CHAPTER ONE
General Subjects

1.1 Introduction
Formation flying was born as a means of mutual support and protection in times of aerial warfare. It was quickly discovered that multiple aircraft working together achieve far greater results while also reducing risk to all formation members. Putting up large numbers of aircraft meant organization was necessary for safety and efficiency. With time and experience, standards and conventions were developed for formation flying. Some of these conventions vary depending on the country of origin, the organization, or the type of flying.

The purpose of civilian formation flying today is different than for military units, but the basic skills and elements are unchanged. We fly formation to improve our flying skills, to demonstrate the capabilities of our aircraft in numbers, for camaraderie, and for the sheer enjoyment of the art of formation flying. There is great satisfaction in being part of a smooth, precise and safely executed formation flight. Conversely, nothing can be more frustrating or precarious than several pilots with different ideas flying in close proximity.

More than any other flying skill, formation builds confidence, teaches situational awareness, and demands discipline. The success of a formation flight is highly dependent on solid flight discipline. That discipline begins with mission preparation, carries through to the flight briefing, continuing with the flight itself and terminates in the post-flight debrief. Uncompromising attention to safety and flight discipline are absolutely essential to the successful outcome of a formation flight.

For most pilots reading this training manual, their purpose for flying formation centers around aerial display at public airshows. However, the priorities of every formation pilot must be the following, in this order:

- Safety
- Mutual support
- Symmetry/Aerial Display

This chapter lays down the foundation for all formation flying and should be well understood before the start of formation flight training.

1.2 Transfer of Aircraft Control
Formation training should not be attempted without a credentialed formation pilot onboard, experienced in providing instruction and occupying a seat with full flight controls. Transfer of aircraft control can result in disastrous crew confusion if not accomplished properly. When the Pilot In Command (PIC) wishes to give control of the aircraft to the Instructor Pilot (IP), he/she will state over the intercom:

"You have the aircraft"

The IP will then take control of the stick/yoke, throttle and rudders, shake the stick/yoke and state:

"I have the aircraft"

The student pilot will acknowledge by relinquishing all controls and momentarily showing his/her hands. The same procedure is used to transfer control back to the student.

A situation may develop where the IP needs to take immediate control of the aircraft to avoid a safety of flight issue. In this case, the transfer protocol described above is not applicable—the IP will take command of the aircraft, announce control ("I have the aircraft"), and the student will ***immediately*** surrender control of the aircraft.

> NOTE
> See the ABNORMALS chapter for transfer of control during intercom failure.

1.3 The Formation Pilot
A successful formation flight is dependent on each flight member possessing, and expressing, solid airmanship, situational awareness, judgment, flight discipline and aggressiveness.

Aggressiveness is a state of mind—it is not to be confused with speed of flight control movement or reckless abandon. Aggressiveness is knowing the rules and parameters, recognizing deviations, and making expeditious, controlled corrections.

The effectiveness, and safe outcome, of every formation flight is directly related to the flight discipline demonstrated by each member of the flight. Uncompromising flight discipline is absolutely essential to becoming a fully qualified formation pilot.

1.4 Responsibilities of the Formation Pilot
Because of the close proximity of formation aircraft, the formation pilot has a special responsibility and he/she must fulfill that role to ensure not only personal safety, but the safety of those who place their trust in them.

1.4.1 Safety Equipment
The list below is the recommended equipment for conducting formation flight. Although these items are mentioned for your safety, those marked with * are required items to receive in-flight instruction.

- Nomex/fire retardant flight suit
- Protective footwear
- Protective gloves
- Current parachute
- Helmet
- Intercom system for two seat aircraft*
- Instructor able to transmit outside the aircraft*

1.4.2 Aircraft Systems and Procedural Knowledge

In addition to having the required equipment, you should be prepared as a pilot. Proper training and currency in the aircraft to be used is a must. You should possess complete systems and procedural knowledge, and know your aircraft's limitations. Since you will only be able to take quick glances at critical engine instruments, you must readily know normal engine parameters and limitations. Further, you must be thoroughly familiar with control and switch locations to minimize attention diverted from your formation priorities. A "blindfold cockpit check" is an excellent way to ensure familiarity with the aircraft. A thorough understanding of all formation procedures and concepts contained in this manual is required.

1.4.3 Physical Preparedness

You must also be physically prepared for the hard work you will experience. Be well rested and hydrated; even experienced formation pilots will sweat! More than ordinary flying, you cannot tolerate any diminished faculties. Do not attempt to fly with impaired equilibrium or depth perception. Your fitness to fly may impact the safety of the other flight members.

1.5 Flight Lead Responsibilities

A carded flight lead possesses special qualifications outlined in the Qualification Appendix. The flight lead is ultimately responsible for safe and effective conduct of the flight. The flight lead sees to the planning of, and briefs/debriefs the flight. In training, he or she assumes the role of training officer for the mission, insuring flight members are given every opportunity to improve their skills. The flight lead position has the authority and responsibility to ensure the flight proceeds as intended.

1.5.1 Specific Flight Lead Responsibilities

- Select wing pilots for the flight
- Verify pilots' credentials and currency
- Verify competency in type
- Verify pilots have their safety equipment
- Brief and debrief each mission
- Train new formation pilots
- Endorse Formation Proficiency Reports (FPRs)
- Recommend pilots for Wing/Lead check rides

As flight lead, you must monitor the wing pilot, clear the area, and plan each maneuver; all while flying a smooth, stable platform to allow the wing pilot to maintain position without undue difficulty. Being a good leader takes judgment, planning, and excellent situational awareness. The flight lead must be familiar with the performance limitations of all aircraft in the formation and the capabilities of the pilots within them.

1.6 Wing Pilot Responsibilities

The three basic aspects of being a wing pilot are maintaining position, mutual support and formation integrity. Initially, you will spend most of your time learning to maintain position, but you should develop other skills that are integral to being a formation wing pilot.

1.6.1 Specific Wing Pilot Responsibilities

- Assist in the mission planning if requested
- Keep Lead in sight at all times
- Be aware of departure, enroute and arrival routing so you can assume lead, if required
- Monitor Lead for abnormal conditions and proper configurations
- Assist during emergencies, as directed
- Monitor radio comm, and assist Lead, as requested
- Maintain a constant awareness of the potential for a mid-air collision
- Trust and follow Lead's direction
- Maintain situational awareness

Strive to constantly improve and refine your formation skills. Stay mentally ahead of the aircraft and the formation to help maintain your situational awareness. Maintain radio discipline: respond promptly and concisely to required radio calls, but otherwise make only essential radio calls (imminent traffic conflict or aircraft malfunction, for example). If you encounter difficulty while in formation, you must immediately notify Lead. Being a good Wing means doing exactly what is expected of you.

You will learn that you must not only understand, but also be able to immediately apply, formation procedures and concepts. Most importantly, you must be devoted to the safety of the formation as your first priority at all times.

1.7 Formation Radio Procedures

All communication must be clearly understood by every flight member. Radio discipline requires not only clarity and brevity in the message, but limiting unnecessary transmissions as well.

1.7.1 The Two-Step Communication Process

Formation radio communication is actually a two-step process. The first part of any radio call is the attention or preparatory step. This step serves to alert the listener that a message is coming and to specify to whom the call is directed. The attention step should always be the receiver's

full call sign regardless of who initiates the call.

"Raven..." (callsign for entire flight)

The second part is the instruction/execution step, and tells the flight member, or members, the action to be taken or information to be passed:

"...extended trail, go"

The flight members should acknowledge with full callsign, and any information requested, unless briefed otherwise.

#2: "Raven 2"
#3: "Raven 3"
#4: "Raven 4"

It is important to note that this basic communication procedure is not limited to calls made by the flight lead; any flight member *initiating* a call will use the receiver's full call sign to preclude confusion, and the flight member the call was addressed to will acknowledge with his/her full call sign. This procedure of using the full callsign by the receiving flight members is used throughout the formation flight from initial check in to shut down.

NOTE
There are situations where the use of abbreviated call signs will not compromise situational awareness and is appropriate. It is the responsibility of the flight leader to make that determination and brief the comm plan accordingly.

Flight lead: "Raven, check"

#2: "2"
#3: "3"
#4: "4"

1.7.2 Frequency Change and Check-In Procedures

All flight members must maintain the capability to communicate with one another. Check-in and frequency switching procedures are critical to achieving this objective.

1.7.2.1 Specific Actions

When directed to change frequencies by the flight lead, on the ground or in the air, the flight lead will expect all flight members to acknowledge the command in sequence:

Flight lead: "Raven, 121.8, go"

#2: "Raven 2"
#3: "Raven 3"
#4: "Raven 4"

With all pilots responding, the entire flight will then switch to the new frequency. If one or more pilots do not respond, all pilots will remain on frequency until Lead sorts out the comm problem—once this is accomplished, the entire flight will switch to the new frequency. The flight leader will then initiate the check-in with wing pilots responding with position number sequentially:

Flight lead: "Raven, check"

#2: "Raven 2"
#3: "Raven 3"
#4: "Raven 4"

At this point, the leader knows that all flight members are on the same frequency and will proceed with ops transmissions. This process of check-ins and frequency change protocols will be used on the ground or in flight as briefed.

NOTE
The flight leader will include the number of aircraft in the flight and his/her tail number on initial contact with Air Traffic Control

"Knoxville Ground, November Five Five Echo Mike, flight of four, taxi with information kilo"

Lead

It is your responsibility to brief how radio operations will be performed during the flight. Before calling for a frequency change, place the flight in route formation. Ensure all calls are clear and concise, and combine calls when practical. Although frequency changes may be called at your discretion, delay the flight check-in as needed based on wing pilot capabilities.

NOTE
For visual signal procedures for directing a frequency change, see Appendix C.

If a wing pilot does not respond to repeated radio calls, the wayward wing pilot may be experiencing radio equipment failure, simply misunderstood the frequency, or mischanneled the radio. In these cases, you should pass the frequency via hand signals to him/her IAW Appendix C. Following the hand signals, You will once again attempt to check-in the entire flight on the radio.

You speak for the flight to all agencies until the flight splits up.

Wing

Follow all basic radio procedures contained in this chapter. Change radio frequency only when directed and only after all flight members have acknowledged with flight position number unless directed or briefed otherwise. If you do not

understand the call, do not acknowledge with position number—request the frequency or applicable information be repeated ("Raven 1, Raven 3, say again").

If Lead calls for a frequency change in flight without moving the flight to route, you should move to route position, stabilize and proceed with the channel change. Do not return to fingertip until Lead directs you, unless briefed otherwise. If you cannot hear or transmit (i.e. on-board equipment failure), follow radio failure (NORDO) procedures covered in the abnormals chapter of this manual.

