DCS - BASIC FLIGHT TRAINING

PRIMARY FLIGHT OPERATIONS

FIXED WING

CURRENT as of Jul 1, 2023

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The author of this publication used only open source documents to generate this document.

The author did not reference and does not have access to any classified documents on this subject matter.

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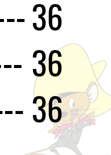

INTRODUCTION

Some words of wisdom from an old pilot. The world of Aviation in general and Combat Aviation in specific is not an exact science, or a precise cause & effect flow. The world of aviation is more art than it is science. Yes, throwing specific switches in a specific order will cause the aircraft to do a specific action. BUT, that is where it stops, in aviation we fight, bend or in some cases break the rules of physics as we know it. As pilots we learn 'tools' and tricks and gain experience with flight time, and many times we employ those tools in weird & new ways, because no 2 flights are the same. Every flight can, and usually does, present a new situation or scenario. You constantly have to be adjusting, managing, and improvising to achieve the desired goals. IT IS NOT A QUICK PROCESS. Give yourself permission to take the time and enjoy the process of learning. Enjoy the journey for it is not short, nor boring.

Creating these manuals and guides are a labor of love and passion, but it doesn't happen in a vacuum. It takes a lot of time, patience and research and support from many people around me. If you enjoy these manuals and they help you, they've accomplished exactly what they are designed to do. If you are feeling like paying it forward and want to help me keep making these manuals and guides, feel free to buy me a beer or a coffee or support me on Patreon.

Thank you for your support, see ya in the skies

NAPA "SPEEDY"

Chapter 1 - GENERAL INFORMATION

1.1 General.

This manual provides the necessary procedures to efficiently and effectively learn the necessary skills to be successful in DCS using the A-29B & T-45C aircraft. The skills developed while flying the trainer aircraft are applicable to flying any aircraft in a simulator environment and provide the foundation for all follow-on flying training. This manual is designed to be used in conjunction with the following documents.

- *Pilot Logbook & Training Guide*
- *DCS A-29B Super Tucano Flight Manual*
- *VNAO T-45C Goshawk Flight Manual*

The Logbook & training guide provides a guided checklist and training plan of all knowledge and practical skill sets needed to be successful in DCS World. The A-29B & T-45C Flight Manuals contain detailed instructions for checks, procedures and also provide detailed information on aircraft systems and systems operation. The Flight Manuals, training guide and this publication complement each other.

1.2. Using This Manual.

In general, this manual is organized in an order that parallels the training flow in basic pilot training. The first five chapters cover topics applicable to every sortie, and the second five chapters cover topics by category of flight. While each chapter builds on skills and concepts introduced in previous chapters, the initial phase of training requires mastery of all concepts and skills introduced in chapters 1 through 6. You will also find specific passages ***highlighted and annotated***. These specific passages are marked because they are the "nuggets" of info that I would highlight or mark if I were reading and studying this document. During subsequent stages of training, study centers on specific category chapters. Regular review of previous material is highly recommended.

1.3. Introduction.

The concepts in Chapter 1 apply to every kind of sortie flown in any aircraft, whether it be fixed wing or rotor-wing. Full understanding of these general concepts is developed through study and flying experience; therefore, regular review of this chapter is highly recommended.

1.4. Flight Discipline.

Flight discipline is at the core of every flying operation.

- Flight discipline begins with mission preparation. Know the rules and procedures, study the profile, and show up prepared to fly. One unprepared crewmember can ruin the mission for everybody.
- Flight discipline continues with the briefing. Be on time, be ready to discuss the mission, and (or) be ready to brief. Ensure all questions are answered and mission requirements are understood.
- Flight discipline is demonstrated in the air by executing the mission as briefed according to governing guidelines, from engine start to engine shutdown.
- Flight discipline should be evaluated and specifically addressed during every mission debrief.

1.5. Checklist Discipline.

In real life, the omission of a checklist item could lead to a dangerous situation, in DCS it could result in a mission failure or inability to complete a task at a critical time. Therefore, positively confirm completion of all checklists regardless of how they are accomplished (for example, memory aid, mnemonic, or flight crew checklist). One technique to ensure accomplishment of every step is to execute a few items from memory; then reference the checklist page to verify completion. Further guidance on checklist use follows:

- It is not necessary to refer to the checklist during critical phases of flight.
- In multi-crew aircraft there will be only one pilot actively controlling the aircraft at any point in time. This pilot is referred to in the rest of this manual as the pilot flying (PF). The PF is responsible for completion of all checklists. *That does not mean, that 2nd crew member can't assist the PF by reading checklist or accomplishing some of the tasks* (if possible)
- Once started, attempt to complete checklists without interruption. If interrupted, or if it is discovered that an item was omitted, a good technique to get back on track is to restart at the first step of the checklist or restarting two to three steps prior to the missed or interrupted checklist step. Do not start a new checklist until completing the previous one.
- Throughout any flying career it is a common practice for checklists and required items to be memorized through mnemonics or standardized phrases. The purposes of these are to help you remember what needs to be done at a specific time. *One caution is that you do not give lip service to performing a checklist when using a standardized phrase or mnemonic. You must perform the checklist item or required check.*

1.6. Cockpit/Crew Resource Management (CRM).

The CRM or Cockpit/Crew Resource Management is a reference to the effective use of ***ALL*** available resources to safely and efficiently accomplish mission objectives. CRM is designed to focus aircrew members on procedures, and resources available to enable mission success. CRM centers on the following six skills:

- **Communication.** Communication is the sharing of information with others to cause action. Communications may direct, inform, question, or persuade.
- **Crew/Flight Coordination.** Proper coordination includes crew/flight integrity and wingman consideration. Crew/Flight integrity requires the utilization of all members of a flight to accomplish the mission.
- **Mission Analysis.** Includes pre-mission analysis and planning, briefing, and post mission debrief.
- **Situational Awareness.** SA is the continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission. It also includes the ability to forecast, then execute tasks based upon that perception.
- **Task Management.** Task management is the ability to establish priorities and alter a course of action based on new information. It includes management of automation, effective use of available resources, checklist discipline, and compliance with standard operating procedures.

1.7. Mission Preparation.

Mission success is directly related to mission preparation. Solid preparation maximizes the effectiveness of the flight. Mission preparation consists of the following four areas:

General Study - Study in general areas builds a foundation of knowledge for pilot training, other formal training courses, and operational missions. Some topics such as the flight manual are aircraft specific and other topics such as local area procedures are location specific. Areas of study including instrument procedures, weather, aerodynamics, flight information publications, and navigation, are generic because they apply to any aircraft, at any location, flying any type of mission. ***General study is a continuous process that is an integral part of any successful pilot.***

Mission-specific Study - Study in areas specifically related to the mission. This includes general study areas that are specifically related to the mission. Mission-specific areas include, but are not limited to, initial approach plate (IAP) review, maneuver review, and daily study topics.

Chair-flying. ***[PRO-TIP]*** - This is an in-depth, mental rehearsal of the sortie. It is visualization of specific maneuvers and techniques, and mental review of checklists and specific tasks. To properly chair-fly, visualize each aspect of the sortie. When initially learning to fly, this should include all aspects of the mission to include each phase of flight in sequence and visualize each action, switch position, and radio call. As you progress through the sortie in this manner, you will identify points during the sortie which require additional study. As experience is gained, chair-flying may only include new events or maneuvers, task intensive phases of flight, or events which have not been recently practiced. Though time consuming, properly chair-flying each sortie will pay dividends as training progresses and throughout your flying career.

1.8. Fuel Considerations.

Unlike many operational and training aircraft, the A29B & T-45C are not fuel limited on most training sorties. Generally, syllabus directives, not available fuel, determine the duration of most sorties; however, *regular fuel checks are still a very good habit to get into, as fuel state becomes more critical as you progress to tactical missions*.

Bingo Fuel: Minimum fuel required to arrive at home base at max range fuel burn rate with reserve. Reserve is typically enough for ½ hour of flight time at max range fuel rate. Bingo fuel is briefed on every mission.

Joker Fuel: Is an assigned amount over Bingo Fuel. A mission may require several joker fuels or none at all. Joker fuel is briefed and set at pre planned transition points in the sortie, if applicable.

1.9. Mission Briefing.

The AC/FL may or may not be the actual briefer, but it is best practice for them to ensure that each mission is thoroughly briefed and debriefed.

- *Briefings set the tone for all missions*.
- There are resources available both on the internet and within Tactical-DCS discord that can provide a framework to help structure briefings and have all recommended briefing items addressed
- Other crew members or formation members will be prepared to assist the AC or FL.
- The briefing should focus on how to successfully accomplish the established objectives.

1.10. Debrief.

The purpose of the debrief is to determine if mission objectives were achieved and what lessons were learned. *The majority of learning will be accomplished during this phase*. The AC/FL should:

- *Cover what went right or wrong, root causes of errors, and how to improve subsequent missions*.
- Debrief by objective, examining how well each objective was achieved.
- Summarize the mission with emphasis on major learning points and considerations for improvement of deficient areas on future missions.

1.11. Radio Procedures.

The PF/FL is responsible for all radio calls. But, that does not mean a 2nd crewman/wingman can't do those tasks if directed to do so by the PF/FL. Radio phraseology & brevity code words can be found in the following publications *OPERATIONAL BREVITY WORDS & DEFINITIONS*. Although these publications do not cover all situations, pilots should attempt to use standard phraseology as much as practical. Standard terminology minimizes radio congestion and facilitates effective communication.

Clarity. The single most important factor in pilot-controller communications is comprehension. Voicing what is required correctly through standard phraseology is paramount. When uncertain of the meaning of standard phrases used by controlling agencies, clarify with plain language. *It is always better to ask a question, and know for sure, than to assume and guess wrong*.

Brevity. *Brevity is second only to clarity. Every second you are talking on the radio is a second that is unavailable to the controllers or other pilots*. Provide controllers with the information needed, nothing more, nothing less, in the format expected. Likewise, do not omit needed information that may require the controller to query you for the missing information as this also wastes air time.

Do not depress the microphone button during other transmissions. Anticipate other party's replies to ATC and (or) pilot transmissions and do not interrupt. Try to avoid transmitting when another aircraft is in a critical phase of flight (for example, in the flare).

Whenever possible, format radio calls as follows:

[WHO ARE YOU TALKING TO] , [WHO ARE YOU], [WHERE ARE YOU], [WHAT DO YOU WANT].

For example, *"San Antonio Approach, Texan 1-1, Area 8 low, request Auger low ILS with bravo."*

Adding verbiage that is not required clutters the radio frequency. Avoid meaningless phrases such as "with you," "checking in," "with a flash," "at this time", "be advised", on congested frequencies. Provide the controllers with the information needed simply and clearly in the format expected. Nonstandard radio calls take more time to understand.

1.12. Emergency Procedures.

Because DCS is a flight simulator, emergency situations in game are not the same as such IRL. But that being said, the procedures laid out here can be applied to when you feel task saturated or overwhelmed with the situation. These procedures will walk you through the process of prioritizing and regaining SA.

Three basic rules apply to all emergency procedures: (1) maintain aircraft control, (2) analyze the situation and take proper action, and (3) land as soon as conditions permit. If the aircraft cannot be recovered safely, ejection may be the only option. A memory aid to help prioritize pilot action, that is applicable in normal and emergency situations, is, ***"Aviate, Navigate, & Communicate"*** in that order.

AVIATE - ***Keep it in the air, don't hit anything.*** In any abnormal or emergency situation it is imperative to "fly the aircraft first!" Maintain an aircraft attitude that allows for an appropriate response to the situation. Set power and trim to help maintain control. In the contact phase, this may involve a contact recovery or out-of-control flight (OCF) recovery.

NAVIGATE - ***Where are you and where do you need to go.*** Aircraft control may include the initial turn and (or) climb to a recovery airfield. In low-level navigation, it may involve starting a climb to the top of the route. In formation, it may involve calling Blind or KIO and executing the appropriate procedure.

COMMUNICATE - ***Communicate to announce intentions or marshal resources to deal with the situation.*** If available, ATC can help identify suitable recovery airfields, find required frequencies, aid navigation with vectors, alert emergency response assets, identify hazardous weather, or help find a chase ship.

Analyze the Situation and Take Proper Action.

CRM in an Emergency. A successful conclusion to any emergency results from thorough systems knowledge, sound judgment, and effective CRM. Several resources are available to aid successful recovery. If multi-crew, the AC determines who flies the aircraft, based on pilot workload and the experience level and ability of both pilots. The crewmember/wingman can read the checklist, monitor systems, provide advice, and maintain SA on the nearest suitable landing field. The flight crew checklist, in-flight guide, flight information handbook, or other FLIP can contain useful information.

Chapter 2 - BASIC FLIGHT PRINCIPLES

2.1. Introduction.

This chapter discusses basic terms that apply to all aircraft. It explains concepts and terms associated with the T-45 as an example of a Jet turbine-driven aircraft. Knowledge and understanding of these terms and their associated aerodynamic effects is essential to successfully fly any high performance aircraft in DCS World.

2.2 Basic Principles of Flight

Thrust, drag, lift, and weight are forces that act upon all aircraft in flight. Understanding how these forces work and knowing how to control them with the use of power and flight controls are essential to flight. In steady flight, the sum of these opposing forces is always zero. There can be no unbalanced forces in steady, straight flight based upon Newton's Third Law, which states that for every action or force there is an equal, but opposite, reaction or force. This is true whether flying level or when climbing or descending.

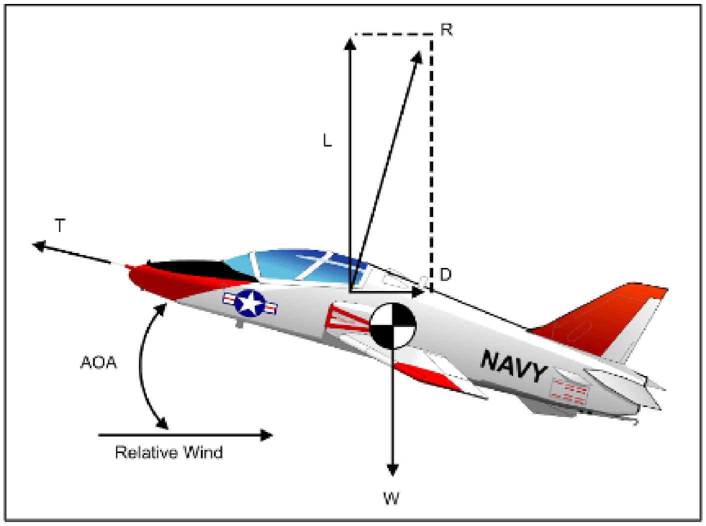

Figure 2.1 Aerodynamic Forces Acting Upon an Aircraft in Flight

The four forces acting on an aircraft in straight-and-level, unaccelerated flight are thrust, drag, lift, and weight. They are defined as follows:

2.2.1 Weight

The combined load of the aircraft itself, the crew, the fuel, and the cargo or baggage. Weight is a force that pulls the aircraft downward because of the force of gravity. It opposes lift and acts vertically downward through the aircraft's center of gravity (CG).

2.2.2 Drag

A *rearward, retarding force caused by disruption of airflow by the wing, rotor, fuselage, and other protruding objects*. As a general rule, drag opposes thrust and acts rearward parallel to the relative wind. There are two types of drag that affect aircraft, Induced Drag & Parasitic Drag.

2.2.2.1 Induced Drag

***Induced Drag** is a result of the generation of lift*. During the process of generating lift, air is split by the airfoil and results in air flowing at two different velocities and pressure. Like a tornado when 2 bodies of air of differing velocity/pressure join it creates vortices/turbulence, this results in a loss of lift on that surface.

2.2.2.2 Parasitic Drag

***Parasitic Drag** is composed of all the forces that work to slow an aircraft's movement*. As the term parasite implies, it is the drag that is not associated with the production of lift. This includes the displacement of the air by the aircraft, turbulence generated in the airstream, or a hindrance of air moving over the surface of the aircraft and airfoil. It essentially can be summed up as anything that disturbs the natural flow of air, e.g. Weapons, Antennas, Pods, Pylons, Lights,

2.2.3 Thrust

Newton's First Law:

"Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."

This means that nothing starts or stops moving until some outside force causes it to do so. An aircraft at rest on the ramp remains at rest unless a force strong enough to overcome its inertia is applied. Once it is moving, its inertia keeps it moving, subject to the various other forces acting on it. These forces may add to its motion, slow it down, or change its direction.

Newton's Second Law:

"Force is equal to the change in momentum per change in time. For a constant mass, force equals mass times acceleration."

When a body is acted upon by a constant force, its resulting acceleration is inversely proportional to the mass of the body and is directly proportional to the applied force. This takes into account the factors involved in overcoming Newton's First Law. It covers both changes in direction and speed, including starting up from rest (positive acceleration) and coming to a stop (negative acceleration or deceleration).

Newton's Third Law:

"For every action, there is an equal and opposite reaction."

In a jet airplane, the engine pushes a blast of hot gasses backward; the force of equal and opposite reaction pushes against the engine and forces the airplane forward. The forward force produced by the powerplant/ propeller or rotor. It opposes or overcomes the force of drag. As a general rule, it acts parallel to the longitudinal axis. However, this is not always the case, as explained later.

2.2.3.1 Turbine Engines

An aircraft turbine engine consists of an air inlet, compressor, combustion chambers, a turbine section, and exhaust. Thrust is produced by increasing the velocity of the air flowing through the engine. Turbine engines are highly desirable aircraft powerplants. They are characterized by smooth operation and a high power-to-weight ratio, and they use readily available jet fuel.

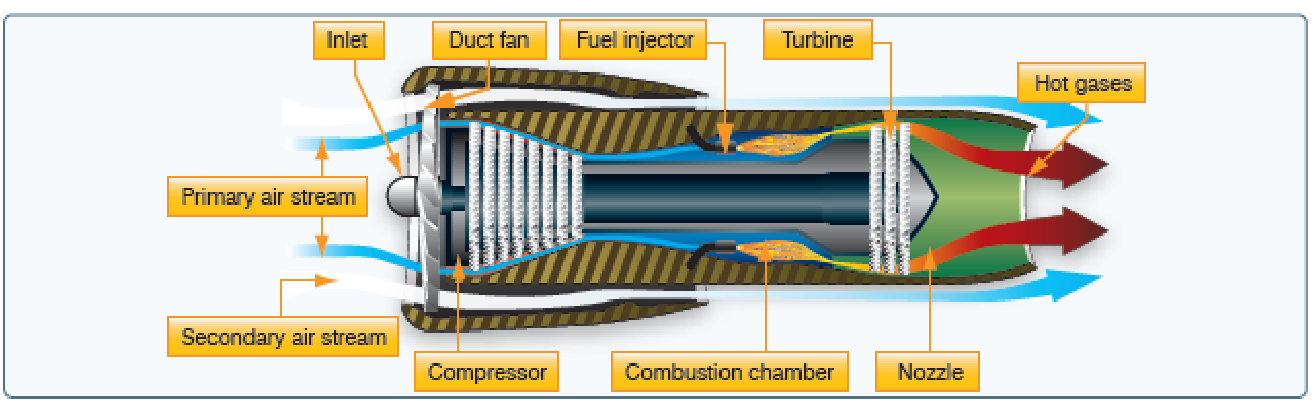

Figure 2.2 Jet Engine

2.2.4 Lift

Bernoulli's Principle of Differential Pressure

Bernoulli's Principle states that as the velocity of a moving fluid (liquid or gas) increases, the pressure within the fluid decreases. This principle explains what happens to air passing over the curved top of the airplane wing.

Lift is a force that is produced by the dynamic effect of the air acting on the airfoil, and acts perpendicular to the flight path through the center of lift (CL) and perpendicular to the lateral axis, also known as lift vector(LV). In level flight, lift opposes the downward force of weight. The pilot can control the lift. Any time the control yoke or stick is moved fore or aft, the Angle-Of-Attack(AOA) is changed.

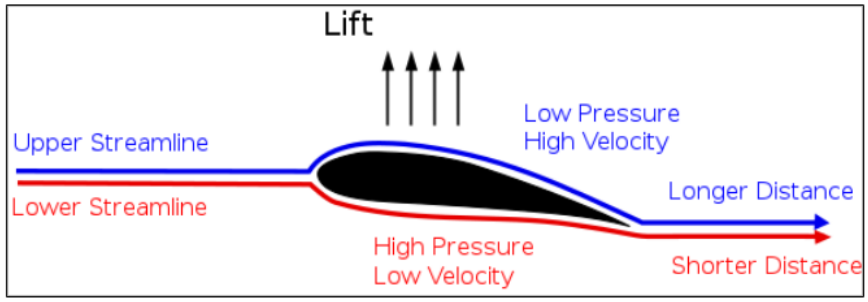

Figure 2.3 LIFT

2.2.4.1 Angle-Of-Attack

The AOA is the angular difference between the wing-chord line and direction of relative wind. *As the AOA increases, lift increases, but so does drag as well*. When the aircraft reaches the maximum AOA, lift begins to diminish rapidly. This is the critical AOA or stall.

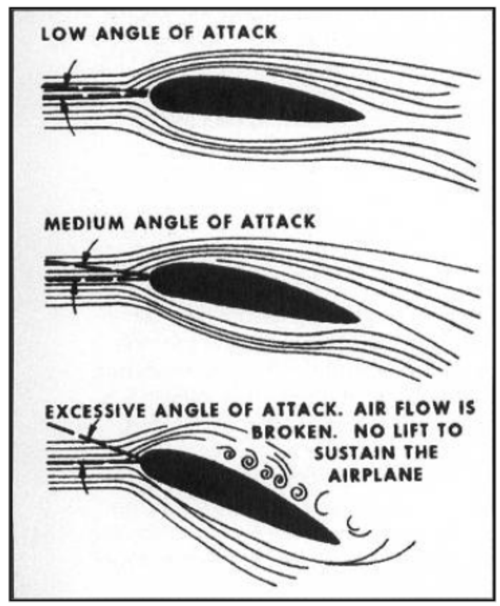

Figure 2.4 Angle-Of-Attack

2.2.4.2. Stalls

An aircraft stall results from a rapid decrease in lift caused by the separation of airflow from the wing's surface brought on by exceeding the critical AOA. A stall can occur at any pitch attitude or airspeed. Stalls are one of the most misunderstood areas of aerodynamics because pilots often believe an airfoil stops producing lift when it stalls. In a stall, the wing does not totally stop producing lift. Rather, it cannot generate adequate lift to sustain level flight, and progresses out from the trailing edge of the wing towards the leading edge. Different wing designs have different stall progressions.

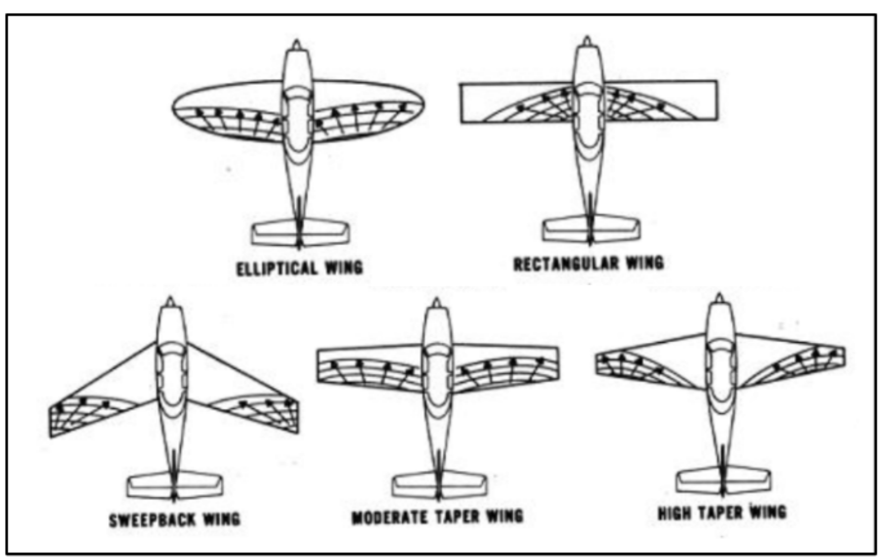

Figure 2.5 Wing Stall Patterns

2.2.4.3. Ground Effect

When an aircraft in flight comes close to the surface, ground or water, a change occurs in the three dimensional flow pattern around the aircraft because the vertical component of the airflow around the wing is restricted by the surface. Which results in *lower induced drag, and in the wing being **more** efficient while in ground effect*.

2.2.4.4. Flaps

In high performance aircraft, typically the trailing inboard portion of the main wings will drop down and change the cord of the wing. Which increases AoA without needing to increase pitch. *This allows the aircraft to be able to maintain a slower airspeed*.

2.2.4.5. Slats

Are leading edge devices that drop down and increase the camber of the wing, also generating more lift. If equipped, they are either spring loaded (T-45) or computer controlled (F-5, F-14, F-15, F-16, F/A-18).

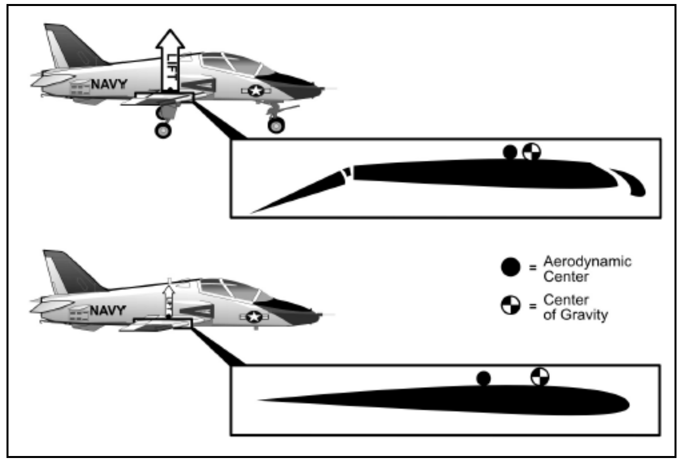

Figure 2.6 Flaps & Slats

2.2.5 Forces in Turns

If an aircraft were viewed in straight-and-level flight from the front, and if the forces acting on the aircraft could be seen, lift and weight would be apparent: two forces. If the aircraft were in a bank it would be apparent that lift did not act directly opposite to the weight, rather it now acts in the direction of the bank. A basic truth about turns is that when the aircraft banks, lift acts inward toward the center of the turn, perpendicular to the lateral axis as well as upward. *What this means for the pilot is that when you turn, you need to increase AoA (back pressure) to maintain level flight because of the loss of vertical lift*.

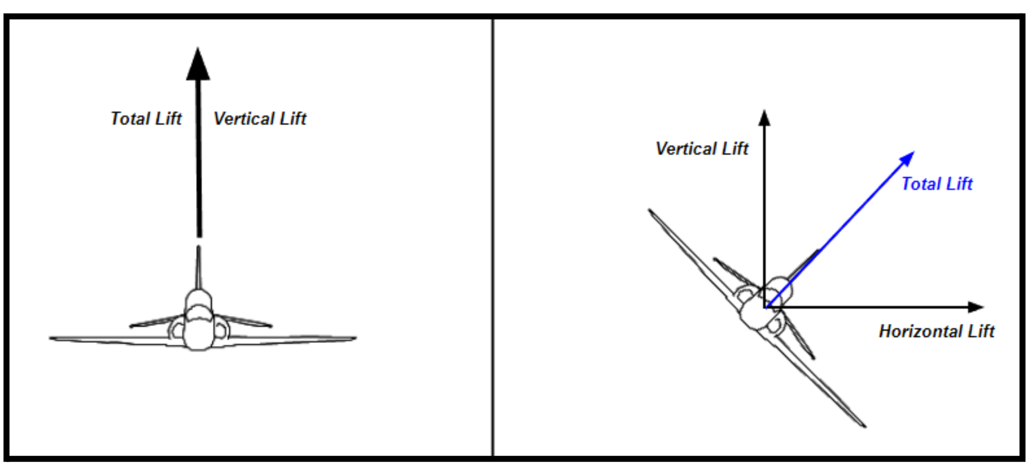

Figure 2.7 Forces During normal, coordinated turn at constant altitude

2.3. Control Axis

Each flight control affects the attitude of the aircraft by controlling movement about one of three axis. Control movements result in the same predictable aircraft responses regardless of the attitude of the aircraft. The pilot is the approximate pivot point about which all changes of attitude occur.

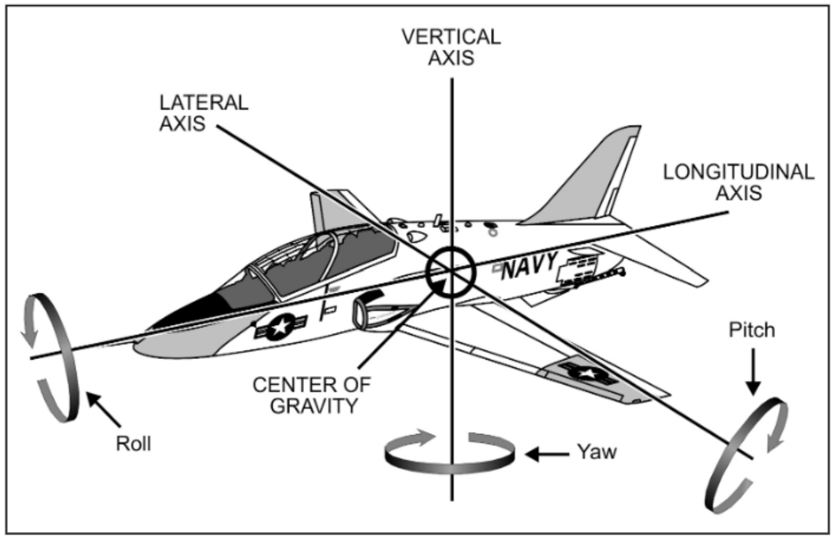

Figure 2.8 Control Axis

2.4. Aircraft Controls.

When a control surface is moved out of its streamlined position, air flowing past it exerts pressure against the control surface and tries to return it to neutral. These air forces on control surfaces are felt on the control stick and rudder pedals.

2.4.1 Yaw - Rudder.

Generally speaking, in high performance fixed-wing aircraft, the Rudder isn't really used except for 2 situations.

1) During Take-off / landing to maintain centerline

2) During High AoA situations, as the rudder has more authority than other control surfaces.

2.4.2 Pitch/Roll - Control Stick.

Smooth, Controlled inputs, is the best technique to use. Hands and arms should remain relaxed.

2.4.3 Thrust - Throttle

The throttle requires relatively little travel to change the power. A small movement of the throttle can result in a larger than desired power change. Highly recommended that you bind the throttle in a way to be able to make granular adjustments.

2.4.4 Drag - Air Brakes

Air Brakes, a.k.a Boards, are devices designed to stick out and disrupt the airflow around the airplane increasing drag, and assisting in slowing the aircraft.

2.4.5 Trim

Trim allows for direct adjustment of desired AoA on control surfaces. This is done with either Trim-Tabs or mechanically actuated surfaces (move the entire control surface). They both work with the same theory though. They set the control surfaces to maintain a particular AoA (which usually means Airspeed).

Trim-tabs are small movable surfaces attached to the primary flight control surfaces that act as levers to equalize pressure exerted on either side of the parent control surface. To equalize pressure, the rudder and elevator tabs move in opposite directions from the parent control.

Mechanically Actuated Control Surface essentially means it directly adjusts the neutral position of the entire control surface. This is the common system used for Fighter Aircraft. Usually involves a motor adjusting the ailerons or stabilator surfaces up or down, as inputted by the pilot.

To correct either fore or aft control stick pressure or to maintain a stabilized attitude, use elevator trim. To correct wing heaviness or rolling tendencies, adjust aileron trim. The aileron trim actually repositions the ailerons.

