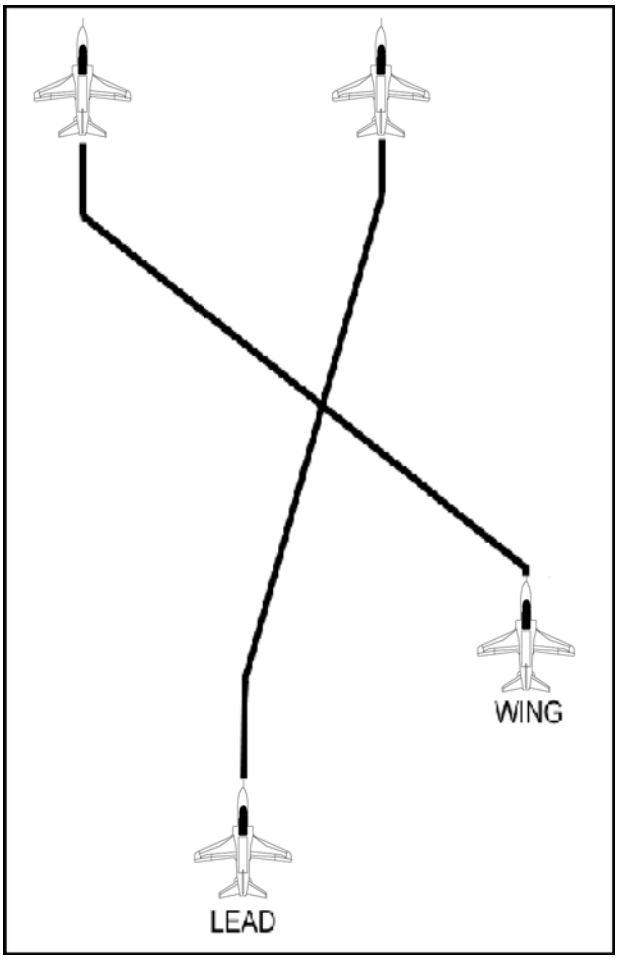


Figure 5-25 Shackle to Redress Formation

Primary lookout doctrine should be to track the turn while in an angle of bank with an occasional scan for obstructions. Once wings level in the 45º heading change, both aircraft should check the mutual 6 o'clock of the section. The wingman is again responsible for deconfliction.

Communication Requirements During Turns

Communication requirements are kept to a minimum during low-level section maneuvering since the mission is to achieve undetected low-level ingress. NFSs are responsible for “visual” and “six clear” calls as detailed in Chapter 4 of this FTI.

Low Altitude Maneuvering Summary

It is imperative that all aircrew master the concept of task management: first and foremost, avoid the dirt; then execute the mission. The workload at low altitude is extremely high. It is critical that the basics discussed are learned correctly and proper habit patterns are practiced from the beginning of your low altitude training. If safety is ever in doubt while in the low altitude environment, initiate an immediate climb to the planned Emergency Safe Altitude (ESA).

506. ROUTE CORRECTIONS/DISORIENTATION

While established on the low-level route, the lead and wing students will navigate the route just as accomplished during Intermediates. As previously stated, the lead will navigate as close to the route center as possible while the wingman can expect to be 1 nm off centerline. Lead may be required to correct either course drift or route timing during the low-level. This section will discuss procedures for corrections.

Course Corrections (Figure 5-26)

If during the low-level the lead finds he is off course, the following procedures will be used:

1. Analyze number of miles off course (according to chart).

2. Chart off course corrections for 360 kts ground speed:

Off Course	Course Base Heading	Length of Corrections 360 KTS
One mile	10 degrees	48 sec
Two miles	10 degrees	1 min 36 sec
	20 degrees	48 sec
Three miles	10 degrees	2 min 24 sec
	20 degrees	1 min 12 sec
	30 degrees	48 sec

Figure 5-26 Course Corrections

3. Make the smallest corrections possible due to section formation limitations.

4. Make the appropriate 10-, 20-, or 30-degree changes to wind-corrected heading only.

5. Be directive to the pilot. For example, assume wind-corrected heading 097º and the lead is 1.5 nm left of course. If the ingress airspeed is 360 kts, the NFS would say, “Right 107, 10 deg correction for 1 minute and 30 seconds.”

6. The student would then monitor the correction and call the pilot back to the appropriate heading when on the route centerline.

Timing Corrections

The goal of every low-level is to arrive on target, on time. The first consideration must be adjusting the indicated airspeed for the outside air temperature to obtain 360 KTAS. This can be done using the following chart (Figure 5-27).

TEMP	360 KTAS
	(IAS)
20º F/-7º C	370
30º F/-1º C	366
40º F/+4º C	362
50º F/10º C	358
60º F/16º C	355
70º F/21º C	352
80º F/27º C	348
90º F/32º C	345
95º F/35º C	342

Figure 5-27 TEMP/Speed Correction

If the lead’s timing is off, the following procedures will be used:

1. Analyze number of seconds off from the preflight plan.

2. A correction is not required until off by 12 seconds or more (due to chart error).

3. For 360 kts, a 30-knot change to airspeed will reduce or add approximately five seconds per minute of correction.

In section formation, speed changes, like heading changes, are best when made gradually. The lead may not make up time by pressing ahead at MRT. Section integrity is vital in a hostile environment for survivability. Precise heading and airspeed control throughout the route will avoid the need for drastic corrections during the target leg.

Disorientation/Lost

The following procedures will solve almost any case of disorientation:

1. Determine the extent of disorientation. “Anxiety disorientation” can occur even with the crew exactly on course if they fail to identify an anticipated checkpoint and misconstrue it as a proof of being lost. When disorientation occurs, the crew must review their progress from their last known position and determine the cause and extent of error. Causes include errors in heading, airspeed control, timing or navigational planning, malfunction of instruments or navigational aids, wind, and/or deviations around weather or enemy defenses.

2. Check the clock immediately. Timing may be a factor in determining the extent of disorientation and the correction required.

3. Check your fuel state and compare with the MCF and Joker fuel states. The disorientation may have caused more problems than just navigation. If completely lost, remember the “Five C's” (confess, climb, conserve, communicate, and conform) before your fuel state becomes a significant factor.

4. Do not complicate matters. Immediately upon realization that a problem exists, decide upon a temporary plan. Avoid wandering aimlessly while planning what to do next. In most cases, continue flying preplanned headings and times while climbing to a higher altitude to increase visibility. In unusual circumstances, enter holding (orbit) or fly toward a known landmark. If practical, climb to conserve fuel, or if holding, slow to maximum endurance airspeed.

5. Reorient. The crew must find landmarks and identify them on the chart. Care must be taken to avoid following a hunch or making a decision based on uncertain information. The crew must comply with FAA speed restrictions if they suspect that they have exceeded the applicable route widths described in AP/1B. A water tower with the town’s name painted on the side has reoriented more than one naval aviator in the past.

6. Correct on course. Once oriented, correct on course using the techniques discussed previously. These procedures will not be possible unless the crew's chart includes sufficient area coverage to account for disorientation.

507. TARGET ATTACKS

During the Weapons syllabus flights, a minimum of one pre-planned target attack will be executed on each low-level. As mentioned in Chapter 4, the lead NFS will direct the section to commit to the A/G mode at a pre-planned ATTACK COMMIT POINT through a directive “ATTACK” call on TAC FREQ and will be acknowledged by the wing NFS with a “TWO” call. Students will then ensure that the A/G combat checks are completed, thus switching the section from a simulated A/A sanitization game plan to the A/G mindset in order to prosecute the first planned target. While many factors, beyond the scope of our objectives, are used to derive this point, in VT-86 this ATTACK COMMIT POINT will be planned to be at 20 nm from the first

target on the route (or as briefed). After the first attack, the NFS will change the HUD mode back to NAV. For the final “road recce” portion of the low-level, Lead NFS will again call “Attack” as the wing aircraft joins into a TAC Wing position.

Air-to-Ground Checks (LATOMS)

Prior to each target attack, NFSs will conduct Air-to-Ground checks utilizing the LATOMS checklist:

L: LAW Set for Delivery

A: Air-to-Ground Delivery Mode: CCIP/MAN

T: Target Elevation entered

O: Ordnance: Bombs/Guns

M: Master Arm On

S: Symbology: No Xs in the HUD

Pop Attacks

During the flights, “pop” attacks will be introduced and practiced. “Pop” attacks enable an attacker to ingress a target at low altitude and “pop” to a higher altitude for a dive run. “Pop” attacks enable a section of T-45Cs to fly a planned low-level, utilize "POP" diagrams, and conduct 10-degree dive runs while maintaining the limits of the low-level route structure.

The crew will have a choice of four types of pop attacks:

1. Shift pop attack (same target)

2. Crossing pop attack (same target)

3. Section pop attack (same target)

4. Mirror pop attack (different targets)

<u>Shift Pop Attack</u>

A SHIFT attack is a tactic that enables a section to create a distance and time separation between the two attacking aircraft in order to prosecute the same target. This has certain advantages and safety considerations that make it a viable and practiced tactic in the fleet. One of the main reasons is that the separation between aircraft allows for fragmentation avoidance from the explosion of the first aircraft’s attack. This initial attack has the added benefit of identifying the target area for the second aircraft and allowing for any corrections, should the initial attack miss its intended target.

Normally, this separation is 30 seconds between aircraft. In VT-86, this separation will be created at 7 nm from the pre-planned target by an "ACTION" call made by the lead IP on TAC FREQ. The wing IP will acknowledge with "TWO" and maneuver the aircraft to turn 90 degrees into the lead's flight path. After rolling out of the turn, the wingman will wait 7 seconds before turning and pointing back in towards the intended target point. Meanwhile, the lead aircraft will continue towards the target point and execute the pop attack at approximately 2.3 nm from the target (1.8 nm from VR-1021C waypoint) or as briefed. The lead's attack shall be followed by the wingman's attack approximately 30 seconds (or 2-3 nm) behind the lead (See Figure 5-28).

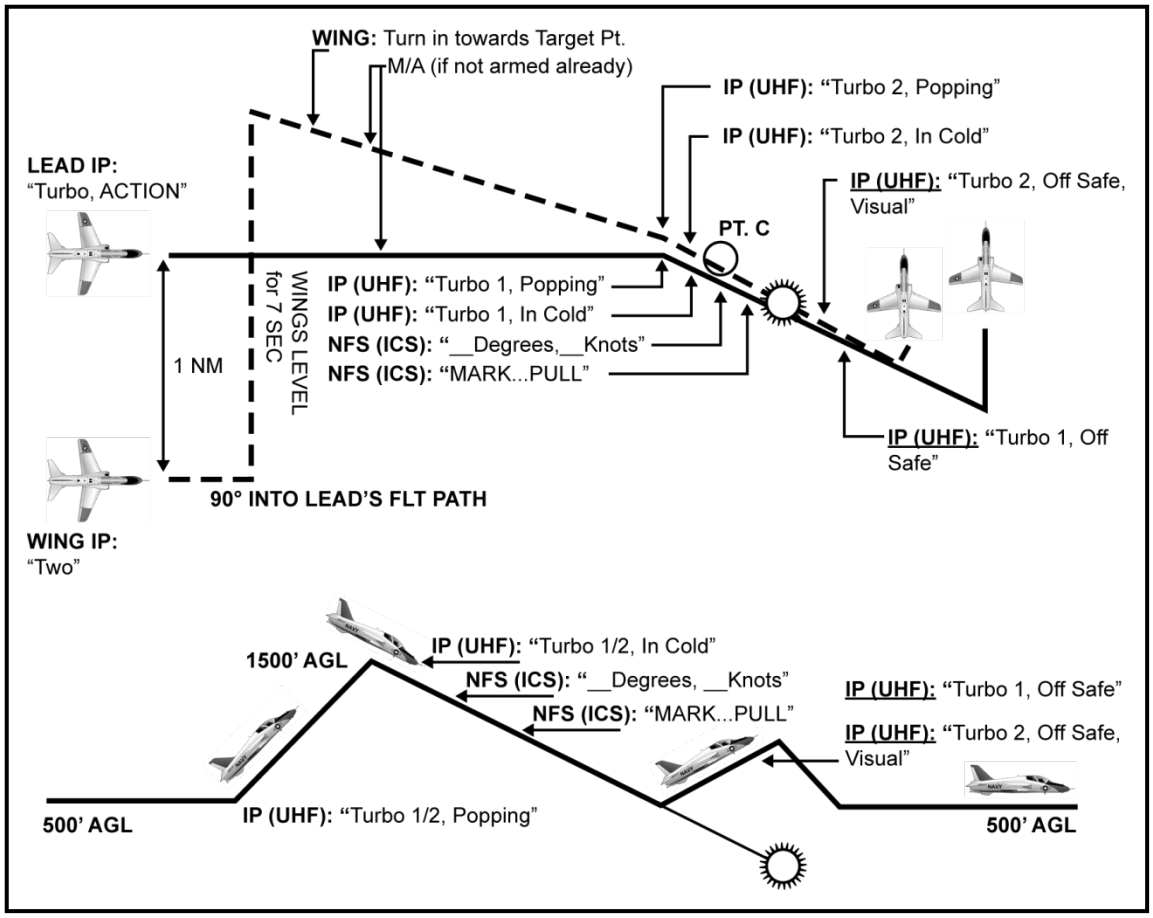


Figure 5-28 Shift Attack (Same Target)

In the case of the VR1021, Point C represents the pre-planned target point. The target is a set of three blue water tanks located just south of Pt. C on a riverbed. At the "ACTION" call, the lead will proceed to Pt. C while the wing executes the shift maneuver. Since Pt. C is offset north of the targeted tanks and the lead is proceeding straight to Pt. C, the pop attack has a natural offset already built into the route which the lead will execute by pulling straight up at 1.8 nm towards Pt. C then rolling in towards the target. This will enable the crew to gain and maintain sight of the intended target as the pop is initiated and established in the attack dive angle. The wingman, upon turn in, will point back towards Pt. C in order to take advantage of the built in offset as well as to follow the leads target attack line. Once off target, the lead may extend upwind until the

wingman calls “Off-Safe” in order to facilitate the wingman’s join up back into combat spread and maintain mutual support.

Each route will have its specific set of considerations that will be managed and mitigated through careful and thorough pre-planning. Each NFS is responsible for their familiarity with the route to be flown and shall have an appropriate gameplan to ingress and execute one of the four pre-planned attacks as well as any “briefed” target of opportunities that may be encountered.

Crossing Pop Attack

A crossing pop attack is a tactic that enables a section to conduct a coordinated two-plane attack on the **same target** (Figure 5-29). The section shall ingress at the planned low-level altitude in combat spread. Unlike the shift attack, the crossing attack does not have a delay or separation maneuver. Instead, the lead NFS will lead the section straight towards the target (bisecting the section to enable proper attack geometry) or the target reference point (referencing the relative position of the planned waypoint if not co-located with the target). At the appropriate distance (approximately 2.3 nm from the target), the lead IP will initiate the maneuver with the “ACTION” call on TAC FREQ. The lead will then make a level turn away from the wing for 30 degrees of heading change and pop by immediately apply 2-3 Gs in a wings level climb (no later than 1.8 nm from the waypoint). The apex of the pop will be the pattern altitude as depicted on the top of the "POP" diagram. Upon reaching pattern altitude, the lead will over-bank the aircraft and intercept the "POP" diagram dive angle and attack parameters. Upon hearing the “ACTION” command, the wingman will acknowledge with a “TWO” and mirror the lead’s maneuvers in the opposite direction after a two-second delay. This delay is designed to keep the lead forward of the wingman’s wing-line and ensure section de-confliction.

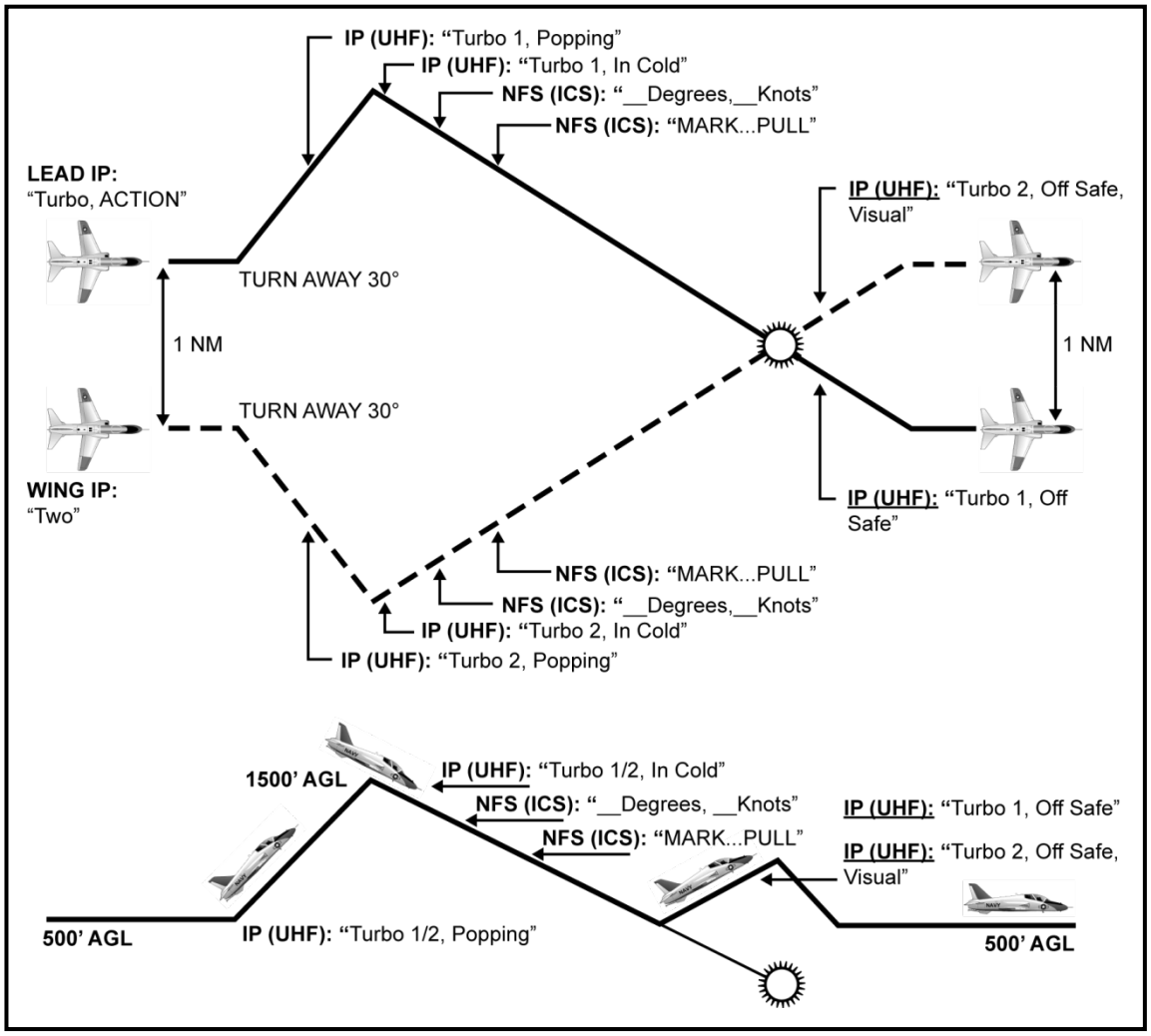


Figure 5-29 Crossing Attack (Same Target)

As indicated in Figure 5-29, both students in the section have required ICS calls to make during the attack and dive recovery. At planned release altitude, each student will call "MARK" over the ICS. The IPs will then smoothly apply "G" for the off target recovery and turn to parallel the route course line once the aircraft nose is above the horizon. The "POP" diagram dive parameters (Figure 5-24) and student's attack comm procedures are identical to the shift pop attack, with the exception that both aircraft perform a multi-axis, near simultaneous attack on the same target. Off the target, the section will cross flight paths and continue on course. Aircraft de-confliction will be the responsibility of the wingman.

Section Pop Attack

The section pop attack is a tactic that enables a section to conduct a coordinated two-plane attack on the **same target** from the same axis (Figure 5-30). The section pop attack will be executed from the TAC WING formation.

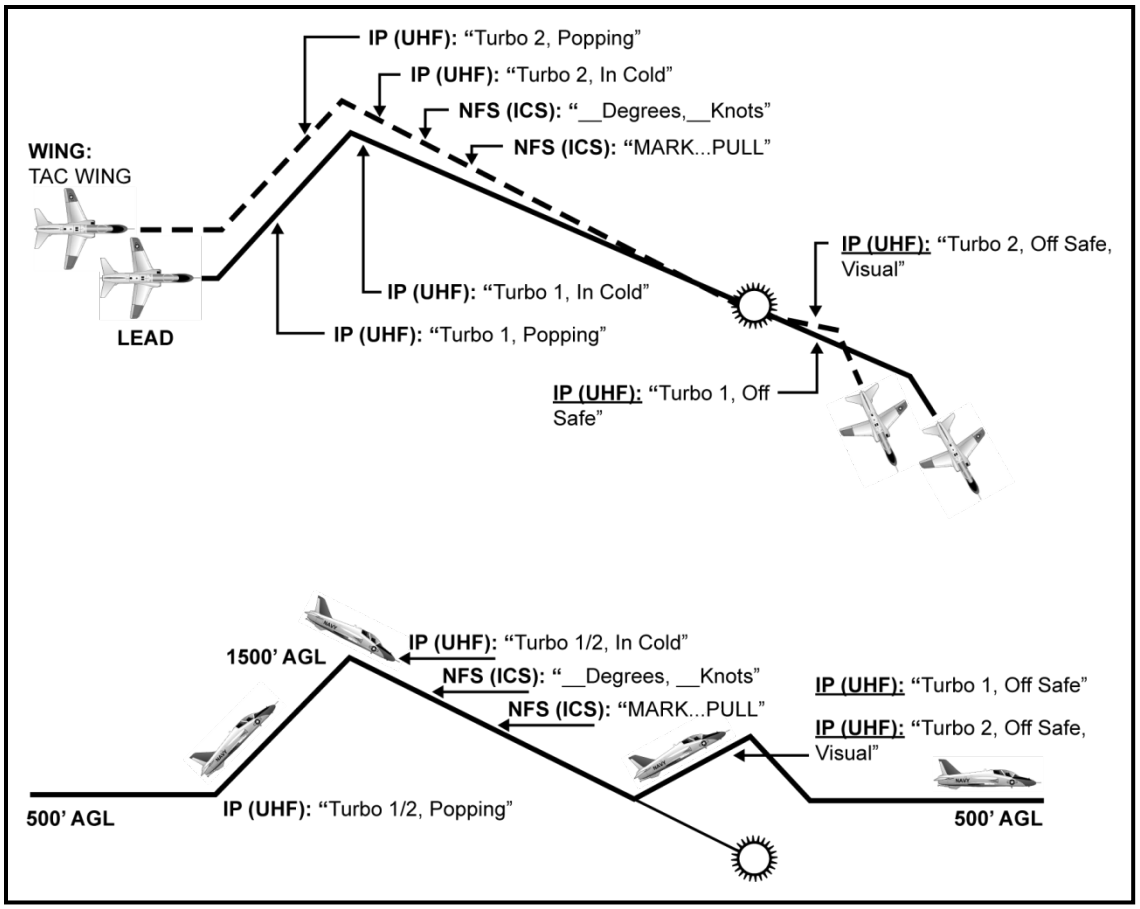


Figure 5-30 Same-Side Section Pop Attack (Same Target)

When approaching the target, the lead NFS will direct a heading toward an offset point that will allow for a straight ahead pop and enable visibility of the target. This will further allow the wingman to look through the lead to the target and be able to have both in sight and maintain de-confliction. At a predetermined point, the lead will execute the pop attack and the wingman, after a slight delay (for aircraft de-confliction), will execute an identical pop. The "POP" diagram dive parameters and student attack comm procedures are identical to previously detailed pop attacks. The section pop attack will be utilized during the final target attack. At the completion of the final dive runs, an off-target rendezvous will be executed.

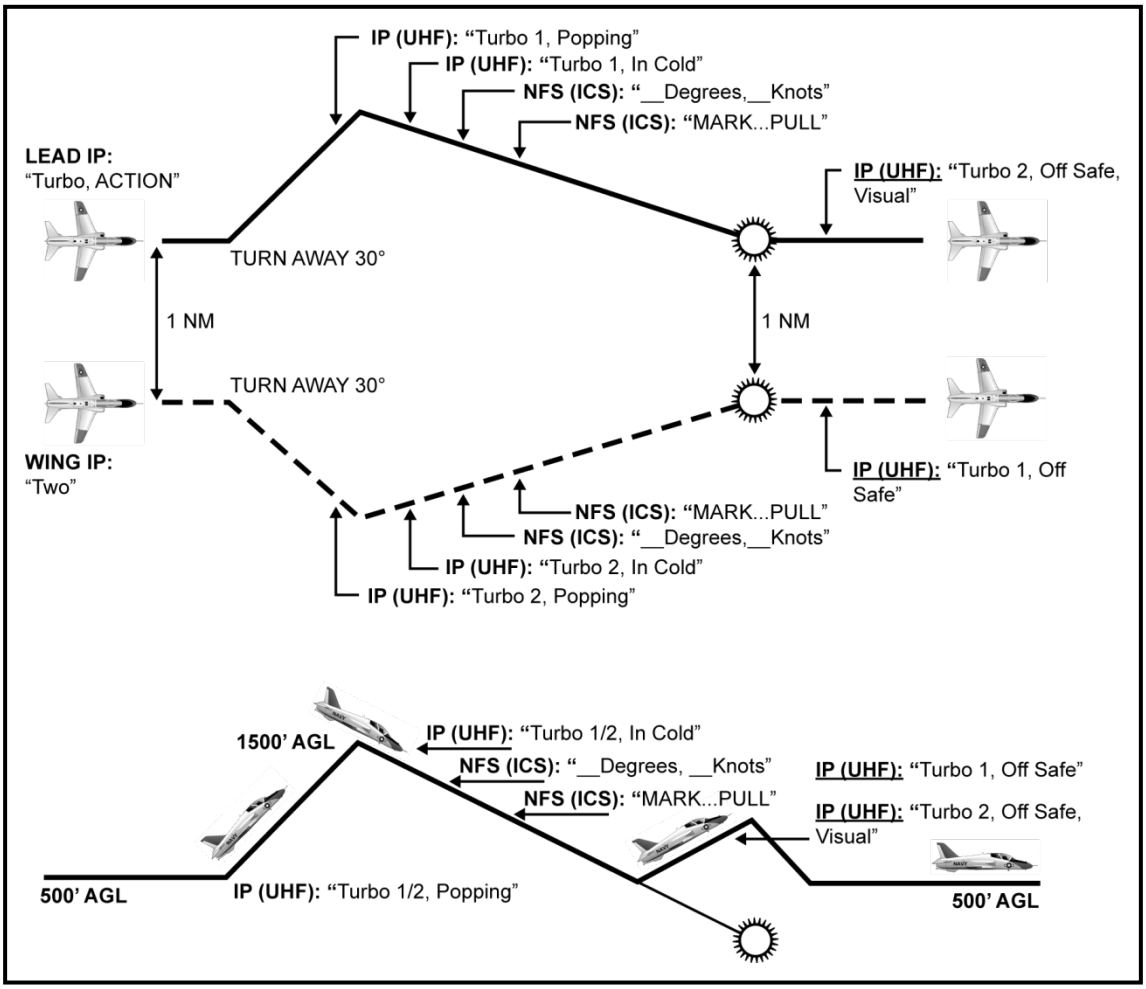


Figure 5-31 Mirror Pop Attack (Different Targets)

Mirror Pop Attacks

A mirror pop attack is a tactic that enables a section to conduct a coordinated two-plane attack on **two different targets** in the same area, usually within 1-2 nm (Figure 5-31). The section will ingress at the planned low-level altitude, in combat spread, towards their assigned target. At the appropriate distance (approximately 2.3 nm from the target, 3.3 nm from the waypoint), the lead IP will initiate the maneuver with the "ACTION" call on TAC FREQ. The lead and wing will acknowledge and execute a turn away from each other for 30 degrees. The mirror pop attacks are then continued just like the crossing attacks, except that two distinct targets are prosecuted. Off the targets, the section will already be de-conflicted through target separation or may cross flight paths and continue on course. Aircraft de-confliction will be the responsibility of the wingman.

Fuel Checks

After each pop attack, after the wingman has called “Off safe, visual” the lead NFS will initiate a fuel check over AUX frequency.

Lead IP (UHF2):	“HAMMER 31, Off Safe”
Wing IP (UHF2):	“HAMMER 32, Off Safe, visual”
Lead NFS (UHF2):	“HAMMER 31, 1.8”
Wing NFS (UHF2):	“HAMMER 32, 1.7”

508. OFF TARGET PROCEDURES/RETURN TO BASE

Exiting the Route

At the completion of the final target attack, the lead will initiate a VFR climb on course and commence the RTB. The wing will complete his target attack and commence an off-target running rendezvous. During the off-target rendezvous, the lead and wing will prioritize their respective tasks as conditions warrant.

Lead:

1. Initiate and maintain a VMC climb (AVIATE, NAVIGATE).
2. Ensure wing calls “Turbo 2 off safe, visual.” (COMMUNICATE).
3. Check off route with appropriate FSS.
4. Change squawk from 4000 to 1200.
5. Switch flight to appropriate ATC frequency.
6. Fence out the section.
7. Ensure Battle Damage Checks are completed.
8. Obtain IFR clearance for recovery.
9. Initiate “Fenced Out” report with fuel check
10. Complete the 10K checklists.

Wing:

1. Conduct running rendezvous.

2. Monitor rendezvous closure rates (provide ICS airspeed calls to pilot).

3. Follow lead's frequency changes.

4. Fence out on lead's direction.

5. Ensure Battle Damage Checks are completed.

6. Complete the 10K checklists.

Approach and Recovery

The section will recover in accordance with standard section procedures set forth in Chapter 4. A section GCA will be flown during the WEPS-1 recovery, and course rules will be utilized for the WEPS-2/3 recovery (weather permitting).

509. SUMMARY

This chapter was designed to give the NFS all of the tools necessary for the successful completion of T-45C tactical low-level weapons flights. At this phase of training, the pilot and NFS work more closely as a crew to share the tasks involved in mission accomplishment. The addition of coordinated section target attacks is the primary difference between T-45C low-levels and previous low-level training. A clear understanding of the procedures set forth in this chapter and ample chair flying will ensure successful mission accomplishment.

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CHAPTER SIX
STANDARD DIVISION PROCEDURES

600. INTRODUCTION

Division formations have three or four aircraft and are comprised of two sections of two aircraft. Dash one (-1) is the lead of the division and of the first section while dash three (-3) is the lead of the second section (if there is a dash four). This formation is commonly used in both administrative and tactical military flights.

601. DIVISION FORMATION

Division Formation Responsibilities

Responsibilities are very similar to two plane formations, except now there are more wingmen to back up the lead. In addition, it is common to detach the second section during severe weather or in the event that an aircraft is having mechanical problems. For these reasons, -3 should be ready at all times to detach with -4 as a section to complete the mission.

Division Formation Communication

Passing hand signals in division is very similar to section work except the lead cannot see all the wingmen all the time. Therefore, it is incumbent on each aircraft to pass hand signals up and down the formation.

Radio communication in division formation is slightly more difficult because of the number of aircraft. In VT-86, we will utilize positive check-ins as previously set forth in the "Section Formation Procedures" chapter: on TAC freq, on deck; and safety-of-flight, airborne.

The lead should refer to the flight as a "flight of four" during initial communications with every new controller. On subsequent transmissions with the same controller the standard callsign (i.e., ROKT 407) may be used. Identifying the formation as a flight of four helps both the controllers as well as other aircraft to plan for the large formation. On the ground, this clarification should prevent other aircraft from taxiing between members of the formation.

Division Formations

Echelon: Normally used for initial join-up after takeoff and prior to the break (Figure 6-1). This formation is cumbersome because turns into the echelon are difficult for the wingmen (especially -4). Echelon may be flown in parade or cruise positions.

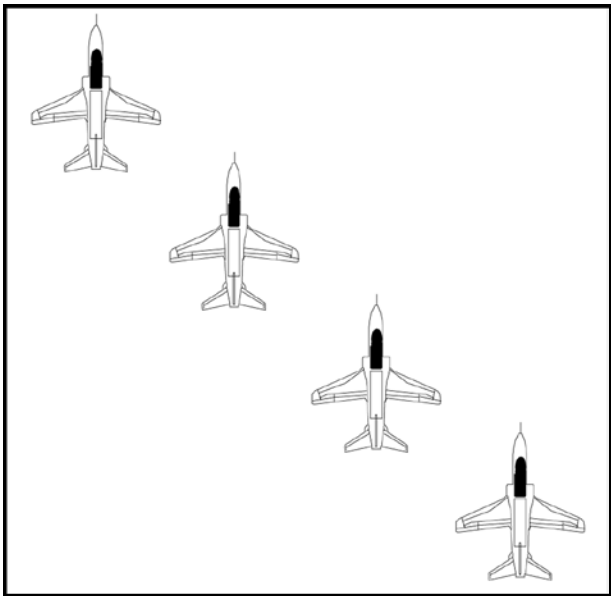

Figure 6-1 Division Echelon Formation

Balanced Cruise/Finger Tip: These are the most common formations used during the transit phase of the flight (Figures 6-2 and 6-3). They allow the lead to maneuver the division easily in any direction. Typically, the second section lead (-3) will pick the side of the formation he wants while -2 moves to the opposite side in order to automatically balance the formation. In balanced cruise formation, -3 should leave room for -2 to cross under into echelon formation if he/she desires or as required (Figure 6-2).

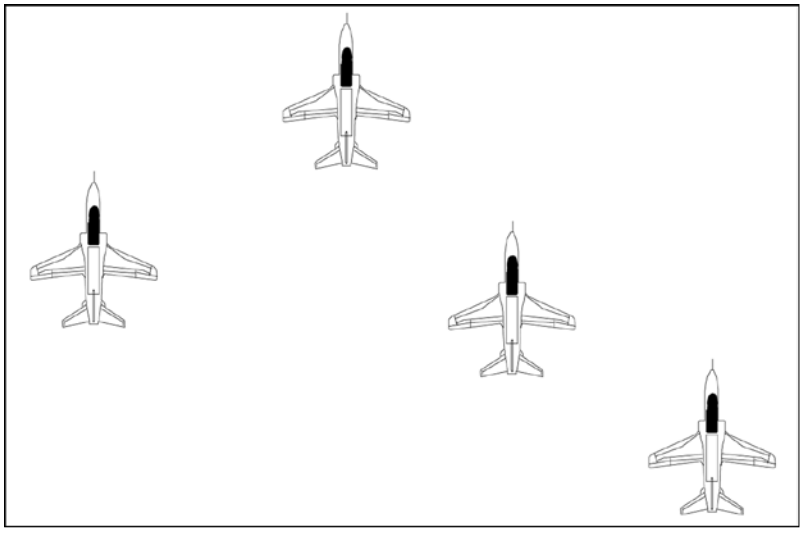

Figure 6-2 Balanced Cruise Formation (Fingertip)

6-2 STANDARD DIVISION PROCEDURES

In fingertip, -3 will match -2's spacing off the lead (Figure 6-3). In this formation, each aircraft is flying a parade position on their respective interval. This formation will be used when the formation encounters IMC weather.

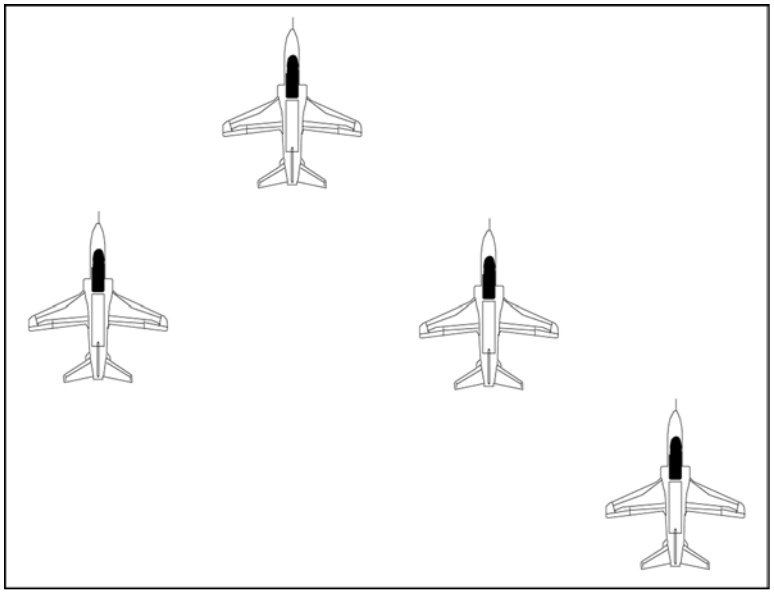

Figure 6-3 Division Fingertip Formation

Tactical Formations: There are many different formations used in tactical operations and it is not practical to try to list them all here. Tactical formations generally offer mutual support to the formation and prevent compromise of the entire formation if one or two aircraft are spotted.

Division Taxi

Division formations will taxi on alternate sides of the taxiway (staggered) to reduce the length of the formation and reduce the hazard of FOD. Squadron SOP directs the minimum distance between aircraft.

Division Takeoff

There are numerous division take off scenarios. The weather and runway available will determine the take off procedure utilized. The types listed below are the most common and are the types you can expect in the T-45C syllabus.

Split the Duals/Section Go: In this procedure, the division will split up into two sections and utilize both parallel runways (Figure 6-4). This requires early coordination with tower in order to accommodate both runways. You will typically request to “Split the Duals” on your taxi call to GROUND in order to provide ample lead time. Once at the Hold-Short and after completing all of your hold-short checks between the division, you will request/reiterate to tower your plan to “Split the Duals.”

Taxiing out of the line, on COMM 1:

LEAD: “Ground, ROKT 407, flight of four, taxi with information Foxtrot, request to split the duals”.

GRND: “ROKT 407, Taxi to runway 7R via Foxtrot, Delta, Alpha, altimeter 2992, split the duals on request”.

At the hold-short and ready for take-off:

LEAD: “Tower, ROKT 407, flight of four, take-off, split the duals”.

TWR “ROKT 407, cleared for take-off runways 7L and 7R, wind 090/10, switch departure”.

Normally the lead and -2 will utilize the outboard runway while -3 and -4 utilize the inboard. After the two sections are on their respective runway, the lead IP will signal to run-up and –3 IP will call “3’s set” when the second section is ready for takeoff (coordinated via standard section procedures on the runway). Once set, both sections will do a standard section go with the second section delaying no more than a few seconds. As soon as both sections are airborne, they begin to rendezvous as a division. Three will call "4’s Airborne" on TAC FREQ when the second section is clean.

NOTE

In every division takeoff scenario the lead will need to know that each aircraft’s run ups are successfully completed. If Dash-3 is not in a position to pass a thumbs-up to lead, a "3’s set" call on TAC FREQ will be made by the **IP**. Dash-3 will make this call once a thumbs-up is signaled from Dash-4. This call will be the lead’s cue that the second section is ready for takeoff.

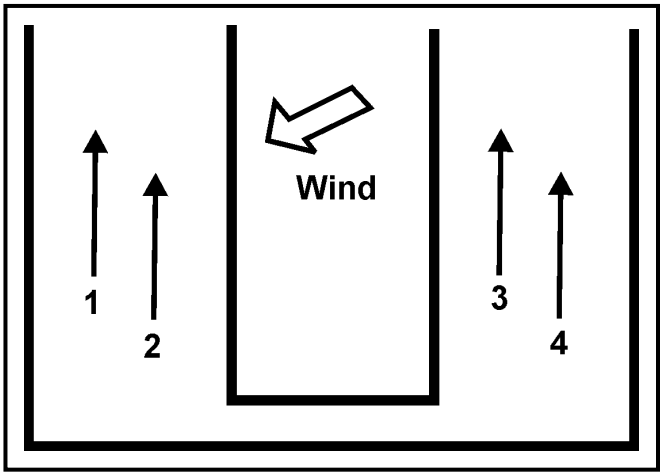

Figure 6-4 Division Take-off (Split the Duals)

6-4 STANDARD DIVISION PROCEDURES

Division Interval Go: This procedure is used when conditions do not permit splitting the duals. The runway width will determine if all four aircraft can take the single runway at once (200 ft or 50 ft per aircraft); or have the first three on the runway with –4 as a stinger waiting at the hold short ready to take the runway as soon as space permits (150 ft). In either case, the division will form up on the runway in a “Banana Echelon” formation that will permit an un-obstructed view between pilots. If –4 is a stinger, the IP will call “4’s set” when the aircraft is in position ready to take the runway. At that point, the lead NFS will check the flight in on departure frequency which initiates the auto run up for those on the runway. In either case, after the run-up and good thumbs-up, the division aircraft will initiate their takeoff rolls in order and in accordance with the SOP mandated intervals. Once the last plane to launch is clean, the student in that jet will call "4’s airborne" (or “3” if three plane) on TAC FREQ. This will be the lead student’s cue to contact Departure.

Division Departure

As in a two-plane running rendezvous, each division student will be expected to monitor closure and join up airspeeds during a division rendezvous. After takeoff, the flight will normally rendezvous in parade at 250 KIAS and the lead will place the flight in a pre-briefed formation, usually balanced cruise. At this point, the division will automatically balance and proceed enroute.

Division Enroute

The division will normally proceed enroute in the balanced cruise formation. Each member of the division will maintain a position such that the lead can keep sight of the flight and hand signals can be passed. Details of the division weapons mission will be covered in chapter 7.

Division Recoveries

VFR: The break (overhead) is the most common recovery for a division. Normally a two second interval break will be used from the echelon formation, although many variations may be briefed and flown. Formations such as finger tip or diamond may be briefed and flown as well (Figure 6-5).

Break interval and order is essential for safety of flight. In the finger tip formation depicted in Figure 6-5, a right break would be executed in a 2 second interval (or as briefed) in the following aircraft order: 2-1-3-and then 4. A right break for the diamond formation in Figure 6-5 would be in the following order: 2-4-1 and then 3.

Similar to section procedures, the division will be put in the proper break formation when 3-5 NM from the initial. For safety of flight considerations, every member of the division is responsible for proper positioning approaching the initial. Out of the break, the lead will call abeam for the flight. The elements of the division will then complete landing checks individually and report "Dash-X three down and locked" in order.

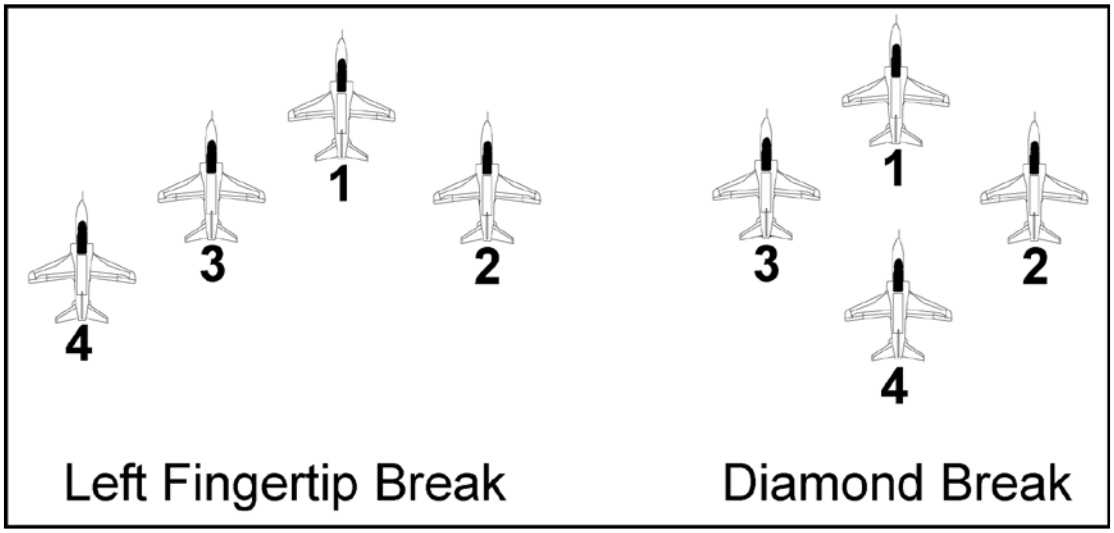

Figure 6-5 Division Break Formations

NOTE

If a formation other than echelon is flown to the break, the first aircraft out of the break to hit the abeam will become the lead. Each aircraft will be renumbered in order and make pattern calls appropriately (i.e., in Figure 6-5, for a right hand break using the diamond formation, dash-2 will assume the role of lead at the abeam.)

IMC: Division IMC recoveries are not normally performed because of the risks associated with dirtying the flight and achieving flight separation in instrument conditions. Therefore, divisions are commonly split into two sections prior to recovery. The section leads (Lead and Dash-3) may then elect to further split into individuals if the conditions at the destination warrant. Sequencing and obtaining individual squawks is normally coordinated with approach control. Headwork dictates that the aircraft be detached in order of fuel criticality.

Inadvertent IMC (Division)

If a formation flight inadvertently enters the clouds and it is obvious that IFR conditions will prevail more than momentarily, the flight lead will transition to instrument flight and level his wings. When steady, the lead may coordinate a new squawk and callsign with ATC, and detach the second section.

Another option for a division lead is to reverse his heading in a shallow, gentle turn to exit the IMC conditions. Turns should be made away from the wingman if in section, or away from the second section if in division.

6-6 STANDARD DIVISION PROCEDURES

CHAPTER SEVEN
DIVISION CLOSE AIR SUPPORT (CAS) TACTICS/PROCEDURES

700. INTRODUCTION

Close air support (CAS) can be conducted at any place and time friendly forces are in close proximity to enemy forces. The word "close" does not imply a specific distance; rather, it is situational. The requirement for detailed integration because of proximity, fires, or movement is the determining factor. At times CAS may be the best means to exploit tactical opportunities in the offense or defense. CAS provides firepower in offensive and defensive operations to destroy, disrupt, suppress, fix, harass, neutralize, or delay enemy forces.

CAS may be used to mass the effects of combat power, in order to exploit opportunities in the offense and defense. Each service prepares to employ CAS within its roles as part of the joint force. As a result, a variety of aircraft are capable of performing CAS. The Joint Force Commander (JFC) and his staff must be capable of integrating all CAS capabilities into the operation of the plan.

Since we are going to engage targets that may be in contact with (or in close proximity to) friendly ground forces, detailed coordination with those units is absolutely necessary to avoid any friendly casualties. We will get into just how we coordinate such a strike later. Right now we need to continue with our discussion of CAS by defining the different types of CAS and describing the advantages of, and the requirements for effective CAS.

701. PRINCIPLES OF CLOSE AIR SUPPORT

Definition of CAS

Air action by fixed-and rotary-winged aircraft against hostile targets that are in close proximity to friendly forces and that require detailed integration of each air mission with the fire and movement of those forces.

Controller

All references to "controller" in the rest of this publication can refer to a Joint Terminal Attack Controller (JTAC), a Forward Air Controller (FAC), or a Forward Air Controller (Airborne) (FAC(A)). If a specific type of controller is required, it will be referenced directly.

Types of CAS

Close Air Support missions are divided into two distinct mission categories, Preplanned and Immediate.

A Preplanned CAS mission is air support in accordance with a program planned in advance of ground operations.

An Immediate CAS mission is air support to meet specific requests which arise during the course of battle and which, by their nature, cannot be planned in advance.

Preplanned

Preplanned CAS missions are further categorized into Scheduled and On-call missions.

A Preplanned Scheduled CAS mission is an air strike which has been requested by a supported ground unit sufficiently in advance to permit detailed mission planning and coordination prior to takeoff. They are flown against a predetermined target and executed at a specific Time-On-Target (TOT) specified by the supported unit.

A Preplanned On-call mission is a mission where the aircraft are preloaded for a particular type of target and then placed in a standby ground or airborne alert status. On-call missions are then executed only when the requesting unit calls for them and detailed mission planning and briefing of aircrews on all mission essential information is normally not possible prior to takeoff.

Immediate

An Immediate CAS mission is an air strike on a target which was not requested sufficiently in advance to permit any mission coordination or planning. These missions are executed in response to urgent requests by the supported ground unit to strike targets of opportunity. Urgency often requires that aircraft be diverted from a preplanned mission for one ground unit to an immediate mission for a different ground unit. Mission coordination is often accomplished while the flight is en route with the aircraft usually being briefed by the terminal controller. Most immediate CAS requests are filled with on-call missions.

Types of Terminal Attack Control

There are three types of terminal attack control or weapons release authorization.

Type 1 Control

Type 1 control is used when the controller must visually acquire the attacking aircraft and target for each attack. Type 1 control is used when the visual acquisition of the attacking aircraft by the controller and the analysis of attacking aircraft geometry is the best means available to reduce risk of the attack affecting friendly forces. Note: attack aircraft validates target location by cross-checking that the position is coincident with the expected target area by using all appropriate

means: map plot, target designation displayed on digital map set, heads-up display symbology, FLIR, radar, etc.

This is the most restrictive type of terminal control and is the default control for training. During Type 1 control you need to hear "CLEARED HOT" from the controller to release ordnance.

Type 2 Control

Type 2 control will be used when the controller requires control of individual attacks and any or all of the conditions exist: controller is unable to visually acquire the attacking aircraft at weapons release, controller is unable to visually acquire the target, and/or the attacking aircraft is unable to acquire the mark/target prior to weapons release.

This control is used in adverse weather, at night or with standoff weapons (JDAM, JSOW, LGB, etc.). During Type 2 control you need to hear "CLEARED HOT" from the controller to release ordnance.

Type 3 Control

Type 3 control is used when the controller requires the ability to provide clearance for multiple attacks within a single engagement subject to specific attack restrictions, and any or all of the conditions exist: controller is unable to visually acquire the attacking aircraft at weapons release, controller is unable to visually acquire the target, and/or the attacking aircraft is unable to acquire the mark/target prior to weapons release. Type 3 control does not require the controller to visually acquire the aircraft or the target; however, all the targeting data must be coordinated through the supported commander's battle staff. The controller will provide the CAS aircraft with targeting restrictions (e.g. time, geographic boundaries, final attack headings, specific target set).

Following mandatory readback by the CAS asset, the controller than grants a blanket weapons release clearance as "CLEARED TO ENGAGE." Prior to initial weapons release, the attack aircraft will provide "COMMENCING ENGAGEMENT" to the controller; after completion of attack runs, the attack aircraft will provide "ENGAGEMENT COMPLETE."

Additional Considerations for All Types of Control

Controllers will provide the type of control as part of the CAS brief. It is not unusual to have two types of control in effect at one time for different flights. For example, a controller may control helicopters working Type 2 control from a Battle Position (BP) outside the controller's FOV while simultaneously controlling medium or low altitude FW attacks under Type 1 or 3 control.

Because there is no requirement for the controller to visually acquire the target or attack aircraft in Type 2 or 3 control, controllers are required to coordinate CAS attacks using targeting information from an observer when they are unable to acquire the target or aircraft. An observer may be a scout, COLT, FIST, UAS, JFO, SOF, CAS aircrew, or other asset with real-time targeting information.

The controller(s) maintain "ABORT" authority at all times.

Advantages of CAS

CAS offers many advantages over other supporting arms. These include:

1. Delivers greater destructive power.

2. Attack targets invulnerable to other supporting arms (i.e., beyond the range of naval gun fire and artillery).

   a. Employ a wide variety of ordnance and tactics.

   b. Engage moving targets.

   c. Reattack if threat environment is permissive.

   d. Can observe the battle area and engage targets unseen from the ground.

Requirements for Effective CAS

In addition to offering many advantages over other supporting arms, CAS also has some very strict requirements that must be met in order to be effective such as:

1. Requires local air superiority to provide security for the strike aircraft.

2. Requires suppression of enemy air defenses.

3. Ground commanders must provide the FACs with a responsive and effective means of marking the targets for the CAS aircraft.

4. Generally requires favorable weather.

5. Requires flexible control.

6. Requires effective two-way communication.

7. Requires a prompt response by the CAS aircraft to the ground commander's request.

8. Requires aircrew and terminal controller proficiency in order to successfully execute the complex CAS mission.

CAS Terms

Now that you have an understanding of what CAS is there are many related terms to know and understand.

7-4 DIVISION CAS TACTICS/PROCEDURES

Fire Support Coordination Measures (FSCM)

A measure employed by land or amphibious commanders to facilitate the rapid engagement of targets and simultaneously provide safeguards for friendly forces. Examples: Fire Support Coordination Line (FSCL), Forward Line Of Own Troops (FLOT), Restrictive Fire Areas (RFA), and No Fire Areas (NFA).

Airspace Coordination Area (ACA)

The three-dimensional block of airspace in a target area, established by the appropriate ground commander, in which friendly aircraft are reasonably safe from friendly surface fires. The airspace coordination area may be formal or informal. (Informal ACAs may be assigned real-time by the DASC, TAC(A), or controller and include phrases such as "stay east of the river," "stay at or above 7 thousand," or "stay north of N 32° 18.0'.")

Contact Point (CP)

A point normally outside the range of enemy surface-to-air weapons where CAS aircraft contact the terminal controller. Marked by coordinates (latitude, longitude), conspicuous terrain feature, or other identifiable object which is given a name or number, it is used as an aid to navigation or control of aircraft. It also serves as a place to receive the target brief and coordinate your attack plan prior to the run-in to the target.

Initial Point (IP)

A point designated to allow a precise navigation update (usually of visual significance) utilized to accurately position and point the aircraft at the target for ordnance delivery.

Egress Control Point

A point located just outside the enemy air defense area used to control egress from the target area.

Sophisticated Threat

Integrated massing of heavy combat power to include EW, SAMs, AAA, and fighters serving to seriously degrade CAS capability.

Restrictive Threat

A threat environment in which specific aircraft performance and weapons systems capability allow acceptable exposure time to enemy air defenses.

Permissive Threat

Threat exists at a predominantly low level, which permits CAS operations and support to proceed along traditional lines with little interference from enemy EW, SAMs, AAA, fighters, etc.

Suppression of Enemy Air Defenses (SEAD)

Measures taken to neutralize, or reduce, enemy air defense effectiveness prior to or during, CAS execution. This may be accomplished using HARM, EW, artillery, attack helicopters, infantry, or any combination thereof.

Fire Support Coordination Center (FSCC)

A single location in which there are centralized communications facilities and personnel incident to the coordination of all forms of fire. Each FSCC is staffed with representatives of the various supporting arms such as: artillery, air, and naval gunfire.

Forward Line of Own Troops (FLOT)

A line that indicates the most forward positions of friendly forces in any kind of military operation at a specific time. The forward line of own troops normally identifies the forward location of covering and screening forces.

Fire Support Coordination Line (FSCL)

A line drawn on easily identifiable terrain and established by the senior ground commander. It serves as a limit to all supporting fire not directly under his control and prevents ordnance from being delivered into his area of responsibility without his authority. Targets may not be attacked between the FSCL and FLOT without first obtaining approval of the local ground commander.

Free Fire Area (FFA)

A specific area into which any weapon system may fire without additional coordination with the establishing headquarters.

No Fire Area (NFA)

An area designated by the appropriate commander into which fires or their effects are prohibited. NFAs usually exist around churches, hospitals, and schools or any other area with a high percentage of noncombatants or of strategic importance.

Restrictive Fire Area (RFA)

An area in which specific restrictions are imposed and into which fires that exceed those restrictions will not be delivered without coordination with the establishing headquarters.

7-6 DIVISION CAS TACTICS/PROCEDURES

Forward Edge of the Battle Area (FEBA)

The foremost limits of a series of areas in which ground combat units are deployed, excluding the areas in which the covering or screening forces are operating, designated to coordinate fire support, the positioning of forces, or the maneuver of units.

Air Tasking Order (ATO)

Provides mission air tasking, assignments, and related information. Also known as the mission frag.

Navy Tactical Air Control System (NTACS)

Maintains command and control of all air operations during the initial phase of the assault until MACCS is established ashore.