1.8 Visual Signals

Visual signals are used to the maximum extent possible to keep radio calls to a minimum. Any non-standard visual signals will be thoroughly briefed before they are used. All members of the flight must be familiar with the visual signals to be used. Normally, aircraft malfunctions or safety related issues will be communicated over the radio.

Lead

Use visual signals in accordance with Appendix C of this manual. You will strive to make visual signals easy to see. Hand signals will be placed in the cockpit against a contrasting background to make them as visible as possible. Aircraft movements and wing-rocks will be big enough to be easily discernible. If a wing pilot does not acknowledge a signal, it should be interpreted as a request for clarification. Repeat the signal or make a radio call. Do not hesitate to use the radio to avoid confusion.

Wing

Acknowledge Lead's hand signals with an exaggerated head nod that is easy to see. Do not acknowledge any unclear visual signals—maintain position until receiving clarification or a repeat of the signal. Lead will repeat the signal until an acknowledgment is received from you. Pass visual signals on to other wing pilots as appropriate. However, while in formation, do not look away from your leaders aircraft for acknowledgment from other wing pilots. Do not hesitate to use the radio to avoid confusion.

1.9 Ops Checks

In-flight checks include any prescribed checklists (climb, enroute, descent) for that particular aircraft as well as periodic systems and fuel quantity checks termed "ops checks" (operational checks). The ops checks allows all pilots to briefly analyze fuel state, engine parameters, G-meter readings and any other parameter desired. All in-flight checks will be accomplished in route formation or extended trail. The flight lead will brief how fuel states will be reported, such as total time, or total fuel on board.

Lead

You will pre-brief and direct required checklists (climb, enroute, decent) and periodic ops checks using a visual signal or radio call. Move all aircraft to route formation and avoid unnecessary maneuvering to allow wing pilots time to accomplish necessary cockpit tasks. You can also initiate an ops check when the flight is stabilized in extended trail. You will initiate the ops check with the following call:

"Raven, ops check, 55 minutes"

Wing

Upon receiving a radio call or visual signal for an ops check, move out to route formation if not already directed and perform the check. Continue to focus your attention on Lead, using only short glances to accomplish cockpit duties. Stay in route until Lead directs otherwise. For ops checks or fuel checks, Lead will expect you to acknowledge with total fuel remaining in time (hours/minutes), or total fuel on board.

"Raven 2, 45 minutes"

After the check is complete, Lead will rock you back into your original position.

> NOTE
> Even if Lead hasn't called for an ops check, take other opportunities when not in close formation to look over your aircraft systems and fuel state.

1.10 Fuel Management

Aircraft in formation often experience un-equal fuel consumption rates so fuel management will play a vital role in mission planning and execution.

1.10.1 Joker Fuel

Joker fuel is the pre-briefed fuel state used to prioritize the remainder of the mission based on Lead's mission objectives. An example is terminating area work and accomplishing a recovery for multiple patterns. Upon reaching joker fuel status, the radio call is "Raven 2, joker." Lead will prioritize any remaining maneuvers as briefed and plan to recover the flight not later than bingo.

1.10.2 Bingo Fuel

Bingo fuel is a pre-briefed minimum fuel state which allows for safe return to base with necessary fuel reserves. Bingo will not be overflown, as it would preclude a safe recovery. In dissimilar aircraft formations, for planning purposes, the normal burn rates will not be identical among all aircraft. For this reason, Lead may brief bingo fuel in time remaining instead of pounds, gallons or liters. If an aircraft reaches bingo fuel, the required call is "Raven 2, bingo."

Lead

You should carefully plan the sortie to determine appropriate joker and bingo fuel. Carefully consider briefed forecasts and current conditions, as well as other factors that may require additional fuel. In formations consisting of one aircraft type, you may brief to report fuel in total pounds, gallons or

liters as the case may be. If flying a dissimilar aircraft formation, careful consideration should be given to each aircraft's operating parameters and fuel endurance. In these cases, it is advisable to reference fuel planning in time rather than gallons/liters, etc. This may be briefed as total time remaining, or time above bingo. If informed a wing pilot is bingo fuel, terminate maneuvers and expeditiously begin recovery to the planned destination.

Wing
On the wing, you will typically burn more fuel than Lead, so monitoring fuel will be important. Lead will consider this in designing and executing the flight profile or cross country mission. However, you have the responsibility of monitoring your own fuel state. Inform the flight lead when reaching joker or bingo and get an acknowledgment.

1.11 Collision Avoidance

Each formation member shares equally the responsibility to avoid a collision. This manual can not possibly address every situation that, if mishandled, could result in an accident or incident. Nothing precludes flight members from taking whatever action is necessary to avoid a collision.

1.11.1 Visual Lookout

Lead
You should focus on traffic, obstacle, and terrain avoidance while leading your flight. Flying in the lead position provides the most flexibility to scan visually while interpreting traffic calls from flight members or ATC. You have the additional responsibility of monitoring the progress of your wing pilots and being directive, as required, to assist them in avoiding conflicts within the flight. You should refrain from calling out traffic while in parade formation to avoid distracting your wing pilots, unless the situation posses a possible conflict (see KIO procedures).

Wing
While maintaining formation, you have a primary responsibility for de-confliction between flight members. You also have standard look-out responsibilities. This is performed in parade formation by "looking through" Lead's aircraft, beyond the flight, while not taking your eyes off Lead's aircraft. If a traffic conflict is discovered that requires immediate action, make a directive call to the flight lead:

"Raven 1, left turn for traffic, now"

Follow up a directive call with a descriptive call including clock position, elevation (high, low or level), and if possible distance.

"Raven 2, tally-ho traffic, right two o'clock high, one mile"

If the traffic is not of an immediate threat, but may become so, use only a descriptive call to assist the flight lead on acquiring the target.

1.11.2 Knock-It-Off and Terminate

The procedures surrounding these two calls must be clearly understood by all formation pilots. Although their application may seem of limited use during the restricted maneuvering environment of parade formation, these terms are critical during exercises such as rejoins and extended trail, when fluid maneuvering may result in the loss of visual contact, exceeding briefed safety limits, and traffic conflicts.

1.11.2.1 Knock-It-Off (KIO) Call

The term "knock-it-off" may be used by any member of the formation to direct ***all*** aircraft to cease maneuvering and will be used when ***safety of flight*** is a developing factor. If danger is imminent, a directive call should be made or break out executed IAW this manual. "Cease maneuvering" does not mean the flight will cease flying formation—the flight lead will decide on the appropriate course of action with the goal of providing a stable platform while clearing his/her flight path. Following a "knock-it-off" called during fluid maneuvering (rejoins or extended trail), all flight members will vigilantly clear their flight paths while terminating individual maneuvers and proceed as directed by the flight lead. For example, if the flight was in the process of executing a rejoin and the KIO call was made, all flight members would stabilize in their current position and wait for instructions from Lead.

1.11.2.2 KIO Procedures

Initiation of a knock-it-off will begin with the flight call sign, and "knock-it-off." If prudent, a short description of the hazard may be included, such as hard deck or traffic. This call will be followed by the flight acknowledging the call, in order. In the following example, Raven flight is flying an extended trail, fluid maneuvering exercise when Raven 3 realizes the flight is quickly approaching the briefed hard deck (lower altitude limit for maneuvering):

"Raven 3, knock-it-off, hard deck"

"Raven 1, knock it off" (flight lead)
"Raven 2, knock it off"
"Raven 3, knock it off"
"Raven 4, knock it off"

In this example, all aircraft were alerted to a safety of flight condition that was developing. Had the flight member witnessed imminent danger, a flight member's pending impact with the ground in this case , the call would instead be directive in nature ("Raven 2, pull up!")

1.11.2.3 Knock-It-Off Situations

Transmit KIO when any of the following situations occur:

- A dangerous situation is developing
- Loss of situational awareness that can't be regained

- Violation of briefed area boundaries or flight through minimum altitudes has or is about to occur
- Recognized radio failure
- Bingo fuel inadvertently overflown such that a direct flight to primary or alternate is required
- Non-briefed or non-participating flight/aircraft enters area and is a potential hazard to the flight
- Over-G/exceeding briefed flight parameters
- Any flight member calls "knock it off"

1.11.2.4 Terminate Call
Call "Terminate" to direct a specific aircraft or flight to cease maneuvering and to proceed as directed. Use "terminate" when safety of flight is not a factor, or as briefed. This call is particularly useful during formation training to inform the flight lead that all desired training has been achieved for a given phase of maneuvering. When hearing a terminate call, all flight aircraft will clear flight paths, stabilize in their current position, and await Lead's instructions.

> NOTE
> In multi-flight formations, as in air shows, the terminate call would be used to cease maneuvering by a specific aircraft or flight only, not the entire airshow.

1.11.2.5 Terminate Procedures
All flight members will acknowledge in order with their call sign and position number. In this example, Raven 3 has completed the desired learning objective:

"Raven 3, terminate" (deputy lead)

"Raven 1, terminate" (flight lead)
"Raven 2, terminate"
"Raven 3, terminate"
"Raven 4, terminate"

1.11.2.6 Call Terminate When

- The desired learning objective is achieved
- Warranted by the situation and KIO is not called for

1.11.3 Specific Collision Risk Factors
Several factors increase the risk of mid-air collisions. You should recognize these situations and guard against them.

1.11.3.1 Failure to keep the lead aircraft in sight at all times
Never move ahead of or go "belly up" to Lead's aircraft. These situations all may result in losing sight of Lead. If you lose sight in close formation, take action immediately—break out IAW the procedures in this chapter. Do not delay by attempting to regain visual contact. Ensuring separation is essential.

1.11.3.2 Failure of Lead to visually monitor wing pilots during critical phases of flight such as rejoins or extended trail
As Lead, you must monitor the wing pilots. Look at the wing pilots either directly or use a mirror. Be prepared to offer assistance or take evasive action if the wing pilot loses sight. Direct proper actions since you may be in the best position to know where they are in relation to other aircraft. However, do not monitor the wing pilot to the exclusion of other duties, such as clearing for other traffic.

1.11.3.3 Failure to maintain lateral or vertical separation
Whether in close formation or fluid maneuvering, as a formation pilot you are expected to be in the proper position at all times and never exceed safe limits set for lateral and/or vertical spacing. During rejoins, always maintain adequate separation until closure rates are under control and you are stabilized.

1.11.3.4 Failure to recognize excessive overtake
You must learn to judge excessive closure with Lead and execute overshoots or other appropriate action when required.