It is highly recommended that you bind these controls to a 4-way hat.

2.4.6 Wheel Brakes

In DCS World, you can bind the Wheel-Brakes to either a button (Full On or Full Off) or Axis (variable pressure) like a set of rudder pedals. Either works, but the jet does respond differently depending on which it is you are using.

2.5. Coordination of Control Inputs.

No single control movement provides all the control input necessary for a successful maneuver. The various aircraft controls must be properly orchestrated and smoothly applied for coordinated flight. Rough, erratic use of any control causes the aircraft to react accordingly. Apply control pressure smoothly and evenly.

2.6. Straight-and-level Flight.

Straight-and-level flight requires familiarity with flight instruments and visual cues. To fly in level flight, consciously fix reference points on the aircraft in relation to the horizon, and compare or cross-check this relationship with the flight instruments. In addition to outside references, refer to the electronic attitude director indicator (EADI), altimeter, and vertical speed indicator (VSI).

In modern jet aircraft that are equipped with a Heads-Up-Display (HUD), they typically have a Flight Path Marker or Total Velocity Indicator (same thing, just different names). That indicator tells you where the aircraft is going, taking into consideration airspeed, AoA, weight, etc. Put that marker on the horizon, and you are straight and level.

2.7. Turns.

Turns involve coordination of all three controls: ailerons, rudder, and elevator. A shallow turn is a turn of approximately 30 degrees bank or less. A steep turn is a turn of approximately 45-60 degrees bank or greater.

As bank increases, increase back pressure to compensate for the loss of vertical lift. In shallow turns, the increase in pitch attitude required is small. As bank increases, the increase in pitch required is more pronounced. For steep turns, a power increase is required to maintain airspeed.

Because the aircraft normally turns as long as there is bank, start the rollout before the desired heading. The aircraft continues to turn during the rollout until the wings return to the level position. The steeper the bank, the more lead is required to roll out on a desired heading.

2.8. Adverse Yaw.

Adverse yaw is the tendency of the aircraft to yaw away from the direction of aileron input. Increased lift on the up-going wing causes more induced drag, which retards forward movement of that wing. This results in the nose yawing or turning opposite the direction of the roll.

Adverse yaw is overcome by use of the rudder. As aileron pressure is applied, simultaneously apply rudder pressure in the same direction as the desired turn. Use rudder pressure as long as the bank is changing.

2.9. Coordinated and Uncoordinated Flight.

In a coordinated level turn (Figure 2.9) with constant bank and airspeed, the flight path of the aircraft is a true circle (no wind). Variation in the circular flight path is also caused by uncoordinated control (improperly trimmed rudder), erratic bank, or changes in airspeed.

A skid is caused by insufficient bank angle in relation to the turn rate of the aircraft. Excessive bottom rudder (rudder deflection to the inside of the turn) during the turn causes a skid.The turn-and-slip ball shows a slip by displacing to the outside of the turn. Skids are dangerous due to the possibility of inadvertent roll at slow airspeeds. The impending stall is known as a skidded turn stall.

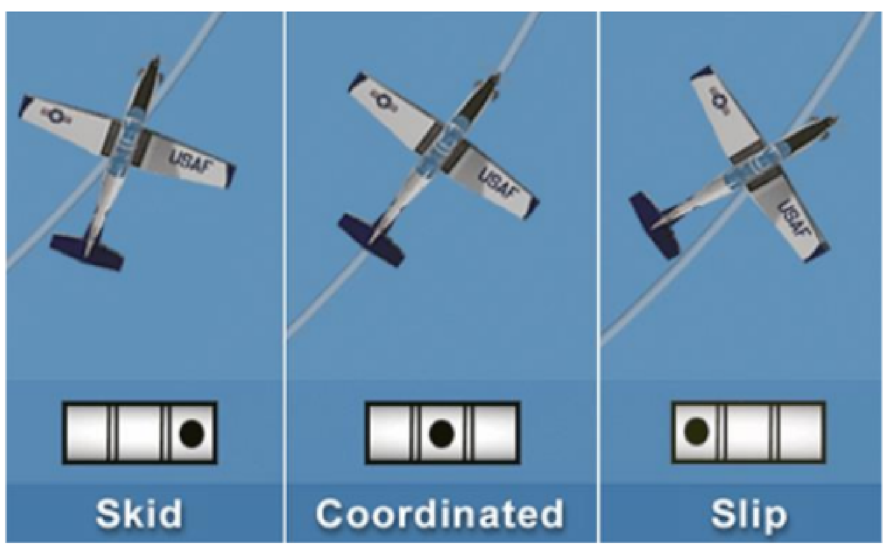

Figure 2.9 Coordinated and Uncoordinated Flight

Chapter 3 - GROUND OPERATIONS

3.1. Introduction.

Mastery of ground ops is an important first step toward mastery in the air. Once you leave the ground the workload and ability to concentrate on a single task becomes exponentially harder.

3.2. Radio Procedures.

If available, monitor Air Terminal Information System (ATIS) before taxi. Include ATIS identifier in taxi call to tower/traffic,

“Texan 11, taxi with Charlie.”

Listen carefully to taxi instructions. Read back the ATC clearance as required locally. In general, read back instructions if they appear to be different than standard or appear unusual.

3.3. Taxi.

When the before-taxi checklist is complete, clear to the front and rear. Before leaving the parking area, clear for taxiing aircraft. Use caution for personnel, ground equipment, foreign objects, and sun shelters. Select nose wheel steering (NWS), release brakes, and increase power as necessary. If a sharper turn is required, press and hold the NWS button, this activates the HI gain NWS mode, and/or use the inside brake to turn. Check the brakes. When parked under sun shelters, slowly pull out from the shelter before checking brakes. Normally, the taxi checklist including NWS, brakes, and heading, turn, or slip indicators is completed on the first turn out of parking. Taxi no faster than 5-7 knots or a fast walk in congested areas, and always be prepared to stop.

Use power to keep the aircraft rolling at a moderate speed. Once the aircraft is rolling, idle power should provide sufficient thrust. Use the brakes as necessary to control taxi speed; however, do not ride the brakes. Normal taxi speed should not exceed 15 knots. NWS is more sensitive as taxi speed is increased.

Always Taxi on Centerline, unless in a staggered taxi, which will be covered in a later chapter. As a visual cue, align the flight path marker on top of the centerline of the taxiway and ensure it is straight down the center of the Heads-Up Display.

3.4. Before Takeoff and Lineup Checks.

In addition to normal checklist items, it is a common technique to scan the cockpit to check various items such as switch positions, systems indications, security of in-flight pubs, etc.

3.5. After Landing.

Do not begin the after landing checklist until reaching normal taxi speed and clear of the active runway. Obtain clearance before crossing active runways and (or) proceeding back to the ramp. Stay alert and taxi with caution. Do not get complacent, the sortie is not complete until the aircraft is parked, the engine is shut down, and all required checklist items are complete.

3.6. Full Stop and (or) Taxi Back.

More than one full-stop landing may be accomplished during a training sortie to achieve training objectives. Anticipate a longer than normal landing roll due to higher fuel weight. Complete the full stop/taxi back checklist.

Chapter 4 - TAKEOFF, CLIMB-OUT, AND LEVEL OFF

4.1. Introduction.

This phase of flight is very dynamic and can be as complicated as any other part of the mission. Complex departure procedures may be required immediately after takeoff in the low altitude environment, and communications can be very busy leaving the terminal area. Emergency situations, when they occur in this phase of flight, require forethought and quick correct action. Solid preparation is essential to success.

4.2. Lineup Check.

Objective. Accomplish checklist items in preparation for takeoff.

Description. This check is normally accomplished while taxiing onto the active runway. The PF must ensure that all items are complete and "BOTH" items are confirmed with the PNF.

Procedure. Clear final prior to crossing the runway hold-short line and accomplish the lineup check.

Technique. A common technique to remember the checklist steps is the acronym **TP- PLAN**:

T — Trim. Set trim to T/O (if applicable).

P — Panel. Caution and Warning panel shows normal lights.

P — Probes. Turn on the anti-ice probes. E.g. Pitot Heat

L — Lights. Ensure all exterior lights are on.

A — ALT. Select the ALT mode on the transponder.

N — NWS. Deselect (NWS)Nose Wheel Steering after the aircraft is aligned with the runway.

4.3. Takeoff

4.3.1 Normal

Two normal takeoff options exist: static and rolling. The static takeoff is used early in training because it provides more time to accomplish required checks and verify proper engine operation. A static takeoff is also required at night and for solo students. A rolling takeoff aids traffic flow in a busy pattern and is a smooth transition from taxi to takeoff roll. Rolling takeoffs have a negligible effect on TOLD and no recalculation is required.

- ***Airspeed*** – 110 KIAS (A-29B). Add one-half the gust up to a maximum of 10 knots with gusty winds.
  125 KIAS (T-45C)
- ***Power*** – MAX.
- ***Pitch*** – 10-12 degrees nose high at rotation.

Static Takeoff. Stop when the aircraft is aligned with the runway and the nose wheel is centered. Pump up the brakes to prevent creep during engine run-up. Clear down the runway and advance the throttle to 80% RPM. Cross-check outside to detect creep and check engine instruments. Release brakes to begin the takeoff roll and smoothly advance throttle to MIL. Check engine instruments when stabilized at maximum power (approximately 3 seconds after throttle reaches MIL) to ensure proper operation.

Rolling Takeoff. Once the aircraft is aligned with the runway and the nose wheel is centered, disengage NWS and smoothly advance the throttle to MIL. Check engine instruments when stabilized at maximum power (approximately 3 seconds after throttle reaches MIL) to ensure proper operation.

Takeoff Roll. Position the elevator approximately neutral to prevent the nose gear from digging in during takeoff roll. Use rudder for directional control throughout the takeoff roll. The flight controls become more effective as airspeed increases, so progressively smaller control inputs are required to maintain aircraft control. At rotation speed, smoothly apply back stick pressure to establish the takeoff attitude (10-12 degrees nose high). Rotation speed is 120 knots.

Wake Turbulence. Anticipate wake turbulence when taking off behind other aircraft on the same or parallel runways, especially if the wind is calm or straight down the runway. Wake turbulence is formed when an aircraft is creating lift, therefore plan to take off at a point prior to the preceding aircraft's takeoff point or after their point of touchdown. The T-45 is very susceptible to rolling motion if within a preceding aircraft's wake turbulence.

4.3.2 Crosswind Procedures

Takeoff. The procedures for a takeoff with a crosswind are the same as for a no-wind takeoff except the aileron is held into the wind to keep the wings level. Aileron deflection is necessary because the upwind wing develops more lift, causing it to fly (begin rising) before the downwind wing. If the upwind wing rises, skipping may result. Skipping is a series of very small bounces caused when the aircraft attempts to fly on one wing and settles back onto the runway. During these bounces, the aircraft moves sideways and increases stress on the landing gear. Anticipate aileron requirement due to the crosswind and either pre-position aileron into the wind or apply aileron into wind as required during takeoff roll. Use rudder to keep the aircraft from weather-vaning (for example, crabbing or turning into the wind).

Climb out. Control inputs change significantly as the aircraft leaves the ground. Crosswind controls must be released after takeoff, as the aircraft is allowed to crab into the wind, to prevent the upwind wing from dipping toward the ground. Rudder requirements change as the wheels leave the ground, airspeed increases, and the aircraft crabs into the wind. Climb in coordinated flight and maintain runway alignment on takeoff leg.

Figure 4.1 Crabbing into Crosswind after Takeoff

4.4. Climb-out.

During this phase the FP wants to put the aircraft in a stabilized climb attitude to climb up to the determined cruising altitude.

Description.

- ***Airspeed*** – Accelerate to climb airspeed 250-280 KIAS minimum
- ***Power*** – As required, normally 85-90%.
- ***Pitch*** – As required to fly desired airspeed (normally 5 -15 degrees)

Procedures. Pilots are not required to make a significant pitch change in order to achieve standard climb speeds when conducting intermediate/small altitude changes (approximately 1000-2000 feet) as this normally leads to an abrupt level off. Initiate the climb check according to the flight manual passing 10,000 feet MSL.

Straight Climb from Level Flight. Adjust throttle and allow the aircraft pitch to increase. If above the desired climb speed, initially set the pitch to achieve the desired airspeed. After reaching the desired airspeed, lower the nose to keep airspeed constant as altitude increases. Make all pitch changes using outside references when available. Maintain heading by using section lines, a prominent point or object near the horizon, or other outside references, cross-checked with the heading on the EHSI. Maintain wings level attitude by outside references cross-checked with the attitude indicator. Trim after power is set and the climbing attitude is established.

<u>Trimming is a continuous process throughout all phases of flight.</u>

Climbing Turns. If standard bank angles are not required to comply with published routings, use shallow-banked turns to maintain a higher rate of climb. Trim used in the turn must be taken out during the rollout.

4.5 Level off.

Start the level off at a lead point that allows a smooth transition to the desired level-off altitude. The standard method to achieve a smooth level off is to use a lead point that is approximately 10 percent of the VSI. For example, if climbing at a rate of 2,000 fpm, start the level off 200 feet below the desired altitude. At the lead point, smoothly lower the nose of the aircraft to level flight. Approaching the desired airspeed, adjust the throttle to obtain the desired airspeed and trim the aircraft.

Chapter 5 - TRAFFIC PATTERNS AND LANDINGS

5.1. Introduction.

In any traffic pattern, the runway is the primary visual reference. Each airfield has specific procedures designed to help prevent conflicts, assign traffic priority, and maximize training. Base-specific traffic pattern diagrams and ground references are contained in the local in-flight guide. In this chapter we will go over the most common visual traffic procedures used in both controlled (with live ATC) and uncontrolled (No ATC) airfields. These are used during what is known as Visual Meteorological Conditions.

5.2. Letdown and Traffic Entry.

In this phase you will descend from cruising altitude and begin planning on how to enter the traffic pattern. Depending on the traffic pattern you will be using or directed to use, This may need to be adjusted. E.g. Standard pattern entry will need to be approx 225 kts IAS, or for OHB pattern you will need to maintain 300 kts IAS until the entry. In busy environments, detailed procedures are used for traffic sequencing and deconfliction. Strive to make all radio calls at the proper location. However, if deviations occur, always report your actual location.

Airspeed - 300 Kts, or according to local directives.

Power - As required.

Speed brake - As required.

Pitch - As required to meet altitude restrictions.

Procedures. - Comply with published or ATC directed routing. Monitor ATIS, if available. Clearing turns during a visual meteorological conditions (VMC) letdown can improve clearing, control rate of descent and appropriately place a dedicated focus on outside visual references.

Before the traffic pattern entry point, use the **GUTS** check:

G — GPS - Select useful waypoint and omni-bearing selector (OBS) to runway heading.

U — UHF/VHF - Set to proper frequencies.

T — Trim - Set to range that aids clearing.

S — Squawk appropriate code. (not necessary in DCS)

5.3. Aircraft Configuration.

Three configurations are used in the T-45.

- Full Flaps / Gear Down - Typical for Full Stop Landings, Touch & Go’s, CV Ops
- Half Flaps / Gear Down - Typical for Cross-Wind Landings, and T/O.
- No Flaps / Gear Down

On-Speed/On-AoA - In high performance aircraft the exact landing speed fluctuates quite a bit depending on various factors, e.g. temp, pressure, GW, crosswind, elevation, etc. But, AoA parameters do not change, so in high performance aircraft they have AoA indicators and/or indexers. Figure 5.1 depicts a typical AoA indexer, in the T-45 located to the immediate left of the HUD. When the gear is extended, the HUD will display an AoA “E-Bracket”, figure 5.2. By flying the FPM/TVV into the center of the bracket will place you on the target AoA for landing.

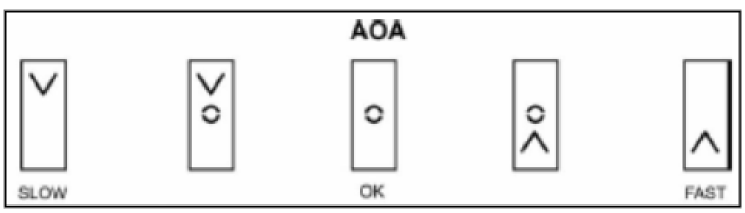

Figure 5.1 AoA Indexer

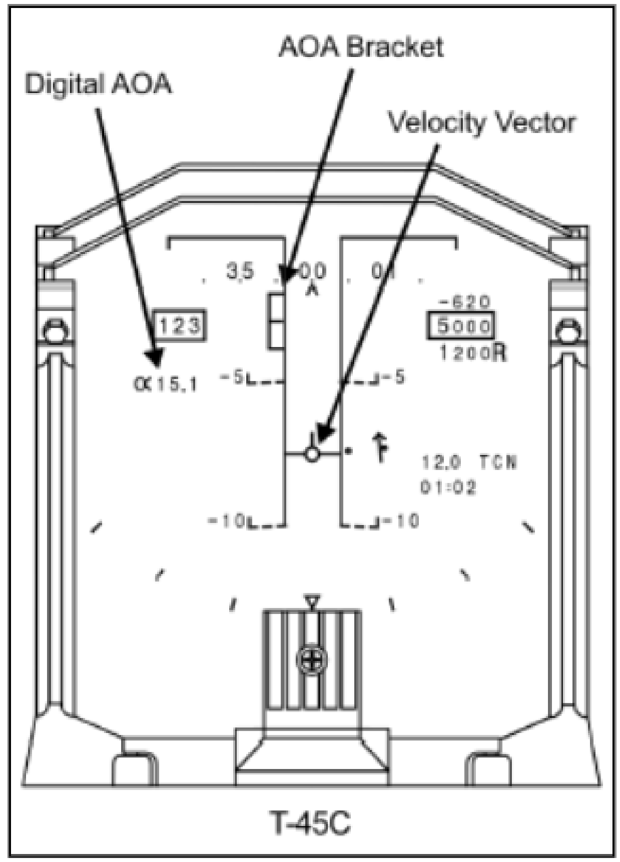

Figure 5.2 AoA Indicators in HUD

5.4. Traffic Patterns.

There are 3 standard type patterns for visual landings that are used in aviation. The Straight-In, Normal Landing Pattern & the Overhead pattern, or more commonly known as the Overhead Break. By using these standard patterns we can easily cycle aircraft in and around airfields. The Straight in Approach essentially places you on an extended Final. The only difference between the normal and overhead patterns is the initial entry to the pattern. Once established in the pattern, the procedure is otherwise identical.

5.4.1 Straight-in Approach.

Visual maneuver that aligns the aircraft with the runway for a constant speed, constant rate descent and landing. Typically used for emergency or urgent situations, e.g. Low Fuel, Control or Mechanical Issues.

Procedure.

- Request straight-in approach according to local directives.
- Descend to 1,500 feet AGL before the 5-mile DME
- Configure aircraft prior to 3-mile point.
- Be On-speed/On-AoA prior to descending on glidepath

Technique.

- With or without flaps, begin the descent when the threshold of the runway (aim point) is in the lower one-third of the windscreen. For flaps UP, begin the descent when the spinner reaches the threshold (aim point).
- Begin descent when you see the runway threshold at approx 3-4 degree below the horizon on the HUD.
- Use straight-in to practice transition from crab to wing-low crosswind controls. A longer final affords more time to practice multiple transitions.

5.4.2 Normal Pattern

Normal Landing patterns is what typically used all civilian type airfields. Entries into a normal pattern are usually through a:

- 45 Entry to Downwind, while not flying directly over the airfield.
- Direct to Downwind
- Crosswind

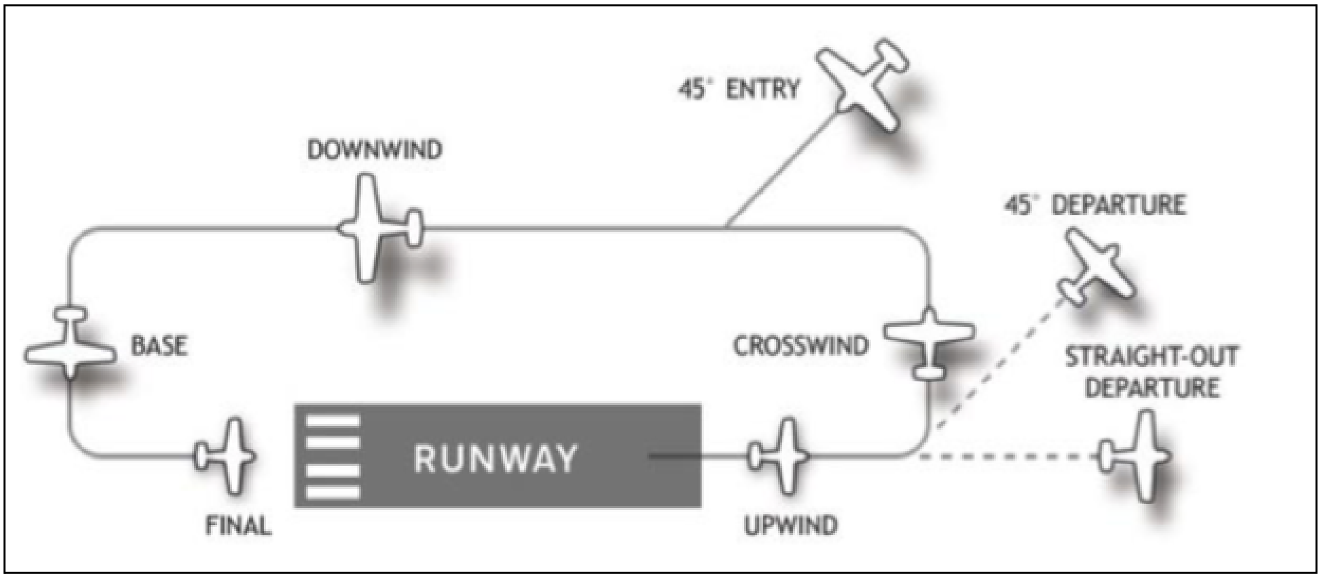

Figure 5.3. Normal Traffic Pattern.

Initial / Entry.

Objective. Align aircraft with landing runway.

Description.

Airspeed - 225 KIAS +/- 20 Kts

Power – As needed.

Pitch - As required for level flight.

Altitude –1,500 feet AGL or according to local directives.

5.4.3 Overhead Pattern

The 360-degree overhead pattern is used to safely accommodate a maximum Dash-of aircraft with minimum congestion. This is the most commonly used pattern in DCS simply because it is FUN to do. . See Figure 5.4 depicting an overhead pattern. You enter into the pattern from an initial point in line with the intended landing runway, and at the "break" conduct a hard turn to burn off energy/airspeed and arrive in downwind at the appropriate pattern airspeed.

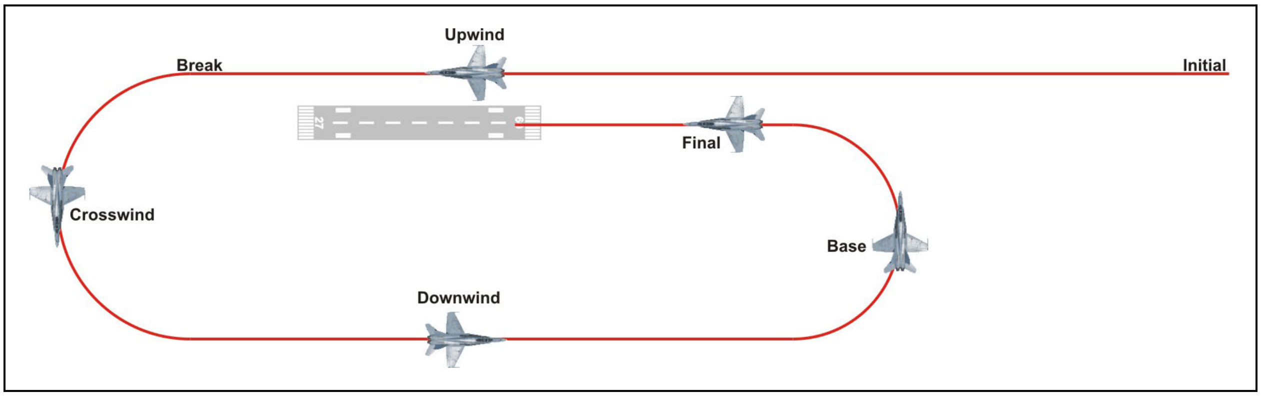

Figure 5.4. Overhead Traffic Pattern.

Initial / Entry.

Objective. Align aircraft with landing runway.

Description.

Airspeed – 225 KIAS +/- 20 Kts

Power – As needed.

Pitch – As required for level flight.

Altitude –1,500 feet AGL or according to local directives.

Break.

Objective. Transition from initial to downwind.

Description. 180 degrees level decelerating turn.

Bank Angle – 60°-70° bank

G-Pull – 3 -4 G's

Airspeed – Decrease to On-Speed/On-AoA

Power – 60% RPM

Pitch – As required for level flight.

Altitude –1,500 feet AGL or according to local directives.

5.5 Airfield Traffic Pattern.

5.5.1 Downwind.

Maintain proper spacing and a ground track parallel to the runway. Apply drift correction and offset inside/closed downwind ground track into the wind to account for the effects of wind on the final turn. *Arrive at base turn point at On-Speed/On-AoA, properly configured, and ready to perform the turn to base.*

Description.

Airspeed – On-Speed/On-AoA

Power – As needed.

Pitch – As required for level flight.

Altitude –1,500 feet AGL or according to local directives.

Figure 5.5. Downwind Visual Cue

Technique. - Upon arrival on inside downwind:

- *Visual Marker*: At the pattern altitude your wingtip should be on top of the Runway
- Begin configuring aircraft, a commonly applied technique is the mnemonics: GGUFS

  G - Gas - Confirm Fuel State

  G - Gear - Down

  U - Undercarriage - 3-Green

  F - Flaps - Down

  S - Speed - On-Speed / On-AoA

- Notify Traffic you are in the downwind using standard comm format and direction of your turns. A good practice is to also verbalize gear position, and intention

Kutasi Traffic, Talon 1-1, Left Downwind, gear down, 3 green, full stop

5.5.2 Base and Final Turn.

Use a descending 180-degree turn to align aircraft with the runway. The final turn is complete when wings level on final.

Description. For a no-wind pattern, the desired base point occurs when the runway threshold is approximately 45 degrees off your shoulder

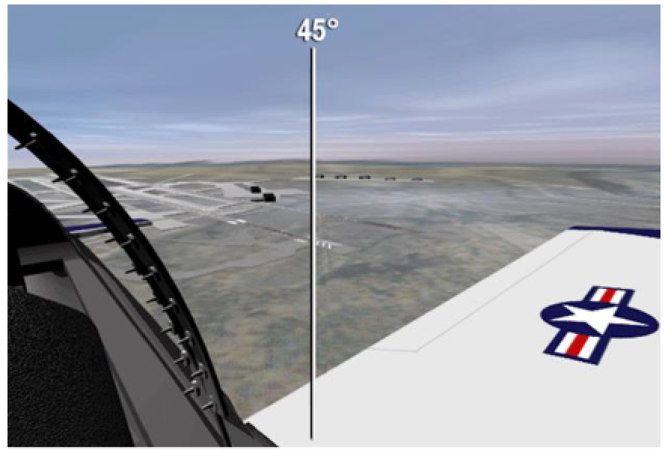

Figure 5.6 Perch Point Reference.

Procedure.

Airspeed – On-Speed/On-AoA

Power – As needed.

Pitch – As required for 3-5° descent.

Altitude –Descending.

Technique.

- *Base Visual Cues* - Touchdown point should be approx. 45 degree behind you, roughly 7-8 o'clock position
- Confirm aircraft configuration prior to the turn - GGUFS
- Start the final turn by adjusting power, lowering the nose, and rolling into 30 degrees of bank. If greater than 45 degrees of bank is required to complete the final turn, go-around is recommended.
- Clear visually and with the radios. Announce you are turning to base

Kutasi Traffic, Talon 1-1, Left Base, gear down, 3 green, Full stop

- Do not start the final turn if conflicts exist or if potential conflicts are not in sight. Break out from downwind (pattern status permitting) using local procedures if:
  - Another aircraft in the final turn is not in sight.
  - A straight in is inside 2 miles and not in sight.
  - Pattern spacing cannot be maintained within the normal ground track.
- Roll out on an extended runway centerline, approximately one-half to three-quarters of a mile from the runway on a 3-to 4-degree glide path.
- If any doubt exists about the safety of continuing the approach, go around. Do not hesitate to disregard the ground track and use traffic pattern stall recovery procedures if required.

5.5.3 Final.

Final provides the opportunity to stabilize airspeed and glide path before entering the landing phase. Stable airspeed, proper glide path, and a fixed aim point provide the consistency required for successful landing.

Objective. Maintain runway alignment, proper glide path, and correct airspeed.

Description. Final begins when wings level after the final turn and ends when the flare begins.

Procedure.

Airspeed – On-Speed/On-AoA

Power – As needed.

Pitch – As required for 3-5° descent.

Altitude –Descending.

Technique

- Maintain proper spacing with preceding aircraft. If spacing is insufficient, go around. After rolling out on final, initially use crab to maintain runway alignment.
- The aim point is usually about 500 feet short of the intended touchdown point and is usually the runway threshold but could vary based on headwinds.

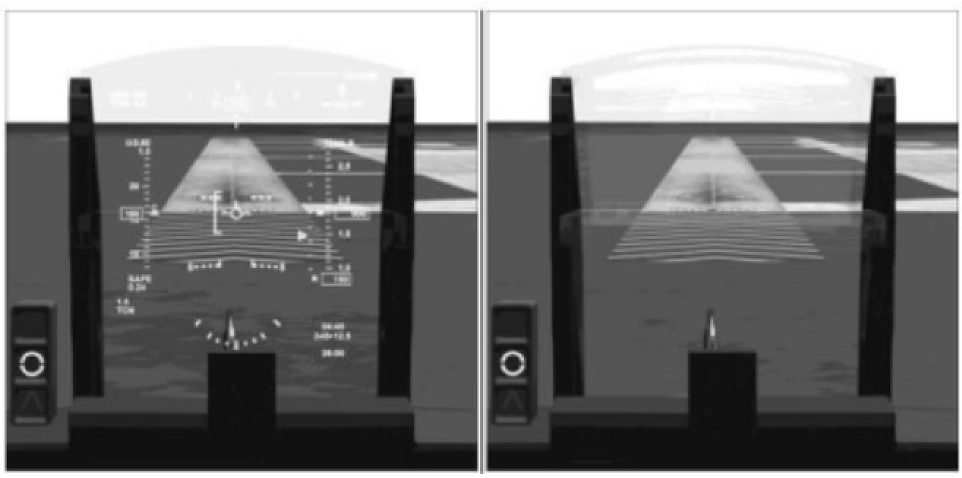

Figure 5.7 Short Final HUD Point-of-View

- Use a cross-check of aim point, FPM/TVI, AoA to focus attention on the most critical items. Visualize a constant glide path to the aim point.
- Be alert & stop excessive sink rates power early.

Crosswind Procedures

- *Crabbing* allows the aircraft to maintain runway/ground track alignment by weather-vaning into the wind. The amount of crab required on final indicates the amount of control deflection needed to transition to the wing-low method. *Do not land the aircraft with crab*.

5.6 Landing/Touchdown.

The landing is divided into three phases: (1) roundout, (2) flare and touchdown, (3) landing roll. Each of these phases serves as a transition from the previous phase to the next. The roundout serves as the transition from final to the flare. The flare is used to reduce energy in the transition from final to touchdown. The landing roll serves as the transition from landing to taxi. Groundspeed is reduced straight ahead on the runway until at safe taxi speed.