Marine Air Command and Control System (MACCS)

A functional duplicate of NT ACS, but operates ashore supporting the landing force through control of air operations. Maintains two centers: TAOC and DASC.

Tactical Air Operations Center (TAOC)

Detects, identifies, and directs the destruction of hostile aircraft and missiles possesses radar capability and also provides navigational aid and control of friendly aircraft to ensure their safety while in the AOA.

Direct Air Support Center (DASC)

The principal air control agency of the U.S. Marine Air Command and Control System (MACCS) responsible for the direction and control of air operations directly supporting the ground combat element. It processes and coordinates requests for immediate air support and coordinates air missions requiring integration with ground forces and other supporting arms. It normally collocates with the senior fire support coordination center (FSCC) within the ground combat element and is subordinate to the tactical air command center. It is Non-radar capable.

Joint Terminal Attack Controller (JTAC)

A qualified Service member who, from a forward position, directs the action of combat aircraft engaged in close air support and other offensive operations. A qualified and current JTAC will be recognized across the Department of Defense as capable and authorized to perform terminal attack control.

Tactical Air Control Party (TACP)

Headed by an Air Officer (a USMC aviator) who is responsible for employment and coordination of assigned supporting aircraft. Accompanies frontline rifle companies and provides terminal control of CAS aircraft with two Forward Air Control (FAC) parties.

Tactical Air Coordinator (Airborne) (TAC(A))

The TAC(A) is an airborne extension of the DASC or ASOC. The TAC(A)'s authority and responsibility can range from simple radio relay all the way to having launch (takeoff), delay, and divert authority over other assets. In order to be effective, TAC(A)s must conduct detailed planning and integration with all supported units including aviation, ground, and command and control C2 units.

Forward Air Controller (FAC)

A Marine officer (aviator/pilot) member of the tactical air control party (TACP) who, from a forward ground or airborne position, controls aircraft in close air support of ground troops. FAC is commonly – and incorrectly – used interchangeably with JTAC.

Forward Air Controller (Airborne) (FAC(A))

A specifically trained and qualified aviation officer who exercises control from the air of aircraft engaged in close air support of ground troops. The FAC(A) is normally an airborne extension of the tactical air control party (TACP).

High Density Airspace Control Zone (HIDACZ)

Airspace overlaying a tactical area and subject to high density use. A ground commander may activate a HIDACZ to restrict a volume of airspace from those not involved in the operation. Effected only for the time needed to fulfill the tactical requirement.

Restricted Operations Area/Restricted Operations Zone (ROA/ROZ)

Specified airspace within which air operations are limited. Established in response to specific situations and requirements such as CSAR or aerial refueling.

Minimum Risk Route (MRR)

A route established that poses minimum hazard to transiting, friendly aircraft in the vicinity of a specified tactical area. Provides safe passage of aircraft through Missile Engagement Zones and Fighter Engagement Zones.

Standard Use Army Aircraft Flight Routes (SAFFRs)

Normally, a route established below the coordinating altitude. Allows the Army commander to safely route the movement of aviation assets performing combat support.
These routes do not cross the FLOT and normally do not restrict target area tactics.

Coordinating Altitude

A procedural airspace control method to separate fixed-wing (FW) and rotary wing (RW) aircraft by determining an altitude below which FW aircraft will normally not fly and above which RW aircraft normally will not fly. The coordinating altitude is normally specified in the airspace control plan and may include a buffer zone for small altitude deviations.

Ground Combat Element (GCE)

Combat troops engaged on the ground that stands to benefit the most from CAS missions.

702. COMMUNICATIONS

Due to the close proximity of enemy and friendly forces during CAS operations, open radio nets are vulnerable to compromise, endangering friendly forces both on the ground and in the air. Secure communications are facilitated by KY-58 (encrypted radio communications) usage and aircrews need to be completely familiar with its use as well as HAVEQUICK and SINCGARS (modes of the radio that provide anti-jam capabilities). Even the most sophisticated forms of communication can still be subject to jamming and intrusion. Always be prepared to conduct your mission through unsecure communications. To ensure general COMSEC during communications on unsecure frequencies, the use of authentication procedures and code words are frequently used.

Authentication Tables

These appear as a square card containing scrambled letters with the numbers zero through nine across the top. There up to twenty-six rows with the letters of the alphabet down the side. In each row are twenty-six letters (Figure 7-1). Authentication cards are only valid for six-hour periods based upon a Zulu time over a 24-hour period (i.e., 0000-0600, 0600-1200, etc.), so it is important to use the proper card for the correct Zulu Time of Day.

	0	1	2	3	4	5	6	7	8	9
A	FA	QLP	GBW	OI	DCX	VMU	EN	TYJ	SKZ	HR
B	LS	FVW	AQI	BX	JHT	PZG	OM	ERD	CNK	YU
C	IY	TVS	FOB	MQ	NAL	EJG	PK	DHU	RCX	ZW
D	UZ	CFN	JPQ	YD	MKG	HER	AT	SIV	OWL	XB
E	RY	KZL	PWJ	IE	DGX	BSQ	TA	UNF	CMV	OH
F	IT	XQW	SYD	ZH	FRB	PJN	VU	MOG	KLC	EA
G	FJ	SUT	WHI	PB	AKV	OZC	QN	MED	LXR	YG
H	ER	TWO	BXN	HC	LQF	VMS	PD	AZU	YGK	IJ
I	NV	YJM	DXG	ZC	IOE	FPT	WB	HLK	SAR	UQ
J	WS	PEC	IAL	TG	QYJ	DKM	HO	RFB	UVX	ZN
K	ZK	UWA	VXE	CI	LQF	HBY	RG	TMJ	NDO	SP
L	ZL	RXT	KHJ	OU	GSW	BFM	IN	QAD	EPC	VY
M	KQ	WBH	NFR	ML	OTY	UAD	GZ	VCJ	PIS	EX
N	QX	YAM	BSL	KH	ORN	ETC	PD	UIF	JGZ	WV
O	MZ	VNS	PIK	QW	CAO	TFU	EB	LHJ	RXG	YD
P	UJ	TDW	FVC	EX	HPA	GSK	IM	NBO	LRZ	QY
Q	PT	XZA	JFD	YO	WEH	RNV	GQ	UIL	SMK	BC
R	TM	APR	KXV	ZJ	WGN	IEU	YO	QDH	BSL	CF
S	WS	PNA	ZMI	YX	FKD	HCE	OR	LVT	JQU	GB
T	XD	LOF	WUT	KV	QGE	HNM	ZC	IBP	SJR	YA
U	RG	HTZ	ICF	DL	WAU	VKB	NM	PQX	JSY	EO
V	GD	ABF	WQX	RM	PKU	VCL	TE	IOY	JSH	NZ
W	JI	ETV	DLX	SN	RZY	GUB	FP	WAH	KQM	OC
X	VX	BZG	NSD	LU	EFT	YHW	MP	CQO	JKI	RA
Y	AP	MEB	KTQ	ZU	FSH	WXY	LG	RJC	NDO	VI
Z	NC	PVF	ZWU	OX	JKI	RMS	LH	DBY	QGE	AT

Figure 7-1 Authentication Table

Authentication Procedure

There are two procedures for authenticating: the two-letter and three-letter methods. In VT-86 you will use the two-letter method, often remembered with the "down, across, down" mnemonic.

1. The challenger states "authenticate" and provides two letters.

2. The receiver reads **down** the left side of the table until the first letter is located, then right, **across** the table until the second letter is found, then **down** one row to the answer. Perform the following example using the provided authentication table:

"Hammer 11, authenticate Alpha Foxtrot."

"Grunt, Hammer 11 authenticates Lima"

Often fighters will “come back” with an authentication of their own to ensure that the individual is confirmed and is not a sapper on the net.

Code Words

Code words are frequently used to refer to enemy threats and capabilities as well as friendly compositions and capabilities. Locations and altitudes are also encoded using a “base” number as a reference to keep from compromising friendly positions, i.e. “altitude base plus four.” The following are examples of code words that might be used in a CAS environment:

SPEAR = SA-6 GAINFUL LAUNCHER

SPYGLASS = STRAIGHT FLUSH RADAR

CHAINSAW = AAA

SLINGSHOT = MANPAD

CUTLASS = SMALL ARMS

BASE = 0

Check-In Brief

As a CAS aircraft you will check in on-deck or airborne with either the TAOC, the DASC or both and the JTAC or FAC(A). The following is the check-in format:

MNPOTTA

M- Mission Number / Identification

N-Number and Type of Aircraft

P-Position and Altitude

O-Ordnance

T-Time on station

T- Type sensor and capabilities (e.g. FAC(A), Datum, JTARS, SITREP, etc..)

A-Abort code (often provided instead by the controller to the striker)

Example:

Hammer 11 – T-45 Strike Aircraft

Spartan - DASC

Hammer 11: "Spartan, Hammer 11 ready to check-in"

Spartan: "Hammer 11, proceed with your check-in"

Hammer 11: "Hammer 11, mission #210, 2 T-45s, on-deck NAS Pensacola, 4 Simulated Mk-82s on-board, 0+45 minutes of playtime, we have JTAR 21-001 and 003, and SITREP G."

After receiving the check-in, the controlling agency (TAOC, DASC, JTAC, FAC(A)) will update the SITREP and pass holding instructions. The JTAC or FAC(A) will also confirm charts on-board, get a time hack and pass the abort code.

Situation Reports (SITREPS)

SITREPS give strikers the current information dealing with friendly and enemy position, threats, ordnance required or restricted and restrictions. SITREPS are usually identified by a letter (managed similarly to ATIS information). Example: The current SITREP is SITREP G. SITREPs will be passed by the TAOC, DASC, JTAC or FAC(A) in the following format:

TTFACOR

T – Targets

T – Threats

F – Friendlies

A – Artillery

C – Clearance

O – Ordnance

R – Restrictions

L – Localized SEAD efforts

H – Hazards

Example of a FAC(A) passing a SITREP:

Snake 11 - FAC (A)

Snake 11: "SITREP G is current"

T – "Targets in the vicinity of the Shelby Airfield"

T – "Cutlass, Slingshot, and an unlocated Spear in the area"

F – "The FLOT runs from MV090802 through MV890654, FSCL runs from MV789093 through 838729"

A – "B5S is at Gun Position 3"

C – "Grunt has Type 1 Control"

O – "1 bomb per pass, no CBUs"

R – "All fixed wing aircraft stay above 10k AGL for threats"

L – "B5S providing interrupted suppression 1km north of your target area"

H – "No other hazards of flight"

Updates to recent information are often passed as changes-only instead of restating the entire batch.

Regardless, TTFACOR is a mnemonic used as a way to remember all bits of information that need to be passed/considered; the order used to convey all the information is largely a matter of technique.

9-Line Brief

The 9-Line brief is the standard JCAS format to transmit target and mission information to strike aircraft. The 9-Line format is as follows:

LINE #1 IP:	Initial Point, often an easily identifiable geographical reference point used to get the aircraft lined up and pointed at the target.
LINE #2 HDG:	Heading, given in degrees magnetic from the IP to the target. Also may include the offset direction (left or right) for weapons delivery tactics, airspace management, threat deconfliction and supporting fires coordination.
LINE #3 DIST:	The distance from the IP to the target given in nautical miles down to tenths.
LINE #4 ELEV:	Target elevation given in feet/MSL.
LINE #5 DESC:	Brief description of the target to help the aircrew anticipate visual cues (i.e. six tanks in column east to west).
LINE #6 COOR:	Target coordinates, given in either UTM grid coordinates or LAT/LONG.
LINE #7 MARK:	The type of mark used to designate the target. Can be ordnance, artillery, white phosphorous, smoke, illumination rounds, laser, IR marker, etc.
LINE #8 FRDS:	Location of the closest friendly position to the target given via cardinal/subcardinal heading and distance in meters (i.e. south 800 meters).
LINE #9 EGRS:	These are the instructions the aircrew use to exit the target area . Egress instructions can be given as a cardinal/subcardinal direction or by using control points (CP). The word "egress" is used before delivering the egress instructions.
REMARKS:	Additional information, including threat location, active gun-to-target line, hazards to aviation, additional target information, other time considerations.

RESTRICTIONS: Instructions/procedures that will affect the aircraft's tactics and weapons delivery. Examples: final attack heading, altitude restriction, ACAs, danger close (DC) (if applicable and with commander's initials), and TOT.

The 9-Line brief is transmitted to the aircrew by the controller who reads only the information necessary to fill in the 9-line brief. The full 9-line brief will be given in groups of 3 lines with a pause between each group of 3 lines. After the 9 lines are given the controller will pass remarks (if any) and restrictions including TOT. Aircrew are required to read back lines 4 and 6 (FROM THE AIRCRAFT SYSTEM'S WAYPOINT PAGE!) as well as restrictions.

During and following the 9-line Brief the aircrew has the following options:

1. During the brief if the aircrew missed 1 or more lines of information respond at the PAUSE between each 3-Line group of information with "Say again line 1" or Say again lines 4 and 5." Never use the word "REPEAT" (it is a term used exclusively for artillery, meaning to fire another salvo on the same target location).

2. If the aircrew is unable to make the given TOT then respond with "unable time 22, but can make time 25." If you are unable to make the TOT then pass a TOT you can comply with in order to keep the situation efficient and get you to the target as quickly as possible. Example: "unable time 22, but can make time 24."

3. If you are able to comply with the given TOT then respond with repeating the TOT, "TOT 22." This is now the contract between the aircrew and the FAC that your ordnance will hit the target at this agreed upon time.

Example:

Hammer 11, 12 – T-45 Strike Aircraft

Falcon 21 - FAC(A) Aircraft

FALCON 21:	"Hammers, advise when ready to copy 9-Line."
HAMMER 11:	"HAMMER 11, ready to copy."
FALCON 21:	"A, 180 Left, 4.5"
FALCON 21:	"300 feet, SPEAR, N3108.4 W08859.0"
FALCON 21:	"None, E 800M, egress east to OLDS. Advise when ready for restrictions."
HAMMER 11:	"HAMMER 11, ready for restrictions."
FALCON 21:	"One bomb per pass, remain east of Highway 29. HAMMERs read back lines 4, 6 and restrictions when ready."
HAMMER 11:	"HAMMER 11, line 4 300 feet, line 6 N3108.4 W08859.0, one bomb per pass, remain east of Highway 29."

HAMMER 12:	"HAMMER 12, line 4 300 feet, line 6 N3108.4 W08859.0, one bomb per pass, remain east of Highway 29."
FALCON 21:	"Readback correct. HAMMER 11 TOT 53. HAMMER 12 TOT 54."
HAMMER 11:	"HAMMER 11, TOT 53."
HAMMER 12:	"HAMMER 12, TOT 54."
FALCON 21:	"HAMMERs, advise when ready for chart talk-on"
HAMMER 11:	"HAMMER 11"

Joint Tactical Air Strike Request (JTARS)

JTARS (Figure 7-2) are preplanned CAS missions utilized by DASCs and FACs to expedite the passing of target information for preplanned targets in the close air support environment. JTARS incorporate their mission information utilizing the same 9-line format. If strikers have a specific JTAR onboard, FACs have strikers execute the appropriate JTAR, changing any of the information as necessary. As with a 9-line brief, strikers have the same obligation to read back lines 4 and 6 (FROM THE AIRCRAFT SYSTEM'S WAYPOINT PAGE!) as well as restrictions.

JOINT TACTICAL AIR STRIKE REQUEST — See Joint Pub 3-09.3 for preparation instructions

SECTION I - MISSION REQUEST

1. UNIT CALLED: CHIEFTAIN51 | THIS IS: GRUNT97 | REQUEST NUMBER: 06-001 | DATE | X SENT | TIME: 0800 | BY: GRUNT97

2. PREPLANNED: A PRECEDENCE 1 B PRIORITY 2 | X RECEIVED | TIME: 0805 | BY: CHIEFTN51
IMMEDIATE: C PRIORITY

3. TARGET IS/NUMBER OF
A PERS IN OPEN ___ B PERS DUG IN ___ C WPNS/MG/RR/AT ___ D MORTARS, ARTY X
E AAA ADA ___ F RKTS MISSILE ___ G ARMOR ___ H VEHICLES ___
I BLDGS ___ J BRIDGES ___ K PILLBOX, BUNKERS ___ L SUPPLIES, EQUIP ___
M CENTER (CP, COM) ___ N AREA ___ O ROUTE ___ P MOVING N E S W ___
Q REMARKS ___

4. TARGET LOCATION IS
A N3108.5 (COORDINATES) B W00858.9 (COORDINATES) C ___ (COORDINATES) D ___ (COORDINATES)
E TGT ELEV 300 F SHEET NO. ___ G SERIES ___ H CHART NO. ___
CHECKED BY

5. TARGET TIME/DATE
A ASAP ___ B NLT 1200/0806 C AT ___ D TO ___

6. DESIRED ORD/RESULTS A ORDNANCE GP/LGB
B DESTROY ___ C NEUTRALIZE X D HARASS/INTERDICT ___

7. FINAL CONTROL
A FAC/RABFAC FAC B CALL SIGN GRUNT97 C FREQ BROWN
D CONT PT BUICK

8. REMARKS
1. IP C
2. HDNG 355 MAG OFFSET: L/R
3. DISTANCE 6.1 NM
4. TGT ELEVATION 300 FEET MSL
5. TGT DESCRIPTION MORTARS/ARTY
6. TGT LOCATION RAMP NE END RWY
7. MARK TYPE NONE CODE ___
8. FRIENDLIES E 700M

9. EGRESS NORTH TO FORD
THE FOLLOWING MAY BE INCLUDED IN THE "REMARKS", IF REQUIRED:
BCN-TGT ___ MAG BCN GRID ___/___
BCN-TGT ___ METERS TGT GRID ___/___
BCN ELEVATION ___ FEET MSL

SECTION II - COORDINATION

9. NSFS | 10. ARTY | 11. AIO/G-2/G-3

12. REQUEST ☐ APPROVED ☐ DISAPPROVED | 13. BY | 14. REASON FOR DISAPPROVAL

15. RESTRICTIVE FIRE/AIR PLAN A IS NOT IN EFFECT B NUMBER | 16. IS IN EFFECT A (FROM TIME) ___ B (TO TIME) ___

17. LOCATION A ___ (FROM COORDINATES) B ___ (TO COORDINATES) | 18. WIDTH (METERS) | 19. ALTITUDE/VERTEX A ___ (MAXIMUM/VERTEX) B ___ (MINIMUM)

SECTION III - MISSION DATA

20. MISSION NUMBER	21. CALL SIGN	22. NO. AND TYPE AIRCRAFT	23. ORDNANCE
24. EST/ACT TAKEOFF	25. EST TOT	26. CONT PT (COORDS)	27. INITIAL CONTACT
28. FAC/FAC(A)/TAC(A) CALL SIGN/ FREQ	29. AIRSPACE COORDINATION AREA	30. TGT DESCRIPTION	*31. TGT COORD/ELEV

32. BATTLE DAMAGE ASSESSMENT (BDA) REPORT (USMTF INFLTREP)
LINE 1/CALL SIGN ___ LINE 4/LOCATION ___
LINE 2/MSN NUMBER ___ LINE 5/TOT ___
LINE 3/REQ NUMBER ___ LINE 6/RESULTS ___
REMARKS ___ *TRANSMIT AS APPROPRIATE

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Figure 7-2 Joint Tactical Air Strike Request (JTARS)

Example:

Hammer 11, 12 – T-45 Strike Aircraft

Falcon 21 - FAC(A) Aircraft

FALCON 21: "HAMMER 11, understand you have JTAR 06-001 on board?"

HAMMER 11: "HAMMER 11, affirmative."

FALCON 21: "HAMMERs, standby to execute JTAR 06-001. Change line 4 to read N3108.3, W08859.0. Advise when ready for restrictions."

HAMMER 11: "HAMMER 11, ready for restrictions."

FALCON 21: "One bomb per pass, remain east of Highway 29. HAMMERs read back lines 4, 6 and restrictions when ready."

HAMMER 11: "HAMMER 11, line 4 300 feet, line 6 N3108.3 W08859.0, one bomb per pass, remain east of Highway 29."

HAMMER 12: "HAMMER 12, line 4 300 feet, line 6 N3108.3 W08859.0, one bomb per pass, remain east of Highway 29."

FALCON 21: "Readback correct. HAMMER 11 TOT 48. HAMMER 12 TOT 49."

HAMMER 11: "HAMMER 11, TOT 48."

HAMMER 12: "HAMMER 12, TOT 49."

DASC Checkout Brief (Inflight Report)

Following your attack the FAC will provide your flight with a Bomb Damage Assessment (BDA). This data must be relayed to the DASC and TACC on your way out (DASC checkout brief/Inflight Report). The BDA is extremely important as CAS agencies must decide if more aircraft are necessary to attack the target. Here is a sample of info contained in a DASC checkout brief.

Line #1: Callsign

Line #2: Mission #

Line #3: Location (latitude/longitude, grid, place name)

Line #4: TOT

Line #5: Results (given by FAC, BDA, "2 BMP'S destroyed")

Remarks (target area weather, significant sightings, essential elements of information, FAC worked with, frequencies used)

Example:

Hammer 11 – T-45 Strike Aircraft

Chieftain 97 - DASC

HAMMER 11: "Chieftain 97, Hammer 11, Inflight Report."

CHIEFTAIN 97: "Ready to copy."

HAMMER 11: "HAMMER 11 and 12; Mission #06-401; executed JTAR 06-001, TOTs 48, 48+30, 6 arty pieces disabled; next target, target coordinates N3108.3, W08859.0 TOT's 53 and 53+30, 1 Spyglass disabled, 1 Spear destroyed; next target, target coordinates N3108.4 W08859.0, TOTs 01 and 01+30, 3 tanks destroyed, 1 disabled, 1 company mechanized infantry killed or wounded. Worked with FALCON and GRUNT on BROWN; weather, clear; Spear launch, time 53+30. How copy?"

CHIEFTAIN 97: "HAMMER 11, say again target coordinates."

HAMMER 11: "Target coordinates N3108.3 W08859.0 and N3108.4 W08859.0."

CHIEFTAIN 97: "CHIEFTAIN 97 copies all. Frequency change approved."

703. CAS TACTICS

Holding

Upon check in with the DASC or controller in the AOR, the strikers will be assigned to holding at a CP at a specific altitude. For the purposes of safety at VT-86, each striker will be assigned an individual altitude for deconfliction and strikers will push as singles. Once all strikers are established in holding at the CP, the controller will pass mission data via a preassigned JTAR or immediate 9-line. Strikers will determine time to push to make their assigned TOT and hold as appropriate to push on time. Typically there are two types of holding techniques used in order to be at the CP at push time: perpendicular and parallel (Figure 7-3).

Perpendicular

Perpendicular holding orients the flight in a "figure-eight" pattern over the CP and perpendicular to the CP/IP run-in line. Eight to ten nautical mile legs are flown centered on the holding CP, adjusted as required for airspeed, push time, threat, and airspace constraints. Turns of 180 degrees are standard, but the tactical situation, number of aircraft and your formation must be considered. Advantages are that the aircraft are kept closer to the CP and it allows for larger timing corrections. Disadvantages are that it may require aircraft to turn hard prior to push, resulting in slower initial airspeeds and the aircraft are not oriented toward the target or threat area to aid in visual lookout or sensor employment.

Parallel

Parallel holding orients the flight in a racetrack pattern over the CP, parallel to the CP/IP run-in line. Six to eight nautical mile legs are flown with 180 degree turns standard.

Advantages are that aircraft can approach the CP on the correct CP/IP heading. It allows for sensor usage and visual lookout to allow you to orient to the threat while flying inbound to the CP. Disadvantages are that it can place aircraft a minute or more away from the CP, and if for some reason the time hack is shortened, it may present a serious timing difficulty.

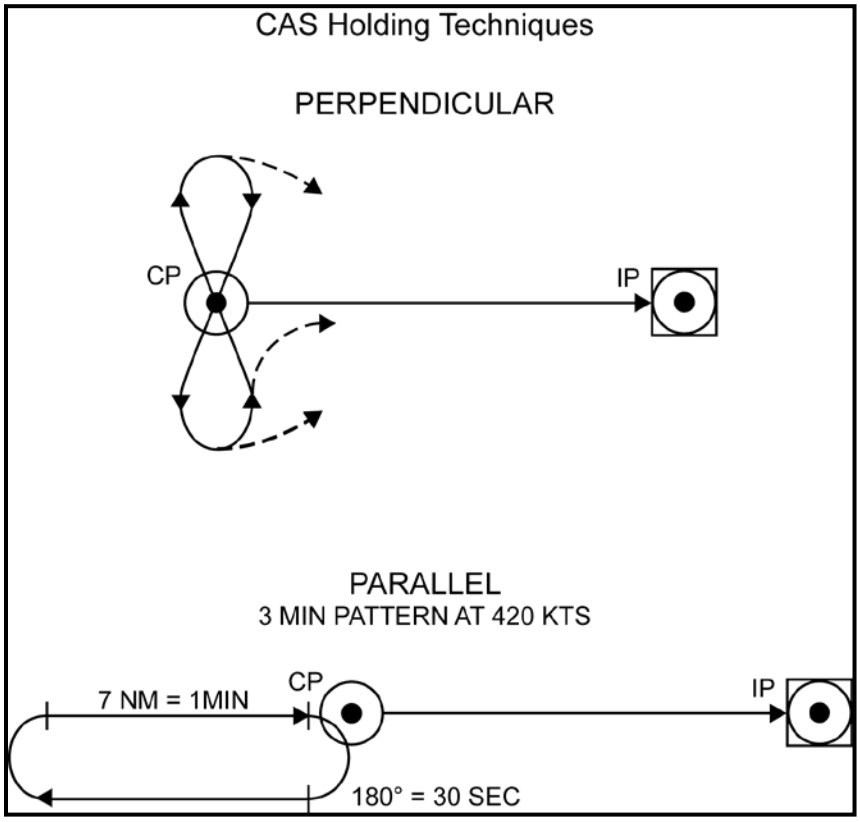

Figure 7-3 Holding Techniques

Ingress/Target Area Tactics

The tactics we use on the ingress and in the target area depend entirely on the expected threat in the target area. In general, there are three distinct threat levels that dictate our target area tactics: low, medium and high threat.

Air-to-Ground Checks (LATOMS)

Prior to each target attack, NFSs will conduct Air-to-Ground checks utilizing the LATOMS checklist:

L: LAW Set for Delivery

A : Air-to-Ground Delivery Mode (CCIP/MAN)

T: Target Elevation entered

O: Ordnance (Bombs/Guns)

M: Master Arm On

S: Symbology: No Xs in the HUD

The LATOMS checklist will typically be executed NLT the IP in the Medium/High Threat ingresses, or NLT than the RIP in the Low Threat scenario.

Low Threat CAS

A permissive, low threat environment is always the preferred scenario when supporting our troops on the ground. It exists only after we have obtained air supremacy, eliminating all air-to-air and surface-to-air threats. In a low threat environment, we can loiter overhead the target with impunity, observing the battlefield and reacting to targets we receive via talk-on from the FAC or FAC(A). Generally, we will operate at higher altitudes in the target area to aid in target acquisition and to provide a sanctuary from enemy small arms fire and possible MANPADS. In the VT-86 syllabus we will employ a 30 degree circular dive pattern (Figure 7-4) overhead the target in a low threat scenario. Multiple aircraft in the will fly across the circle from each other in the overhead pattern will be deconflicted in altitude by the controller.

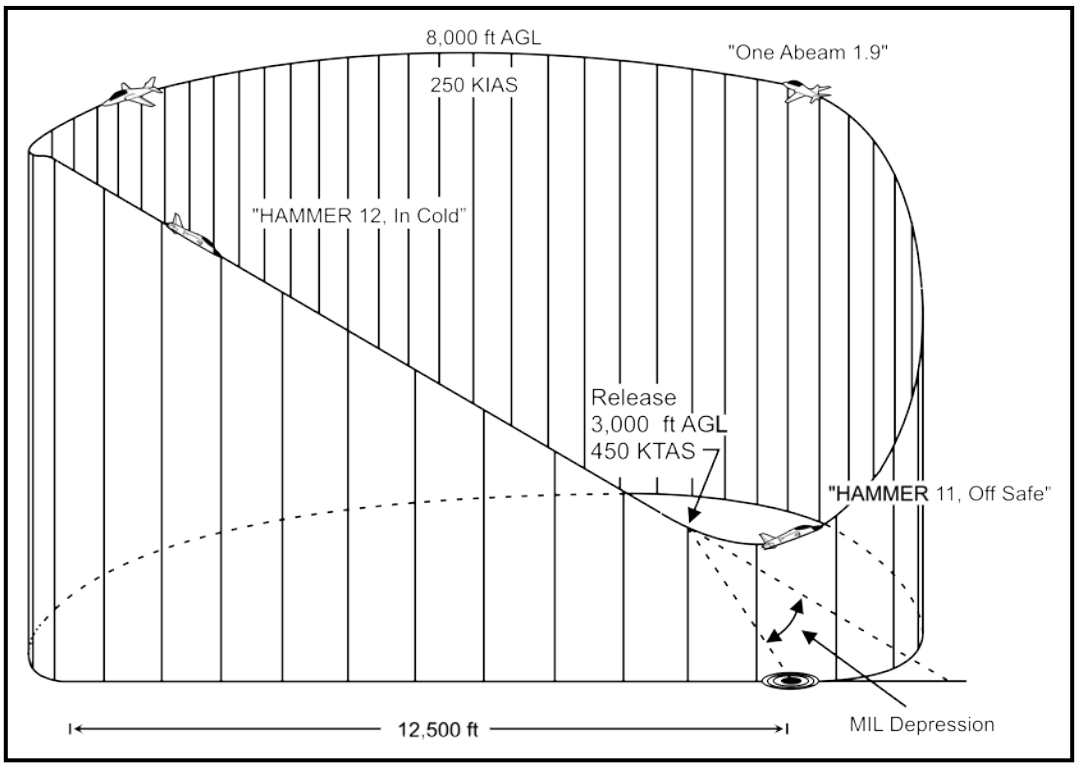

Figure 7-4 30-Degree Dive Pattern

30-Degree Pattern

Pattern altitude:	8,000 ft. AGL
Pattern airspeed:	250 KIAS
Planned Release altitude:	3000 ft AGL
No-Later-Than Release altitude:	2700 ft AGL
Release airspeed:	450 KTAS
Release rpm:	92-94%
Manual MIL setting:	128 mils
Weather requirements:	8,500/5

Figure 7-5 30-Degree Pattern

Medium Threat CAS

There may be certain scenarios where the threat level in the target area prohibits the loitering of friendly aircraft overhead the battlefield. Those threats could consist of heavy AAA or unsophisticated mobile SAM batteries. In those cases, strikers will generally hold outside the target area at an assigned CP/IP and ingress into the target area at high altitude to provide an altitude buffer above those threats, allowing sufficient time and airspace to defend against such a threat as required as well as good overview of the target area for target acquisition. After completing their attack, strikers are directed to egress back to a CP/IP outside the threat ring for follow-on tasking or RTB. For the VT-86 syllabus, strikers will ingress into the target area at 8000’ AGL, utilizing a 30 degree dive attack.

High Threat CAS

When there is a significant surface-to-air threat in and around the target area, comprised usually of sophisticated SAM systems (or a low ceiling combined with small arms and/or MANPAD threats), the use of high threat tactics become necessary. High threat tactics usually consist of a low level ingress to utilize terrain masking, as well as SEAD support, to provide limited exposure to the threat. Utilizing low pop tactics, strike aircraft are only vulnerable for a short period of time, at the expense of target acquisition time. For that reason, chart talk-on is generally a FAC technique to provide SA of the target area prior to striker ingress. Strikers are generally directed to egress at low altitude back to a CP outside the threat ring for follow-on tasking or RTB. VT-86 aircraft will utilize the same low level pop tactic previously introduced in the Section WEPS phase (Figures 7-6 and 7-7), either as singles with one minute separation or as a same-side section attack.

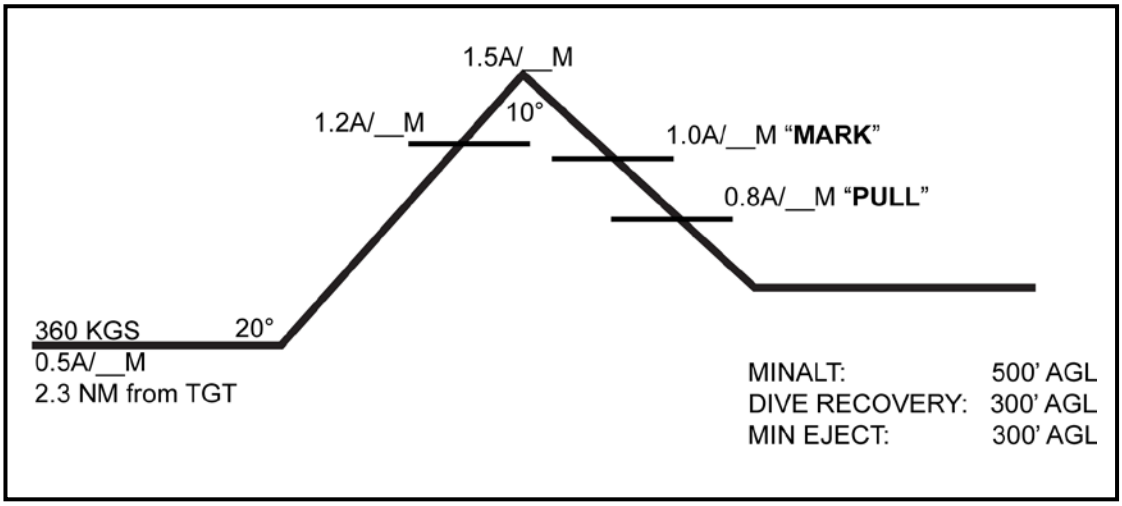

Figure 7-6 Low-Altitude Pop Attack

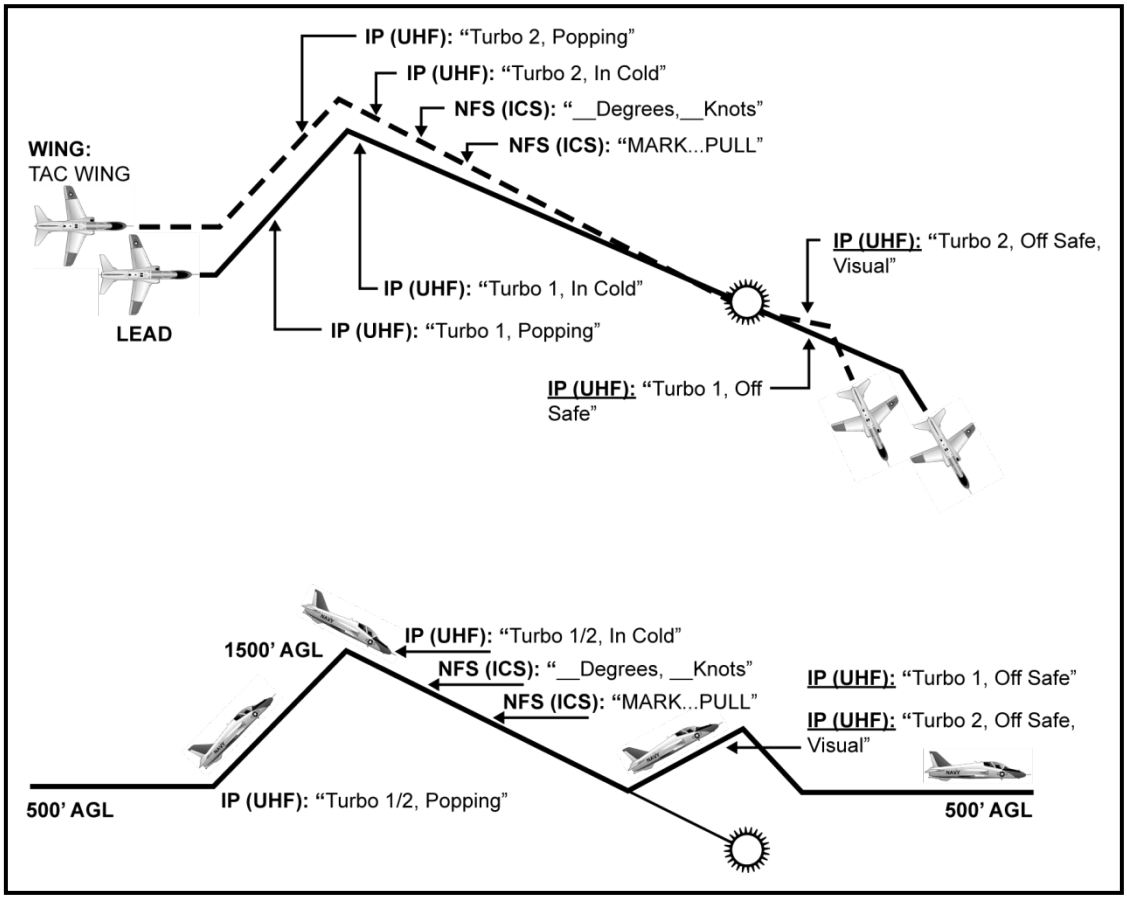

Figure 7-7 Same-Side Section Pop Attack (Same Target)

Weather Contingencies

Should weather preclude the use of the 30 Degree dive pattern for the Low or Medium Threat scenarios, the 10-Degree and 20-degree patterns (Figure 7-8) will be briefed as an administrative contingency.

10-Degree Pattern

Pattern altitude:	2,500 ft. AGL
Pattern airspeed:	350 KIAS
Planned Release altitude:	1,000 ft AGL
No-Later-Than Release altitude:	800 ft AGL
Release airspeed:	450 KTAS
Release rpm:	MRT
Manual MIL setting:	128 mils (bombs) /47 mils (strafe)
Weather requirements:	3,000/5

20-Degree Pattern

Pattern altitude:	6,000 ft. AGL
Pattern airspeed:	300 KIAS
Planned Release altitude:	2,000 ft AGL
No-Later-Than Release altitude:	1,800 ft AGL
Release airspeed:	450 KTAS
Release rpm:	95-97%
Manual MIL setting:	130 mils
Weather requirements:	6,500/5

Figure 7-8 10 and 20-Degree Dive Patterns

704. WEAPONS DELIVERY PRINCIPLES

Up to this point, we have discussed procedural matters. We now come to the most important topic of all: how to deliver the weapon onto the target. All the procedures discussed, though they are certainly important, have one common purpose: to allow you to arrive at the roll-in point (RIP). It is what you do between roll-in and release that will determine the accuracy of your delivery. In order to introduce the procedures to be used during the weapons run, we must first

discuss some of the basic principles involved. This brief discussion is introductory and the mathematics have been shortened or deleted.

Theory of Weapons Delivery

DEFINITIONS (See Figure 7-9)

Line of Flight

The path of the aircraft through the air.

Dive Angle

The angle between the line of flight and the ground.

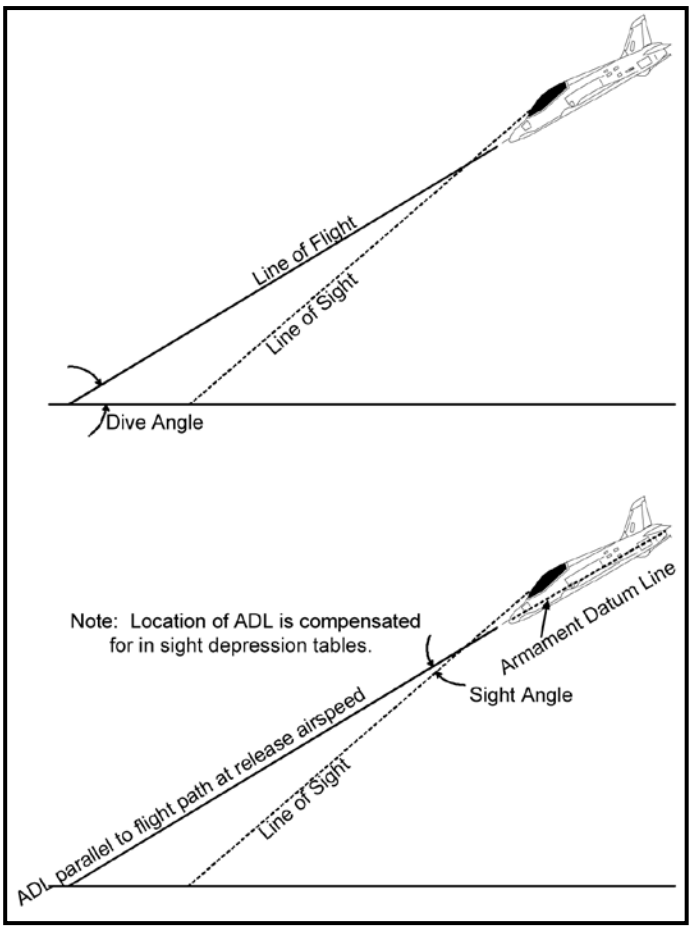

Figure 7-9 Dive Terminology

Line of Sight

A line transcribed from the pilot's eye through the pipper. This line does not normally pass through the target until release.

Armament Datum Line

The armament datum line (ADL) is a fixed reference line on the aircraft. It will be parallel with the flight path at 450 KTAS release airspeed. At other than release airspeed, it will vary from parallel. The angle between flight path and ADL is called the angle of attack of the armament datum line; this is not the same as the AOA measured by the aircraft instrument. This angle decreases to zero (ideally) as the aircraft accelerates to 450 KTAS, so flight path and armament datum line are the same at release airspeed.

Sight Angle

Sight angle is the angle between the ADL and the line of sight. It is sometimes called sight depression angle. With a sight angle of zero, the line of sight is parallel to the ADL. With any depressed sight angle, the line of sight will be below the ADL. The sight angle is set with the SET DEP rocker on the data entry panel of the HUD.

MIL

An angular measure defined as 1/6,400 of a circle. Sight angle is measured in mils. A mil is a convenient unit of measurement because a mil subtends approximately one unit at one thousand units. That is, if two lines spread apart with an angle of one mil, they will be one foot apart after 1,000 ft., two feet apart after 2,000 ft., and so on out.

Time of Fall

Time of Fall (TOF) is the length of time between release of a weapon and its impact with the ground. This is the time during which gravity acts on the weapon to bend its trajectory below the aircraft line of flight.

Factors Affecting Trajectory

For each type of weapons run you make, you will have a mil setting, which will compensate for the extent to which a weapon will drop below your aircraft flight path. Each mil setting is calculated so that if you release your weapon at the proper altitude, with correct airspeed, dive angle, and G, with wings level, zero yaw, and the pipper on the target, the weapon will hit the target, assuming no wind. However, a change in any of these parameters will affect the trajectory of the weapon. The effect of changing each parameter will now be considered. The following factors are discussed from a perspective of using a Depressed Sight Line (DSL) pipper in the T-45C manual (MAN) bombing mode.

Release Altitude

Releasing high will increase the time of fall of the weapon, and so will increase the time during which gravity can act to bend its trajectory. You are also releasing a greater distance from the target. Therefore, if you release high, with all other parameters correct, the weapon will hit short. Similarly, if you release low, the hit will be long.

Release Airspeed

Any deviation from planned release airspeed will cause a false sight picture. For example, a fast release will decrease your AOA and bring the pipper short of the impact point, causing a long hit. A slow release will show the pipper long and cause a short hit. Airspeed also has an effect on the weapon time of fall.

Dive Angle

Deviations from planned dive angle will also cause a false sight picture. A steep dive will cause a long hit and a shallow dive a short one. Changing the dive angle will change the extent to which gravity will bend the weapon trajectory below the line of flight. Suppose you release a weapon at a dive angle of 90 degrees. Since gravity works straight down, there will be no effect on the trajectory. You can see that a steeper angle requires a smaller mil setting; if you release steep, your mil setting is too large and the bomb will strike beyond the target. If you are shallow, you need a greater mil setting, just as you do for a shallow pattern, and your hit will be short.

G at Release

Proper G at release depends on dive angle. For a 30-degree delivery, about 0.87 G is required to maintain a straight flight path. A 10-degree dive requires almost 1 G. A 60-degree dive (not used in the training command) would require only 0.5 G. The mil setting for each type of delivery is valid only at the proper G. Incorrect G at release will change the angle of attack of the ADL and will invalidate.

Bank

Because of the depression of the sight line below the line of flight, any bank will cause a false sight picture. This error is caused by the pendulum effect (Figure 7-10), so that if you roll to the right, your pipper will appear to move to the left along the ground. Thus, if you release with the pipper on target while you are in a right bank, your hit will be to the right and short.

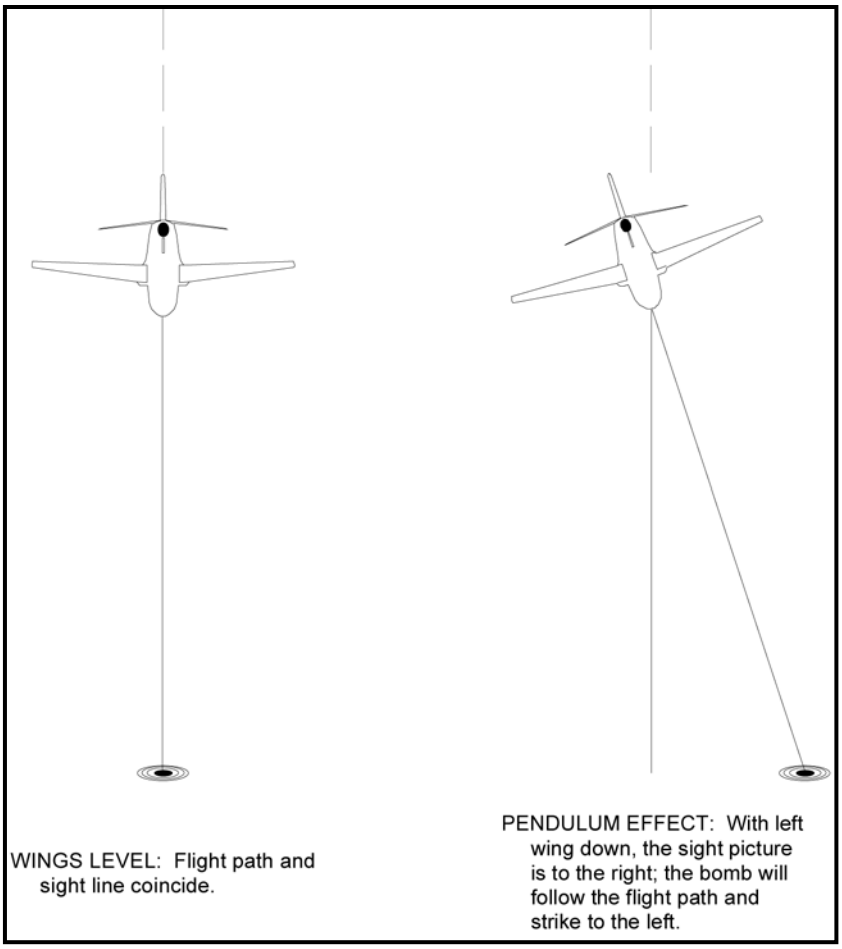

Figure 7-10 Pendulum Effect

Yaw

A skid or sideslip can also affect the trajectory of the weapon by causing a false sight picture. Unless the ball is centered (balanced flight), the aircraft will not be moving in the direction the pipper is looking. So, if the ball is out to the right (the aircraft yawing to the left) when you release a bomb with the pipper on the target, your hit will be to the right of the target.

You correct for wind effects by varying your bank angle as you fly around the pattern. During the tracking phase you will need to make adjustments in your roll-in point and initial aimpoint. Wind effect on the bomb after release is corrected by the offset aimpoint you calculate.

Delivery Procedures

Having discussed the factors that affect the path of a weapon, we can now introduce the procedures and techniques for a weapons run. Except where noted, these procedures will apply to all patterns and ordnance used in the Training Command.

Straight-path Tracking

During straight-path tracking, a constant dive angle is maintained and the pipper is allowed to track straight to the aimpoint. The G load will become slightly less than one G. With wings level after roll-in, scan both pipper position and dive angle. The pipper should be short of the final aimpoint at completion of the roll-in (Figure 7-11).

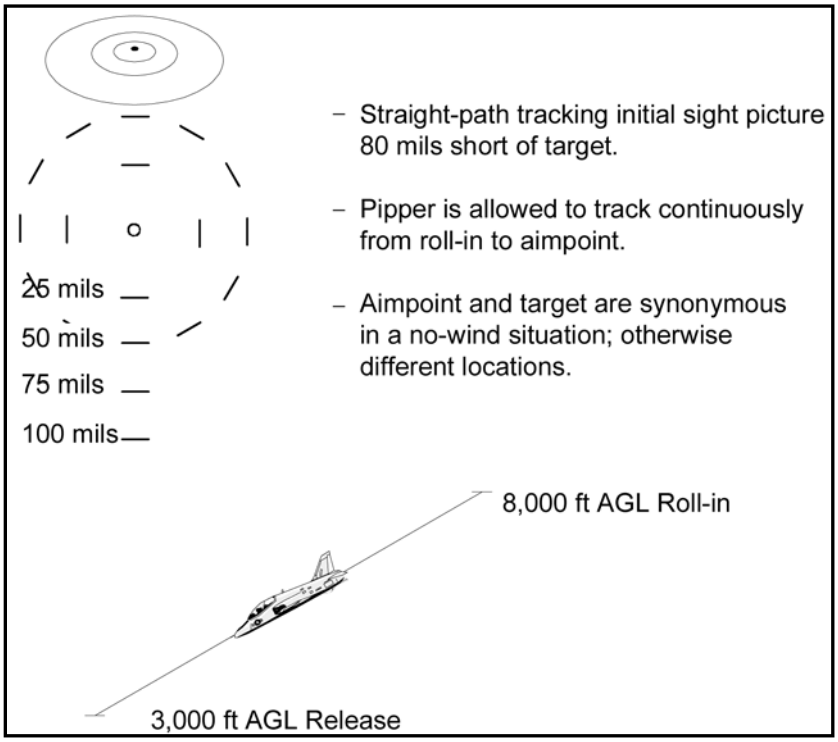

Figure 7-11 Straight Path Tracking Method

Make corrections for pipper position early in the run. Note deviations from expected dive angle so that you can more easily calculate necessary corrections in release altitude. While tracking, you must not only control the motion of the pipper, but also continually cross-check your altitude, airspeed, and dive angle. Initially in the run, dive angle and pipper placement are most important. Altitude becomes more important as it decreases. As you approach release altitude, scan the pipper and altitude on your HUD, with occasional references to dive angle and airspeed. You can check airspeed more precisely after you pickle to allow for power corrections on subsequent runs. You may even have to compute a corrected release altitude. The pipper should reach the final aimpoint (the bull if there is no wind) just as the aircraft arrives at the release altitude of 3,000 ft. AGL.

The guidelines for pipper tracking during straight path tracking are:

2/3 of the mil setting below the aimpoint at three times the release altitude.

1/2 of the mil setting below the aimpoint at two times the release altitude.

1/3 of the mil setting below the aimpoint at one and a half times the release altitude.

Curvilinear Tracking

During curvilinear tracking, the aircraft flight path becomes convex, with the dive angle continuously increasing. This is accomplished by placing the pipper on a point on the ground and holding it in position with forward stick pressure. During curvilinear tracking, G will gradually approach zero; because of this, an attempted release will either hit long or become hung. For these reasons, curvilinear ONLY tracking is not practiced.

Curvilinear/Straight-path Tracking

This method begins with a curvilinear tracking run, then transitions to straight-path tracking to release. Upon roll-in, the pipper is held short of the target (or offset aimpoint) by one-third of the mil setting until reaching one and a half times the release altitude, at which time, straight-path tracking begins. This method provides checkpoints which allow the pilot to determine the required corrections well before reaching release altitude (Figure 7-12).

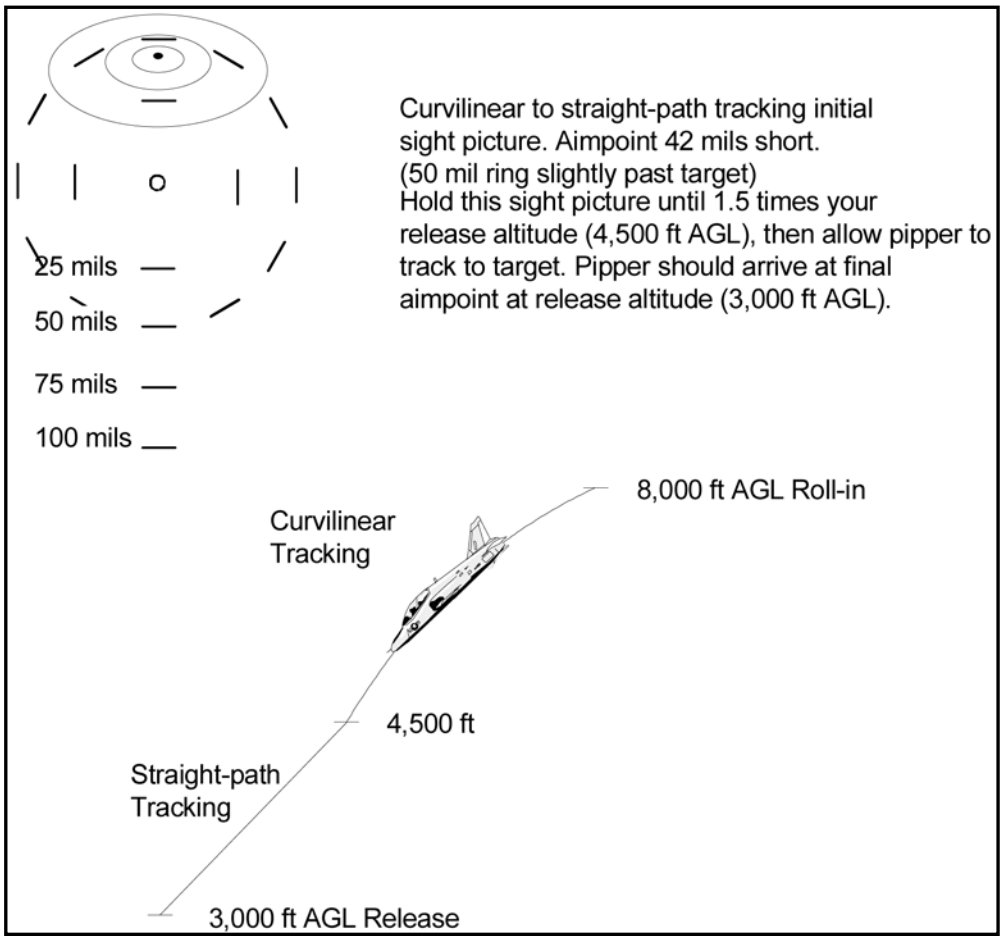

Figure 7-12 Curvilinear Tracking Method

Release

In a bomb or rocket run, the weapon is normally released as the pipper reaches the final aimpoint at release altitude, as stated. In a strafing run, however, there is no single release altitude. Instead, there is an open-fire altitude and a cease-fire altitude. In a 10-degree strafing run, these altitudes are 1,100 ft. AGL and 800 ft. AGL. The pipper should be at the top of the target when open-fire altitude is reached, and should be eased toward the bottom of the target. This compensates for decreasing slant range and consequent decrease in effect of gravity on the weapon.

Error Corrections

The previous section described what should happen during an ideal run. In practice, you will find that it is difficult to achieve an ideal run. Although you must strive to arrive at the release point with proper airspeed, dive angle, and so on, you will frequently find that at least one of your delivery parameters is in error. In such a case, if you simply continue the run and release at normal altitude, you will miss the target. In the Training Command, you have the option of

aborting the run and trying again. In a combat environment, however, you normally get just one chance. Even on a training flight there is a limit to the number of runs you can abort and still expend all your ordnance within the allotted target time. Therefore, you must learn to make corrections during your run for each type of error that can occur.