1.11.3.5 Failure to consider the effects of wingtip vortices and jet/prop wash
Vortices and prop/jet wash can be quite strong close to another aircraft. They may be encountered while performing fingertip maneuvers (particularly cross-unders) or during extended or close trail. Learn where these vortices are and avoid them. In fingertip, the vortices may cause a rolling moment into the lead aircraft. If maneuvering with higher G-loads, the vortices will be stronger and will trail up behind the lead aircraft (along Lead's flight path). Use positive control inputs to fly out of the turbulence. Break out, if needed, to ensure separation.

1.11.4 Formation Break Out Procedures
The purpose of a break out is to ensure immediate separation and to avoid a mid-air collision.

Lead
If a wing pilot has broken out of the flight, you may continue the current maneuver with the current power setting to aid in aircraft separation. If the wing pilot is in sight, you will be directive and maneuver to obtain separation based on the wing pilot's altitude call or visual contact.

Wing
As the wing pilot, you must break out of the formation if you:

- Lose sight of your lead aircraft
- If you are unable to rejoin or stay in formation without crossing directly under or in front of Lead
- If you feel your presence in the formation constitutes

a hazard.
- When you are directed to do so by Lead

NOTE
See Chapter 6 Abnormal Operating Procedures for guidance on inadvertent penetration of IMC and Lost Wing Pilot procedures.

If you have lost sight, clear, then break in the safest direction away from the last know position or flight path of Lead and other aircraft. One technique: "look for blue sky and pull" is appropriate for many situations but there may be conditions where you would actually pull toward the ground, depending on your attitude and relative location to the rest of the flight. Call the breakout and your altitude: "Raven 2, breaking out, climbing to 4500 feet."

After gaining safe separation, you should confirm that Lead is, or is not, in sight and transmit "visual", or "blind" IAW with this chapter. If you have reacquired Lead, remain in the same general area but make no attempt to close on the flight until Lead directs you to rejoin.

WARNING
The wing pilot may encounter a hazardous situation in which an aggressive break out is inappropriate. For example, if the aircraft drifts into a position dangerously close to Lead, an aggressive breakout may possibly result in collision. In this situation, the wing pilot should move away from Lead, using smooth and positive control inputs as required.

1.11.5 Lost Sight Procedures

There may be cases during extended trail where you lose sight of the aircraft while maneuvering and a breakout is not warranted. This occurs when spacing between aircraft is such that a mid-air collision in not an immediate concern. An example would be losing sight after rolling out from a pitch-out several thousand feet in trail of Lead or during fluid maneuvering exercises such as extended trail.

1.11.5.1 The Blind Aircraft

If the other aircraft is not in sight when anticipated, ***and proximity does not warrant an immediate break out***, the pilot will notify the flight using the term "blind", and state altitude;

"Raven 2, blind, 4500 feet"

In some cases, heading information may be warranted, but avoid long transmissions/descriptions. Do not rejoin on Lead until directed to do so.

1.11.5.2 The Visual Aircraft

If Lead has not lost the visual, he/she will help the wing pilot reacquire visual by transmitting his/her position from the wing pilot's perspective.

"Raven 2, visual, Lead at your right, two o'clock high"

In this case, Raven 2 simply needs to look to his/her two o'clock high to begin reacquiring Lead.

In all cases, Lead should be directive and ensure altitude separation. Lead will then decide on a course of action.

1.11.5.3 Both Aircraft Blind

If both aircraft are blind (lost sight), the flight will immediately follow "Knock-It-Off" procedures IAW this chapter. ***Lead will ensure altitude separation is maintained until making visual contact.*** Consult your instructor for techniques to resolve such situations efficiently.

1.12 Briefings

The team concept of mutual support requires an effective communication process within, and among, the flight. This begins with the formal briefing and does not end until conclusion of the debriefing after the flight.

1.12.1 Formation Briefing

The flight lead will ensure the flight objectives, weather, sequence of events and communications are briefed before every formation flight. Qualified formation pilots are expected to be knowledgeable of the standard operating procedures contained in this manual, thus mission elements may be briefed as "standard" provided they are published and the proficiency level of all flight members allows them to be briefed as such. Non-standard procedures and information unique to the mission will be briefed in detail. As a minimum, review the formation briefing guidance contained in Appendix D.

1.12.2 Formation Debrief

Even though the mission is over, the learning isn't. After everyone has had a chance to secure his/her aircraft, the flight members assemble for the debrief. This is a critical tool of the formation program. The flight lead will restate the objectives and review how the flight performed in all phases from engine start to shut down, with emphasis on what occurred, why it occurred, and how to improve in the future.

NOTE
See Appendix A for expanded guidance on Formation Briefing and Debriefings.

1.13 Summary

This chapter begins the building of our Standard Operating Procedures to safely conduct formation flight training. With these procedures fully understood, let's move on to basic, two-ship, parade formation.

CHAPTER TWO
Basic Maneuvers: Two-Ship

2.1 Introduction

This chapter will describe fundamentals and walk through two-ship basic maneuvers from engine start to shut down. First, we need to define some terms. Simply put, any group of more than one aircraft is called a "flight." A flight may consist of two aircraft, 16 aircraft or 116 aircraft all flying with respect to one another.

Flights are made up of "elements." An element consists of a Lead and a Wing. The two-ship element is the basic building block of all formation flying. There are never more than two aircraft in an element. For instance, a flight of four aircraft is made up of two elements; a flight of six is made up of three elements, and so on.

2.2 Fingertip Formation

Two-ship formation will form the basis for all your formation flying. Fingertip formation is so named because this configuration resembles the fingertips of your hand, when viewed from above. Fingertip formation is also referred to as "close formation" or "parade formation."

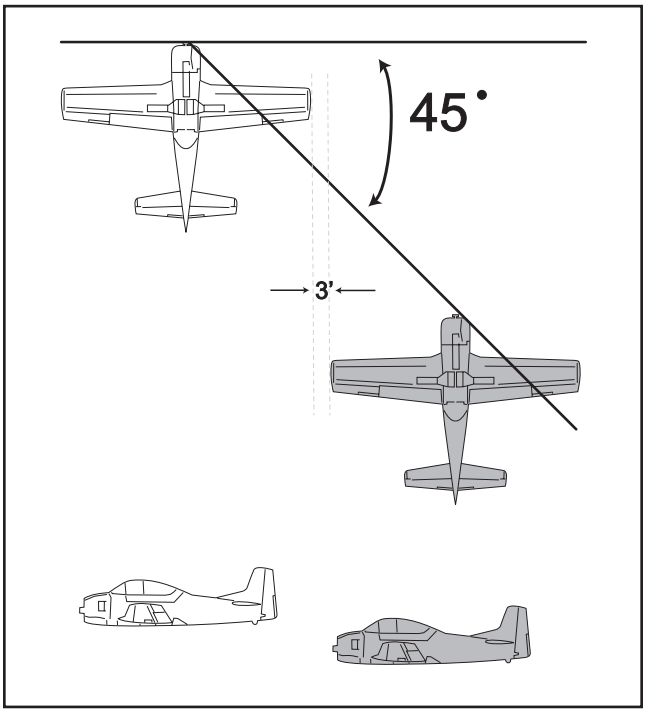


Figure 2.1 Bearing Line

2.3 Bearing Lines and Sight-lines

The bearing line is a line that originates at the lead aircraft's nose and extends along the nose of each aircraft in the flight. The angle of the bearing line should be determined for each type aircraft and is generally in the 30° to 45° range. There are two main factors that determine which angle is best for a given aircraft. Safety is the first factor: does the bearing line position provide sufficient spacing and visibility? When we talk about spacing, we are looking at the three-dimensional clearance between aircraft, laterally and vertically. When we talk about visibility, we are looking at the visibility required for a wing pilot to clearly see Lead's hand signals. There is a trade-off here—as the wing aircraft moves aft to a greater degree bearing line, separation will increase but visibility may decrease. The second factor is symmetry—does the flight look balanced and pleasing to the eye when viewed by spectators?

There is a third, less critical factor that may come into play: sight-lines. As you develop bearing lines for a particular aircraft, you will want to consider sight-lines (Figure 2.2). These are the lines of reference the pilot will use to fix his/her position on the lead aircraft (or reference aircraft in the case of #3 and #4). Ideally, the sight-lines should provide at least two points of reference on Lead to triangulate, or fix, the wing pilot's position in space. An additional reference will provide stack-down, or vertical clearance. As you experiment with sight-lines, you may find that adjusting your bearing line fore or aft by a few degrees will give you excellent, easily identifiable sight-lines that will make the job of station-keeping much simpler.

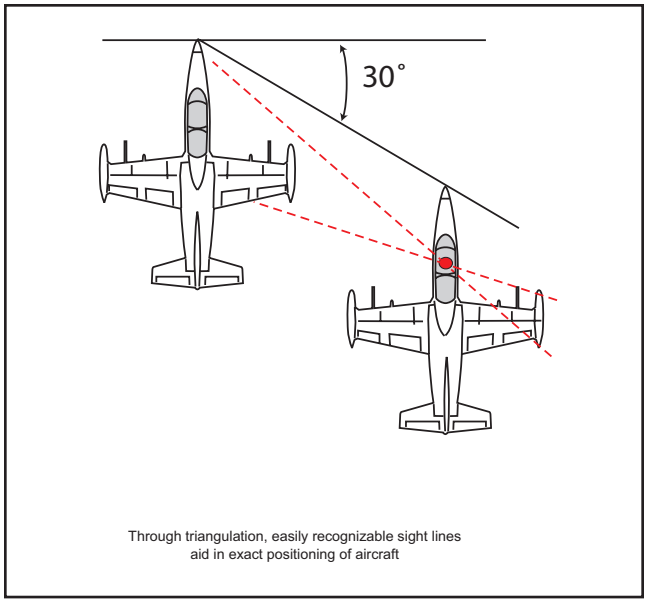


Figure 2.2 Sight-lines

Sight-line consideration will also come into play when flying dissimilar aircraft in formation. Lead will need to cover each aircraft's unique sight-lines as part of the briefing.

2.4 Position

The fingertip position is flown on an angle approximately 30° to 45° back from Lead (angle dependent on aircraft type and sight-line references used) with approximately three

feet of wingtip clearance. "Stack down" appropriate to your aircraft will be used to provide vertical separation ("stack up" may be required for some high-wing aircraft). Your Instructor will point out the references that apply to your aircraft. Do not stare at one reference. Look at the whole aircraft and clear through your Lead. Scanning from reference to reference will help you detect small changes in position.