5.6.1 Normal Touchdown Process

Roundout. Use slight backstick pressure to reduce descent rate to a near horizontal flight path. Start a smooth power reduction to Idle, to slow from final approach speed to touchdown speed. Good visual cue in the HUD is to move FPM/TVI from touchdown point to further down the runway.

Flare and Touchdown. In the flare, back stick pressure is held allowing the energy to naturally decrease while letting the aircraft gently settle down to touchdown. The aircraft will be in a slight descent or level flight depending on altitude, airspeed, power setting, and rate of deceleration. Maintain the FPM/TVI on the far side of the runway.

- Use caution to avoid excess back stick which could lead to a climb in the flare.
- As the nose rises, forward visibility is reduced and peripheral vision becomes the key factor in height and drift assessment. Hold back stick pressure to maintain the pitch attitude, as descent rate and airspeed decrease, the aircraft gently settles onto the runway.
- Ensure throttle is idle at touchdown.
- In the flare, power can compensate for errors in judgment. Faster or slower power reductions can compensate for errors made in the roundout and early flare. Apply power and go-around any time control effectiveness is lost, the aircraft experiences an approach-to-stall indication during a high flare, balloon, or at any phase of the roundout or flare where the aircraft is not in a position to safely touchdown.
- Go around if an excessively long touchdown will occur.
- Ensure feet are not on brakes when aircraft touches down.

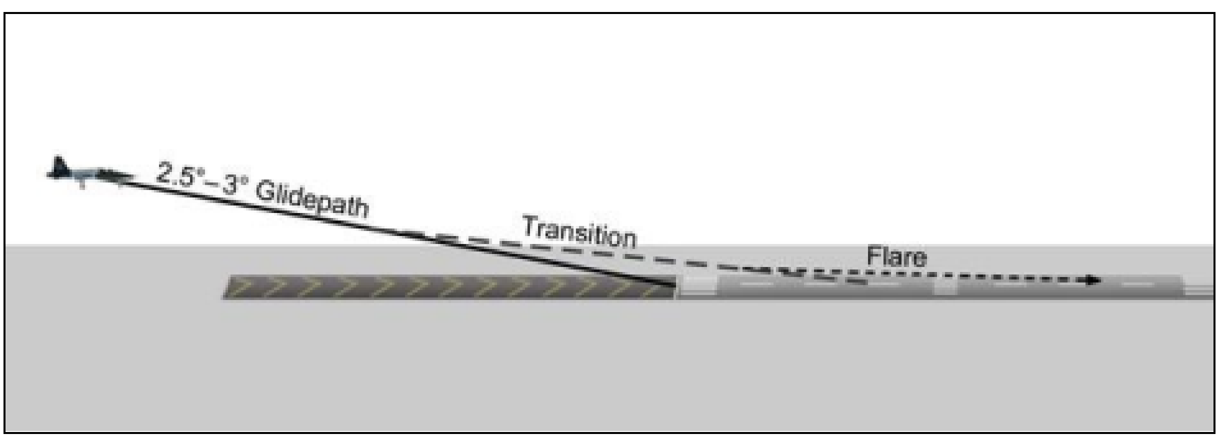

Figure 5.8 Final Approach Glidepath

Landing Roll. After touchdown and below approximately 90 KIAS on a full stop landing, slowly relax back stick pressure to smoothly lower the nose gear to the runway. Avoid banging the nose gear.

With the nose gear on the runway smoothly apply brakes and increase back stick pressure. This increases weight on the main gear and helps prevent the nose gear from digging in, however, do not allow the nose gear to lift off the runway. Continually increase back stick and brake pressure as the aircraft decelerates. Always brake in a straight line; do not turn and brake. Maintain directional control with rudder. Use caution to avoid over controlling when applying brakes.

Select NWS when the aircraft is below 60 KIAS and the rudder pedals are centered. Center rudder pedals before selecting NWS. At higher speeds, NWS is extremely sensitive and should only be used if directional control cannot be maintained with rudder and brakes. Intercept taxi line to transition from the runway to the taxiway.

Landing Considerations with Crosswinds. Introduce crosswind controls (wing-low) as required on short final. This requires rudder deflection to align the nose of the aircraft with the runway and aileron deflection into the wind to stop drift. Crosswind controls increase drag, rate of deceleration, and stall speed. A small addition of power is necessary to counter these effects.

If power is used during the flare, retard the throttle to idle at touchdown. Crosswind controls must be held through touchdown and landing roll to prevent the upwind wing from rising and the aircraft from skipping. With significant crosswinds, expect one main gear to touchdown before the other.

When introducing crosswind controls (wing-low), a common memory aid is the acronym **RAP**:

R - Rudder to align the nose with the runway.

A - Aileron into the wind to prevent drift.

P - Power to counteract increased drag (uncoordinated flight).

5.6.2 Touch-and-go landing.

Touch-and-Go's are a training procedure used to get in multiple landings and take-offs in a single sortie. Very useful for building time and experience in the landing pattern and take-off's and landings.

Description. Normal landing immediately followed by normal takeoff. After touchdown, power is advanced to MIL to execute takeoff.

Procedure - Accomplish a normal landing. As main gear touchdown, smoothly apply power to MIL. As the throttle is advanced, slightly lower the nose to attain the takeoff pitch picture, but maintain sufficient back stick pressure to keep the nose gear off the runway. Do not pull the aircraft off the runway below normal takeoff speed.

Maintain desired ground track throughout touchdown and takeoff roll. If necessary use Crosswind control techniques

The elevator trim required for final and landing may cause premature lift-off as power is applied. Anticipate this and control accordingly. Trim as necessary to alleviate the pressure.

5.7. Go-around.

A go-around is termination of an approach after the aircraft is configured. Do not delay the decision and do not try to salvage a bad approach. There is no shame in executing a go-around, for a bad pattern. Better to execute a go around, then to crash and end up with a new (unwanted) callsign.

Procedure

- Apply MIL Power
- Climb to Pattern Altitude (1,500 ft AGL)
- Continue Normal Visual Landing Pattern back to downwind
- Execute normal landing pattern procedures

5.8 Common Irregularities in Approach Patterns.

Depending on nature and magnitude of irregularity and aircraft flight parameters, correction and continued final approach may be possible. However, a go-around is always acceptable.

5.8.1 Low (Drug-in) Final.

Aircraft below the proper glide path.

Causes.

- Early descent on straight-in approach.
- Long base coupled with normal pitch and descent rate.
- Excessive altitude loss from diving final turn.
- Failure to maintain proper glide path.

Effects

Normal power settings are too low to maintain airspeed on a shallower glide path. Airspeed and (or) altitude may decrease.

Recovery.

- Add power, level off, and intercept the proper glide path.
- If too low or slow, go around. Avoid obstacles.

5.8.2 Steep Final.

Aircraft above proper glide path:

Causes.

- Too close to the runway on the inside downwind.
- Early turn to base.
- Level final turn.

Effects.

- High descent rate with low power setting.
- Low power setting, coupled with the pitch change required to intercept normal glide path, could result in rapid decrease in airspeed and high sink rate. Possibly resulting in a HARD touchdown.

Recovery.

- Go around if the sink rate is too high or if it is not practical to intercept normal glide-path with a normal descent rate.
- Use slightly higher than normal descent rates as soon as deviation is recognized.
- Use power as required to control airspeed in descent and maintain airspeed when on normal glide path.

5.8.3 Slow Final.

Increased pitch attitude is required to maintain lift as airspeed is reduced.

Cause.

Improper glide path and /or power setting.

Effects.

- Higher than normal pitch attitude.
- Inaccurate perception of the proper glide path.
- Increased AOA and increased likelihood of stall, especially in gusty wind conditions.

Recovery.

- Apply power at an altitude high enough to reestablish the correct airspeed and attitude.
- If altitude is insufficient, go-around.
- Correct aim point and glide path to reestablish proper airspeed.

5.9 Common Irregularities in Landing.

5.9.1 High Flare.

Cause. Roundout performed too early or with excessive pitch up.

Effects

- Airspeed decay and or hard, long landing.
- Possible premature touchdown of nose gear caused by abrupt pitch down to compensate for high flare.
- Stall if flare continued with excess altitude.
- Hard landing due to high sink rates as airspeed decreases at higher than normal altitude.

Recovery.

- With adequate airspeed and runway remaining, release a small amount of back pressure to increase descent rate.
- As aircraft approaches normal altitude, increase back pressure to reestablish normal flare.
- If in a landing attitude and excess altitude would require an end swap to land, do not attempt landing, and initiate a go-around.
- Remember, as landing attitude is attained, the aircraft is rapidly approaching a stall and there is insufficient margin of error for radical pitch changes in the flare.

5.9.2 Late and Rapid Roundout.

Cause. Higher than expected descent rate or misjudged altitude.

Effects.

- Possible incomplete flare, ballooned flare, hard touchdown.
- Firm touchdown due to higher than normal descent rates or insufficient time to complete flare.
- Abrupt roundout to prevent premature or firm touchdown may lead to an accelerated stall. This is a dangerous situation that may cause an extremely hard landing and damage to the main gear.

Recovery.

- Immediately position the controls to attain the takeoff attitude and simultaneously advance the throttle to MIL, to initiate a go-around.
- The main gear may contact the ground a second time, but if recovered properly, the second contact is usually moderate.

5.9.3 Porpoising.

Cause. Incorrect landing attitude and airspeed. At touchdown, the nose gear contacts the runway before the main gear.

Effects. The aircraft bounces back and forth between the nose gear and main gear. Repeated heavy impacts on the runway ultimately cause structural damage to the landing gear and airframe.

Recovery.

- Immediately position the controls to the takeoff attitude to prevent the nose wheel from contacting the runway, simultaneously advance the throttle to MIL, and initiate a go-around.
- Do not try to counteract each bounce with opposite control stick movement, this will aggravate the porpoise.
- Hold the controls in the recovery position to dampen the oscillations. Power increases control effectiveness by increasing airspeed.
    - Do not raise the landing gear after a porpoise.

5.9.4 Floating.

Cause. Late power reduction, excessive airspeed, or improper flap setting.

Effects. Long landing. Possible balloon or bounce.

Recovery. Dependent on magnitude of float and runway remaining.

- For a slight float, airspeed permitting, gradually increase pitch attitude as airspeed decreases and landing speed is approached.
- Avoid prolonged floating, especially in strong crosswinds. If a long landing is inevitable, initiate a go-around.

5.9.5 Ballooning.

Cause. Rapid roundout or flare. Raising the nose to the landing attitude before lift has decreased sufficiently.

Effects. Altitude gain (dependent on airspeed and pitch rate).

Recovery.

- Landing may be completed from a slight balloon. Hold the landing attitude as the aircraft settles to the runway. Maintain wing-low crosswind controls through the balloon and landing.
- Go-around from a pronounced balloon. Do not attempt to salvage the landing.

5.9.6 Bouncing.

Causes.

- Firm or hard touchdown causes aircraft to bounce off the runway.
- Contact with ground before landing attitude is attained.
- Late recognition that aircraft is settling too fast, combined with excessive back stick pressure.

Effects. Height reached depends on the force with which the aircraft strikes the runway, the amount of back stick pressure held, and the speed at touchdown.

Recovery. Same as a balloon, depending on severity of bounce.

Slight Bounce.

Continue the landing. Maintain direction with wing-low crosswind controls and smoothly adjust pitch to the landing attitude just before touchdown.

Severe Bounce *(Aircraft Rising Rapidly).*

- Do not attempt a landing from a significant bounce, go-around immediately.
- Simultaneously apply MAX power, maintain direction, and lower nose to a safe pitch attitude.
- Continue go-around even if another bounce occurs.
- Leave the landing gear extended if a hard landing is encountered.

Bouncing in Crosswinds.

Use extreme caution. When one wheel strikes the runway, the other wheel touches down immediately after. The crosswind correction is lost and the aircraft drifts. Reestablish crosswind controls to stop the drift and either continue the landing or go-around, depending on the situation.

5.9.7 Landing in a Drift or Crab.

Aircraft contacts the runway in a crab or drifting sideways. Throughout final, flare, and touchdown, in a crosswind, the aircraft should track in a straight line down the runway. With wing-low crosswind controls, align the fuselage with the runway. Insufficient wing-low crosswind controls result in landing with a drift, in a crab, or a combination of both.

Cause. Failure to apply sufficient wing-low crosswind corrections.

Effects. Excessive side loads on landing gear, potential gear damage.

Recovery. Go-around if unable to apply proper crosswind controls before touchdown.

5.9.8 Wing Rising After Touchdown.

Cause. Lift differential combined with rolling moment. During crosswind landing, air flow is greater on the upwind wing because the fuselage reduces air flow over the downwind wing. This causes a lift differential. The wind also strikes the fuselage on the upwind side, and this causes a rolling moment about the longitudinal axis which may further assist in raising the upwind wing. When effects of these two factors are great enough, one wing may rise even though directional control is maintained.

Effect. Depending on the amount of crosswind and degree of corrective action, directional control could be lost. If no correction is applied, one wing can raise enough to cause the other wing to strike the ground.

Recovery. Use ailerons to keep the wings level. Use rudder and (or) asymmetric braking to maintain directional control. Aileron is more effective if applied immediately. As the wing rises, the effect increases as more wing area is exposed to the crosswind.

Chapter 6 - CONTACT

6.1. Introduction.

Contact flying develops the skills and techniques necessary for success in every other type of flying. The use of outside references emphasizes the composite cross-check. Basic skills, such as checklist use, systems operation, and task management are introduced and developed in preparation for more complex sorties. The basic maneuvers learned and practiced in contact are the basis for all other flying. Furthermore, understanding the difference between approach to stall conditions and a full aerodynamic stall increases safety—both in the traffic pattern and during area work. Instrument training in the aircraft is only accomplished after the basics of flight are learned in the contact phase. Energy awareness, position awareness, and overall SA developed in three dimensional contact maneuvering are universally applicable. mThese maneuvers are the basis of any familiarization flight when learning a new airframe. These maneuvers will allow you to learn the handling characteristics of any new airframe.

6.2. Checks.

Accomplish appropriate checks before performing maneuvers. Checks are not required between individual maneuvers, but verification is a good practice.

FENCE Check - Tactically, a FENCE check is typically performed when entering or exiting a hostile area. It ensures aircraft systems are set for combat. To instill an easily transferable habit pattern, during training, a FENCE check should be performed when entering the training area and again when the training is complete. FENCE in the T-45/A-29 would be:

- ***F*** Fuel - Check balance, total, NORM feed, Set Bingo
- ***E*** Emitters - Use the acronym TRAIL
    - ***T*** TACAN. Check operation. Set as briefed.
    - ***R*** Radar. Not applicable with the A29 or T45 in DCS since neither has a radar modeled
    - ***A*** ALQ & ALR. Set RWR as required.
    - ***I*** IFF. Set modes, codes, and Auto/Man as required.
    - ***L*** Lights. As desired
- ***N*** Navigation - INS check/verify steerpoints.
- ***C*** Chaff and flares - ARM and check operation airborne.
- ***E*** Employment - Recheck SMS programming. Check arming options to include weapon, fuze arming option, release pulses, spacing, and delivery modes. Ensure Master Arm is set as required, HUD has correct symbology, proper arm indication, and SOI in proper place. Confirm TGP laser code is set IAW mission requirements and Arm as required.

6.3. Energy Management.

THIS CONCEPT IS IMPORTANT! YOU WILL SEE THIS MATERIAL AGAIN!

Efficient energy management allows the sortie profile to be accomplished with minimum wasted time and fuel. Energy level is defined by airspeed (kinetic energy) and altitude (potential energy) and is manipulated with power, drag, and G loading. Plan maneuvers in an order that minimizes the requirement for deliberate energy changes, and make use of the inherent energy gaining or losing properties of individual maneuvers.

Altitude and Airspeed Exchange - Potential energy (altitude) and kinetic energy (airspeed) can be traded. For example, by lowering the nose, without adjusting the power, you will increase airspeed by virtue of using gravity to assist.

Losing Energy - Energy may be decreased with low power settings, increased drag (for example, speed brake), or increased AOA (G loading). A simple way to lose energy is to perform a constant speed descent until the desired energy level is reached.

Gaining Energy - Energy gain is enhanced with low AOA and high power.

6.4. Power-on Stalls.

Proper recognition of a full aerodynamic stall. Proper recovery with minimum loss of altitude. Recognizing secondary stall if entered and properly recovering.

Description. Aircraft pitch and bank angle are held constant until control effectiveness is lost, indicated by uncommanded nose drop or unplanned rolling motion. Recover to a wings level, climbing attitude. An entry speed of 160 KIAS results in about 1,500-2,000 feet altitude gain.

- ***Airspeed –*** As required to achieve desired pitch, power, and bank.
- ***Power –*** Entry: 30-60 percent torque. Recovery: MAX.
- ***Pitch –*** Entry: 15-40 degrees nose high.
- ***Bank –*** 0 degrees for straight-ahead stall, 20-30 degrees for a turning stall.

Procedure. Straight-ahead Stall.

- Raise the nose to a pitch attitude between 30 - 40 degrees.
- Adjust the throttle to 60 percent rpm prior to first indication of stall, then push to MIL power
- Maintain attitude using increasing back pressure & Keep the wings level with coordinated rudder and aileron.
- Initiate recovery when control effectiveness is lost. An uncommanded nose drop, despite increased back pressure, or an uncommanded rolling motion indicates loss of control effectiveness.
- Do not attempt to maintain pitch attitude or bank angle after control effectiveness is lost. In almost all cases, full aft stick will not occur before recovery is required.
- While it is possible under certain conditions to maintain a nose high pitch attitude and counteract a rolling motion with aileron inputs, if the stick has reached the aft stop and the aircraft is losing altitude (aft stick stall), the aircraft is fully stalled and a recovery should be initiated.

Recover - Simultaneously and smoothly relax back stick forces as necessary to break the stall, and use coordinated rudder and aileron to level the wings. As AOA decreases and stall is broken, positive pressure is felt in the controls. Minimize altitude loss by maintaining recovery AOA until recovery is complete. While the recovery AOA is approximately 15.5-18 units, the primary reference for maintaining recovery AOA is a positive, vertical nose track. Recover with a minimum loss of altitude. Recovery is complete when the aircraft is wings level, safely climbing and not decelerating.

Turning Power-on Stall - Setup is the same as the straight-ahead stall, except 20-30 degrees of bank in either direction is added. Hold the bank angle with rudder and aileron pressure until control effectiveness is lost. Recovery is the same as for the straight-ahead stall. A precision entry is not as important as proper recognition and recovery from the stall.

Technique

- Use “MAX, Relax, Roll,” to guide initial recovery actions.
- After actions to break the stall, pull the nose up until the firelight is on the horizon. If the nose begins to stop tracking before the firelight reaches the horizon, release back pressure slightly momentarily to let airspeed increase to avoid a secondary stall. As power and airspeed increase, increased back pressure is needed to establish a climb.

Secondary Stall - During stall training, a common recovery error is entering a secondary stall. This is the effect of an overly aggressive return to level flight after a stall or spin recovery. Encountering a secondary stall demonstrates the value of smooth back pressure and the importance of obtaining flying airspeed during the stall recovery. Avoid secondary stalls, but if encountered, release back pressure slightly to decrease AOA, allow the airspeed to increase, and then resume the recovery.

6.5. Slow Flight.

Familiarization and proficiency with aircraft performance and characteristics at minimum flying airspeed. Demonstrate importance of smooth control application at slow speeds. Validate the concept of coordinated turns.

Description.

Airspeed – A-29B(110-115 KIAS)
T-45C(125-130 KIAS)

Gear – Down

Flaps – As desired.

Procedure. Slow flight is conveniently flown before or after traffic pattern stalls; however, slow flight may be performed at any time. Slow below 150 KIAS, configure the aircraft as briefed, and perform the before landing checklist. Maintain altitude as airspeed decreases. When target slow-flight airspeed is reached, adjust power to maintain airspeed and altitude. Trim as required.

Approach-to-stall indications (stick shaker or light buffet) are common while executing slow flight; however, if the aircraft actually stalls during slow flight, recover the aircraft by alleviating the condition that caused the stall (decrease the AOA, lower the flaps, decrease bank, etc.). This is not the primary method of stall recovery and is used only during slow flight. If the stall condition is not immediately corrected, or if an approach-to-stall indication occurs at any other time, initiate traffic pattern stall recovery procedures.

6.6 Inadvertent Departure from Controlled Flight.

The aircraft is in OCF (Out-of-Controlled-Flight) if it does not respond immediately and in a normal manner to control inputs. If in OCF, apply the OCF recovery procedure to return the aircraft to level flight.

6.6.1 OCF Recovery Procedure

The OCF recovery is accomplished by *SIMULTANEOUSLY* :

- Reducing the throttle to idle
- Neutral flight controls

After the controls are neutralized, expect the nose to lower as the aircraft seeks to regain flying airspeed. Initially, aircraft control authority is minimal, but it returns to normal as airspeed increases in the dive. Allow the nose to lower until positive control pressure is felt. The nose may near the vertical during this stage of the recovery. Upon regaining flying airspeed, recover the aircraft to level flight. An unloaded recovery may result in considerable altitude loss.

The OCF recovery is also used when the aircraft is in a nose-high unusual attitude, and SA is lost to the point of disorientation. Depending on flight parameters when SA is lost, the initial steps of the OCF recovery procedure either start the recovery or prevent departure. In either case, the OCF recovery provides a guaranteed predictable method to return to level flight and regain SA.

6.7 Aerobatics.

Aerobatic maneuvers develop techniques for obtaining maximum flight performance from the aircraft. Aerobatics explore the entire performance envelope of the aircraft and should be smoothly executed. Aerobatic practice improves feel for the aircraft and the ability to coordinate the flight controls, while remaining oriented, regardless of attitude. Aerobatics increase confidence, familiarize the pilot with all attitudes of flight, and increase the ability to fly an aircraft throughout a wide performance range. The concepts learned from aerobatic practice are applicable in formation maneuvering and other advanced missions.

Training emphasis is on smoothness and proper nose track during the maneuver. Strive to use the briefed entry parameters, but power and airspeed adjustments may be made to enhance energy planning or expedite the profile flow. Normally, the left hand is on the throttle, and the right hand is on the control stick. Avoid using a two-handed control stick technique to maintain a wings-level attitude. Indicated torque varies relative to altitude and airspeed without changing the throttle position.

6.7.1 Aileron Roll

Description. The aileron roll is a 360-degree roll about the longitudinal axis of the aircraft. The maneuver is complete when the wings are again parallel to the horizon.

Airspeed – A-29B(250 KIAS)
T-45C(350 KIAS)

Power – 85-95% RPM

Attitude – Wings-level entry, 20-30 degrees nose-high pitch attitude.

Procedure. Attain briefed entry parameters. Smoothly raise the nose to 20-30 degrees nose-high pitch attitude. Relax back stick pressure and stop nose track, then roll the aircraft left or right using coordinated aileron and rudder. The nose of the aircraft does not roll around a specific point in the roll. As the aircraft approaches wings level, neutralize the rudder and aileron, and return to level flight. In the T-45, an aileron roll to the left requires less rudder and aileron deflection than a roll to the right due to engine torque.

Technique. Visual references help keep focus outside. At 20 degrees nose high, the clock is approximately on the horizon. At 30 degrees nose high, the STBY airspeed indicator is on the horizon.

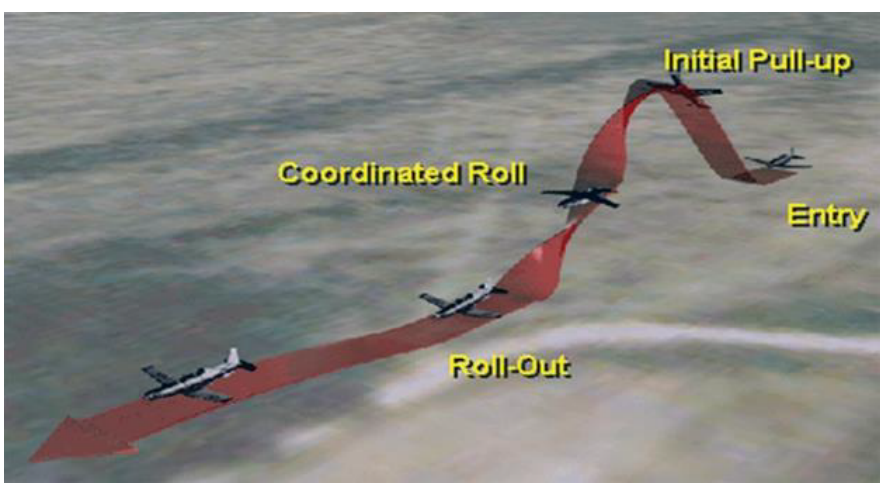

Figure 6.1 Aileron Roll.

6.7.2 Wing Over

Airspeed – A-29B(225 KIAS)
T-45C(350 KIAS)

The Wingover is a 180-degree reversal of the direction of flight through the vertical as well as the horizontal plane. Perform it by combining a smooth climbing turn for 90 degrees and a smooth descending turn for 90 degrees, recovering at approximately the same airspeed and altitude at which you began the maneuver, but on the opposite heading. The Wingover develops your ability to control the aircraft smoothly in balanced flight through constantly changing attitudes and airspeeds. Perform the maneuver in either direction in a series of two (in opposite directions) so that the series is completed on the same heading at which the first wingover was started

Procedures - Complete the pre-stall and aerobatic checklist prior to performing the Wingover. Begin the maneuver on speed, on altitude, and aligned on a prominent terrain feature or section line. Select a reference point on the horizon that is approximately 90 degrees off the current aircraft heading. Raise the nose smoothly, keeping the wings level, to approximately 20 degrees nose up attitude. As the nose continues up, initiate a slow roll in the direction of the reference point. The nose should describe an arc above the horizon, reaching a maximum pitch of 45 degrees at approximately 45 degrees of heading change and 45 degrees AOB. As the AOB continues to increase, start the nose smoothly downward toward the horizon. After 90 degrees of heading change, the nose passes through the horizon on the referenced point, with 90 degrees AOB and an airspeed of approximately 150-170 KIAS. Reverse the roll and begin to decrease the AOB as the nose falls through the horizon. The nose should describe a similar arc below the horizon, reaching a maximum pitch of 45 degrees nose down, at approximately 135 degrees of heading change and 45 degrees AOB. Roll out of the maneuver at a constant rate, increasing back stick pressure to control airspeed and altitude. Upon completion of the maneuver, you should be in straight and level flight at starting AS, 180 degrees from the original heading, and at approximately the same altitude as at the beginning of the maneuver. Now immediately raise the nose to continue the maneuver in the opposite direction. Your aircraft should be on its original heading upon completion of the second Wingover.

Techniques - When the Wingover is introduced, visualize the aircraft's path. Pay close attention to the relation of the aircraft to the horizon as you see it from the cockpit. Once you are able to visualize this relation, the Wingover is merely a matter of flying the aircraft through the pattern. As the aircraft's speed changes throughout the maneuver, you will have to adjust the amount of control deflection to maintain a constant rate of pitch and roll. As your bank angle increases, it is difficult to keep the nose coming up without drastically increasing your turn rate. If you are not getting 45 degrees nose up, you may be rolling too fast during the initial part of the maneuver.

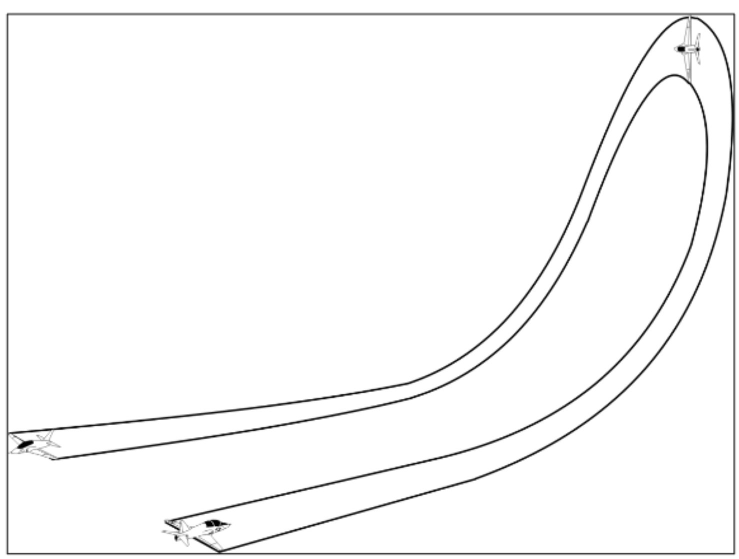
Figure 6.2 Wing Over

6.7.3 Lazy Eight

Description. This is a slow, lazy maneuver that describes a horizontal figure eight at the horizon. The horizon line bisects this figure eight lengthwise. Pitch, bank, and airspeed constantly change. The maneuver is complete after two 180-degree turns with the aircraft in level flight.

Airspeed – A-29B(250 KIAS)
T-45C(350 KIAS)

Power – 85-95% RPM

Attitude – Entry: wings level, 90 degrees MAX bank, 45 degrees MAX nose-high pitch.

Altitude - Approximately 2,000 feet above and 1,000 below entry altitude.

Procedure. Control pressure constantly changes due to changing bank, pitch, and airspeed. To help fly symmetrical leaves, select a prominent point on the horizon (90 degrees off aircraft heading, for example, off the shoulder) or a ground reference, such as a section line or road (perpendicular to aircraft). Selected points should be far enough from the aircraft (not beneath the wing) so you don't fly over it. Mentally project an imaginary line from the aircraft to the horizon. Look in the direction of flight turn and clear throughout the maneuver.

- Begin in straight-and-level flight with briefed entry airspeed and power setting.
- Select the desired reference point on the horizon or ground, and align the aircraft so the reference point is directly off a wingtip.
- Blend aileron, rudder, and elevator pressures simultaneously to start a gradual climbing turn in the direction of the reference point. The initial bank should be very shallow to prevent excessive turn rate.
- As the nose is raised, the airspeed decreases, causing the rate of turn to increase. Time the turn and pull-up so the nose reaches the highest pitch attitude (approximately 45 degrees) when the aircraft has turned 45 degrees or halfway to the reference point. Use outside references and the attitude indicator to cross-check these pitch-and-bank attitudes.
- Bank continues to increase as the nose falls.
- The aircraft should be pointed at the reference point as a maximum bank of 80-90 degrees is reached and the nose reaches the horizon. The lowest airspeed occurs just as the nose reaches the horizon (approximately 100 knots below entry airspeed).
- *Avoid freezing the pitch or bank at the horizon.* Passing the horizon, let the nose fall, and begin rolling out of the bank.

The second half of the leaf (nose below horizon) should be symmetric and approximately the same size as the first half (nose above the horizon). The bank should change at the same rate as during the nose-up portion of the leaf. When the aircraft has turned 135 degrees, the nose should be at its lowest attitude and the bank should be 45 degrees. Continue blending control stick and rudder pressure to simultaneously raise the nose and level the wings. Monitor the progress of the turn by checking the outside reference point (off opposite shoulder from maneuver start). The aircraft should be wings level at entry airspeed as the nose reaches the horizon, having completed 180 degrees of turn. Without pausing, begin the second leaf in the opposite direction of the first.

Technique.

- Set up perpendicular to a long road or section line. Visualize the road as the straight line part of a dollar sign ($). The two turns of the maneuver complete the “S” portion of the dollar sign. If ground references are unavailable, the heading bug can be set to the initial heading and used to monitor the progress of the turns.
- During the nose-up part of turns, pull to put the bottom foot (foot on inside of turn) on top of the horizon and roll around it until reaching approximately 60-degree bank. The nose will begin to fall at 60- to 90-degrees of bank. Use AOB to control the lift vector and achieve the desired nose low pitch attitude without freezing at 90-degrees of bank. It is permissible to vary the roll rate to control the lift vector without stagnating. Proper lift vector control is the key to a successful lazy eight.
- When bringing the nose back to the horizon from a nose-low attitude, the Dash-of knots below wings level airspeed should be approximately equal to the Dash-of degrees nose low. For example, if the desired wings-level airspeed is 280 knots, the airspeed should be approximately 250 knots at 30 degrees nose low, 260 knots at 20 degrees nose low, etc.