Error Sensitivities

In order to make proper corrections, you must know how much each error will affect your accuracy. We have already discussed in general terms the effects of deviating from each of the various parameters such as airspeed, dive angle, and altitude. For example, we showed that a dive angle steeper than planned will cause a long hit, so releasing high can compensate for a steep dive angle. However, in order to actually make such a correction, you must know how high to release to compensate for each degree you are steep. In other words, for each type of run, you must know exactly how dive angle, airspeed, and altitude affect accuracy, and how they relate to one another. The table (Figure 7-13) summarizes this information and should be memorized.

TABLE OF ERROR SENSITIVITIES

	Dive Angle		Airspeed		Release Alt		Error
10° bombs	+/-1°	=	+/-10 kt	=	-/+70 ft	=	+80 ft
10° strafe	+/-1°	=	+/-10 kt	=	-/+100 ft	=	+30 ft
20° bombs	+/-1°	=	+/-10 kt	=	-/+100 ft	=	+50 ft
20° rockets	+/-1°	=	+/-10 kt	=	-/+100 ft	=	+20 ft
30° bombs	+/-1°	=	+/-10 kt	=	-/+100 ft	=	+50 ft
30° rockets	+/-1°	=	+/-10 kt	=	-/+100 ft	=	+20 ft

Figure 7-13 Error Sensitivities Table

This table shows, for example, that a 1-degree error in dive angle in a 30-degree bomb run will cause your hit to be 50 ft. long or short, and that a 10-knot airspeed error will have the same effect. How these relationships can be used in a run will be discussed below.

Altimeter Lag

The HUD electronic altimeter readout should not lag, so if your release altitude is 3,000 ft AGL, hit your pickle when the barometric altitude readout on the HUD is 3,000 ft MSL, plus or minus target elevation. However, ordinary barometric altimeters do not react as fast as your aircraft descends, so to preclude misses because of a failed transducer and consequent use of head-down instruments, figure your altimeter lag for the release airspeed. You should know what your standby altimeter will read at the correct release. Use this table for 450 KTAS and add the correction:

Dive Angle	Altitude Correction
10 degrees	60 ft.
20 degrees	130 ft.
30 degrees	190 ft.

Error Correction Techniques

Corrections for Dive Angle

You can read your dive angle directly from the pitch scale on your ADI or, depending on tracking technique, your dive may steepen or shallow slightly during the run and should indicate the proper dive angle at release. In a 30-degree run, for example, your HUD or ADI should indicate 30 degrees at release. If you find that your dive angle is too steep, to avoid losing valuable tracking time, maintain your dive angle and adjust your release altitude accordingly. If you know your error sensitivities, this is a simple correction to make. For example, if in a 30-degree bomb run, your HUD indicates 32 degrees as you approach release altitude, you can compensate by pickling 200-ft. high. To correct for a shallow dive angle, add power to increase your airspeed. For example, if in a 30-degree bomb run you find that your HUD is indicating 28 degrees as you approach release altitude, you can compensate by increasing power by about 4% rpm, allowing the aircraft to accelerate to 470 kts and pickling at the planned altitude.

You must also be careful not to release with excessive G, because, as has already been explained, this can cause a false sight picture. Never press the run below normal release altitude to correct for a dive parameter or for any other reason.

Corrections for Airspeed

Experience will help you to anticipate large errors early in the run and to make appropriate power corrections. Maintain awareness of airspeed during the final portion of the run to be sure you are at release airspeed when you reach release altitude. Last-minute corrections for airspeed errors are similar to those for dive angle errors. For example, if in a 30-degree bomb run you find that you will be 20 knots fast at release, you can compensate either by pickling 200 ft. high or by pickling at normal altitude with the pipper 100 ft. short of the target. If you are 20 knots slow, you can allow the pipper to drift 100 feet past the target by release altitude. Never release below normal release altitude to correct for a dive parameter or for any other reason.

Correction for Pipper Position

The position of your pipper at release is probably the most important single factor in determining where your weapon will hit. If you release with the correct altitude, airspeed, dive angle, etc. (no wind), the weapon will impact where the pipper was positioned at release. If the pipper was 300 feet past the target, that is where your hit will be, even though you did everything else right. Experience will help you recognize early in the run that the pipper is not going to arrive at the final aimpoint by release altitude, and to make early corrections. Sometimes it is an improper roll-in that leads to improper pipper position. For example, if you start a straight-path tracking

run with the proper dive angle, but you find that you have to shallow your run to make the pipper reach the target by release altitude, then the problem could be that you have rolled in too far from the target, or that you have allowed your nose to drop during the initial part of the roll-in. Sometimes, however, even though you may have the proper dive angle and airspeed, you will find that the pipper is not where you want it to be as you approach your release point. The pipper may be reaching the aimpoint too early or too late, or it may be deflected to one side or the other.

Corrections for Early Sight Picture

If your pipper arrives at the aimpoint before you reach the normal release altitude, then you have an early sight picture. In such a case, assuming all parameters correct and no wind, if you were to pickle with the early sight picture, your hit would be short because of your altitude error. On the other hand, if you were to pickle at normal release altitude, your hit would be long because the pipper would be past the target. If you were to try to hold the pipper on the target until release altitude, your dive angle would increase and you would release with insufficient G. The proper correction is to notice the altitude at which you get the early sight picture and to split the difference between that altitude and release altitude. For example, suppose that in a 30-degree bomb run, your pipper arrived at the aimpoint at 3,400 ft AGL. With proper airspeed, dive angle, etc., you could compensate by continuing to hold your 30-degree dive and pickling at 3,200 ft AGL. However, improper pipper position can often be traced to an improper roll-in. If you find that you are consistently getting an early sight picture, and your dive angles are correct at release, then the problem may be that you are rolling in too close to the target or have too much noseup trim. In contrast to an early sight picture, a late sight picture cannot be corrected at release.

Corrections for Late Sight Picture

If you reach release altitude and the pipper has not reached the aimpoint (late sight picture), you must either release at normal altitude and take the short hit, or you must abort the run. Never release below normal release altitude to correct for a late sight picture or for any other reason. If you recognize during the run that you are going to have a late sight picture, you can correct by using very slight back pressure on the stick to make the pipper track faster, or you can use slight back pressure to change pipper placement and then resume proper G. You should be aware, however, that this technique will shallow your dive angle and may necessitate another correction. In any case, you should try to analyze the reason for the late sight picture. It could have occurred because you rolled in too far from the target, or because you did not maintain altitude during the initial part of the roll-in, or because you pulled your nose down too far during the final part of the roll-in.

Corrections for Deflection

If your pipper is offset to one side of the desired initial aimpoint, the correction you can make for this deflection error depends on the type of ordnance being used. With bombs, there is no last-minute correction for deflection. Kicking in rudder to move the pipper to the desired aimpoint will not appreciably affect the trajectory of the bomb, and your hit will not be improved. Rolling into an angle of bank at the last moment will not be effective either, because the pendulum effect will cause a false sight picture. You must recognize the problem early in the run, make a correction using small amounts of bank, and be sure that your wings are level at release.

Conversely, with forward-firing ordnance, it is possible to use your rudder to make a last-minute correction for pipper deflection. Unlike bombs, forward-firing ordnance will initially travel in the direction it is fired, even in unbalanced flight where the firing direction is not the same as the aircraft direction of flight. The ordnance will then curve as it aligns itself with the relative wind. Because of this realigning tendency, you cannot simply move the pipper over to the desired aimpoint. You must make a larger correction. With rockets, your correction should be four times the deflection error. For example, suppose that your pipper is 10 mils left of the aimpoint. Use your rudder to move the pipper a total of 40 mils to the right, so that it will be 30 mils to the right of the aimpoint. With guns, because the bullets have a higher initial velocity and have less tendency to align themselves with the relative wind, a smaller correction is needed. Your correction should be 1.25 times the deflection error. For example, if your pipper is 20 mils to the left of the desired aimpoint, use your rudder to move it a total of 25 mils to the right, so that it will be 5 mils to the right of the aimpoint.

Corrections for Multiple Errors

In each of the foregoing discussions of error correction techniques, it was assumed that only one dive parameter was in error, and that the rest were correct. For example, when we say that a 2 degree error in dive angle will cause a 100-foot miss, we are assuming that the weapon is released at the proper airspeed and altitude, wings level, and with correct G and the pipper on the aimpoint. However, you will frequently find that one or more of your dive parameters is in error as you approach release. In such a case, the errors may be additive, or they may tend to cancel each other. For instance, suppose that in a 30-degree bomb run, you notice that your dive angle is 1 degree shallow and that your airspeed is 10 knots slow. If you have learned your error sensitivities properly, you know that each of these errors will cause your hit to be 50 ft. short, for a total of 100 ft., and that you could correct by allowing the pipper to drift 100 ft. past the target by release altitude. On the other hand, if you happen to be 1 degree shallow and 10 knots fast, you know that these errors cancel each other and no correction is needed. You can probably see, however, that trying to mentally compute corrections for multiple errors during the few seconds before release could become excessively complicated. Imagine trying to figure a correction for steep dive angle, fast airspeed, and early sight picture. For now you are in a training environment, and you have the option of aborting your run at any time. If you find yourself in a run that is really fouled up, don’t drop.

Wind Corrections

All of the procedures given up to this point have assumed that there was no wind. In most cases, however, there will be a wind at release altitude, and you will have to make some slight changes in your roll-in point, tracking procedure, and release point. As we mentioned, the primary effect of wind is to change the aircraft ground speed and direction. During the run, the motion of the aircraft relative to the air mass is determined by the aircraft airspeed and heading. At the same time, if the air mass is drifting, the aircraft will drift with it and will impart this drift to the weapon at release. For example, if your aircraft is drifting to the left at 20 feet per second (12 knots) when you release a bomb, then the bomb will continue to drift left at 20 feet per second all the way to impact. If you release with the pipper on the bull, with all your dive parameters correct, and if the time of fall of the bomb is 7 seconds, then your hit will be 140 feet left of the

target (7 X 20 = 140). It is easy to see, then, that you will have to offset your final aimpoint to compensate for the wind at release altitude. In addition, you will have to change your initial aimpoint and tracking procedure to compensate for the drift of the aircraft during the run.

Wind-Corrected Tracking

Because the wind will cause your aircraft to drift during the run, you must modify your tracking technique. Figure 7-14 shows how the pipper moves during three stages of tracking: no-wind, pipper-to-bull, and wind-corrected. No-wind tracking refers to the method given earlier and involves tracking the pipper along the run-in line so that it reaches the target at release. Pipper-to-bull is a simplified method designed to obtain a consistent grouping of hits downwind from the target. This will demonstrate the effect of the wind so you can visualize corrective action. It is discussed below.

As Figure 7-14 shows, wind-corrected tracking requires that both the initial and final aimpoints be offset. For this reason, the roll-in point must also be offset so that when you roll out, your pipper will be on the initial aimpoint. As the pipper tracks toward the final aimpoint during tracking, your heading should be parallel to the run-in line. If there is a crosswind, your pipper will track diagonally and not parallel to the run-in line.

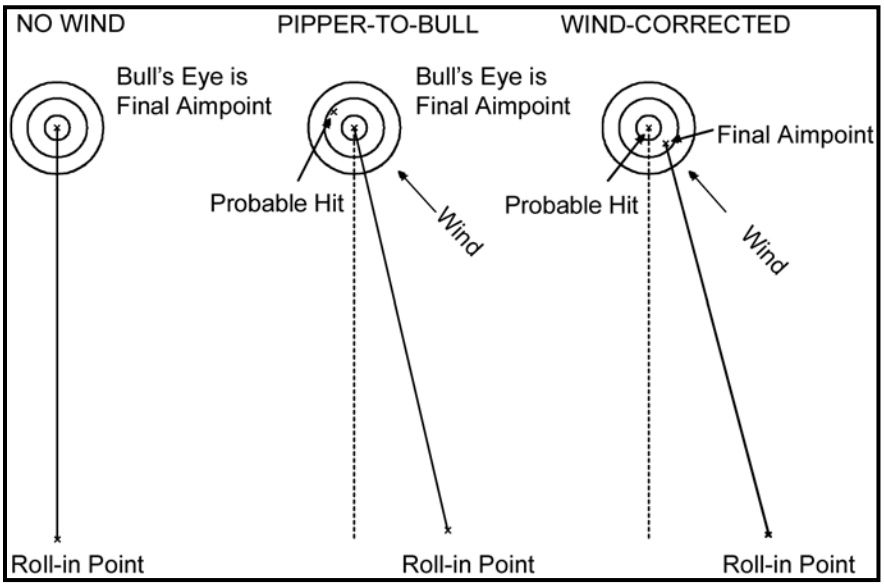

Figure 7-14 Tracking Techniques

Experience will help you judge how far laterally to offset your roll-in and initial aimpoint so that the pipper will track smoothly to the final aimpoint by release altitude. If you find that the crosswind is causing you to drift more or less than expected, you can correct by making slight heading changes. However, be sure that your wings are level when you release any bank will invalidate the sight picture.

Another technique for the wind-corrected method is to roll in, simulating a no-wind (straight) pipper track to the computed final offset aimpoint, and make small wing dips into the wind, controlling the pipper track to the release point. Ensure that release is accomplished in a wings level attitude.

Pipper-To-Bull Tracking

The object of pipper-to-bull delivery is not to hit the target, but to obtain a consistent grouping of hits. Figure 7-12 shows what the path of the pipper should be. The procedures for pipper-to-bull tracking are exactly the same as those given above for wind-corrected tracking, except that the bull's eye is the final aimpoint.

FLYING THE PATTERN

The Attack Cone

The concept of the attack cone (Figure 7-15) is taught to emphasize the idea that, although you will be using a fixed run-in line, an effective run-in can actually be made from any direction. For a given target and dive angle, the pattern of all possible flight paths forms a cone above the target. In combat, you would maneuver to intercept this cone from the most advantageous direction for your run-in.

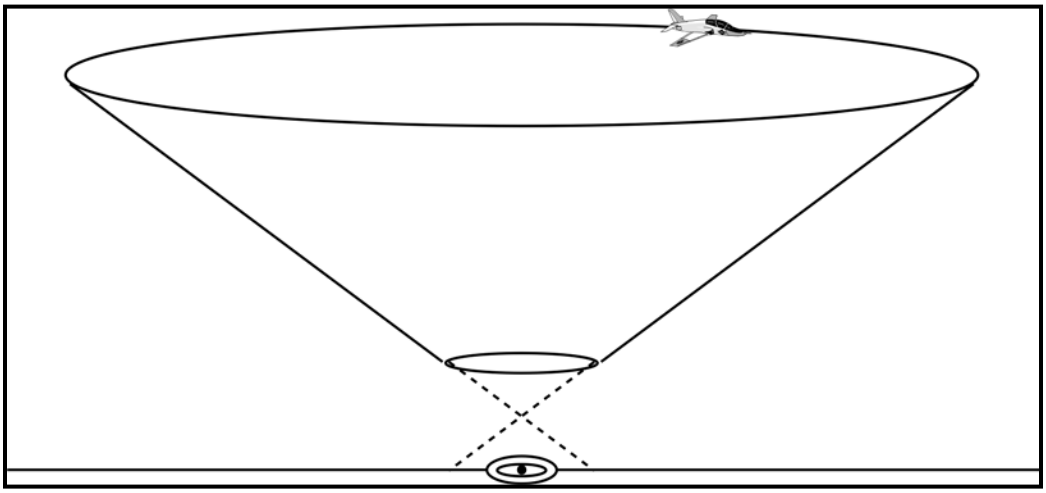

Figure 7-15 The Attack Cone

The Roll-In

The roll-in begins about 30° of heading prior to the run-in heading. At this point, the IP will roll the aircraft to about 120° AOB and smoothly pull the aircraft nose low such that it is aligned with the run-in line. The NFS will make a COMM 1 call when the aircraft nose is below the horizon, "One in cold." (Cold indicates that no weapons will be released.) The aircraft will be rolled wings level and acquire the proper initial "pipper" placement. Once you are established in

the dive run, the dive angle and airspeed will be checked and reported on the ICS by the student. The dive attack will be flown and the appropriate COMM 1 and ICS calls will be made by the student.

Basic Weapons Delivery Theory

This section will discuss the theory behind Air-to-Ground weapons delivery. Flying the aircraft to the planned release parameters increases the likelihood of success. Some of the topics covered will be the bombing triangle, the factors affecting trajectory, and aim-off distance and dive angle to include their effects on release solution altitude ("Wires").

The Bombing Triangle

The bombing triangle (Figure 7-16) is created at weapons release. It is composed of ***altitude***, ***slant range*** from the aircraft to the target, and the ***down range travel*** of the weapon. In the Training Command, we reference the bombing triangle which is created with release altitude, the flight path of the aircraft, and the distance over the ground from the aircraft to the point on the ground where the flight path intersects.

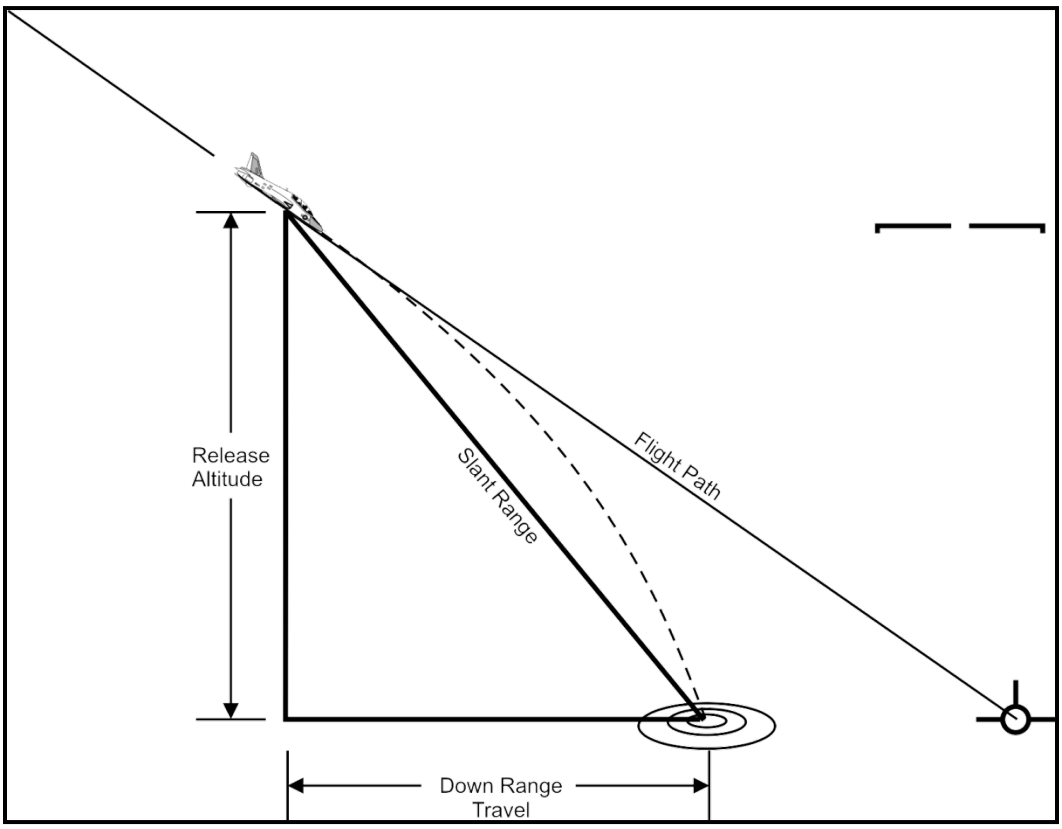

Figure 7-16 Bomb Delivery Triangle

Aim-Off Distance: The distance measured from the target to a point at which the flight path intersects the ground.

Dive Angle/Flight Path Angle: The angle at which the velocity vector is placed below the horizon.

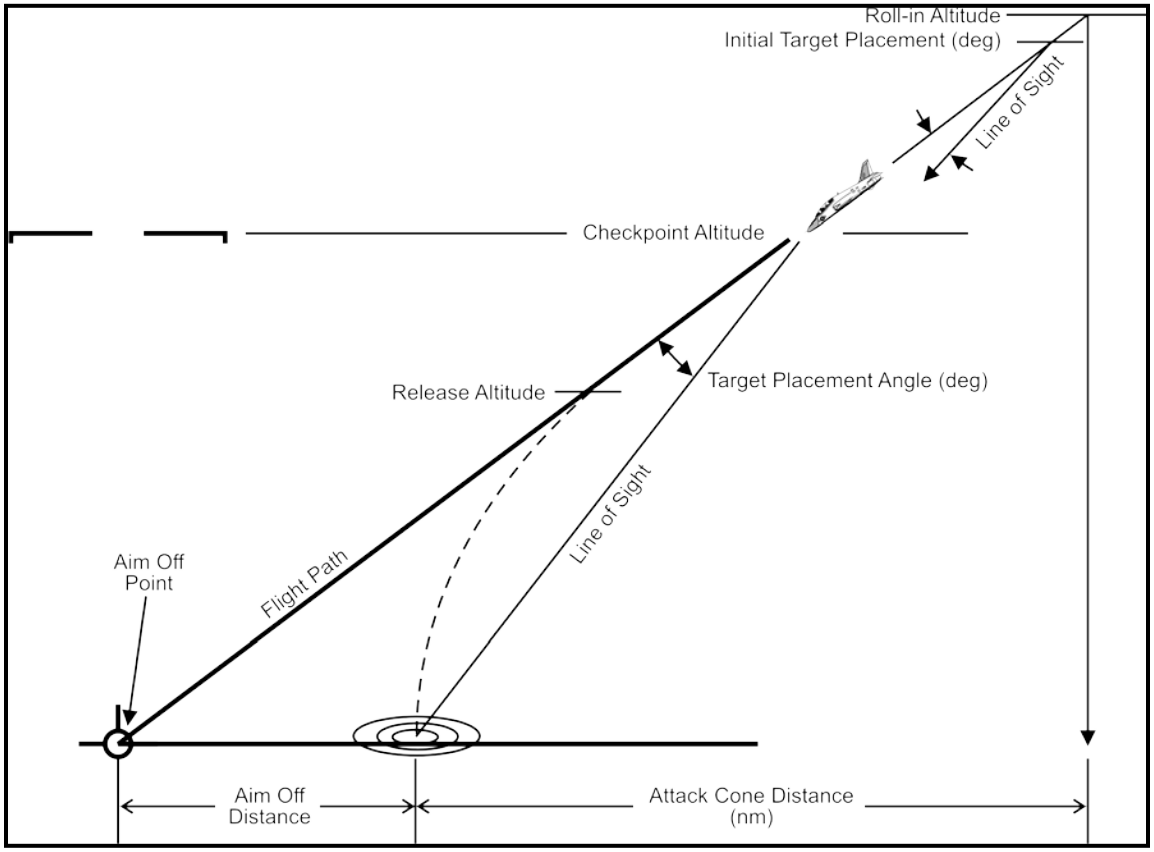

Figure 7-17 Planned Release Parameters

Wires

For the purposes of this discussion, the term "wires" will be used to represent specific combinations of dive angle and aim-off distance that deviate from the planned release parameters (Figure 7-17). Aside from being on a dive delivery profile coincident with your planned release parameters, there are 4 possible wires:

Steep Wire (Figure 7-18): Aim-off distance is correct, but dive angle is steep, resulting in a higher than planned weapon release solution.

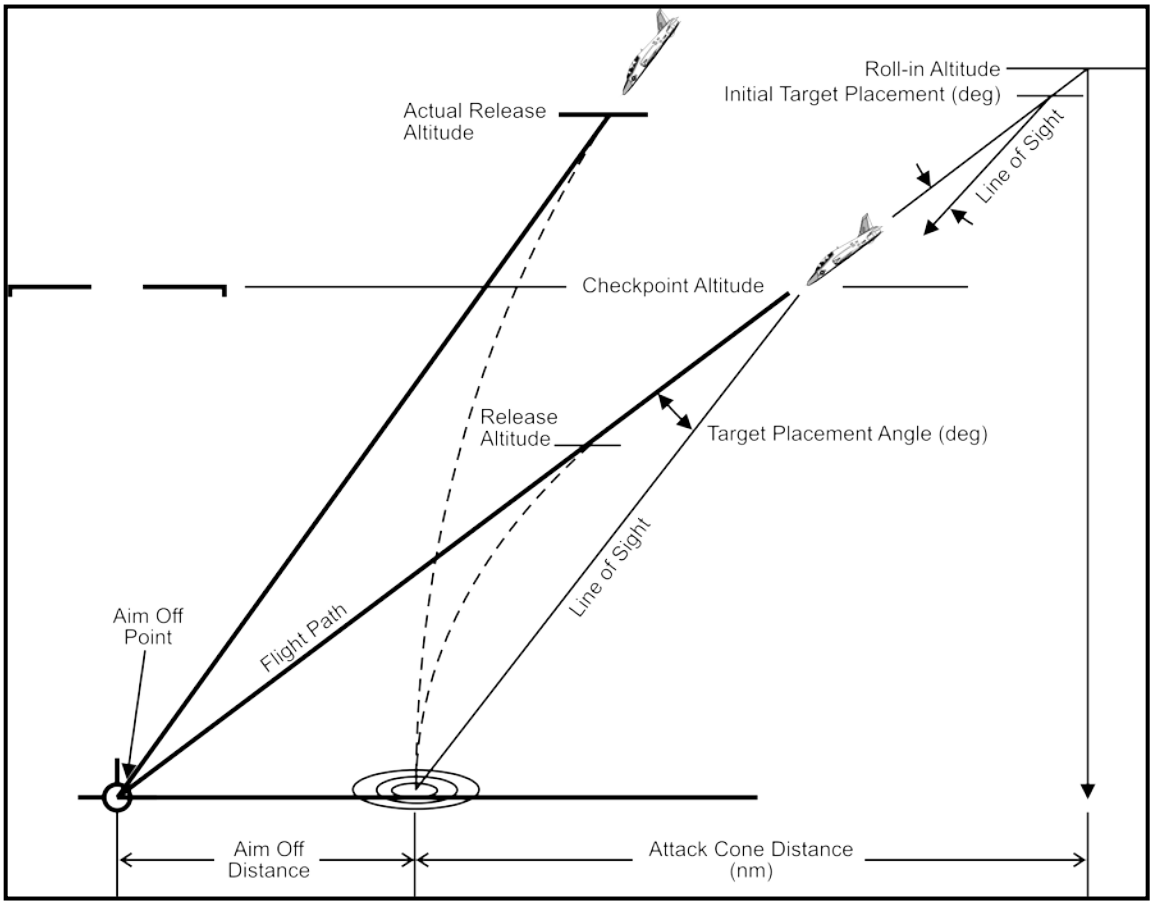

Figure 7-18 Steep Wire

Shallow Wire (Figure 7-19): Aim-off distance is correct, but dive angle is shallow, resulting in a lower than planned weapon release solution.

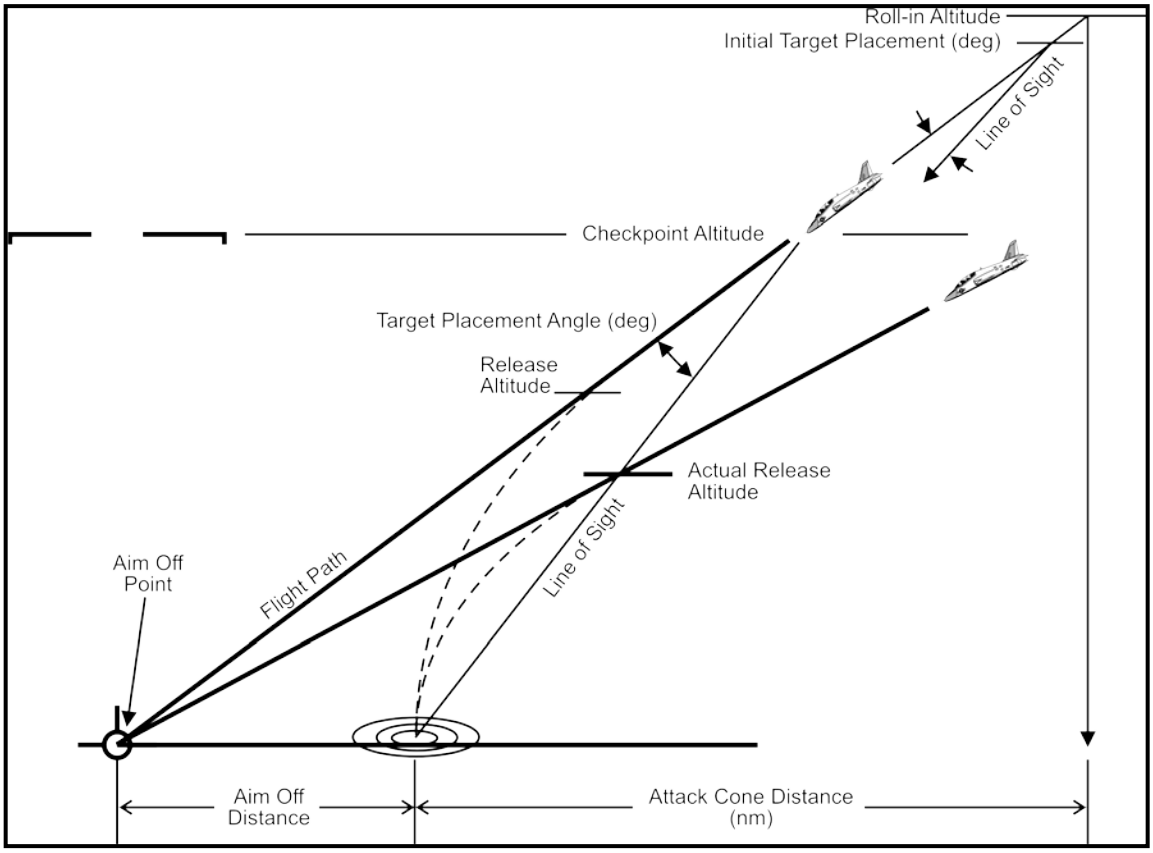

Figure 7-19 Shallow Wire

High Wire (Figure 7-20): Aim-off distance is long, but dive angle is correct, resulting in a higher than planned weapon release solution.

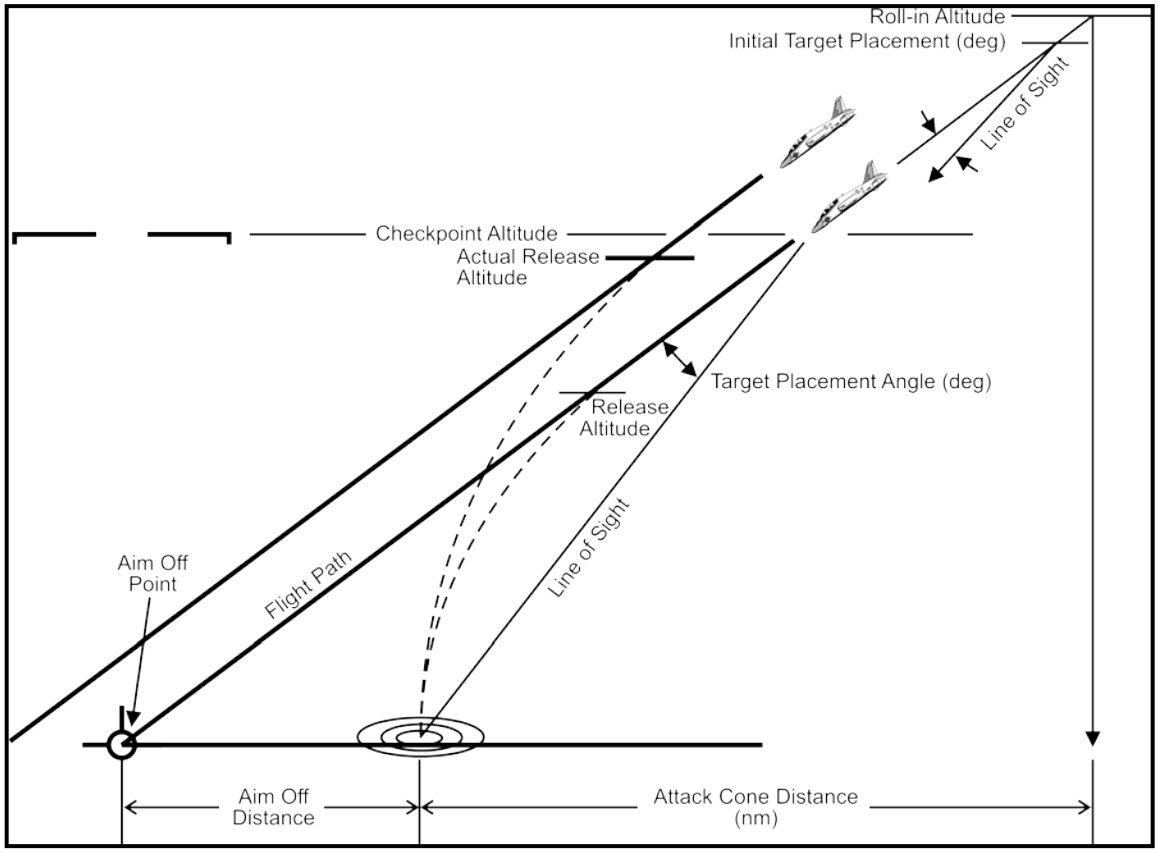

Figure 7-20 High Wire

Low Wire (Figure 7-21): Aim-off distance is short, but dive angle is correct, resulting in a lower than planned weapon release solution.

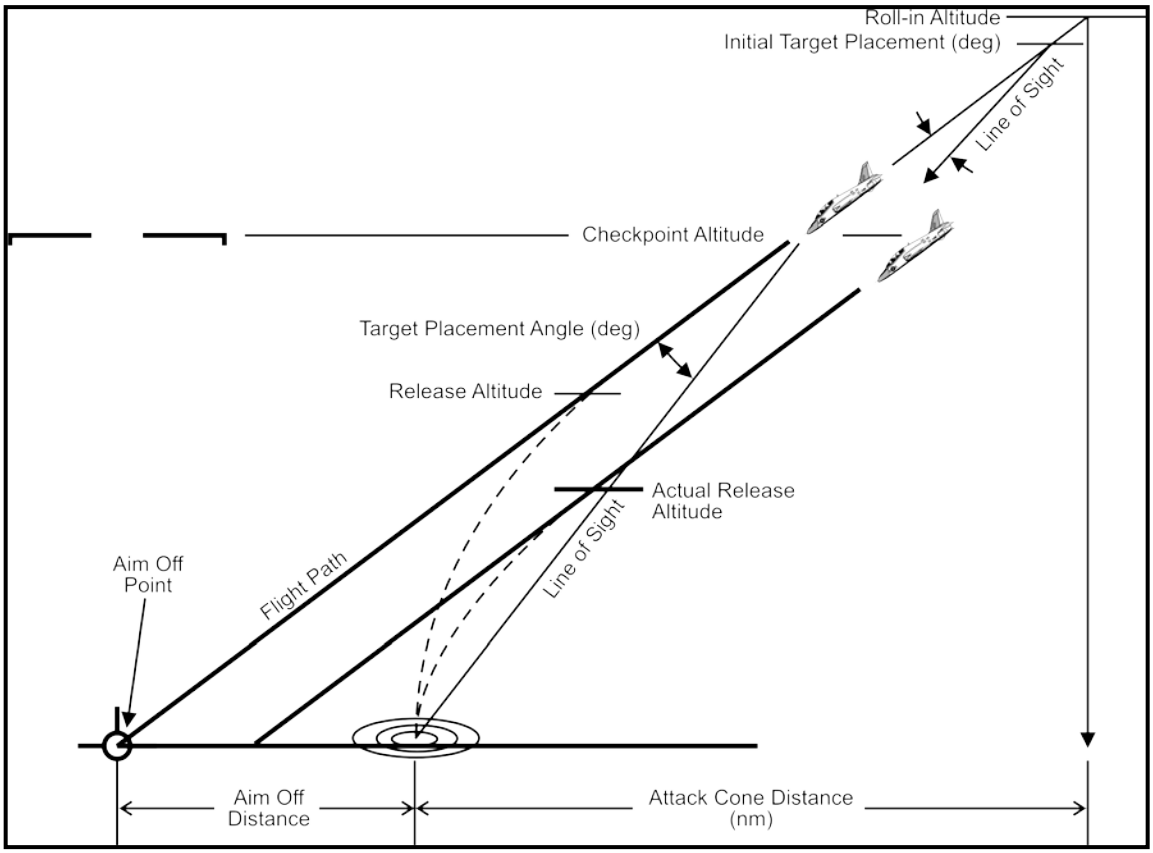

Figure 7-21 Low Wire

Weapon Delivery Validation (Figure 7-22)

Simulated and actual dive deliveries will be validated based on several parameters:

Dive Angle: At simulated or actual weapon release, the velocity vector is within 5 degrees of planned dive angle for a 10 degree delivery, and is within 7 degrees of planned dive angle for a 20 or 30 degree delivery.

Airspeed: At simulated or actual weapon release, the True Airspeed is within 20 KTS of planned release TAS (normally 450 KTAS).

Altitude: At simulated or actual weapon release, the aircraft's altitude is no lower than the planned No Later Than weapon release altitude.

Weapon Impact Point (WIP) Placement: At simulated or actual weapon release, the CCIP WIP is on the target.

Safe Escape Maneuver: After simulated or actual weapon release, the pilot achieves a minimum of 4Gs within 2 seconds, and sustains at least 4Gs until the velocity vector is at or above the horizon.

If any one of the above criteria is not satisfied, the delivery will be assessed as “Invalid.” Should any of the above criteria not be able to be discerned due to HUD limitations, the delivery will be assessed “Unassessable for HUD.” Should HUD tape be unavailable, deliveries will be assessed “Unassessable for Tape.”

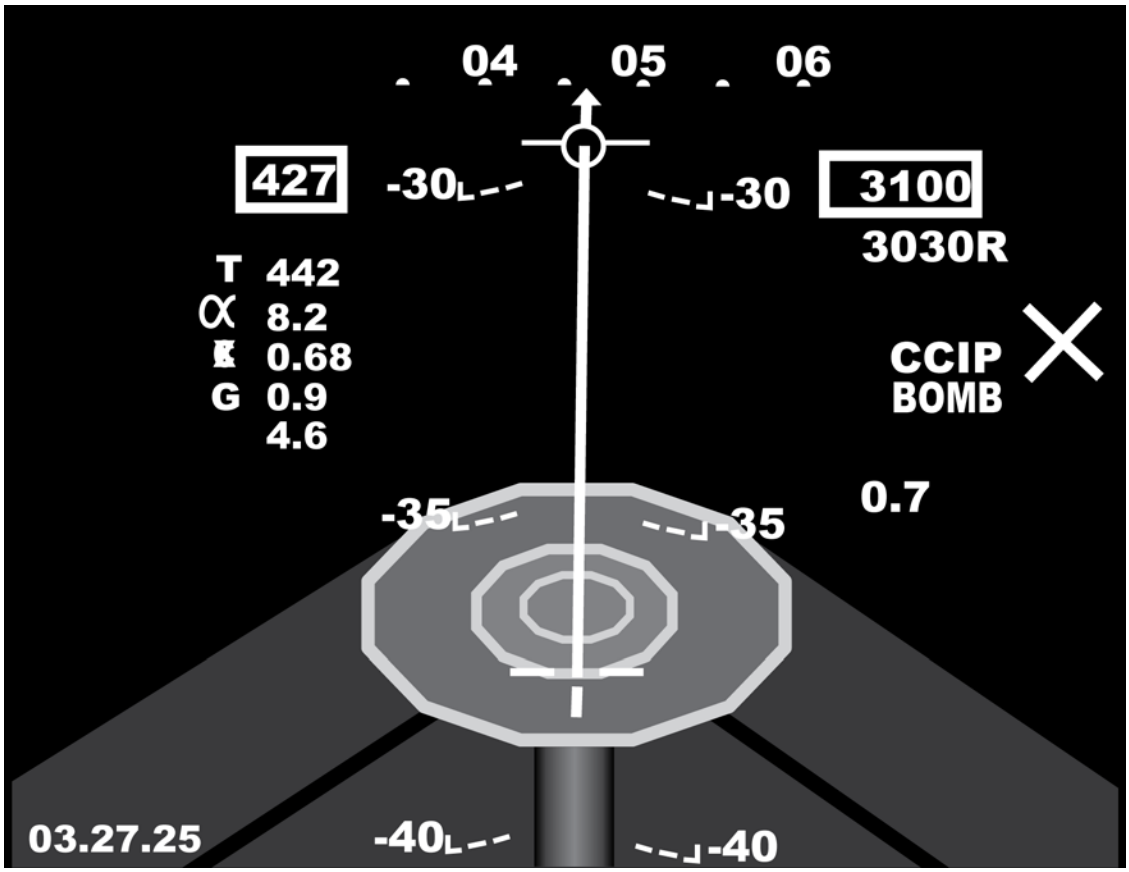

Figure 7-22 A/G Delivery HUD Validation

Recovery

At the planned release altitude, with the dive attack parameters met (dive angle and airspeed) the NFS will call "MARK." The IP will execute/simulate a weapons release and initiate dive recovery. A half second pause will be used to allow the real or simulated weapon to clear the aircraft. An additional "PULL" call will be made by the NFS if the aircraft reaches the no-later-than (NLT) release altitude, even if the weapon has not been released or a solution reached. If dive recovery (DR) is not felt or initiated after the first “Pull” call, the NFS will use a greater voice inflection to call a second “Pull!” or “Recover!” call to induce a recovery. These calls will be made on the ICS.

The IP will begin the dive recovery by smoothly applying 4-5 Gs in a wings-level attitude. Application of "G" should be immediate but gradual, obtaining 4 Gs within 2 seconds. As the nose of the aircraft comes through the horizon, the IP will increase power to MRT and continue the recovery. Once the nose is above the horizon and the Master Arm is Safe, the NFS will call "C/S OFF SAFE" on COMM 1 (Figure 7-23).

STRIKER:	“HAMMER 11 in cold”
CONTROLLER:	“HAMMER 11, continue dry”
STRIKER:	(NFS over ICS, once rolled wings level) “27° / 400kts”
STRIKER:	“MARK” – at the Planned Release Altitude
STRIKER:	(NFS over ICS) “PULL” – when/if the No-Later-Than Release altitude is reached
STRIKER:	“One off safe.”
CONTROLLER:	“Egress to Buick, angels base +5”

Figure 7-23 Sample Attack Comm

705. CAS PLANNING/FLIGHT PREPARATION

Chart Preparation

The first step in planning a CAS mission is to prepare a chart of the AOR or target area. Use a TPC (1:500,000) or preferably a JOGAIR (1:250,000). Plot all the CPs/IPs that are listed by Lat/Long or UTM grid in the Air Annex of the Air Tasking Order. Remember CPs/IPs are easily identifiable geographical reference points from which the FAC can coordinate a CAS mission and get aircraft to the target. Once in your aircraft you may enter each CP/IP under a waypoint so that you will have GPS/INS steering to each when needed. Next, plot the Forward Line of Troops (FLOT) and the Fire Support Coordination Line (FSCL). These lines can change rapidly depending upon the speed of the advance so you should glean the latest updates from the DASC. Any air-delivered ordnance between these two lines must be coordinated with the ground commander who owns the area.

Ideally, we will have a 1:50,000 chart for a more detailed breakout of the target area to plot target coordinates as passed by the FAC/FAC(A) airborne. In the absence of a 1:50,000 chart, for this syllabus we will use satellite imagery of the target complex to mark and identify targets passed by the FAC via talk-on.

CP - IP Matrix

Once you have plotted each CP and IP, build a heading and distance matrix. Take a blank CAS Briefing Card and list all the CPs down the left side and all IPs across the top.

Next, measure the heading and distance from each CP to each IP and enter it in the appropriate box. This matrix provides a quick reference for determining the distance from each CP to each IP. Simply add the IP to target distance to the CP to IP distance to determine the total distance to the target.

Distance/Groundspeed Matrix

The Distance/Groundspeed Matrix is a quick reference for computing the enroute time from the CP to the target, depicting Time-to-Go. TTG reflects the time required to fly a given distance, based on a groundspeed of 360 knots (6 nm/min).

TOT is the time at which ordnance will impact the target, not the time your aircraft will be overhead the target. Because of this, the aircrew must take into account the effect that the delivery maneuver and bomb time of fall will have on timing to the target. For all T-45 tactics we will use 15 seconds for maneuver and bomb time-of-fall. NFS will use TTG to overfly the target plus 15 seconds to figure push time to make the FAC assigned TOT.

Brief

The following items should be present or completed prior to the CAS -1/2X briefs:

1. File DD 175 or put appropriate stereo route on file.

2. Set up briefing board with Z diagrams (in MSL and AGL) and safety data.

3. Prepare a kneeboard card for the instructor with Z diagrams in MSL and AGL.

4. Kneeboard packs should also include all charts and planning materials covered above.

5. Have a briefing guide and T-45C models in briefing room.

6. Have a tactical call sign for the flight.

The Instructor aircrew will conduct a FAC-to-Fighter brief outlining general CAS AOR procedures, deconfliction and safety. After the FAC-to-Fighter brief, the lead NFS will conduct an admin brief, covering Admin, TAC Admin, Emergencies and expected delivery tactics. Finally, Lead IP will finish with a more in-depth discussion of formation coordination and tactics.

"Z" Diagrams

"Z" diagrams (Figure 7-24) are useful presentations of pattern and weaponeering information that will be included on briefing boards and kneeboard cards. During the division weapons pattern, a 30° and 10° dive pattern will be employed, with a 20° pattern as a backup. All three weapons pattern altitudes are depicted in the "Z" diagrams in Figure 7-25. Similar to the earlier Weapons flights, the "Z" diagram altitudes will be adjusted to reflect MSL target elevation. To minimize in-flight calculations, all kneeboard card "Z" diagrams will again be presented in

MSL/AGL.

Students should be able to explain how the minimum altitudes and dive recovery numbers are derived. Z diagrams will be labeled as follows:

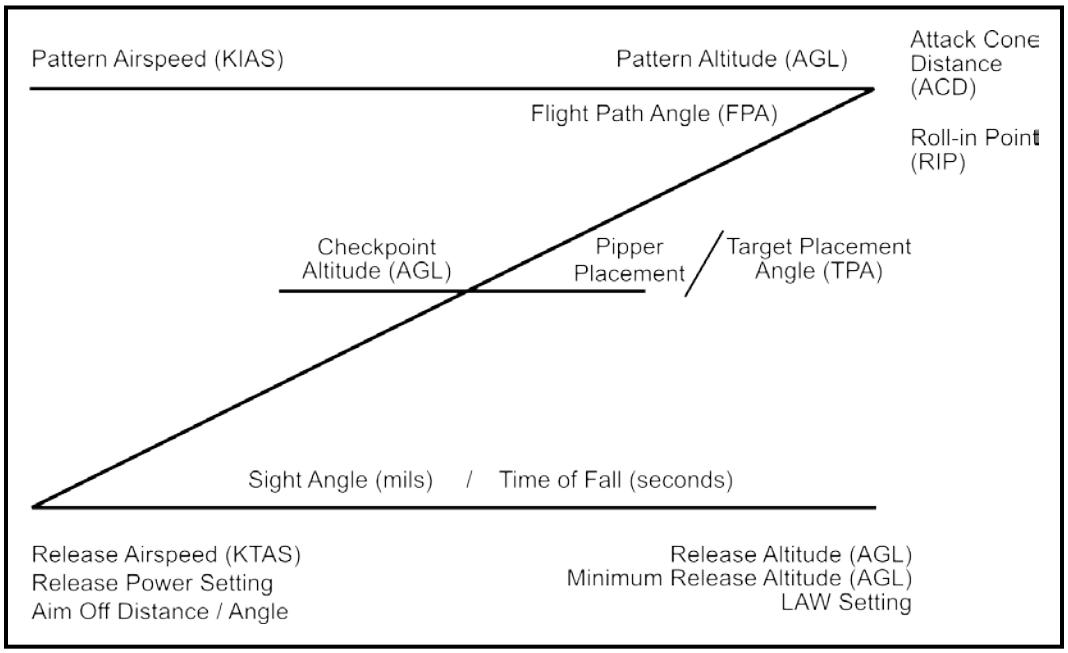

Figure 7-24 Generic "Z" Diagram

When altitudes are below 5,000 feet AGL, an AGL altitude will be listed in addition to the MSL altitude. LAW will be set to MINALT for the delivery profile in use.

The following are examples of Z diagrams for the three primary weapons delivery profiles:

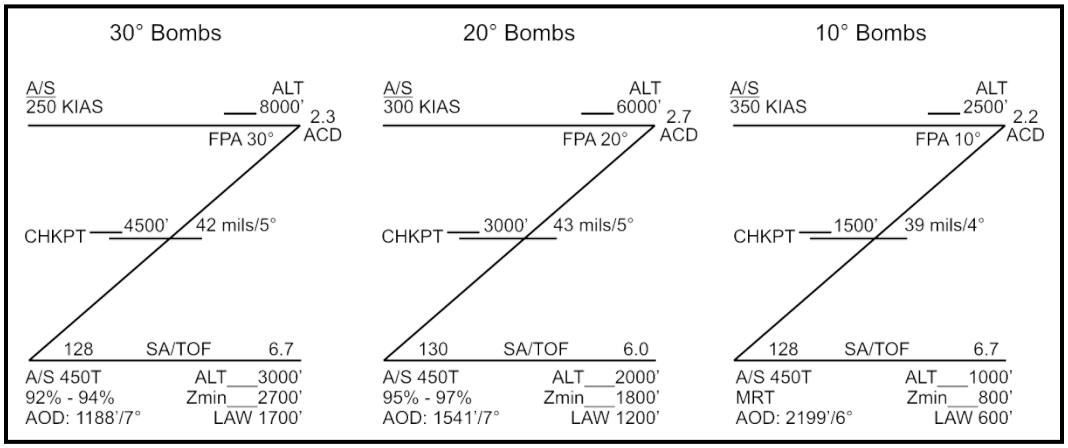

Figure 7-25 30/20/10-Degree "Z" Diagrams

NOTE

The numbers for the 10° dive pattern are different than the 10° section pop-attack diagram (Figure 7-26). The differences are due to the low-level route altitude restrictions and ingress altitude of 500 feet.

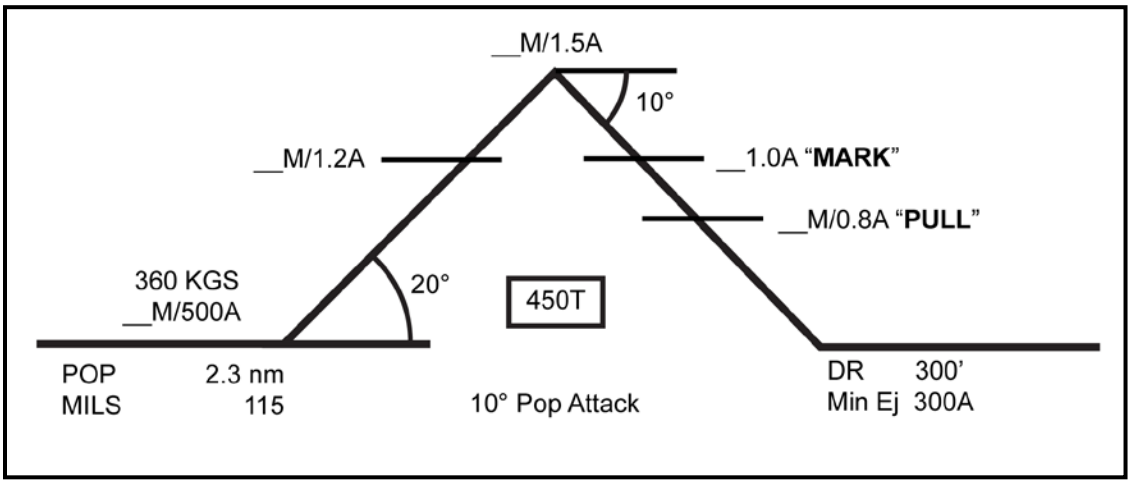

Figure 7-26 Low-Altitude Pop Attack Diagram

706. FLIGHT CONDUCT

On Deck

Lead NFS will check-in with the DASC on TAC Freq prior to taxi and will be passed current SITREP, holding instructions and FAC frequency.

Enroute

The flight will adhere to the IFR clearance. Approaching the target area, the flight will obtain a lower altitude from Center to cancel IFR, weather permitting, for entry into the MOA/Restricted area.

When weather precludes the use of the range (normally SHELBY range in R-4401), Areas 1-4 of the Pensacola South (GATOR) MOA will be used as an alternate target area. Waypoints are available in the STAN guide. The use of the PNSS MOA will require use of amended delivery altitudes to remain above the 11,000' floor of the MOA.

Fence In / Fence Out Checks

As the target is approached, the students shall complete the A/G combat checklist. This is accomplished by fencing in the flight with a "FENCE IN" call over TAC FREQ. This directs the flight to switch from an administrative conduct to the tactical conduct of the mission. This will generally be directed when you have cancelled IFR, you have SA on the target area, and have established communication and entry into the area in use. Students shall endeavor to complete it prior to entering into the area, or approaching the target, to allow total focus on the task at hand once established in the range.

LEAD NFS: "Hammers, switch button 23, Fence In."

-2: "2"

-3: "3"

-4: "4"

A/G Combat Checklist (STAMPS):

1. **Screens…**
   a. L MFD……..……..……..ADI
   b. R MFD – STRS/WEPS/Sta Sel……BOMB/GUN/ROKT
   c. MAN, CCIP…….……select as briefed
   d. Target Height/Elevation…….……...Entered
2. **Tapes (VTR**)…….……...ON/AUTO
3. **Altitudes (Baro Alt/ LAW)**……...……UPDATE
4. **Master Arm**……...……..AS BRIEFED
5. **Pattern**…….BRIEF
6. **Symbology (HUD)**……A/G CHECK

After completion of the G-Warm, the lead NFS will initiate the fenced in call on TAC FREQ:

LEAD: "Hammer 11, Fenced In, 2.4." (2.4 being the fuel state)

-2: "Hammer 12, Fenced In, 2.4."

-3: "Hammer 13, Fenced In, 2.3."

-4: "Hammer 14, Fenced In, 2.2."

At an appropriate time, after the conduct is complete and the flight is safely joined up, the lead NFS will direct the flight to FENCE OUT. This will transition the division from a tactical

mindset back to an administrative one in which the A/G checklist is reversed and set into NAV mode for the RTB.

Switchology

Prior to the initial push, reset LAW to standard setting:

30-degree pattern – 1700 ft.
20-degree pattern – 1200 ft.
10-degree pattern – 600 ft.
10-degree pop – 450 ft.

These settings are based on a 450 KTAS dive recovery with a 4 G pull. During the trim run, you may set your armament switches, except for the Master Arm switch. Be sure that your appropriate pipper symbology or gunsight comes on and that you have the correct mil settings for your intended ordnance and pattern.

1. Verify the MFD Weapon selection to BOMB on the desired station.

2. Check for correct MAN or CCIP settings.

3. Approaching roll-in, set the Master Arm switch to ARM. Check that the ”X” indicating WEAPON-SAFE has been removed from the selected weapon in the HUD A/G display, and MFD STORES A/G page indicates ARM.

4. To release (“pickle”) a bomb, the IP will press the release button, called the pickle, located to the left of the trim switch on the stick grip.

5. Upon recovery from each run, the IP will set the Master Arm switch to SAFE. For succeeding runs, operate only the Master Arm switch. After the last run, ensure the IP has set the Master Arm switch to SAFE. Check for SAFE on the STORES page deselect BOMB select NAV to reconfigure the HUD then select HSI mode.

Strafing Switchology

1. Verify the MFD Weapon selection to GUN.

2. Check for correct MAN or CCIP settings.

3. After roll-in, and after the aircraft in front of you has called “Off” and cleared your line of sight, place the Master Arm switch to ARM.

4. To simulate firing, depress the trigger on the front of the stick grip. A release tone will come through your ICS and an “X” indicator will appear on the right side of the HUD display. Be sure to release the trigger at the correct cease-fire altitude.