2.4.1 Maintaining Position

Finally, it is time to get to the nuts and bolts of formation. Maintaining position, or "station keeping," is very challenging. At first, you may bounce around like a well-hit golf ball in a tile bathroom. In time you will learn to judge relative motion from Lead and make small, prompt corrections to stay in position. Good formation is the result of anticipation, planning and always striving for the perfect position. Keep these points in mind:

- Relax! Just as in basic flying, you must feel what the a plane is telling you. Tension leads to over-controlling, which can cause oscillations that are tough to stop.
- Trim the airplane. Being out of trim increases fatigue.
- Try resting your flight control arm on something stationary—like your leg, in aircraft with sticks.
- Rest your other hand on either the base of the throttle quadrant, if your aircraft is so equipped, or adjacent to the prop lever, to gage movement and reduce over-controlling.
- Crosscheck, but do not fixate on, your sight-line reference points—look at the whole aircraft and clear through your Lead.

2.5 Technique

Good formation is the result of recognition, anticipation, planning, and the application of small, prompt corrections. The easiest way to detect motion is by crosschecking the sight-line references on the lead aircraft. Each aircraft type has established references to help you stay in position. By lining up two points on the lead aircraft, you will be able to detect very small movements. Motion will occur along all three axes. In general, fore and aft spacing is controlled with use of the throttle; vertical position is maintained with the elevator. Lateral spacing is controlled with coordinated use of the ailerons and rudder. This is a simplified way of dividing up the control inputs and corrections. Seldom, though, is it that easy. Most of the time, corrections will have to be combined. For instance, if you are low and apply back pressure to move up into position, you will likely fall behind unless you add power to maintain your airspeed.

Being behind the fingertip bearing line is referred to as being "sucked," (Figure 2.3) while being ahead of the line is called "acute." (Memory aid: Being behind sucks while being ahead can be dangerous—or acute).

When out of position, correct first to the fingertip bearing line. That way, your relative motion to the lead aircraft will always have the same appearance. (The only exception to this is if you are too close to Lead. In this case you should first obtain more lateral spacing, and then correct to the line.) The next most critical error to correct for is vertical position and, finally, correct for lateral spacing. It is also important to keep the aircraft trimmed and coordinated.

Your instructor will have you practice exercises that help increase your judgment and teach you the corrections required to get you back into position.

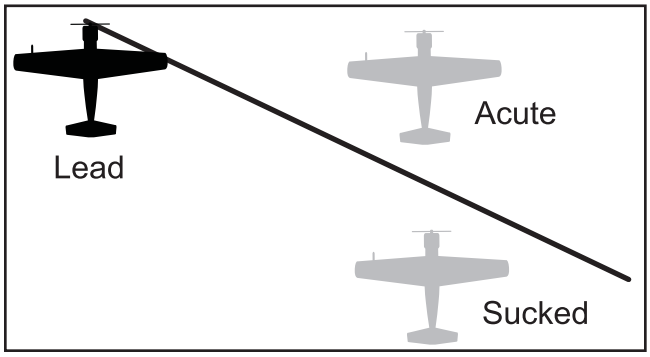


Figure 2.3 Deviation From Bearing Line

2.5.1 Turns in Fingertip

When Lead rolls into a turn, it will immediately put you out of position unless you anticipate and make the required control inputs. The wing pilot maintains the same relative position while rolling into and out of bank. This means that besides rolling with Lead, you have to move vertically to stay in position. This in turn requires a power change. All this happens while Lead is rolling into the turn, but the corrections must be taken out when Lead stops rolling and is established in the bank. The effects are reversed when rolling out of the bank. We will dissect specific examples.

2.5.2 Turns into the Wing Pilot

Let's take the case where you are #2 on Lead's right side. Lead begins a smooth roll to the right. Match Lead's right roll to match your bank angle. At the same time, you will need to descend to maintain vertical position. This descent will increase your airspeed, causing you to get ahead of Lead, unless you coordinate with a power reduction. This effect will be compounded by the fact that, on the inside of the turn, you are flying a smaller turn circle and will therefore travel a shorter distance than Lead. Once Lead stops rolling and is stabilized in the bank, you will have to stop the descent and adjust power to stay in position. These are the individual control inputs explained; now how is it really done? As soon as Lead starts to roll towards you, simultaneously reduce power, roll with Lead and apply forward pressure to stay in position.

2.5.3 Turns Away from the Wing Pilot

Now let's look at the case where Lead turns away from you. In fingertip right, Lead starts a left turn. You will have to

climb and roll to stay in position on the wing. This will require back pressure to move up vertically, and also a sizable power addition lest you lose airspeed and fall behind. Keep in mind, you are also on the outside of the turn flying a larger turn circle, and thus must increase airspeed slightly to keep with Lead.

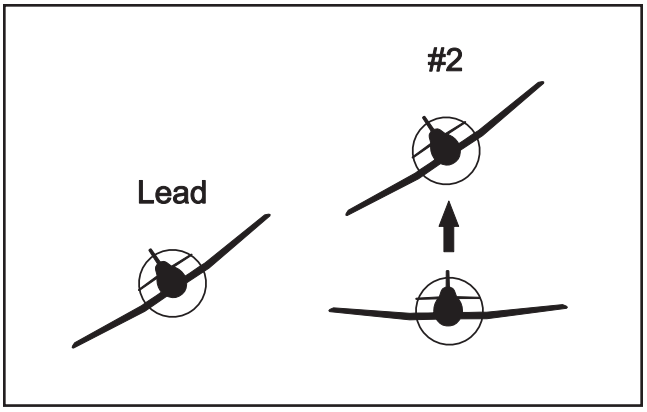


Figure 2.4 Turn Away From Wing Pilot

Here's what will probably happen on your first few "turns away." You will be a little slow to roll, which will push you out away from Lead. Thus, to stay in position vertically will require a larger climb. You will probably not add enough power, which will cause you to get sucked. So, there you are, wide, below and behind Lead, with full throttle and unable to catch up. With time you may catch back up with Lead—generally about the time Lead decides to roll out. To keep this from happening, make positive inputs as soon as Lead rolls. Add a bunch of power, stay right with Lead's roll, and ease on up to stay in position. If you add too much power initially, it is easy to correct by taking a little off. However, it is difficult to catch back up if you are shy with the power and fall behind. Once Lead reaches his/her desired bank angle and stops his/her roll, ease off the back pressure, stabilize your bank, and adjust power to maintain position. Now get ready; anticipate Lead's roll out of the bank. Lead's rolling out of the left turn will have the same effect as rolling into a right turn—it is just a turn *into* the wing pilot.

Summary

That covers the basics of remaining in position, turns, climbs, and descents. Your first few formation flights should concentrate on building a strong foundation in these basics. Once comfortable with these principles you will move on to bigger and better things. Now let's take a look at a typical two-ship training sortie.

2.6 Ground Operations

2.6.1 Engine Start, Taxi, and Takeoff

If the aircraft are parked together, start engines on a visual signal; if they are parked separately, use a pre-briefed starting time or radio call. If you are late arriving at the aircraft, do not omit items on your preflight or rush engine starting procedures. Be expeditious, yet thorough, during preflight so you're ready when the flight lead needs you to be ready. If delays occur, inform the flight lead as soon as possible but not later than the pre-briefed check-in time. Inform Lead of any difficulties that may delay your departure.

2.6.2 Check-In

Engine start and check-in procedures will be as briefed by the flight lead. Flight members will be ready for check-in at the pre-briefed time. All aircrews should monitor the current automated weather information (ATIS or AWOS) prior to start/taxiing. When Lead looks at you, give a "thumbs up" if you are ready to proceed.

After engine start, Lead will check the flight in on the radio. Acknowledge with your formation position. After the flight checks in, Lead will call for taxi clearance, as necessary. The formation then taxis out, assuming proper position when pulling out of the parking area. Taxi position for the wing pilot is two ship-lengths behind Lead when taxiing staggered. Increase the spacing to four ship-lengths when taxiing directly behind Lead.

2.6.3 Taxi

Lead should taxi at the speed that allows wing pilots to attain proper spacing. As a wing pilot, match Lead's configuration. Lead and Wing will inspect each other for proper configuration and any abnormalities prior to takeoff. Continue this inspection throughout the sortie and into the chocks. This is the starting point for mutual support.

2.6.4 End of the Runway Lineup

Upon reaching the run-up block, #2 should stop parallel with the flight lead. When #2 is ready for engine run-up, he/she will signal Lead with a "thumbs up." Lead will signal for the run-up and both flight members will initiate their run-up procedures and complete their pre-take-off checks. When #2 is ready, he/she will pass a "thumbs up" to Lead.

2.7 Formation Takeoff

2.7.1 Runway Lineup

For element takeoffs, runway lineup is normally determined by the direction of the wind. However, if the winds are determined to be insignificant (less than five knots of crosswind), other factors such as direction of turn out of traffic, sun angle, and weather will determine runway lineup. Anticipate clearance to take the active so as to minimize time taken to lineup and be ready for takeoff. Lead will taxi a sufficient distance down the runway to ensure his/her Wing has enough room to maneuver into position. Flight lead will usually take the center of his/her half of the runway. Lead places the wing pilot on the upwind side for takeoff when the crosswind component exceeds five knots to keep him/her from entering wake turbulence in the event he/she falls behind. The wing pilot lines up in the center of his/her side

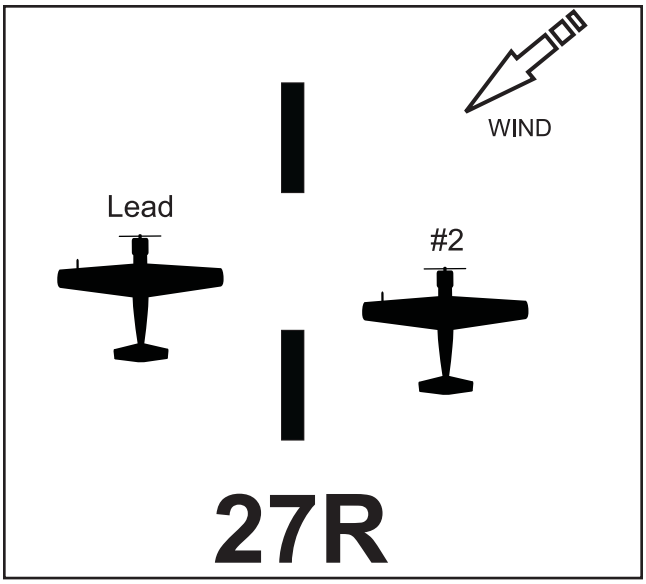


Figure 2.5 Runway Lineup

of the runway, forward of the fingertip line (acute position) with a minimum of 10 feet of lateral wingtip clearance. Once in position, the wing pilot will look at Lead in anticipation of the run-up signal.

2.7.2 Engine Run-Up

Lead

You will give the run-up signal when Wing is in proper position, is looking at you in anticipation of run-up, and has given you a head nod. Set power to the briefed setting and cross-check instruments one last time. Look at Wing to see if he/she is ready for brake release, as indicated by a head nod. A helmet tap is the preparatory command for brake release. The execution command is a head nod. As your chin hits your chest, simultaneously release brakes and smoothly advance power to the briefed takeoff power setting. Once the power is set, do not adjust the throttles unless the wing pilot requests it. As with a single-ship takeoff, use differential braking/nose-wheel steering until the rudder becomes effective. Perform the takeoff, concentrating on tracking straight ahead while monitoring the wing pilot with your peripheral vision.