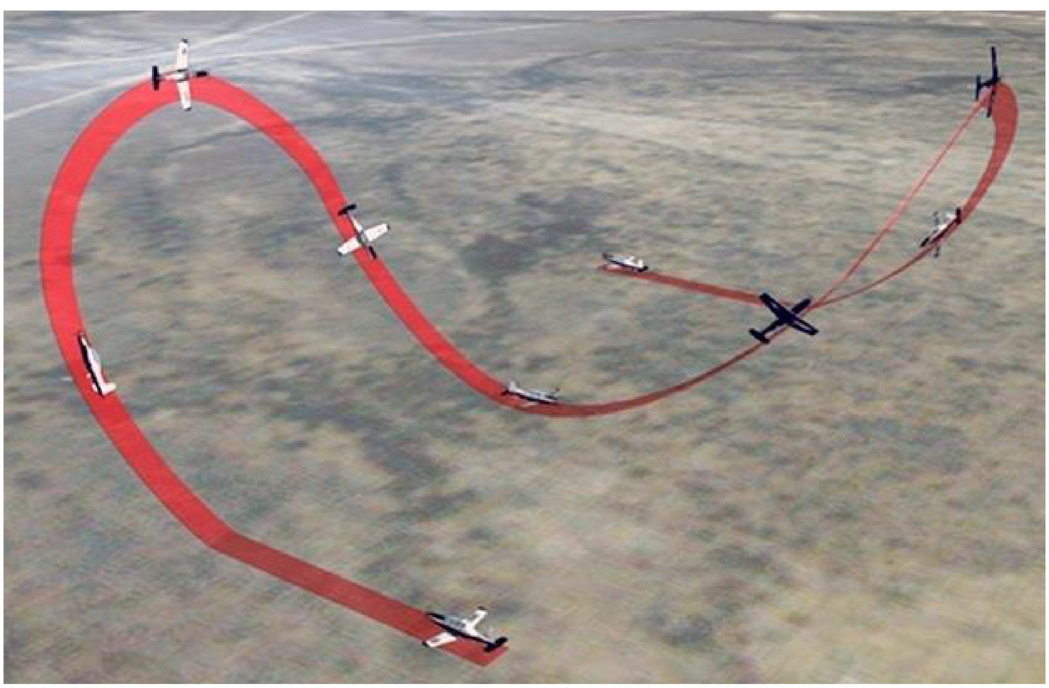

Figure 6.3. Lazy Eight.

6.7.4 Barrel Roll

Description. A barrel roll is a coordinated roll in which the nose of the aircraft describes a circle around a point on or near the horizon. Practice in both directions. The maneuver is complete when the aircraft is wings level, abeam the reference point on the original side, at approximately entry airspeed.

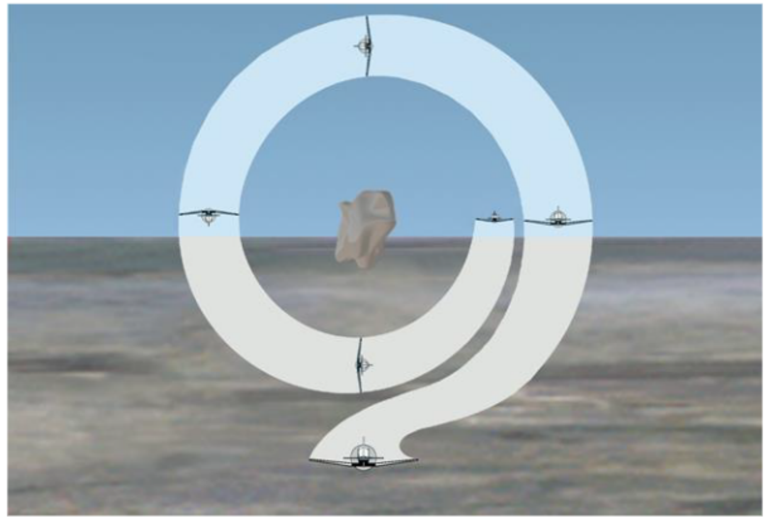

Figure 6.4 Barrel Roll

Airspeed – A-29B(250 KIAS)
T-45C(350 KIAS)

Power – 85-95% RPM

Attitude – Entry: wings level.

Altitude – Approximately 2,000 feet above and 1,000 feet below entry altitude.

Procedure.

- Select a reference point, such as a cloud or landmark, up to 45 degrees off the nose of the aircraft, on or slightly above the horizon.
- Set briefed power and attain briefed entry airspeed with the nose of the aircraft below the horizon.
- Begin a coordinated turn in the opposite direction of the desired roll, as necessary, to place the aircraft up to 45 degrees to the side of the reference point. The distance from the reference point should remain constant throughout the maneuver.
- As the bank reaches 90 degrees, the aircraft should be directly above the reference point.
- Passing 90 degrees of bank, relax some back pressure and increase aileron deflection to continue the roll with reduced airspeed.
- Plan the roll so the wings become level just as the aircraft reaches the inverted level-flight attitude. The aircraft should be displaced from the reference point the same distance as at the beginning of the maneuver.
- As the bank again reaches the 90 degrees at the bottom of the maneuver, the nose track should continue to arc around the reference point.
- Maintain coordinated control pressure to continue the roll so the nose completes the circle around the reference point, ending up wings level at the horizon.

Technique. Choosing a reference point above the horizon and within the canopy bow helps ensure reasonable displacement and barrel roll size.

6.7.5 Loop

Description. The loop is a 360-degree turn in the vertical plane with constant heading and nose track. Because it is executed in a single plane, the elevator is the principle control surface. Ailerons and rudder are used to maintain directional control and coordinated flight. The maneuver is complete when wings are level at the horizon on the same heading as at entry.

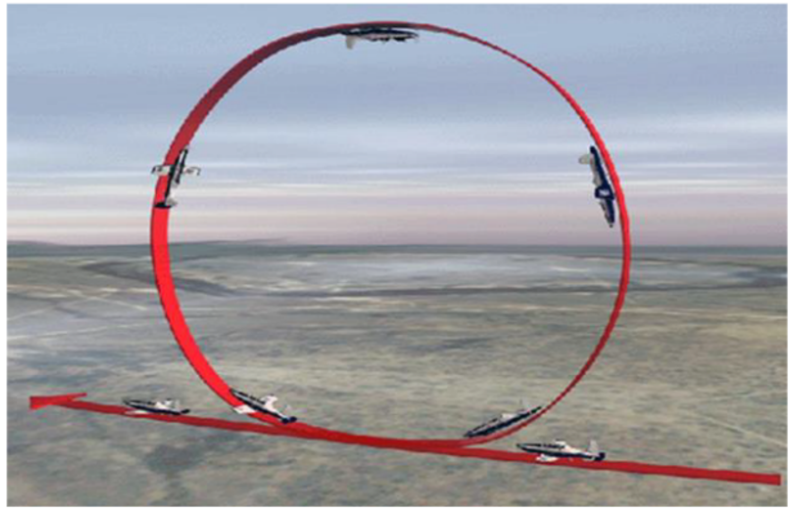

Figure 6.5 Loop

Airspeed – A-29B(250 KIAS)
T-45C(350 KIAS)

Power - MIL.

Attitude - Wings level to horizon throughout maneuver.

Altitude - Approximately 3,000 feet above entry altitude.

Procedure.

- Begin straight-and-level to 20 degrees nose low, with briefed entry airspeed and power setting.
- Smoothly pull the nose up using 3-4 Gs.
- Maintain wings level (straight pull) by keeping the wingtips equidistant from the horizon.
- Back stick pressure and G loading decrease to maintain a constant nose track as airspeed decreases; however, aft control stick displacement increases.
- Pull straight through the vertical and increase G loading to maintain a constant nose track until a level flight attitude is reached. Maintain coordinated rudder as the airspeed increases in the dive.

Technique.

- Align the aircraft with a road or section line to provide a visual reference for a straight pull.
- Keep aligned with selected reference throughout the loop. If a ground reference is not available, the heading bug may be used to ensure a straight pull.
- As the horizon disappears, use the cross-check of "wingtip, wingtip, ball" to keep the wings level and flight coordinated. Make sure the wingtips are equidistant from the horizon. Roll away from the wingtip that has the most ground above it to level the wings.
- Near vertical, tilt the head back and try to locate the horizon as early as possible. If the wings are not level, improper rudder application is most likely the problem.

6.7.6 Immelmann

Description. The Immelmann is a half loop followed by a half roll, all flown in the same vertical plane. The maneuver is complete after a momentary pause in level flight with wings level on an opposite heading from entry.

Airspeed - A-29B(250 KIAS)
T-45C(350 KIAS)

Power - MAX.

Attitude - Wings level to horizon before and after half roll at top.

Altitude - Approximately 3,000 feet above entry altitude.

Procedure.

- Begin in straight-and-level flight, with briefed entry airspeed and power setting.
- Smoothly pull the nose up using 3-4 Gs.
- When the forward view of the horizon disappears in the pull-up, maintain wings level (straight pull) by keeping the wingtips equidistant from the horizon.
- Back stick pressure and G loading decrease to maintain a constant nose track as airspeed decreases; however, aft control stick displacement increases.
- As the aircraft reaches a point approximately 10 degrees above the horizon inverted, relax back stick pressure and apply aileron with coordinated rudder in either direction to initiate a roll to level flight.
- The maneuver is complete after a momentary pause in level flight following the rollout.

Technique. Reference the technique for the first half of the loop.

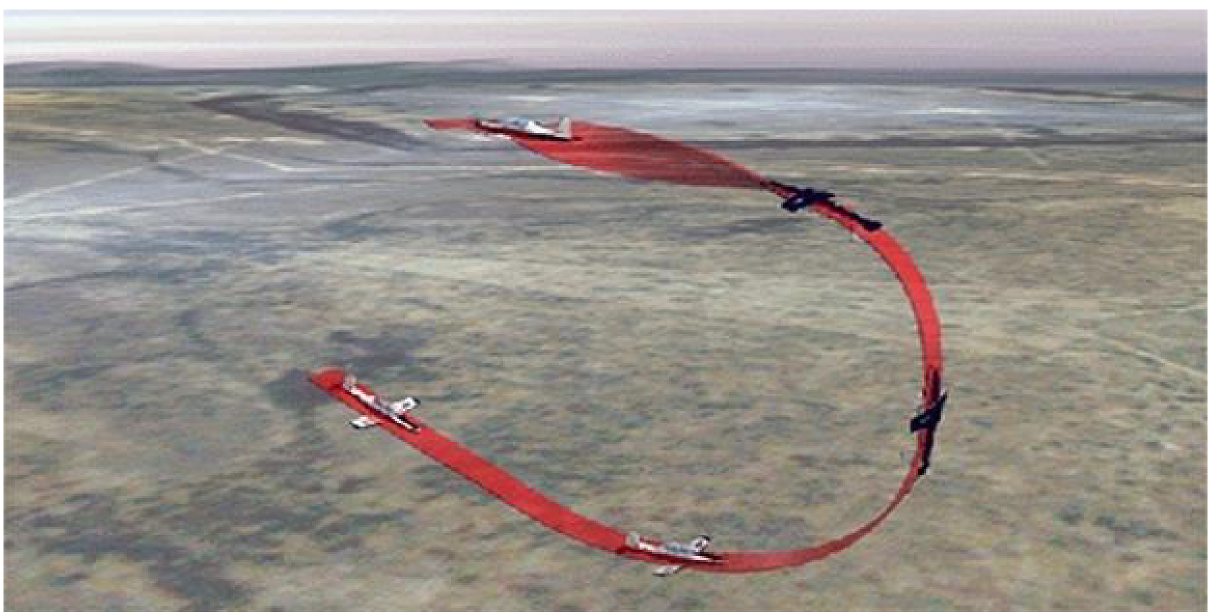

Figure 6.6 Immelmann.

6.7.7 Split-S

Description. The split-S combines the first half of an aileron roll with the last half of a loop. It demonstrates how much altitude is lost if recovery from inverted flight is attempted by pulling through the horizon. The aircraft climbs during entry and descends during recovery. The maneuver is complete when the aircraft returns to level flight.

Airspeed - A-29B(250 KIAS)
T-45C(350 KIAS)

Power - Idle to 80% rpm

Attitude - Entry: 20 degrees nose high. Wings level before and throughout pull.

Altitude - Approximately 2,500 feet below entry altitude.

Procedure.

- Begin in straight-and-level flight.
- Briefed power setting may be established any time before or during the half roll.
- Roll the aircraft to the wings-level, inverted attitude.
- Apply back pressure to bring the nose through the horizon.
- The maneuver is complete after a momentary pause in level flight following the rollout

Technique.

- Attempt to set up the maneuver over a road or section line.
- Ensure wings are level- inverted before starting pull.
- Imagine pulling to the “zipper” to ensure a straight pull.

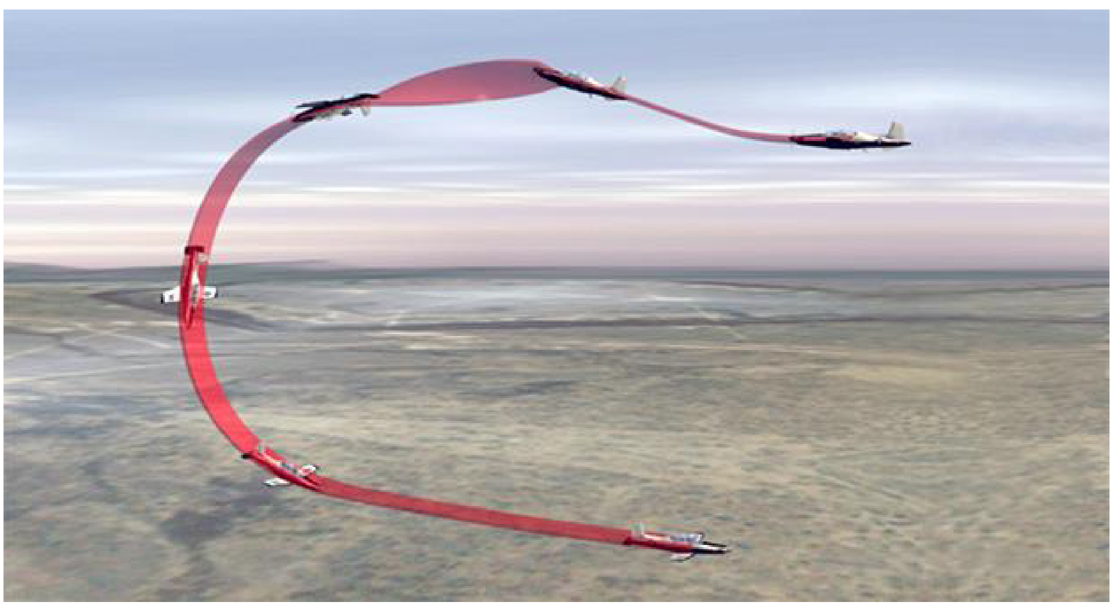

Figure 6.7 Split-S.

6.7.8 Cuban Eight

Description. Each half of this maneuver is a combination of a slightly modified loop and Immelmann. The first portion of each leaf is approximately the first five-eighths of a loop followed by a half roll. The pull and roll is then repeated in the opposite direction. The maneuver looks like an “8” on its side. The maneuver is complete at level flight, with entry airspeed and on original heading.

Airspeed - A-29B(250 KIAS)
T-45C(350 KIAS)

Power - MAX.

Attitude - Wings level to horizon throughout maneuver.

Altitude - Approximately 3,000 feet above entry altitude.

Procedure.

- Begin in straight-and-level flight, with briefed entry airspeed and power setting.
- Perform the first part of a loop until over the top, inverted.
- After passing through inverted-level flight, continue the loop until approaching 45 degrees nose low, inverted.
- Execute a coordinated half roll in either direction. Relax the elevator pressure to keep the nose track in the same vertical plane.
- After completing the half roll, maintain 45 degrees nose low until beginning the pull-up for the second half of the maneuver.
- Plan to initiate the pull-up to attain briefed entry airspeed at the horizon (passing through level flight). To accomplish this, begin the pull-up approximately 35-40 KIAS below briefed entry airspeed (the airspeed lead point is approximately equal to the Dash-of degrees of nose-low pitch). Continue the pull-up into another loop entry. The second half of the Cuban Eight is identical to the first except the roll is in the opposite direction.

Technique. Use ground references, or the heading bug, as in other over-the-top maneuvers. Upon reaching 45 degrees nose low, inverted flight (seat on the horizon), momentarily freeze the control stick before the coordinated roll. To maintain 45 degrees nose low, pick a point on the ground and freeze it in the windscreen. Verbalizing the roll direction on the first half of the maneuver will help ensure the roll on the second half of the maneuver is in the correct direction.

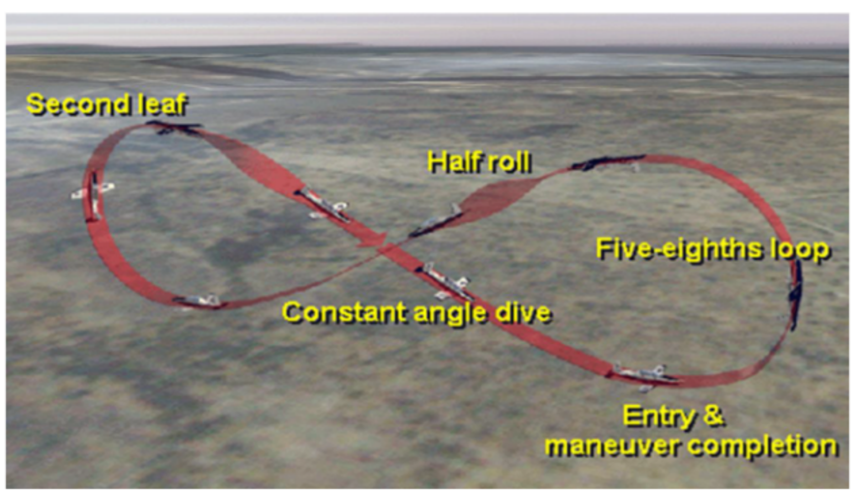

Figure 6.8 Cuban Eight

Chapter 7 - VISUAL NAVIGATION

7.1. Introduction.

As many things when comparing IRL to simulation, Navigation in DCS World is very different from real world operations. There are a number of concepts & considerations that don't come into play with DCS Word. For example NOTAMs, Crew Rest, PIREPs, Ground Crew coordination and major weather considerations, just to name a few. This chapter will cover navigational concepts as it pertains specifically to DCS. All flights within DCS are essentially VFR with IFR tasks, depending on time of day and weather conditions. As such this chapter will be tailored around those more common skills and tasks one will find within DCS World.

7.2. Mission Analysis.

Choosing a destination. Basic considerations to determine if an airfield is acceptable for use include runway length, command restrictions, and instrument approach availability.

Weather. With the recent update to 2.7 open beta. Eagle dynamics has put us in a position where we need to take possible weather complications into consideration. RTB divert, or even weather at the target site. As such, we need to take those possibilities into consideration and plan accordingly.

Flight Plan. Within DCS world, the mission planning auto loads flight plans and waypoints into the INS of the assigned aircraft. Or you can manually input the waypoints assuming the system allows for it. A paper flight plan on your kneeboard is the "old school" way, but still very effective.

TOLD. TOLD otherwise known as Take Off & Landing Data.

Navigation Checklists. Most units have excellent navigation planning checklists and (or) briefing guides that contain detailed information about the mission analysis process. A common memory aid to ensure completion of major planning steps is WANTS.

W - Weather (departure, enroute, destination).
A - Activate flight plan (complete and file). (N/A within DCS)
N - NOTAMs (Use this to review intel or info pertaining to route or target area).
T - TOLD (compute).
S - SID (review departure procedure); S – STAR (plan for destination)

7.3. Briefing.

A thorough brief is essential and ensures awareness of possible hazards (for example, crossing routes, towers, terrain) and other potential threats. A solid briefing also reviews sortie objectives and prepares the crew for effective training. Use caution to avoid spending excessive time on the route briefing; extensive route study is understood. The briefing is not a substitute for chart study. Likewise, the route may be briefed after completion of briefing guide items.

7.4. Radio Procedures.

Standard radio calls used at home station simplify communications and reduce radio congestion in the highly regulated local flying environment. Outside the local area, radio calls may not be as standardized, but efficient communication is still the goal.

7.5. Task Management and (or) Cockpit Organization.

The principles for instrument sorties apply to navigation sorties; however, navigation sorties may be more complex and require more organization. For example, a navigation sortie could include an IFR portion to a VFR low level followed by VFR point-to-point navigation to the destination and concluded with practice instrument approaches. In general, strive to find ways to get ahead and prepare for upcoming tasks.

7.6. Cross-Country Flight Planning

The following are the different phases of a cross-country flight. Each phase needs to be thought through and planned. This section will list the basic & fundamental questions that should and can be addressed during flight planning.

Plan the Flight / Fly the Plan

(1)Taxi / Take-Off

- Where is the aircraft of the flight parked?
- What is the route the flight will use to taxi to the active?
- What order does the flight taxi in?
- Section Take-off or Staggered? How long is the interval between aircraft?
- Any obstacles, threats that need to be avoided during the Take-off?
- TOLD Data?
- Freq's? NAVAids?

(2)Departure

- Which direction to turn to after takeoff?
- What airspeed to use for formation rejoin?
- What airspeed to use for climb to cruise altitude?
- What formation to use for climbout?
- What will be the climb angle?
- How long should it take to climb to cruise altitude?
- Comm's? NAVAids?

(3)En-route

- What is the cruise altitude?
- What is the cruise speed?
- Any obstacles, threats that need to be avoided during the enroute phase?
- Is the flight rejoining with a tanker? Or other aircraft? Freq's? Tacan? Altitude?
- How much time should the enroute phase take?
- Comm's? NAVAids?

(4)Arrival

- How far away should we begin our descent to arrive at the desired pattern entry altitude?
- Where is the initial for entry to the traffic pattern? Where is the secondary?
- Where is the alternate airfield if needed? How do you get there?
- Comm's? NAVAids?

(5)Landing Pattern

- Freq's? Navaids?
- What airfield pattern is going to be used/requested?
- Which is projected to be the active runway?
- Projected weather at primary destination? Alternate?

(6)Taxi / Park

- Freq's?
- What is the layout of the destination field?
- Projected route of taxi?
- TOLD Data?

7.7 Abnormal Procedures.

Lost Procedures. GPS and VOR or DME can be useful in maintaining or regaining positional awareness. If lost, follow the three “Cs”:

Climb - Visibility, fuel efficiency, and radio range improve.

Conserve - Slow to maximum endurance airspeed.

Confess - Call ATC (help with current position, get a vector, etc.).

Weather Along the Route. Weather may not be as forecast along the route and continued flight under VFR may not be possible. Under these conditions you need to do a risk evaluation to determine if continuing is a possibility:

- Do you have the ability (skills, equipments. documents) to continue this flight in IFR conditions?

If the answer is no, divert to another field with VFR weather and conclude the flight.

Emergency. Constant positional awareness is critical to successful recovery if an aircraft emergency prevents continued flight to the planned destination. Two common techniques to increase SA and reduce workload in the event of an emergency are:

- Circle emergency airfields in red circle. Annotate tower or common traffic advisory frequency frequencies.
- Use EHSI or nearest function on the GPS to provide constant display of airfields near the route of flight.

7.8 Low-Level VFR Navigation Introduction.

Flying high performance aircraft on low-level missions significantly increases exposure to risk. Operating at or below 3,000 feet AGL is considered low-level navigation, reaction times & margin for error are greatly reduced when operating close to the ground. Thorough preflight planning & preflight briefings are imperative for effective low-level training. The goal of low-level navigation is to fly a selected ground track & arrive at a designated time over target.

7.8.1 Emergencies.

The first reaction to any emergency encountered at low level is to abort the route and climb as high as necessary to safely analyze the situation. Altitude equals time.

Engine Malfunctions. If the engine fails on a low-level route, recovery is unlikely unless a suitable landing field is within approximately 3 miles. Normally, airfields within an arc circumscribed by the wingtips can be reached with an immediate turn and climb in the direction of the airfield.

Route Aborts. Route aborts occur for various reasons (insufficient fuel to complete the route, aircraft malfunction, bird hazards, and weather). Low-altitude flight increases the danger of distraction and complicates recovery. Use the map, GPS, and NAVAIDs to maintain positional awareness or to find the nearest suitable recovery airfield. After aborting the route, do not re-enter.

VMC. Maintain safe separation from the terrain, comply with VFR altitude restrictions (if possible), squawk an appropriate transponder code, maintain VMC, and attempt contact with a controlling agency, if required.

IMC. An abort into IMC is an emergency. Execute an immediate climb to the emergency route abort altitude (minimum). If in a multi-ship formation, execute the briefed lost wingman procedure.

7.8.2 Mission Analysis.

A successful low-level mission begins with meticulous & extensive mission analysis.

- The first step is to become familiar with route requirements.
- Select a ground speed that is easily converted to miles per minute but allows for airspeed corrections (240, 300, or 360 knots GS).
- Check the forecast weather for the route. Use the forecast temperature, pressure altitude, and winds to compute indicated airspeeds.
- Use flight manual charts to determine the fuel flow for the planned true airspeed.

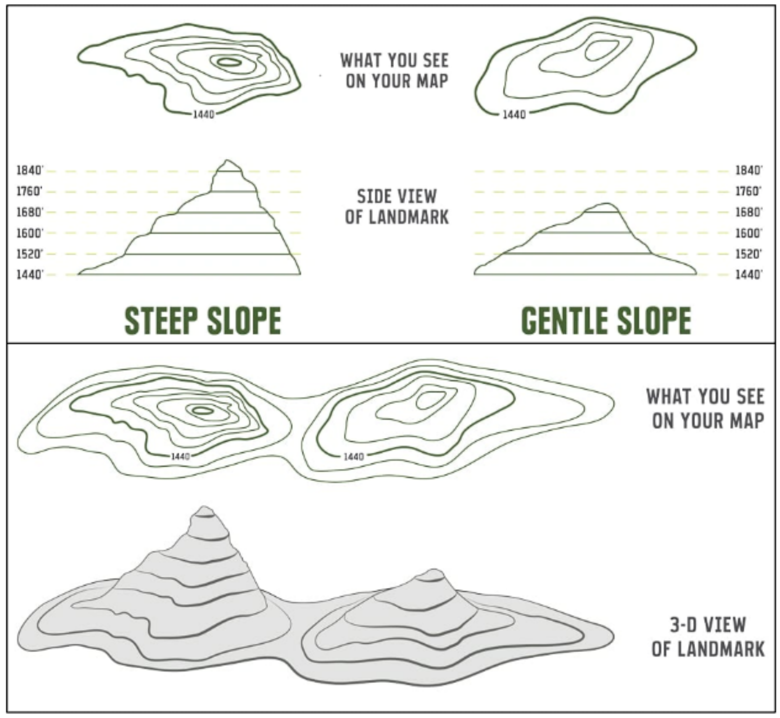

Figure 7.1 Map Contour Lines

- Find the best altitude for the route that will keep you above projected obstacles or threats as well as using terrain for masking. By using map contour lines you can visualize the shape & slope of the terrain.

7.8.3 Chart Preparation.

The following are recommended best practices for effective planning of a low level route

- Draw the route corridor
- Identify all significant obstacles and high terrain within the route corridor.
- Select easily recognizable points as waypoint/steerpoints. It is preferable to use natural features to identify the target and turn points, as they seldom change. Choose turn points for uniqueness, vertical development, funneling features, and surrounding terrain. Avoid features that may be hidden by high terrain or trees.
- Choose the target first, then the initial point (IP), turn points, and entry point.
- Choose an IP about 1 to 3 minutes from the target. An IP is an easily identifiable point used to fine tune navigation and increase the probability of target acquisition. Minimize the heading change at the IP in order to increase the accuracy of the IP-to-target leg.
- Begin timing measurement at the route start point. Timing runs continuously from start point to target.
- A thorough and detailed chart study is an essential part of mission analysis.
- Visualize key points on the route and the general features around them to minimize the requirement for constant reference to the map.

7.8.4 Chart Marking

The use of flight planning software like CombatFlite is highly recommended. For it will auto generate some of the maps that are mentioned below. But, doing it by hand is also acceptable. But *these preparations are highly recommended for a successful low level sortie*.

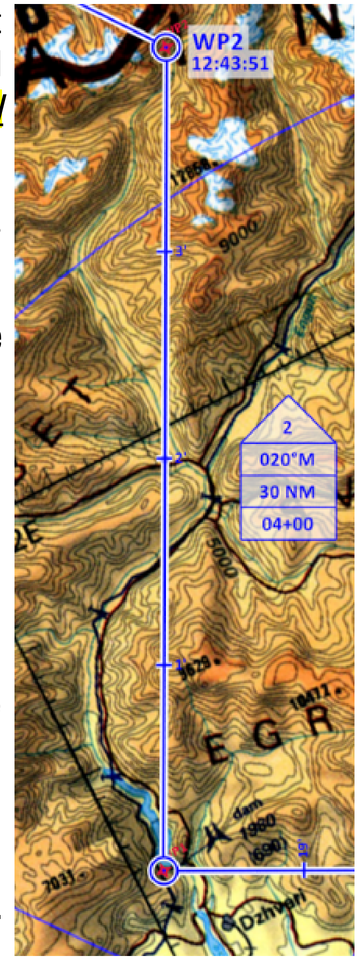

Figure 7.2 Strip Map

- Route lines and circles around turn points. Do not obscure critical details with the black line or turn circles.
- Timing lines along the planned ground track. Marks at a 1- or 2-minute interval are sufficient.
- Information boxes aligned with each leg that include heading, leg time, and any other relevant information.
- Highlighted obstacles or high terrain along the route.
- Fuel calculations.
- Continuation fuel for the start point and other selected points along the route. Continuation fuel is the minimum fuel required to complete the route at planned speeds and altitudes and to return to base with required fuel reserves.
- Bingo fuel from the most distant point on the route to the recovery airfield. Bingo fuel is calculated for the most practical means of recovery (route and altitude). Consider factors such as cloud ceilings, winds.
- Compute an Emergency Route Abort Altitude (ERAA) for the planned portion of the low-level route and clearly annotate it for easy in-flight reference. Compute this altitude to provide 1,000 feet clearance above the highest obstacle within 25 nm either side of the route.
- Circles around emergency and alternate airfield locations, and appropriate information for those fields
- Route and timing to and from the low-level route.

7.9 Flying the Route.

With proper planning, Dead Reckoning (DR) (flying accurate headings and airspeeds) should result in a ground track close to black line and accurate timing.

7.9.1 Departure.

Attempt to fly the planned route to the entry point. If the route is a long distance away or IFR flight is required to the entry point, identify a point short of the entry point from which DR can begin. The point may be visual, a GPS waypoint, or a VOR radial or DME. The easier it is to identify, the more accurate DR navigation will be.

7.9.2 Route Entry.

Before the entry point, accomplish a descent check and compare the EHSI heading with the magnetic compass to verify accuracy. Prepare the clock and review the hack procedure with the other pilot. Identify the entry point as early as possible. Maneuver to hit the entry point on the correct first leg heading. Use "ready, ready, hack" to initiate timing. Regardless of the timing or cadence of the calls, "hack" always follows the second "ready." Inside the route structure, accelerate to planned airspeed.