5. Upon recovery from each run, place the Master Arm switch in SAFE. For succeeding runs, operate only the Master Arm switch. After the last run, set the Master Arm switch to SAFE.

6. Check for SAFE on the STORES page deselect GUN select NAV to reconfigure the HUD, then select HSI mode.

Range Check-In

Clearance into the range will be obtained from Range Control. A restricted area may not be entered without clearance from the appropriate controllers. Clearance to enter the Range will be requested from the controller aircrew (-3 or -4) after canceling IFR and detaching; however, the NFS shall be prepared to make the range check-in if necessary. The following flight information will be passed to Range Control on check in:

1. Flight call sign

2. Number and type of aircraft in the flight

3. Position (relative to the target)

4. Ordnance onboard

The controller aircraft will proceed overhead the target for check-in while the remaining aircraft in the division will proceed to the holding CP as assigned by the DASC. Once established in holding, the flight will check in with the (instructor) controller.

Range Procedures

The controller will run the CAS scenario and will be the overall coordinator for safety and deconfliction airborne. All dive clearances in the target area will be given by either Shelby Range Control or by the controller. All direction given by the controller and/or Shelby is mandatory, including assigned altitudes or directive comm.

Final Rendezvous

At the end of the scenario, all aircraft will be directed to an egress CP to rendezvous for the RTB. All aircraft will maintain their assigned altitude until they have all aircraft in sight. The controller aircraft will join as Dash 3 or 4 as appropriate. Once the flight is rejoined, the controller aircrew will check out with Range Control.

Return To Base

Lead NFS will coordinate with ATC for a division recovery.

As the flight RTBs, the lead NFS will direct the flight to" in the same fashion the flight Fenced In. This is done in order to switch from a tactical conduct to the administrative conduct for the

return home. This task shall be done as soon as everyone is safely in formation and attention can be divided inside and outside the cockpits.

The lead IP will initiate a division fuel check via hand signals and the flight will proceed on course at a VFR altitude until an IFR clearance is received. The lead NFS will coordinate the IFR clearance with the appropriate controlling agency. The division will recover via course rules in accordance with the standard division formation procedures.

If the Tower is **not** accepting break traffic, the lead will coordinate splitting the division into two sections. The sections will recover using the following preferences (at the section lead's discretion):

Visual straight-in

PAR/ILS

ASR

TACAN

Section leads may coordinate "splitting the duals" or "taking their own separation" on final for the same runway. Additionally, section leads have the option to further split their flight into individual aircraft for recovery if conditions warrant.

Division RTB flight conduct and landing pattern communications will be in accordance with this FTI and squadron SOP.

Battle Damage Checks (BDC)

In VT-86 division flights, battle damage checks, which are usually performed after FENCE OUT calls, will be performed on the rendezvous as each aircraft crosses under for the join up in echelon. As each aircraft approaches the point to cross under, the crew will inspect the top of all aircraft already joined up. As the cross under is executed, the joining crew will inspect the bottom of all aircraft. As the crossing aircraft joins to the outside of the formation, the crew will inspect the opposite side of each aircraft already in echelon.

Lead crew, and those already in formation, will also visually check each joining aircraft as they perform their cross under. This will ensure that –4 (or –3 in a Three plane) is checked as the last aircraft to join up. Silence is consent, meaning, that if no reports are made over UHF of any visible or suspected damage then it is understood that all aircraft are clear of any discrepancy and can proceed normally.

If ordnance is loaded, the hung ordnance check is made during the off-target rendezvous. During the final stages of the rendezvous, the lead checks each wingman for hung bombs. Each wingman will check all others in formation, as in BDC, as each wingman crosses under. The flight lead places the flight in cruise at which time -2 balances the formation. Upon lead’s command, the flight members report their switches safe, highest G pulled, and fuel remaining

over the TAC FREQ; -4 (or -3 if in a light division) adds “flight clean” if no bombs are hung or indicate which aircraft has hung ordnance.

RTB/Field Entry

Upon return to the field, flights will normally proceed to the initial and all NFSs shall ensure the formation is in the correct side for the break. The normal formation for the break is the echelon formation. At the Division Lead’s discretion, a Diamond Break formation can be pre-briefed.

Post Flight

After arriving back in the line and previous to engine shutdown, lead NFS will check out with the DASC on TAC and pass BDA via the Inflight Report format in addition to the normal maintenance and base calls.

In addition to the usual walk-around, check for any weapon-specific problems that may have occurred airborne. If installed, inspect the pylons, bomb rack(s) and wing undersurfaces for evidence of wing-to-bomb collision. Check the tail surfaces, especially leading edges, for evidence of damage from loose particles.

Debrief

A division flight debrief will be conducted in accordance with VT-86 standards. In addition to Safety, Admin and TAC Admin, NFSs will be required to debrief actual TOTs, delivery validation, as well as produce target imagery with attacked targets identified to verify target acquisition.

707. DIVISION WEPS SAFETY

Standard division safety factors were introduced in chapter 6. The dynamics of CAS and the weapons pattern require additional attention. The controller aircraft is the overall safety observer in the range complex and will provide for deconfliction of aircraft.

Lost Sight/SIMO Run

If the proper interval is established and maintained throughout the individual patterns, the danger of a midair collision is greatly reduced. All crewmembers must exercise extreme caution and take particular care not to cut the aircraft ahead out of the pattern. During a dive run, the attacking aircrew’s focus is on the target and the aircraft’s flight parameters. This is required for a safe and accurate delivery of ordnance. These dynamic tasks often cause the aircrew pulling off target to lose sight of their interval (aircraft ahead). This is the highest risk section of the pattern in terms of midair collisions. If aircrew are not visual the other aircraft anticipated to be in the vicinity (e.g. lead or -2) then they will call "blind" and level off before climbing through other aircrafts' altitudes (or descending out of their assigned altitudes).

Any time an aircraft loses sight of his proper interval, the potential for a midair exists. A similar danger can also arise near the roll-in point. A simultaneous run (simo run) is a short interval at the roll-in, usually resulting from an early or deep roll-in on the part of one aircraft. Any aircrew that sees a simo run shall call "**SIMO RUN**" on the UHF.

In order to avoid dangerous situations, these rules must be followed:

1. Maintain proper pattern airspeed and altitude as assigned by the controller.

2. Use proper voice procedures.

3. If "SIMO RUN" is called while in a dive run, the IP shall:

    a. Call "ABORT" on the UHF and abort the dive run by lateral displacement from the run in line.

    b. Regain sight of all other aircraft.

    c. Reestablish flight sequence at lead's discretion.

Target Fixation

Every crew would like to get a bull's-eye on every run, but unfortunately, some have become so engrossed in achieving hits that they have flown into the ground by fixating on the target and disregarding their release altitude. This is especially a problem with forward firing ordnance where it is easy to "follow" the projectile’s flight path. Last-second corrections usually result in both a false sight picture and a loss of altitude. NFSs have traditionally played a large part in preventing mishaps due to pilot target fixation. Safety requires a continual scan of the altimeter in the low altitude environment. Aborting a dangerous dive run is the responsibility of each member of an attack aircrew.

Lame Duck Pattern

The "lame duck" pattern is an administrative holding pattern for aircraft with problems that do not require an emergency divert but rather prevent the aircraft from continuing with the weapons pattern.

The lame duck pattern will be overhead the target at an altitude briefed by lead and is normally 1000 feet above the TAC (A)’s assigned altitude. Aircraft in the "lame duck" pattern will orbit in left hand turns to indicate NORDO, or right hand turns to indicate another or additional system problem. The aircraft will maintain assigned altitude. The controller aircraft will join on the lame aircraft after the scenario has been terminated and lead it to the off-target rendezvous. The NORDO or Lame aircraft will then be shuffled to the -2 position for division or section recovery.

The Lame Duck Pattern will be used for any minor emergency (i.e., immediate divert not required), overstress, airsickness, NORDO, etc.

Exceeding "G" Limits

Overstressing the aircraft in the weapons pattern is usually the result of snapping on G, instead of applying it smoothly when beginning the pullout after release. An overstress is determined by the G pulled relative to the aircraft weight. See the NATOPS manual for limitations. If an overstress occurs, the aircrew will notify the flight lead and proceed to the "lame duck" pattern.

Lost Communications

An aircraft with lost communications will remain at their assigned holding point and altitude where the controller of flight lead will conduct a rendezvous. If an aircraft goes NORDO while prosecuting an ingress, the NORDO aircraft will climb to enter the lame duck pattern overhead the target.

If an aircraft experiences a serious problem while NORDO, the aircrew has the option to squawk the appropriate code and return to base or divert to an emergency airfield as required. The lead may dispatch a wingman to assist.

708. CAS REVIEW

1. What are two, key factors that distinguish a CAS mission from any other air-to-ground mission?

2. Identify the two types of Close Air Support.

3. What is the function of the DASC?

4. Identify the two primary control points used in conjunction with a CAS mission.

5. What is the process used to confirm your identity to a CAS agency on the communications net?

6. What are the two methods used for CAS holding?

7. If during a dive delivery, you discover you are on a steep wire, what effect will it have on your mark altitude?

8. For frag avoidance considerations, you should ensure a separation of ____ seconds between aircraft.

9. True or False? When faced with possible AAA and hand-held IR missile threat, you should plan to stay as low as possible.

10. State the meaning of SEAD and describe its role relative to CAS mission execution.

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CHAPTER EIGHT
BASIC FIGHTER MANEUVERING THEORY

800. INTRODUCTION

No other phase of aviation places greater demands on the aircrew/aircraft combination than Basic Fighter Maneuvering (BFM). The skills required in BFM (situational awareness, crew coordination, lookout doctrine, performance of complex procedures under stress, etc.) are common to every tactical aircraft in the fleet. For these reasons both Strike and Strike Fighter students will be exposed to BFM in VT-86. Whether you are a future WSO or ECMO/EWO, you will find this final portion of the T-45C syllabus the most enjoyable and rewarding flying to date.

Definition of Basic Fighter Maneuvering (BFM)

BFM is one aircraft vs. one aircraft (1v1) air-to-air combat training utilizing canned maneuvering drills for the purpose of gaining proficiency in solving range, angle, and closure problems in order to achieve a positional advantage and either employ a weapon or deny an opponent a shot opportunity. BFM encompasses just one portion of the larger arena called Air Combat Maneuvering (ACM).

Purpose of Learning BFM

Undeniably, 1 v 1 Air Combat Maneuvering (ACM) training is fun, but there are a number of other reasons why it is important that Strike Fighter aircrew continue to study and train in 1 v 1 air combat.

- Combat Lessons Learned. Despite operating in an era of all-aspect, beyond visual range missiles, history has continuously proven that the majority of air battles are fought and won in the visual arena. Even in the largest furball or multi-plane engagements, for that brief moment when the decision is made to engage an opponent, we are involved in a 1 v 1 engagement. Strikefighter aircrew MUST be proficient at 1 v 1 ACM to minimize time-to-kill and ensure they leave merges unscathed.

- Develops Fundamental Tactical Skills -- Through ACM we are allowed to practice briefing debriefing, communications, crew coordination, and tactical decision making in a high stress, dynamic environment. The development of these core tactical skills and the confidence we gain in maneuvering our aircraft throughout its flight envelope improve our ability to perform and maintain situational awareness in other strike-fighter missions. The fundamental tactics and maneuvers of air combat have changed little in the last 70 years. In this stage, we will introduce the classic fighter versus fighter maneuvers and discuss how to employ them in staged and dynamic situations. It is incumbent upon all Strikefighter aircrew to have a sound understanding of 1 v 1. The 1 v 1 ACM discussion will use a building block approach, progressing from basic aerodynamic review to a look at the maneuvering capabilities of our aircraft, offensive and defensive sight pictures and execution, and finally to 1 v 1 gameplan development and execution.

Tactical Role of the NFO

The Naval Flight Officer is an integral member of the Strike Fighter team, and as such, has a pivotal role in the employment of Strike Fighter aircraft in the ACM arena. While no current Naval Strike Fighter aircraft in the U.S. inventory has flight controls in the rear cockpit, the occupant of that cockpit is no less important. A thorough understanding of BFM principles in both cockpits is required for the crew to succeed. During the execution phase of an air combat engagement, each aircrew will have distinct responsibilities in order for them to prevail. While the pilot will be actively engaged in maneuvering the aircraft in order to gain a positional advantage or deny an advantage to our opponent, the NFO, through solid crew coordination, will be an SA enabler that serves to increase the overall combat efficiency of the Strike Fighter Team. As such, the basic ACM skills that each NFO need to master revolve around the basics of: Visual Lookout, Sensor Nose Recognition, Deck Awareness and Basic Airwork Recognition (BAR).

Lookout Doctrine

For fighters, the extra set of eyes of an NFO provides a quantum advantage when compared to single seat aircraft. In an engagement, the NFO proves invaluable in maintaining sight of friendly and adversary aircraft, particularly in the multi-bogey arena, while the pilot may focus on prosecuting one particular aircraft. An effective lookout doctrine is the cornerstone of mutual support. Most air-to-air kills in combat were achieved through complete surprise. The abeam position with lateral separation used in combat spread affords the maximum visual coverage of the rear hemisphere of the flight (the high threat area). Figure 8-1 illustrates the pilot and NFO lookout responsibilities.

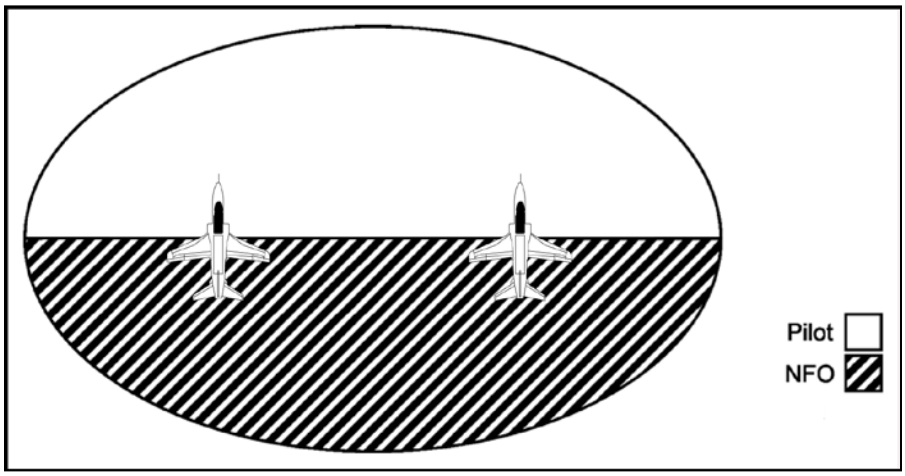

Figure 8-1 Crew Lookout Responsibilities

While the pilot is responsible for the area forward of the wingline, the NFO should direct his visual search from deep six o'clock to the abeam position inside the section. This scan pattern covers outside both sides of the section, and double covers the inside of the section. Remember to scan all altitudes. Be sure to focus your eyeballs on the horizon (or a distant object) so you are not staring at the glass of the canopy and unable to see objects outside the cockpit.

8-2 BASIC FIGHTER MANEUVERING THEORY

Some "Rules of Thumb" for lookout doctrine:

1. Always look in the direction of a turn and aft of the wing-line.

2. Remember that ACM is three-dimensional. You must scan more than just the horizon (look high and low).

3. Do not fixate on the wingman.

4. If your neck does not hurt, you're not looking far enough aft.

5. Turn your entire body, not just your head.

6. If you wear glasses (or contacts), wear them!

Sensor Nose

"Sensor Nose" is a term that we as Strike Fighter aircrew use to indicate that our opponent has arrived in a position to employ the capabilities of his aircraft's weapons suite. If we wait to react until our opponent has employed a weapon, we have waited too long. In the fleet, many threat aircraft will have the ability to employ weapons at us even though they are not "nose on." To survive in the air combat arena, we need to have the ability to recognize when our opponent is reaching the angular capabilities of his weapons system and react accordingly. Even against threat aircraft that employ boresight only weapons, if we wait until our opponent is "nose on" to defend, we will find ourselves fighting our opponent's missile and not our opponent's aircraft. In the VT-86 BFM syllabus, we will be assuming a boresight-only, IR missile threat. Even so, with the field-of-view of most IR missiles and the instantaneous turn rates associated with modern aircraft, we can find ourselves threatened much sooner than "nose on." For the purposes of the VT-86 syllabus, we will define "sensor nose" as 30 degrees target aspect: that provides for a 20 degrees missile field of view and 1.5 seconds of instantaneous turn rate in the T-45 should our opponent execute an energy excursion to pull for a shot. As a crew member in the aircraft, any time we see our opponent arriving sensor nose-on, we should call for our pilot to execute a break turn and simulate expending flares to keep our opponent's IR missile on the rail. For example:

NFS (ICS): "Break right, bogey right five."

NFS (UHF): "Flares."

Deck Awareness

Most 1 v 1 engagements trend downhill and generally arrive at or near the Hard Deck, or simulated ground. While our opponent may have a variety of weapons at his disposal, the P_k of the ground is generally 1.0 and is our greatest concern. As a crewmember sitting roughly six feet behind our pilot, if he flies himself into the ground, we are only a half-second behind him. Particularly if we find ourselves defensive, our pilot will be concentrating more outside the aircraft on our opponent and less on his instruments inside the cockpit. As a participating

crewmember, it is incumbent upon us to back up our pilot on altitude and nose position as we approach the deck. As a general rule of thumb, it takes about 6000' for a T-45 to execute a pure nose-low, Split 'S' maneuver. Anytime we find ourselves below 6K' above the deck, we will want to employ the 10° Rule: 10 degrees nose-low for every 1000' above the deck, i.e. 4000' above the deck = no more than 40° nose low. As we approach the deck, the NFO should be providing altitude calls at least every 1000', and if we find ourselves violating the 10° Rule, give a "Watch the Deck" call. Voice inflection becomes an important tool we can use if our deck transition is more extreme than we might prefer. Remember that the "Hard Deck" is a Training Rule and if we ever find ourselves below the briefed deck, it is the responsibility of the aircrew who recognizes it first to immediately call "Knock-it-Off."

Basic Airwork Recognition(BAR)/Crew Coordination

Again, during a 1 v 1 engagement, our pilot will most likely be spending the majority of his time concentrating his visual scan on our opponent. As a participating crewmember, we can aid our pilot in employing our aircraft most efficiently if we can provide him with information that his preoccupation is preventing him from scanning: airspeed and altitude. Generally, any time we find ourselves going nose-high, we would like to provide our pilot with airspeed calls; airspeed tells him how nose-high he can go. If we find ourselves nose-low, we would like to provide our pilot with altitude calls; altitude tells our pilot how nose-low he can go. Any time we find ourselves outside our target airspeed band for the type fight we are trying to fight, an airspeed call would most likely be appropriate. And of course, anytime we find ourselves below 6000' above the deck, we want to be spring-loaded to start making Deck Transition calls.

By concentrating on the four principles mentioned above, at a minimum, we will find ourselves, as an NFO, a participating member of a lethal Strike Fighter Team and not just a passenger.

801. ACM ENVIRONMENT

Before discussing the types of maneuvers and engagements, and the procedures for executing them, you should understand something about the airspace in which ACM takes place, so that you can exploit it to your best advantage. The ACM environment, like any other arena, has dimensions you can measure with rules and limitations, beyond which you are severely penalized. Even though the environment is larger and more dynamic than a simple arena, it is a three-dimensional environment through which you will maneuver in an infinite number of planes, ranging from the pure vertical, through the oblique, to the pure horizontal.

The limitations stem from a combination of the effects of gravity, your energy state and airspeed, the limitations of your aircraft, and your individual situation given a "snapshot of time" during an engagement, all of which we will consider before we talk about specific procedures. Why? Most fighter aircraft bleed energy as they maneuver and do not have a thrust-to-weight ratio greater than one. Therefore, their energy package is finite. ACM is a series of tradeoffs. A continuous series of decisions based on what you know about your aircraft, your enemy's aircraft, and your situation.

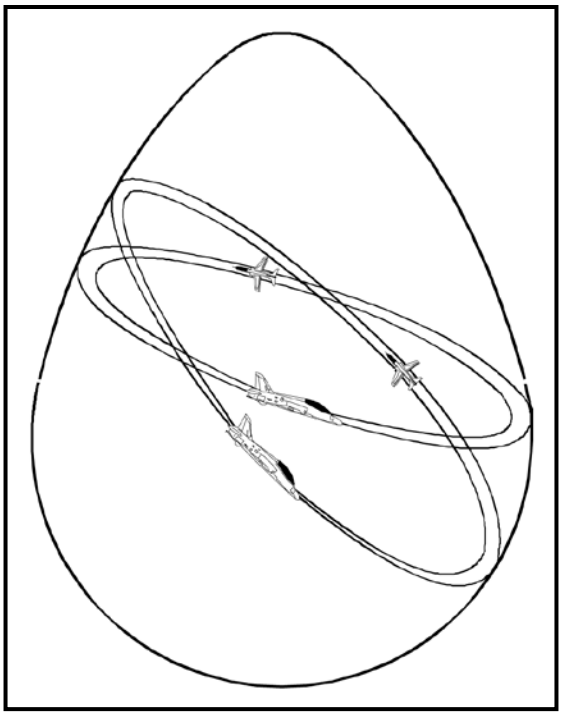

Figure 8-2 ACM Environment

Figure 8-2 depicts "the egg," representing a three-dimensional sphere showing the effects of gravity as you maneuver in all planes. Throughout an ACM engagement, the effects of gravity affect our turn performance relative to our opponent and his position on the egg. In order to capitalize on the benefits, or mitigate the counter-effects, of gravity in the ACM arena, we must first understand how "God's G" affects the performance of our aircraft as it maneuvers.

Horizontal Maneuvering

The most basic of all aerodynamic principles states that an aircraft, to maintain straight-and-level flight, must generate exactly 1 G to overcome the effects of gravity. Because the amount of lift required to maintain a 1-G flight is based on the weight of the aircraft (excluding the effects of drag), the vector representing gravity remains constant as long as the weight of the aircraft remains constant.

An aircraft in a turn at any angle of bank (AOB) must generate additional load factor in order to meet the same effective lift. The load factor increases because your lift vector is moved out of the pure vertical. If we assume that the effective lift of the aircraft opposes gravity (which is a constant force), the load factor will vary according to how tightly you want to turn the aircraft. As you can see in Figure 8-2, both aircraft (a) and (b) are in level turns at a constant true airspeed (TAS). Aircraft (a) is in an 80-degree AOB and aircraft (b) is in 60-degree AOB. Because aircraft (a) is turning at an 80-degree AOB, his load factor is greater than aircraft b turning at a 60-degree AOB. Notice that because gravity and the effective lift remain constant forces, the

resultant vector, referred to as “radial G,” actually turns the aircraft. Radial G is the horizontal component of lift. If you pull harder in a turn, which is indicated on your accelerometer and referred to as “indicated G,” you are increasing the load factor. Depending on your situation (your snapshot in time), this triangle will change. Simply put, the larger the radial-G vector, the better the turn performance. As you see in Figure 8-3, in a purely horizontal turn, the greater the AOB, the greater the load factor to maintain effective lift. This greater load factor produces greater induced drag, resulting in a higher energy loss.

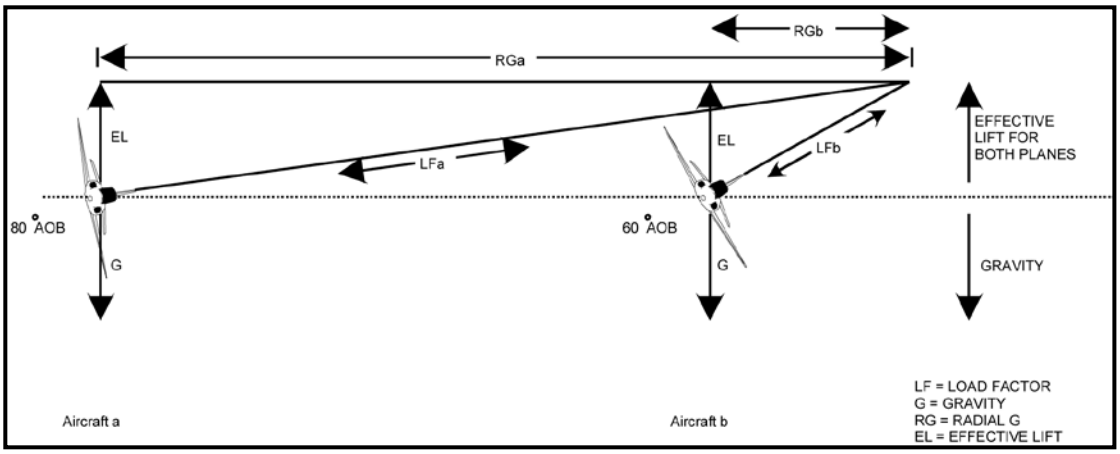

Figure 8-3 Horizontal Maneuvering

Vertical Maneuvering

Figure 8-4 represents another theoretical loop in the vertical plane at constant TAS and constant indicated G. Unlike a purely horizontal turn, your turn performance in a purely vertical turn is affected differently depending upon where you are in the turn.

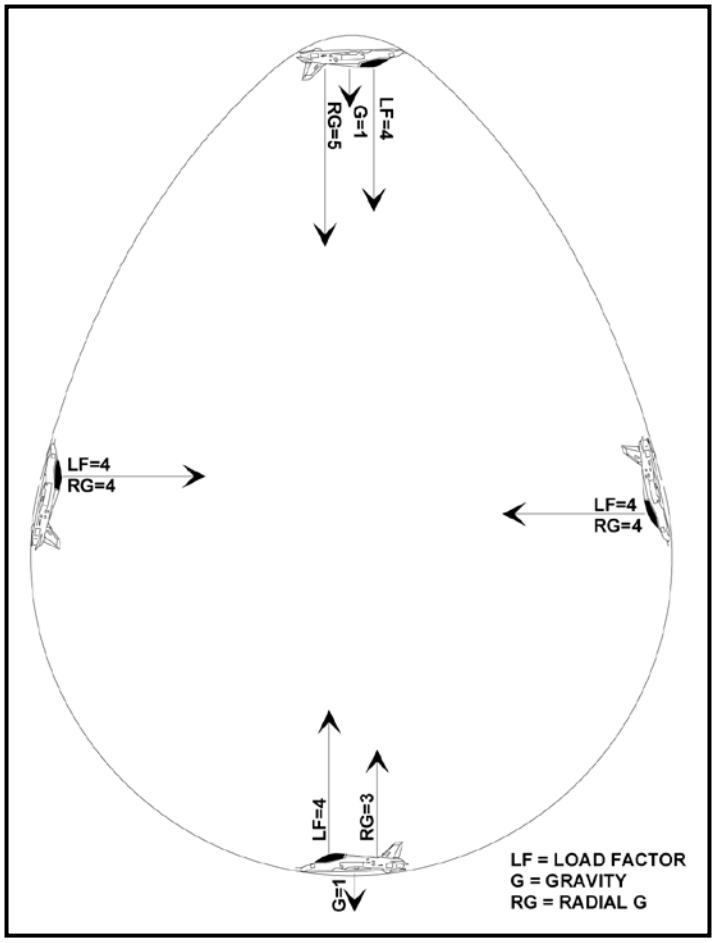

Figure 8-4 Vertical Maneuvering

When the aircraft lift vector is above the horizon (at the bottom of the egg), radial G decreases because gravity opposes the load factor of the aircraft, resulting in a larger turn radius and a lower turn rate. When the lift vector is below the horizon (at the top of the egg when the fighter is inverted), radial G increases because gravity assists the load factor and lift, resulting in a smaller turn radius and faster turn rate. When the aircraft is pure vertical (side of the egg) the load factor is parallel to the horizon and, therefore, equals radial G, indicating an intermediate turn performance. So when your lift vector (load factor) falls below the horizon, gravity assists your turn performance.

Vertical Airspeed

While the T-45C has the ability to perform a loop at a minimum of 250 KIAS, it would be far from a tactical maneuver as the pilot would have to devote an inordinate amount of attention to completing the maneuver at the expense of focusing on his opponent. In addition, the aircraft would be left with insufficient kinetic energy at the top to allow for “tactical” turn performance, whether in turn rate or turn radius performance. However, we will define 250 KIAS as our

"Minimum Vertical Airspeed" that we can maneuver vertical in the oblique. In order to perform a pure vertical maneuver that allows for tactical maneuvering at the top requires approximately 300 KIAS, which we will define as our "Tactical Vertical Airspeed."

Energy Management (E-M Diagram)

As we have seen already, an aircraft's turn performance is relative to the amount of radial G that aircraft can generate. Other than gravity, the greatest parameter affecting the amount of radial G an aircraft can generate is its energy package, or Total Energy. Total energy (TE) is the combination of the aircraft's altitude (Potential Energy - PE) and airspeed (Kinetic Energy - KE).

The Energy-Maneuvering (E-M) diagram, Figure 8-5, is a graphical comparison of the aircraft's turn performance capability in relation to its energy state. The E-M Diagram is a mosaic of several graphs all overlaid on a Cartesian Plane, depicting Turn Performance (in degrees per second) versus Airspeed (in KIAS). It is the blueprint by which we determine how we will employ our aircraft in the BFM arena. The following is a representation of the T-45C E-M Diagram for a T-45C in the clean configuration, at MRT power at 10,000' MSL:

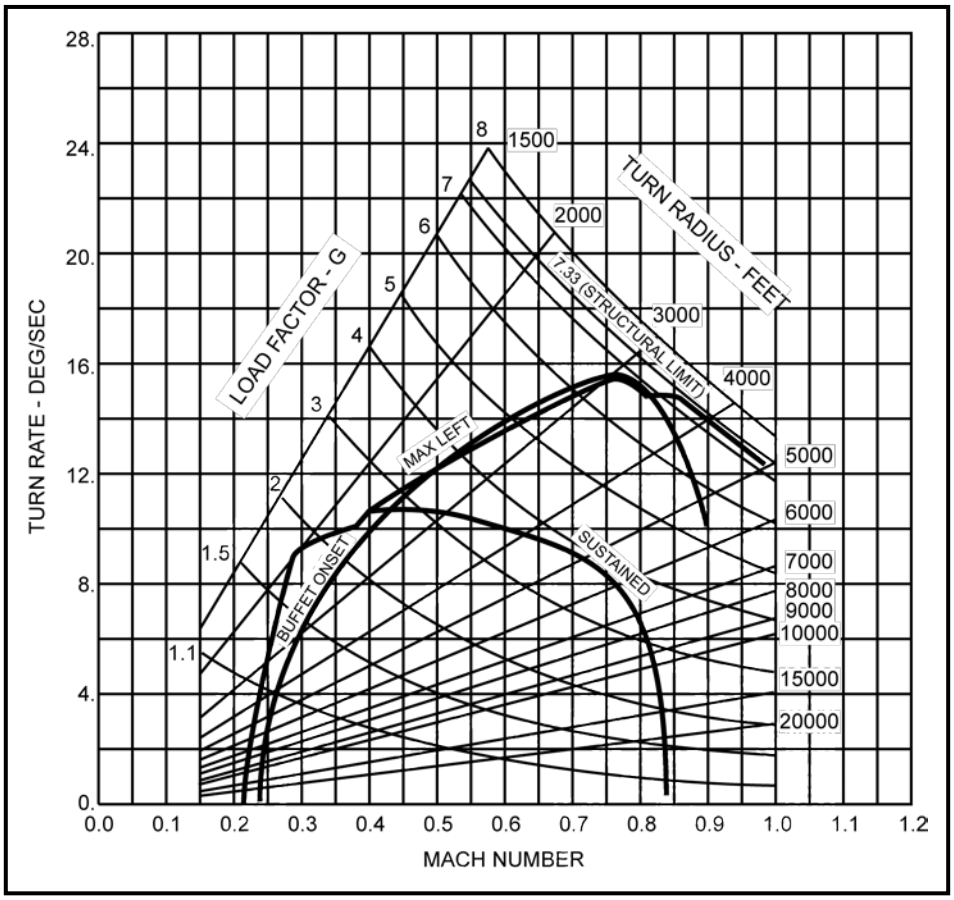

Figure 8-5 T-45C E-M Diagram (10,000' MSL)

The T-45 E-M Diagram is unique in regards to its depiction of aircraft performance in the clean configuration. The inability of the T-45 to use maneuvering devices/flaps, found in most fighter aircraft, in the high AOA regime results in a maneuvering curve that is atypical of most fleet aircraft. Notice that the lift limit curve does not intersect the structural limit curve of 7.33 at 10,000' (indicating that the aircraft cannot be overstressed at 10,000' MSL). This is mainly due to the stalling of the horizontal stabs due to blanking of the control surfaces at higher AOAs at higher airspeeds, manifested as the characteristic T-45 "pitch buck" (a direct result of the lack of maneuvering flaps/slats). In fact, our corner airspeed of 410 KIAS is reflected by the peak of the lift limit curve at 6.5 Gs. For the purposes of discussing the E-M Diagram, we will examine a generic, more representative model.

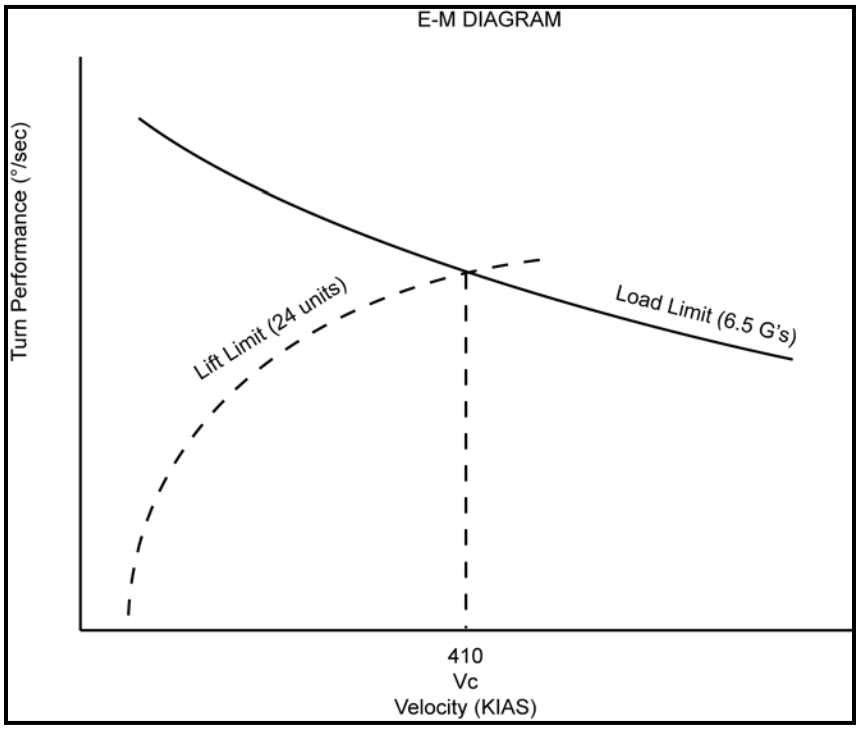

Figure 8-6 Corner Airspeed

Lift Limit

The first component of the E-M Diagram is the intersection of the Lift Limit curve and the Load Limit curve. We call the airspeed where this intersection occurs: "Corner Airspeed." The significance of Corner Airspeed is that below Corner we will reach our lift limit prior to our G limit, meaning that we cannot overstress below corner. It is possible that a significant onset rate could cause the aircraft accelerometers to overshoot, but we cannot exceed the aircraft's structural limit at those airspeeds. In addition, we achieve our highest turn rate/turn performance where the curves peak at their intersection, i.e. Corner. At any airspeed below corner, if we pull more than 24 units AOA, regardless of power setting, we will stall the aircraft in what we call an "accelerated stall." By easing our pull to below the lift limit, we recover immediately from the stalled condition.

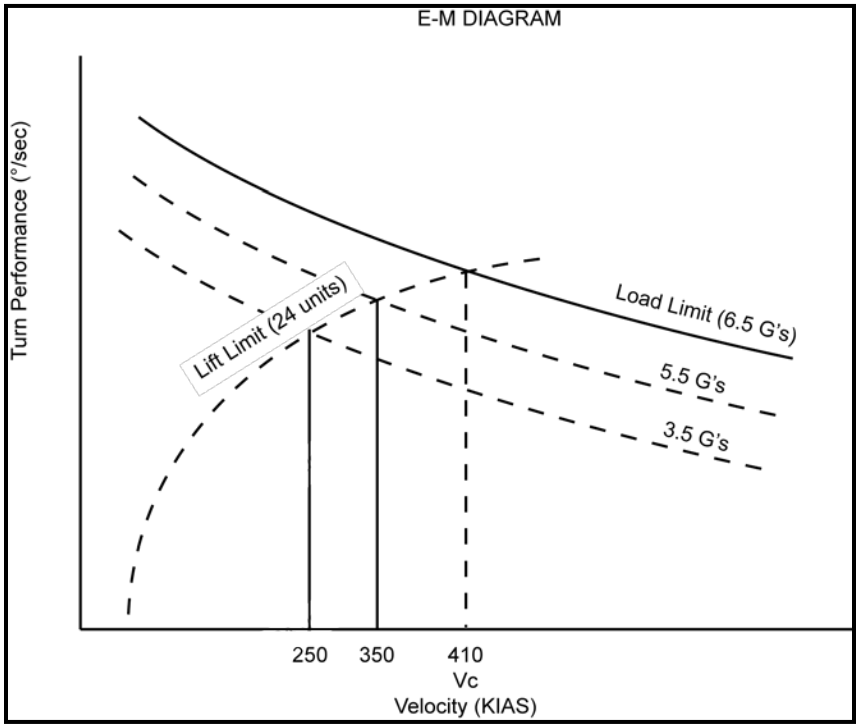

Figure 8-7 G Available

Max G Available

As depicted in Figure 8-7, there will be an infinite number of G curves that parallel the G-limit curve, each intersecting the Lift Limit at subsequently lower airspeeds. From this depiction, it is easy to see that with a decrease in airspeed, our G available also decreases as we reach our Lift Limit at a lower G and turn rate. As a general rule of thumb, we will lose 1 G for every 50 KIAS below Corner. Therefore as our airspeed decreases, our ability to generate radial G, and turn performance, subsequently decreases.

Max Instantaneous Turn Performance

The best turn performance of our aircraft, at any given airspeed, is defined by the limits of the Lift Limit and Load Limit curves: above Corner we get our best turn performance at our G-Limit, while below Corner we achieve our best turn rate on our Lift Limit. At Corner we achieve our Max Instantaneous Turn Performance, achieving our best turn rate and smallest turn radius at the expense of energy. In fact, at our Lift Limit we are achieving our maximum turn performance given our airspeed and our aircraft will bleed energy as it is operating in a stalled condition. For that reason we will say we are "Max Performing" our aircraft when we are operating on our Lift Limit. Above corner airspeed, we cannot reach our Lift Limit due to the structural limit of our aircraft and therefore are "arcing" or not "Max Performing." Unfortunately, due to the lack of leading edge maneuvering devices, the T-45C tends to generate uncommanded wing rock at its lift limit, making lift vector control difficult at best.

Due to this instability of the aircraft's roll performance at 24 units, we will target 19-21 units to "Max Perform".

Sustained Turn Performance

As we have already pointed out, an aircraft cannot maintain a stabilized energy state while operating on its Lift Limit. In fact, as an aircraft continues to "Max Perform," its airspeed decays and with it, its turn performance as it follows the Lift Limit curve to the left. There are an infinite number of turn performance curves, relating to AOA that parallel the Lift Limit curve below it. Each reduced AOA curve results in a lower turn rate but also less energy bled during the turn. The turn rate which we can sustain without any energy loss, either in altitude or airspeed, is defined by another set of graphs overlaid on the E-M Diagram called the Ps curves.

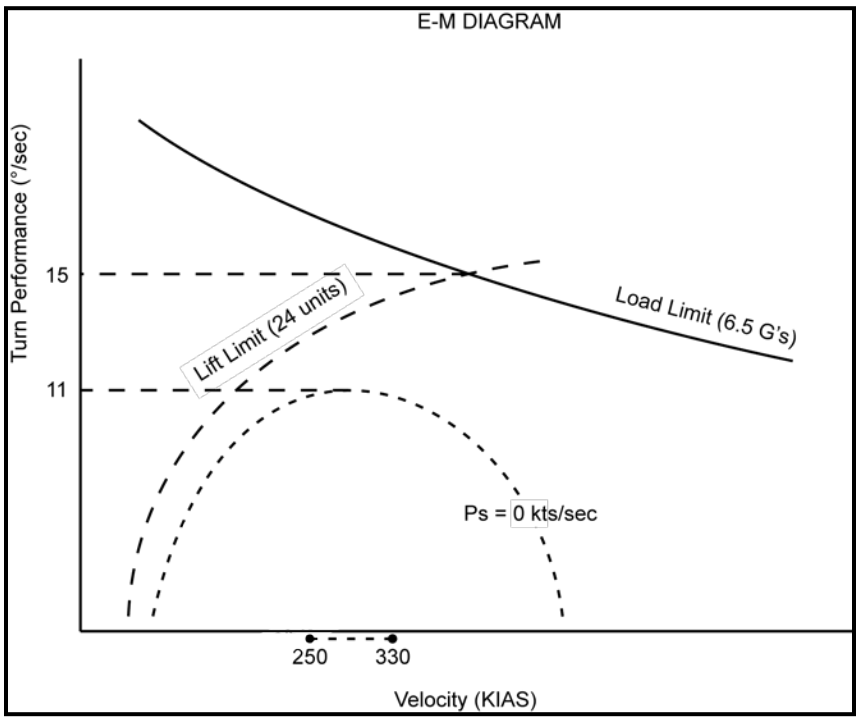

Figure 8-8 Ps=0 Curve

Like the AOA and G curves, there are an infinite number of Ps curves, each relating to a turn performance and stabilized energy change. The Ps curves are defined by the loss in KIAS per second to maintain the corresponding turn performance although it is important to note that energy loss can be either in airspeed or altitude. The curve that we are most concerned with is the Ps=0 curve which gives us our best "sustained" turn performance without any loss of energy. The Ps=0 curve usually plateaus across a range of airspeeds and in the case of the T-45, this occurs between 250 and 330 KIAS. At the upper end of this plateau, at approximately 300 KIAS, the Ps=0 curve intersects the 14 unit AOA curve. If we again look at the Ps=0 curve we see that it plateaus between 250 and 330 KIAS. This gives us our best sustained turn performance. Sustained turn performance only applies when we cannot, or do

not desire to, expend any more energy, for example when we are on the deck. While at 250 KIAS, our sustained turn performance gives us about one more degree per second, and we begin to lose other options, i.e. the ability to break turn or a vertical move option. For this reason we will target between 300 and 330 KIAS for our sustained turn performance, or our "Rate Band." However, if sustaining energy is not a priority (we need to honor sensor nose or we have altitude to lose) our best turn rate for any given airspeed occurs on our lift limit. Figure 8-9 depicts the Sustained Rate Band for the T-45C.

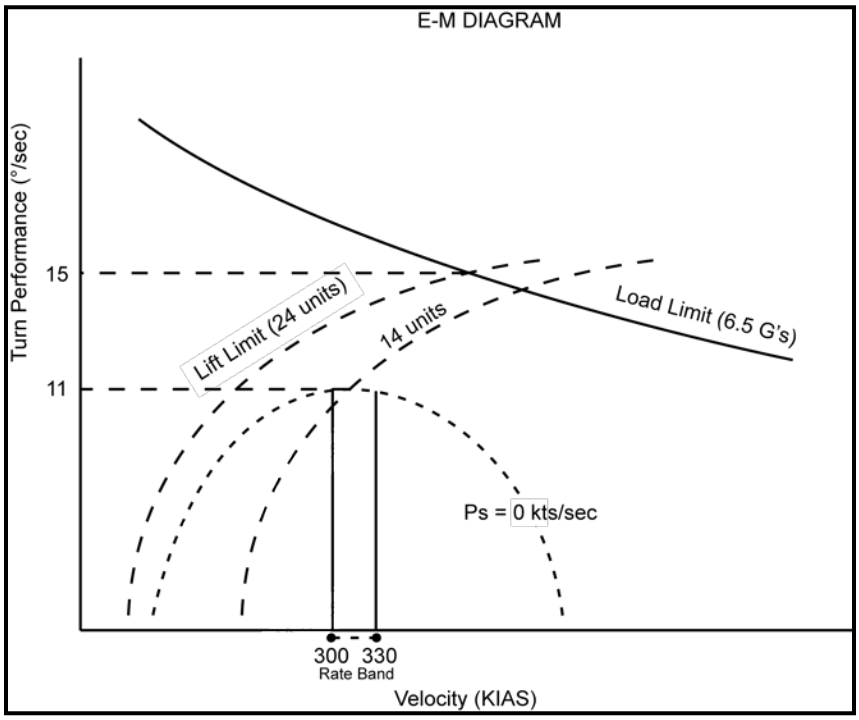

Figure 8-9 Sustained "Rate" Band

Turn Radius Performance

The minimum turn radius for any given airspeed occurs along our Lift Limit. In fact, the radius curves on the E-M Diagram generally parallel the Lift Limit curve and vary not much more than a couple hundred feet of radius all the way to Corner Airspeed. While it is true that our smallest turn radius occurs between 130 and 150 KIAS, at that airspeed, we have few other options should we need to "Max Perform" for any given reason, i.e. break turn, vertical counter, etc. For that reason we will target a "Radius Band" of 150 to 300 KIAS, as depicted in Figure 8-10. Extending our radius band up to 300 KIAS gives us a rate benefit and the ability to go into the vertical without sacrificing much in the way of radius. No matter our airspeed in that band, "Max Performing" our aircraft at 19 to 21 units AOA will give us our smallest turn radius.

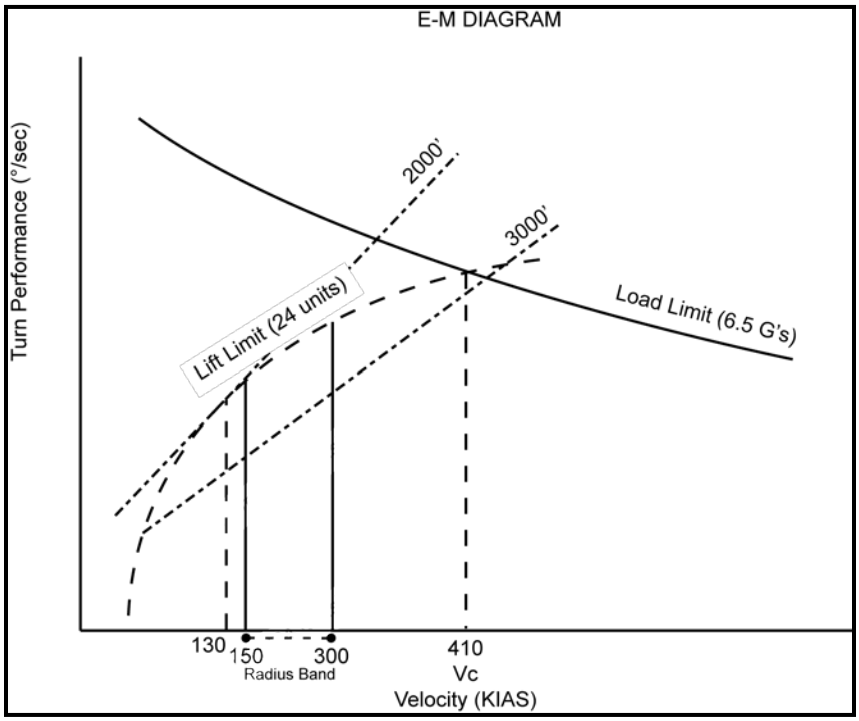

Figure 8-10 Turn "Radius" Band

In summary, Figure 8-11 summarizes the key performance characteristics of the T-45C from the E-M Diagram:

Terminology	Performance	Airspeed	AOA
Radius Band	Smallest Turn Radius	150-300 KIAS	19-21 units
Rate Band	Best Sustained Turn Rate	300-330 KIAS	13-14 units
Hard turn	Compromise Performance	N/A	16-18 units
Break turn/Max Perform	Max Instantaneous Turn	410 KIAS	19-21 units
Extension/unload	Optimum energy addition	250 KIAS	5-10 units
Min Vertical Airspeed	Oblique Vertical	250 KIAS	16-18 units
Tactical Vertical A/S	Pure Tactical Vertical	300 KIAS	16-18 units

Figure 8-11 E-M Diagram Performance Numbers

802. BFM GEOMETRY

With an understanding of the basic aerodynamics and aircraft performance characteristics, we can now introduce the geometry of BFM required to employ our aircraft efficiently to arrive in a Weapons Engagement Zone (WEZ) or mitigate our opponent's angular advantage should we find ourselves defensive. BFM revolves around the central spatial relationships of range, angles-off and closure rates between aircraft and the management of each in the ACM arena.

Range, Angles-Off, and Closure Rate (RAC)

Range, Angle-off the tail, and Closure are the three basic geometric variables of BFM that the fighter crew manages throughout an ACM engagement. RAC can also be interchanged with the terms “lateral separation” or “turning room” in different contexts of BFM.

- Range - the linear distance between two aircraft, generally delineated in thousands of feet or in nautical miles. All weapon envelopes are defined in terms of range. Range also determines how much room we have to maneuver our aircraft in relation to our opponent.

- Angle-off the tail (AOT) - your angular position off the bogey's tail. Figure 8-12 illustrates different AOTs referencing a target aircraft. AOT is generally a measure of fuselage alignment and one indicator of offensive advantage. Weapons envelopes are also defined in terms of angle off.

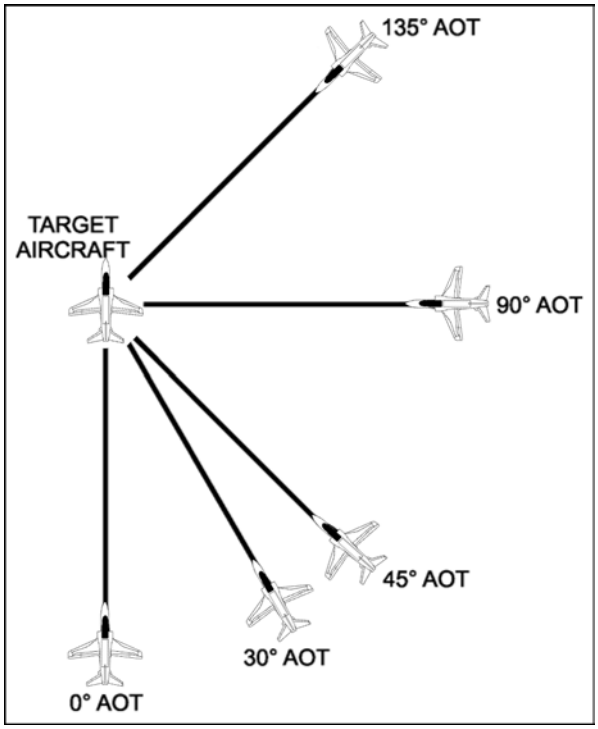

Figure 8-12 Angle-Off-the-Tail (AOT)

- Closure rate (V_c) – the relative change in separation between aircraft, generally measured in knots. Without an air-to-air radar to measure closure, the fighter crew must visualize how fast range to the bogey is changing. Closure must be controlled in order to achieve or maintain a positional advantage.

Turn Circle Components

Figure 8-13 shows the various components of the turn circle as an aircraft maneuvers in the ACM arena.

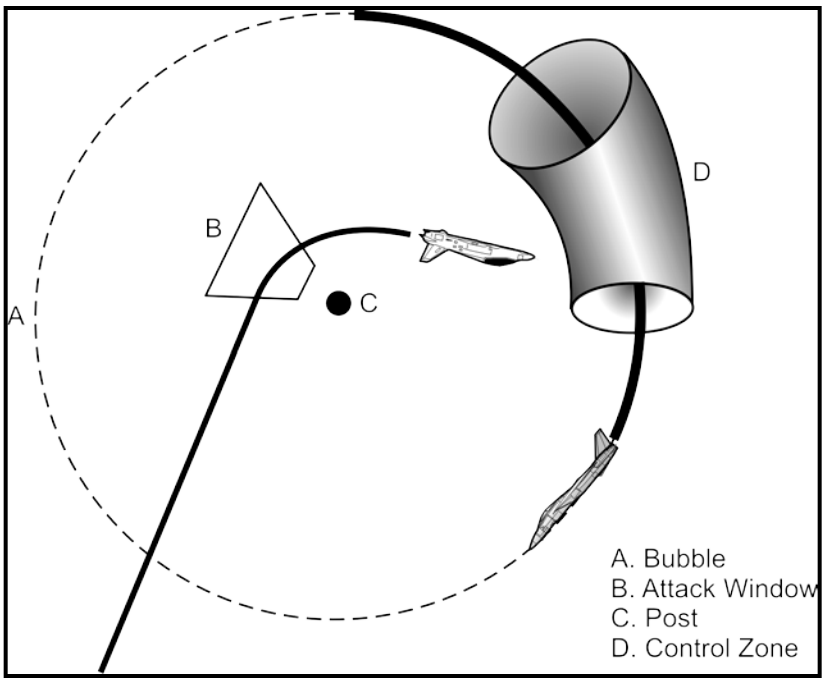

Figure 8-13 Turn Circle Components

The Bubble

Often in Naval Aviation we find “the Bubble” improperly defined as simply our turn circle. While an aircraft's "Turn Circle" is the circular path an aircraft scribes through the sky at any given time, "the Bubble" is more correctly defined as our turn circle when we are “Max Performing” our aircraft for any given airspeed. That means we are getting our smallest turn radius and greatest turn rate for that airspeed. This is significant in the fact that if we are defensive and our opponent is inside our bubble (assuming similar performing aircraft), we cannot deny him turning room no matter how hard we pull. Likewise if our opponent is outside our bubble, we can take angles away from him. So how do we know if our opponent is inside our bubble? Sight picture is the key. If our opponent is outside our bubble, we can take away angles from him and therefore it will be manifested in the ability to pull him forward on our canopy. When our opponent stabilizes on our canopy and starts to drift aft during our pull, our opponent has achieved bubble entry. Likewise, if we are offensive, and are outside our opponent’s bubble, any pull our opponent makes will appear as target aspect change as he denies us angles. As we enter our opponent’s bubble, target aspect change will transition to line of sight change, a sign our opponent can no longer deny us angles. Bubble entry is one of the most important concepts of both offensive and defensive BFM and will be discussed in more detail later.

Control Zone

In the past, discussions of BFM often referred to the "Control Point". While the "Control Point" does exist, it is an unachievable goal. Instead, now we refer to the "Control Zone." an area in space where assuming similar performing aircraft at similar energy states, we can counter any maneuver a defensive aircraft performs. The control zone is roughly one third of a turn diameter in length, centered around the control point, one half of a turn diameter behind the defensive aircraft. For example, for the T-45 with an average turn diameter of 6000' over time, the control zone would be from roughly 2000' to 4000' behind the defensive aircraft. On the near side, the control zone is roughly 20° either side of flight path extending to 40° either side of flight path on the far side. As the attacker, we are always striving to arrive in the defender's control zone while he is trying to deny us his control zone.

Attack Window

The "Attack Window" is defined as that point in space where, as the attacker, if we were to max perform our aircraft we would arrive in the defender's control zone with angles and closure under control. Unfortunately, the attack window is commonly explained improperly as a geographic window in space behind the post. The attack window is actually a "line of sight" cue that varies based on what angle we enter the bubble from. From a 40° angle off the tail scenario, the line of sight cue may, in fact, correspond to a position behind the post. But, if we are entering the bubble from the forward quarter or elsewhere, the attack window line of sight cues may not be as obvious or correspond with the exaggerated offensive scenario. The intricacies of attack window entry and mechanics timing will be discussed later during the perch scenarios.