To give your wing pilot an airspeed safety margin, you will rotate and lift off at a slightly higher airspeed than you would if you were flying single-ship (approximately five knots).

Do not retract the gear and flaps until you confirm the wing pilot is safely airborne, clear of obstacles, in position, and stable. Use the standard or briefed gear retract signal.

Wing

When you have stopped in the proper position and are ready for run-up, look at Lead and nod your head. Acknowledge Lead's run-up signal with a head nod. During the engine run up, continue to primarily focus your attention outside the aircraft with only short glances inside the cockpit. When ready for brake release, signal Lead with a head nod.

Monitor Lead for the preparatory and execution signals. Release the brakes and smoothly advance the throttle when Lead's chin starts down. In the low-speed range, tap brakes as required to maintain fore and aft position. Strive to maintain the line-up position for the remainder of the takeoff roll. If a power advantage or disadvantage is apparent, request one additional increase or decrease in power (e.g., "Red 1, give me one/push it up"). As with a single-ship takeoff, use differential braking/nose-wheel steering as necessary to maintain directional control until the rudder becomes effective. Rotate with Lead's aircraft and concentrate on maintaining proper position. Normally, the first indication of Lead's rotation will be the movement of the elevator/stabilator or the extension of the nose gear strut. A late rotation could result in overrunning Lead; an early rotation could result in falling behind.

Duplicate Lead's pitch attitude for lift off. When both aircraft are airborne, maintain a stacked-level, acute position until the gear and flaps are retracted, then move into fingertip. In the stacked-level position, the picture is the same as when lined up on the runway. Confirm the gear and flaps are retracted.

If Lead lifts off before you do, do not retract the gear and flaps until you are safely airborne.

2.7.3 Wing Overrunning Lead

Lead

Unless aborting the takeoff, transmit "Red 2, you have the lead on the right/left," select maximum power and perform an individual takeoff. Maintain aircraft separation and direct appropriate measures to regain flight integrity.

> NOTE
> This call is simply an acknowledgement that the formation takeoff has been terminated and each pilot is to continue single-ship. Lead is still responsible for the flight and will determine how to rejoin the flight when safely airborne.

Wing

After requesting a power increase, if you still cannot prevent overrunning Lead, maintain the appropriate side of the runway, advance throttles to maximum power, and make an individual takeoff. Do not attempt to fly formation after passing Lead. Concentrate on making a single-ship takeoff. When safely airborne, retract the gear and flaps and fly the briefed departure until instructed otherwise by the flight lead.

> WARNING
> When reducing power, it is critical to monitor airspeed so as not to get too slow.

2.7.4 Wing Falling Behind Lead

Lead

Be sure not to retard the throttle too far. If the wing pilot cannot stay in position, he/she will make a separate takeoff. Limit maneuvering until after you have rejoined the flight and the wing pilot is stabilized in position.

Wing

If you are behind Lead and unable to regain position, call for a power reduction (e.g., "Red 1, give me one"). If you continue to fall farther behind following the radio call, check the throttle at maximum, ensure proper engine operation, maintain your half of the runway, and make a separate takeoff. Rejoin on Lead after becoming safely airborne and retracting the gear and flaps.

2.7.5 Single-Ship/Interval Takeoff

Perform a single-ship/interval takeoff when weather or runway conditions prevent an element takeoff.

Lead

You can position both aircraft on the runway prior to initiating the takeoff roll or you can perform a rolling, feed-on takeoff. No hand signals are required. To help expedite the rejoin, avoid steep climb angles, and climb at a reduced power setting. Clear and look for your wing pilot.

Wing

Delay brake release until you see Lead's main gear have lifted off the runway. Once airborne, join on the left wing for straight-ahead rejoins, or on the inside of the turn for turning rejoins. If the mission or flight requirements dictate other than above, the flight lead will pre-brief or call (while airborne) and state the desired formation position.

2.8 Basic Formations and Maneuvers

2.8.1 Fingertip

Fingertip is used for weather penetration, airdrome arrivals/departures, and show formations.

Lead

Maintain a stable platform for the wing pilot by using smooth and consistent roll rates and avoiding sudden changes in back pressure. As an exercise fly a series of modified lazy-eight type maneuvers. As the wing pilot becomes more proficient over time, increase bank angles to at least 45° in combination with ± 20° of pitch change.

Wing

Use all of Lead's aircraft as a reference; avoid fixating on any one spot. Use trim, small throttle and stick movements to maintain position.

Be aware of collision potential at all times. In turbulence, while flying maximum performance maneuvers or maneuvers which are not frequently flown, the collision potential increases. Under these conditions, avoid wingtip vortices because a rapid roll into the leader may develop. Should a breakout become necessary, use rudder, aileron, power, and speed brake as the situation dictates. Break out in the direction that will ensure immediate separation.

2.8.2 Route

Route is an extension of fingertip. In route, the flight loosens up to a minimum of two to four ship-widths out to a maximum of 500 feet from Lead. Fly no farther forward than line-abreast, no farther aft than the fingertip line and, when wings-level, maintain stack-level. Route formation provides flexibility. It allows the wing pilot to check aircraft systems and personal equipment, look around, or simply relax. It also enhances Wing's ability to provide visual lookout. The two to four ship-width spacing is used for frequency changes, in-flight checks, or position changes. The greater spacing is used to relax, as on a cross-country flight, or to allow the wing pilots to look around and help clear for traffic. With route formation, Lead should restrict maneuvering to moderate turns and pitch changes. Maximum bank angle in route is approximately 60° away from the wing pilot and approximately 30° toward the wing pilot.

When Lead directs a move to route formation from fingertip for radio channel changes, in-flight checks, or position changes, wing pilots will fly two to four ship-width spacing unless briefed otherwise.

Lead

Use a radio call or rudder walk/tail wag to send the wing pilot to route.

Wing

Go to route when Lead directs or gives the loosen formation signal. Fly with the lateral spacing of two ship-widths to 500 feet. Fly no farther aft than the normal fingertip line, no farther forward than line-abreast, and vertically the same as fingertip. On the inside of the turn, descend only as necessary to keep Lead in sight and stay below Lead's plane of motion. When on the outside of the turn, maintain the same vertical references used in echelon. During turns, you may need to maneuver behind the fingertip line to maintain spacing and keep sight of Lead. Do not cross to the opposite side unless directed by lead. Route cross-unders may be directed with a radio call or wing dip.

2.8.3 Echelon

Echelon is a configuration where all the wing aircraft are either to the right (echelon right) or to the left (echelon left) of Lead. The aircraft all maintain the same relative position on the fingertip reference line, each flying off the preceding aircraft using the appropriate sight-line references. Echelon is used in the traffic pattern, and to position aircraft for pitchouts. Echelon is limiting in that Lead will normally only turn away from the flight. If Lead does have to turn into the echelon, it must be executed only with very, very shallow-

banked turns.

Turning more than a few degrees into the flight could cause a dangerous situation where the wing pilots (especially #4) cannot prevent going ahead of Lead, or could possibly lose sight of Lead.

> WARNING
> Echelon turns are not recommended for high wing and solid canopy type aircraft because there is insufficient field of vision to safely complete the maneuver. Normal stack up references, as in a fingertip turn, are recommended for these types of aircraft.

Echelon turns away from the flight are accomplished differently than in fingertip. As we covered above, in fingertip everyone maintains the same position references and relative position. In echelon turns, the wing pilots maintain the same lateral spacing, however they ***do not*** move up vertically to stay on the same lateral plane as Lead. Instead, all aircraft will move up just enough to almost be on the same ***horizontal*** plane as Lead. There is a slight amount of stack-down in echelon formation because of the reference we use (fuselage of aircraft ahead bisecting the horizon). Echelon gives the wing pilots a better power advantage to stay with Lead. As Lead rolls into the turn, match bank angles and climb only slightly to split the lead aircraft with the horizon line. The references will be demonstrated to you, but the horizon should bisect the longitudinal axis of the preceding aircraft. Since you are on the outside of the turn, you will be traveling a longer distance than Lead. Add power to prevent falling behind. Maintain the same lateral spacing from Lead in the turn. When Lead starts to roll out, start a power reduction as you roll back out with Lead.

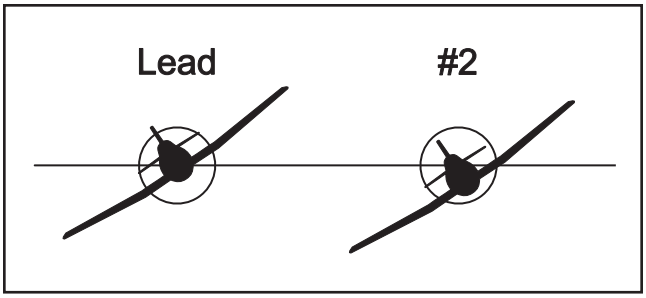


Figure 2.6 Echelon Turn

2.8.4 Cross-Under

The purpose of performing a cross-under is to efficiently and safely move from one wing position to the opposite wing position. A cross-under may be accomplished from either fingertip or route formation positions. Lead signals for the cross-under by holding up a clenched fist (two-ship), making a radio call, or by dipping a wing in the desired direction of change.

Lead

Direct a cross-under with a visual signal, aircraft signal or radio call.

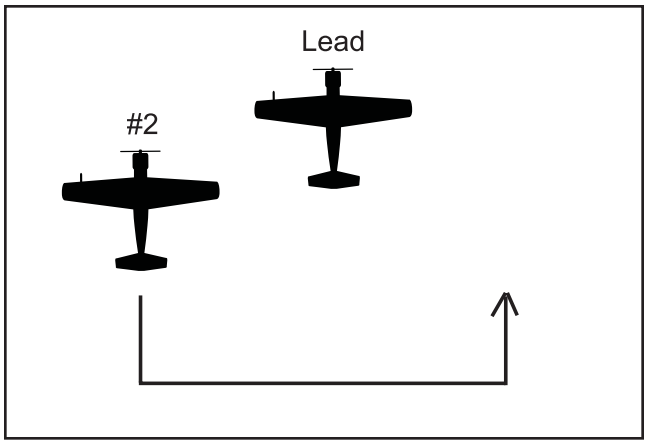


Figure 2.7 Cross-Under

Wing

Initially, perform a cross-under in three definite moves. Reduce power slightly and, as airspeed is reduced, move a few feet lower than normal position. Move aft to obtain nose-tail clearance; then increase power slightly to maintain this spacing. (Anticipate the power increase to prevent falling too far behind.) Bank slightly toward the new position to change the aircraft heading by a few degrees. Roll wings level, and fly to the opposite side. A heading change of only 1° or 2° will cause the aircraft to fly smoothly from one side of Lead to the other. Keep proper nose-tail clearance with power; a power increase is necessary to maintain this clearance. Do not cross directly under any part of Lead's aircraft! When you have wingtip clearance, return to Lead's heading. Add power, and as you move forward, move up to attain proper pitch references. As you approach the fingertip position, reduce power to stop in position.