7.9.3 Route Basics.

Sound task prioritization and an organized approach are essential to a successful low-level mission. On the route, there are three distinct mission elements that must be integrated. These mission elements, listed in priority order, follow:

Safety - Stay clear of terrain, obstacles, and other aircraft. Focus on terrain clearance is most critical during turns. While turns only make up 10 percent of flying in the low-level environment, they make up about 50 percent of the accidents.

Systems Operation - Perform required checks. Monitor systems and fuel consumption.

Navigation - Follow the route & identify required points. Meet the TOT goal.

Mission - The challenge is to work efficiently, so sufficient time is available for success in all mission elements. As you accomplish all the other above priorities, keep the overall mission intent in mind.

7.9.4 Priority.

The highest priority task is clearing the ground, obstacles, other aircraft, and birds. The neutral position during low level where 80 percent of time should be spent is "head up and eyes out." Always return focus to clearing after momentary diversions to accomplish other tasks or subtasks. During turns, fly the aircraft and clear; do nothing else. If all else fails , always remember the old aviation adage of *AVIATE, NAVIGATE, COMMUNICATE.*

7.9.5 Fly Accurately.

Successful DR is based on solid planning and accurate flying. Failure to maintain heading and airspeed can corrupt the entire process. Visual navigation with the chart is based on being close to the expected position.

Trim the Aircraft. Trim the aircraft and set the proper IAS or power setting for the planned groundspeed. A stable platform makes navigation much easier.

Clock-to-Map-to-Ground. Use the "Clock-to-Map-to-Ground" method as previously described in this chapter to maintain course and timing.

Identify. Start trying to identify turn points about 1 to 1-1/2 minutes out (approximately 3.5 to 5 miles at 210 knots GS). If possible, verify the point with multiple features. If the point is not identified, turn on time. Turns at low altitude require extra emphasis on clearing and aircraft control.

7.9.6 Big Picture.

Keep an eye on the big picture. Use major terrain features (mountains, lakes, obvious geological formations, etc.) to improve positional awareness.

7.9.7 Altitude Control.

Visually assess the height above the ground. Occasionally cross-check the altimeter against the known elevation of towers, lakes, airfields, and peak elevations. Visual navigation is easier as altitude increases. When in doubt, climb early if the route structure allows it.

7.9.8 Heading Control.

Pick a ground reference in the distance and fly to it. Set the heading bug on the wind-corrected heading. ARC mode on the EHSI can be helpful. Heading deviations occur often during low level (obstacle avoidance, poor wind analysis, etc.). One method to correct the course is to aim for a distant feature on the route. Landmarks that parallel the route or funnel toward the route (roads, rivers, drainage patterns, etc.) are also useful. See Navigation for Pilot Training for course correction methods based on the 60-to-1 rule. At 210 knots GS, a heading change of 17 degrees held for 1 minute causes a 1-mile course shift.

7.9.9 Timing.

Accurate DR relies on a good clock “hack” started at the actual start point. Features perpendicular to the ground track, such as roads, rivers, power lines, and pipelines, are good timing update points. For every second early or late, increase or decrease indicated airspeed by 1 knot, and hold that change for the Dash-of minutes equal to the NMs per minute you are flying. For example, if flying at 210 knots GS (3.5 miles per minute) and 10 seconds late, increase indicated airspeed by 10 KIAS and hold for 3.5 minutes.

7.9.10 In-flight Checks.

Perform normal in-flight checks during low-level missions. Compare actual fuel to planned fuel. Do not perform checks during turns. Primary techniques to update required items before or after turn points include the “SHAFT” check or a variation of the “six Ts”:

SHAFT.

S - Speed for new leg.

H – Heading for new.

A - Altitude for new leg.

F - Fuel at turn point. Compare to plan.

T - Timing at turn point. Compare to plan, determine correction/Threats for new leg.

Six Ts.

T - Time ahead or behind.

T - Turn to specific heading for new leg.

T - Torque set to hold desired airspeed, check fuel, and fuel flow.

T - Twist heading bug or course arrow to proper heading.

T - Track course centerline at desired altitude.

T – Threats for new leg/Talk if at a required reporting point.

7.12 Low Level Ridge Crossing Techniques

There are 3 main techniques that are used to cross ridge lines in a tactical environment when low level.

- Perpendicular
- Parallel
- Saddle Ridge

7.10.1 Perpendicular

This crossing minimizes enemy radar or visual acquisition but should be done only when you know your six is clear. Accelerate as required to maintain tactical airspeed during the pull-up. ***Pull early enough to avoid a large overshoot crossing the ridge, so you crest the ridge at your specified minimum low level altitude***. To go down the back side, bunt or roll and pull. A totally inverted pulldown is not recommended. At the crest, unload and roll to approximately 135° of bank, then slice down. At the desired nose low position, roll out and resume low level flight. Initial attempts at this technique should be limited to a 15° nose low attitude. ***DO NOT bury the nose in the new valley.*** This maneuver may put you belly up to unexpected high terrain on the other side of the mountain. Also, the wing flash during the maneuver is highly visible to threats. The roll and pull technique is most effective when crossing large, steep, isolated ridge lines. A bunt or pushover is more appropriate in milder, rolling terrain. The pull-up for a bunt/pushover should be initiated early enough to avoid excessive ballooning over the ridge. The advantages of bunt are straight line navigation, no wing flash, and less disorientation.

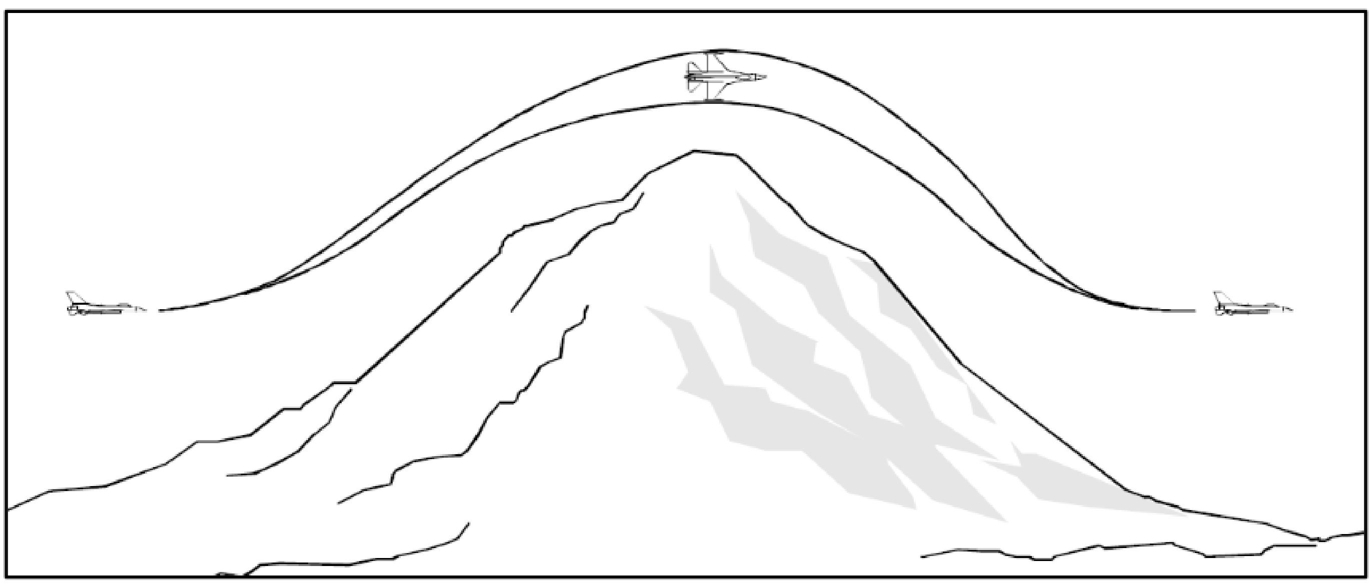

Figure 7.2 Perpendicular Ridge Crossing

7.10.2 Parallel

This type of approach is appropriate if your six is, or may be, threatened (Figure 7.3). It denies the bandit a blue-sky background and provides a difficult guns environment. Instead of a straight approach to the ridge, turn to arrive at the pull-up point with approximately 45° of crossing angle to the ridge. Pull up later than for a perpendicular crossing, and continue to turn in the climb to be parallel to the ridge crest just below the top. Roll and pull into the ridge, to cross the crest at your specific minimum altitude. Continue a loaded roll to fly down the backside of the ridge, on a heading 90° to 135° from the ridge line. Roll out and continue the low level.

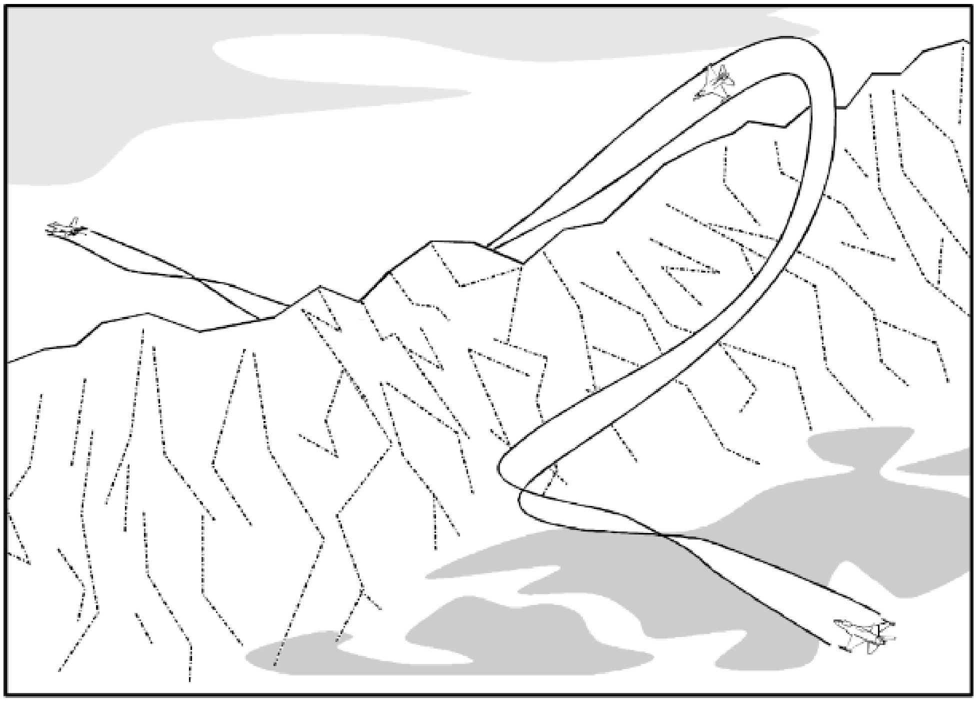

Figure 7.3 Parallel Ridge Crossing

7.10.3 Saddle Ridge

The saddle type ridge crossing is similar to the parallel and can be used when threatened (Figure 7.4). Turn to parallel the ridge line below the crest until you can use a saddle, canyon, or the end of the ridge to cross to the other side. The exact maneuver is dictated by the terrain characteristics, but can be as easy as a level turn.

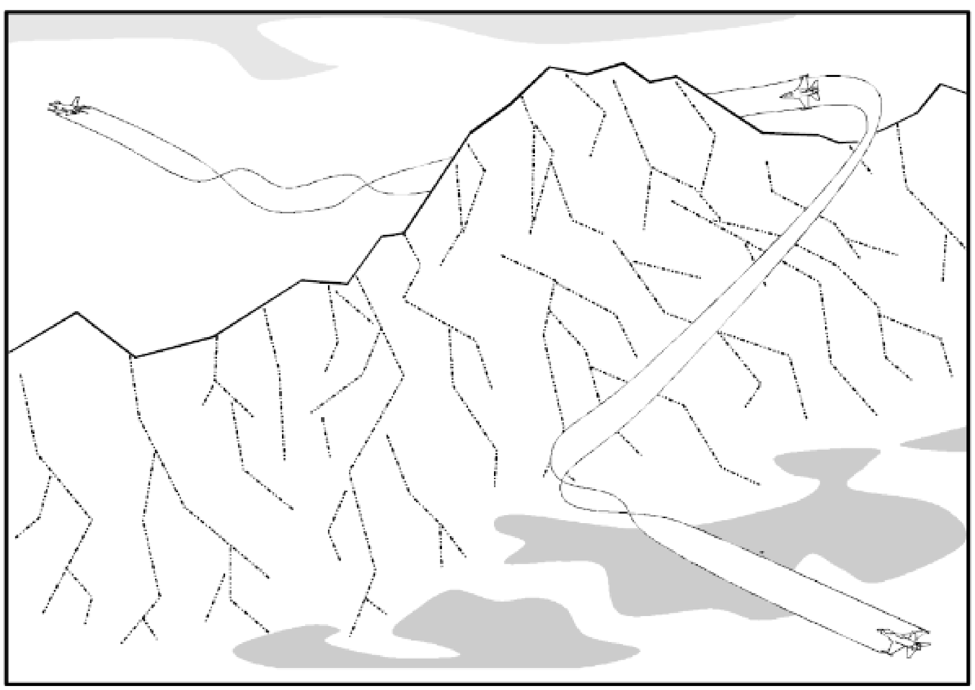

Figure 7.4 Saddle Ridge Crossing

Chapter 8 - TWO-SHIP FORMATION

8.1. Introduction

Two-ship formation, also known as an element, is the smallest unit used in combat aviation. You always have a wingman, and operate as a 2-plane team. This chapter will begin your indoctrination into the team concept of combat aviation.

Purpose. *The primary purpose of flying formation is mutual support*. Not to mention more fun within the context of DCS. Formation skills & procedures are intended to turn the potential liability of two aircraft flying close together into the benefit of mutual support, but only through precise compliance with the obligations of the “Dash-1” & “Dash-2” aircraft, as presented in this chapter. Formation, more than any other type of flying, builds confidence, develops teamwork, teaches self-discipline, and promotes the proper application of aggressiveness to military flying. While the dynamics of working with and being responsible for another aircraft are new, the maneuvers are not. Formation maneuvering is an extension & combination of skills learned in other categories.

Flight Discipline. Flight discipline means strict adherence to the plan given in the preflight brief and any real-time alterations directed by Dash-1 during flight. It begins with mission preparation and continues through briefing, ground ops, flight, and debrief. Dash-2 is a participating member of the flight, not just a spectator along for the ride. If the directed tasks are beyond Dash-2’s ability, they must immediately inform Dash-1.

Flight discipline also means flying in the proper parameters for the formation position directed by the flight lead with no tolerance for remaining out of position. As Dash-2, always strive to fly within the proper formation position parameters. As Dash-1, correct any wingman deviations immediately by directing Dash-2 to the proper position if appropriate corrections are not being made. Dash-2 will query Dash-1 immediately if unsure of assigned position. Uncompromising flight discipline is absolutely essential for successful mission execution. Flight Discipline is a habit, and mindset.

Formation flying requires “thinking ahead of the aircraft” and proactive planning. Everything takes a little longer to accomplish in a formation. Common tasks like changing radio frequencies or maneuvering require more time in formation; therefore, Lead will have to plan accordingly.

Aggressiveness. Aggressiveness in formation flying is a state of mind, an attitude not to be confused with the speed of flight control movement. As Dash-1, thinking ahead of the aircraft and profile while anticipating the need for changes and adjustments before they actually occur is an indication of the proper aggressive attitude for Dash-1. As Dash-2, correcting for positional deviations while mentally anticipating the next phase of flight or maneuver indicates proper aggressiveness. Do not act until directed by Dash-1. A smooth and timely response to Dash-1’s directives demonstrates the proper aggressive attitude for Dash-2.

8.2. Responsibilities.

8.2.1. Flight Lead.

The flight lead is ultimately responsible for the safe and effective conduct of the mission, and does not change during a mission under normal circumstances. This position gives both the authority & the responsibility of ensuring mission success to one individual who will be clearly identified prior to the mission. The flight lead is responsible for the planning, briefing, execution, and debriefing of the flight. The flight lead may delegate some or all of these mission elements but retains overall responsibility. The flight lead must focus on mission accomplishment, achievement of objectives, and safety. Consideration of the capabilities and experience levels of all flight members will help the flight lead plan a mission that optimizes training, and ensures accomplishment of objectives.

NAV Lead. This may be used when the flight lead wants the wingman to navigate and clear. The flight lead will fly the wing position, deconflict within the flight, and keep the radios.

Administrative (Admin) Lead. This is used to pass lead responsibilities to another member of the flight. The admin lead is expected to run all aspects of the profile to include navigating, managing the radios, and making changes to the profile if external conditions dictate. However, the flight lead still retains ultimate authority for the formation.

8.2.3. Responsibilities of # 1 & # 2.

Within the element, there are two distinct roles with well-defined responsibilities: Dash-1 and Dash-2. As described in the preceding paragraph, the designated flight lead does not change during the mission, however to enhance training opportunities, Dash-1 and Dash-2 will often swap formation positions during a sortie. The mutually understood procedures, standards, and briefed tasks form a contract between Dash-1 and Dash-2 that results in a safe operating environment. (Note: Do not confuse the terms “flight lead” and “Dash-1”; they are not the same.)

Dash 1 is responsible for executing mission elements while in flight. Dash-1’s basic responsibilities include:

- **Clear for the Formation.** Maneuver the formation away from other aircraft and maintain a safe altitude above the ground or any obstacles.
- **Plan Ahead of the Aircraft.** Altering the profile and (or) maneuvers as appropriate and ensure fuel and time are used judiciously to accomplish mission and training objectives.
- **Monitor Dash-2.** Ensure Dash-2 is properly maintaining the assigned position. This also includes assessing parameters during maneuvers and ensuring Dash-2 is in a safe position prior to executing a new maneuver. Furthermore, this includes ensuring in-flight checks are completed by the entire formation in a timely manner.
- **Navigation.** Ensure the formation is at the proper altitude, airspeed, and position relative to NAVAIDs, routing, instrument approaches, obstacles, airfields, etc.
- **Communication.** Transmit and receive information for the formation. To the air traffic controller, a formation is treated as a single entity with a single voice: Dash-1. Unless pre-briefed or included in unit standards, radio frequencies will not be changed unless directed by Dash-1.

Dash 2's primary responsibility is to maintain flight path deconfliction & proper position as directed by Dash-1. Dash-2's basic wingman responsibilities include:

- **Do Not Hit Dash-1.** Flight path deconfliction is paramount. Unless Dash-2 has called "blind", Dash-2 is responsible to deconflict flight paths and prevent a collision.
- **Keep Dash-1 in Sight.** Collisions within formations often occur when Dash-2 has lost sight of Dash-1. Hitting Dash-1 is much less likely when Dash-2 can see Dash-1. Losing sight is not uncommon and is only a problem if Dash-2 fails to call "blind" with their altitude (this concept will be described later in this chapter).
- **Be in Position and on Frequency.** This is commonly referred to as "being there." If Dash-2 is in position and on frequency, it is much easier to keep Dash-1 in sight and for Dash-1 to monitor Dash-2. Being in position is also a requirement for mission accomplishment.
- **Clear for the Formation.** Dash-2 is able to clear quadrants that are impossible for lead such as Dash-1's 6 o'clock. Dash-1 should put Dash-2 in route or fighting wing, as appropriate, whenever possible as it allows Dash-2 to clear more effectively.
- **Back Up Dash-1.** A good wingman is ready to take the lead at a moment's notice to accomplish any tasks assigned by lead. Dash-2 should strive to actively monitor navigation, communication, fuel state, mission accomplishment, etc. When Dash-2 is able to consistently back up Dash-1, it usually shows a readiness to become a flight lead. Never let these duties interfere with the higher priority responsibilities. If clearing, being in position or keeping lead in sight is degraded by "backing up lead," immediately reprioritize in the order shown above.

8.2.3. Collision Avoidance.

Although Dash-s 1 and 2 are both responsible for adequate separation, generally *Dash-2 has the primary responsibility for flight path deconfliction within the element unless Dash-2 is unable to maintain visual.* In that case, Dash-2 conveys a blind status to Dash-1. This responsibility does not transfer to Dash-1 unless Dash-2 calls "blind." Periodic cross-check of Dash-2's position will ensure that Dash-1 does not execute a maneuver that will compromise safety should Dash-2 be out of position.

The following factors contribute significantly to the potential for a midair collision:

- ***Failure of Dash-1 to properly clear or visually monitor Dash-2 during a critical phase of flight, such as a rejoin or the extended trail (ET) exercise.*** Dash-1 must monitor Dash-2, either directly or with the mirrors. If Dash-1 loses sight and is uncertain of Dash-2's position, query Dash-2 by requesting "posit" ("Texan 2, posit"). The "posit" call is a question as to the position of Dash-2 relative to Dash-1. Dash-2 responds with his position as in the example: "Texan 2, 5 o'clock, low, 500 feet".

- ***Failure of Dash-2 to execute lost wingman procedures promptly and correctly if visual contact is lost in IMC.*** In IMC, if Dash-2 cannot maintain the close formation position (hereafter referred to as "fingertip"), using normal visual references, or loses sight of Dash-1, initiate appropriate lost wingman procedures as described in this manual.

- ***Failure to recognize excessive overtake.*** During rejoins, compare actual airspeed with the directed airspeed. Use power and (or) speed brakes as necessary. Dash-1 should direct an overshoot or breakout if necessary.

- ***Failure to maintain lateral or vertical separation.*** For turning or straight-ahead rejoins, Dash-2 must maintain lateral or vertical separation until closure rates are under control and stabilized.

- ***Failure to consider the effects of wake turbulence.*** Dash-2 may encounter wake turbulence when maneuvering too close to Dash-1. Control difficulties associated with wake turbulence are very dangerous. Fly within the parameters described in this chapter to avoid them. If encountered, control the aircraft, maneuver away from Dash-1 or perform a breakout as necessary.

8.2.4. Call Signs.

Aircrew of each aircraft in the formation will be assigned a call sign that has a unique word prefix and a two-digit numeric suffix. For example, Texan 1-1 (pronounced "Texan one-one") and Texan 1-2 would be members of Texan 1-1 flight. No two airborne formations should have the same word prefix in their call sign.

During the preflight briefing, the designated flight lead will be given the call sign that ends in 1, and the other flight member will be given the call sign that ends in 2. Under normal circumstances, if the formation breaks up, the aircraft will assume the call signs given in the preflight briefing.

All radio calls to an agency outside the formation should begin with the full call sign which includes the word prefix and the double-digit suffix; for example, "Texan 11 level, one-five thousand." When directing other members of the flight, it is also common to use the full word prefix and single digit suffix of their position in the flight, for example, "Texan 2, break out." When immediately responding to an in-flight directive, Dash-2 may simply use "2" to predicate or concisely answer radio transmissions.

8.2.5. Radio Discipline.

Clear, concise, correct communications are a good indicator of flight discipline. Minimize and combine radio calls on common-use frequencies to reduce radio congestion. Unless otherwise briefed or directed, when communicating with agencies outside the formation, *Dash-1 will speak for the flight until the formation splits up*.

Dash-1 owns the radios; which means Dash-2 will only change frequencies when directed by Dash-1.

- If Dash-1 uses the term "***go***" for a frequency change, Dash-2 will acknowledge before changing the frequency:

"Texan, 11 go channel 5"; acknowledged with " 2"

- If Dash-1 uses the term "***push***," Dash-2 should change to the new frequency without acknowledging

"Texan 11, push channel 5"; no acknowledgment

- Dash-1 can add the suffix ***"victor"*** or ***"uniform"*** for the VHF or UHF radios, respectively calls (for example,

"Texan 11, push channel 2 victor"

If Dash-1 sends Dash-2 to the wrong frequency, Dash-2 should go back to the previous frequency and wait. Dash-2 should never change frequencies without being directed by Dash-1, and Dash-2 should not go hunting for Dash-1 (if Dash-1 and Dash-2 end up on different frequencies).

When in fingertip formation, wingmen should automatically move to the route position when Dash-1 directs a channel change, and they will return to fingertip after being checked in on the new frequency. If in a position wider than fingertip, wingmen will remain in that position unless directed otherwise by Dash-1. If solo in IMC, change the frequency when workload permits. Wait until VMC, if necessary, and use the discrete frequency to communicate within the formation.

When filling the Dash-1 position, do not use the term "lead" when referring to own ship parameters. Use "one," (for example, "Texan, ops check, one is 600, 4 Gs"). The only time the term "lead" should be used over the radio is when executing a lead change (for example, "Texan 2, you have the lead on the right"). Wingmen will normally respond to all directive calls unless briefed otherwise or if the action is obvious. If a radio call is unclear, Dash-2 will query Dash-1.

For traffic calls, transmit call sign, traffic direction (left or right), clock position, elevation (low, level, or high), and an approximate distance. For example, Dash-2 obtains visual contact with a potential traffic conflict: "Texan 1, traffic right, 2 o'clock, 3 miles, slightly high." Military aviators use brevity code words to achieve clear, concise, correct, and effective communication. These code words are listed and defined in *OPERATIONAL BREVITY WORDS & DEFINITIONS*. Common brevity code words which aid in collision avoidance include blind, visual, no joy, tally ho, and padlocked. When referring to aircraft within the formation, use the terminology blind (lack of visual contact) or visual (positive visual contact) as appropriate. When referring to aircraft outside of the formation, use the terminology no joy (lack of visual contact) or tally ho (positive visual contact). Padlocked indicates that the pilot cannot take his or her eyes off an aircraft or ground object without losing sight of that aircraft or object.

8.3 Taxi Operations

2-Ship taxi operations do not differ much from single-ship operations. Only in that now, you must coordinate your movements with your flight lead. There are 2 standard ways of taxing as a formation, Trail & Staggered.

8.3.1 Trail

Flight lead will be in the Dash-1 slot, with his nose wheel on the centerline and establishing the pace of the taxi. All following aircraft will be approximately 2 'plane' lengths away and also centered on the taxiway. This is the most commonly used, as it is the easiest and simplest way to follow the lead aircraft. But it does take up the most space, and can take longer for aircraft to get into position upon reaching the runway.

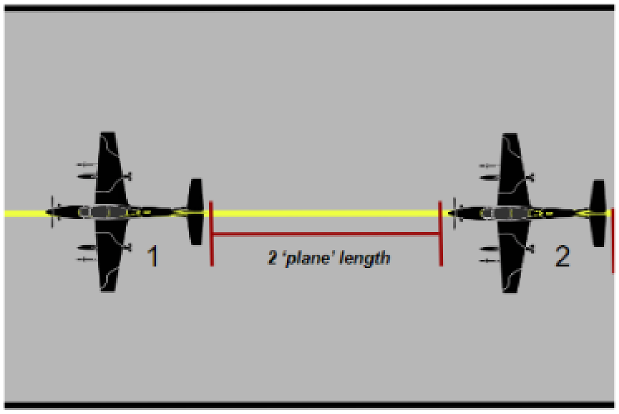

Figure 8.1 (a) Trail Taxi - Diagram

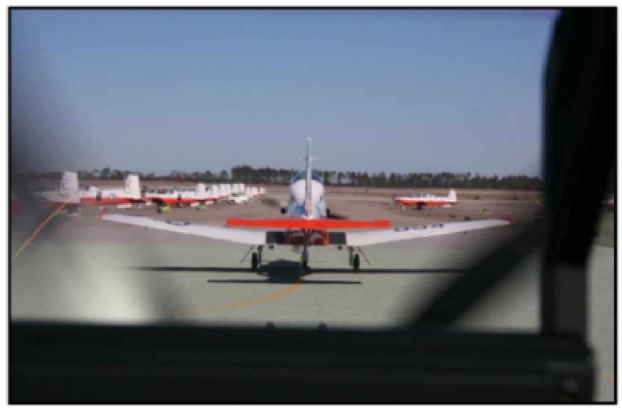

Figure 8.1 (b) Trail Taxi - Point-of-View

8.3.2 Staggered

Lead aircraft will be on the appropriate side (standard is right side), centered in that 'lane'. While the wingman will be centered in the opposite lane, with approximately one 'plane' length between the preceding tail and his nose.

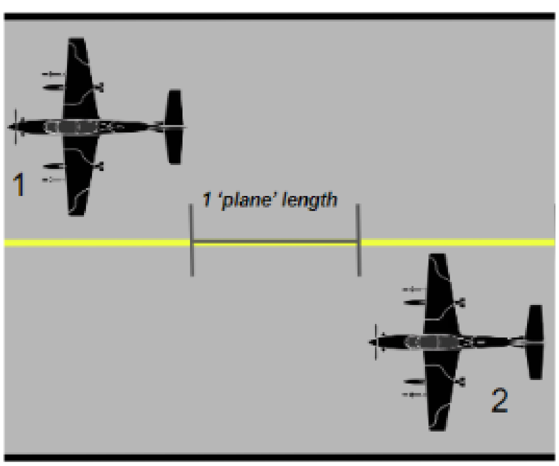

Figure 8.2 (a) Staggered Taxi - Diagram

Figure 8.2 (b) Staggered Taxi - Point of View

8.4. Take off

There are essentially 2 types of formation take-offs, *Staggered* and *Tandem*. Formation take-offs are typically limited to VMC conditions only, when flight members can maintain separation throughout the entire Take-off/Departure process. The line up is the same in either case.

8.4.1 Runway Line-up:

The proper visual cues you are looking for on runway line up as a 2-ship is:

1. Centered on the appropriate side of the runway.
2. In line with the exhaust can/trailing edge of horizontal stab of lead.

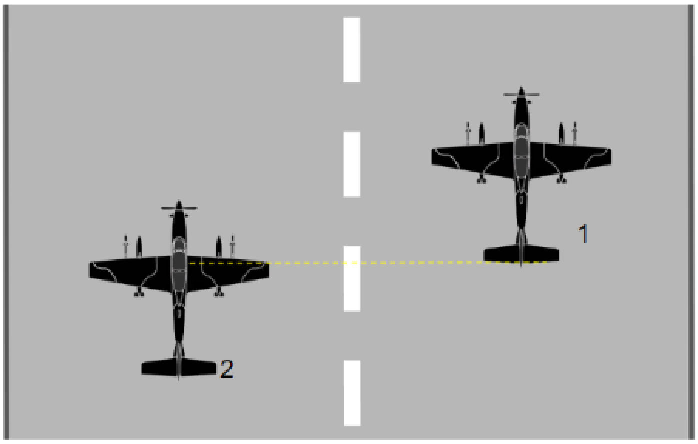

Figure 8.3(a) Runway Line-up - Diagram


Figure 8.3(b) Runway Line-up - Point of View

8.4.2 Staggered Take-off:

This is the typical formation take-off used in a training environment. It is less stressful for the flight members and easier to accomplish. In a Staggered take–off Flight members will take-off together but with a time separation to develop a safety margin during take-off. Typically between 5-9 sec, at the Flight Leads discretion. Timing is briefed ahead of time.

Comm's Example (7sec spacing):

Hammer 1-1 Pri: *"Nellis Traffic, Hammer Flight, 2-Ship, Take-off Runway 09, departing to the north"*

Hammer 1 Aux: *"Hammer Flight, Run it up" ... "1, Green Jet"*

Hammer 2 Aux: *"2, Green Jet"*

Hammer 1 Aux: *" 1, Rolling"*

Hammer 2 Aux: (7 sec later) *"2, Rolling"*

8.4.3 Tandem Take-off:

This is an advanced formation technique. In a Tandem take-off, flights will begin the take-off roll together and takeoff simultaneously. For this type of take-off, coordination is key. Brakes release, rotation, Landing Gear movement all need to be coordinated. To do this, there is a standard comm language and cadence that facilitates this.

"Brakes, Brakes, Brakes" - After the 3rd repetition, is the signal for brake release.