In-Plane/Out-of-Plane (OOP) Maneuvering

Plane-of-Motion (POM) can be summarized simplistically as the target's track across the sky relative to the horizon. We will define out-of-plane maneuvering as any time our plane-of-motion is greater than 45° above or below our opponent's POM. If we are within 45° of our opponent's POM we are considered to be in-plane with our opponent. Also, we often reference OOP Maneuvering relative to the horizon; for example, if we execute an OOP maneuver it would be one more than 45° nose-high or nose-low.

Pursuit Curves

The concept of pursuit geometry between attacker and defender in the BFM environment is basic to every tactical maneuver and are the cornerstone maneuvers for the management of the RAC ACM problem. Pursuit curves are technically defined by the orientation of the attacking aircraft's relative velocity vector. If we are In-Plane with our opponent, nose position determines our pursuit curve. If we are Out-of-Plane from our opponent (>45°), lift vector placement defines our pursuit curve.

Depending on where your nose/lift vector is pointed, you will fly a distinctive pursuit curve in relation to your opponent (Figure 8-14). The three basic types of pursuit curves and their effects upon RAC are as follows:

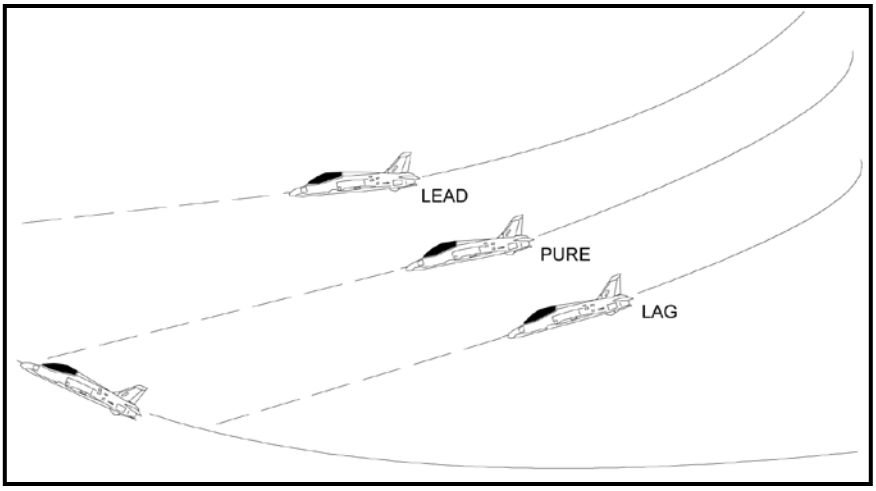

Figure 8-14 Pursuit Curves

1. Lead Pursuit - If your nose/lift vector is pointed out in front of your opponent, you are flying a lead pursuit curve (Figure 8-15). Lead pursuit is generally flown during maneuvers designed to decrease range or during gun attacks. Lead pursuit will:

Decrease nose-to-tail/range
Increase AOT
Increase closure (V_c)

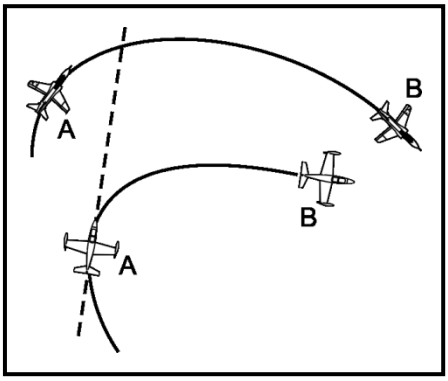

Figure 8-15 Lead Pursuit

2. Pure Pursuit - If your nose/lift vector is pointed at your opponent, you are flying a pure pursuit curve (Figure 8-16). Pure pursuit is similar to but less extreme than lead pursuit. Pure

pursuit is most often utilized when deploying a weapon, i.e. bore sight IR missile shot (FOX-2). Assuming the attacker is co-speed inside your opponent's turn circle, pure pursuit will (to a lesser degree than lead pursuit):

Decrease nose-to-tail/range
Increase AOT
Increase closure (V_c)

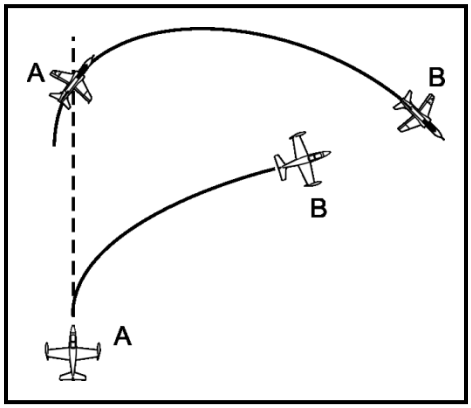

Figure 8-16 Pure Pursuit

3. Lag Pursuit - If your nose/lift vector is pointed behind your opponent, you are flying a lag pursuit curve (Figure 8-17). Lag pursuit will:

Increase/maintain range
Decrease/maintain AOT
Decrease/maintain V_c

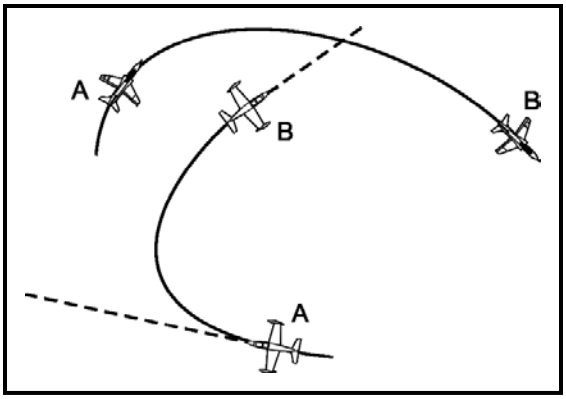

Figure 8-17 Lag Pursuit

Flow

In the BFM arena, there are generally two types of flow: Two-Circle and One-Circle flow.

Two Circle Flow

If after a merge both aircraft turn across each other's tail, the flow is said to be "Two-Circle" because each aircraft is on their own turn circle (Figure 8-18). Note, in a two circle flow, the two aircraft are fighting nose-to-tail and are turning in the same direction.

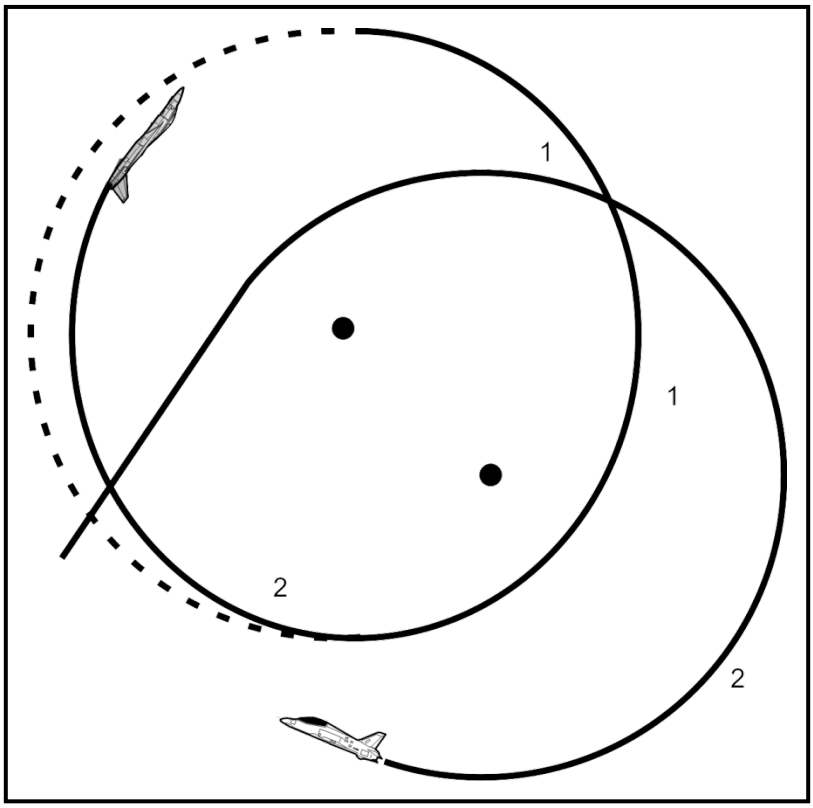

Figure 8-18 Two-Circle Flow

In a two circle fight, the aircraft with the higher turn rate (degrees per second) will gain the positional advantage. A two circle fight therefore is a turn RATE fight, meaning that the aircraft with the greater turn rate, irrespective of radius, will come nose on first with the ability to employ a weapon. From our previous E-M Diagram discussion, we may come to the incorrect conclusion that our best turn rate occurs within our rate band, 300 and 330 KIAS. This is a misnomer. If we go back to our original E-M Diagram, we can see that our greatest achievable turn rate actually occurs at our Corner Airspeed of 410 KIAS. Remember, our rate band gives us our best sustained turn performance. Sustained turn performance only applies when we cannot or do not desire to, expend any more energy, for example, when we are on the deck. However, if sustaining energy is not a priority (we need to honor sensor nose or we have altitude to lose) our best turn rate for any given airspeed occurs on our lift limit. So, assuming we have altitude to

trade for turn performance, the correct method to execute in two-circle flow is to max perform at 19-21 units, trading altitude for airspeed and turn performance, until our deck transition where, on the deck, we will continue to max perform until we capture 300 - 330 KIAS. Then, we will ease our pull to 14 units where we can maintain our best sustained turn performance on the deck. There are reasons why we might not want to trade altitude for turn performance which will be covered later in this chapter.

One-Circle Flow

If after the merge, both aircraft turn towards the same direction, the flow is said to be "One-Circle" because both aircraft are turning opposite directions to create one circle (Figure 8-19). Note that in a one circle flow the two aircraft are fighting nose-to-nose.

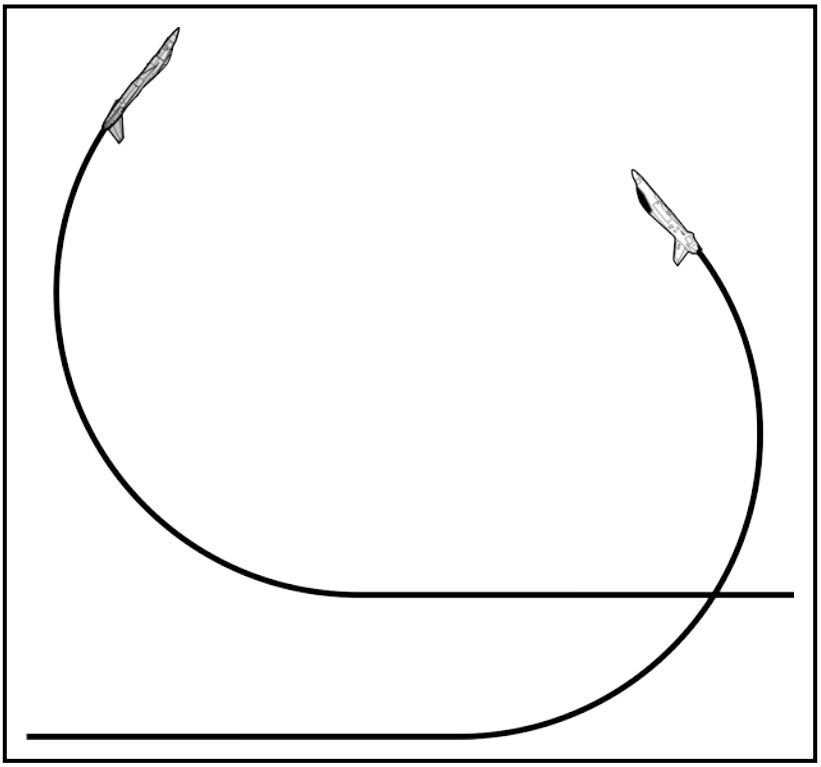

Figure 8-19 One-Circle Flow

In a one circle fight, the aircraft with the smaller turn radius will develop a positional advantage by turning inside the opponent's turn circle. A one circle fight therefore is a RADIUS fight, meaning that the aircraft with the smaller turn radius, irrespective of rate, will come nose on first with the ability to employ a weapon. As we discussed earlier in the E-M Diagram section, we achieve our smallest turn radius at any given airspeed by "max performing" our aircraft at 19-21 units AOA. If we find ourselves in a one circle fight, we want to target our radius band of 150 to 300 KIAS.

Out-of-Plane (OOP) Maneuvering

While not generally considered a type of flow in itself, OOP maneuvering is often included in the flow discussion because OOP maneuvering, with proper lift vector placement, can often force a specific type of flow. For example, by initiating an OOP maneuver and putting our lift vector into lead pursuit, we can turn two-circle into one-circle flow.

RAC Management

As we have discussed earlier, BFM is an exercise in the management of the Range, Angles and Closure between us and our opponent. To manage RAC we have several tools at our disposal, some of which will be more effective than others. In the following discussion, we will define several of the tools that have been utilized since the dawn of aerial combat. In today's ACM arena, several of the tools have become outdated with the advent of advanced missile technology. However, we will still define those methods, describe why they are no longer desirable or effective, and detail how to exploit those methods as BFM errors. Finally, in this section, we will outline the possible consequences of not managing RAC and subsequent maneuvering scenarios.

High Yo-Yo

A high yo-yo is an offensive lag pursuit maneuver originally designed to prevent an overshoot by controlling excessive closure and preserving range. It is an out-of-plane maneuver designed to control excessive down range travel so the fighter does not overshoot the flight path of his intended target. As a fighter sees an overshoot developing, the fighter executes a quarter roll away and raise the nose to slow the closure on the defender's flight path. The out-of-plane maneuvering will place the nose of the fighter above the plane of attack and exchange airspeed for altitude. The combination of the out-of-plane maneuvering and the slower airspeed will allow the fighter to turn with a smaller radius while aligning fuselages. The fighter's slower airspeed will also reduce the closure rate allowing him to maintain or increase range. The severity of the pull up and final nose position is dictated by the rate of closure (Figure 8-20).

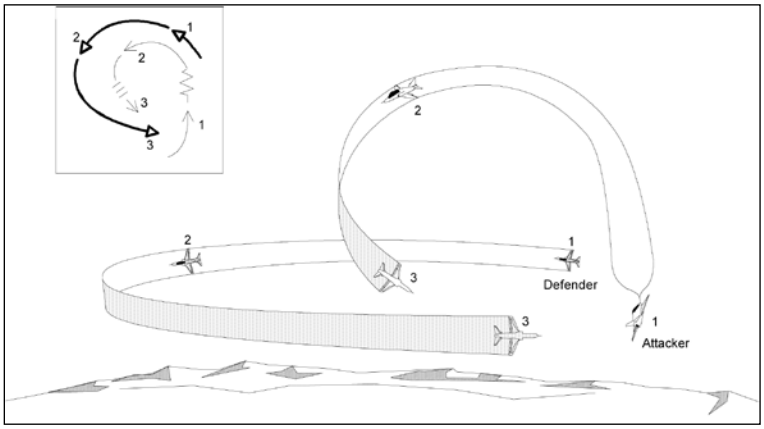

Figure 8-20 High Yo-Yo

The theory behind the maneuver is that by converting airspeed to altitude and utilizing radial "G" to control closure and angle off, the offensive fighter will be able to maintain his position on the inside of the defender's turn and prevent an overshoot. While this may have been a viable tactic for Sopwith Camels during World War I, in an age of highly maneuverable Within-Visual-Range (WVR) missiles, the High Yo-Yo has the adverse effect of taking the pressure off of our opponent and increasing time-to-kill. In addition, by maneuvering nose-high OOP, we decelerate out of our rate band during a two-circle fight - not where we want to be. A better alternative, that we will spell out in more detail in our Offensive BFM discussion, would be to maintain our rate numbers, accept the flight path overshoot, and allow the concept of misaligned turn circles work for us, bringing us much more quickly into a rear quarter IR missile WEZ.

As a defender, if we find our attacker mismanaging RAC through the execution of a High Yo-Yo, we should count our lucky stars. For, by taking his lift vector off of us, our opponent has let us off the hook by taking the pressure off and allowing us to ease our defensive pull and get some precious energy back. We will continue to unload and get back as much energy as we can before our opponent puts the pressure back on through the use of the required follow-on Low Yo-Yo.

Low Yo-Yo

The low yo-yo is a lead pursuit maneuver originally designed to decrease range by increasing closure rate when the attacker finds himself trapped in lag. A low yo-yo is usually employed when the attacker is in a low closure or low angle off situation as may be found after the execution of a High Yo-Yo. A low yo-yo is accomplished by flying inside the bogey's turn while descending below the target’s plane of motion (Figure 8-21). As such, depending on how nose-low the aircraft maneuvers, it is generally characterized as an OOP nose-low maneuver.

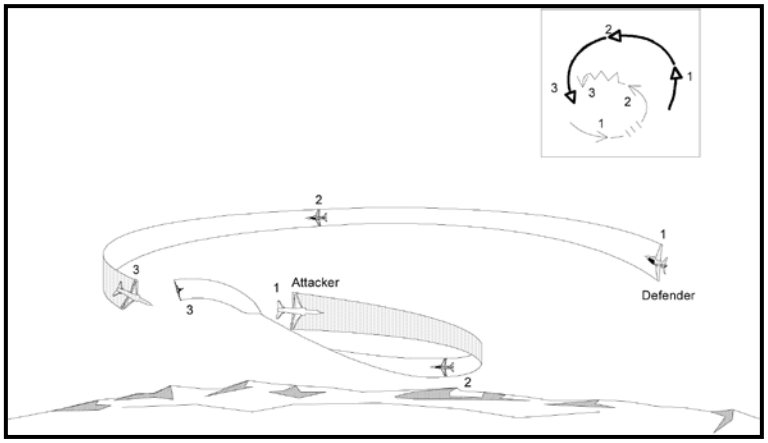

Figure 8-21 Low Yo-Yo

Like the High Yo-Yo, the Low Yo-Yo is an outdated tactic that has little necessity in the world of modern ACM. We will see in our Offensive BFM discussion that one of the attacking aircraft's primary concerns is the preservation of separation (or RAC) between aircraft. Lateral

separation is preserved through the use of in-plane, two circle flow. If we initiate a nose-low, OOP maneuver (like the Low Yo-Yo), we actually lose some of the separation between aircraft in our attempt to align fuselages. In addition, by initiating a nose-low maneuver, we entice our opponent to do likewise, further collapsing the fight and taking away the separation we wish to preserve.

If, as the defender, we observe our attacker executing a Low Yo-Yo, again we should count our blessings. He has again let us off the hook. Our response should be to match him nose-low and match his pull to generate as much closure as possible and collapse the range between aircraft.

That's not to say that there is never a time for a Low Yo-Yo. If we have executed poor Offensive BFM and found ourselves trapped in lag on our opponent's turn circle and outside of our rate band, our only option may be this antiquated tactic; in for a penny, in for a pound. If uncountered, we may dig ourselves out of our hole, but a savvy opponent will counter and make us pay for our mistake.

Displacement Roll

Like the High Yo-Yo, a displacement roll is a maneuver designed to reduce angle off, closure rate, or displace the aircraft into a "lag pursuit" position. Normally the displacement roll begins with an attempt to align fuselages on the inside of the defender's turn. The nose is then pulled up and the aircraft is rolled opposite the direction of the defender's turn. The roll rate and amount of vertical displacement used will depend on how much nose-to-tail separation is desired. (Figure 8-22).

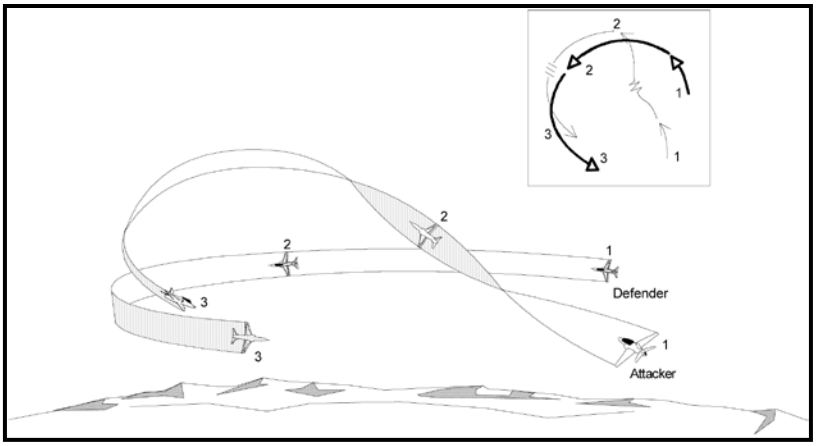

Figure 8-22 Displacement Roll

Like the High Yo-Yo, the Displacement Roll takes the pressure off our opponent and allows the defender a chance to get energy back. For that reason it is not the preferred method for managing RAC. Where it can be useful is as a last ditch attempt to avoid an in-close overshoot and possible role-reversal. In that case, we have again committed an egregious BFM error by holding lead/pure pursuit for too long and let the closure problem get out of control. By initiating the Displacement Roll, we can take the excess kinetic energy we are carrying and

convert it into potential energy while stopping our down range travel with the vertical component of the maneuver. Assuming that our opponent does not have the energy to counter our nose-high maneuver, once we have our down range travel stopped, we can roll back in behind our opponent with closure under control. Again, in that scenario we are trying to salvage a bad situation presented through poor Offensive BFM; the Displacement Roll should not be used as a substitute for sound Offensive BFM.

Overshoots

The consequences of poor RAC management is excessive closure, decreasing range, and increasing AOT, all of which can result in an overshoot. There are two basic types of overshoots: the 3-9 Overshoot and the Flight Path Overshoot.

1. 3-9 Overshoot (Wingline): The 3-9 line is defined by the line drawn between the wings of an aircraft. A 3-9 overshoot occurs anytime an attacker flies from aft of the defender's 3-9 line to a position forward of the defender's 3-9 line. This may also be called "flying out in front." In Figure 8-23, aircraft (A) illustrates a 3-9 overshoot.

2. Flight Path Overshoot: A flight path overshoot occurs any time the attacking aircraft flies through the defender's flight path (i.e., defender's extended 6 o'clock). Aircraft (B) in Figure 8-23 illustrates a flight path overshoot.

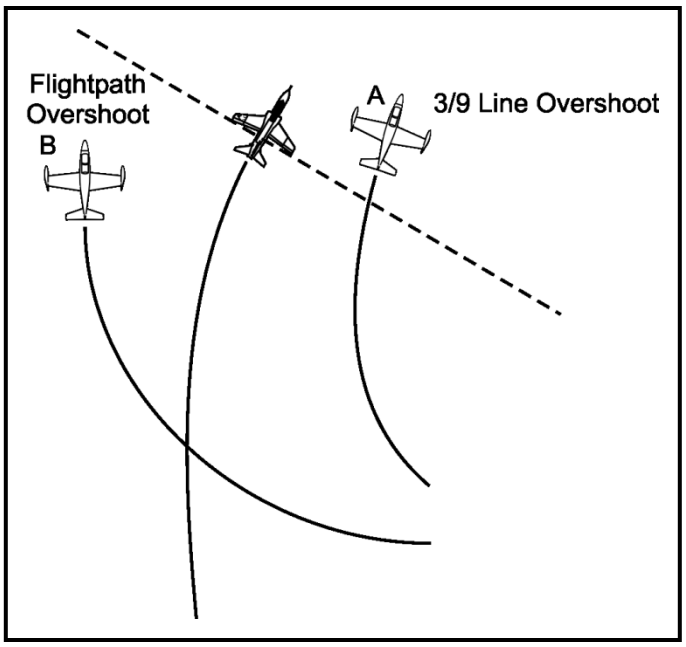

Figure 8-23 Overshoots

Though the attacker has overshot the defender's flight path, it is not always wise for the defender to reverse his flight path in an attempt to neutralize the attacker. For if the attacker overshoots the defender's flight path in or aft of the control zone, a reversal by the defender only serves to turn the attacker's lag into lead, solving his RAC problem. Figure 8-24 shows

two possible scenarios during a Flight Path Overshoot. In Scenario 2, the defender reverses, placing himself almost immediately back into an IR weapons envelope. While in Scenario 1, by continuing his current direction of turn, the defender keeps his attacker in lag and delays time-to-kill.

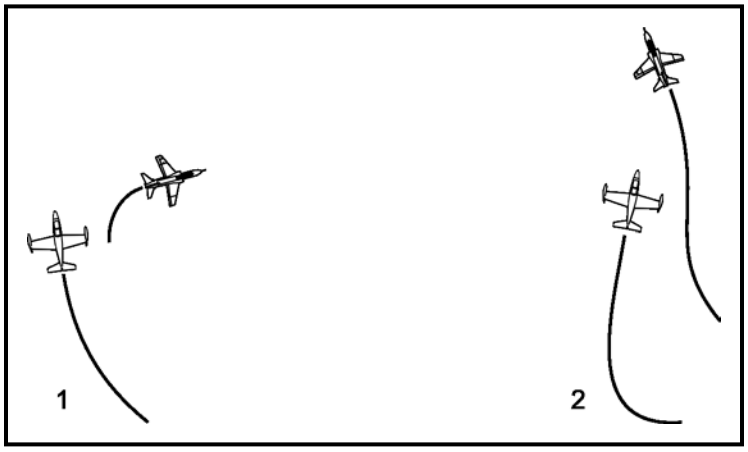

Figure 8-24 Flight-Path Overshoot and Reversal

In-Close Overshoot: An In-Close Overshoot occurs when the attacker crosses the defender's flight path inside the defender's control zone. In-Close Overshoots are significant in that an instantaneous reversal by the defender could possibly cause a follow on 3-9 overshoot, which may result in a role reversal (i.e., the defensive aircraft becomes offensive). The defender's options in this scenario are based on three conditions: range, angles, and closure. The higher the AOT and closure the attacker has at the overshoot, the farther across the extended 6 o'clock he will travel. Figure 8-25 illustrates this type of flight path overshoot in which a timely reversal results favorable positional advantage for the defender.

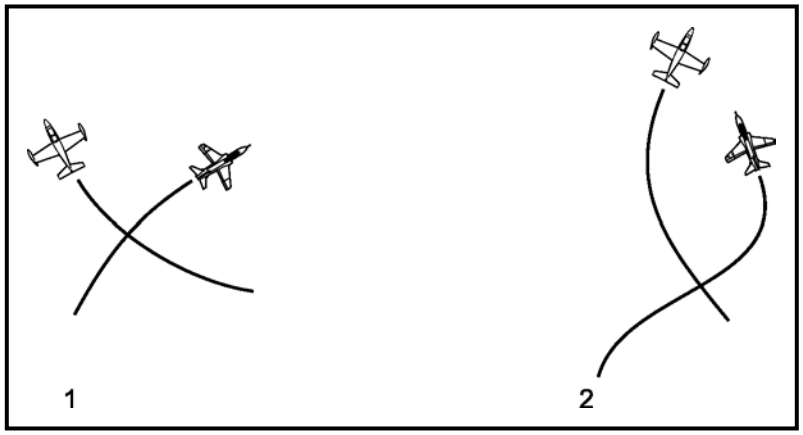

Figure 8-25 In-Close Overshoot

To determine if an In-Close overshoot meets the criteria to warrant a reversal, it must meet three criteria:

1. In-Close: Inside the Control Zone (<2000')

2. High Angle Off: Target Aspect > 60°

3. High Track-Crossing-Rate/Closure: We can mentally project that if we reverse, we will have a 3-9 overshoot and role reversal.

If any of the above criteria are not met, we do not reverse! Instead, we are better off continuing in our present direction of turn, increasing our survival time.

Reversal Timing: If we decide to reverse, when do we do so? Our timing is critical so as to maximize the potential for neutralizing our opponent or establishing a role reversal. To that end, we will use the axiom: "No earlier than lag, no later than line-of-sight rate." We want to start our reversal no earlier than our opponent's nose/lift vector falling aft of us and no earlier than when our opponent crosses our extended six. That is a rather large window and when we reverse in that window depends on our opponent's line-of-sight rate. If our opponent has a large track-crossing-rate, we will want to reverse closer to when his nose falls into lag; however, if the track-crossing-rate is low, we will want to wait closer to when our opponent crosses our six. It is not an exact science; judgment and experience will play a vital role in the execution of a well-timed reversal.

Scissors Maneuvering

The consequences of poor RAC management and subsequent overshoot often result in some sort of slow-speed scissors maneuvering, of which there are two types: the Flat scissors and the Rolling Scissors. In any scissors maneuvering (Flat or Rolling), the key elements to obtaining a positional advantage are to stop down range travel, primarily through the use of solid lift vector placement in lag.

Flat (Horizontal) Scissors

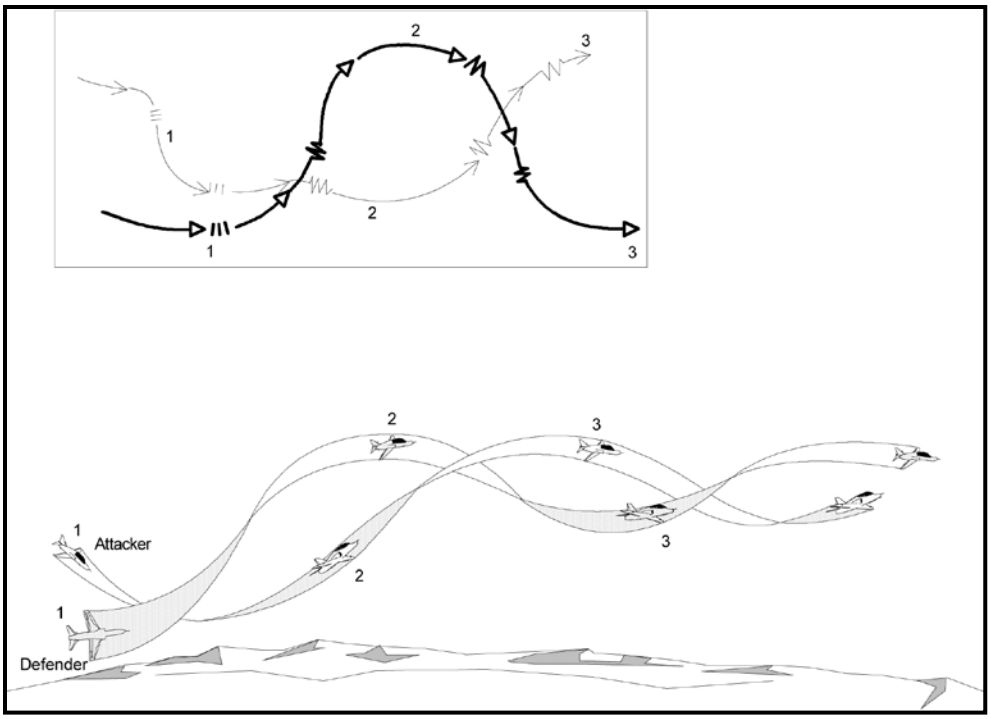

Figure 8-26 Flat Scissors

The Flat Scissors is a series of nose-to-nose (1-Circle) turns and horizontal overshoots performed by two fighters essentially in the same maneuver plane, each crew attempting to get behind the other for positional advantage (Figure 8-26).

While all Flat Scissors are one-circle, or radius fights, not all one-circle fights are Flat Scissors. The Flat Scissors is a slow speed, high AOA fight where both fighters are attempting to decrease their down range travel more efficiently than their opponent by continuously crossing each other's flight paths in a series of weaves. The aircraft that can reduce its forward velocity component more than his opponent will gain a positional advantage. This can be achieved through multiple means: by max performing our aircraft in radius, flying our aircraft slower than our opponent, or through proper use of lift vector, out-of-plane, to place it in lag of our opponent.

Disengaging from a Flat Scissors is difficult at best. Because both aircraft are generally operating at slow speeds in close proximity to each other, the opportunity to achieve valid "Bug" criteria is usually nonexistent. "Never transition from a slow to a fast fight."

Rolling (Vertical) Scissors

Like the Flat Scissors, the Rolling Scissors is the result of an overshoot. However, while a Flat Scissors is the result of a horizontal overshoot, a Rolling Scissors is generally the result of a vertical overshoot where one aircraft breaks the other's altitude. A developed Rolling Scissors will consist of a series of horizontal and vertical overshoots (Figure 8-27). Though it appears initially like the Rolling Scissors is two-circle flow, a neutral Roller is actually one-circle flow. This is easier demonstrated from a God's-eye view where we can see the aircraft turning in opposite horizontal directions with one aircraft nose-high and the other nose-low. Only once one aircraft begins to gain a positional advantage and begins to align fuselages does the Roller become two-circle, but by then it has transitioned more to a looping fight than a Roller. Like the horizontal scissors, positional advantage in a roller is achieved by reducing down range travel relative to the bogey. In a roller, this is accomplished by using vertical maneuvering with proper energy and lift vector control.

A key determinant in winning the roller is the ability to get your nose up when you are at the bottom of a roller before your opponent can get his nose down when he is at the top, and vice versa (utilizing the tactical egg to your advantage). If you continually do this without sacrificing your energy or position, you will gradually gain a positional advantage on your opponent. "Oppose the Nose" is the rule to live by in a Rolling Scissors. Any time our opponent is coming nose-high and we are not coming down to meet him, he is gaining angles and an offensive advantage. Likewise, if we are at the bottom of the Roller and cannot (or do not) go up when our opponent comes down, our opponent is gaining an angular advantage.

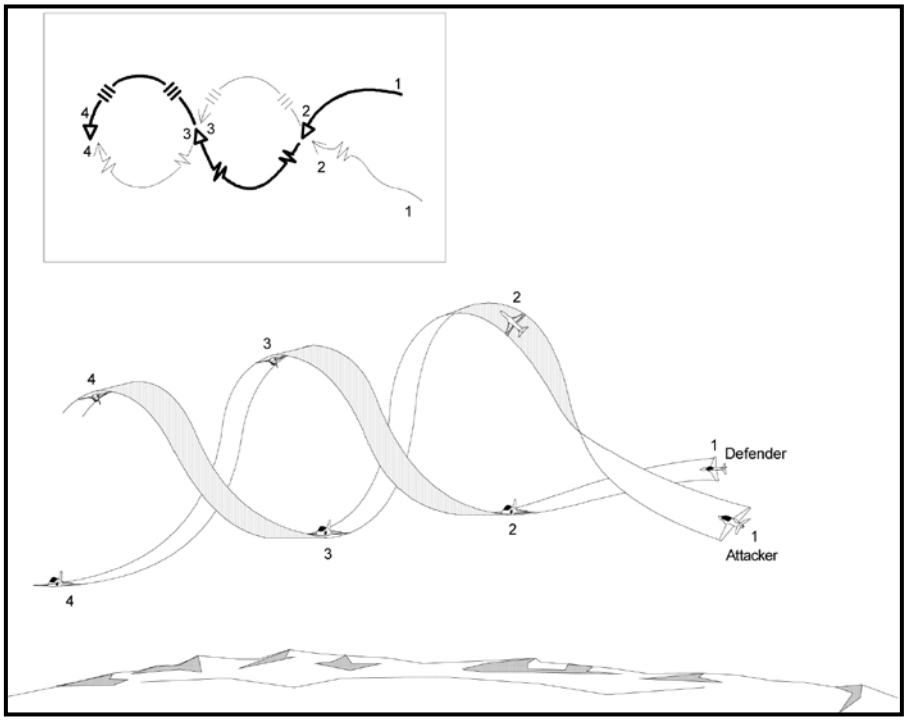

Figure 8-27 Rolling Scissors

The old saying used to be "lag at the bottom and lead over the top". This is misleading because it mostly refers to stick and rudder skills rather than a geometric analysis of how to win a rolling scissors. What we are really trying to do, after establishing the highest reasonable nose attitude, is to get your nose down before the bandit gets his nose up (a.k.a. “LEAD” him/her) and then “LAG” him/her down the back side to gain turning room and 3-9 advantage and ensure the opponent travels further down range. So in essence, we want to early turn the bandit over the top and pull down to then place the lift vector towards his control zone or in lag (about 1500 feet behind him).

Proper lift vector control in a Rolling Scissors generally consists of lag pursuit. Throughout slow speed portions of the Roller, particularly over the top, it is very tempting to pull lead either to align fuselages or pull for a shot. Because we are typically inside each other's bubble most of the time in a Roller, lead pursuit typically leads to increasing our down range travel and flushing out in front. There are generally only two times when we want to pull lead in a Rolling Scissors: if we find ourselves offensive and outside our opponent's bubble and we need to achieve bubble entry (whereupon we would immediately transition to lag again); or when we are pulling for a shot nose-high. As a general rule of thumb, we will only pull lead going nose-high because if we overshoot going nose-high, our opponent cannot generally reverse and take advantage of it. Any time we find ourselves nose-low, we want our lift vector in lag to counteract the larger turn radius generated by our increasing airspeed and decrease in radial G available due to the force of gravity.

In general, each aircraft will generally feel offensive at the top of a roller and defensive on the bottom. This may be an optical illusion due to the effects of radial G and the tactical egg. In general, if most of the time your opponent is in the forward part of your canopy, you are offensive and vice versa.

Because most fighter aircraft do not have a 1:1 Thrust-to-Weight ratio that can overcome the bleed rates associated with BFM maneuvering, the Rolling Scissors tends to degenerate in altitude. At some point, one of the aircraft will be unable to roll again due to proximity to the deck and will reverse level, transitioning the fight into a Flat Scissors. The first aircraft to go flat is generally at a disadvantage and usually ends up "treed" or defensive. For that reason, proper energy management and lift vector placement are essential to fly an efficient Roller so as not to transition first.

803. WEAPONS EMPLOYMENT

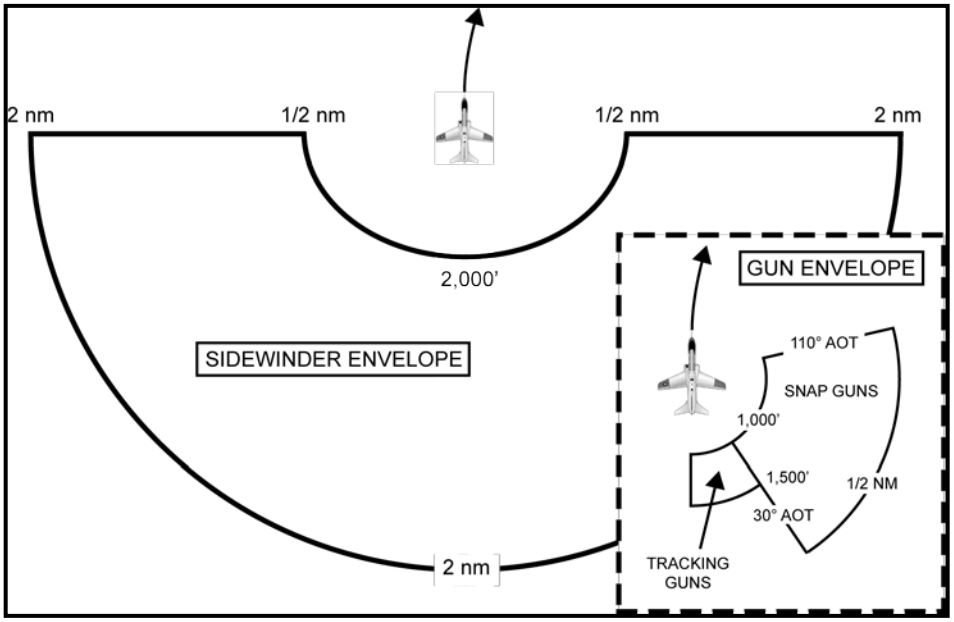

Figure 8-28 CNATRA IR Missile Envelope

In the fleet, there will be a large variety of weapons available to the crew in the air combat arena, including high off-boresight radar and IR missiles and, of course, the gun. For the purposes of demonstrating the basics of BFM, here at VT-86 we will concentrate on the basic, rear quarter weapons envelopes delineated by CNATRA in Figure 8-28.

IR Missiles

The rear-quarter IR missile is the most basic of air-to-air missiles, utilizing heat from the target's engine exhaust to guide to impact. They are generally fairly maneuverable but limited in employment range, making them capable WVR ACM weapons. Even though the depicted IR missile envelope shows no capability forward of the 3/9 line, we should not be lured into a false sense of security that a sanctuary exists forward of the wingline. Most rear quarter IR missiles are limited by fuzing and not seeker head and can acquire a full powered aircraft in the forward hemisphere. Only the closure generated by a break turn will adequately defeat such a missile once employed. For this reason, any time we recognize "sensor nose" we should be reacting with either a break turn (attacker in WEZ) or hard turn (attacker forward of 3/9 line) as appropriate.

IR Missile Employment

Lacking IR missile symbology in the T-45, the following criteria will be used for the purposes of determining a valid shot:

1. Target on the waterline, between the airspeed and altitude boxes

2. Target AOT assessed stadiametrically as less than 90 degrees

3. Range assessed between 0.5 NM and 2.0 NM through the use of yardstick

4. If target is wings level, tail-on (i.e. bugging), utilize the Rules-of-3:

   < 250 KTS opening at 0.5 NM

   < 200 KTS opening at 1.0 NM

   < 150 KTS opening at 1.5 NM

   < 100 KTS opening at 2.0 NM

Training Rules

IR missile employment is mitigated in accordance with OPNAVINST 3710.7U Training Rules, specifically: “No forward quarter missile employment within 9000’ and 20 degrees of the target’s nose”.

NFS Responsibilities

Upon recognition of “sensor nose” (impending shot), defensive NFS will call for a break turn over the ICS and “flares” over the UHF. Preemptive break turns and “flares” calls (prior to the shot call; “Sensor Nose” = 30° TA) will result in denying missile employment and the offensive IP calling “continue.” For the purposes of training, NFSs have unlimited flares.

Air-to-Air Gun

The gun is by far the most widely used and simple air-to-air weapon ever devised. It is also the most misunderstood in regards to its employment. In effect, the gun, for all intents and purposes, is an all-aspect weapon with no minimum range. In the interest of safety, however, both training rules and the CNATRA Guns Envelope (Figure 8-29) limit its employment in the training environment.

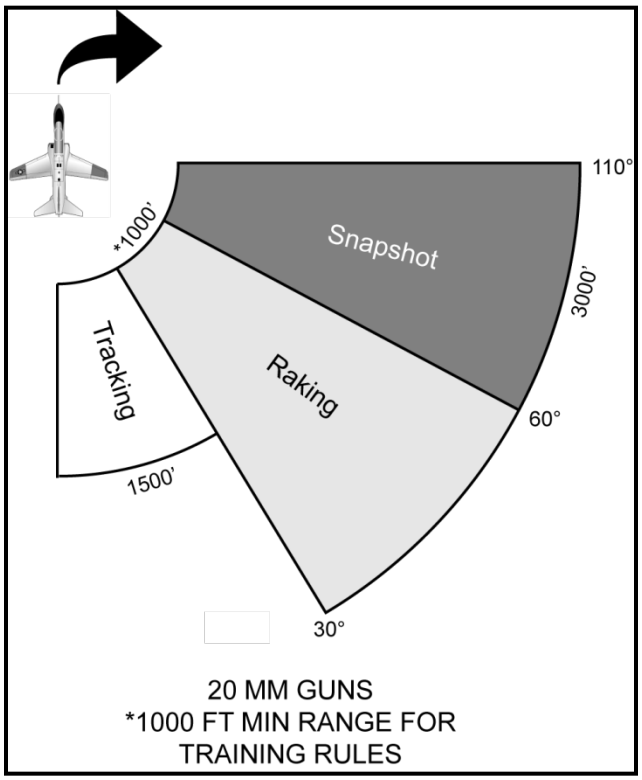

Figure 8-29 CNATRA Gun Envelope

The air-to-air gunnery problem is a difficult one; it involves hitting a moving target from a moving platform with projectiles that follow curved paths at varying speeds. The Probability of Kill (P_k) of the gun is a function of mainly two factors: bullet velocity and bullet density at target range. Bullet velocity at impact is affected by target range and closure, while bullet density is a function of target range (in the form of bullet pattern dispersal), track crossing rate, and employment parameters of the shooting aircraft. Therefore, not all quadrants of the Gun Employment Envelope will achieve the same P_k. In fact, the quadrant that provides the highest P_k is actually precluded by training rules and CNATRA: forward quarter gun employment. Forward quarter gun employment provides the greatest lethality by providing the highest combination of bullet velocity and density with little track crossing rate, high rates of closure, and decreasing range. The next most lethal sector would be the tracking region from 0° to 30° AOT, within 1500'. This region provides very little track crossing rate, and therefore very little lead or maneuvering from the shooter, providing a high bullet density; while the decreased range provides the bullet with adequate kinetic energy. Less lethal would be the "snap" or "raking" shots taken from the beam, anywhere from 30° to 150° AOT. These shots generally have very high track crossing rates, and therefore higher lead requirements, resulting in much lower bullet densities at target range. Of course, the greater the range, P_k drops dramatically due to the combined effects of track crossing rates and range = low bullet density and velocity. Finally, the lowest P_k for gun employment would be that area defined by low AOT but beyond 1500', a region not even depicted by the CNATRA envelope. In this region, by the time bullets reach target range, bullet pattern dispersal and bullet deceleration have taken such a dramatic toll on its

lethality that the P_k becomes negligible. Of all the factors we have discussed, range has the most crucial impact on gun lethality; for not only does it affect bullet velocity and density, but the lead requirements required generally begin to put it beyond the limitations of our HUD, even inside the published WEZ of 3000'. With the U.S. M61A Vulcan cannon firing bullets at 6000 rounds-per-minute and a limited arsenal of generally 500 to 600 rounds, bullets are a precious commodity we can ill-afford to waste. For these reasons, we generally will limit gun employment to high-percentage shots inside 1500'. Limitations of our HUD/Gunsight will be covered in the following discussion.

HUD/Gunsight Limitations

Contrary to popular belief, the gunsight in our HUD is not a "death dot" that we can place over our opponent in any scenario and hope to place bullets on target. For a "pipper" to be accurate, it must factor in a multitude of information, to include target range/closure/motion as well as the shooting aircraft's maneuvering. In the T-45C, the aircraft utilizes the Real Time Gun Sight (RTGS) as an aid to air-to-air gun employment. RTGS in the T-45C is similar to the Lead Computed Optical Sights (LCOS) found in most U.S. fighter aircraft when they are denied target information via the radar. In determining a valid gun solution, the RTGS/LCOS takes the information it knows from the INS (own-aircraft speed, G, roll rate, AOB, etc.) and makes assumptions about things it does not know (target range/closure/track-crossing-rate/Plane-of-Motion). RTGS assumes a target range of 1000' and that the target is maneuvering in the same phase, load factor, and plane-of-motion as the shooting aircraft. Even in a fighter aircraft with a "Director" gunsight (one that gets information from the fire-control radar), only target range is accounted for, with a radar lock; the other parameters are also assumed. If any of those assumptions are untrue, the solution is invalid. We will further investigate the limitations of our RTGS as we discuss air-to-air gun employment.

Air-to-Air Gun Employment

To effectively employ the gun against a moving target in the air-to-air arena the shooter needs to solve for three basic parameters: lead, range, and plane-of-motion. For the purposes of our discussion we will discuss the "Big Three" in the order in which we solve for them: Plane-of-Motion, Range, and Lead.

Plane of Motion (POM) – Plane-of-Motion can be summarized simplistically as the target's track across the sky relative to shooting aircraft. Because predicting when and where to put a bullet on time-of-flight into the future is problematic, we increase our chances of putting a bullet on target if we can project a stream of bullets along our target's projected plane of motion. In the HUD we have an indicator of our own aircraft's plane-of-motion, and therefore our projected bullet stream, in our RTGS solution's pipper placement. Its placement in the HUD is based on the calculations of our GINA of where a bullet fired "now" will be after one-second TOF. If we can line up the tracking of our pipper in line with our target's POM, we maximize our chances of putting a bullet on target. For example, if our opponent is tracking one wingspan, level across the horizon, we could put our pipper an equal distance above the horizon, pulling level through him, and we would have POM solved for. Unfortunately, rarely do we find our opponent cooperating by pulling level across the horizon, so distance solving for POM becomes an

exercise in extrapolation. We would like to solve for POM early because every time we make a correction through aircraft movement, it takes time for the INS to sense, calculate, and adjust the correction for the RTGS. Therefore, we would like to make large corrections early and fine tune them as we get closer to employment so that our system has a chance to provide as accurate a solution as possible.

Range – the linear distance from the gun to the target. As mentioned before, our RTGS solution does not know target range and always assumes a range of 1000'. As an aid for solving for range, we dial in the wingspan of 31' for a T-45 into the A/A Stores page during the A/A Checklist, providing us with a pipper that is 31 mils in diameter (1 mil = 1' at 1000' slant range). Therefore, if we put our target wingtip-to-wingtip inside the reticle of the pipper we have stadiametrically ranged our target at 1000'. Solving for range in a dynamic, maneuvering fight is not easy and will require us to constantly assess range and closure, and modulate our pull to arrive at the desired range by the time we have arrived at our firing solution. Generally, there are three methods that we can utilize to maneuver our aircraft to solve for a range problem that exceeds our desired 1000' solution:

"Pull Through" Technique – The "Pull Through" technique is accomplished by maintaining the POM solution in our current AOB and merely ease our pull to collapse the range to the target prior to it arriving at our firing solution. The "Pull Through" technique has several advantages: first, we limit the amount of disruption to our POM solution and our RTGS symbology is disrupted as little as possible. Second, we are not advertising our intentions of gunning our opponent and therefore, he may not defend: Additionally, we might find it easier to correct if our opponent does decide to defend. Finally, we are working in lag, toward our opponent's six and control zone. On the other hand, there are some disadvantages of the "Pull Through" method: higher track-crossing-rate means lower bullet density at target range; and though we are working in lag, we are not achieving our ultimate goal of working in-plane, in-phase with our opponent.

"Reversal" Technique – The "Reversal" technique is the second way that we can collapse the range during a gun attack, rolling into an opposite AOB and essentially pulling lead on our opponent to collapse the range. Like the "Pull Through" method, the "Reversal" technique also has its advantages and disadvantages. On the "plus" side: a reversal slows down the track-crossing-rate and increases our bullet density at target range, and we are now working in-plane, in-phase with our opponent. On the "other" side: the reversal disrupts our POM and our RTGS symbology and it may take several seconds for it to settle back down and provide us a valid solution. Second, we advertise to our opponent our intention to employ the gun, providing him with the ability to defend, and, should he defend, we will find it much more difficult to correct for follow-on gun employment, particularly if defends nose-low.

"Wings Level" Technique – The "Wings Level" maneuver is the final technique we will discuss in regards to collapsing for a rangy solution. By merely rolling wings level and driving in to the desired solution, we can collapse the range prior to weapons employment. Similar to the other techniques, the "Wings Level" method has its good and others: like the "Pull Through," we don't necessarily advertise to our opponent our intention to employ the gun, possibly providing us with a delayed, or no reaction. And, with the "Wings Level" method, because we have no radial G on

the aircraft, we achieve our highest bullet density, providing an uninterrupted stream of lead downrange. On the other side: like the "Reversal" method, both POM and follow-on gun employment become more difficult.

Should we find ourselves in a situation where the range is closer than we would like (remember, the pipper is only valid at 1000' even though bullets have no min range), how do we preserve the range prior to gun employment? The answer is a "Pull Through" where we pull harder to lag to try and arrive at our lead solution before the range can collapse to less than 1000'. If that is not possible, in training we break off the attack so as to not violate Training Rules.

Lead - the Gun Bore Line must be ahead of the target to project the bullets ahead of the target and consummate an intercept. Remember, the pipper only provides a valid solution when we are in-plane, in-phase, under the same radial G, and 1000' from our target. If any of those parameters are not met, the solution is invalid. What our pipper is really telling us is where the bullets will be one second after we squeeze the trigger at a slant range of 1000'. So, assuming POM and range are met, but we are not in-plane and in-phase, we have to determine ourselves when we need to squeeze the trigger so that we have bullets downrange when our target flies through our pipper at bullet TOF. How much lead is required is mainly a function of range and track-crossing-rate. Assuming a range of 1000' and a nominal track-crossing-rate of roughly 400 knots, a "Pull Through" technique generally requires about 20° of lead, which exceeds the dimensions of our HUD. Our canopy bow is roughly 20° from the Gun Bore Line, however, and if we go "trigger down" prior to the target arriving at our canopy bow, we should have bullets downrange at target range at TOF. For a "Reversal" method, the track-crossing-rate will be significantly less and therefore the lead requirement will be less. Therefore, for the "Reversal" technique, we will use the backside of the HUD as our lead requirement. For the "Wings Level" technique, the lead requirement will be somewhere in between.

Finally, in our guns employment discussion we will address the concept of bullet conservation. The M61A Vulcan cannon has a limited supply of bullets at its disposal. In the F-18, an arsenal of 550 rounds, at 6000 rounds/minute (100 rounds/second), we are afforded less than 6 seconds of "trigger down" time. Therefore, bullets are at a premium and we only want to have the hammer down when we are sure we have the ability to put rounds on target. We have already talked about our lead requirement; any bullets put out late are wasted (as they will pass harmlessly behind our target) and any rounds put downrange before are wasted (though at least we will have bullets at target range at TOF). However, when do we release the trigger? Without a BATR (Bullets at Target Range) cue, we cannot be certain that we have rounds downrange on target. Therefore, we will release the trigger as our target passes through our pipper. In a snap shot scenario, while those rounds released when the target is under our pipper are wasted, we are assured that we have bullets at target range. If we come off early, we may or may not have bullets at target range and may have wasted all bullets expended. If we come off the trigger late, all bullets after the target passes through our pipper are wasted. General rule-of-thumb: better on early, off late.

Guns Defense

Our discussion of Air-to-Air Gun Employment would not be complete if we did not discuss the concept of defending against the gun. As the attacking aircraft is trying to solve for the "Big Three:" lead, range, plane-of-motion, as the defender, we are trying to deny or disrupt them. Unfortunately, as the defender, we can generally only affect one of the three requirements. In a "Tracking" solution, where the attacker has established himself in-phase and in-plane, the attacker has most likely solved for both plane-of-motion and range and is merely pulling for lead. In that case, the only parameter we can influence is his lead requirement which is accomplished through the use of a Guns Weave maneuver. The Guns Weave will be covered in-depth during our Defensive BFM discussion later in this chapter. In a "Snapshot" scenario, where the attacker is in-plane but not necessarily in-phase, the attacker will most likely have solved for range and lead, leaving plane-of-motion as the only parameter we can disrupt. To do so, we must accomplish two goals: two get wingtip on and present as small a target as possible; and to pull out of our attacker's plane-of-motion, either nose-high or nose-low.

Nose-high – There are several reasons why we might want to initiate a "Nose-high" Guns Defense. We might find ourselves on the deck with no ability to go nose-low, or maybe we do not want to initiate a slow speed, nose-low maneuver that would be extremely easy for our opponent to follow. In addition, if our opponent was coming from high-to-low, a nose-high maneuver would be extremely difficult to follow. However, for the most part, nose-high maneuvers are not difficult to follow and allow the attacker to pull lead pursuit, not fearing the repercussions of an overshoot. In addition, the reduction in radial G due to the effects of gravity provide for less displacement away from our original plane-of-motion and our attacker's solution.

Nose-low – Similarly, there are several reasons why we might want to initiate our defense "Nose-low." A nose-low maneuver has the combined effect of increasing our radial G and our displacement by the force of gravity while also preserving some of our kinetic energy. However, if we initiate a slow-speed, nose-low maneuver, it will be fairly easy for our attacker to follow. If we find our attacker coming from low-to-high, we may again find going opposite his plane-of-motion much to our advantage. However, maintain sight in a "Nose-low" Guns D is difficult and makes follow-on BFM problematic.

Wings Level Bunt – The "Wings Level Bunt," either upright or inverted, is another option once we have established ourselves wingtip-on to our attacker. The bunt is normally accomplished by reducing positive AOA or establishing negative AOA to displace the aircraft opposite the lift vector. While it is an option, it is not necessarily recommended as it relies mainly on deception, our performance under negative G being much less effective and therefore providing much less displacement from our original plane-of-motion and our attacker's solution.