As your skill increases, you may round out under the cross-under to execute it as one smooth maneuver. Regardless of your technique, never pass under Lead.

To fly good cross-unders, you must anticipate each power change and make the smallest possible changes in pitch and bank. Once you become proficient, cross-unders may be completed during turns.

2.8.5 Close Trail

Trail formations are flown, as the name implies, with the wing pilots maneuvering behind Lead. There are two distinct types of trail formation—close and extended. We will discuss the differences further in the fluid maneuvers chapters.

Close trail maneuvering consists of turns, climbs, descents, and modified lazy eights. Proper spacing is one to two aircraft lengths, nose-to-tail, behind Lead and just below Lead's prop/jet wash (Figure 2.8). When flying directly be-

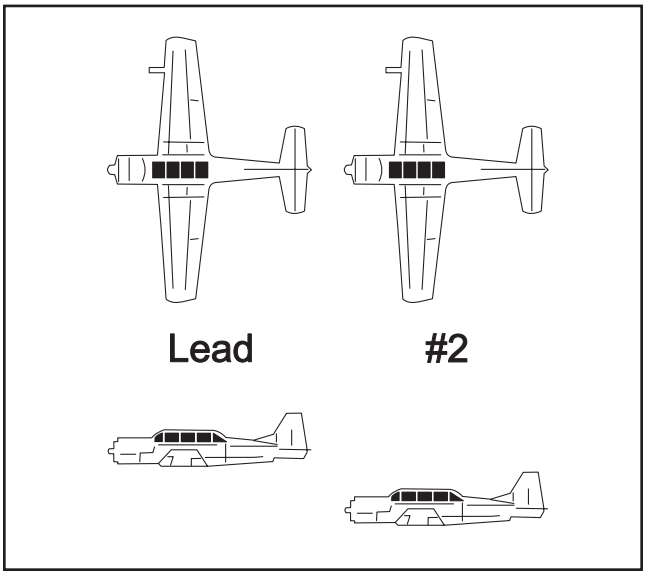


Figure 2.8 Close Trail

hind Lead, closure rates become difficult to determine. If excessive spacing exists, do not attempt to move forward with power alone. Add power and establish a small amount of Lead pursuit (see Chapter Three) while in a turn. If wings-level, move off to one side to obtain a better perspective of Lead. The two most important points to remember are to remain below Lead's prop wash/jet wash and always keep Lead in sight.

Close trail maneuvering will be terminated by either reforming to fingertip or moving to extended trial. If reforming to fingertip, Lead must avoid any significant power changes until the wing pilot is in fingertip. If moving to extended trail, Lead will follow extended trail entry procedures.

Lead signals for close trail by holding up a clenched fist, thumb extended aft, motioning aft. Lead can also porpoise his/her aircraft or make a radio call.

Lead
Initiate close trail with a hand signal, aircraft signal, or a radio call and only from fingertip, echelon or route. Wait for the wing pilot to call in before maneuvering. Be smooth, predictable and maintain positive G-force at all times. Avoid sudden releases of back pressure and rapid turn reversals.

Wing
Acknowledge the call to go to close trail, maneuver to the trail position, and call when in position. Avoid flying too high to prevent encountering Lead's prop/jet wash or wingtip vortices. Maintain position primarily through the use of power. However, when Lead is turning at a higher G-loading, you may need to fly slightly inside the turn to maintain position.

2.8.6 Lead Changes
Lead will initiate a lead change with a visual signal or radio call. The "stable platform" concept is very important when executing this maneuver—the pilot giving up the lead position will remain wings level and stable while the pilot assuming lead maneuvers into position.

Lead
Move the wing pilot out to route position. If using hand signals, point to the wing pilot and then point forward to indicate you are transferring lead. If you are using the radio, transmit "Raven 2, you have the lead on the right/left." Maintain straight-and-level flight with a constant power setting.

Wing
When Lead gives you the lead-change hand signal, acknowledge with a head nod and move to route, if not already there, and then move forward to line abreast. When stabilized at line abreast, signal the surrendering lead pilot by tapping your head/helmet and pointing forward, indicating that you now have the lead. Increase power slowly and advance forward to assume the lead position. As you move forward, the surrendering lead will pick up the normal route fingertip references and maintain station-keeping.

If a radio call is used: "Raven 2, you have the lead on the right/left," you will respond, "Raven 2" and move to line abreast, route position. Once stabilized, you will call "Raven 2 has the lead on the left/right," increase power slowly and move forward. The new wing pilot will maintain route until directed by the new lead. Once the flight is stabilized in the new configuration, Lead will check the flight in on the radio: "Raven, check." The new Wing will respond: "Raven 2."

2.9 Traffic Pattern and Landing
There are several traffic pattern options—landing single-ship following a 360° overhead pattern, landing single-ship after taking spacing at some point in the pattern, or landing as an element. There are also several variations to the overhead pattern, detailed below.

The 360° overhead pattern is an efficient way to get a formation flight on the ground. The overhead pattern involves flying an upwind leg aligned with the landing runway at pattern altitude (called "initial"), followed by a steep-bank "break" turn to the downwind when over the runway, and a close-in descending turn to base and final approach. This pattern allows you to bleed off airspeed in the turn to downwind for gear extension, and keeps the aircraft in close to the runway.

The wing pilot should try to remain aware of location while Lead brings the flight into the traffic pattern. This will help anticipate Lead's actions. Lead will direct the flight to change to the appropriate frequencies on arrival.

Once established in the pattern, turns away from the wing pilot will normally be in echelon unless directed otherwise.

Pilots will land on alternate sides of the runway unless specific aircraft ops dictate otherwise, or high crosswind landing procedures are in effect.

2.9.1 Overhead Pattern

Lead

On or before turning initial, place the wing pilot on the side opposite the direction of the break. Give the wing pilot the hand signal for pitch-out and interval (interval not required if pre-briefed). Over the numbers, or as required by the tower, wind conditions, or desired touchdown point, initiate the break to downwind. Reduce power as necessary and fly a 2-G, 60° level turn to downwind, slowing to the briefed traffic pattern airspeed. The perch position is the point on downwind, at traffic pattern altitude, where Lead begins the descending, final turn for landing. Its location is a function of the intended point of touchdown. Lead will plan the perch position so as to roll out on final approach, at the desired wings level, stabilized final approach segment distance. Approaching the perch position, lower the gear and flaps, and complete the before landing checklist. Transmit a "gear down" call. At the perch position, initiate a continuous, descending turn to land. Lead will land on the "cold" side of the runway—the cold side of the runway is that side closest to the ramp or taxiway exit. The "hot" side of the runway is opposite the turn-off side. All following aircraft that land on the opposite side as Lead will move to the cold side of the runway when slowed to taxi speed and cleared to do so by the succeeding aircraft. The hot side of the runway is reserved for aircraft needing to go around or incapable of slowing at the same rate as the preceding aircraft.

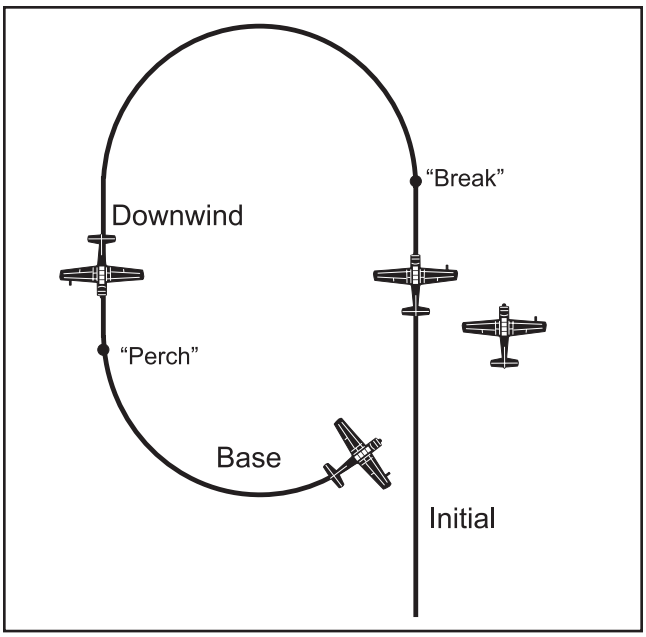


Figure 2.9 Overhead Pattern

Wing

After Lead breaks, delay for the briefed or signaled interval before initiating the break. Roll out on the downwind behind Lead, at the briefed airspeed. Approaching the perch point, lower the landing gear and flaps, complete the before landing checklist, and cross-check the runway and Lead to ensure proper spacing from both. Do not begin the final turn unless Lead is in sight. After initiating the final turn, fly your normal pattern. Complete your "before landing checklist." Transmit a "gear down" call. Continue to cross-check Lead throughout the turn and on final to ensure adequate spacing exists. Fly your pattern so as to touch down approximately five to 10 seconds behind Lead. Land in the center of the opposite side of the runway from Lead. Taxi to Lead's exit point. If Lead has to cross in front of you in order to clear the runway, wait until you are slowed to taxi speed and under control before clearing Lead to cross.

2.9.1.1 Pitch-up Break

One variation of the 360° overhead break is the pitch-up break. For the pitch-up break, Lead will bring the aircraft up initial at less than pattern altitude (500 feet works well) and fly a climbing break, rolling out on downwind at pattern altitude. All other procedures remain the same.

2.9.1.2 Downwind Break

If a 360° overhead is not feasible, Lead can obtain the proper spacing at any point in the pattern where a 90° turn will be made—crosswind, downwind, or base, although the turn to base usually works best. Lead will slow the flight to normal pattern speed, make a directive radio call to take spacing, or give the appropriate hand signal.

Lead will break to the appropriate leg of the pattern. After the interval (normally five seconds), the wing pilot will break. As each pilot starts the turn he/she will reduce power, lower the gear, extend the flaps and complete the before landing checklist. Land on alternating sides of the runway following the same procedures used in the 360° overhead pattern.

2.9.2 Element Approaches and Landings

Lead

Slow to gear/flap extension speed and use a radio call or visual signals to configure the element for landing. After confirming a safe gear indication from both aircraft, transmit a "gear down" call for the flight.