"Rotate" - Signal to rotate to Take-off attitude

"Gear Up" - Signal to raise landing gear and flaps into cruise configuration.

Comm's Example :

Hammer 1-1 Pri: *"Nellis Traffic, Hammer Flight, 2-Ship, Take-off Runway 09, departing to the north"*

Hammer 1 Aux: *"Hammer Flight, Run it up"* ... *"1, Green Jet"*

Hammer 2 Aux: *"2, Green Jet"*

Hammer 1 Aux: *"Brakes, Brakes, Brakes"…"MAX Power"…"Rotate"… "Gear Up"*

8.5 In-flight Checks.

Dash-1 and Dash-2 perform the checklist appropriate for the phase of flight (ops check, descent check, etc.). Use the intraflight radio to initiate checks if practical. If forced to turn during a check, Dash-1 should call the turn and ensure Dash-2 is attentive before turning. Dash-2 resumes the check after the turn is complete. In-flight checks are normally accomplished in the following manner:

Dash-1. Allow enough time for Dash-2 to complete the check. Check Dash-2 in with a visual signal or a radio call. On the radio, check in by transmitting call sign and OBOGS status for the climb check and total fuel for ops checks and descent check (for example, "Texan 1, OBOGS good" or "Texan 1, 800").

Dash-2. Dash-2 will acknowledge Dash-1's visual signal or radio call to initiate checks, move to route spacing (if the check was directed while in fingertip and weather allows), and perform the appropriate checklist items. Accomplish the check one item at a time, checking position on Dash-1 between each item. Prioritize tasks. Fly formation first and accomplish checklist items as workload permits. During turns, fly the aircraft and resume the check after the turn is complete.

8.6 Fuel Awareness.

All flight members must understand the factors and assumptions used to determine joker and bingo fuels. Flight members should increase the frequency of fuel checks during high fuel flow ops (ET, low altitude) and when approaching joker and bingo fuels.

Dash-1 must continually monitor the flight's fuel state and adjust the profile, frequency of ops checks, and joker or bingo as necessary. Unless already on the recovery, Dash-2 will inform Dash-1 when reaching joker and (or) bingo fuel, and Dash-1 will acknowledge the call.

8.7 Lost Sight "Blind" Procedures.

When flying in close or route spacing, anytime a wingman loses sight of lead and is unable to immediately regain visual, inform lead with a BLIND radio call and execute the appropriate lost wingman procedure.

8.7.1 Wings-Level

1. Inform lead.
2. Simultaneously *turn away 30 degrees from the last known heading and hold heading for 30 seconds*.
3. Resume heading.

8.7.2 Outside of Turn

1. Inform lead.
2. Simultaneously *reverse the turn 30 degrees from the last known heading and hold heading for 30 seconds*.
3. Continue straight ahead and ensure separation before resuming the turn.

8.7.3 Inside of Turn

1. Reduce power to ensure nose-tail separation.
2. Simultaneously inform the lead to roll out of the turn.
3. Maintain existing bank angle to ensure lateral separation.

8.8 Lead Changes.

Dash-1 and Dash-2 exchange formation positions. As previously explained, the designated flight lead retains his responsibility and authority throughout the mission. That role is not affected by a lead change.

Procedure. Lead changes can be made with the formation in many flight attitudes. Dash-1 will call or signal for the lead change. If in fingertip, Dash-2 will move out to route, then assume a route position near line abreast (LAB) and approximately two ship widths. If the formation is already in route or greater spacing, Dash-1 may use the radio to transfer the lead. Dash-2 will acknowledge the lead change and become the new Dash-1 regardless of the method of lead transfer (visual signal or radio call). If Dash-1 uses a radio call to initiate the lead change, the new Dash-1 accepts the Dash-1 position with a radio call.

When a lead change is initiated from fingertip, Dash-2 moves out and forward to ensure wingtip separation. Dash-2 accepts the lead after reaching a position abeam Dash-1 and immediately assumes responsibility as the new Dash-1. The old Dash-1 will assume wingman responsibilities. Unless changed by the new Dash-1, the formation will remain in the position from which the lead change was initiated. For example, if the lead change was initiated from route, the flight will remain in route. If Dash-1 uses a radio call to initiate the lead change, the new Dash-1 accepts the Dash-1 position with a radio call. If the old Dash-1 uses a visual signal, the new Dash-1 accepts the Dash-1 position with a head nod.

The new Dash-1 turns on the TAS and switches the transponder to ALT after assuming the Dash-1 position. The new Dash-2 will turn off the TAS and switch the transponder to STBY following the lead change but must prioritize tasks. Wingman consideration dictates that after completing the lead change, the new Dash-1 utilizes a power setting that allows the new Dash-2 to stabilize in the assigned position.

8.9. Intercept/Rejoin Theory

Common terminology and concepts applicable to formation flight are used throughout the Air Force. The following are fundamental concepts:

8.9.1 Heading Crossing Angle (HCA) .

The angular difference between the longitudinal axes of two aircraft. (HCA is also synonymous with the term angle off.)(Figure 8.4)

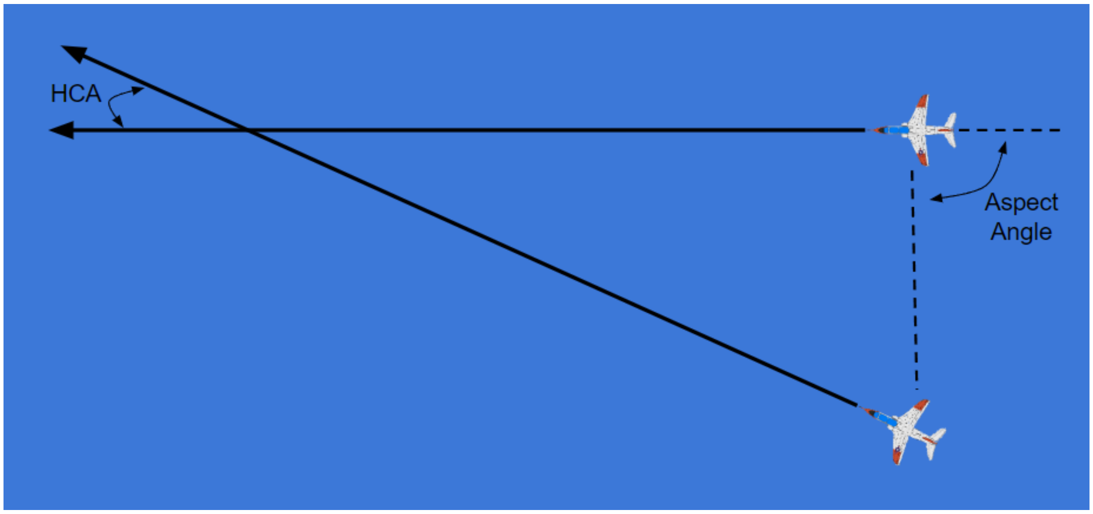

Figure 8.4 HCA and AA.

8.9.2. Aspect Angle (AA)

Aspect is expressed in degrees off the tail of the reference aircraft, commonly expressed in multiples of 10. For example, at 6 o'clock to the reference aircraft, the aspect is zero. At 40 degrees left, the aspect is "4L." AA is not a clock position and is independent of aircraft heading. Two important AAs used extensively in T-45 training are 30 and 45 degrees (Figure 8.6). (Note the position of the vertical stabilizer on the outside wing.) (Figure 8.4 & Figure 8.6).

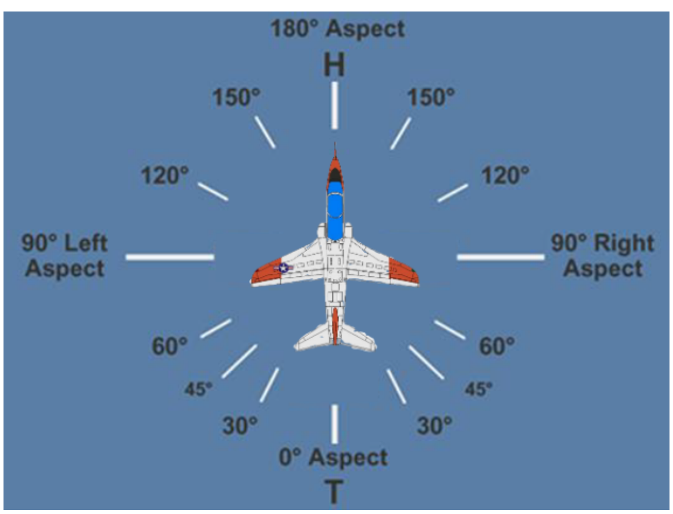

Figure 8.5 Aspect Angle

Figure 8.6 - 40° Aspect Angle

8.9.3. Closure.

Overtake created by airspeed advantage and (or) angles; the rate at which range decreases. Closure can be positive (decreasing range) or negative (increasing range), and is usually measured by the velocity rate (knots) at which the range increases/decreases.

8.9.4. Lift Vector

The vector that is always positioned straight through the top of the canopy. The magnitude is based on G loading.

8.9.5. Velocity Vector

Where the aircraft is going. The magnitude of the velocity vector is controlled by changing airspeed.

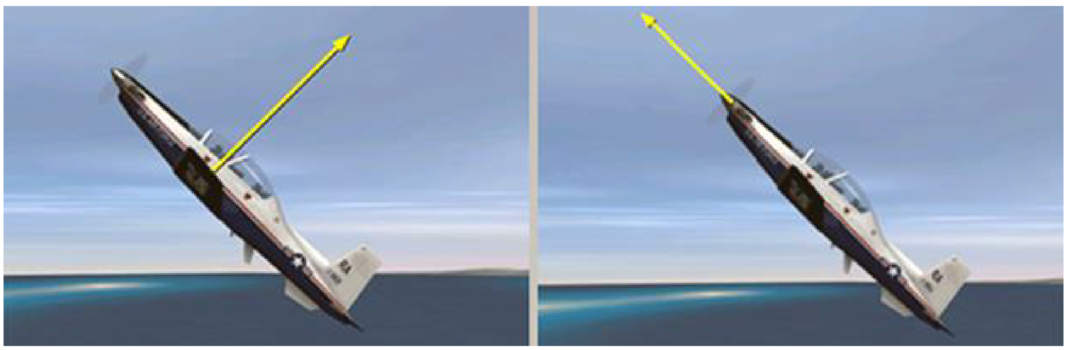

Figure 8.7 Lift and Velocity Vectors.

8.9.6 Line of Sight (LOS).

A straight line from the pilot's eye to another aircraft. Commonly expressed as “forward LOS” (other aircraft moving forward on canopy toward the nose) and “aft LOS” (other aircraft moving aft on the canopy toward the tail).

8.9.7 LOS Rate.

The speed at which forward or aft LOS is occurring, expressed with adjectives rather than a unit of measurement.

8.9.8 Plane of Motion (POM).

The plane containing the aircraft flight path. In a level turn the aircraft's POM is parallel to the ground, regardless of bank angle. In a loop the POM is perpendicular to the ground.

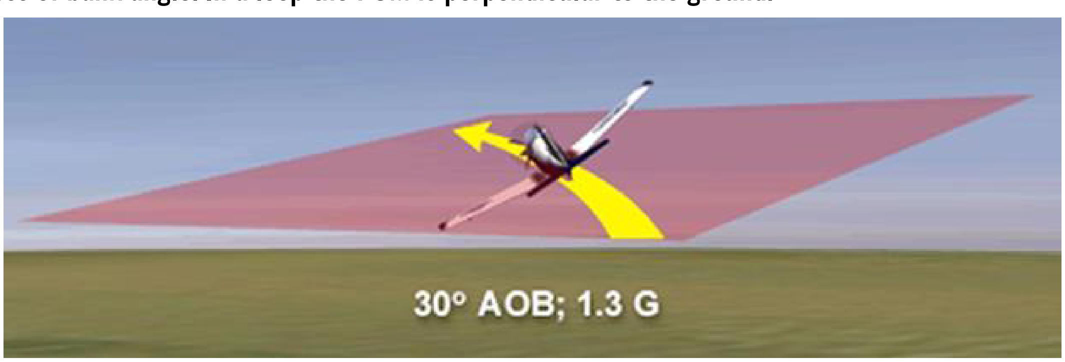

Figure 8.7 POM.

8.9.9 Lead Pursuit

Dash-2 aims the nose of the aircraft in front of Dash-1's flight path. With enough lead pursuit, AA and closure will increase, and HCA will decrease. Various lead pursuit pictures may result in aft LOS, no LOS, or minimal forward LOS depending on the magnitude of lead pursuit and other parameters such as relative airspeed and G.

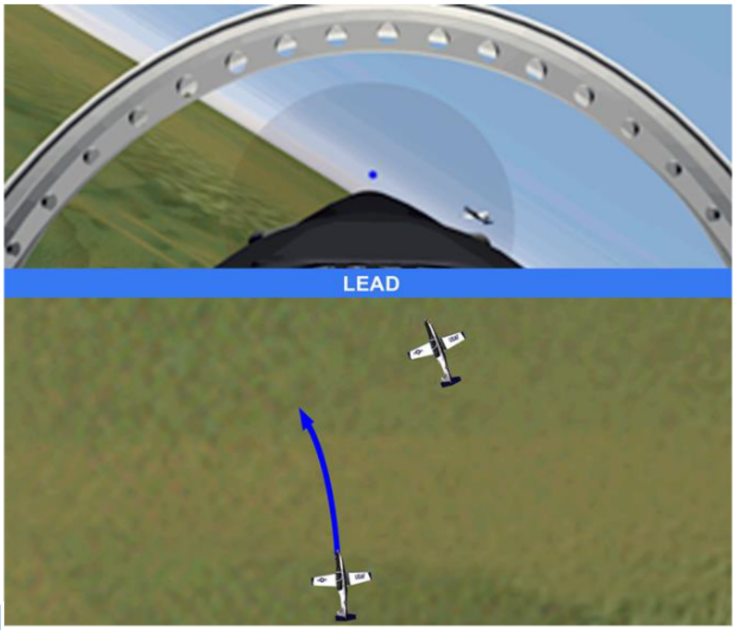

Figure 8.8 Lead Pursuit

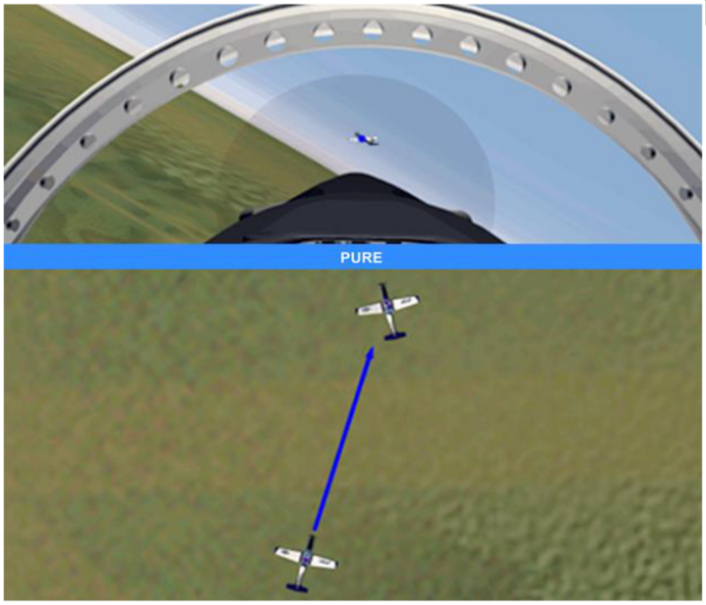

Figure 8.9 Pure Pursuit

8.9.10 Pure Pursuit

Dash-2 aims the nose of the aircraft directly at Dash-1. In pure pursuit there is initially no LOS; the other aircraft remains fixed at 12 o'clock in the canopy. A pure pursuit picture initially creates closure that diminishes over time. AA equals HCA, which also both diminish over time. If both aircraft are co-airspeed, an attempt to sustain pure pursuit eventually evolves into lag pursuit, resulting in increasing range and a decreased AA.

8.9.11 Lag Pursuit

Dash-2 aims the nose of the aircraft behind Dash-1's flight path. Although there may still be some closure initially, closure soon decreases, AA decreases, and HCA increases.

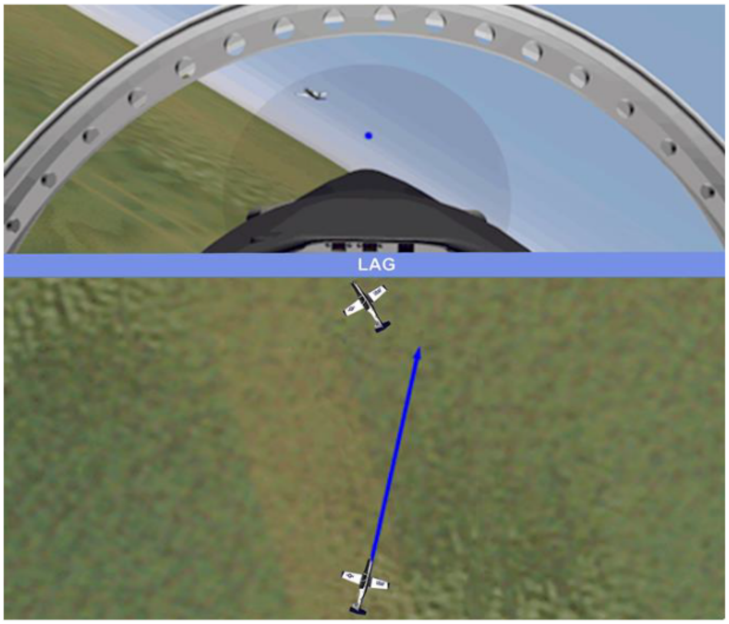

Figure 8.10 Lag Pursuit

8.9.12. Aircraft 3/9 Line

This is an imaginary line extending from the aircraft's lateral axis (parallel to the wings and perpendicular to the fuselage). The Dash-s "3" and "9" have reference to clock position. Dash-2 should normally remain aft of Dash-1's 3/9 line during maneuvering. This line equates to a 90-degree AA (9 aspect).

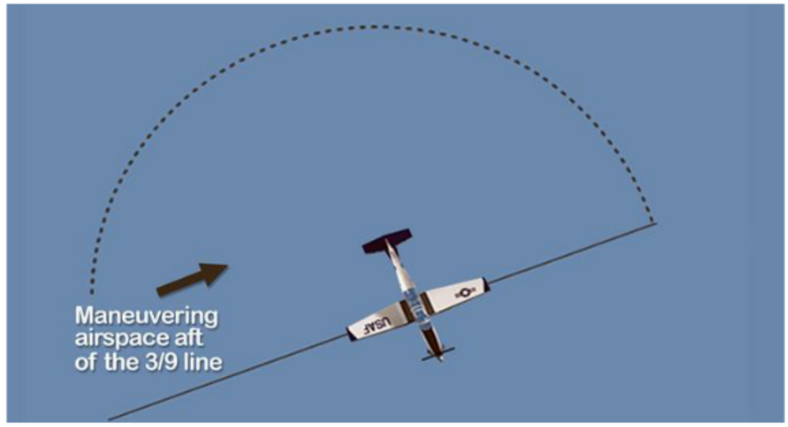

Figure 8.11 3/9 Line

8.9.13. Turn Circle.

As an aircraft maneuvers in a turn, the flight path describes an arc, referred to as a turn circle.

8.9.14. Turn Rate.

This is the rate of heading change (nose track), normally measured in degrees per second. At about 10,000 feet MSL, at 30-degree bank, 180 KIAS (for example, a normal rejoin), the T-45 turn rate is approximately 3 degrees per second.

8.9.15. Turning Room.

This is the volume of airspace (vertical and horizontal) that is available to execute maneuvers that change aspect, angle off, and closure. In the T-45, turning room is mostly used aft of the 3/9 line.

8.9.16. Safe Airspace.

Generally, this is an area where any immediate threat of collision is unlikely if an out-of-plane maneuver is initiated. Pulling toward Dash-1's high six o'clock is a common example of safe airspace for Dash-2.

8.9.17. Lag Reposition (High Yo-Yo)

A high yo-yo is a reposition of Dash-2's aircraft that uses various combinations of pursuit and a move out-of-plane above Dash-1's POM to control closure and aspect to prevent a potential 3/9 line overshoot. It creates turning room by using the vertical POM (out-of-plane). Creating a large HCA will result in a rapid increase in range.

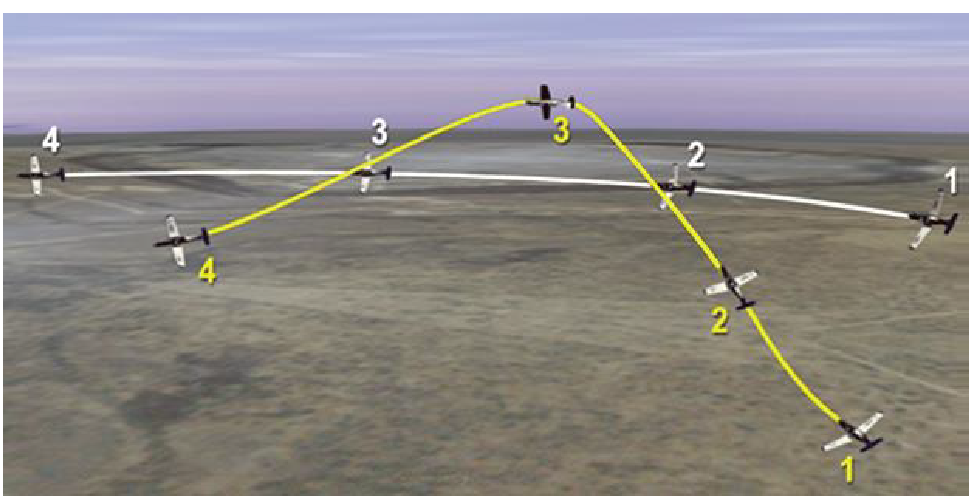

Figure 8.12 High Yo-Yo.

8.9.18. Quarter Plane

A quarter plane is an aggressive, last ditch, out-of-plane lag maneuver used to control closure and aspect in order to preserve the 3/9 line. In a true quarter plane, Dash-2 establishes a POM that is 90 degrees to Dash-1's POM. This situation may be caused by a late decision (or no decision) to execute a high yo-yo or a failure to control closure and aspect. Indicators that a quarter plane is needed are similar to those of a high yo-yo. However, aspect, HCA, range, and closure cues are more significant and require a much more aggressive maneuver than a lag reposition. A large HCA will result in a rapid increase in range. Caution should be used to maintain visual contact with Dash-1 throughout the reposition maneuver.

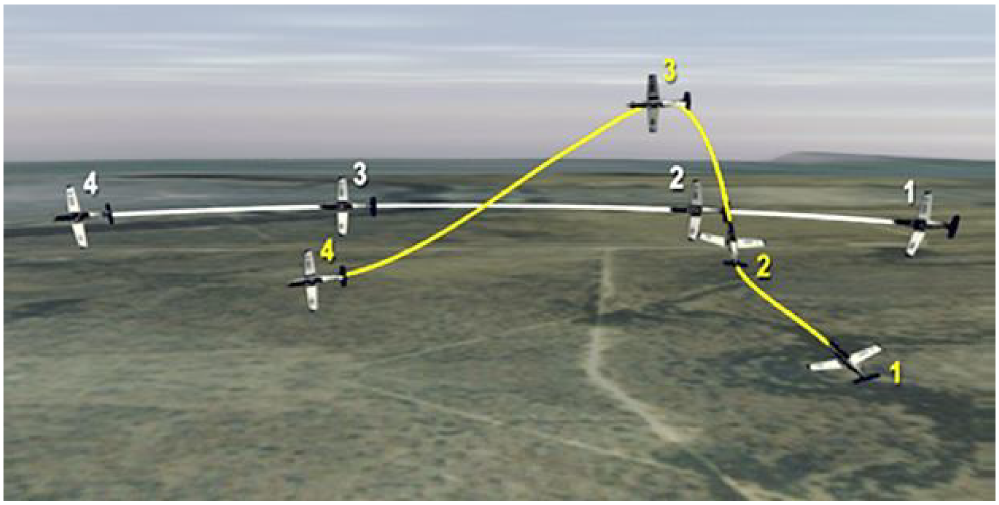

Figure 8.13 Quarter Plane.

8.9.19 Lead Reposition (Low Yo-Yo)

A low yo-yo is a reposition of Dash-2's aircraft, using various combinations of pursuit and a move out-of-plane below Dash-1's POM to increase closure and AA.

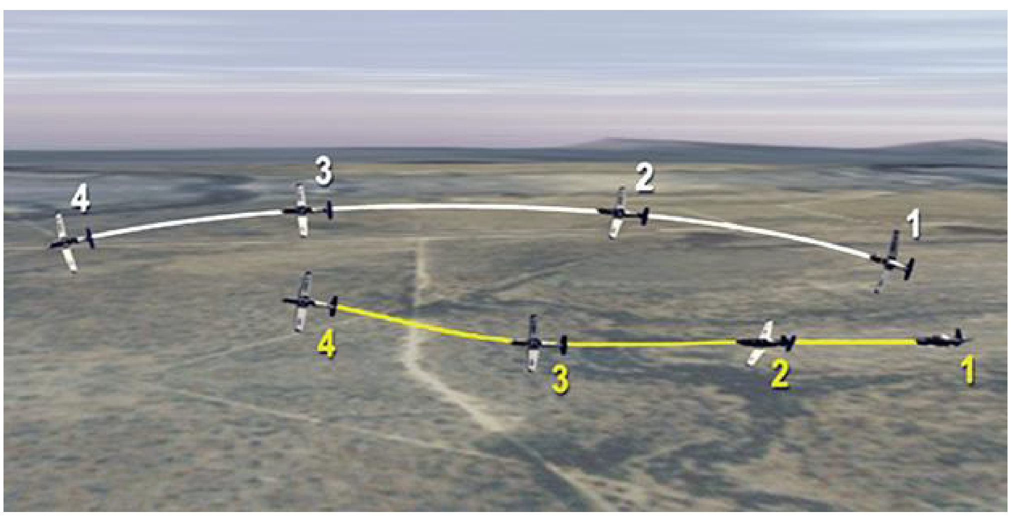

Figure 8.14 Low Yo-Yo.

8.10 Basic Administration Type Formations

Essentially, formation flying is nothing more than controlling the relative motion between aircraft. Lead is considered to be fixed, and any movement between aircraft is considered movement of the Wingman in relation to the Lead. In the Contact stage, the horizon is used as the primary attitude reference. In Formation, Lead's aircraft becomes the primary reference for attitude control for their wingman.

This section describes the basic administrative formations and positions. Positions are defined with regard to the formation position and the formation spacing.

- The basic formation positions are:
  - Fingertip
  - Echelon.
- The basic spacing options are:
  - Close
  - Route.

8.10.1 Fingertip

Fingertip formation is used for weather penetration, airfield arrivals and departures, and show formations. The fingertip position is flown on an angle approximately 30 degrees aft of the 3/9 line (equates to a 6 AA), with approximately 10 feet of wingtip separation. It is the closest that number 2 will be to number 1 during formation flying. Therefore, maintaining the proper position is critical to flight path deconfliction. In fingertip, the contract is that number 1 will fly a smooth aircraft, and number 2 will adjust to maintain proper position.

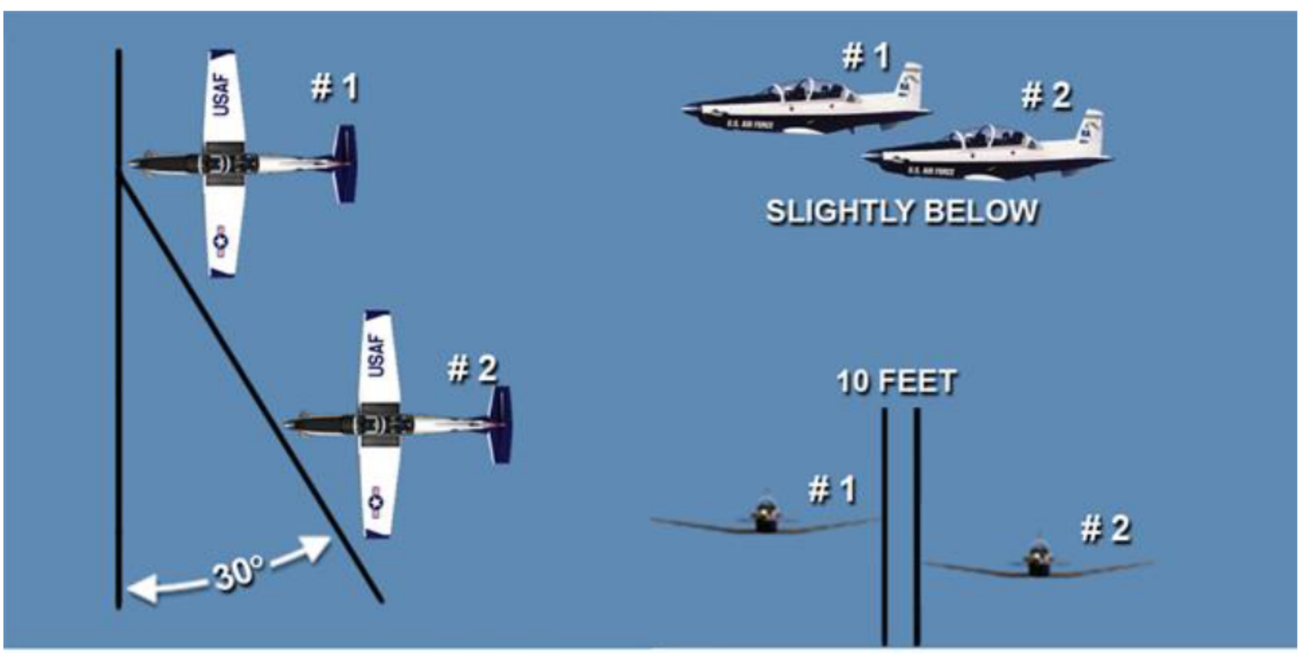

Figure 8.15 Finger-Tip Formation Position

Turning while in Fingertip. Wingmen maintain their position with the roll, and climb or dive respectively with their position in the turn.

Figure 8.16 Finger-Turn Into and Away Positions

8.10.2 Echelon

Echelon is a multi-ship formation where all wingmen are on the same side of the formation. Lead directs the flight into echelon by dipping a wing in the desired direction or making a radio call ("Sling, echelon left/right").

Figure 8.17 Echelon Formation

Echelon turns can be performed at a variety of airspeeds. A common technique as lead is to initiate echelon turns between 300 to 350 KCAS and to minimize throttle movements during the turn in order to give the wingmen a more stable platform to follow. Unless pre-briefed (like turns in the VFR overhead pattern), lead normally directs echelon turns with a radio call. In a three or four ship formation, an echelon turn is implied when the wingmen are on the same side. All aircraft must be very aware of the importance of smooth corrections, positive backstick pressure, and the need to avoid unloading while in the turn.

Figure 8.18 Echelon Turn

Except for very gentle turns into the echelon, *always turn away from the echelon* and plan to limit the AOB to 60 degrees maximum. Once established in a turn, the horizon should split lead's aircraft. Use power to make fore/aft corrections, backstick pressure to maintain horizontal spacing, and bank to make corrections up or down.

8.11 Formation Position

8.11.1 Close Spacing

8.11.1.1 A-29B Close Spacing

In the A-29B, Dash-2's primary FCP reference to maintain proper vertical (up and down) position is to place the exhaust stack on top of Dash-1's closest wing. Dash-2's primary reference to maintain proper longitudinal (fore and aft) position is to center Dash-1's aft portion of the wingtip on the front edge of the engine exhaust stack opening and align Dash-1's pitot tube with the aft edge of the engine exhaust stack opening (which should be visible above the wing). Dash-2's primary reference to maintain proper lateral spacing (distance between Dash-1 and Dash-2) is when Dash-2's FCP pilot is aligned with the forward edge of Dash-1's horizontal stabilizer and the rudder hinge. This lateral reference maintains approximately 10 feet of wingtip spacing between the aircraft.