804. OFFENSIVE/DEFENSIVE BFM

Offensive/Defensive Perch BFM. Offensive and defensive BFM principles are the overriding concepts which lay the foundation of our understanding of air combat maneuvering. For that reason, we use a "building block" approach to learning BFM, starting with offensive and

defensive perch sets where we can learn to recognize the appropriate sight cues from an exaggerated perspective and react accordingly. We learn offensive and defensive BFM from a 40° perch, because at 40° AOT, all of the visual sight cues are exaggerated and bubble entry generally occurs through the use of pure pursuit.

Regardless of how offensive or defensive we may find ourselves, the overarching goals remain the same:

1. Offensive BFM Goals:

    a. Preserve lateral separation/turning room (Control RAC)

    b. Pressure the defender

    c. Maneuver to arrive in the control zone

    d. Employ weapons

2. Defensive BFM Goals:

    a. Deny weapons employment opportunities

    b. Collapse the fight, denying angles/turning room

    c. Create fuselage misalignment

    d. Separate/Neutralize/Kill

        To that end, there are **Four Axioms of Defensive BFM:**

        i. **Maneuver To Survive** - Recognition of "sensor nose" and responding with break turns or Guns Ds as appropriate.

        ii. **Attacker Outside the Bubble: Pull Attacker as Far Forward as Possible** - Sensor nose on = break turn (19-21 units), sensor nose off = hard turn (17 units)

        iii. **Attacker Inside the Bubble: Decrease in Target Aspect = Increase in pull** - and vice versa.

        iv. **Sensor Nose On and Cannot Pull Forward of 3/9 Line = Redefinition/Ditch**

These goals are best reinforced/practiced through the utilization of perch sets. The standard perch sets that we will utilize during the VT-86 syllabus are the 9K', 6K', and 3K' sets at 40° AOT. The following discussions will focus on these sets, their specific training objectives, and how they are applied from both the offensive and defensive perspectives.

- **9000' Perch Set (Attacker Outside the Bubble)**

Offensive Training Objectives

Bubble Entry

Attack-Window-Entry-Mech

Rate War/Misaligned Turn Circles

2nd Bubble entry

Bubble Entry. The attacker begins outside the defender's bubble. As discussed earlier, the first goal of the attacker is to maintain/preserve turning room. As long as the attacker is outside the defender's bubble, the defender can take away angles/turning room. Therefore, the first priority for the attacker is to penetrate the defender's bubble as quickly as possible. Simple geometry tells us that the shortest distance to bubble entry is directly at the post. Depending on the quadrant of entry, that could be any one of the three pursuit curves: lead, pure, lag. For the purposes of a 40° AOT scenario, pure pursuit will generally be adequate.

Attack-Window-Entry-Mech. Once we have achieved bubble entry (target aspect change turns to line of sight change), we will work toward lag until we see our Attack Window Entry cues (line of sight rate starts to explode). At that point we will initiate our Attack-Window-Entry-Mech: place the defender one fist above the canopy bow and maintain whatever pull is required to hold him there, up to max perform (19 to 21 units). We will continue to pull as required until we can no longer hold that sight picture without bleeding below our rate band (300 to 330 KIAS).

Misaligned Turn Circles. We do not want to lower our nose more than 10 degrees for if our opponent counters, he collapses the fight, violating goal #1: preserve turning room. Additionally, we will accept the flight path overshoot as long as it does not meet the criteria of an in-close overshoot as defined in the FTI. Should we try and execute a high yo-yo, we take the pressure off our opponent, violating goal #2, and allowing him to get energy back. If we are patient and remain in our rate band, "misaligned turn circles" (Figure 8-30) will work for us and we will arrive nose on again in a follow-on missile WEZ and second bubble entry.

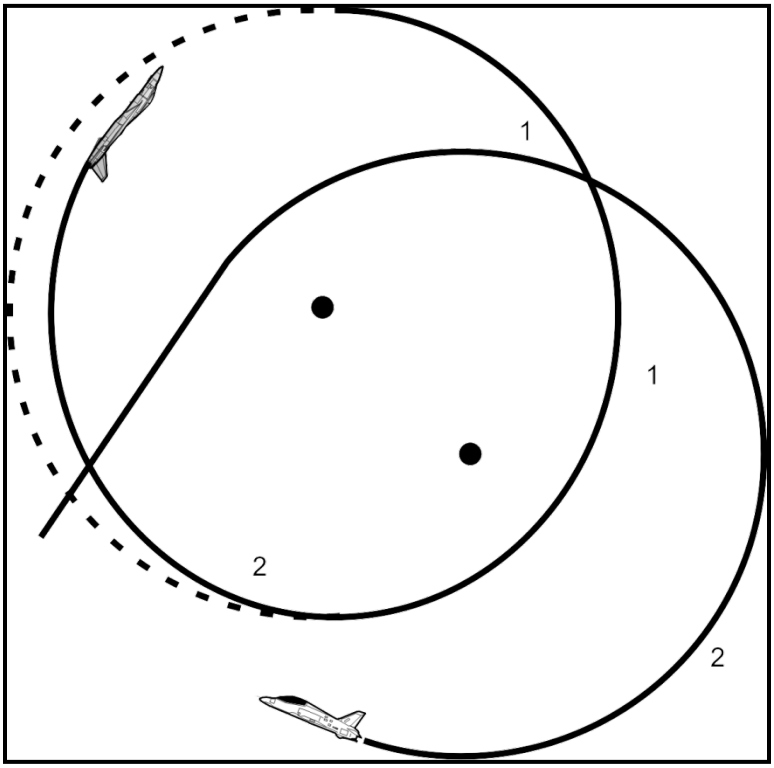

Figure 8-30 Misaligned Turn Circles

Defensive Training Objectives

Break Turn

Bubble Entry

Misaligned Turn Circles/Rate War

Bug

2nd Bubble Entry

From the defensive perspective, surviving is cookie cutter: just follow the four defensive axioms.

Break Turn. At the start of the set, the attacker is nose on, outside the bubble. The first axiom applies: maneuver to survive. Any time our opponent is sensor nose on, we execute a level (no more than 10° nose-low), idle break turn with flares to keep the shot on the rail. This of course has the added benefit of taking away angles as long as our opponent is outside our bubble (axiom #2). We execute the break turn level because an in-plane pull with the attacker outside the bubble denies the greatest amount of angles. Any out-of-plane maneuver we execute with our opponent outside the bubble just preserves turning room for him (violation of goal #2).

Bubble Entry. Once the attacker has achieved bubble entry, we must evaluate his intentions. If he remains sensor nose on, we must continue to defend. If he correctly falls into lag, we will ease to gain back some energy lost during our break turn. A common mistake at this point is for the defender to lower his nose to gain back airspeed. As the defender, we do not want to lower our nose more than 10 degrees below the horizon for two reasons: 1) we need to preserve altitude in the case we meet redefinition/ditch criteria, and 2) we are evaluating the BFM prowess of our opponent. If we can win in a rate war, we would like to do so "level" as to preserve all of our options. However, if our opponent makes a mistake and drops his nose in an effort to low yo-yo, we will counter and collapse the fight (reinforcing goal #2).

Misaligned Turn Circles. Once established in the rate war, we will ease when the attacker eases and tighten when the attacker tightens (Axiom #3). In this manner we are misaligning fuselages and turn circles to the max extent possible and setting ourselves up for a high aspect pass. If we can get ourselves across the circle from our opponent outside his bubble, we can cut across the circle in an attempt to bug (should he counter).

Bug. To bug we need a 180° out pass, close aboard and on the deck (so that our opponent cannot follow in the vertical).

2nd Bubble Entry. If at any time the attacker is approaching sensor nose and we cannot pull him forward of the 3/9 line (Axiom #4), we must redefine. We will discuss redefinition/ditch in the 6K' Perch discussion.

- **6000' Perch Set (Attacker at Bubble Entry)**

Offensive Training Objectives

Bubble Entry

Attack-Window-Entry-Mech

Ditch Follow, Timing/Mechanics

Deck Transition

Bubble Entry/Attack-Window-Entry-Mech. The 6K' Perch set begins at bubble entry. We will execute exactly as we did in the 9K' set although we will be more offensive and the sight cues will occur more quickly. If we execute proper Attack-Window-Entry-Mech, we should find ourselves with a slight flight path overshoot which will quickly resolve itself as misaligned turn circles come into play.

Ditch Follow. As we approach sensor nose on for the second time, we should have bled our opponent down to below his rate band. With no airspeed to hold our nose off any longer and assuming enough altitude above the deck, he should try to redefine in the vertical (his 'Last Ditch' maneuver). We can expect a savvy opponent to execute a "Ditch" maneuver: a Split 'S' type nose-low maneuver in which our opponent rotates his lift vector out in front of us to deny us his control zone. It is not a difficult move to

follow and the mechanics are identical to the Attack-Window-Entry-Mech we executed previously, albeit now in the vertical. Our first priority is to pull toward the defender's point of departure. A common mistake is for the attacker to think he has to get to the point of departure before following, resulting in a late follow. This is not the case. We will pull toward the point of departure, but it will be the line of sight cues of the attack window that will signal our timing to follow. Once we achieve the proper follow sight picture we will follow "in plane" using as much pull as necessary to remain on the defender's turn circle. Realize that our opponent was slow when he ditched - otherwise he would not have ditched. Another common mistake is carrying too much airspeed into the follow, resulting in breaking the defender's altitude. As we arrive sensor nose on again, we can expect our opponent to ditch again, assuming he has the altitude to do so. If not, we begin our transition to the deck.

Deck Transition. As we approach the deck we have two options: a pure positional deck transition or an oblique, energy rate deck transition. If at any time we have the altitude to do so, we would like to go pure nose-low to convert that altitude to angles on the deck. We would like to use a compromise pull (17 units AOA) to arrive on the deck in our rate band. If, however, we do not have the altitude to go pure nose-low, we will use an energy rate deck transition (utilizing the 10° rule: 10° nose-low for every 1000' above the deck) to arrive on the deck, offensive and in our rate band.

Defensive Training Objectives

Break Turn

Bubble Entry

Ditch, Timing/Mechanics

Deck Transition

Break Turn/Bubble Entry. As stated during the offensive discussion, the 6K' set begins at bubble entry. We will execute just as we did in the 9K' set, understanding that we will be more defensive and the sight pictures will occur much more rapidly. Utilizing Axiom #3, we will find ourselves pulling more than we did in the 9K' as we are being pressured far more than in that set. Very quickly we will find ourselves below our rate band with the attacker approaching sensor nose on. When we can no longer pull our opponent forward of the 3/9 line and sensor nose is a factor we will redefine/Ditch (Axiom #4).

Ditch. With no other options available and assuming we have the altitude (~6000' above the deck in the T-45) we will execute our ditch maneuver. Utilizing coordinated stick and rudder, we will roll/pull into a bullseye nose-low maneuver, rotating our lift vector as to put it out in front of our attacker. This has the effect of rotating our control zone as far as possible away from our opponent. Once established nose-low, we will max perform our aircraft in order to minimize our altitude loss, using idle power and speedbrakes if necessary. All the while, we are continuing to roll our aircraft to keep our lift vector out in front of the attacker. As our opponent follows, when sensor nose again becomes a factor,

and assuming we have the altitude, we will ditch again to maximize the misalignment of fuselages. You probably will not have the altitude to execute a second ditch in the T-45.

Deck Transition. Once we find ourselves within 6000' of the deck, we must start working our deck transition. As the defender, we again have one of two scenarios available to us: positional or energy rate. Any time we find ourselves with fuselages still aligned (defensive), we will execute a positional deck transition, max performing our aircraft to take out angles. If we have the altitude to go pure nose-low (6000') it becomes just another ditch; if we do not have the altitude, we will use the 10° rule but with the understanding that we are max performing (19-21 units) in the oblique. If we find that fuselages have become misaligned (more neutral), we can afford to do an energy rate deck transition, either pure nose-low or oblique, depending on our altitude. In either energy rate case, we are striving to get back as much airspeed as possible when we arrive on the deck. Should we find ourselves on the deck, bled down and our opponent coming sensor nose on, we must again redefine. This time, however, we cannot ditch, so we will execute the very controversial and much maligned "On Deck Reversal." You may be asking yourself "I thought we didn't reverse unless all three reversal criteria were met? Aren't we just solving his problem for him?" Our opponent has no problem. He is about to employ a weapon. If we had the energy to break turn into him, we should have been doing that already (Axioms #1, 2 and 3). We have met ditch criteria (Axiom #4) but do not have the altitude to do so. Our only option (other than die) is to reverse and hope that our opponent makes a mistake.

3000' Perch Set (Attacker Inside the Bubble)

Offensive Training Objectives

Attack-Window-Entry-Mech

Ditch Follow/Guns D, Timing/Mechanics

Deck Transition

Finishing

For the 3K' set, we start inside the defender's bubble. We will execute Attack-Window-Entry-Mech, Ditch Follow, and Deck Transitions just as we did in the 6K' set with the exception that it will all occur much quicker and with us in a substantially more offensive position. All things being equal, we should arrive on the deck in our opponent's control zone. All we need to worry about now is finishing.

Finishing. Easier said than done. Our opponent will be doing all he can to maneuver his aircraft to deny us a weapons opportunity, cause us to overshoot, or scrape us off the deck. We can expect to arrive on the deck in some sort of weave, a cross between a flat scissors and a snap shot drill. Our number one focus is to not hit the deck, requiring constant vigilance. Our second priority is to preserve our offensive advantage. The defender will be trying to maximize our closure problem. We should be striving to always be pulling for lag, only early turning if we have sufficient nose to tail to align fuselages (minimum of 1000'). This will be the quintessential knife fight, so max

performing our aircraft (19-21 units) is the key to success. Finally, our last priority is weapons employment. Any time our nose is going to pass through the defender, we should be prepared to employ the gun.

Defensive Training Objectives

Ditch/Guns D, Timing/Mechanics

Deck Transition

Guns Weave

As with our offensive discussion, for the 3K' set, the attacker starts inside our bubble. We will execute our Ditch almost immediately and find ourselves in a deck transition soon after. We will execute these maneuvers just as we did in the 6K' set with the exception that our ditch may end up being closer to a Guns 'D' depending on our attacker's intentions. The key is that any time our opponent is threatening us with his nose, we are defending as appropriate (Axiom #1). With our attacker starting from such an extremely offensive position, it is likely that we will find ourselves on the deck, out of energy, with the attacker approaching a guns tracking solution.

Guns Weave. Never give up! Axiom #1 rules the day: Maneuver to Survive. As we find ourselves on the deck, out of energy and our opponent pulling lead for the gun, we have but one option left: initiate a guns weave. As with the offensive discussion, our number one priority is to not hit the deck as we are concentrating on our opponent behind us. For this reason we will target 500' above the deck. Our opponent must have three things solved to employ the gun: plane of motion, range, and lead. With us on the deck, in plane and in phase with our attacker, two of the three are already taken care of. Plane of motion is solved for by the deck limiting our ability to go down and our lack of energy limiting our ability to go up. Range is most likely also solved for as our opponent will easily be inside a half mile. The only element we can now affect is lead. Our opponent cannot shoot us nose on; he must pull lead. With our attacker in phase pulling for lead, we will target 150 KIAS and max perform our aircraft (19-21 units) to maximize the closure, then reverse just as he is pulling nose on, disrupting his lead solution. Once established in the opposite AOB and turn, we will again max perform and look to reacquire our opponent again at our 5 or 7 o'clock position. When he again approaches nose on, we will reverse, thereby disrupting his lead solution. As we max perform, the attacker will be pulling aggressively to lag to try to preserve nose to tail. It should only take a couple of iterations of this before we can hopefully get out of phase with the attacker. Now we have turned a high percentage guns tracking scenario into a low percentage snapshot scenario. With our opponent out of phase now, we will continue to max perform into him to maximize the closure and attempt to get an overshoot. Any time our opponent's nose comes to bear in a snapshot, we will go "wingtip on" to reduce our planform, then reverse. We will continue to maneuver to survive until we scrape our opponent off on the deck, he runs out of fuel, runs out of bullets, or our wingman comes to save the day.

805. HIGH ASPECT BFM

High Aspect BFM encompasses much more than just one or two circle flow. It is an opportunity to start from a neutral start and employing a well designed gameplan, recognize and transition to either offensive or defensive BFM as the scenario plays out. To be successful at BFM, one must have a firm understanding of those concepts: gameplan development, execution, and the offensive/defensive transition.

Gameplan Development

The concept of "gameplan" is the most misunderstood and often misused terms in BFM. Ask any Strike Fighter aircrew in the fleet what his gameplan is at the first merge and you will often get responses like "My gameplan is to go up." That's your plan, Ray? "Get him." That is not a gameplan! It may be an initial move that may be part of a gameplan (and not a good one at that), but it in itself is not a gameplan. A gameplan is a comprehensive concept that revolves around three components. It is a combination of mindset and flow versus a specific threat.

Threat: The focus of our gameplan is the threat we face. We must look at the performance characteristics of our aircraft versus the characteristics of our opponent. We do that through the use of the E-M diagram. From a comparison of the two aircrafts' E-M diagrams we can find the strength and weaknesses of both platforms and design a gameplan that maximizes the strengths of our aircraft while minimizing the strengths of our opponent and exploiting his weaknesses. The other contingency we must consider is the weapons suites both aircraft bring to the table. Again, we will develop a gameplan that minimizes the strengths of our opponent's suite while maximizing the strengths of our own. The consideration of these factors manifests itself in our gameplan through the application of mindset and flow.

Mindset: There are two parts to our mindset discussion: energy and weapons separation. The first part we must consider is how much energy we are willing to sacrifice for the sake of performance. If we have an inferior performing aircraft than our opponent, we may be willing to expend energy to gain or deny angles on our opponent. However, if we have an equal or superior performing aircraft, we may be unwilling to expend energy, relying on the performance of our aircraft to gain or deny those angles. The second part of the equation is how much weapons separation we are willing to allow between aircraft. If we have a forward quarter weapons advantage over our opponent, we would prefer a lot of separation between aircraft to take advantage of our superior weapon's capabilities. However, if our opponent also has a forward quarter weapon, we would be unwilling to allow much separation between aircraft, for it does us no good to have separation to employ our weapon if our opponent also is able to employ, resulting in both aircraft dying at the merge. The separation component of our mindset leads right into our discussion of flow.

Flow: The final component of our gameplan development formula is flow. As we have learned earlier, there are two types of flow: one circle and two circle. In addition, we often discuss out-of-plane maneuvering in our flow discussion. Though not a type of flow in itself, out-of-plane maneuvering with proper lift vector placement is the easiest way to force a

specific type of flow. We will define out-of-plane maneuvering as any time our plane-of-motion is greater than 45 degrees above or below the horizon. In addition to forcing flow, OOP maneuvering provides the added benefit of buying a delayed reaction from our opponent as well as, if it goes uncountered, allowing us the ability to cut across the circle and gain or take away angles from our opponent. As a general rule we would like to initiate OOP maneuvering and if our opponent initiates it, go more out-of-plane.

In general, the amount of separation we are willing to allow from our mindset will dictate the type of flow we choose. Two-circle, in plane flow provides the most separation between aircraft; one-circle, in plane flow provides the least amount of separation, with one-circle and two-circle, out-of-plane, falling in between. So, based on our above discussion, a sample gameplan may sound something like: "We will look to execute an energy conserving, in-plane, two-circle flow to maximize the capability of our forward quarter weapons suite and take advantage of our opponent's rear quarter IR only capability." Once we decide on a gameplan, it is something we strive to execute the entire engagement. We do not change our gameplan in the middle of an engagement just because it is not going our way (i.e. switch from two-circle to one-circle flow). That would be playing into our opponent's gameplan. If our gameplan is not working for us, perhaps the best course of action is to disengage prior to becoming defensive and live to fight another day. That is not to say that we force flow at all costs when we are not in a position to execute a particular type of flow (i.e. two-circle, nose-high). Rather, we will execute smartly, always striving to get back into our desired flow.

Execution

Once we find ourselves in our desired flow, we will execute per our previous discussion during our analysis of the E-M Diagram. However, there will be several situations that will present themselves during the high aspect arena that will require unique consideration in order to gain the advantage and prevail.

Exclusive Use Turning Room: Generally, turning room between aircraft belongs to the aircraft that takes advantage of it first. However, there are several scenarios wherein only one aircraft will be able to take advantage of the turning room between aircraft. We call that turning room "Exclusive Use Turning Room" (Figure 8-31) and it can manifest itself in several ways. The first way exclusive use turning room could manifest itself is at the hard deck where there is separation between aircraft but the merge happens within one turn diameter of the deck. In that case, the low aircraft can take that turning room (assuming he has the airspeed to do so), but the high aircraft cannot without hitting the deck. Another scenario which results in exclusive use turning room is the top of a slow speed merge where neither aircraft has enough airspeed to go up again and there is vertical separation between aircraft. Because the low aircraft does not have enough airspeed to go up, only the high aircraft can take advantage in the separation between aircraft, making it exclusive use. Any time we have exclusive use turning room available to us, we obviously want to take that turning room, capitalizing on free angles and gaining the offensive advantage. There is one other instance of exclusive use turning room which we will address that requires special consideration: the vertical merge.

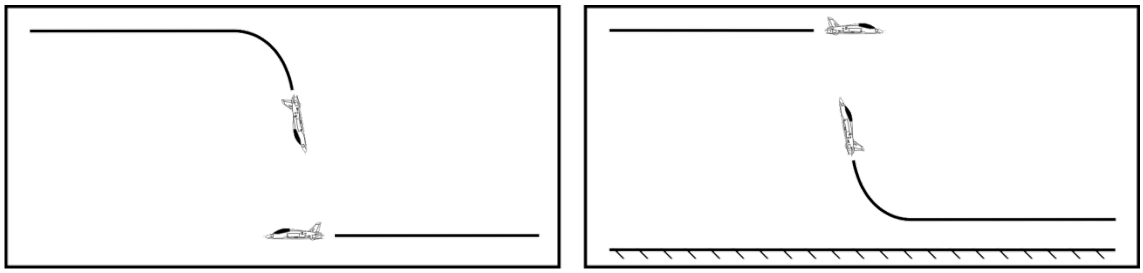

Figure 8-31 "Exclusive Use" Turning Room

Vertical Merges: The vertical merge (Figure 8-32) is an instance of exclusive use turning room because as one aircraft merges nose-high, its turn radius and rate will benefit from the additional force of gravity. Meanwhile, the nose-low aircraft is hampered by increased turn radius and slower rate due to the effect of God's G negatively impacting the aircraft's turn performance. The resulting disparity in aircraft performance effectively provides the nose-high aircraft with an exclusive use turning room scenario. As the nose-high aircraft in the scenario, we have the opportunity to gain a significant offensive advantage, but our execution depends upon the reaction of our opponent. If our opponent tries to extend out of this merge, we will execute an early turn to gain as many angles as we can prior to the merge. Our timing and execution will look very similar to the Attack-Window-Entry-Mech that we discussed under the Offensive Perch BFM discussion, putting our opponent on the canopy bow and pulling, as required, to maintain him there. If our opponent opts to max perform and stop his vertical overshoot, we will extend in the vertical to try and maintain lateral separation (exclusive use in the vertical). On the other hand, if we find ourselves getting set up for the vertical merge, our first priority should be to avoid it. If our opponent is coming up at us, we obviously need to oppose the nose and come down to meet him. However, we will always strive to work up and behind him in order to flatten out the merge and make it less vertical. With a merge in the oblique, we now have the option to force flow into two-circle with us accelerating into our rate band or disengage. If we cannot flatten out the merge and we arrive on the defensive end (nose-low), our reaction will be dictated again by our Axioms of Defensive BFM, specifically Axiom #3. If our opponent tries to early turn, we will match by max performing to minimize our altitude loss (Decrease in TA = Increase in Pull). If our opponent tries to extend through the merge to gain altitude, we will extend as well in an effort to exit our opponent's bubble whereupon we will again be able to deny him angles.

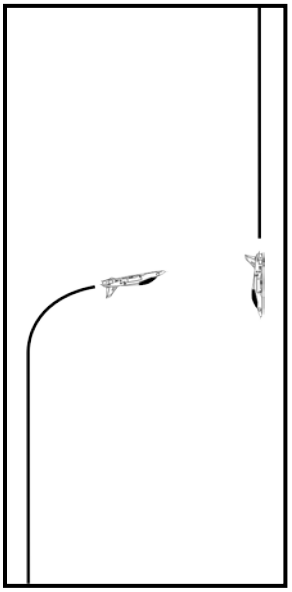

Figure 8-32 Vertical Merge

We will finish our execution discussion with a look at two other unique merge situations where we can look to gain angles.

Slow Speed Merge: As both aircraft go nose-high and arrive at the top, slow, there exists a scenario where angles can be gained or lost if not executed precisely. With both aircraft slow, we do not want to reverse to force one circle flow, even if that was part of our gameplan. Doing so provides exclusive use turning room for our opponent and puts us immediately down range in a radius fight. Instead, we will look to go across our opponent's tail and look to initiate an OOP maneuver nose-low. However, we have to be careful not to go down too soon. Turn radius at those slow speeds, coupled with the added effect of God's G, will result in our opponent's ability to roll in right on top of us. It has the effect of immediately putting our opponent inside our bubble. Instead, we want to wait until opponent exits our bubble, or one turn diameter, before we initiate our nose-low maneuver. If our opponent initiates first: with us inside his bubble, we use the offensive sight picture to time our follow. If outside his bubble, we follow immediately, going at least as nose-low as he did. Uncountered, we arrive at the bottom with an angular advantage. Countered, we look to arrive at the bottom, in our rate band for follow-on options.

Nose-High Counter: The other unique scenario we can find ourselves in is a merge on the deck where up appears to be the only option. If our opponent decides to go up, we could opt to go up immediately but we would be unable to gain any angles. This is because we would be going up on each other's bubble (we cannot gain angles on/inside our opponent's bubble). If we go across our opponent's tail and wait for him to exit our bubble, there exists an opportunity to gain angles. We learned the sight cues for entering the bubble in Offensive BFM. Therefore, in the nose-high counter we will look for those sight cues in reverse: when our opponent's track crossing rate slows down and transitions to aspect change, he is exiting

our bubble. At that point, we can initiate our nose-high maneuver and look to pull lead in the vertical. If our opponent does not honor our nose and come back down, we are gaining uncountered angles. If he does honor the nose, we are setting him up for the vertical merge and we will execute as previously discussed. This scenario can also be used if our opponent goes up and we do not have the energy to follow. In that case, as we go across our opponent's tail, we will need to ease our pull to get as much energy back as possible so that we can go up prior to our opponent coming back down. Of course, if we initiate a nose-high maneuver and our opponent executes a nose-high counter against us, we need to be in damage control mode and working up and aft of our opponent to try and shallow out the follow-on vertical merge.

First Move Options

Based on the discussion above on the "Four Unique Merges," we will now discuss our initial move options as we approach the first merge. While "Go up" is not a gameplan in itself, it may be part of a First Move Option that may be part of our gameplan. At the merge, we will want to initiate our desired mindset and flow via a well thought out first move. In general, there are three possible options: Level, OOP Nose-High, and OOP Nose-Low. While we will not go into a detailed discussion of how we would execute in each scenario, we will explore the possible reasons one might choose each initial move and the implications of our opponent's response to each.

- **Level:** We will define a "level turn" as one that is executed within 45° of the horizon. There tends to be a stigma associated with level maneuvering, but in fact, there is a time and place for a level turn across the horizon. Some have already been discussed in our analysis of Perch BFM. In High Aspect, we often will turn level across the horizon to evaluate the intentions of our opponent. That is not to say that we are executing a "reactionary" gameplan; rather, we have our gameplan in place, but are evaluating our opponent's first move in an effort to force the desired mindset and flow. For instance, if we wanted to force one-circle flow and arbitrarily chose to go nose-high at the merge, what is the effect if our opponent goes nose-low? Are we in the flow that we wanted? By going level initially, we can evaluate our opponent's first move, and reorient our lift vector so as to force the flow where we want. By no means do we want to continue level if our opponent initiates out-of-plane maneuvering, for uncountered OOP maneuvering will eventually result in our opponent arriving with a positional advantage. Rather, we will evaluate our opponent's flow and smartly counter when the proper sight picture develops (for example, the Nose-high Counter).

- **Out-of-Plane Maneuvering:** Again, we define Out-of-Plane maneuvering as any time our plane-of-motion exceeds 45° above or below the horizon. In general, we initiate OOP maneuvering to correspond with the mindset portion of our gameplan.

  Nose-High: We might initiate a nose-high maneuver as part of a mindset where we are willing to sacrifice energy for positional advantage. While it is possible that under unique scenarios it might be associated with two-circle flow, generally the nose-high OOP maneuver is used in conjunction with one-circle flow. If our

opponent matches us nose-high, we have the one-circle flow we desire. If our opponent goes nose-low OOP, we must be careful in that we are now in two-circle flow and potentially setting ourselves up for the dreaded High-Low Vertical Merge. If our opponent goes level and does not counter, with proper lift vector placement, we can execute bubble-post mechanics to arrive in an offensive position in the control zone. If he does counter, again we are looking at the possibility at arriving at a vertical merge.

Nose Low: We might initiate a nose-low maneuver as part of an energy conserving mindset. That might be either one-circle or two-circle. If our opponent goes nose-high, that tends to lead itself into two-circle flow. We must be careful: due to the effects of God's G, our opponent may come nose on first over the top as his radial G will be greater. However, in the end we may have set ourselves up for a vertical merge whereupon we have the advantage coming uphill. On the other hand, if our opponent goes nose-low we may end up with either one or two circle flow depending on how nose-low he goes. If we go more nose-low than our opponent either in one- or two-circle flow, we will reap an advantage at the bottom, either in the form of less downrange travel in one-circle flow or through a positional advantage in angles in two-circle flow. If our opponent matches us and we end up pure nose-low, the fight transitions to one-circle in the vertical. Again we must be careful: while we may be tempted to max perform to achieve a smaller turn radius downhill (IAW a radius fight), as we approach the deck, we will find that the lateral separation we generate is unusable by us due to the deck; it becomes exclusive use turning room for our opponent. In addition, if we bleed below Tactical Vertical Airspeed in an attempt to do so, we have put ourselves in a situation where our opponent may be able to go up and we cannot follow. If our opponent goes level, we will treat it just as we did uncountered nose-high, utilizing bubble-post mechanics to arrive in the control zone with a positional advantage.

Transition to Offensive/Defensive BFM

Arguably the hardest part of BFM is recognizing the sight cues and transitioning appropriately to either offensive or defensive BFM. Almost immediately after the first merge, roles will be established even though the advantage may be as little as 20 degrees.

The aircraft that recognizes that advantage, or disadvantage, and makes the transition first is usually the one that prevails. The key to understanding the transition process is to realize that the same sight cues we learned in perch BFM still apply in high aspect, albeit more subtle and fleeting. For example, let’s take the scenario that two aircraft are approaching the second merge and one of them has a 30° bite (Figure 8-33). We will examine the transition phase from both perspectives:

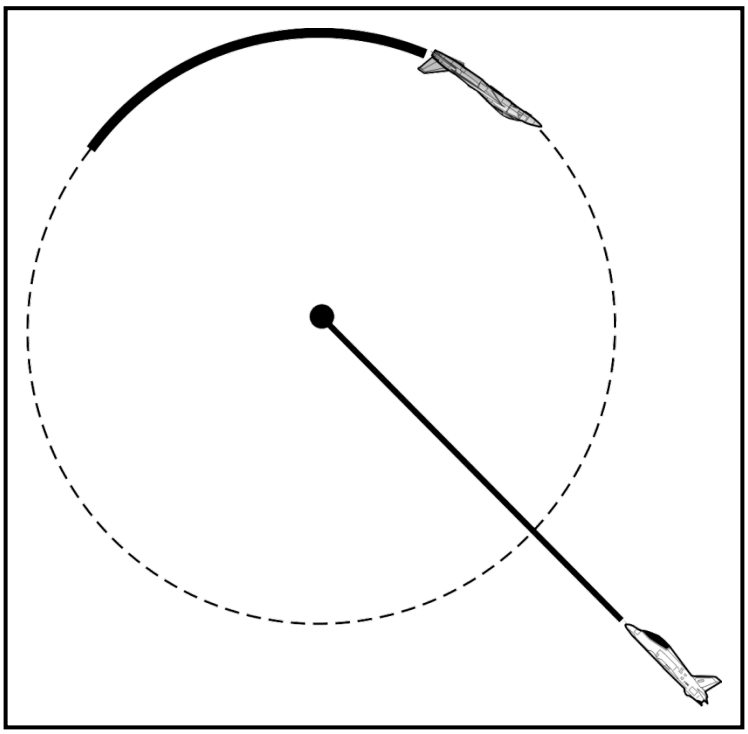

Figure 8-33 Offensive/Defensive BFM Transition

Offensive: From the offensive perspective, remember our first priority is to preserve lateral separation. From our discussion of perch we learned that any time we are outside the defender's bubble he can take angles from us. Therefore, like in perch, we are striving for bubble entry as quickly as possible. While in perch, at 40° AOT, we did this roughly through pure pursuit. However, in the forward quarter, as we can see in the above figure, pure pursuit will keep us out of the bubble longer and allow the defender to take out more angles. The quickest way to enter another aircraft's bubble is always to point at the post. With the closure rates associated with an impending merge, taking a cut away from the defender is not a recommended option; a lag (or even just an ease of pull) toward the post may be all that is required. As in perch, once we see the line of sight rates associated with the Attack Window, we will execute our in-plane, Attack-Window-Entry-Mech (pull as necessary to maintain just above the canopy bow) to arrive in the control zone. In this scenario, the cues for bubble entry and attack window will happen near simultaneously, so quick recognition and reaction is crucial. In this manner, we preserve lateral separation while working to align fuselages.

Defensive: From the defensive perspective, once we recognize the slightest advantage by our opponent, we must fight the tendency for denial and transition to the four axioms we learned earlier. The most important of these at the moment is to take out as many of those angles as possible before the attacker enters our bubble (Axiom #2). Whether we wish to redefine the flight with either a reversal or bug, we cannot afford to give our opponent an angular advantage. Regardless of the angular advantage of our opponent, whether it is 10 degrees or 90 degrees, the four axioms of defensive BFM will serve us well.

806. CONCLUSION

Throughout this chapter, we have discussed, in basic terms, the theory behind Basic Fighter Maneuvering between two aircraft. In the following chapter, we will introduce the procedures for the drills and maneuvers that will allow us to recognize the sight pictures behind these theories and put them into practice.

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CHAPTER NINE
BASIC FIGHTER MANEUVERS (BFM)

900. INTRODUCTION

With a solid grasp of the BFM theory presented in chapter 8, tactics and procedures utilized during the BFM syllabus flights may now be introduced. A "building block" approach will be utilized during the BFM syllabus where we first demonstrate the T-45C aircraft performance in flight. The tactical material will become more complex as we introduce the offensive and defensive components of two plane engagements. Finally, we will train to fight 1V1 BFM engagements from a neutral start.

This chapter presents the maneuvers and procedures the student will perform during the BFM phase in chronological order. It is not meant to be an all-encompassing tutorial of BFM, rather this chapter lays out the mechanics of the procedures that will be introduced during the VT-86 BFM syllabus. For an in-depth discussion of the theory behind the execution, NFSs should refer to Chapter 8 of this FTI, BFM Theory.

The six syllabus flights will be flown in section to a local working area. Thorough knowledge of the working area procedures is required. Basic section procedures are utilized and lead responsibilities are normally shared on alternating flights between paired students. Solid contact procedures such as checklists, fuel management, and navigation are expected.

Solid flight preparation is required and expected from the NFS prior to the arrival at each brief. There is too much material to cover during the BFM syllabus to allow for "lecturing" and hand-holding throughout the events. Students should come to each brief armed with the knowledge from this FTI. The brief should be used as a forum to clarify concepts that are difficult to visualize and to answer questions. The flights are an opportunity to demonstrate sight pictures and practice concepts learned through pre-flight study. Students that arrive at the brief unprepared waste valuable training time, fuel, and assets.

901. WEAPONS ENVELOPES

For the purposes of demonstrating the basics of BFM, here at VT-86 we will concentrate on the basic, rear quarter weapons envelopes delineated by CNATRA in Figure 9-1. NFSs are encouraged to recognize offensive weapons employment opportunities and to call for their pilot to "pull for the shot" as appropriate.

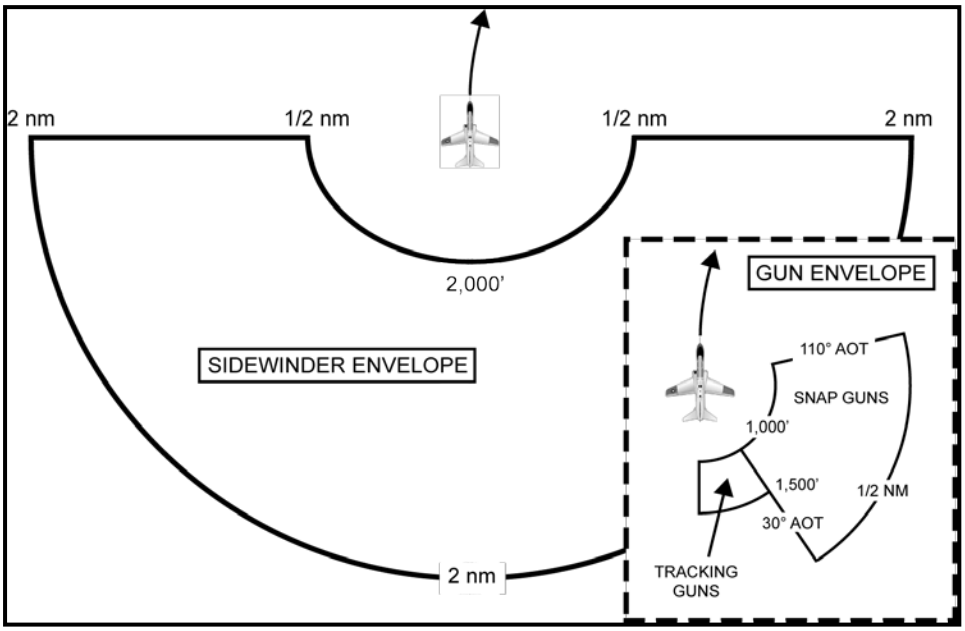

Figure 9-1 CNATRA Weapons Envelope

IR Missiles

The rear-quarter IR missile is the most basic of air-to-air missiles, utilizing heat from the target's engine exhaust to guide to impact. They are generally fairly maneuverable but limited in employment range, making them capable "Within Visual Range" ACM weapons. Even though the depicted IR missile envelope shows no capability forward of the 3/9 line, we should not be lured into a false sense of security that a sanctuary exists forward of the wingline. Most rear quarter IR missiles are limited by fuzing and not seeker head and can acquire a full powered aircraft in the forward hemisphere. Only the closure generated by a break turn will adequately defeat such a missile once employed. For this reason, any time we recognize "sensor nose" we should be reacting with either a break turn (attacker in WEZ) or hard turn (attacker forward of 3/9 line) as appropriate.

<u>IR Missile Employment</u>

Lacking IR missile symbology in the T-45, the following criteria will be used for the purposes of determining a valid shot:

1. Target on the waterline, between the airspeed and altitude boxes

2. Target AOT assessed stadiametrically as less than 90 degrees

3. Range assessed between 0.5 NM and 2.0 NM through the use of yardstick

4. If target is wings level, tail-on (i.e. bugging), utilize the Rules-of-3:

9-2 BASIC FIGHTER MANEUVERS (BFM)

< 250 KTS opening at 0.5 NM

< 200 KTS opening at 1.0 NM

< 150 KTS opening at 1.5 NM

< 100 KTS opening at 2.0 NM

NFS Responsibilities

Upon recognition of "sensor nose" (impending shot), the defensive NFS will call for a break turn over the ICS and "flares" over the UHF. Preemptive break turns and "flares" calls (prior to the shot call; "Sensor Nose" = 30° TA) will result in the denial of missile employment and the offensive IP calling "continue." For the purposes of training, NFSs have unlimited flares.

Air-to-Air Gun

The gun is by far the most widely used and simple air-to-air weapon ever devised. It is also the most misunderstood in regards to its employment. In effect, the gun is, for all intents and purposes, an all-aspect weapon with no minimum range. In the interest of safety however, both training rules and the CNATRA Guns Envelope (Figure 9-2) limit its employment in the training environment.

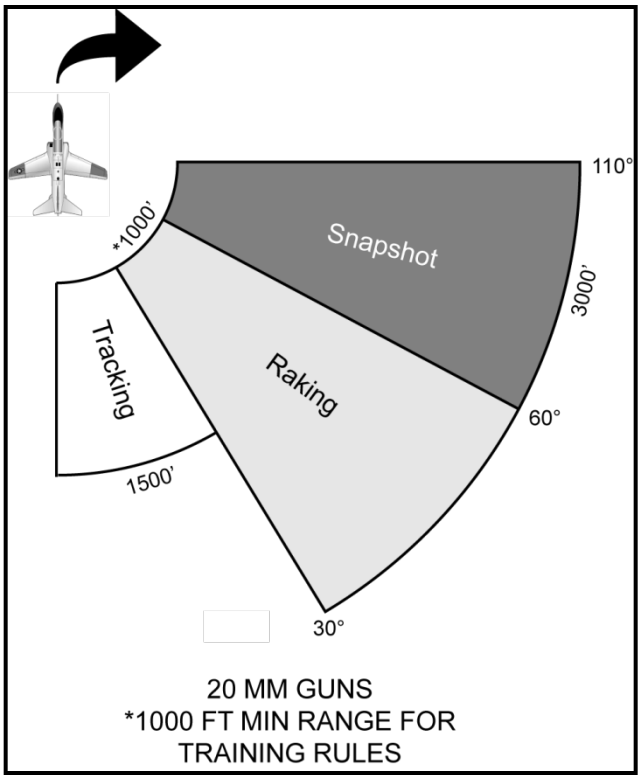

Figure 9-2 CNATRA Gun Envelope

NFS Responsibilities

Upon recognition of an impending gunshot, the defensive NFS will call for a Guns 'D' over the ICS.

902. TRAINING RULES

The following ACM training rules apply to all BFM training and shall be strictly observed. These rules include those found in OPNAVINST 3710.7U. Because you will hear these rules before each flight, their meaning may become just “so many words.” For the most part, they will be the same rules you hear in the fleet. But it is important to note that these rules were developed over a long period and each is based not only on common sense but on situations where pilots were guilty of making serious and even tragic mistakes.

1. Brief Departure / Spin procedures. All participants are responsible for knowing the T-45C Out-of-Control procedures VERBATIM. The briefing or designated SNFO, shall verbalize these procedures at the beginning of every coordination brief with all members of the flight present.

2. Scheduled face-to-face brief. All participating aircrew will attend the coordination brief. Brief items shall include the conduct of the flight, the maneuvers flown, selected safety of flight aspects, spin avoidance and recovery procedures, and training rules.

3. ACM authorized by cognizant commander. All BFM events will be annotated on the flight schedule or approved via the chain of command.

4. Designated ACM area. All BFM will be conducted inside Military Special Use Airspace.

5. Currency.

   OPNAV 3710.7U: Pilots with < 750 hours in type/class: 1 in 6, 2 in 14

   Pilots with > 750 hours in type/class: 1 in 14, 2 in 30

   NFOs: 1 in 14, 2 in 30

   All crewmembers (IPs, NFSs, NFOs, Observers) will have flown the requisite number of flights within the preceding time period (days) to establish BFM currency prior to participating in a BFM event.

6. Weather. All engagements shall be conducted under VMC conditions with the following additions:

   5nm visibility and a defined horizon

   Cloud Sep: 2,000’ vertically and 1nm horizontally

No maneuvers through cloud layers

11,000’ between broken/overcast layers

Top of cloud layer will not exceed 7000’ MSL (Solo)/8000’ MSL (Dual)

7. Decks

Hard Deck: 10,000’ AGL or 5000’ above an undercast

An engagement shall automatically cease when any aircraft descends below 10,000 ft, and that aircraft shall be considered a safety/training rule violation (and to a lesser extent, a “kill”). Any aircrew who recognizes a deck violation (including an NFS) will immediately call "Knock-it-Off, Deck."

8. No sustained slow speed, high AOA maneuvering (<120 kts AND >24 units AOA). These parameters should only by transitory at best. Prolonged maneuvering in this marginal control region can lead to out of control flight if attention is not paid accordingly.

9. Configuration changes other than speedbrakes are not authorized. Use of flaps is not allowed.

10. Comm Requirements: All aircraft must have operable UHF (Transmit / Receive), ICS (multi-crew) and monitor Guard. If both radios or the ICS is lost, ACM shall be terminated via a "wing rock." If comms cannot be reestablished, the flight will be terminated, rendezvoused and RTB.

11. Prior to ACM

Perform G-awareness maneuver. A 180° G-warm for the max G expected during an engagement will be performed (4G for 90°, 6G for 90°)

Flight Lead confirm weather, type war, altimeter setting, decks. OPNAV 3710.7U requires that the flight lead confirm the airspace, weather, type war, hard deck and local altimeter before the commencement of ACM.

Altimeter warnings set. The LAW will be set to 5000'.

12. Commencement of ACM

Collision Avoidance:

- 500’ bubble around all aircraft at all times
- Always assume the other aircraft does not see you

- Head-on pass: Maintain the established trend; where no trend exists, give way to the right to create a left-to-left pass. Broadcast your own intentions. Pass calls are made for the purposes of maintaining a 500' bubble and preventing midair collisions, not for the purposes of gaining an advantage at a merge. If there is no clear trend, we create one by giving way to the right so as to pass left-to-left. Pass calls are always given from the perspective of being earth-stabilized (aircraft upright) to avoid any confusion. Under no circumstances do we cross flight paths to make a pass happen. If there is any doubt, or the called pass cannot be accomplished safely, a "Knock-it-Off" should be called.

Converging flight paths:

- Nose high goes high
- Nose low has collision avoidance responsibility
- Broadcast your own intentions

  In a slow-speed engagement, aircraft have limited maneuverability and ability to avoid a collision, the nose-low aircraft typically has more energy and maneuverability and therefore the onus for making a safe pass happen. Under no conditions will we cross flight paths to do so.

Never intentionally maneuver to lose sight (no blind lead turns). A blind lead turn occurs when an aircraft maneuvers "belly-up" to an opponent in an attempt to pull lead.

Up-sun aircraft has responsibility for collision avoidance. If down-sun aircraft lost sight, transmit “Callsign, blind” and turn away from predicted collision bearing. Down sun aircraft will lag the up-sun aircraft's last known position until sight is regained.

If lost sight, transmit “Blind” and remain predictable. Other aircraft shall acknowledge with “visual, continue” or “knock-it-off” as appropriate, providing directive comm as necessary for safety of flight and own ship altitude in thousands of feet. Once sight is regained, transmit “visual.”

A/S < 85 kts (nose high/decelerating) call “Knock-it-off, ballistic”. If A/S is 85 kts (nose low accelerating) requires call “85 knots, continue.” Ballistic aircraft are in out-of-control flight.

No head-on missile acquisition inside 9000’ (within 20 degrees of the nose). Inside 9000' and 20° of our opponent's nose, the pilot's undivided attention will be devoted to the safe separation of aircraft.

No forward quarter gun attacks (within 45 degrees of the nose). Because of the closer proximity of aircraft in the gun envelope, inside 45° of the target's nose, no gun shots will be taken and the pilot's full attention will be devoted to collision avoidance.

Break off all gun attacks at 1,000'. Gun attacks will be broken off at 1000' so as to pass no closer to 500'.

13. Terrain Avoidance:

Offensive aircraft will monitor the defender's altitude, attitude, and airspeed and will break off the attack prior to either aircraft breaking the hard deck. The defensive aircrew will most likely be devoting a majority of their scan outside, over their shoulders, at the offensive aircraft, compromising their deck awareness. It is the responsibility of all members of the flight to ensure no aircraft break the deck. If any aircraft executes an extreme nose-low maneuver in close proximity to the deck, any aircrew who recognizes it should call "Watch the Deck" or "Knock-it-Off, Deck" depending on the situation's severity.

14. Termination of ACM

ACM shall cease when:

- Any training rule is violated
- "Knock it off" / "Terminate" is called and all players echo

"Knock it off" for any of the following:

- Interloper. Any unbriefed aircraft enters the fight or working area
- Departure / Spin
- G-LOC
- Min alt broken. Deck violation
- NORDO/aircraft rocks its wings
- Overstress
- BINGO fuel
- Inadvertent IMC. Any aircraft touches a cloud.
- Loss of SA / any unsafe condition develops
- Training objectives obtained
- In a BFM engagement, both aircraft lose sight
- Approaching training area boundary
- Any training rule is violated

15. Post Termination of ACM

Be aware of high midair potential following the “Knock it off” or “Terminate” call. The highest potential for midair exists at the KIO where both aircraft are at low energy states, in unpredictable flow and in close proximity to one another. Collision avoidance should be the number one priority following acknowledgement of the KIO call.

903. FLIGHT CONDUCT

Brief

At the scheduled brief time, the students will have a briefing board prepared in accordance with the "ATM Student Briefing Guide". Administrative flight data will be displayed to include a drawing of the scheduled operating area. Additionally, the applicable weapons envelopes will be drawn on the briefing board and incorporated into the brief. NFSs should expect to spend approximately 30 minutes briefing their required items, whereupon the lead IP will take the remaining 45 minutes to brief BFM concepts more in-depth. The NFS portion of the brief should include the following:

- Mission Training Objectives (~1 Minute)
- Admin (~5 Minutes)
- TAC Admin (~4 Minutes)
- Flight Conduct (~5 Minutes)
  - Walk/Preflight
  - Taxi/Takeoff
  - Enroute
  - RTB
  - Recovery
- Emergencies/Safety (~5 Minutes)
- Tactical Conduct (~10 Minutes)
  - PADS
  - Comm Sequence
  - Safety Considerations
  - NFS Responsibilities

Special emphasis during the brief will be placed on the students’ thorough understanding and verbatim recitation of the Out-of-Control Flight (OCF) recovery procedures.

During the coordination brief, training rules and OCF Procedures will be covered with all aircrew present.

Launch/Enroute

BFM flights will plan and brief as operating as a flight to and from the working area. A "Section Go" or "Interval Go" will be briefed and executed as conditions dictate. Should the weather preclude operating as a section (WX < Circling Mins), a plan to launch as singles and rendezvous in the working area will be briefed as a contingency.

NFSs will conduct the section per procedures previously demonstrated during the Section Weapons Phase. NFSs will manage the flight so as to arrive at the entry point of the working area fenced in and ready for maneuvering flight.

BFM Working Areas

The primary operating area for BFM is the W155A (Figure 9-3). The Pensacola South MOA serves as the secondary operating area and is used when the W155A is unavailable or is unworkable due to weather. The flight schedule will assign a working area for the section (i.e., NPA-13 for the W155A or NPA-8 for the Gator South MOA).

W-155 Procedures

If W-155A is scheduled, a mission number may be assigned and annotated on the flight schedule. The students will have this mission number available in-flight.

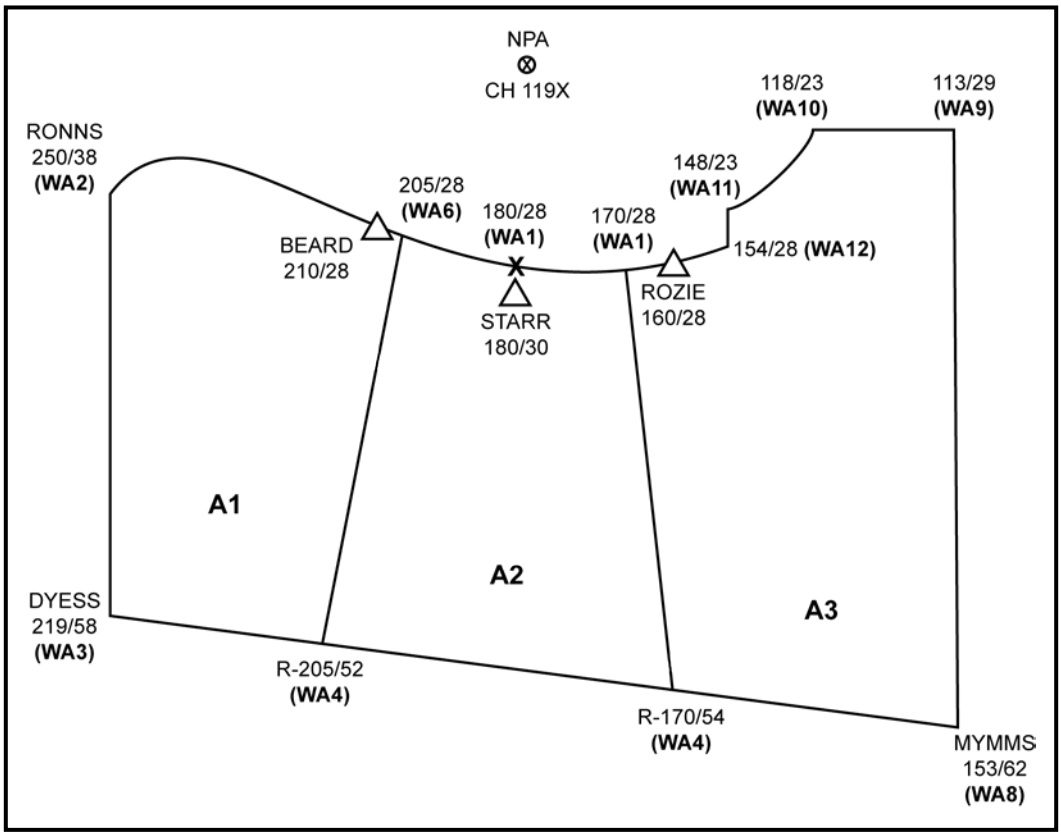

Figure 9-3 W-155A

The W-155 area will be sequenced via the waypoint library per the in flight guide. It is recommended that NFSs input the entire working area (W-155A1, 2 &3) to provide better area awareness and due to the possibility of flexing areas airborne (for traffic, weather, etc.).

- **W-155 Check-In**

The lead student will be responsible for all navigation and UHF communication to and from the operating area. Shortly after departure, the controller will direct the flight to contact Seabreeze (the controlling agency for W155) and to "Fence-in." For example:

Lead NFS (UHF2): “VIPERs, switch button 15, fence in.”

Wing NFS (UHF2): "2"

The lead student will request frequency change if it has not been received by 20 DME. On initial contact with Seabreeze, the lead student will request one, two, or all three of the W155-A operating areas (as de-conflicted with other sections with concurrent times and leaving a corridor for other aircraft to transit to W-155B).

If unable to comply with the flight's request (i.e., the requested areas are occupied), Seabreeze

will assign the available working area/s. Since two, and even three, sections can be scheduled into the W155 area simultaneously, all students are responsible for area and COMM de-confliction prior to the brief. This will enable expeditious coordination with Seabreeze for entry and exit out of the area.

Upon receiving clearance to a working area, the lead student will navigate the section to the applicable entry point for the assigned area. During this transit, Seabreeze should provide clearance into W-155A. If Seabreeze delays the clearance, or very slow in providing it, the NFS is expected to be proactive and assertive to expedite the coordination without undue delay.

As the flight approaches the entry point, Seabreeze will assign a separate squawk for the wingman and assign a discrete frequency. Both will be required before Seabreeze will authorize aircraft to maneuver within the confines of W-155. Therefore, NFSs will be proactive to ensure that all requirements have been met prior to arrival at the Entry Point so that the section can begin maneuvering immediately upon entry into the working area. Upon the switch to discrete, Lead NFS will initiate a check-in on the discrete/Safety-of-Flight frequency:

Seabreeze:	"ROKT 403, switch to discrete, 274.2"
Lead NFS (UHF1):	"ROKT 403, switching 274.2"
Lead NFS (UHF2):	"VIPERs, check Pri."
Lead NFS (UHF1):	"VIPER 11."
Wing NFS (UHF1):	"VIPER 12."
Lead NFS (UHF1):	"Seabreeze, ROKT 403, with you on 274.2"

After both aircraft have checked-in on discrete/SOF, all tactical comms will be made on the SOF frequency. NFS fuel checks will continue to be made on Aux.