When flying a formation approach with some aircraft, you have the option of initially configuring the formation with partial or full flaps. If planning a formation landing and configured with partial flaps, lower full flaps upon intercepting the visual glide path. To avoid any confusion, brief the desired initial configuration during the preflight briefing.

Plan to position the wing pilot to land on the upwind side of the runway when crosswinds are a factor, (e.g., greater than five-knot crosswind).

When you turn final, line up on the center of the appropriate side of the runway and establish an aim point that will

allow a touchdown approximately 500 to 1,000 feet beyond the threshold.

In the flare, make a smooth, slow power reduction to just above idle power.

Wing
Maintain the normal fingertip position until turning final, then move up to stack level with Lead (Lead's head superimposed on the horizon). Spread laterally a minimum of 10 feet and fly the stacked-level position. Move to the same acute position used for formation takeoffs. Wing should begin to acquire the runway with peripheral vision and start to divide attention between Lead and the runway. Plan to land in approximately the center of your half of the runway with no less than 10 feet of wingtip clearance. (Minimum runway width for training should be 100 feet.)

Lateral spacing for the landing should allow adequate room if a problem occurs during touchdown or landing roll, but this spacing must not place you near the runway edge.

Lead is the primary reference for the wing landing. Crosscheck the runway on short final to ensure proper alignment, then fly the proper position off Lead throughout the flare and touchdown. You should touch down slightly before or at the same time as Lead. If you touch down after Lead, it is likely that you will "float" past Lead on the runway. If you overrun Lead, accept the overrun and maintain the appropriate side of the runway and aircraft control. The most important consideration is wingtip clearance. After touchdown, maintain relative position on your side of the runway and use normal braking technique, regardless of Lead's deceleration rate. You should pass Lead rather than over-brake to maintain position.

If the element Lead must cross the runway center line to exit, you must ensure that you have safe spacing, safe speed and are under control before clearing Lead to cross in front of you.

2.9.3 High Crosswind Landing Procedure
If the crosswind component exceeds a safe limit for conducting "staggered" landings, all pilots will land on the runway centerline and, when slowed down to a safe taxi speed, move to the "cold" side of the runway.

> NOTE
> For some aircraft, particularly certain tail-draggers, landing on the centerline may be standard ops for all conditions.

2.10 Go Arounds From Overhead Pattern
There will be occasions when one or more members of a flight will have to go around after the pitch-out from the overhead pattern. Once the go around is executed, all go-around aircraft are considered single ship, independent of the formation. The go-around aircraft will fly a normal single-ship go around and reenter the overhead traffic pattern, or the normal traffic pattern, for landing. The single-ship status will terminate if the flight gets back together on the taxiway to return to the ramp.

2.11 Element Go Arounds
In the final stage of an element landing both aircraft are at low altitude, low airspeed, relatively high angle of attack and have high drag. Because of these factors, formation go arounds must be executed carefully and deliberately. Although element integrity is important, it is secondary to maintaining obstacle/ground clearance and safety of flight.

Lead
When confronted with a potential go-around situation, the earlier the decision is made to execute the go around the easier it will be for the element to make the transition to stabilized, clean-configured flight. Use directive radio calls or hand signals to alert your wing pilot and reconfigure the flight.

When the decision has been made, announce "Raven going around" and advance the throttle smoothly to a suitable go-around power setting. Make allowances for an extra margin of power for your wing pilot. If using hand signals, signal your wing pilot with a "power up" hand signal. When the flight is no longer descending, call or signal for flaps up and raise the flaps. Once you have established a positive rate of climb for the flight, call or signal for gear up and raise the gear. Continue to climb and accelerate until you have achieved the desired altitude and airspeed.

If your wing pilot cannot maintain formation position or he/she calls for a single-ship go around, announce "Raven, execute single-ship go around" and advance your throttle to maximum or go-around power. Try to keep your wing pilot in sight as you climb and accelerate. Once established at the desired altitude and airspeed, rejoin the flight or direct your wing pilot to continue single ship.

Wing
When you hear Lead make the go-around call, or see the "power up" hand signal, increase power as necessary to maintain the acute, stacked-level position, just as you would for a normal takeoff. Be prepared for the sequential radio calls or hand signals directing you to clean up the airplane during the go around—execute on Lead's command.

If you fall behind or out of position, establish an "offset" trail position so as to avoid prop/jet wash and vortices. Advance your throttle to normal single-ship, go-around power and execute your own go around. Announce "Raven 2, single-ship go around" to alert Lead to your intentions. Maintain the offset trail position and keep Lead in sight.

2.12 Taxi In and Shutdown

Once clear of the runway, Lead assembles the flight for taxi to the ramp. Flaps will be retracted on Lead's signal or as briefed.

If parking together, the flight can shut down together. If conditions permit (i.e. no aircraft, people, or obstructions behind the formation), Lead will signal to perform the pre-shutdown run-up, if required. Reduce power to idle and shut down on Lead's signal.

2.13 Debrief

After everyone has a chance to secure his/her aircraft, the flight members assemble for the debrief. The goal of the debrief is to improve safety, performance, communication, and understanding.

See the debrief section of this manual for details.

CHAPTER THREE
Fluid Maneuvers: Two-Ship Pitch-Outs and Rejoins

3.1 Introduction

So far, in our formation training, we've been discussing "close" formation where you have been maneuvering in close proximity to Lead using easily discernible references. In this chapter we are going to introduce the fundamentals of fluid maneuvering (FM). FM is the ability to use pursuit curves and dynamic maneuvering to maintain relative position to another aircraft. Fluid maneuvering skills are critical to successful rejoins and all trail formations.

First, we will define a few concepts and look at their relationship to one another; we will then discuss how to employ these concepts towards the successful formation rejoin.

3.2 Concepts and Terminology

3.2.1 3/9 Line

An extension of the aircraft's lateral axis. The wing pilot must remain aft of Lead's 3/9 line during all fluid maneuvering.

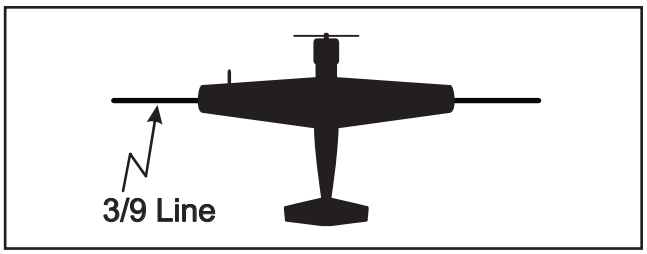


Figure 3.1 The 3/9 Line

3.2.2 Line of Sight (LOS)

A line from the pilot's eye to the object the pilot is viewing.

3.2.3 LOS Rate

The rate of movement of an object across the canopy. If you are overtaking another aircraft, that aircraft will move aft across your canopy at a rate commensurate with the overtake—producing an aft LOS rate. Likewise, if you are falling behind, the aircraft will move forward across your canopy at a proportional rate—producing a forward LOS rate. The speed at which you are passing or falling behind will produce a high or low LOS rate. Pulling lead pursuit (section 3.2.11) is another situation where you can produce an aft LOS rate (figure 3.2).

3.2.4 Aspect Angle (AA)

Angle between Lead's longitudinal axis and the line-of-sight to the wing pilot. The angle is measured from Lead's six o'clock to the Wing's position. The wing pilot's heading is irrelevant. Aspect angle values range from 0° to 180°. A wing pilot at Lead's six o'clock position would be at 0° AA, at Lead's three or nine o'clock the wing pilot would be at 90° AA, and if the wing pilot is directly off Lead's nose, the AA would be 180°. (See figure 3.4)

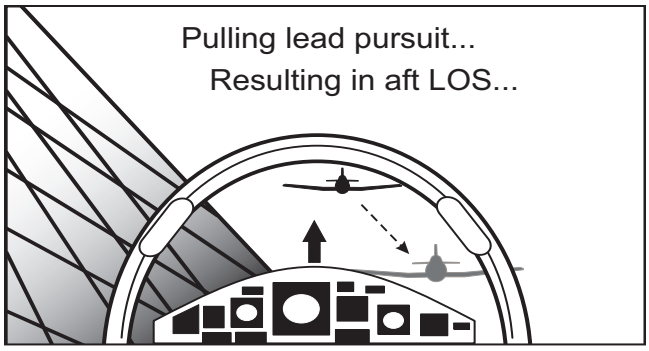


Figure 3.2 Aft LOS

3.2.5 Heading Crossing Angle (HCA)

The relative nose position of two aircraft. The angular difference between the longitudinal axis of the wing pilot and the longitudinal axis of the leader. This concept is dependant on the aircraft's heading. HCA is also known as Angle Off. (See figure 3.4)

3.2.6 Turn Circle

The circular flight path created by a maneuvering aircraft. The turn circle can be in any dimension—horizontal for a level, turning aircraft, vertical for a looping aircraft, or any combination in between for a turning/pulling aircraft.

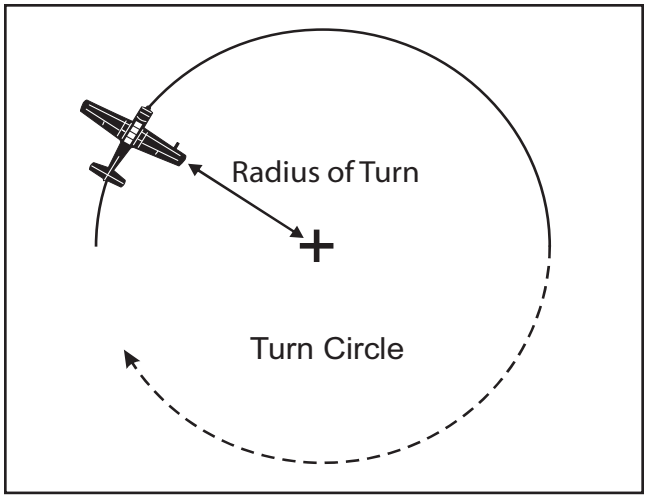


Figure 3.3 Turn Circle and Turn Radius

3.2.7 Turn Radius

The distance between an aircraft's flight path and the center of the turn circle.