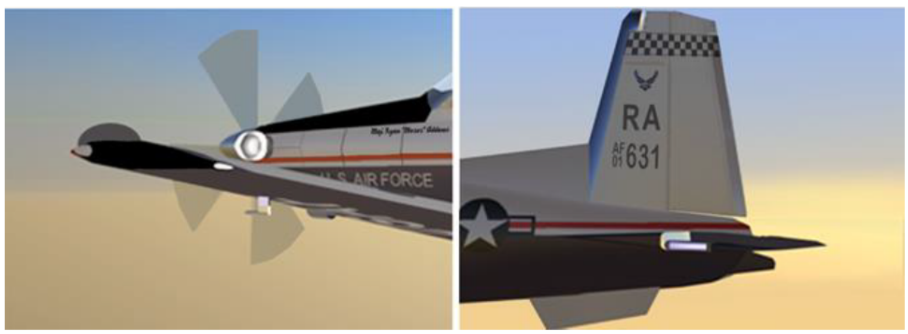

Figure 8.19 A-29B Close Spacing References

8.11.1.2 T-45 Close Spacing

Wing will maintain a position from which the front cockpit (FCP) pilot aligns the closest wingtip light with and just beneath the rear pilot's helmet / rear seat head pad, and directly abeam the engine exhaust can's.

Figure 8.20 T-45C Close Spacing References.

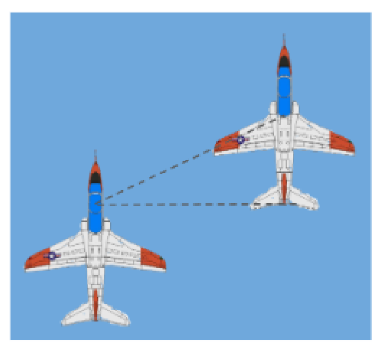

Figure 8.21
T-45C Close Formation Spacing

Good close spacing is the result of recognizing deviations, anticipating required control inputs, and applying deliberate corrections. Make continuous, small, and controlled corrections to stay in position. Keeping the aircraft trimmed and coordinated decreases workload and generally makes it easier to maintain position. Dash-1 should maintain a constant power setting or make smooth power changes, so Dash-2 can make small, precise power changes instead of large changes. Power corrections usually require three PCL movements: one to start the correction, one to stop the aircraft, and finally one to stabilize the aircraft in the proper position.

8.11.2 Route Spacing.

A route formation (Figure 8.21) is flown to enhance clearing and visual lookout, increase flight maneuverability, and ease the completion of inflight checks, radio changes, and other cockpit tasks. Lead will send wingmen to route with a radio call or visual signal. Route is flown from two wing-widths of spacing out to approximately 500 feet. Fly no farther aft than the extended fingertip line, no further forward than line abreast, and, when wings level, maintain a level stack. On the inside of a turn, stack below lead's POM only as necessary to keep lead in sight. On the outside of a turn, maintain the same vertical references used in echelon. Lead should limit bank angle to 60 degrees with wingmen in route. During a climb, the wingman should strive to stack slightly high signaling to lead that the wingman has more power available.

Route LAB. When LAB, strive to remain between the extended 3/9 line and approximately 10 degrees aft of LAB. Typically, Route is flown LAB and out toward the 500-foot limit when weather conditions are not a factor, and when visual clearing, flight path deconfliction and maneuvering are formation priorities. LAB at 2-4 wing widths is typically flown when anticipating a turn away while in route (echelon turn).

Turns In Route. When inside a turn, Dash-2 maneuvers below Dash-1's POM only as necessary to keep Dash-1 in sight just above the canopy rail. On the outside of a turn, Dash-2 maintains the same vertical references used in echelon turns. As in fingertip, Dash-2 will not cross to the opposite side unless specifically directed to do so verbally or by a crossunder signal from Dash-1.

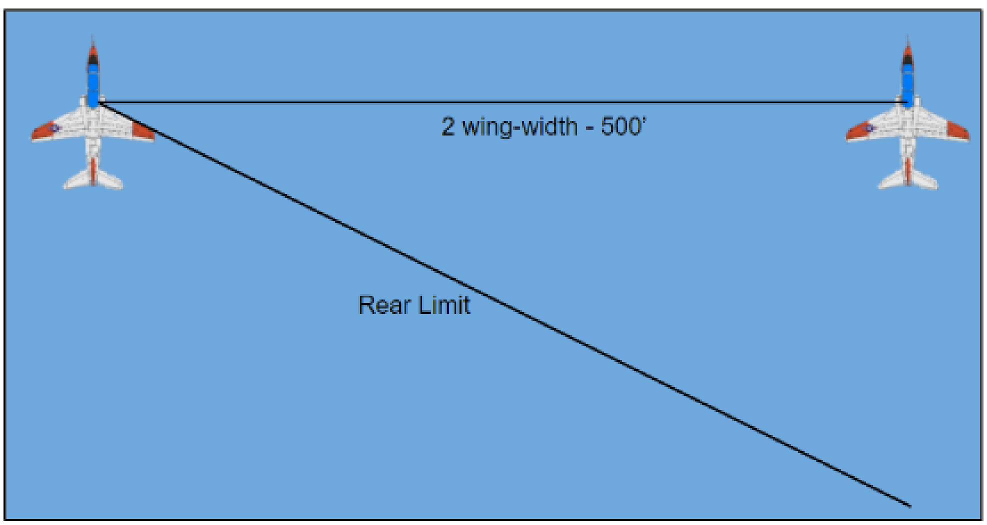

Figure 8.22 Route.

8.11.3 Corrections

Essentially, formation flying is nothing more than controlling the relative motion between aircraft. Lead is considered to be fixed, and any movement between aircraft is considered movement of the Wingman in relation to the Lead. In the Contact stage, the horizon is used as the primary attitude reference. In Formation, Lead's aircraft becomes the primary reference for attitude control for their wingman. Relative motion can be resolved into movement about any one or combination of all three axes.

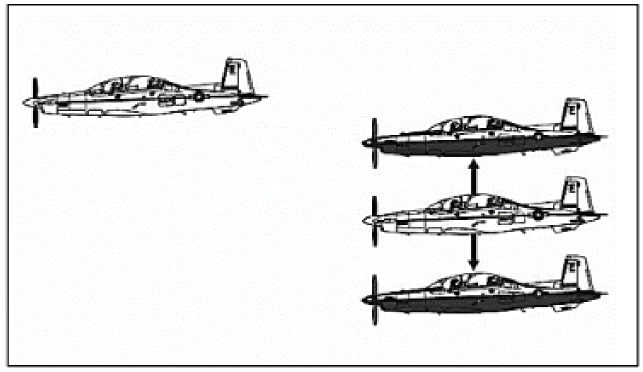

Figure 8.23 Vertical Movement

Vertical movement is primarily controlled by elevator inputs to climb/descend relative to Lead.

Horizontal movement can be controlled by using power to move fore/aft and by using aileron to move left/right relative to Lead.

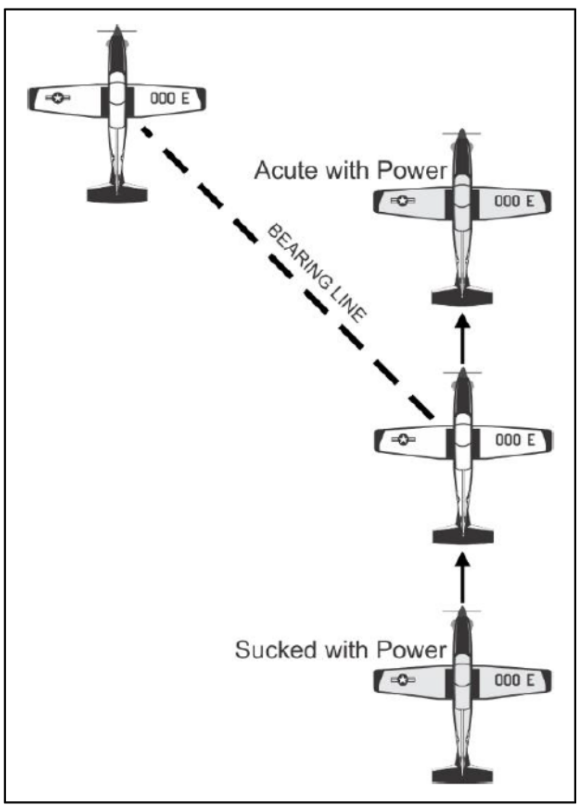

Figure 8.24 Horizontal Movement with Power

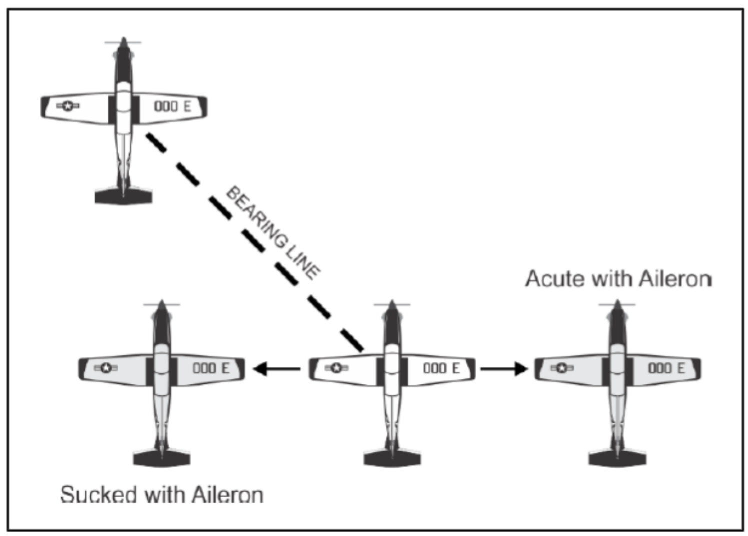

Figure 8.25 Horizontal Movement with Aileron

Strive to maintain perfect positioning, but understand that Wing will only be there for a fleeting moment. The best formation pilots in the world rarely maintain position for an extended period of time. What makes a good formation pilot is the ability to recognize and limit deviations and make timely and efficient corrections.

8.12 Crossunder

Two-Ship Crossunder. Except for pre-briefed events, lead normally directs a crossunder with a radio call. When using a wing dip signal, the size of lead's signal should be appropriate for the distance to the wingman. On lead's signal, the wingman reduces power as required until a small forward line-of-sight (LOS) rate develops. The wingman will move back and slightly below lead's POM and add power to stop lead's forward LOS. He or she will then move across and behind lead with a minimum of nose-tail clearance, adding power as required so as not to fall any further behind. Once on the opposite side and with wingtip clearance, the wingman will add power to move up and forward into fingertip (Figure 8.22).

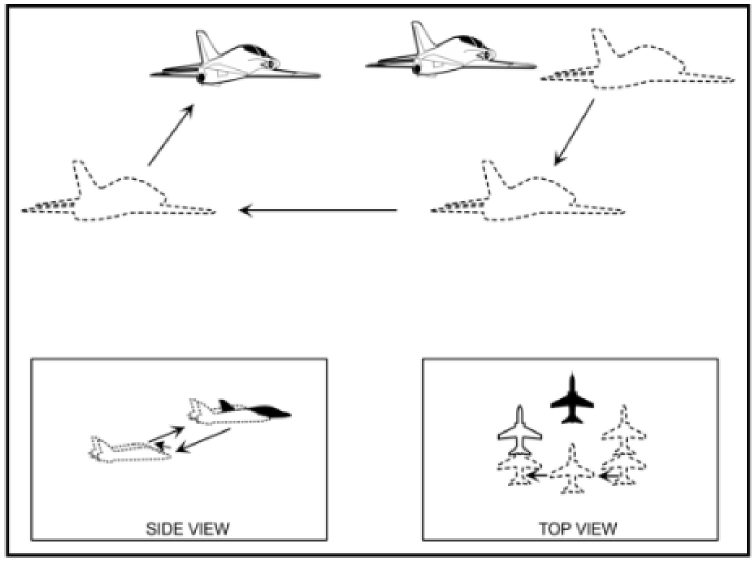

Figure 8.26 Box Crossunder

8.13 Reforms.

Reforms are commonly used when Dash-1 desires to bring Dash-2 in from close trail, fighting wing, or route. Reforms may be to route or fingertip. Dash-1 directs a reform with a radio call or visual signal (wing rock). The size of the wing rock is based on distance between aircraft and may use slight climbs or descents when necessary for energy management or area orientation. The procedure for accomplishing a reform varies based on Dash-2's position and distance relative to Dash-1. To reform from route to fingertip, maneuver as necessary to stabilize at a 2-ship width route position on the fingertip line, and then slowly move up the line to fingertip. Guidance on reforms from fighting wing and close trail are found in their respective sections of this chapter.

8.14 Rejoins.

Rejoins are commonly practiced from pitch outs and after Dash-2 has taken spacing. They are also accomplished after breakouts, practice lost wingman, instrument trail departures, and lost-sight situations (anytime the formation is split).

Procedure. Dash-1 initiates rejoin with radio call or visual signal and may use slight climbs or descents during a rejoin when necessary for energy management or area orientation. Dash-1 should consider using a radio call to initiate a rejoin when Dash-2 is not in sight. All rejoins are to fingertip unless directed otherwise by Dash-1. Unless otherwise briefed, rejoin airspeed in the T-45 is 250 KIAS. Dash-1 calls out current airspeed if it differs more than 10 knots from briefed or expected rejoin airspeed. The size of the wing rock is based on distance between aircraft. Dash-1 should monitor Dash-2 closely during all rejoins. If Dash-1 perceives an unsafe situation developing at any time during the rejoin, take positive action immediately to prevent a midair collision.

8.14.1 Straight-ahead Rejoin.

Use straight-ahead rejoins when a turn is not possible or practical. Airspeed closure is used to effect a straight-ahead rejoin. Dash-1 should maintain a stable platform (level, climbing or descending), clear and monitor Dash-2 during the rejoin.

Dash-1. Direct the rejoin. If a turn is required after a straight-ahead rejoin is initiated, inform Dash-2 and clear. Do not turn into Dash-2 if it would exceed Dash-2's capabilities or prevent a safe rejoin. Due to the location of Dash-2 behind and below Dash-1, Dash-2 will be difficult to see until the final stages of a straight-ahead rejoin.

Dash-2. Rejoin to the left side unless directed otherwise. Increase airspeed to generate closure (initially use 20 to 30 knots of overtake). Establish a position behind and slightly below Dash-1 with a vector toward Dash-1's low 6 o'clock position. Placing Dash-1 slightly above the horizon will help maintain separation from Dash-1's wake turbulence. Continue to close until approximately 500 feet (when details on Dash-1's aircraft, such as the pitot tubes, can be seen). At this point, bank slightly away from Dash-1 ("make a bid"), toward a position two to four ship widths out from Dash-1's wingtip. The velocity vector should angle away from Dash-1. Decrease overtake with a power reduction, and plan to arrive in the route position with the same airspeed as Dash-1. As a technique, reduce the power such that the throttle moves aft to match Dash-1's aft LOS in the windscreen. After stabilized in route, move into fingertip. If Dash-1 turns during a straight-ahead rejoin, transition to a turning rejoin, and be alert for possible overshoot situations.

8.14.2 Turning Rejoin.

Use a combination of airspeed and angular closure to effect a turning rejoin.

Dash-1. Direct the rejoin. If using a wing rock, attempt to make the first wing dip in the direction of the rejoin. Maintain 30 degrees of bank unless otherwise briefed. After a pitchout, delay long enough for Dash-2 to roll out in trail. Establish a turn, maintain bank angle, and rejoin airspeed in level flight. Bank and pitch may be varied if required for area orientation. A slight climb or descent is acceptable for energy management. Monitor Dash-2's AA and closure. Be ready to take evasive action if required.

Dash-2. Base closure and desired aspect on energy and aircraft position relative to Dash-1. When Dash-1 starts to turn, begin a turn in the same direction to intercept the desired aspect. Simultaneously establish desired vertical separation (place Dash-1 within approximately two widths of the horizon) and closure. Manage aspect with minor adjustments to bank angle. Dash-1 must be visible to pilots in both cockpits.

Begin with approximately 20-30 knots of closure and a moderate lead pursuit picture (pull nose in front of Dash-1) to increase aspect. As Dash-2 moves inside of Dash-1's turn circle, the vertical stabilizer appears to move toward Dash-1's outside wingtip as AA increases. When the vertical stabilizer approximately bisects the outside wing (3 aspect/30 degrees AA), reduce bank angle to maintain this relative reference line. When stable, there is no LOS.

If the vertical stabilizer appears to move toward the wingtip, AA is increasing. If the vertical stabilizer appears to move toward the wing root, the AA is decreasing. Use varying degrees of bank angle to manage aspect during a rejoin. Shallow the bank angle to decrease aspect and increase the bank angle to increase aspect. As range decreases toward close spacing, the vertical stabilizer will appear to move toward the outside wingtip.

Dash-1 should appear slightly above the horizon. Maintain Dash-1 within approximately two relative ship widths above the horizon. The star on the left wing (or the "SA" in USAF on the right wing) should be directly over the star on the aft fuselage. This is referred to as the "saddle" between where the leading edge of the vertical stabilizer meets Dash-1's fuselage and the aft portion of Dash-1's canopy.

The critical stage of the rejoin begins approximately 500 feet from Dash-1. Inside 300 to 500 feet, the normal close (fingertip) fingertip references will become visible. Descend slightly and move forward (increase aspect with lead pursuit) onto an extension of the fingertip reference line. Begin decreasing closure with a power reduction and speed brake as necessary. Monitor bank and overtake closely during the last few hundred feet to ensure aspect and closure are under control. Plan to stabilize in route with slight positive closure but approximately co-airspeed with Dash-1, and then move into fingertip at a controlled rate.

During two-ship formation ops, unless pre-briefed or directed otherwise, Dash-2 normally rejoins to the inside of the turn. To rejoin to the outside of the turn the event will either be pre-briefed or directed. Dash-2 may request to rejoin on the outside, and Dash-1 may consent on the radio. Rejoins to the outside of the turn are initially flown exactly like rejoins to the inside of the turn. In the later portion of the rejoin, Dash-2 will cross below and behind Dash-1 with at least nose-tail separation to get outside of Dash-1's turn circle. Maintain enough positive closure (about 10-15 knots) to facilitate this move to the outside. Stabilize in route echelon on the outside and then move into finger-tip at a controlled rate.

8.15 Overshoots.

Objective. Safely dissipate excessive closure and (or) aspect.

Description. A properly flown overshoot will safely dissipate excessive closure and (or) aspect during a rejoin. Dash-2 must not delay an overshoot with an unusually aggressive attempt to save a rejoin.

Procedure. Keep Dash-1 in sight at all times during any overshoot. Reduce power and use speed brake (if required) as soon as excess overtake is recognized.

8.15.1 Straight-ahead(Running) Rejoin Overshoot.

A straight-ahead(running) rejoin is a result of excessive closure rate which results in a pure airspeed overshoot. Maintain lateral spacing on a parallel or divergent vector to Dash-1. Do not turn into Dash-1, which is a common error while looking over the shoulder at Dash-1's aircraft. This can cause a vector into Dash-1's flight path and create a dangerous situation requiring a breakout. A small, controllable 3/9 line overshoot is easily managed and can still allow an effective rejoin. There is no need to breakout if flight paths are not convergent and visual contact can be maintained. After beginning to slide back into formation, retract the speed brake and increase power prior to achieving co-airspeed (no LOS) to prevent excessive aft movement.

8.15.2 Turning Rejoin Overshoot.

A turning rejoin with excessive closure airspeed results in a combination airspeed/aspect overshoot in a POM about 50 feet below Dash-1. Attempt to overshoot early enough to cross Dash-1's 6 o'clock with a minimum spacing of two ship lengths. Breakout if unable to maintain nose-tail separation. Reduce power and use speed brakes as required. Once outside the turn, use bank and back stick pressure as necessary to stabilize in route echelon position. Fly no higher than route echelon. Excessive back pressure causes closure. A co-airspeed overshoot due to excess aspect may not require maneuvering outside of Dash-1's turn circle. Instead, there may be sufficient space in Dash-1's low 6 o'clock to align fuselages and stop the overshoot. When under control with no aft LOS, complete a crossunder to the fingertip position (or as directed) on the inside of the turn. If aft LOS is not adequately controlled, #2 may need to reestablish the rejoin line inside #1's turn and complete the turning rejoin.

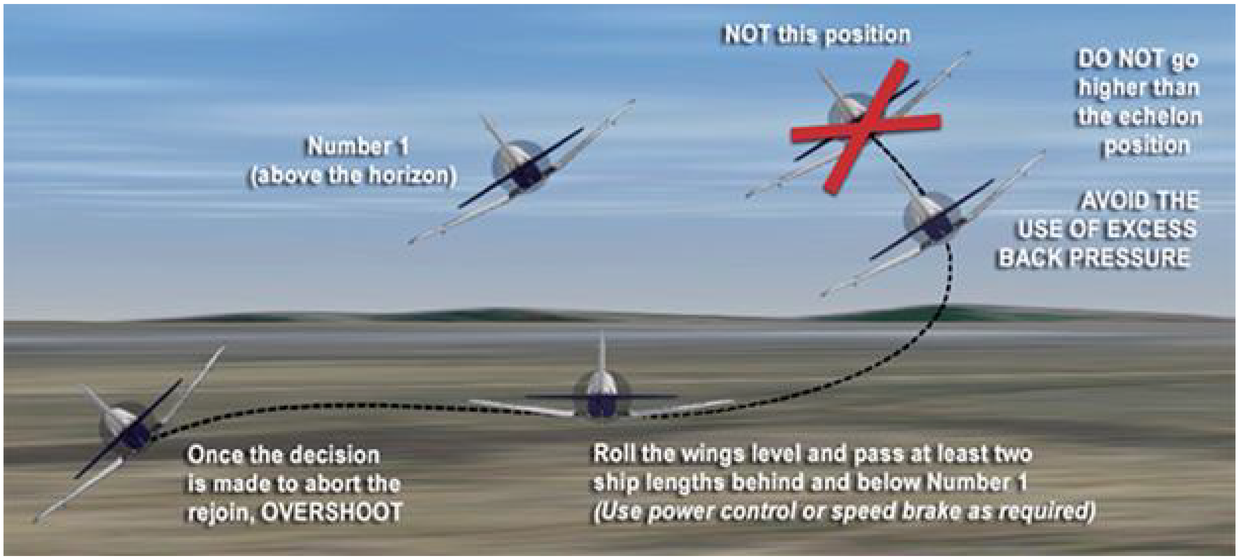

Figure 8.27 Overshoot.

Appendix 1 - ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AA........................aspect angle

A-A........................air-to-air (master mode or TACAN)

AAA......................anti-aircraft artillery

AAM.....................air-to-air missile

AB........................afterburner

ACAL....................altitude calibration

ABCCC.................airborne battlefield command and control center

ACM.....................air combat maneuvering

AD........................arming delay

ADC......................air data converter

ADI ....attitude director indicator

AFAC....................airborne forward air controller

AFTO....................Air Force Technical Order

AG........................air-to-ground switch position

A-G ....air-to-ground (master mode)

AGL......................above ground level

AGM.....................air-to-ground missile

AGR......................air-to-ground ranging

AHC......................aircraft handling characteristics

AI..........................air interdiction

AIM ....air intercept missile (e.g., AIM-9L/M)

ALB ....air land battle

ALO......................altitude low mnemonic

ALOW.................automatic altitude low warning

ALT ....altitude

AOA......................angle of attack

AOD......................aim-off distance

APC......................armored personnel carrier

API........................armor piercing incendiary

AR.........................action range

ARCT....................air refueling contact time

ASAP................... as soon as possible

ASOC.................. air support operations center

ATA..................... antenna train angle

ATC..................... air traffic control

ATO .... air tasking order

ATT..................... attitude

AUTO.................. automatic

AWACS............... airborne warning and control system

AZ .... azimuth

BA .... burst altitude

BARO.................. barometric

BATR.................. bullets at target range

BCN..................... beacon mnemonic

BDA..................... battle damage assessment

BDU..................... bomb dummy unit

BFL .... bomb fall line

BFM.................... basic fighter maneuver

BL .... bomb live

BLK .... block

BLU........ bomb live unit

BORE........ boresight

BP........ bypass

BR .... bomb range

BSU .... bomb stabilizing unit

BUC........ backup fuel control

BVR........ beyond visual range

C3I........ command, control, communications, and intelligence

CADC........ central air data computer

CARA........ combined altitude radar altimeter

CAS........ close air support or calibrated airspeed

CAT........ category

CATA........ collision antenna train angle

CBU........ cluster bomb unit

CCD .... camouflage, concealment, and deception

CCIL........continuously computed impact line

CCIP........continuously computed impact point

CCRP........continuously computed release point

CENTAF........Central Air Forces

CENTCOM ....Central Command

CEP........circular error probable

CLM ....climbing safe escape maneuver

COMSEC........communications security

cos ....cosine

CRC........control and reporting center

C.S. ....call sign

CSAR........combat search and rescue

CTVS........cockpit television sensor

CZ........cursor zero

DB........dive bomb

DBS........doppler beam sharpening

DED ....data entry display

DEG........degree

DEST ....destination

DGFT........dogfight (master mode)

DIR ....direct aim

DME ....distance measuring equipment

DMPI........desired munitions point of impact

DR........dead reckoning/decision range

Es ....specific energy

ECM ....electronic countermeasures

ECS........environmental control system

EEGS........enhanced envelope gunsight

EID........electronic identification

EL BAR........elevation bar

ELV ....elevation

EO........electro-optical

EOR........end of runway

EPU........ emergency power unit

EU .... electronic unit

FAC..................... forward air controller

FCC..................... fire control computer

FCNP................... fire control navigation panel

FCR..................... fire control radar

FEBA .... forward edge of the battle area

FEDS................... firing evaluation display system

FL........................ flight level

FLCS................... flight control system

FLIR.................... forward looking infrared

FM....................... frequency modulation

FMU.................... field maintenance unit

FO .... flame out

FOV..................... field of view

FPM .... flight path marker/feet per minute

FPS/fps ....feet per second

FRAG.................. fragmentation

FRL. .... fuselage reference line

FSCL................... fire support coordination line

FTIT.................... fan turbine inlet temperature

FTT .... fixed target track

FWD................... forward

FZ........................ freeze

g........................... in math formula (32'/sec2)

G.......................... total G on aircraft/pilot

GBU .... guided bomb unit

GCI .... ground controlled intercept

GE....................... General Electric

GFI...................... ground forces intelligence

GFIS.................... ground forces intelligence survey

GLOC .... G-induced loss of consciousness

GLO.................... ground liaison officer

GM...................... ground map

GMT .... ground moving target
(MFD mnemonic for GMTI)

GP .... general purpose

GPS .... global positioning system

GR........................radial G

GS........................ground speed/glide slope

HADB..................high altitude dive bomb

HCA.....................heading crossing angle

HEI ....high explosive incendiary

HHQ....................higher headquarters

HOM....................home mnemonic

HSI.......................horizontal situation indicator

HST......................target history mnemonic

HUD.....................head-up display

IAW ....in accordance with

IMC ....instrument meteorological conditions

INS.......................inertial navigation system/set

INSM ....inertial navigation system memory

IP..........................initial point or instructor pilot

IPP ....initial pipper placement

IR.........................infrared

JETT..................jettison

JFS......................jet fuel starter

JMEM.................Joint Munitions Employment Manual

KCAS..................knots calibrated airspeed

KIAS...................knots indicated airspeed

KIO.....................knock it off

KTAS..................knots true airspeed

Kt(s) ....knot(s)

LAB ....low angle bomb

LADD..................low altitude drogue delivery

LAHD ....low angle high drag

LALD..................low angle low drag

LANTIRN...........low altitude navigation and targeting infrared night

LAS.....................low angle strafe

LAT/LNG...........latitude/longitude

LCOS..................lead computing optical sight

LDGP..................low drag general purpose

LLLD..................low level low drag

LMD.................. left miscellaneous display (FCNP mnemonic)

LOC .... line of communication

LOS.................... line of sight

LUU.................... launch unit universal

M........................ fuze designator

MM.................... millimeter

MAP................... minimum attack perimeter

MD..................... miss distance

METRO............. pilot to metro voice call

MFD................... multifunction display

MFL................... maintenance fault list

MiG.................... Mikoyan Gurevich (Soviet aircraft designator)

MIL.................... military power

mil(s) .... milliradian(s)

min .... minute or minimum

MISC.................. miscellaneous

MK..................... mark (Navy weapon designation)

MPC................... mission planning cell

MRA................... minimum release altitude

MRGS................ multiple reference gunsight

MSA................... minimum safe altitude

MSL .... missile mode or missile or mean sea level

MSS.................... mission support system

MTR................... moving target reject

MTT................... multi-target track

NAM................... normal air mode

NAV .... navigation mode

NB .... narrow band

NLT.................... not later than

NM..................... nautical miles

NORDO .... .no operative radio

NORM................ normal

NSTL.................. nose/tail arming mnemonic

NVP.................... navigation pod

NWS................... nose wheel steering

OAP.................... offset aimpoint

OPSEC............... operations security

OPT ....option

OVRD.................override

PDP.....................pull-down point

PIREP.................pilot report

Pk........................probability of kill

Ps.........................specific excess power

PGM ....precision guided munition

POM ....plane of motion

PUP.....................pull-up point or pop-up point

PW......................Pratt and Whitney

R..........................turn radius

RCP.....................radar control panel

RDR.....................radar

RDY.....................ready mnemonic

REL ....release mnemonic

REO....................radar/electro-optical

RMD...................right miscellaneous display (FCNP mnemonic)

ROE....................rules of engagement

RP ....release point

RTB ....return to base

RTN TO SRCH ...return to search (switch position)

RTS.....................return to search

RWR...................radar warning receiver

RWS....................range while search

SA ....surface attack or situation(al) awareness

SACM.................selectable air combat mode

SAM....................surface-to-air missile

SBC.....................symbology, brightness, and contrast

SCAN..................AIM-9L/M nutating mode mnemonics

SCP ....stores control panel

SEA.....................sea search mode

SEAD..................suppression of enemy air defenses

SEL.....................select or selective

SFO.....................simulated flameout pattern and approach

SGL.....................single

SID .... standard instrument departure

SIM .... simulated

sin. .... sine

SLAV.................. slaved AIM-9L/M SMS mnemonics

SMS.................... stores management system or set

SNAP.................. snapshoot

SOI..................... sensor of interest

SPOT.................. AIM-9L/M non-nutating mode

SS .... snapshoot

STBY.................. standby mnemonic

STRF.................. strafe mnemonic

STT .... single target track

TACAN............... tactical air navigation

TAS .... true air speed

tan .... tangent

TCTO.................. time compliance technical order

TD .... target designate

TDA..................... tactical decision aid

TF........................ terrain following

TFR..................... terrain following radar

TGP..................... targeting pod

TGT..................... target

TIMS.................. time/inertial/map/scope

TLL..................... target locator line

TOF..................... time-of-flight; time-of-fall

TOS..................... time over steerpoint or time on station

TOT..................... time over target

TWS.................... track-while-scan

UAP..................... upwind aimpoint

UFC..................... upfront controls

UHF..................... ultra-high frequency

V.......................... velocity

Vc .... closing velocity

VAH.................... velocity/altitude/heading (switch)

VHF ....very high frequency (radio)

VID ....visual identification

VMC....................visual meteorological conditions

VR........................visual reconnaissance

VTR..................... video tape recorder

VVI...................... vertical velocity indicator

WB...................... wide band

WEZ.................... weapons employment zones

WOC................... wing operations center

WPN.................... weapon (mnemonic)

WPN DEL........... weapon delivery (switch position)

WR...................... weapon release

Appendix 2 - GLOSSARY

The following is a glossary of terms and definitions commonly used.