- **W-155A 10 Minute Prior RTB Call**

Approximately 10 minutes prior to RTB, the lead student will inform the wingman that he/she will be off PRI for 1 minute. Lead NFS will switch COMM 1 to Seabreeze's PRI frequency to notify the 10 minute prior with recovery intentions (Course Rules, GCA, etc…) and obtain the weather, altimeter, and duty runway. Upon return to the discrete frequency, the Lead NFS will report back up and pass the applicable information to wing.

- **W-155A RTB**

This transition from BFM to section navigation during the RTB segment of flight is one of the more challenging evolutions in the syllabus. The lead student will direct the lead IP to descend to 7000 feet (the W155A exit altitude), and will provide an initial heading towards the applicable exit point (Beard, Starr, or Rozie for Area 1, 2, and 3, respectively). As this is executed, the lead student will have the section switch to Seabreeze's primary frequency.

Lead NFS (UHF2):	"VIPERs, switch button 15 Pri, fence out."

Wing NFS (UHF2): "2"

That being said, remaining within the confines of the assigned working area is paramount until clearance to exit is granted. Once the lead student feels comfortable the flight is ready to safely proceed towards the exit point, he will contact Seabreeze on primary. If the lead student anticipates the flight will arrive at the exit point before further clearance is received, the lead student will direct his pilot to orbit within the confines of the assigned area until Seabreeze is able to coordinate the handoff to Pensacola Approach.

Once coordination has been accomplished with Pensacola Approach, the flight complies with the instructions from the controllers and the applicable Course Rules.

Gator South MOA

The Gator South MOA (Figure 9-4) will be utilized if scheduling conflicts or weather prevents use of W-155A. The confines and procedures for MOA use are detailed in the T-45C Student In-flight Guide. The Gator South MOA's standard confines are 11,000 – 17,500 feet. Utilization of the MOA "high-block" up to 23,000 feet must be coordinated with ATC. Remember that the high-block only exists in Areas 1-4. Note that this will require adjustment of the "hard deck" and the PADS as necessary which shall all be pre-briefed or verbalized real time. Because it is a general use area, there are several procedural differences from operating in the Warning Area.

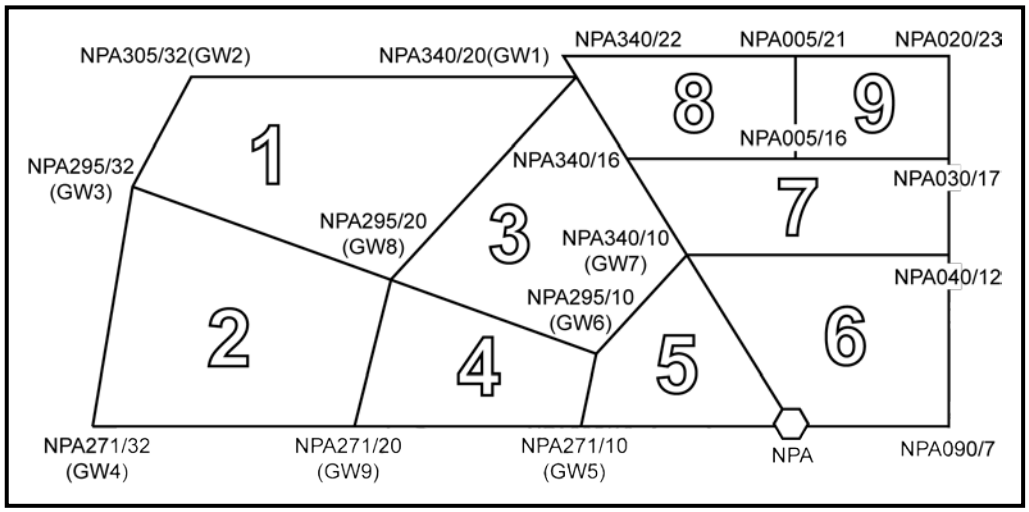

Figure 9-4 Pensacola South (GATOR) MOA

- **PNSS MOA Check-In**

The lead student will be responsible for all navigation and UHF communication to and from the operating area. Shortly after departure, the controller will direct the flight to enter the MOA and authorization to switch to the MOA frequency. Because the MOA frequency is a common

use/Safety-of-Flight frequency, the section will execute a positive check-in on Button 18. Thereafter, Lead NFS will coordinate deconfliction with other aircraft working in the MOA.

Lead NFS (UHF2): “VIPERs, switch button 18, fence in.”

Wing NFS (UHF2): "2"

Lead NFS (UHF2): "VIPERs, check Pri."

Lead NFS (UHF1): "VIPER 11."

Wing NFS (UHF 1): "VIPER 12."

Lead NFS (UHF1): "99 in the Gator MOA, ROKT 403, flight of two T-45s, checking in, who's working?"

Once working area is deconflicted:

Lead NFS (UHF1): "ROKT 403 and flight will take areas 1 and 2."

BFM flights typically require at least two of the four working areas. Once the flight is established within the horizontal and vertical confines of the designated area, the Lead NFS will report:

Lead NFS (UHF1): "ROKT 403, established areas 1 and 2."

- **PNSS MOA RTB**

Since the MOA is a general use area, there is no 10-min prior call required. In its place, lead NFS can prepare to RTB from the MOA by directing the wingman to switch up ATIS on COMM 1 (or as briefed) and report back when complete. Wing NFS will acknowledge and switch to obtain ATIS. When complete, wing NFS will report back with the information. Once the flight is RTB, the Lead NFS will check out of the MOA:

Lead NFS (UHF1): "ROKT 403, checking out of areas 1 and 2 to the south in one minute."

Lead NFS (UHF2): "VIPERs, switch button 6 Pri, fence out."

Wing NFS (UHF2): "2"

Rendezvous

The RTB will be initiated by the lead IP at the completion of the last engagement (after the engagement “knock it off” call and subsequent fuel check initiated by Lead NFS).

Lead IP (UHF1): "VIPERs RTB, with a 'visual', clear to join."

Wing IP (UHF 1): "VIPER 2, visual."

With the lead in sight and the "visual" call made, the wing student will monitor closure and call airspeeds during the rejoin. The lead student will reply to the wingman's call with his own fuel state and establish the section's low state. As the wingman joins up, the lead student will monitor the rendezvous to ensure safety of flight is maintained. If either student deems an under-run as necessary, then it is that student's responsibility to direct its execution via TAC FREQ. Concurrently, while the join up occurs, the lead student's primary responsibility is to direct the flight out of the working area and back to base in a safe and efficient manner. As always, the best way to accommodate this is to rely on the standard hierarchy of priorities: aviate, navigate, and communicate.

During any rendezvous, the number one priority for all aircrew involved is the safe and expeditious joining of aircraft. Therefore, other tasks should only be accomplished on a "not-to-interfere" basis with our primary responsibility. Tasks such as fencing out, frequency changes, etc. shall be done only if the wingman is far away enough during the join up that he is able to momentarily go head down and take his attention away from the rendezvous. Otherwise, safety of flight is the priority and the lead student will wait until the rendezvous is completed before directing any tasks to the wingman. Rendezvous flow should occur as follows:

1. Fencing Out (if time permits: outside 0.5 NM)

2. Rendezvous

3. Complete Fencing Out (If not completed previously)

4. Report Fenced out

   Lead NFS (UHF2): "VIPER 11, fenced out, 1.0"

   Wing NFS (UHF2): "VIPER 21, fenced out, 0.9"

5. Battle Damage Checks

6. Wingman in Cruise Formation

7. Pre-Descent Checks

Recovery

BFM Flights will execute section recovery procedures IAW Chapter Four of this FTI, Section Flight Procedures. Section Fan Breaks will be the standard during the BFM Stage. Flight leads have the prerogative to brief interval breaks should conditions dictate. NFSs should always be prepared to execute weather contingencies (Section Approaches, Individual Approaches, etc.). The flight is not over after the "Knock-it-Off."

Emergencies

Section emergency procedures will be briefed as in Section Weapons. However, the following special considerations for Section BFM will be briefed.

Lost Comm/Lost Sight

There are five individual scenarios that must be discussed when briefing Lost Comm/Lost Sight. An overview of the scenarios and considerations follow:

1. **Lost Comm, Enroute/RTB:** Should an aircraft lose communications during the administrative portion of the flight, that aircraft will be placed as the wingman and be brought back to the field utilizing standard section NORDO procedures.

2. **Lost Comm during an engagement:** Should an aircraft go NORDO during an engagement. that aircraft will attempt to knock off the engagement by transmitting "Knock-it-Off" in the blind while simultaneously rocking its wings. The NORDO aircraft will then establish the nearest "safe" altitude (Lead-Odd, Wing-Even) and establish a 30° AOB turn (LHT - no other problems, RHT - additional system problems) and await the other aircraft to join. Once the aircraft are joined, the lead will be passed to the aircraft with the good radios and the flight will RTB via standard section NORDO procedures. If an immediate rejoin cannot be accomplished, aircraft will proceed via Scenario #5.

3. **Lost Sight, Enroute/RTB:** Aircraft will deconflict via squadron SOP Lost Sight Procedures. The flight will "fess up" to ATC to facilitate the coordination of separate clearances for each aircraft in the flight. After safely deconflicted, a determination can be made if the aircraft can rejoin in the area or RTB as singles.

4. **Lost Sight/Good Comm in an engagement:** If one aircraft loses sight in an engagement, that aircraft will call "Blind" and remain predictable. Assuming the other aircraft has sight, the fight can be continued with the visual aircraft providing deconfliction and striving to talk the other aircraft back on. Should training or safety deteriorate or both aircraft are blind, an immediate "knock-it-off" will be called. Both aircraft will maneuver to the closest safe altitude (Lead-Odd, Wing-Even) and the flight lead will give a flow heading to facilitate deconfliction. The flight will then utilize comms, yardstick and geo-refs to facilitate regaining sight before attempting to rejoin.

5. **Lost Comm/Lost Sight in an engagement:** Should aircraft lose comm and lose sight, they will KIO IAW Scenario #2 above. If yardstick verifies that greater than 1.0 mile of deconfliction is available, Lead aircraft will climb to 15,000' (or 1000' below an overcast) and Wing will climb to 14,000' (or 2000' below an overcast). Aircraft will proceed to the pre-briefed Lost Comm/Lost Sight Point to affect a rendezvous and RTB via standard section NORDO procedures.

OCF

Lead NFS will be responsible for reciting the OCF boldface during the training rules portion of the coordination brief. Beyond that, section responsibilities should be briefed during the section brief. Specifically, it is the responsibility of any aircrew that observes an aircraft out-of-control to transmit "Knock-it-Off, Neutralize." If an out-of-control aircraft is known to be below the 10,000' NATOPS recommended eject altitude and not recovering, consideration should be made for wingman to direct the OCF aircrew to "Eject" over UHF, utilizing that aircraft's callsign.

Debrief

The Debrief is the most important part of any flight; it is where the majority of the learning is accomplished. For BFM debriefing to be effective, it is broken up into three distinct phases: Recall, Reconstruction, and Analysis.

Recall

The first phase of the debrief revolves around being able to remember what actually happened during particular engagement. To that end, we have several means by which we can aid our memory in remembering the particular details of an engagement.

- **Notes:** Notes are the primary and most effective means of recalling the details of a particular engagement. Taking effective notes is an acquired skill that is perishable and requires diligence and practice to maintain. A common temptation is to try and draw out or spell out every detail of an engagement on the kneeboard card in front of us. In practice, that technique is neither tenable nor effective. Our notes should merely be a prompt to jog our memory during the reconstruction phase of the debrief. As such, the important things to record during the flight are initial start headings and formation (260°, left), passes and headings at merges (R/R, 350°), flow out of merges (2C left), headings of shots, headings going into and out of ditches, and knock-it-off headings. You will find that with adequate notes and sound reconstruction techniques, you will begin to be able to recall most engagements.

- **HUD Tapes:** A common tendency in the fleet is to rely on our HUD Tape to aid in recall. While it is definitely a tool we can have in our arsenal to help us in filling in holes in recall, it should not be used as our primary means of regenerating the details of an engagement. A tape is a crutch for poor recall techniques and is unreliable as the only means of aiding recall: VCR malfunctions, sun-washed HUDs, or poor switchology all serve as failure points of the tape as a debrief tool. In short, while the HUD tape does have its place in the BFM debrief, it is a poor substitute for well-taken notes.

Reconstruction

Before we can analyze an engagement and take away the learning points, an accurate reconstruction of the engagement must occur. There are several methods by which we can

reconstruct an engagement during a debrief, the most popular being listed below. Which debrief method we choose to employ generally revolves around the experience level of our audience.

- **Whiteboard Debrief:** Though time consuming, the whiteboard debrief is by far the most effective reconstruction tool in regards to debriefing BFM. It is the method of choice for debriefing aircrew with little BFM experience. Providing a God's-eye view of the engagement, it provides the most representative picture of what happened during an engagement, provided that it is done correctly. To that end, scale is of the upmost importance: if one marker-length represents one mile at the start of the engagement, that scale must be maintained throughout the reconstruction. Additionally, the length of arrows must be representative of the relative velocity of the aircraft being depicted (i.e. faster aircraft are represented by longer arrows). If the reconstruction is kept to scale, proper whiteboard reconstruction can even fill in holes in recall through simple deductive reasoning. Figure 9-5 represents the symbology typically used in a whiteboard debrief.

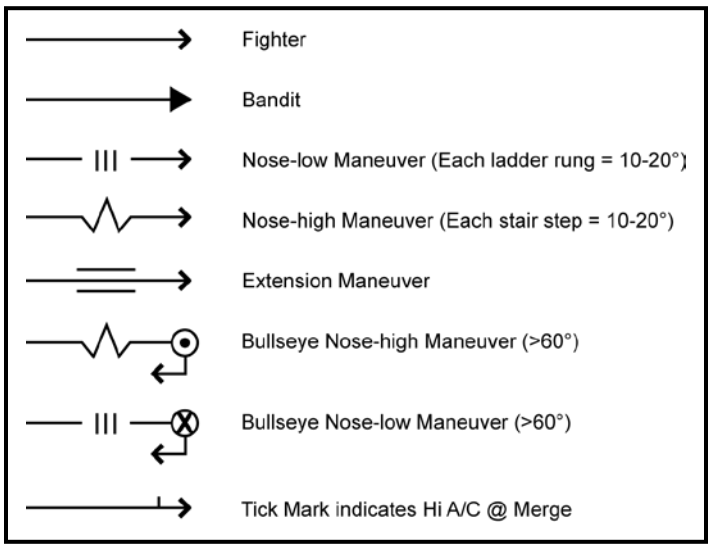

Figure 9-5 Whiteboard Reconstruction Symbology

- **Model Debrief:** Models are one of the most misused training tools in Naval Aviation, both in briefing and debriefing. While excellent tools when used correctly, most aircrew do not know how to use them correctly, resulting in them being distractions vice assets. The most important concept to remember when using models is to avoid distractions. Color and movement attract the eye, of which models generally possess both. Anything that takes attention away from the speaker is a distraction. Common mistakes often found with models are: using them as pointers, idle playing with them while talking, gesturing with them (as they become extensions of your hands), and "flying the models." The reason we do not "fly the models" is that, with the scale involved, we cannot realistically demonstrate the proper motion of an aircraft flying through the sky. Most BFM models are 1:72 scale, meaning that 1" on the model corresponds to 72" in real life. At that scale, a 1 NM abeam distance

would have to be represented by holding the models 83 feet apart! Even a snapshot of 1000' would required us to hold the models 12' apart. Because it is unrealistic to move the models in a representative fashion, we use them to represent visual sight pictures or general spatial relationships between aircraft via snapshots in time. We should limit any movement of the models to no more than 30-45° of turn, merely for general reference. Finally, when we are finished demonstrating the sight picture, we put down the models so as to not distract our audience from us and our message.

- **Chalk-Talk Debrief:** The Chalk-Talk is a debriefing tool commonly used when time or facilities prevent us from using one of the other debriefing tools. It can also be used to quickly debrief simple concepts that do not need to be demonstrated in great visual detail. It is a debriefing tool primarily limited to experienced aircrew who have a solid BFM background, that can mentally visualize the BFM arena and BFM concepts. Aircrew with limited experience profit little from the chalk-talk as they do not have the baseline experience often needed to visualize dynamic BFM concepts.

- **Tape Debrief:** Like in recall, many aircrew are tempted to rely on the HUD tape as a method of reconstruction. While it can provide some useful information in regards to aircraft performance, it does nothing to show the spatial relationships between aircraft during an engagement. For that reason, it should be used more as an analysis tool than a reconstruction tool.

Analysis

The analysis phase of the debrief is the time when most of the learning is accomplished. A common mistake that occurs during debriefing it to begin analysis of an engagement before an accurate reconstruction has occurred. If a reconstruction is not accurate, especially if there is disagreement as to the conduct of an engagement, any analysis is premature. If all members of the flight do not agree as to what happened, it is unlikely that they will buy in to the analysis. Likewise, if it is inaccurate, our analysis may be flawed. For that reason, we do not start analysis until the reconstruction is complete and all parties agree (to the extent that they can) that it is, in fact, an accurate depiction of the engagement. Then, and only then, will the debriefer look for snapshots in the engagement that bring out the significant learning points, or are turning points in an engagement. At a minimum, we will want to pull out specific training objectives (ditch timing, mechanics, for example) and any shots, both to determine the validity and reasons for their opportunity.

- **Tape Debrief:** The analysis phase is where the HUD tape truly has some marginal utility. When debriefing a pilot's stick-and-rudder skills during a particular maneuver, the HUD tape can provide invaluable information in regards to aircraft handling and performance.

- **Shot Validation:** The most prevalent use of the HUD Tape debrief is to validate our shots throughout the engagement. This is how we will use the HUD to debrief in VT-86. NFSs will review their HUD tapes prior to the debrief, validating each shot and bringing a filled out Shot Validation Card to the debrief. For the purposes of VT-86 Shot Validation, the following criteria will apply:

IR Missile Valid Shot Criteria

At trigger squeeze:

1. HUD in A/A Mode, Witness X in HUD
2. Target on the waterline, between the airspeed and altitude boxes
3. Target AOT assessed stadiametrically as less than 90 degrees
4. Range assessed between 0.5 NM and 2.0 NM through the use of yardstick

    * If all parameters met, shot is Valid at Trigger Squeeze, otherwise Invalid

For Time-of-Flight (6sec/NM after Witness X, play tape for TOF):

1. No flares call during TOF
2. If target is wings level, tail-on (i.e. bugging), utilize the Rules-of-3:

    < 250 KTS opening at 0.5 NM
    < 200 KTS opening at 1.0 NM
    < 150 KTS opening at 1.5 NM
    < 100 KTS opening at 2.0 NM

    * If above parameters met, shot is Valid for TOF, otherwise Defeated by TOF

Gun Tracking Shot

At trigger squeeze:

1. HUD in A/A Mode, RTGS Gunsight, Master Arm-On, Witness X in HUD
2. Target in-phase, in-plane, stabilized under pipper for 1 sec prior to Trigger Squeeze
3. Target stadiametrically ranged at 1000' (wingtip-to-wingtip inside reticle)
4. Pipper on Target at trigger squeeze

    * If all parameters met, shot is Valid at Trigger Squeeze, otherwise Invalid

For Time-of-Flight (play tape for 1 sec after Witness X):

1. No Guns 'D' within TOF (otherwise Defeated at TOF)
2. Pipper remains over target for TOF (otherwise Invalid for TOF)

Gun Snap/Raking Shot

At trigger squeeze:

1. HUD in A/A Mode, RTGS Gunsight, Master Arm-On, Witness X in HUD

2. Target in same POM as pipper

3. Target stadiametrically ranged at 1000' (wingtip-to-wingtip inside reticle)

4. Trigger down 1 sec prior to Target flying through pipper

   * If all parameters met, shot is Valid at Trigger Squeeze, otherwise Invalid

For Time-of-Flight (play tape for 1 sec after Witness X):

1. No Guns 'D' within TOF (otherwise Defeated at TOF)

2. Pipper remains stabilized in same POM as target for TOF (otherwise Invalid for TOF)

3. Pipper passes over target between TOF and 1 sec after release of trigger (otherwise Invalid for TOF)

904. BFM TAC ADMIN

The following administrative procedures and maneuvers will be conducted on each of the six BFM flights.

Environmentals (Sun/Winds)

Both NFSs will, at some point prior to fencing in, record the location of the sun and the winds for the purposes of bringing that information to the debrief. Sun angle will be recorded in bearing (degrees azimuth) and elevation (in degrees above horizon).

A/A TACAN Plan

The flight lead will take a channel equal to the last two digits of his ROKT call sign. The wingman will add 63 channels to that, while both will switch to the A/A mode on the TACAN switch in order to effect the A/A TACAN gameplan. For example, ROKT 403 would have lead on 03X and the wingman on 66X.

G-Warm

Upon completion of fence checks and entry into the working area, the lead IP will push his wingman into combat spread and direct the flight to unload and accelerate for the G-warm. Once the wingman is established in combat spread and the flight is at 14,000’, the lead IP will say,

"Turbo accel G-warm" on TAC. The wing IP will acknowledge with a "TWO" call and both aircraft will push over 5-10 degrees nose low to achieve 350 knots minimum. The Lead IP will then direct a 90 degree turn into the wingman (or away, depending on area constraints or a specific situation) for a sustained 4G turn.

LEAD IP: "Turbo, ACCEL, G-Warm."

WING IP: "Two."

LEAD IP: "Turbo, G-Warm 90 right/left, Go."

After the turn, both aircraft will roll out and continue to unload to keep accelerating to corner airspeed (410 knots) in order to be able to reach a peak of 6Gs and ease to 4Gs sustained for the second half of the G-warm. The lead IP will direct the flight to resume to the original heading or turn in the appropriate direction to establish desired heading.

LEAD IP: "Turbo, 90 left/right, Go."

When complete, flight will climb accordingly to the next PADS and initiate the conduct.

Fence In / Fence Out Checks

Fencing In

Prior to entering the working areas and commencing maneuvers, the lead shall direct the flight to FENCE IN. This call is made to transition the flight from an administrative mindset to the tactical portion of the flight by prompting the NFSs to complete the A/A combat checklist and the Pre-Stall and Aero checklist (both found in the T-45C In-flight Guide as well as in the NATOPS Pocket Checklist). NFSs should endeavor to complete these checks before crossing the border of the area in order to maximize the limited time and fuel in the area.

For efficiency sake, it is recommended that the Lead NFS direct the flight to fence in in conjunction with the switch to the working area frequency.

Lead NFS (UHF2): "TURBOs, switch button 18, Fence In"

Wing NFS (UHF2): "2"

Each NFS will be responsible for completing the A/A combat checks:

1. **A/A TACAN**……Set/Receiving/TACAN Boxed
2. **HUD A/A Mode**……...Select (MENU/STRS/ A/A)
3. **A/A Gun Mode**……....Select RTGS
4. **Wingspan**…….Verify 31 feet
5. **Master Arm**…….As Briefed (direct IP to arm up)

6. **Tapes**……VCR Check ON (direct IP / verify BIT page)

7. **IFF**……As assigned

The NFSs will report the completion of the checklist to establish the section as ready for tactical maneuvering. The lead NFS will initiate the fenced report, with alibis, over the TAC FREQ after completion of the G-Warm.

Lead NFS (UHF2): “TURBO 11, Fenced In, 2.5"

Wing NFS (UHF2): “TURBO 12, Fenced In, 2.4, negative yardstick."

Fencing Out

Upon completion of the BFM conduct and safe join up, the lead NFS will direct the flight to fence out. This is just the opposite transition to get the flight from a tactical mindset to an administrative role. In the interest of efficiency, the Lead NFS should initiate Fencing Out in conjunction with the frequency change to Seabreeze (W-155A)/Approach (PNSS MOA):

Lead NFS (UHF2): "TURBOs, switch button 15 Pri, fence out"

Wing NFS (UHF2): "2"

Each NFS will be responsible for setting up the aircraft for the admin RTB:

1. **TACAN**……A/A Deselected/Set/Receiving

2. **HUD Mode**…….....NAV Mode

3. **IFF**……Wingman Standby

4. **Master Arm**……...Safe (direct IP to safe up)

5. **Tapes**……VCR Check Off (direct IP / verify BIT page)

6. **Fuel**……....BINGO Setting set to “Divert” setting

Once aircraft are fenced out and safely rendezvoused, the Lead NFS will initiate the "Fenced Out" report.

Lead NFS (UHF2): "TURBO 11, fenced out 1.0"

Wing NFS (UHF2): "TURBO 12, fenced out 0.9"

After reporting completion of the fence out checks, lead IP will initiate Battle Damage Checks (BDC). It is very important that we confirm "fenced out" and all switches safe prior to maneuvering under each other's aircraft.

Weather/Decks/Altimeter

OPNAV 3710.7U requires that the flight lead confirm the airspace, weather, type war, hard deck, and local altimeter before commencing ACM. After fencing in and before executing the first set, the flight lead will report those items in the following format:

> "VIPERs, Welcome to the BFM-1 (optional), we have the airspace from 7000 to FL 400; weather: we have a low scattered layer at 5000, visibility good in all quadrants; VIPER 1 confirms: all altitudes, clear of clouds, hard deck as briefed, altimeter 29.92."

Wingman confirms by repeating the local altimeter: "VIPER 2, 29.92."

The following are the standardized TOPGUN type war recommendations appropriate for VT-86:

- "All altitudes, no restrictions"
- "All altitudes, clear of clouds"
- "High war above XXXX', hard deck XXXXX', clear of clouds"
- "Low war below XXXX', clear of clouds"
- "War between the layers, XXXX' to XXXXX', hard deck XXXXX', clear of clouds"

Fuel Checks

Fuel checks shall be conducted after every set conducted in the flight. This check will ensure that the flight maintains the situational awareness for their fuel state and maximize their time in the area accordingly. Lead student will initiate the fuel checks after every set is completed and "knock it off" is called. The wingman will reply accordingly. While it is the lead's responsibility to initiate these checks, the wingman must always be ready to initiate Joker/Bingo calls, as appropriate, if the request is not made. In addition, fuel checks will be conducted after any lead change, initiated by the new Lead NFS. In general:

After the "knock it off" calls are completed and area management has been resolved:

LEAD NFS:	"Turbo 11, 1.8."
WING NFS:	"Turbo 12, 1.7."

Engaging Turns

Throughout the tactical portion of the flight, whenever the section conducts an engaging turn (Tac or In-place), the NFSs will be responsible for reporting "six clear" and "visual" in the same manner introduced during the Section Weps phase. For the purposes of reinforcing those concepts, we will refresh ourselves with the proper use of each call:

> "Six Clear": Reported by the either NFS when his/her aircraft is turning into his wingman. Made after 90° of turn.

"Visual": Reported by the Wing NFS when reacquiring his/her lead anytime he turns away from the lead in an In-Place Turn.

COMM Brevity

To further enhance section communication, the fighter community has carefully defined tactical in flight terminology. Utilizing the correct word or phrase will greatly increase situational awareness during an engagement.

Bandit/Bogey

- BANDIT: Known enemy aircraft. Does not necessarily give us authorization to employ weapons.
- HOSTILE: A BANDIT whose engagement ROE has been met, allowing us to employ weapons.
- BOGEY: A radar/visual contact whose identity is unknown.

Tally/Visual

- TALLY: Sighting of a target/bandit; opposite of “NO JOY”
- VISUAL: Sighting of a friendly aircraft; opposite of “BLIND” (typically used during 1 v 1 BFM as our opponent is actually still our wingman)

No Joy/Blind

- NO JOY: No visual contact with target or bandit; opposite of “TALLY”
- BLIND: No visual contact with friendly aircraft; opposite of “VISUAL” (typically used during 1 v 1 BFM as our opponent is actually still our wingman)

Knock-it-off/Terminate

- KNOCK-IT-OFF: Term used to stop an entire multi-plane engagement/exercise. In the context of 1 v 1, used to end a specific engagement/exercise (i.e. SSD)
- TERMINATE: Term used to stop an isolated engagement without knocking off the overall exercise.
- SKIP IT: Typically used during a Snap Shot Drill; equivalent to "TERMINATE"

"PADS"

While conducting BFM training, numerous formation and tactical setups will be used. The "PADS" acronym is a quick method for referencing the aircraft’s setup parameters. Each letter in "PADS" stands for a specific flight parameter and have a specific tolerance:

P – Position

A – Altitude (+/- 100 ft)

D – Distance (+/- 0.1 nm)

S – Speed (+/- 10 kts)

Combat Spread

Once the flight is fenced in and cleared to maneuver, the lead IP will "push" the wingman into combat spread with a hand signal. Combat spread is the most basic two-plane formation utilized in the air-to-air combat arena. This formation combines optimum offensive capability with maximum defensive flexibility allowing both aircraft to provide mutual support while maintaining excellent maneuverability.

The basic concept is: two aircraft fly with enough separation so they cannot be attacked as a single unit, but close enough so as not to lose sight of each other and provide effective mutual support. The three variables to the combat spread position are bearing, distance abeam, and altitude separation. Of these three variables, bearing is by far the most critical. The distance abeam varies with aircraft size and turning performance, with additional consideration to threat aircraft size (visual detectability). Figure 9-6 demonstrates the standard combat spread formation.

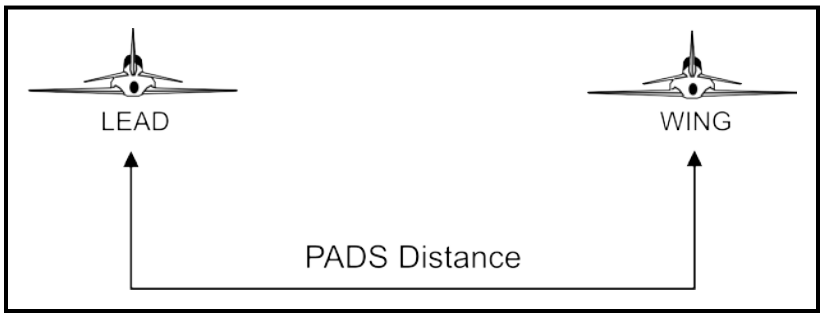

Figure 9-6 Combat Spread

Perch Setups

The following format (depicted in Figure 9-7) will be utilized for all Perch setups, to include Tail Chase Exercise, Offensive/Defensive Maneuvers, Intro-to-Ds, Uncalled Ds, as well as Offensive and Defensive Perch Sets:

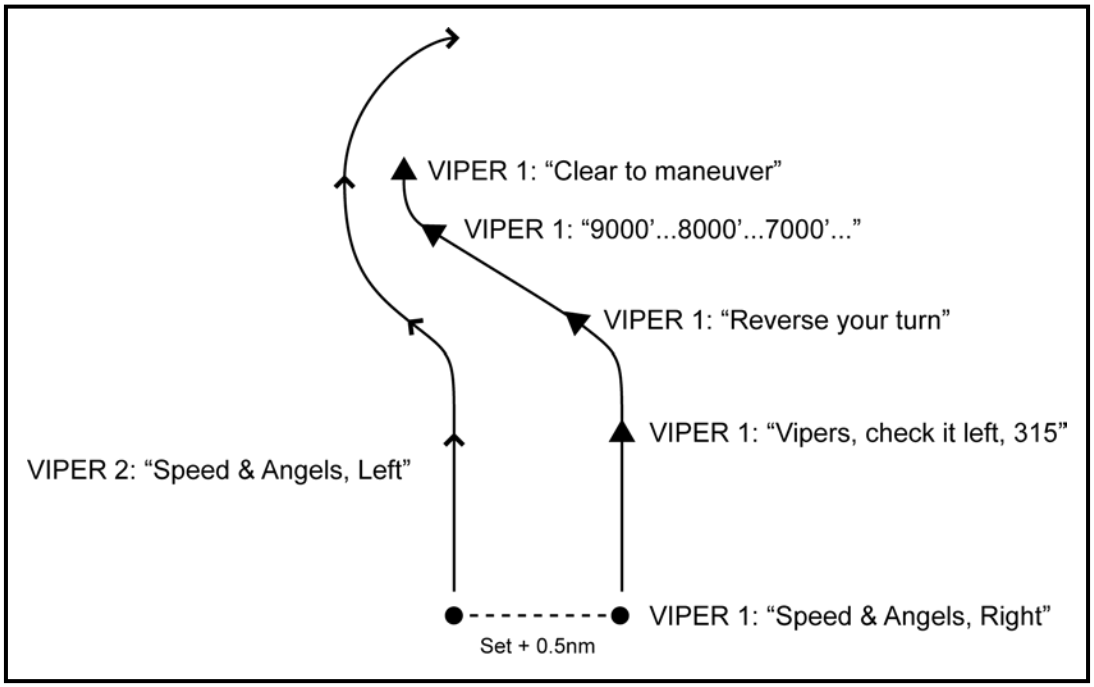

Figure 9-7 Perch Setup

- **Setup:** Aircraft will start abeam, coaltitude (15K' for NFS sets, 18K' for IUT sets), at a half a mile farther than the desired perch distance (for NFS sets: 1.5 NM abeam), aircraft call "speed and angels," flight lead checks the flight into the defensive aircraft (45 degrees for NFS sets, 50 degrees for IUT sets), offensive aircraft pulls nose on and calls for the defender to reverse his turn, offensive aircraft calls out range in thousands of feet until the desired range where he calls "Fox-2" (with a valid shot) or "clear to maneuver." At the "clear to maneuver," NFSs will initiate their comm sequence.

- **Safety:** NFSs will brief safety and deconfliction during the brief, for example: "Should any unsafe situation arise, anyone in the flight can call 'Knock-it-off', whereupon the defender will roll wings-level and maintain 15,000'; offensive aircraft will clear defender's altitude by a minimum of 500'. VIPER 1 will call a flow heading to facilitate both aircraft maintaining sight; both aircraft will report visual whereupon VIPER 1 will check the flight to put both aircraft back abeam. Once both aircraft are back on their PADS, VIPER 1 will reinitiate the sequence with 'Speed and Angels'."

High Aspect Sets

All High Aspect sets will utilize Butterfly Sets (as depicted in Figure 9-8) to ensure a neutral sight picture at the merge. In addition, during High Aspect engagements, the pilot in control will transmit ALL pass calls to ensure safety of flight. Pass calls will be made to "maintain the established trend," as per training rules, not establish the trend.

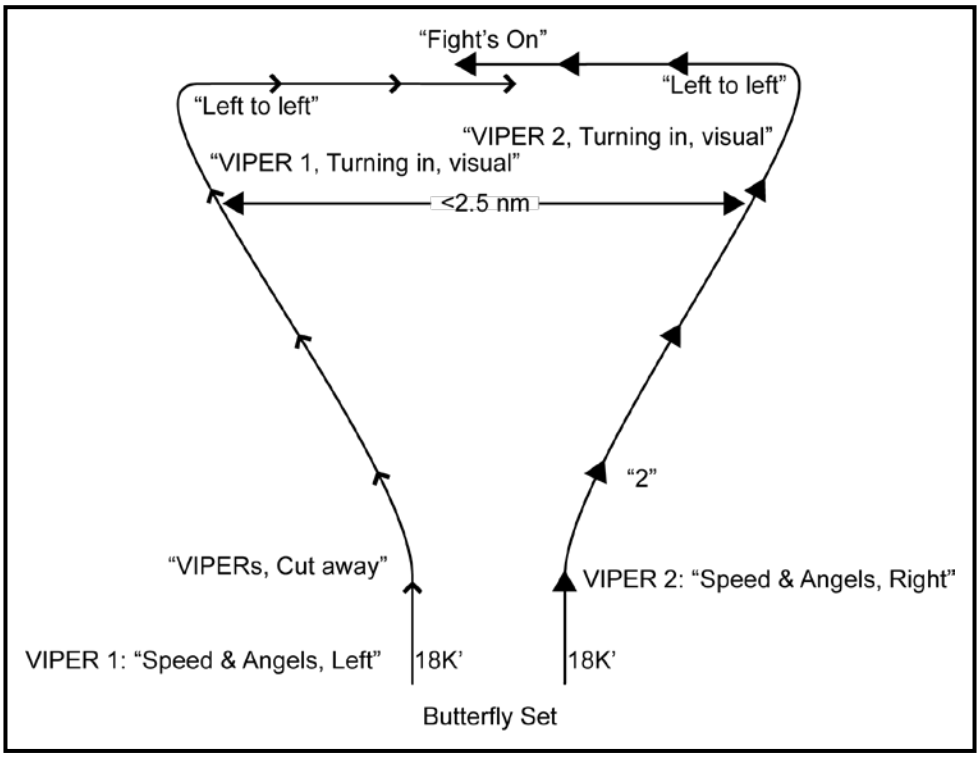

Figure 9-8 High Aspect Butterfly Setup

- **Setup**: Aircraft will start 18K', 300 KIAS, 1.5 NM. Lead initiates "Speed and Angels," echoed by wing. Lead initiates a 30 degree cut away for both aircraft to establish roughly 2.5 NM separation. Prior to 2.5 NM or no later than either aircraft losing sight, either aircraft can call "turning in, visual" to be echoed by other aircraft. Lead pilot at the controls will initiate the pass call, echoed by remaining PIC. Each aircraft will arrive at the merge no closer than 500', 180 degrees out, wings level and flight lead will call "Fight's On" at 3/9 passage, echoed by the Wing IP.

- **Safety:** NFSs will brief safety and deconfliction considerations in the brief. For example: "Should an aircraft lose sight approaching the merge, he will level his wings and transmit "Blind." Assuming the other aircraft maintains sight, he will maneuver to make a neutral merge happen, trying to talk the other aircraft on to his aircraft prior to the merge. Should the blind aircraft fail to regain sight prior to the merge, a "knock-it-off" will be called, followed by a flow heading for the purposes of regaining sight. If both aircraft lose sight, or there is flight path conflict approaching

the merge, either aircraft can call “knock-it-off”, in which case, -2 aircraft owns 16K’ and lead will vacate that altitude by at least 500’. Once yardstick shows increasing separation, lead aircraft will call a flow heading for the purposes of regaining sight. With both aircraft visual and back on their PADS, lead will again initiate the set.

Knock-it-Off

The highest potential for a midair collision in the BFM arena exists after the knock-it-off, where aircraft are in close proximity, at potentially low energy states and no predictable flow exists. For those reasons, communication and standardization after the “Knock-it-Off” call are crucial. During this critical phase of flight, there should be no question as to what is expected and who is to speak next. TOP GUN delineates a clear set of priorities and responsibilities following the Knock-it-off:

1. Following initial “Knock-it-off” call, all aircraft (including lead, even if he initiated the KIO) establish a “roll call”, in order, to acknowledge the KIO.

2. Lead provides a flow heading for aircraft deconfliction and to facilitate each aircraft regaining sight.

3. Lead initiates turns to facilitate area management.

4. Lead initiates a fuel check.

5. Flight establishes climb to next PADS parameters as defined by lead.

6. Lead checks flight to ensure that wingman is in proper position for the next set.

7. Flight reports “Visual, Notes complete” to indicate they are visual and ready for the next set.

8. Lead initiates “Speed and Angels.”

KIO Comm, and follow-on sequence, should sound as follows:

Any member of flight: “Knock it off, deck”

LEAD IP: “VIPER 1, Knock it off”

WING IP: “VIPER 2, Knock it off”

LEAD IP: “VIPERS flow 180, VIPER 1’s at your left seven o’clock”

WING IP: “VIPER 2, visual”

LEAD IP: “VIPERS, in-place left, 360”

WING IP: “2”

LEAD NFS: “VIPER 1, 2.0”

WING NFS: "VIPER 2, 1.9"

LEAD IP: "VIPERS, climb 16K', 300 Knots, 1.5 miles abeam for the next butterfly set"

WING IP: "2"

LEAD IP: "VIPERs, check it left 350. VIPER 1, visual, notes complete"

WING IP: "VIPER 2, visual, notes complete"

LEAD IP: "VIPER 1, speed and angels, left"

WING IP: "VIPER 2, speed and angels, right"

905. NFS RESPONSIBILITIES

In the BFM Theory Chapter, we outlined the tactical responsibilities of the NFO. The sections above, detailing the specific BFM maneuvers that will be performed in the syllabus, lay out specific expectations for the NFS in stage. In addition, NFSs in the VT-86 BFM syllabus will be expected to show proficiency in the following areas:

- Solid Admin/TAC Admin
- Fuel Management
- Area Management
- Lookout Doctrine
- Sensor Nose Recognition
- Deck Awareness
- Crew Coordination/BAR

Specific expectations for each have previously been laid out in this chapter and the BFM Theory Chapter.

BFM Sets NFS Tactical Responsibility

During the High Aspect Engagements, the focus will be on basic gameplan development and execution. NFSs will be expected to develop a sound gameplan prior to the brief based on loadouts and maneuvering characteristics of each aircraft. Throughout the course of the High Aspect sets, the NFS will strive to execute the gameplan developed preflight. The amount of instructor input provided during the execution phase is determined by the "type" engagement (Figure 9-9), with less and less input being provided as the flight progresses.

TYPE ENGAGEMENT	ENGAGEMENT CONDUCT
DEMO fight	IP demonstrates concepts/sight pictures.
MAX input fight	Student directs maneuvering with maximum IP coaching input.
MIN input fight	Student directs maneuvering with minimum IP coaching input.
AUTO fight	Student directs maneuvering with no IP coaching input; IP still provides direct, real-time feedback to facilitate learning and prevent negative training.
CREW fight	Student and IP work together as a tactical team; NFS will concentrate on those NFO responsibilities laid out earlier: lookout, sensor nose recognition, deck transitions and BAR.

Figure 9-9 NFS Tactical Responsibility

906. BFM SYLLABUS

BFM-1

Eyeball Cal Exercise x 2 (DEMO) 15K’/300 KIAS/1.0 NM

Snapshot Drill (DEMO) 15K’/300 KIAS/1.0 NM

Off/Def Maneuvers x 2 (DEMO) 15K’/300 KIAS/1.5 NM

Performance Characteristics (DEMO)

- Accelerated Stall
- High AOA/Deep Stall Investigation
- 70° Nose-High Departure
- Level vs. Unloaded Accelerations
- Hard Turns vs. Energy Sustaining Turns
- G-Available Exercise

TACAN Rendezvous

Flat Scissors Drill (DEMO) 15K'/300 KIAS/1.5 NM

Rolling Scissors Drill (DEMO) 15K'/300 KIAS/1.5 NM

BFM-2

Snapshot Drill (DEMO)	15K'/300 KIAS/1.5 NM
Intro-to-Ds (6 total) (MAX)	15K'/300 KIAS/1.5 NM
First Move Option One-Circle (DEMO)	18K'/300 KIAS/1.5 NM
First Move Option Two-Circle (DEMO)	18K'/300 KIAS/1.5 NM
High Aspect Flow Demo (DEMO)	18K'/300 KIAS/1.5 NM
Two-Circle Flow	
One-Circle Flow	
Rolling Scissors	
Flat Scissors	

BFM-3 Offensive/Defensive Perch

Snapshot Drill (MAX)	15K'/300 KIAS/1.0 NM
Uncalled Ds (4 total) (MIN)	15K'/300 KIAS/1.5 NM
9K' Perch (DEMO)	18K'/350 KIAS/2.0 NM
6K' Perch (MAX)	18K'/350 KIAS/1.5 NM
3K' Perch (MIN)	18K'/250 KIAS/1.0 NM
Repeat (as necessary/fuel permitting)	

BFM-4 Offensive/Defensive Perch

Snapshot Drill (MAX)	15K'/300 KIAS/1.0 NM
Uncalled D's (4 total) (MIN)	15K'/300 KIAS/1.5 NM
9K' Perch (DEMO)	18K'/350 KIAS/2.0 NM
6K' Perch (MAX)	18K'/350 KIAS/1.5 NM
3K' Perch (MIN)	18K'/250 KIAS/1.0 NM
Repeat (as necessary/fuel permitting)	

BFM-5 High Aspect BFM/Gameplan Development

Snapshot Drill (MIN)	15K'/300 KIAS/1.0NM
Uncalled Ds (4 total) (AUTO)	15K'/300 KIAS/1.5 NM
High Aspect Sets (x4)	18K'/300 KIAS/1.5 NM
MAX, MIN, AUTO, CREW	

BFM-6X High Aspect BFM/Gameplan Development

Snapshot Drill (MIN)	15K'/300 KIAS/1.0 NM
Uncalled Ds (4 total) (AUTO)	15K'/300 KIAS/1.5 NM
High Aspect Sets (x4)	18K'/300 KIAS/1.5 NM
MAX, MIN, AUTO, CREW	

907. BFM DRILLS

Eyeball Calibration Exercise

PADS: 15K'/300 KIAS/1.0 NM Abeam

The dynamic nature of the BFM arena is fast-paced and requires us to be heads out a majority of the time during an engagement. In addition, closure rates generated between two aircraft often exceed the computing capabilities of our aircraft systems (yardstick in the T-45, specifically). For that reason, it is vitally important to be able to discern an opposing aircraft's range stadiametrically. To that effect, the BFM syllabus will incorporate an Eyeball Calibration Exercise to cage our eyeball to the sight picture of a T-45 at known distances and aspects. Each NFS in the flight will be demonstrated an Eyeball Cal with a lead change in between. The Eyeball Cal will be conducted as follows:

Aircraft will start from an abeam position at 15,000', 300 KIAS and 1.0 NM. The wing aircraft will be given the lead for the purposes of the exercise and will maintain airspeed and altitude while observing the exercise. At one nautical mile, the lead aircraft will roll to show the wing NFS both the top and bottom of the aircraft at a mile. At one nautical mile, the NFS should be able to break out the canopy from the rest of the aircraft. The lead will then cut away to establish his aircraft at 1.5 NM, again showing the wing NFS the top and bottom of the aircraft at that distance. At 1.5 NM the NFS should not be able to discern the canopy against the top of the aircraft. Lead will then direct the wing to take a 45 degree cut away, pulling nose on and calling for wing to reverse his turn. The wing establish a 30 degree AOB turn into the lead, maintaining 14,000' and 300 KIAS. Lead will close the distance, nose on, calling out slant ranges. During this rendezvous, Lead will point out significant milestones with "sensor nose on," to include the limits of the IR missile envelope, the beginning of the gun envelope, and the 1000' min range depicted by training rules. Passing 1000', Lead will direct the Wing to roll wings level, whereupon he will cross under and show the NFS a 500' position on the opposite side (to demonstrate the limits of the 500' safety bubble). Once stabilized 500' abeam, lead will be passed the formation lead from wing.

Snap Shot Drill

PADS: 15K'/300 KIAS/1.0 NM Abeam

The Snap Shot Drill (SSD) is a *cooperative* maneuver designed to teach employment of the gun at high angles off (Figure 9-7). More importantly, the SSD is an eyeball calibration exercise that you will execute prior to every BFM flight for the remainder of your career. Because we know that the attacking aircraft is striving to be at 1000' at the "trigger down," the SSD provides an ideal environment for us to capture the sight picture, both offensively and defensively, of an attacking aircraft at 1000' and at the initial starting parameters of abeam at 1 NM.

The SSD will be set up at 300 KIAS and 15,000 feet with the shooter and target aircraft setting up abeam at 1.0 NM. As with all BFM setups, the drill will begin with “Speed and Angels” calls initiated by the Lead IP and echoed by wing, once the PADS parameters are achieved. The lead IP will always initiate the comm, calling in with his role: shooter/target. The comm sequence will be as follows:

LEAD IP:	“Turbo 1, Speed and Angels left/right.”
WING IP:	“Turbo 2, Speed and Angels right/left.”
LEAD IP:	“Turbo 1, In shooter.”
WING IP:	“Turbo 2, In target.”

The two aircraft will turn in towards each other with the “target” placing and holding the shooter at the 10 or 2 o’clock position and the “shooter” solving for the three basic parameters: lead, range, and POM. The shooter will then call "Trigger Down" when he has achieved all three and call "snap" with an assessment (good, high, low, unassessable, etc.) when he assesses bullets have reached target range at time-of-flight.

Generally, three snapshots will be flown for each student as illustrated in Figure 9-10. On the last snapshot, the lead IP will call, “Turbo 1, In target/shooter, maneuver.” As the shooter approaches the snap shot envelope, the target student will call for a “Guns-D.” At this command, the target IP will put his near or opposite wingtip on the attacker and maneuver out of plane to defeat the snapshot. Upon completion of the first maneuvering run, the aircraft will swap rolls but lead will maintain the comm lead, calling in with his role as Target.

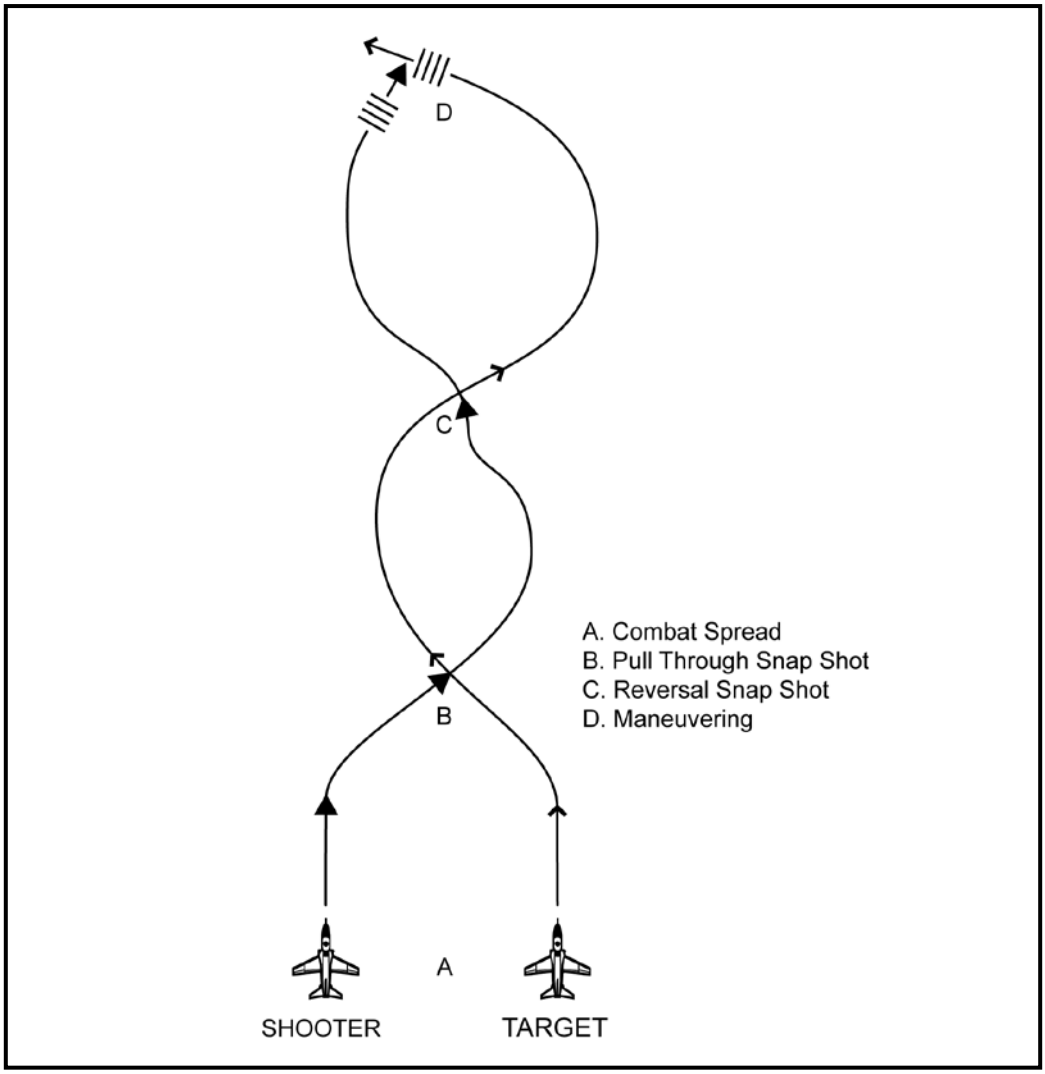

Figure 9-10 Snapshot Drill

Safety

If an unsafe situation develops (shot inside 1000' or within 45° of the target's nose), any member of the flight can call "Skip it," "Terminate," or "Knock-it-Off," in which case the shooter will break off the attack and all aircraft will shoot for recovery. If there are any flightpath deconfliction issues at that merge, the target owns the outside of the turn and up, the shooter owns the inside of the turn and down. Lead IP will call for a flow heading and each aircraft will strive to achieve that flow heading, 1 NM abeam, co-altitude at 300 KIAS. Once stabilized, the Lead IP will again call "in" with his role, repeating the run the flight "skipped." In the event of a "Knock-it-Off," maneuvering flight will not be continued until after a reinitiation of "Speed and Angels."

NFS Responsibilities

In addition to striving to achieve a solid eyeball cal, NFSs will be responsible for calling "Trigger Down" when offensive and "Guns 'D'" when defensive over the ICS. NFSs will use real-time feedback from their IP and the other aircraft to adjust their timing throughout the exercise.

Offensive-Defensive (ODM) Maneuvering Exercise

PADS: 15K'/300 KIAS/1.5 NM Abeam

The purpose of the ODM exercise is to demonstrate the following basic offensive RAC Management maneuvers:

High Yo-Yo

Low Yo-Yo

Displacement Roll

Lead/Lag/Pure pursuit

Guns 'D' - Once stabilized in a firing position, the defensive aircraft will demonstrate a guns defense (Guns D).

The ODM will be initiated utilizing the 40° AOT Perch Set discussed in the Tactical Admin portion of this chapter. After the "clear to maneuver" call, the offensive aircraft will demonstrate a High Yo-Yo followed by a Low Yo-Yo as it relates to the pursuit curves. It will be followed by a Displacement Roll that presents another way of executing a lag to lead maneuver. After establishing himself behind the defender, the offensive aircraft will continue to use the pursuit curves to control closure and AOT while demonstrating the different segments of the guns envelope. When the offensive maneuvering demonstration is complete, the offensive aircraft will stabilize in the gun envelope where the offensive IP will call “Established” on UHF. This call will clear the defensive aircraft, who has been cooperatively turning level across the horizon, to execute a Guns D, transmitting “Coming at you, Guns-D” on the UHF. Immediately following the Guns D, both aircraft will execute Deck Transitions and follow-on BFM. Both NFSs will be expected to demonstrate solid deck transition responsibilities as well as recognition of follow-on weapons employment opportunities. Upon completion of the engagement, the flight will set up another perch setup, swapping roles.

Performance Characteristics Exercise

The purpose of the performance characteristics exercise is to demonstrate the performance capabilities of the aircraft as it relates to the E-M Diagram. The exercise will demonstrate timed accelerations, timed turns, as well as instantaneous "G" available at different airspeeds.

The maneuvers will be demonstrated independent of the other aircraft. To initiate the exercise, the section will divide the working area and take flight separation. At 15,000 ft. MSL, the following performance exercises will be demonstrated:

- Timed acceleration from 250 to 300 kts straight and level at MRT.
- Timed acceleration from 250 to 300 kts unloaded at "zero G". (The timed accelerations will demonstrate the advantage of unloading the aircraft for rapid energy addition.)
- Timed turn at 14 units AOA for 180º of turn maintaining 300 KIAS.
- Timed turn at 17 units AOA for 180º of turn maintaining 300 KIAS. (The timed turns will demonstrate the higher turn rate available at 17 units AOA versus 14 units AOA. During the 17 unit AOA turn however, a loss of airspeed will be the expected as a performance trade off for the increased turn rate performance.)
- Instantaneous "G" available at 250 kts.
- Instantaneous "G" available at 300 kts.