A-Pole	The distance from the launching aircraft to the target when a missile begins active guidance.
Abort (w/direction)	Abort is maximum performance, 135 degree overbank, nose slicing turn to put the threat at the 6 o'clock position and accelerating to .7 IMN
ACA (Airspace Coordination Area)	A three-dimensional box in the sky defined by grid and/or land references and an altitude block (AGL). The intent of an ACA is to allow simultaneous attack of targets near each other by multiple fire support means, one of which is air.
ACBT Air Combat Training;	A general term which includes (D)BFM, (D)ACM, and (D)ACT.
Acceleration Maneuver	An offensive or defensive maneuver, flown in the vertical plane, if possible, designed to increase or reduce distance from an object. A low yo-yo is an acceleration maneuver.
ACM	Air combat maneuvering; training designed to achieve proficiency in element formation maneuvering and the coordinated application of BFM to achieve a simulated kill or effectively defend against one or more aircraft from a preplanned starting position.
ACO	Airspace Control Order; document that details all approved airspace requests. The ACO will complement the ATO cycle and serve as a single planning document for airspace considerations.
ACT	Air combat tactics; training in the application of BFM and ACM skills to achieve a tactical air-to-air objective.
Adverse Yaw	The tendency of an aircraft to yaw away from the applied aileron while at high angles of attack.
Advisory Control	A mode of control in which the controlling agency has communications but no radar capability.

Aerodynamic Center	(A point on the wing chord through which aircraft lift is directed.) This definition is really for the center of pressure. The aerodynamic center is usually defined as the point on the longitudinal axis of the airplane where the lift vector is centered. The distance between the aerodynamic center and the center of gravity is static margin, and is the major factor affecting the longitudinal static stability if the aircraft.
AHC	Aircraft handling characteristics; training designed to gain proficiency in and to exploit the flight envelope of the aircraft, consistent with operational and safety constraints.
Air Refueling Time	Planned lapsed time from the ARCT to drop off.
Air Refueling Track	A flight path designated for air refueling.
Airborne Order	A command authorization for tactical flight (departure time will be specified).
Angle of Attack (AOA)	The angle between the mean chord line and the relative wind.
Angle Off	The angle formed by the extension of the longitudinal axes of two aircraft. Angle is measured from defender's six o'clock. Also called track crossing angle.
Arcing	Flying a circular flight path which allows another aircraft the use of cutoff to gain closure.
ARCP	Air refueling control point; the planned geographic point over which the receiver(s) arrive in the observation/precontact position with respect to the assigned tanker.
ARCT	Air refueling control time; the planned time that the receiver and tanker will arrive over the ARCP.
ARIP	Air refueling initial point; a point located upstream from the ARCP.
Armament Safety Check	Action taken by an aircrew to review armament selection switches to preclude the inadvertent launch/release of armament (switches safe).
Aspect Angle	Angle between defender's longitudinal axis and the line of sight to the attacker. The angle is measured from the defender's six o'clock. Attacker heading is irrelevant.

Attack Restriction	Ingress, ordnance delivery, or egress restrictions depending on situation, i.e., threats, weather, terrain, training rules, etc.
Banzai	Informative/directive call to execute launch and decide tactics.
BFM	Basic Fighter Maneuvers; training designed to apply aircraft handling skills to gain proficiency in recognizing and solving range, closure, aspect, angle off, and turning room problems in relation to another aircraft to either attain a position from which weapons may be employed, deny the adversary a position from which weapons may be launched, or defeat weapons employed by the adversary.
BRA	Bearing, range, and altitude of the target.
Break Away	Tanker/receiver call indicating immediate vertical and horizontal separation between tanker and receiver is required.
Broadcast Control	A mode of control that passes target information by referencing a designated location, series of locations, or grid system.
Buffer Zone (BZ)	Airspace of defined dimension and adjacent to or near orders which may have special restrictions.
Bugout (w/direction)	Separation from that particular engagement / attack / operation; no intent to re-engage/return
CAP	Combat Air Patrol; Refers to either a specific phase of an air-to-air mission or the geographic location of the fighter's surveillance orbit during an air-to-air mission prior to committing against a threat.
Center of Gravity (CG)	That point along the horizontal axis, fore and aft of which airplane weight is equal.
Chaff	Chaff is a passive form of electronic countermeasures used to deceive airborne or ground based radar.
CL Max	Maximum coefficient of lift; occurs at that angle of attack at which lift is maximum, thereby creating the maximum turn rate and maximum G loading for any condition of flight.
Clock code	Description of position using the aircraft as a reference;

	the nose is twelve o'clock, the tail is six o'clock.
Close Control	A mode of control varying from providing vectors to providing complete assistance including altitude, speed, and heading.
Closure	Relative velocity of one aircraft in relation to another.
Collision Course	A flight path along which an aircraft is directed towards a point at which it will collide with another aircraft.
Comm Jamming	Attempt to interrupt communications.
Comparison Diagram	A chart comparing turn rate, radius, and excess power for two different aircraft.
Compass Call	A C3CM platform.
Composite Force Training	Scenarios employing multiple flights of the same or different types of aircraft, each under the direction of its own flight leader, and performing the same or different roles. Requires a minimum of three different types of aircraft in three different mission roles.
Condition of Vulnerability	A condition with the defender in the lethal envelope of the attacker's weapon system. It is possible for combatants to arrive at a mutual condition of vulnerability, particularly during a head-on pass.
Corner Velocity	The minimum airspeed at which the maximum allowable aircraft G limit can be generated.
Crank (w/direction)	Maneuver in the direction indicated. Implies illuminating target at or near radar GIMBAL limits
Defensive Maneuvering	Maneuvers designed to negate the attack/ordnance of a threat.
Defensive Spiral	A descending, accelerating dive using high G and continuous roll to negate an attack and gain lateral separation.

DOR	Desired out range/MOR (minimum out range) Range from the closest bandit where an aircraft's "out" will defeat any bandit's weapons in the air or still on the jet and preserve enough distance to make an "in" decision with sufficient time to reengage the same group with launch-and-decide tactics. This also gives trailing elements a "clean" picture, reducing identification problems when targeting.
DR	***Dead reckoning***; navigation technique estimating position based on last known position, heading, speed, and time. or ***Decision Range:*** "The minimum range at which a fighter can execute the briefed notch maneuver, remain there for a pre-briefed period of time in an attempt to defeat spikes, and then execute an abort maneuver. This maneuver will kinematically defeat any missiles shot at the fighter and momentarily keep the fighter outside the threat's maximum stern weapons employment zone (WEZ) once the abort maneuver is completed. This definition does not address an adversary's capability to eventually enter a stern WEZ by continuing to run down the fighter."
E-Pole	The range from a threat aircraft that a drag must be accomplished to kinematically defeat any missile the bandit could have launched or is launching.
ECM	Electronic countermeasures; actions taken to prevent or reduce the effective use of the electro-magnetic spectrum.
Element	A flight of two aircraft.
Engagement	Maneuvers by opposing aircraft attempting to achieve/prevent weapons firing positions.
Extend (w/direction)	Short-term maneuver to gain energy, distance, or separation normally with the intent of reengaging.
F-Pole	The distance from the launching aircraft to the target at missile impact.

FR (Factor Range)	During merge tactics, the minimum acceptable distance between the group being merged with and the next nearest group. Groups outside of this range are unlikely to affect the merge with the targeted group. FR should allow engaging and killing the targeted group, egressing tail aspect to the second group, and remaining outside that group's maximum stern WEZ. FR is driven by threat weapons capability, fighter weapons capability, closure, and proficiency.
Group	Defined as two or more contacts within 5 NM range, 5 NM azimuth and within 5,000 feet in elevation
HCA	Heading crossing angle; the angle formed by the intersection of the fighter's present heading and the target's present heading.
High Angle (Snap) Shot	A gun shot made with a high track crossing angle, normally attempted because a tracking shot was not possible or desired.
Hostile	A contact positively identified as enemy in accordance with command rules of engagement.
Hunter-Killer	Flight mix of F-4G Wild Weasel and other aircraft employed in SEAD operations.
Intercept	A phase of an air-to-air mission between the commit and engagement.
Jinking	Aircraft maneuvers designed to change the flight path of the aircraft in all planes at random intervals (usually to negate a gun attack).
Lag Pursuit	An attack geometry that will cause the attacker to fly behind the target.
LAR	A three dimensional volume of space around a hostile aircraft into which the fighter must fly in order to have a chance to successfully employ its weapons. The fighter will maneuver in altitude, airspeed, and heading in order to achieve the best weapon solution for his opponent. The LAR is largest (i.e., longest RMAX) with 0 TA, at high airspeed and high altitude and is smallest (i.e.,shortest RMAX) in the rear quarter at low altitude and low airspeed. Missiles like altitude, airspeed, and closure to achieve maximum kinematics.
Lateral (Pitch) Axis	A reference line running left and right through the center of gravity of an airplane.

Lead Pursuit	An attack geometry that will cause the attacker to fly in front of the target.
Lethal Envelope	The envelope within which the parameters can be met for successful employment of a munition by a particular weapons system.
Line of Sight	A line from the pilot's eye to the object (usually target) being viewed.
Line of Sight Rate	An image's rate of movement across the canopy.
Line Up	Fighter briefing to a FAC.
Longitudinal (Roll) Axis	A reference line running fore and aft through the center of gravity of an airplane.
Lufberry	A circular stagnated fight with no participant having an advantage.
Maneuverability	The ability to change direction and/or magnitude if the velocity vector.
MAR (Minimum abort Range)	The range at which an aircraft can execute a maximum performance out/abort maneuver and kinematically defeat any missiles and remain outside an adversary's WEZ
Maximum Performance	The best possible performance without exceeding aircraft limitations.
Maximum Rate Turn	That turn at which the maximum number of degrees per second is achieved.
MiG	Fighter aircraft designed and produced by the Mikoyan Gurovich Aircraft Bureau.
Military Crest	A position along a ridge or hill two-thirds the distance from the base to the summit.
Mixed Force	The employment of a single flight of different types of aircraft, performing the same tactical role, under the direction of a single flight leader.
Mutual Support	The coordinated efforts of two or more aircraft to provide combined firepower and survivability.
Notch (w/direction)	Directive (informative) for an all-aspect missile defensive maneuver to place threat radar/missile near the beam
Off-Station	Not in position.

Offensive Maneuvering	Maneuvers against an opponent to achieve weapons parameters.
On-Station	In position, ready for mission employment.
Ops Check	Periodic check of aircraft systems performed by the aircrew (including fuel) for safety of flight.
Out (w/direction)	Informative call indicating a turn to a cold aspect relative to the known threat.
Popeye/IMC	Flying in clouds or area of reduced visibility.
Primary Force	The flight(s) that are being protected/escorted.
Pump (w/direction)	A briefed maneuver to low aspect to stop closure on the threat or geographical boundary with the intent to re-engage
Pure Pursuit	An attack geometry that will cause the attacker to fly directly at the target.
Radial G	Effective "turning" G.
Rate of Turn	Rate of change of heading, normally measured in degrees per second.
Relative Wind	The oncoming, instantaneous wind. For practical purposes, the direction of the relative wind is exactly opposite the flight path of the airplane.
Sandwich	A situation where the defending aircraft/element finds itself in between the attacking element.
Sanitize	Area clear of threats.
Scissors	A maneuver in which a series of hard turn reversals are executed in an attempt to achieve the offensive after an overshoot by an attacker.
Scramble	Takeoff as quickly as possible.
Scramble Order	Command authorization for combat flight establishing an immediate departure time.
SEAD	Suppression of enemy air defenses.
Semi-Active	A system wherein the receiver uses radiation or reflections from the target which has been illuminated by an outside source.

Separation	Distance between an attacker and defender; can be lateral, longitudinal, or vertical.
Short Skate	Informative or directive call to execute launch-and-leave tactics and be out no later than minimum abort range (MAR)/decision range (DR).
Skate	Informative or directive call to execute launch-and-leave tactics and be out no later than desired out range (DOR)/minimum out range (MOR).
Slice	Maximum performance, nose-low turn. Usually performed at or near maneuver speed (corner velocity) with nose lowered sufficiently to maintain airspeed. This maneuver falls between a horizontal turn and a split-S.
Sorting	Using any available information such as radar presentation, GCI information, etc., to determine which bandit to attack.
Specific	Energy Total Mechanical energy per pound. Can be loosely described as an airplane's total energy resulting from airspeed and altitude.
Specific Excess Power (Ps)	A measure of an airplane's ability to gain or lose energy in terms of altitude, airspeed, or combination thereof. Also called energy rate and expressed in feet per second or knots per second.
Split-Plane	Maneuvering Aircraft or elements maneuvering in relation to one another, but in different planes and/or altitudes.
Strike	An attack which is intended to inflict damage, seize, or destroy an objective.
Suppressor	Aircraft designated to employ ordnance against defenses.
TAC-A (Tactical Air Coordinator-Airborne)	An airborne agency located far enough away from threats and jamming to provide a communications relay between fighters, FACs, and ground agencies. Typically aboard a FAC aircraft, ABCCC, or AWACS.
Tactical Control	A mode of control similar to close control with regard to type information provided except vectors are not provided to the aircrew by the weapons controller.

Velocity Vector	A line representing the direction and magnitude of the path of travel.
Vertical (Yaw) Axis	A reference line running up and down through the center of gravity of an airplane.
Vertical Rolling Scissors	A defensive descending rolling maneuver in the vertical plane executed in an attempt to achieve an offensive position on the attacker.
Weapons System	In regard to an airplane, weapons system refers to the combination of airplane/pilot/ordnance/ground crew/avionics, etc.
WEZ (Weapons Engagement Zone)	The three-dimensional volume of airspace around a fighter into which the hostile aircraft must fly to employ weapons
Whifferdill	A maneuver used to change direction approximately 180°. Nose is raised 30° to 60°, then 90° + bank is used to reverse direction of flight and pull nose down below horizon.
Wild Weasel	Dedicated radar defense suppression aircraft.
Willy Pete	A white phosphorus smoke, rocket, grenade, or artillery round used to provide a ground reference. Can be employed as a bomb to provide a smokescreen.

Appendix 3 - CODE AND BREVITY WORDS

The following is a list code and brevity words for use during combat and daily training flights. It is intended to provide common understanding and minimize radio transmissions. This common understanding is dependent on the following rules:

- These lists are not all inclusive.
- Words listed below should be used in lieu of words or phrases with similar definitions.
- Some words are informational in nature while others are intended to direct action.
- When a flight lead makes directive calls, the wingman must respond with the directed action to the best of his ability.
- If the wingman uses a "directive" term/word, it is a request and the flight lead reserves the right to approve/deny the wingman's requested action.
- When working with allied nations, remember that some of the terms/words listed here may have different meanings.

ABORT	Directive to cease action/attack/event/mission.
ACTION	Directive to perform a pre-briefed attack sequence or maneuver.
ALPHA CHECK	Request for bearing and range to described point.
ANCHOR	Orbit about a specific point; ground track flown by tanker. Information call indicates a turning engagement about a specific location.
ANGELS	Height of aircraft in thousands of feet.
APEX/ALAMO	Training term used to denote simulated launch of enemy, all-aspect radar missile.
ARM/ARMED (Safe/Hot)	Select armament (safe/hot), or armament is safe/hot.
AS FRAGGED	Fighter, FAC, mission package, or agency will be performing exactly as stated by the air tasking order.
ASPECT	Request/comment regarding target aspect information.
APHID/ARCHER	Training term used to denote simulated launch of enemy heat seeking missiles.
ATTACK/ATTACKING ( )	Indicates air-to-surface attack on a specific ground target.
AUTHENTICATE ( )	To request or provide a response for a coded challenge.
AUTONOMOUS	Aircrew is operating without benefit of GCI/AWACS control.

BANDIT (Radar/Heat/Striker)	Known enemy aircraft and type ordnance capability, if known.
BASE (Number)	Reference number used to indicate such information as headings, altitudes, fuels, etc.
BEAM/BEAMER (Direction)	Aircraft maneuvering stabilized within 70—110° aspect; generally given with cardinal directions; east, west, north, south.
BELLY CHECK	A momentary unloaded bank to check the blind side of a turning aircraft.
( ) BENT	Identified system inoperative.
BINGO	Fuel state at which RTB must commence.
BLIND	No visual contact with friendly aircraft; opposite of term "VISUAL."
BLOW THROUGH	Directive/informational call that indicates aircraft will continue straight ahead at the merge and not turn with target/targets.
BOGEY	A radar/visual contact whose identity is unknown.
BOGEY DOPE/DOPE	Request for target information as briefed/available.
BONE	Term used to indicate the formation will remain in a racetrack-type holding pattern (with all wingmen's turns into lead); exit formation must be specified by lead.
BOX	Groups/contacts/formations in a square or offset square.
BRACKET	Indicates geometry where aircraft will maneuver to a position on opposing sides either laterally or vertically from the target.
BREAK (Up/Down/Right/Left)	Directive to perform an immediate maximum performance turn in the indicated direction. Assumes a defensive situation.
BREVITY	Term used to denote radio frequency is becoming saturated/degraded and briefer transmissions must follow.
BROADCAST	Request/directive to switch to broadcast control.
BROKE LOCK	Loss of radar/IR lock-on (advisory).
BUDDY LOCK (Position/Azimuth)	Receiving friendly AI RWR.
BUGOUT (Direction)	Separation from that particular engagement/attack; no intent to re-engage.
BULL'S EYE	An established reference point from which the position of an aircraft can be determined.

BUMP	A fly-up to acquire line of sight to the target or laser designation.
BURNER	Directive to select/deselect afterburner.
BUZZER	Electronic communications jamming.
CAP/CAP (Location)	An orbit at a specified location. Establish a combat air patrol at (location).
CHAFF	Call indicating chaff has been detected or to deploy chaff.
CHAMPAGNE	An attack of three distinct groups with two in front and one behind. The leading two groups are attempting to bracket with the trailing third group flying up the middle.
CHATTERMARK	Begin using briefed radio procedures to counter comm jamming.
CHECK ( )	A directive statement made to momentarily monitor (specified items/systems). No response is required if status is normal.
CHECK (°Left/ °Right)	Turn ( ) degrees left/right and maintain new heading.
CHICKS	Friendly fighter aircraft.
CHRISTMAS TREE	Directive to briefly turn on exterior lights to enable visual acquisition.
CIRCLE ( )	Flight lead directed defensive maneuver in which the flight establishes a circular holding pattern for mutual support.
CLEAN	No radar contacts.
CLEARED	Requested action is authorized (no engaged/support roles are assumed).
CLEARED DRY	Ordnance release not authorized.
CLEARED HOT	Ordnance release is authorized.
CLOSING	Bandit/bogey/target is getting closer in range.
COLD	In context; attack geometry will result in a pass or roll out behind the target; or, on a leg of a CAP pointed away from the anticipated threats. Air-to-surface, dry or no ordnance attack.
COMEBACK (Left/Right)	Directive to reverse course.
COME OFF (Left/Right/High/Low)	A directive to maneuver as indicated to either regain mutual support or to deconflict flight paths for an exchange of engaged and supporting roles. Implies both "visual" and "tally."

COMMITTED/COMMIT	Fighter intent to engage/intercept; weapons director continues to provide information.
CONTACT	Radar/IR contact at the stated position; should be in bearing, range, altitude (BRA), bull's eye, or geographic position format.
CONTINUE	Maneuver for attack; does not imply clearance to engage or expend ordnance.
COVER	Directive to assume briefed support position and responsibilities.
CRANK (Direction)	F-pole maneuver; implies illuminating target at radar gimbal limits.
CROSS TURN/CROSS	A 180° heading reversal by a flight where aircraft turn into each other.
CUTOFF	Request for, or directive to, intercept using cutoff geometry.
DEADEYE	Informative call by an airborne laser designator indicating the laser is inoperative.
DEFENSIVE (Spike/Missile/SAM/Mud/AAA)	Aircraft is in a defensive position and maneuvering with reference to the stated condition. If no condition stated, maneuvering is with respect to air-to-air threat.
DEPLOY	Directive for the flight to maneuver to briefed positioning.
DIVERT	Proceed to alternate mission/base.
DOLLY	Data link equipment.
DRAG/DRAGGING (Direction)	Aircraft maneuver to 60° or less aspect.
ECHELON (Cardinal Direction)	Groups/contacts/formation with wingman displaced approximately 45° behind leader's wing line.
ELEMENT	Formation of two aircraft.
ENGAGED	Maneuvering with the intent of achieving a kill. If no additional information is provided (bearing, range, etc.), engaged implies visual/radar acquisition of the target.
ESTIMATE	Using information available to provide required data; implies degradation.
EXTEND (Direction)	Directive to gain energy and distance with the possible intent of returning.
EYEBALL	Fighter with primary visual identification responsibility.
FADED	Previous radar contact lost.
FAST	Target speed is estimated to be 600 knots ground speed, Mach 1 or

	greater.
FEET WET/DRY	Flying over water/land.
FENCE	Boundary separating hostile and friendly area.
FENCE CHECK	Set cockpit switches as appropriate.
FEW	Two to four aircraft.
FLANK/FLANKING	Target with a stable aspect of 120—150°.
FLOAT	Directive/informative to expand the formation laterally within visual limits to maintain a radar contact or prepare for a defensive response.
FLUSH/FLUSHED	Precautionary launch or aircraft for survival.
FOLLOW DOLLY	Follow data-link commands.
FOX	Air-to-air weapons employment.
FOX ONE	Simulated/actual launch of semi-active radar-guided missile.
FOX TWO	Simulated/actual launch of IR-guided missile.
FOX THREE	Simulated/actual launch of an active radar-guided missile.
FURBALL	A turning fight involving multiple aircraft.
GADGET	Fire control radar.
GIMBALS (Direction)	Radar target is approaching azimuth or elevation limits.
GO ACTIVE	Go to briefed Have Quick net.
GO SECURE	Directive to activate secure voice communications.
GORILLA	Large force of indeterminable numbers and formation.
GREEN (Direction)	Direction determined to be clearest of enemy air-to-air activity
GROUP	Radar target(s) within approximately 3 NM of each other.
GUN (Direction)	Visual acquisition of gunfire, AAA site, or AAA fire.
GUNS	An air-to-surface gunshot.
HARD (Direction)	High G energy sustaining turn.
HEADS DOWN	Call to inform aircrew that leader/wingman is head down in the cockpit and leader/wingman is responsible for clearing.

HEADS UP (Direction/Altitude)	Enemy/bogey got through; no kill.
HIGH	Target between 25,000 MSL and 40,000 MSL.
HIT	Radar return in search (air-to-air). Weapons impact within lethal distance (air-to-ground).
HOLD DOWN	Directive to key transmitter for DF steer.
HOLDING HANDS	Aircraft in visual formation.
HOME PLATE	Home airfield.
HOOK (Left/Right)	Directive to perform an in-place 180° turn.
HOT	In context; attack geometry will result in roll out in front of the target; or on a leg of the CAP pointing toward the anticipated threats (air-to-air). Ordnance employment authorized, expected, or completed (air-to-ground).
HOTEL FOX	HF radio.
ID	Directive to intercept and identify the target; also aircrew ID accomplished, followed by type aircraft.
IN PLACE (Left/Right)	Perform indicated maneuver simultaneously.
JINK	Unpredictable maneuvers to negate a tracking solution.
JOKER	Fuel state above bingo at which separation/bugout should begin.
JUDY	Aircrew has radar/visual contact on the correct target, has taken control of the intercept, and only requires situation awareness information; weapons director will minimize radio transmissions.
JUDY ANGLE	Aircrew is taking control of intercept in azimuth only; weapons director continues to provide range information.
KILL	Directive to commit on target with clearance to fire; in training, a fighter call to indicate kill criteria have been fulfilled.
LADDER	Three or more groups/contacts/formations/aircraft side-by-side.
LINE ABREAST	Two groups/contacts/formations/aircraft side-by-side.
LOCKED (BRA/Direction)	Final radar lock-on; sort is not assumed.
LOW	Target altitude below 5,000 feet AGL.
MAGNUM	Launch of AGM-88 HARM by Wild Weasel.

MANY	Five or more aircraft.
MARKING	Leaving contrails or otherwise marking aircraft position.
MEDIUM	Target altitude between 5,000 feet AGL and 25,000 feet AGL.
MERGED	Informative that friendlies and targets have arrived in the same visual arena. Call indicating radar returns have come together.
MICKEY	Have Quick time of day (TOD) signal.
MIDNIGHT	Initiate advisory control (due to loss of GCI-type radar).
MIL	Directive to select military power.
MUD (Direction)	Indicates RWR ground threat displayed; followed normally by clock position.
MUSIC	Electronic radar jamming. On AI radar, electronic deceptive jamming.
NAKED	No RWR indications.
NO JOY	Aircrew does not have visual contact with the target/bandit; opposite of "TALLY."
NOTCH (Direction)	All-aspect missile defensive maneuver to place threat radar/missile near the beam.
OFF (Direction)	Informative that attack is being ceased and repositioning in the indicated direction.
OFFSET (Left/Right)	Informative call indicating maneuver in a specific direction with reference to the target.
PACKAGE	Geographically isolated collection of groups/contacts/formations.
PADLOCKED	Informative that aircrew cannot take eyes off another aircraft/ground target without losing tally.
PAINT	Friendly AAI/APX interrogation return.
PARROT	IFF transponder.
PICTURE	Situation briefing which includes real-time information pertinent to a specific mission.
PIGEONS (Location)	Magnetic bearing and range to a specified point.
PITCHBACK (Left/Right)	A call for fighter/flight to execute a nose-high heading reversal to

	reposition as stated.
PLAYTIME	Amount of time which aircraft can remain on station.
POINT	Directive for an element to turn towards each other either as a defensive response or to reestablish a mutually supportive formation.
POP	Starting climb for an air-to-surface attack.
POPEYE	Flying in clouds or area of reduced visibility.
POSIT	Request for position; response normally in terms of a geographic landmark, or off a common reference point.
POST ATTACK (Direction)	Weapons director's transmission to indicate desired direction after completion of the intercept/engagement.
POST HOLE	Rapid descending spiral.
POWER	Reminder to set the throttles appropriately considering the IR threat and desired energy state.
PRESS	Directive to continue the attack; mutual support will be maintained. Appropriate engaged and supporting roles will be assumed.
PUMP	Directive to perform a pre-briefed sequential maneuver to stop relative forward motion while maintaining situation awareness on the threat.
PURE	Call indicating pure pursuit is being used or directive call to go pure pursuit.
PUSH (Channel)	Go to designated frequency.
RANCH HOUSE (Altitude)	Informative or directive indicating subject fighters will/should return to CAP.
REFERENCE (Direction)	Directive to assume stated heading.
RIFLE	AGM-65 launch.
ROGER	Indicates aircrew understands the radio transmission; does not indicate compliance or reaction.
SAM (Direction)	Visual acquisition of a SAM or SAM launch. Should include position.
SANDWICHED	A situation where an aircraft/element find themselves between opposing elements.
SAUNTER	Fly at best endurance.

SEPARATE	Separation from a specific engagement.
SHACKLE	One weave; a single crossing of flight paths; maneuver to adjust/regain formation parameters.
SHADOW	Follow indicated target.
SHIFT	Directive to illuminate second target with laser designator.
SHOOTER	Aircraft designated to employ ordnance.
SHOTGUN	Launch of antiradiation (SHRIKE) missile by Wild Weasel.
( ) SICK	Described equipment is degraded.
SILENT	"GO SILENT" directive to initiate briefed EMCON procedures.
SKIP IT	Veto of fighter commit call; usually followed with further directions.
SLICE (Left/Right)	Directive to perform a high G descending turn in the stated direction; usually 180° turn.
SLOW	Target with ground speed of less than 300 knots.
SNAP SHOT	High angle/high LOS gun shot.
SNAP ( )	An immediate vector (bearing and range) to the group described.
SORTED	Criteria have been met which ensure individual flight members have separate contacts; criteria can be met visually, electronically (radar) or both.
SPARKLE	Target marking by a gunship or FAC using incendiary rounds.
SPIKE	RWR indication of an AI threat in track, launch, or unknown mode. Include bearing and clock position/azimuth and threat type if able.
SPITTER (Direction)	An aircraft that has departed from the engagement.
SPLASH	Target destroyed (air-to-air); weapons impact (air-toground)
SPLIT	Request to engage a threat; visual may not be maintained; requires flight lead acknowledgment (airto- air). Also, directive to begin pre-briefed maneuver/attack.
SPOOFING	Informative that voice deception is being employed.
SPOT	Informative that laser target designation is being received.
SQUAWK ( )	Operate IFF as indicated or IFF is operating as indicated.

STACK	Two or more groups/contact/formation with a high/low stack in relation to each other.
STATUS	Request for an individual's tactical situation; response is normally "offensive," "defensive," or "neutral." May be suffixed by position and heading.
STERN	Request for, or directive to, intercept using stern geometry.
STINGER	Formation of two or more aircraft with a single trail.
STRANGER	Unidentified traffic that is not participant in the mission.
STRANGLE ( )	Turn off equipment indicated.
STROBE	AI radar indications of noise radar jamming.
SUNRISE	A minimum of broadcast control is available (due to return of weapons director's radar).
SUPPORTING	Act of assisting the engaged fighter in killing the bandit while maintaining overall battle situation awareness.
SWITCH/SWITCHED	Indicates an attacker is changing from one aircraft to another.
TALLY	Sighting of a target/bandit; opposite of "NO JOY."
TARGET	Specification of sort responsibility. Directive call that may not necessarily follow the sort contract.
THREAT (Direction) (GCI/AWACS)	Informative that an untargeted bogey is within 10 NM of a friendly.
TIED	Positive radar contact with an element/aircraft.
TRACK	A series of related contacts indicating direction of travel.
TRACKING	Stabilized gun solution.
TRAIN (Formation)	Tactical formation of two or more aircraft following one another.
TRAILER	The last aircraft in a formation.
TUMBLEWEED	Indicates limited situation awareness; no tally, no visual, a request for information.
UNIFORM	UHF/AM radio.
VERY HIGH	Target altitude above 40,000 feet MSL.
VERY LOW	Target altitude is below 300 feet AGL.

VIC	Three groups/contacts/formations with the single closest in range and an element in trail.
VICTOR	VHF/AM radio.
VISUAL	Sighting of a friendly aircraft; opposite of "BLIND."
WALL	Three or more groups/contacts/formations line abreast/side by side.
WEAVE	Continuous crossing of flight paths.
WEDGE	Tactical formation of two or more aircraft with the single in front and the other aircraft laterally displaced on either side behind the leader's wing line.
WEEDS	Indicates that aircraft are operating close to the surface.
( ) WELL	Described equipment is functioning properly.
WHAT LUCK	Request for results of mission/tasks.
WHAT STATE	Request for armament/fuel status; reported as follows: ( ) Radar = # radar missiles remaining. ( ) Heat = # heat missiles remaining. ( ) Fuel = pounds of fuel or time remaining.
WILCO	Will comply with received instructions.
WINCHESTER	No ordnance remaining.
WORDS	Pertinent mission information.
WORKING ( )	Wild Weasel is gathering electronic order of battle on a designated emitter.
ZIPPER	Acknowledge radio transmissions with two clicks of the mike button.

Appendix 4 - REFERENCES

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