Stalls and Departures

Numerous stalls and departures will be flown to demonstrate the edge of the aircraft’s envelope. During a BFM engagement, maximum performance from your aircraft will be demanded. The stalls and departures will demonstrate aircraft performance and handling characteristics at the "edge of the envelope." The tactical crew must be able to fly the aircraft to the limits of the envelope in order to take full advantage of its capabilities. Thus, it is likely that the limits will occasionally be exceeded and the crew may suddenly be in uncontrolled flight. Although sometimes spectacular, it is a phase of flight that should not be feared; it is a natural consequence of flying the aircraft to its limits. Every tactical aviator must be prepared to handle uncontrolled flight by:

1. Knowing the Aircraft. Study the NATOPS Flight Manual. Particularly the "flight characteristics" sections of NATOPS. Know the associated AOAs cold (i.e., expect rudder shakers at 21.5 units AOA, etc).

2. Knowing the Procedures. The recovery procedures must become second nature. The stall recovery and out-of-control flight recovery procedures must be emphasized during flight preparation. In VT-86, the T-45C OCF procedure will be reviewed prior to every flight and shall be briefed VERBATIM.

3. Being Patient! Hasty direction of control application can aggravate the recovery.

4. Checking the Altimeter. When the aircraft is out of control, altitude becomes time. NATOPS will dictate altitude limits for out-of-control flight. Knowledge of such NATOPS limitations is crucial.

Out of control flight is simply another phase of flight that every tactical aviator must be familiar with. By knowing the procedures and maintaining a cool head, the aircraft should quickly be under control.

Departure/Spin Recovery Procedures

Forcefully centering the rudder pedals and neutralizing the control stick usually recovers the aircraft from a departure. Forcefully centered to stabilize the control surfaces in a fixed position prevents any surface blow outs. If the rudder blows out due to sideslip forces, a spin is possible and recovery will be delayed. Extended speedbrakes are destabilizing and may aggravate the departure and delay recovery, so they must be retracted to provide as much smooth airflow as possible through the aircraft. You should expect engine anomalies following any departure. Retarding the throttle to idle will minimize engine problems but will not eliminate the potential for a flameout or locked-in surge.

You should check the altitude, AOA, airspeed, and turn needle to monitor your recovery progress or to determine if you are in a spin. Altitude will tell you if time is available to attempt recovery or if you are at your minimum altitude limit. With altitude underneath you, you can verify AOA and confirm if you are in a spin or not. If AOA is pegged at 0 units, your airspeed is oscillating between 50 and 160 KIAS, and the turn needle is pegged, then you are in an inverted spin. Although a stabilized upright spin is unlikely, it would be indicated by AOA above 28 units with similar airspeed and turn needle indications.

Your patient and deliberate assessment of these parameters will enable you to direct and verify the correct anti-spin controls. Do not rush through these steps. While timely control inputs are very important, the correct inputs take precedence over the speed of the application.

Departure Checklist

You and your IP will complete the following checklist prior to the first departure.

1. Stall/aero checklist – complete
2. Lap belts – tighten
3. Helmet visor – tighten down
4. Rudder pedals – adjust aft for full throw
5. Shoulder harness – locked
6. Landing gear and flaps/slats – up; speedbrakes – retracted
7. BATT switches – on
8. CONTR AUG – SBI

9. Turn needle, airspeed, AOA – check operation

10. ICS – hot mic

11. Throttle friction – set

After the IP returns the aircraft to wings level following each of the maneuvers, check that the oil pressure warning light is out before adding power. It is possible that, during gyrations, the oil may cavitate out of the pump, and oil pressure may drop to zero. If all engine instruments are indicating normally, the IP will add power. When the IP recovers from the last departure, you and your IP will complete the following post-departure checklist:

High AOA/Deep Stall Investigation/Rudder-Induced Departure

This stall will be an IP optional presentation with fuel and time permitting. If able, you will begin with an exploration of the fully stalled characteristics of the T-45. Previously, you have practiced stalls to learn recognition and recovery from the onset of the stall. This maneuver will demonstrate the flight characteristics much farther into the stall, up to approximately 30 units AOA.

Before entering a high AOA/deep stall condition, you should know what indications to expect. You will not necessarily experience all of the following indications of deep stall, nor will you experience them in any particular sequence:

Increasingly heavier buffeting as stall deepens
Adverse Yaw
Increasing sink rate
Wing drop
Reduced lateral control

Start above 20,000 ft. with landing gear, flaps/slats, and speedbrakes retracted. The IP will then reduce power to IDLE RPM and raise the nose 10 degrees to trade altitude for airspeed as the aircraft slows to 20 units AOA. The IP will not trim past 150 KIAS. You should notice that the rudder and aileron effectiveness will be adequate at 20 units.

As the IP increases AOA, you will get the rudder shakers at 21.5 units. As you slowly increase the AOA to 24-26 units, you will experience your first buffet and wing drop with very little warning. At 25-26 units AOA, the aircraft will be in light to moderate buffet, and you may encounter mild porpoising. Notice that the rudder and aileron effectiveness are reduced. Notice the adverse yaw generated by aileron deflection.

The IP will increase the AOA to 28-30 units by smoothly but firmly applying full back stick. You will experience heavy buffet, wing drop, stall noise, and a large sink rate. Airspeed will be approximately 110-120 KIAS. The aircraft is fully stalled, and aileron effectiveness is marginal. The IP will attempt to maintain wings level with rudder only; he will not use aileron to counter any roll tendencies. If the aircraft rolls into an angle of bank of 90 degrees or more, then the IP

will recover. If the IP is able to hold wings level with rudder, he will induce a departure with rudder only by maintaining full back stick and input half rudder in one direction to achieve greater than 30 degrees AOB. Then, he will try to return to level flight by inputting full rudder in the opposite direction. The aircraft should start to roll in the direction of the last rudder input, then quickly roll back into the initial direction and depart.

Anytime maneuvering is attempted below 120 KIAS, NFS should question the control of the aircraft to the IP by asking "Do you have control?" If the IP responds with "NO" or as the aircraft departs, the student will recite/direct the OCF procedures. The aircraft will quickly recover and airspeed will begin to build. The IP will recover to the nearest horizon at or greater than 150 KIAS with AOA between 5 and 20 units by rolling wings level and commencing an optimum AOA pullout (17 units). The IP should avoid pulling into an accelerated stall during recovery. After recovery and before adding power, check OIL PRESS light out so the IP can set power for next maneuver.

Accelerated Stall

The accelerated stall and recovery demonstrates the characteristics of and recovery techniques for a high-speed stall. It illustrates that excessive AOA, regardless of the cause, will result in a stall; in this stall, however, higher G forces cause the stall to occur at a higher airspeed.

Review the stall and aerobatic checklist. Once established at 280 KIAS, the IP will set an RPM to maintain airspeed. You will roll into a 70 to 80-degree AOB turn and apply back stick pressure through the onset of buffet and into a stall. Because the stall buffet is very clear, it provides good warning of the stall. Stall characteristics may include a wing drop, pitch oscillations, or the control stick reaching the full aft position. With all these parameters met, you can expect the aircraft to stall within the first 90 degrees of the turn.

To recover, your IP will simultaneously release back stick pressure, advance the power to MRT, and roll wings level. The maneuver is complete when the wings are level and the aircraft is in a level flight attitude. Recovery is immediate when back stick pressure is relaxed.

70-Degree Nose-High Departure

The objective of the low airspeed departure is to demonstrate the effects of inertia and loss of aerodynamic forces. At zero airspeed, the only forces acting on the aircraft are gravity and the inertia generated before reaching zero airspeed. If the IP holds the controls neutral, the effect of gravity will cause the aircraft to seek the relative wind.

As the aircraft accelerates, flight controls will become effective before the AOA is reduced below stall. Consequently, any lateral control input (stick or rudder) will introduce a yaw rate. Coupled with a stalled AOA, this is a pro-spin input.

Low airspeed departures can occur anytime airspeed is so low that aerodynamic forces are negligible, and the aircraft is functionally ballistic. This can occur above 0 KIAS and in any nose-high attitude (not necessarily vertical). The IP will not initiate any low airspeed departures within 20 degrees of pure vertical.

To enter the 70-degree nose-high departure, start at 300 KIAS minimum and no lower than 16,000 ft. AGL. Begin a smooth 15-17 unit pull to 70 degrees nose-high and reduce power to idle as you decelerate below 150 KIAS. The IP will apply aft stick as necessary to maintain 70 degrees nose up (referencing the ADI) while decelerating. The IP should not use trim in this maneuver. The departure is indicated by airspeed decreasing to 0 KIAS (actually 50 KIAS is the minimum on the airspeed indicator) and the nose falling. The IP will neutralize flight controls as they become ineffective and will not try to counter any oscillations as the nose falls through. At near zero airspeed, there will not be enough control authority to prevent oscillations. Any deviations from neutral may aggravate the situation as airspeed increases. If performed correctly, you should notice that the inertia of the aircraft will carry the nose through 90 degrees nose-low during recovery until the aerodynamic forces increase and allow the aircraft to seek the relative wind. As airspeed increases through 160 KIAS (OCF minimum recovery airspeed), the NFS shall direct the IP to recover to the nearest horizon as in the high AOA/deep stall departure.

The student should notice this imminent departure from controlled flight. As the airspeed decreases below 120 KIAS, the NFS shall ask the IP “Do you have control?” If the answer is “NO”, then students should start verbalizing the OCF procedures, verify them, assess if they are in a spin,and react accordingly.

Post Stall/Post Departure Scan

After returning the aircraft to level flight following each of the above maneuvers, check the oil pressure is normal before adding power. This is checked by looking at the OIL Warning light and verifying it is NOT illuminated. It is possible that during the gyrations, the oil may cavitate out of the pump, and oil pressure may drop to zero. Perform a thorough scan of all your instruments and standby indicators for correct indications. Upon completion of the last maneuver, the STBY ADI will most likely have to be realigned and erected.

A careful post-flight inspection of the aircraft will be made upon return from flights during which departures have been conducted. Look for popped rivets, loose or missing screws and fasteners, and wrinkled or cracked skin, placing emphasis on the empennage area.

TACAN Rendezvous

A TACAN rendezvous is a procedure commonly used to rejoin flights that have been separated, conducting separate conducts, or required to rejoin after a lost-sight scenario.

The section lead will commence his rendezvous turn at any pre-briefed TACAN fix, altitude, direction of turn, and airspeed (usually 250 KIAS). Upon reaching the fix, the section leader will call "Call Sign - Point 1" and commence a 30° angle-of-bank turn (Figure 9-11, left side). The lead will call the four points of the circle as they are overflown. The wingman will maintain an altitude separation of 1,000 ft. below the lead's pre-briefed altitude until both aircraft have each other in sight. At this time the wingman should fly in order to affect a co-altitude rendezvous with the lead on the inside of the lead's radius of turn (Figure 9-11, right side).

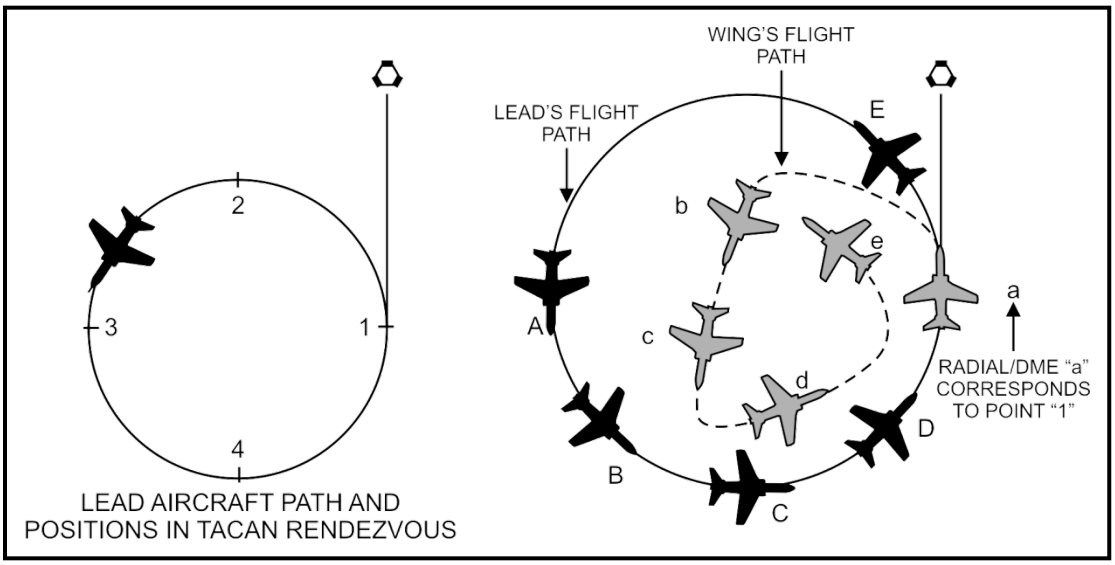

Figure 9-11 TACAN Rendezvous

In the above example, as the wingman arrives at Pt. 1, the lead is at Pt. 3. (A/a) The wingman should maneuver his aircraft to point his nose ahead of the lead's aircraft (B/b). Using lead and lag the wing IP will rendezvous with the lead. To expedite the rendezvous, the lead may choose to join on the wingman. Aircraft positioning may make such a scenario (lead joining on wing) more effective. In either case, the student in the joining aircraft will monitor closure and call out airspeeds as required.

Flat Scissors Drill

PADS: 15K'/300 KIAS/1.5 NM Abeam (CTM = 40° AOT @ 6000')

The Flat Scissors Drill (Figure 9-12) will be initiated from a perch setup as delineated earlier in the TAC Admin portion of this chapter. At the “FOX-2” or “Clear to maneuver” call, the defensive NFS will initiate the appropriate comm: calling for the IP to "Break Left/Right" over the ICS and calling "Flares" over the UHF. The offensive aircraft will continue to press the attack, pulling excessive lead. The defending NFS should note the high closure rate caused by the excessive lead and should note to his IP the continued attack with a "Lift vector on" call. The attacker will then execute an in-close overshoot which the defender will capitalize from this mistake by reversing. The defensive NFS will direct this reversal, calling for his IP to "Reverse nose-high; pull for his six." Once both aircraft are established in the flat scissors, both the offensive and defensive NFSs will direct the maneuvering of the aircraft, each with their own responsibilities.

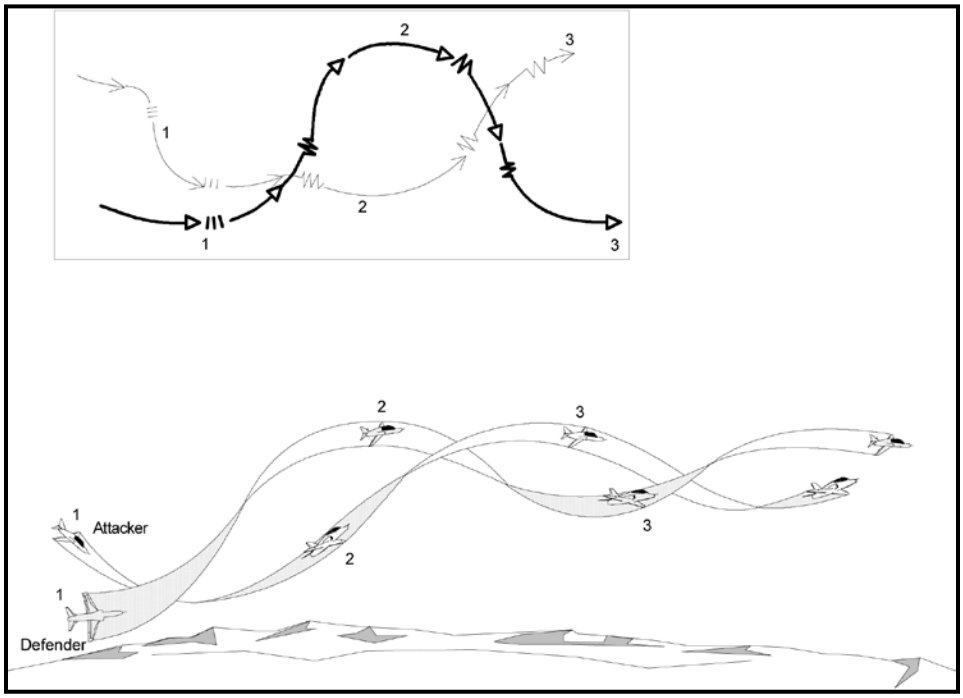

Figure 9-12 Flat Scissors Drill

Offensive maneuvering in a Flat Scissors: The ultimate goal of the offensive aircraft in a flat scissors is to maneuver into a position to employ the gun. However, his primary responsibility is to maintain his offensive advantage. Because the flat scissors is a one-circle fight, where the goal is to slow the aircraft's down-range travel more than the other aircraft, proper lift vector placement and reversal timing are the primary objectives. After each reversal, the NFS will call for his IP to place his lift vector behind his opponent: "Pull for his six." After he has achieved the proper lag lift vector placement, reversal timing becomes the next objective. As the offensive aircraft, we are always striving to arrive in-phase, in-plane, with RAC under control. We do this similar to the way we did in the snapshot drill. If we see that we will have at least 1000' of range, we wish to preserve that range via an early turn: called by the NFS by communicating to his IP over the ICS, "Early Turn." If we will not have 1000' nose-to-tail, we want to continue to pull behind our opponent until our nose is behind him, whereupon the offensive NFS will call "Reverse." At any time, if we see a gun employment opportunity developing, we should look to employ: offensive NFS calls, "Pull for the shot."

Defensive maneuvering in a Flat Scissors: The goal of the defensive aircraft in a flat scissors is to "maneuver to survive." Like the offensive aircraft, the defender will maneuver his aircraft so as to reduce his down-range travel through the proper use of lift vector placement: defensive NFS calls "Pull for his six" after each reversal. In addition, the defender is always trying to keep the offensive aircraft out-of-phase, out-of-plane to deny him a high percentage gun tracking shot. Reversal timing is critical. The defensive NFS will call for the defender's reversal with a "Reverse" call, no earlier than the attacker going into lag and no later than the attacker crossing the defender's extended six. The timing of the reversal within that window is entirely dependent on the track crossing rate of the offensive aircraft. The sooner we can execute our reversal, the

more out-of-phase we can get with our opponent. With a high track-crossing-rate, we can afford to reverse as soon as our opponent's nose falls behind us. If the track-crossing-rate is low, we might have to wait until the attacker crosses our six. Most importantly, if we see our opponent solving for the "Big Three" we must resort to the first axiom of defensive BFM: "maneuver to survive". The defensive NFS will call "Guns D" any time he recognizes an impending gun employment opportunity.

Rolling Scissors Drill

PADS: 15K'/300 KIAS/1.5 NM Abeam (CTM = 40° AOT @ 6000')

Like the Flat Scissors Drill, the Rolling Scissors Drill (Figure 9-13) will be initiated from a perch setup as delineated earlier in the TAC Admin portion of this chapter. At the “FOX-2” or “Clear to maneuver” call, the defensive NFS will initiate the appropriate comm: calling for the IP to "Break Left/Right" over the ICS and calling "Flares" over the UHF. The offensive aircraft will continue to press the attack, pulling excessive lead. The defending NFS should note the high closure rate caused by the excessive lead and should note to his IP the continued attack with a "Lift vector on" call. The attacker will then execute an in-close overshoot which the defender will capitalize from this mistake by reversing. The defensive NFS will direct this reversal, calling for his IP to "Reverse nose-high; pull for his six." The defender will pull his nose up in the reversal to arrive above the attacker with a 90 degree heading difference off the attacker’s nose. Since this is a cooperative maneuver, the attacker, at the overshoot, will turn level across the horizon to position himself underneath the defending aircraft. The goal of the attacker is to also reach the 90 degree heading difference between the two aircraft and directly over each other with a *minimum* separation of *approximately* 2000 feet. This stacked separation, with a 90 degree heading difference, is the neutral starting point of the rolling scissors. Once the high aircraft has achieved a position behind the low aircraft's 3-9 line (but no later than the low aircraft starting nose-high), the high NFS will call for his IP to "Roll" and then "Lag him." As the aircraft is approaching the bottom of a neutral roller, the NFS will call "Nose high, pull for his six" as like the flat, the goal of the roller is to reduce one's down-range travel. If we find ourselves offensive in the roller (which we can tell by the other aircraft appearing forward of our 3-9 line as we go nose-high), the offensive NFS can start working lead pursuit <u>uphill</u> to gain angles or for weapons employment: "Lead him." As always, crew coordination is paramount. NFSs should be giving their IPs airspeed calls as the aircraft goes up and altitude calls as the aircraft goes nose low. Additionally, any time we recognize a weapons employment opportunity, NFSs should be calling "Pull for the Shot" or "Guns D/Break (left/right), flares" as appropriate.

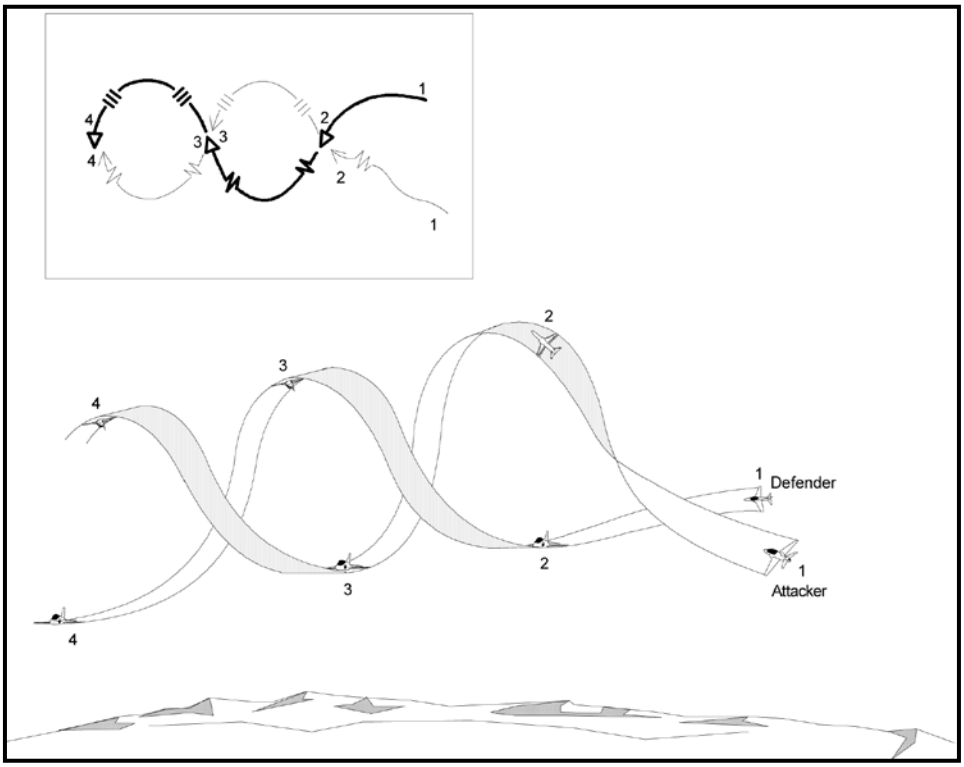

Figure 9-13 Rolling Scissors Drill

Due to the limited thrust-to-weight of most aircraft, the rolling scissors tends to be a descending fight, with each subsequent roll bringing the two aircraft closer to the hard deck. It takes approximately 3000' for a T-45 to execute a complete roll in a rolling scissors. As the aircraft approach the deck, one of the aircraft will have to redefine the rolling scissors, as it will have insufficient altitude to accomplish a complete rolling maneuver. This is typically done through a horizontal reversal at the top of the roller, resulting in the fight transitioning to a flat scissors. Should NFSs recognize that they have less than 3000' above the deck at the top of the roller, they should call "Reverse" vice "Roll" to transition the fight into a flat scissors.

Intro-to-Ds/Uncalled Ds

To continue with the "building block" approach to BFM, canned defensive scenarios will be introduced on BFM-2 and practiced on all subsequent BFM flights. Three distinct attacks will be flown requiring specific defensive responses.

The three attack scenarios will be detailed in this section:

1. High-Low Yo-Yo (High-Low)

2. In-Close Overshoot (ICO)

3. Valid Attack to Guns-D (VAGD)

The Intro-to-Ds will demonstrate all three of the scenarios on the BFM-2. On subsequent BFM flights, only two of the three scenarios will be presented, requiring the NFS to both identify the scenario and respond with the correct procedures.

The "Intro-to-Ds" and "Uncalled Ds" scenarios will begin from the standard 40° AOT Perch Set parameters introduced during the TAC Admin portion of this chapter. At the "Clear-to-Maneuver" or "Fox-2" the NFS will initiate maneuvering through use of the following comm:

Defensive NFS (ICS): "Break Left/Right"

Defensive NFS (UHF): "Flares"

High-Low Yo-Yo Defense

This scenario will simulate an attack by a bogey that initially attacks with excessive closure and incorrectly corrects with a High Yo-Yo (out of plane lag maneuver).

A "Lift vector on" call will be made by the NFS any time "sensor nose" continues to be a factor, forcing a break turn into the threat. At some point after CTM, the attacking bogey will initiate a high yo-yo as an out of plane maneuver to prevent an imminent overshoot.

As the bogey begins his high yo-yo with a roll to wings level and pull out of plane (or a rolling pull), the defensive student will call "Nose Off, ease" on the ICS. The "Nose Off" call informs the defensive pilot that the attacker's nose/lift vector is not an immediate threat. Thus, the "ease" call directs the defensive IP to ease the turn (easing Gs) to regain as much of the depleted energy as possible lost in the initial break turn until the attacker's nose/lift vector becomes a factor again.

When the attacker creates enough separation, he will shift his lift vector in front of the defender, towards lead, by aggressively going nose low. This Low Yo-Yo (out of plane lead maneuver) is executed to decrease separation. The attacker's nose/lift vector becomes a threat again at this point. As the attacker rolls to pull his nose down (cracks his wings) out of the High Yo-Yo, the defensive student will again call, "Lift vector on."

Prior to the attacker's aircraft reaching the horizon, the defending NFS should call for a nose low turn into the attacker. The defender should anticipate this follow on move by the attacker attempting to close the gap between aircraft. Thus, it is very important to timely call "Nose low left/right" in order to offset the attacker's energy gain in his nose low attitude. If the attacker is allowed to reach or go below the horizon before you direct a defensive nose low turn into him, the attacker would gain enough of an energy package over the defender that would be difficult to oppose. If these defending maneuvers are properly timed, they should result in a less defensive position, decreased separation between aircraft, and possibly an overshoot, or at least, an increase in the attacker's time to kill.

These maneuvers should result in a two circle flow. Each NFS is responsible for follow on BFM (defensive / offensive) as required and shall not stop directing the fight until a logical conclusion has been reached and/or the training objective has been met, signaled by a KIO.

NFS Responsibilities:

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: “Break right!” UHF: "Flares."	Break turn into bogey
Sensor nose still on	“Lift vector on.”	Maintain break turn into bogey
Wings level, out of plane, high yo-yo maneuver	“Nose off, ease.”	Ease turn, unload, get knots back- energy addition
Attacker starts to commit nose back to defender (recognized by wings crack)	“Lift vector on.”	Hard turn back into bogey
Attacker’s aircraft reaching the horizon.	“Nose low right / left (into the attacker)”	Nose low turn into bogey
Deck Transition	Deck Transition Calls (Alt/Nose Position)	Energy rate/Positional Deck Transition (as appl.)
Follow on BFM as required		Follow on BFM as required

Figure 9-14 High/Low Yo-Yo NFS Requires Comm

<u>In-Close Overshoot</u>

This scenario will demonstrate a bogey attack with excessive closure that results in an overshoot of the defender’s wing-line or “3-9 line.” This attack presents a reversal opportunity for the defender.

At the CTM/Fox-2 the attacker will continue to threaten the defender with his nose. The defensive student will honor this threat with a "Lift vector on" ICS call to his pilot. The “Lift vector on” call will serve to maintain a break turn into the threat aircraft, which will complicate the bogey’s attack by increasing his AOT and closure. The break turn will force the attacker to overshoot the defender’s flight path at close range (inside the control zone).

Recognizing the in-close overshoot, the defensive student will capitalize on this reversal opportunity and call "Reverse, pull for his six." A timely reversal may result in a follow on 3-9 overshoot and a role reversal in which the defender gains positional advantage. Depending on aircraft energy, bogey’s correction and timeliness, this overshoot can result in a neutral or defensive flat or rolling scissors.

NFS Responsibilities:

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: “Break right.” UHF: "Flares."	Break turn into bogey
Sensor nose still on	“Lift vector on.”	Maintain break turn into bogey
Overshoots extended six o’clock	“Reverse, pull for his six”	Reverse to force a 3-9 overshoot if possible
Follow on BFM as required		Follow on BFM as required

Figure 9-15 In-Close Overshoot NFS Required Comm

Valid Attack to Guns-D

This scenario will demonstrate an attack by a bogey that is able to maneuver and achieve a guns attack. The defensive response will be a last ditch defensive maneuver (Guns D).

At the CTM/Fox-2, the attacking bogey will threaten the defender with his nose. The defensive student will honor the threat with a "Lift vector on" ICS call to his pilot, maintaining the break turn into the threat as long as "sensor nose" is a factor.

The key determinant of whether we will pull for an overshoot or execute a Guns 'D' will be whether our opponent has solved for the "Big Three." If the attacker has solved for lead, range, and POM, we will defend. Otherwise, we will continue to break turn to maximize a possible overshoot. As the bogey pulls lead for an imminent guns shot (approaches 1500' Rake/Snap shots), the defensive student will call "Guns-D." Upon hearing this command, the defensive pilot will execute a last ditch out-of-plane Guns-D as described earlier in this chapter.

NFS Responsibilities:

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: “Break right.” UHF: "Flares."	Break turn into bogey
Sensor nose still on	“Lift vector on.”	Maintain break turn into bogey
Presses attack, in guns range and able to pull lead for a shot	“Guns-D.”	Execute Guns-D to defeat shot
Deck Transition	Deck Transition Calls (Alt/Nose Position)	Energy rate/Positional Deck Transition (as appl.)
Follow on BFM as required		Follow on BFM as required

Figure 9-16 VAGD NFS Required Comm

Offensive/Defensive Perch BFM

PADS: 18K'/250-350 KIAS/Set+0.5 NM Abeam (CTM = 40° AOT @ Set range)

On the BFM-3 and 4, perch BFM will be introduced to the NFS. The purpose of perch is to introduce the concepts and sight pictures associated with offensive and defensive BFM from a canned 40° AOT scenario. NFSs will be exposed to either the offensive or defensive scenario on the BFM-3 with the alternate scenario being demonstrated on the BFM-4. Offensive and Defensive Perches will be conducted from the standard 40° AOT Perch setup described in the TAC Admin portion of this chapter. Three separate perch scenarios will be demonstrated: the first at 9000’ slant range, outside the bubble; the second at 6000’ slant range, at bubble entry; and the last at 3000’ slant range, starting inside the bubble. The PADS and training objectives for each of the perch scenarios are delineated as follows:

<u>Offensive Perch</u>

9K’ Offensive Perch 18K’/350 KIAS/2.0 NM

- Bubble Entry
- Attack Window Entry Mech
- Rate War/Misaligned Turn Circles
- 2nd Bubble entry

6K’ Offensive Perch 18K’/350 KIAS/1.5 NM

- Bubble Entry
- Attack Window Entry Mech

Ditch Follow, Timing/Mechanics

Deck Transition

3K' Offensive Perch 18K'/250 KIAS/1.0 NM

Attack Window Entry Mech

Ditch Follow/Guns D, Timing/Mechanics

Deck Transition

Finishing

At the "FOX-2" or "Clear to Maneuver" the offensive NFSs first concern is bubble entry. To facilitate entering the bubble, the offensive NFS will call for his IP to "Lead him." Once the NFS recognizes the sight cues that define bubble entry, he will direct his IP to ease his pull to the attack window by calling "Lag him." Attack Window Entry Mech will be initiated by the NFS through the use of a "Lift vector on" call until the aircraft decelerates into the rate band, whereupon the NFS will call "Capture 300."

Should the defender ditch, the offensive NFS will direct the follow with comm that is similar to Attack Window Entry Mech, calling for the IP to "Lag him" until the same line-of-sight rates dictate the timing for the ditch follow. NFSs will initiate the follow via a "Lift vector on" call. Of course, in the ditch follow, like any other nose-low maneuver, the NFS will be responsible for making deck transition calls. As the scenario approaches the deck and transitions to a logical conclusion (i.e., flat/rolling scissors, weapons employment, etc.), NFSs will recognize and direct appropriate follow-on BFM.

<u>Defensive Perch</u>

9K' Defensive Perch 18K'/350 KIAS/2.0 NM

Break Turn

Bubble Entry

Misaligned Turn Circles/Rate War

2nd Bubble Entry

Bug

6K' Defensive Perch 18K'/350 KIAS/1.5 NM

Break Turn

Bubble Entry

Ditch, Timing/Mechanics

Deck Transition

3K' Defensive Perch 18K'/250 KIAS/1.0 NM

Ditch/Guns D, Timing/Mechanics

Deck Transition

Guns Weave

At the "FOX-2" or "Clear to Maneuver," the defensive NFS's primary concern is the execution of a defensive break turn, both to defeat a missile shot and take away angles from the attacking aircraft. This will be accomplished through the defensive NFS calling "Break Left/Right" over the ICS and "Flares" over the radio. Per the priorities set forth in the Defensive Axioms in Chapter 8, the priority while the attacker is outside the bubble is to take away as many angles as possible. This will be directed by the NFS with a "Lift vector on" call until he recognizes the sight picture associated with bubble entry. Upon bubble entry, the NFS will match the performance of the attacking aircraft, calling "Nose off, ease" when his opponent eases or "Lift vector on" anytime his opponent is pressuring. If at any time the defensive NFS recognizes a bug scenario (180° out merge), the NFS will call for a "Bug" and "Unload" at the merge. Of course, in the bug, the NFS must strive to maintain sight of the attacker and if the bug will not be successful, call for a break turn back into the attacker with flares.

Once the attacker meets the ditch criteria laid out in the BFM Theory lecture, the defensive NFS will direct the redefinition through the use of a "Ditch" call. In the ditch, the NFS will direct the proper orientation of the lift vector through a "Lead him" call. Of course, anytime the aircraft is nose-low, the NFS should follow with deck transition calls. As the scenario approaches the deck and transitions to a logical conclusion (i.e. flat/rolling scissors, weapons employment, etc…), NFSs will recognize and direct appropriate follow-on BFM (to include scissors maneuvering, guns weave, rate war, etc...).

High Aspect BFM

The next building block in the BFM syllabus is to initiate a 1V1 engagement from a neutral setup and maneuver post-merge. We will arrive at the merge with a well thought out gameplan that maximizes the strengths of our aircraft and our weapons system and mitigates the strengths and exploits the weaknesses of our opponent. As we execute our gameplan, we will endeavor to recognize the offensive or defensive sight pictures, previously demonstrated to us, and transition appropriately to either offensive or defensive BFM. High Aspect BFM will be demonstrated to the NFS in two stages: first through a demonstration of the types of flow available (in the First Move Option Exercise), and also in a series of High Aspect Engagements which will focus on gameplan development and basic execution.

<u>First Move Option Exercise</u>

PADS: 18K'/300 KIAS/1.5 NM Abeam

The First Move Option exercise will be conducted from the High Aspect Butterfly Setup previously discussed in the TAC Admin portion of this chapter. At the merge, the Lead aircraft will maneuver nose-high and set a particular flow while the wing aircraft will maneuver across the tail slightly nose-low. With the flow established, two scenarios will be presented, showing how a poorly executed gameplan will quickly result in a weapons employment opportunity.

One-Circle Flow Demo: LEAD NOSE HIGH, WING NOSE LOW

At the merge, the Lead IP will pull nose up and force a one circle flow while the wing will pull across the lead's tail, nose-low. Pulling to place the lift vector towards the wing's six o'clock will allow the lead to turn inside his turn circle as the OOP nose-high maneuver goes uncountered. Once the high aircraft has a positional advantage, it will generally reverse, resulting in a transition to two-circle flow and subsequent weapons employment opportunity. The defensive NFS should recognize sensor nose and call for a break turn with flares prior to weapons employment. A general depiction of the One-circle Demo is shown in Figure 9-17.

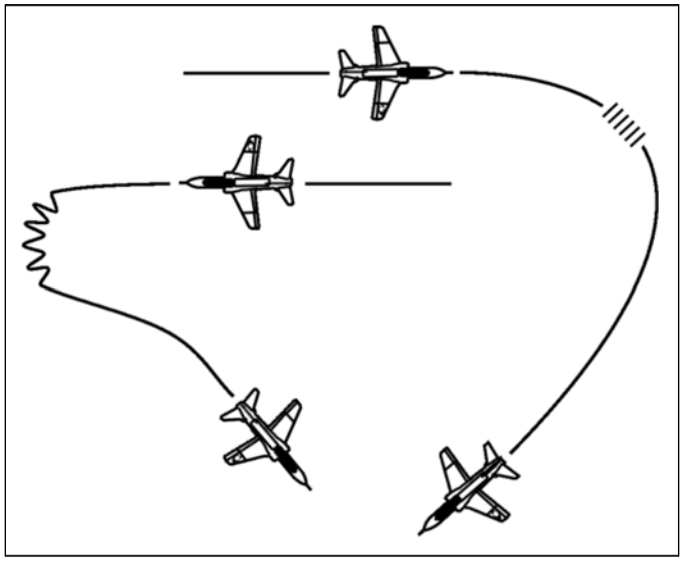

Figure 9-17 First Move Option (One-Circle Flow)

Two-Circle Flow Demo: LEAD NOSE HIGH, WING NOSE LOW

At the merge, the Lead IP will pull nose up and force a two circle flow, while the wing will pull across the lead's tail, nose-low. The resulting decrease in the lead's turn performance as the aircraft decelerates should be clearly evident, and the nose-low aircraft should rate around to come nose-on first. The defensive NFS should recognize sensor nose and call for a break turn with flares prior to weapons employment. A general depiction of the Two-circle Demo is shown in Figure 9-18.

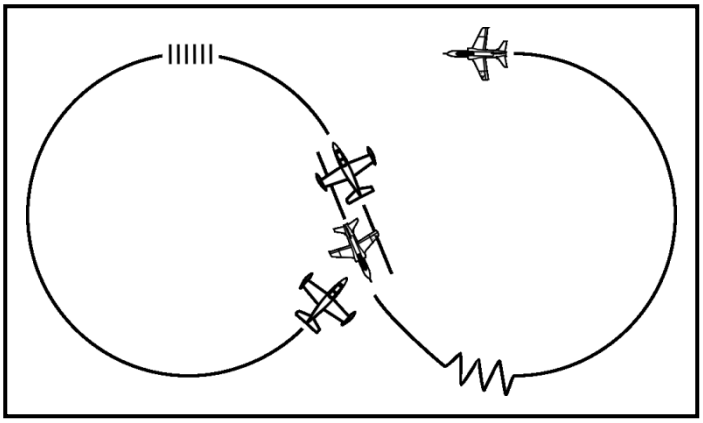

Figure 9-18 First Move Option (Two-Circle Flow)

High Aspect Sets

The culmination of the VT-86 BFM syllabus occurs with the introduction of 1 v 1 Neutral High Aspect engagements during the BFM-5 and 6. Like the First Move Option Exercise, these neutral sets will be executed from the Butterfly Setup delineated in the TAC Admin portion of this chapter. The focus of the 1 v 1 Neutral High Aspect sets is three-fold: sound gameplan development, basic execution, and transition from high aspect to offensive/defensive BFM.

Gameplan Development:

In the BFM-5 and 6X, the primary focus of the High Aspect sets will be "Gameplan Development." As we discussed in the BFM Theory chapter, "Gameplan" is a function of three components: Mindset and Flow based on our expected Threat. Prior to arrival at the brief, NFSs will have developed a gameplan that they intend on executing, for that particular flight, based on the threat that they expect to face. The specifics of gameplan for the purposes of the VT-86 syllabus are detailed as follows:

- Threat: For the BFM-5 and 6X, each NFS will be given a different weapons loadout in which to formulate their gameplan. NFSs will take into account the strengths and weaknesses of their own platform as compared to their opponent. For the BFM-5, the lead aircraft will formulate its gameplan based on an All-Aspect IR Missile with no gun facing a wingman with an IR-only missile and gun. On the BFM-6X, the loadouts will swap, with the lead having IR-only missiles with a gun against a wingman with All-Aspect missiles but no gun. The goal of alternating weapons loadouts on the BFM-5 and 6X is to force the NFS to develop a different gameplan for each flight.

- Mindset: Mindset is a complicated concept and will be covered in greater detail in the fleet. For the purposes of the VT-86 BFM syllabus, we will simplify the concept, concentrating on the energy management aspect of the mindset discussion. For simplicity sake we will define two "mindsets" that may be employed as part of our

BFM gameplan: positional and energy fights. Realize that these are terms picked exclusively for the VT-86 syllabus and will have different and more in-depth terminology in the fleet. Here at VT-86, we will define these mindsets as:

Positional: As part of our gameplan, we are willing to sacrifice energy (airspeed) to gain or deny angles/turning room. This mindset is generally utilized when our opponent has a superior performing aircraft to our own.

Energy: As part of our gameplan, we are unwilling to sacrifice energy, conserving our airspeed to allow for other options (vertical performance, bug, etc…). This mindset is generally utilized when our aircraft has a superior turn performance than our opponent.

- Flow: Hand-in-hand with our mindset discussion is our consideration of desired flow. In the BFM Theory chapter, we detailed how flow provides for different amounts of separation between aircraft. We will choose our desired flow based on the amount of weapons separation we desire between aircraft during an engagement.

  One-Circle: If our opponent has a superior weapons system/loadout to our own, we would want to limit the amount of separation between aircraft during an engagement. In that case, one-circle flow would be our flow of choice.

  Two-Circle: If we have a superior weapons system/loadout over our opponent, then we would want as much separation between aircraft as possible, allowing us time and space to employ our weapon. In that case, we would opt for two-circle flow.

As an example of our gameplan development, if our aircraft was "Gun Only" against a similar performing opponent with an IR Missile capability, our gameplan may sound something like: "Positional fight, utilizing one-circle flow to counter the IR missile threat." Most importantly, because our gameplan is based on our threat, once we establish our gameplan, we do not change gameplans; rather, we execute as planned and if our gameplan is not working, we look for opportunities to disengage.

Gameplan Execution:

- Pre-engagement

  With our gameplan in hand, the student will coordinate his gameplan execution with his IP prior to each initial merge. At a minimum, NFSs should indicate their desired target airspeed at the merge (300-330 KIAS for nose-low, 300-330 KIAS for level, and 330-350 KIAS for nose-high) and their desired initial first move (nose-high, nose-low) based on their gameplan's mindset.

- At the Merge

  At each merge, NFSs should direct their IP which direction to turn to force the flow they desire (e.g. “nose low, left”; “nose-high, right”), again based on the mindset and flow determined by their predetermined gameplan.

- Post Merge

  Following each merge, we need to analyze the engagement and how it corresponds to our predetermined gameplan. At a minimum, NFSs should consider the following:

  1. **Describe.** Which way did our opponent turn? NFSs should report direction of the bandit to their IP.

  2. **Determine Flow.** What type of flow are we in? NFSs will report to their IP the established flow.

  3. **Evaluate.** Are we in the flow we wanted in accordance with our gameplan?

  4. **Adjust.** If we are in our desired flow, execute in accordance with our gameplan (1C: “max perform, pull for his six”; 2C: “nose-low, capture 300”). If we are not in our desired flow, how do we get back to the next merge to force our desired flow at that merge? (e.g. “nose-high, lift vector on”)

  5. **React.** Once we recognize that an engagement has transitioned from neutral to either offensive or defensive BFM, we perform accordingly. The particulars of how NFSs will direct the offensive/defensive transition will be laid out in more detail in the following section.

Offensive/Defensive Transition:

The purpose of High Aspect BFM is to recognize the transition of an engagement from a neutral start to either an offensive or defensive scenario and react accordingly. It is the most critical phase of the engagement and usually the most difficult to execute. The purpose of the BFM syllabus up to the BFM-5/6X was to introduce the NFS to the offensive/defensive sight pictures and objectives. Now in the BFM-5/6X we will put these skills into practice.

- Offensive BFM

  If we recall from our theory discussion in the previous chapter, any time we recognize the sight cues that define offensive BFM, we start working to control range, angles and closure. That is first accomplished by entering our opponent’s bubble. Like the perch setups, anytime the NFS recognizes the sight cues of being outside the opponent’s bubble, he will direct the IP to “Lead him” to facilitate bubble entry. Once established inside the bubble, “Lag him” would be the appropriate call, indicating to the IP that he should work toward the attack window. As in the perch sets, once the NFS sees the sight picture that would define the attack window, he

should call "lift vector on" to direct his IP to perform Attack Window Entry Mech. Of course, any time we see a weapons employment opportunity, NFSs should aggressively call for the shot ("trigger down" or "pull for the shot").

- Defensive BFM

  Any time NFSs find themselves recognizing defensive sight cues (i.e., opponent coming nose-on first) they should start working the transition to defensive BFM. A methodical execution of the four Axioms of Defensive BFM will give the defender the best chance of surviving.

  1. **Maneuver To Survive.** Recognition of "sensor nose" and responding with break turns ("Break Left/Right"/"Flares" or Guns Ds as appropriate.

  2. **Attacker Outside the Bubble: Pull Attacker as Far Forward as Possible**. Sensor nose on = "Break Left/Right"/ "Flares" (19-21 units), sensor nose off = "Hard Left/Right" (17 units).

  3. **Attacker Inside the Bubble: Decrease in Target Aspect = Increase in pull and vice versa.** "Lift vector on" as our opponent pressures or "Nose off, ease" as our opponent eases.

  4. **Sensor Nose On and Cannot Pull Forward of 3/9 Line = Redefinition/Ditch.** If we have the altitude to ditch, NFS should call "Ditch." If the NFS finds himself on the deck with no altitude to trade for angles, he should call "Reverse."

908. 1V1 ENGAGEMENT COMMUNICATIONS

Clear, concise, directive comm is essential for a successful 1V1 fight. Our goal in VT-86 is to have the student demonstrate an understanding of BFM sight pictures, execution and procedures through use of specific comm calls.

The following calls are intended to provide the student with some guidance with regard to the directive comm that a student will use during the VT-86 BFM syllabus. Realize that many of the calls will most likely not be used by an NFO in the fleet but are used in the training command to validate the understanding of the BFM concepts.

"Flares"

The only UHF call required from an NFS during a BFM engagement. The "flares" call will be used any time an NFS recognizes "sensor nose" to preclude an IR missile shot from being taken by his opponent. In any case, should there be a "FOX-2" call, indicating an opponent's weapons employment, the defensive NFS will call "flares" to simulate the expending of items. "Flares" calls are usually used in conjunction with a break turn call.

Airspeed calls

Airspeed calls should be initiated by the NFS any time his IP initiates a nose-high maneuver. Airspeed tells the pilot how nose-high he can go. Generally, the T-45 needs ~250 KIAS at a minimum to initiate a nose-high OOP maneuver with a minimum of ~300 KIAS to go pure vertical.

Altitude calls

Altitude calls should be initiated by the NFS any time his IP initiates a nose-low maneuver. Altitude tells the pilot how nose low he can go. Generally, the T-45 requires ~6000' of altitude to execute a pure nose-low, Split-S maneuver. In a deck transition, NFSs should be making altitude calls a minimum of every 3-5 seconds or 1000' of altitude loss.

"Break Left/Right"

A break call is a call for the pilot to max perform his aircraft at 19-21 units to defend against missile employment, defend against sensor nose, or take away angles any time our opponent is in a WEZ. It is usually associated with a "flares" call.

"Bug"

Used anytime the NFS wishes to disengage from an engagement: able to achieve a 180º out pass from a defensive scenario, preplanned gameplan is not working, in a disadvantageous position (high/low merge), or time-to-kill/fuel is becoming a factor. NFSs should strive to call for the bug early as they approach the merge so that the IP can set it up appropriately.

"Capture 300"

Used anytime the NFS wishes to perform in his Sustained Turn Rate Band: on the deck in two-circle flow, or working in-plane in two-circle flow where one does not want to give up altitude for turn performance (Attack Window Entry Mech).

"Ditch"

Used by the NFS to initiate a redefinition in the vertical (ditch) when an attacker has met ditch/redefinition criteria.

"Early Turn"

Generally used in an offensive scenario to:

1. Take angles in an "Exclusive Use Turning Room" scenario (nose-high approaching a vertical merge).

2. Solve for excessive range (>1000’) and work in-plane, in-phase; generally in a snapshot scenario, guns weave, flat scissors, etc.

“Guns D”

Used by the NFS to initiate a guns defense anytime his opponent is solving for the “Big Three.” lead, range (~1500’), and plane-of-motion.

“Hard Left/Right”

Used by the NFS to initiate a hard turn (17 units) to take away angles when defensive and our opponent is outside the bubble but not in a WEZ or “sensor nose” is not a factor.

“Lag him”

Used by the offensive NFS anytime we want our pursuit curve in lag:

1. After bubble entry, to work toward the attack window

2. In a ditch follow, while waiting for ditch-follow timing

3. In a roller, anytime we find ourselves nose-low, in our opponent’s bubble

“Lead him”

Used by the offensive NFS anytime we want our pursuit curve in lead:

1. To facilitate bubble entry

2. To gain angles/employ weapons nose-high in a roller

3. To employ weapons

Used by the defensive NFS to facilitate proper lift vector placement in a ditch.

“Lift vector on”

Used by the NFS, typically under the following conditions:

1. Offensive: When inside the bubble and we wish to preserve turning room/lateral separation between aircraft (Attack Window Entry Mech, Ditch Follow).

2. Defensive: Any time our opponent is pressuring us i.e. inside the bubble.

3. Neutral: Any time we need to make it to the next merge.

“Max Perform”

Used whenever we want our aircraft to perform on the lift limit (19-21 units), other than in response to a "sensor nose" or weapons employment. We will use a break turn call for those two defensive scenarios. Specifically, in each type of flow, we will execute as follows:

1. One circle: to minimize our turn radius.

2. Two circle: anytime we find ourselves above our rate band and can afford to bleed airspeed to maximize our turn rate.

“Nose-high, Left/Right”

Used to initiate a nose-high, out-of-plane maneuver in the specified direction either at a merge or at an in-close overshoot. Should be followed by an airspeed call.

“Nose-low, Left/Right”

Used to initiate a nose-low, out-of-plane maneuver at a merge in the specified direction. Should be followed by altitude and deck transition calls.

“Nose off, ease”

Used by the defensive NFS when the attacker is inside the bubble and executes a lag pursuit curve (high yo-yo or ease) and is no longer pressuring the defender.

“Pull for his six”

Utilized to indicate to the IP to place his lift vector behind the other aircraft to reduce down range travel, typically in one circle flow (flat/rolling scissors, one circle execution).

“Pull for the shot”

Used by the offensive NFS anytime he recognizes an impending missile or gun employment opportunity.

“Reverse”

Used by the defensive NFS in the following scenarios:

1. Upon meeting reversal-timing criteria in an in-close overshoot scenario.

2. In a defensive flat scissors: no earlier than the attacker going into lag and no later than the attacker passing the defender's extended six (based on track crossing rate).

3. In a neutral to slightly offensive flat scissors: after the nose is aft of our opponents 3-9 line.

4. At the top of a roller where we do not have altitude to roll again. Aft of the 3-9 line we will call for the reversal to transition to a flat scissors.

5. On the deck when the defender has met ditch criteria but cannot ditch.

6. In a guns weave, just prior to the attacker meeting his gun lead requirement.

“Roll”

Used at the top of a rolling scissors, once established aft of our opponent's 3-9 line (or no later than him going nose high), to indicate when to commit nose low.

“Trigger down”

Used by the offensive NFS in a snapshot scenario (or in the Snapshot Drill) to direct gun employment when he has met his lead requirement.

“Unload”

Used at the merge of a bug/disengagement scenario. Indicates to the IP to execute an unloaded acceleration to increase energy/airspeed.

“Watch the deck”

Used by the NFS during a deck transition in the following situations:

1. Anytime we are violating the "Rule of 10:" no more than 10° for every 1000' above the hard deck.

2. Anytime we are less than 500' above the deck and the nose dips below the horizon.

“300-330, Nose-low”

First move execution command, for a nose-low option, given prior to the start of an engagement to indicate to the IP the desired initial direction and target airspeed.

"300-330, Level"

First move execution command, for a level turn option, given prior to the start of an engagement to indicate to the IP the desired initial direction and target airspeed.

“330-350, Nose-high”

First move execution command, for a nose-high option, given prior to the start of an engagement to indicate to the IP the desired initial direction and target airspeed.

909. CONCLUSION

BFM is a fluid and highly dynamic maneuvering environment. Sight pictures and windows of opportunity are often extremely subtle and fleeting in nature. Throughout training in the NFO pipeline, it has been often stressed: directive before descriptive comm. While that axiom is generally valid, while initially learning the concepts of BFM, often the opposite is more helpful. By describing what they are seeing, NFSs can often cue themselves as to how to execute.

The VT-86 BFM Syllabus is by no means designed to facilitate proficiency for the NFS in the BFM environment. Rather, it is designed to introduce the NFS to the concepts and sight pictures prevalent in the ACM environment, thereby laying a solid foundation that can be built upon in the FRS and the fleet.

APPENDIX A
GLOSSARY OF TERMS

A100. NOT APPLICABLE

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APPENDIX B
AIR TASKING ORDER (R4401)

ANNEX A

Waypoint	LAT/LONG	Notes
Target (TGT)	N 31° 08’ 31” W 088° 58’ 56”	Nuke Bull
Control Points (CP’s)		
FORD	N 31° 19’ 13” W 088° 56’ 29”	Richton-Perry Airfield Above 3K’ AGL
CHEVY	N 31° 15’ 27” W 088° 53’ 40”	Bridge over River
OLDS	N 31° 06’ 07” W 088° 49’ 15”	Highway Bridge over River
BUICK	N 31° 00’ 24” W 088° 50’ 39”	Road Intersection/SW of lake Below 5K’ (Desoto 2 MOA)
PONTIAC	N 30° 55’ 04” W 088° 54’ 37”	Lake divided by levee Below 5K’ (Desoto 2 MOA)
Initial Points (IP’s)		
A	N 31° 13’ 03” W 088° 58’ 48”	Highway with parallel RR road intersection
B	N 31° 08’ 10” W 088° 54’ 18”	Horseshoe Lake
C	N 31° 02’ 26” W 088° 58’ 18”	Chicken Ranch

FSCL North/South line on W 089º 30' 00"

FLOT North/South line on W 088º 58' 40"

NFA 500m radius centered on N 31º 08' 38" W 088º 59' 00"

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APPENDIX C
AIR TASKING ORDER (PNSS/GATOR MOA)

ANNEX A

Waypoint	LAT/LONG	Notes
Target (TGT)	N 30° 23' 05" W 087° 24' 28"	Blue Angel Recreation Park/ Bronson Field
Control Points (CP's)		
CORVETTE	N 30° 24' 55" W 087° 49' 29"	Weeks Bay, North Fork
MALIBU	N 30° 33' 47" W 087° 48' 37"	Silverhill Airfield
IMPALA	N 30° 37' 44" W 087° 36' 55"	Highway Overpass
MUSTANG	N 30° 30' 26" W 087° 38' 46"	Summerdale Airfield
CHARGER	N 30° 39' 00" W 087° 21' 05"	Bend in HWY 29
NOVA	N 30° 34' 03" W 087° 13' 38"	Smokestacks on Escambia River
Initial Points (IP's)		
A	N 30° 30' 52" W 087° 27' 00"	Fork in Perdido River
B	N 30° 23' 59" W 087° 14' 34"	Bayou Chico Bridge
D	N 30° 23' 30" W 087° 37' 46"	Barin Airfield
H	N 30° 32' 35" W 087° 22' 03"	Helo OLF

Altitude Block: 11K' – 17.5K' MSL

FSCL East/West line on N 30º 21'

FLOT East/West line on N 30º 23' 51"

NFA 2 500m radius centered on N 30º 23' 18" W 087º 23' 54"

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