3.2.8 Plane of Motion (POM)

An imaginary plane defined by an aircraft's *actual* flight path. When the wing pilot is maneuvering in Lead's plane of motion, as in a rejoin, the Wing is operating "in-plane." If the wing pilot is not maneuvering in the same plane as Lead,

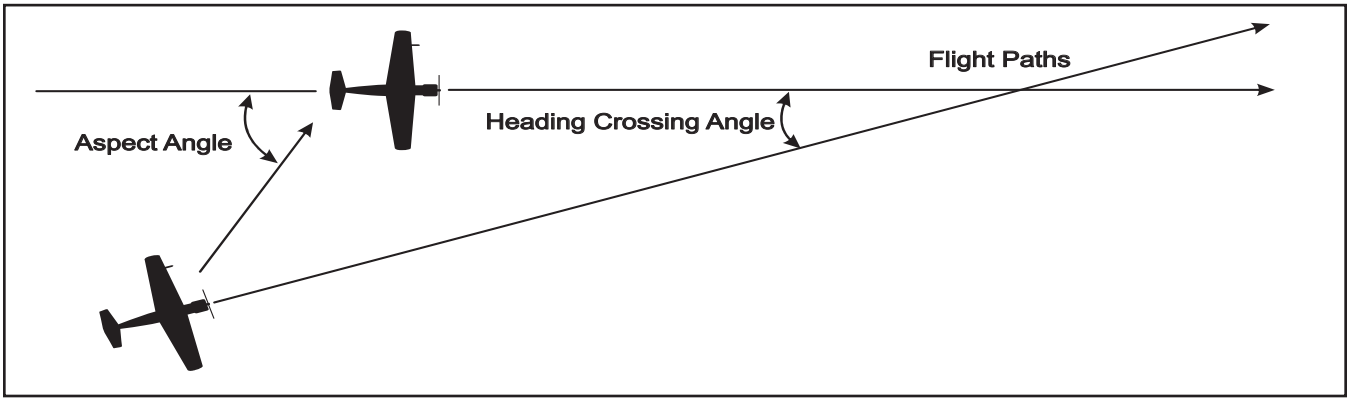


Figure 3.4 Maneuvering Fundamentals: Aspect Angle and Heading Crossing Angle

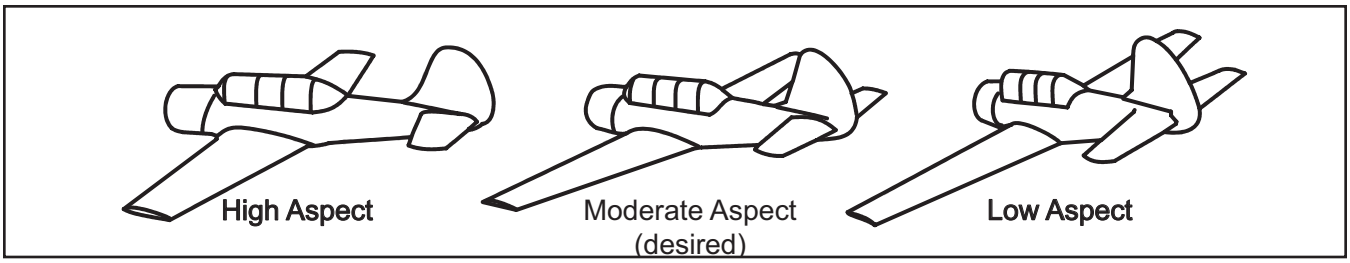


Figure 3.5 Aspect Angle Recognition

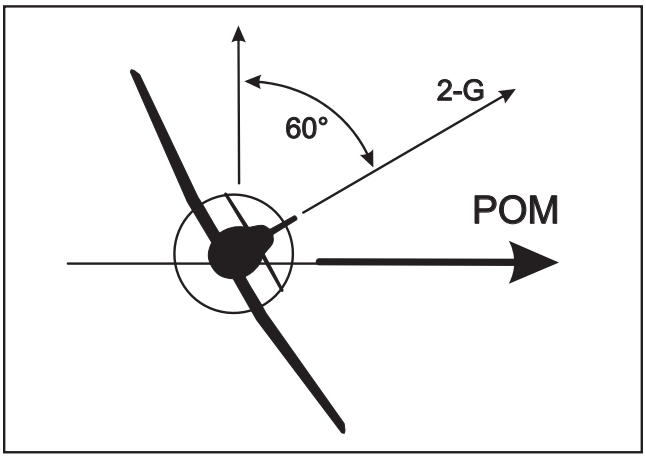


Figure 3.6 Plane of Motion

the Wing is "out-of-plane." Out-of-plane maneuvers will be discussed in the next chapter. (See figure 3.6)

3.2.9 In-Plane

When a wing pilot orients his/her turn circle in the same plane of motion as Lead, he/she is in-plane. To be able to stay on or inside Lead's turn circle, in-plane, the wing pilot must be able to meet or exceed Lead's turn rate and radius performance.

3.2.10 Pure Pursuit

Wing pilot's maneuvering such that his/her nose is pointed at Lead. Note that in pure pursuit, heading crossing angle equals aspect angle. (Figure 3.7)

3.2.11 Lead Pursuit

The flight path a wing pilot's aircraft will follow if he/she

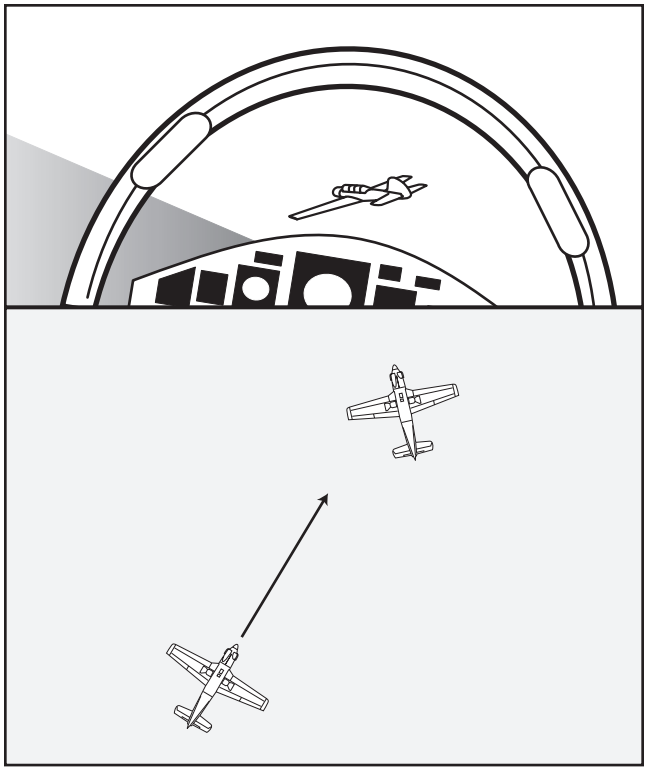


Figure 3.7 Pure Pursuit (two perspectives)

flies toward an imaginary point in front of the lead aircraft. This results in a situation where the wing pilot is "cutting off" Lead. Uncorrected, lead pursuit will result in the wing pilot moving in front of the lead aircraft. During maneuvering (turning), pulling lead pursuit results in the wing pilot flying a smaller turn circle than Lead, and thereby closing the interval, or creating closure, with Lead. You can modulate the effect of your lead pursuit by choosing an aim point nearer or farther away from Lead's nose––nearer resulting

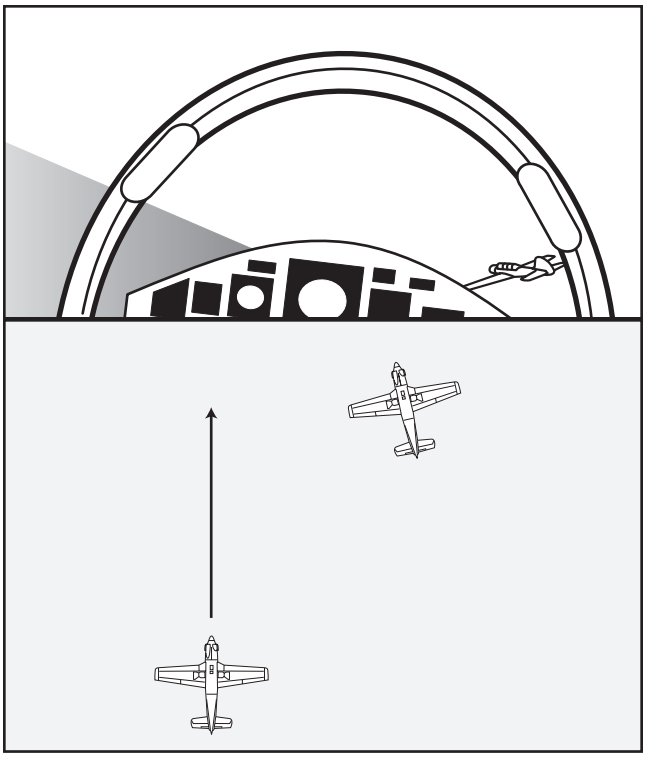


Figure 3.8 Lead Pursuit (two perspectives)

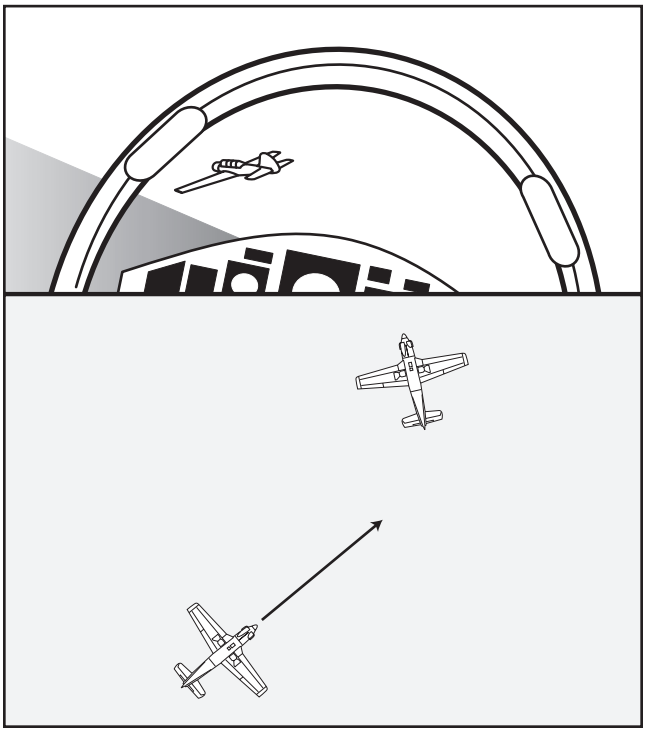


Figure 3.9 Lag Pursuit (two perspectives)

in a less aggressive cut off. When you initiate a lead pursuit curve there will be distinct visual cues to include an aft LOS rate and increasing aspect angle. (Figure 3.8)

3.2.12 Lag Pursuit

The path a wing pilot's aircraft will follow if he/she flies toward an imaginary point aft of the lead aircraft. Left uncorrected, lag pursuit will result in the wing pilot flying aft of the lead aircraft. During maneuvering flight, lag pursuit is achieved when the wing pilot's nose position and flight path are on an arc outside of the curve flown by Lead. This results in a situation where the wing pilot is flying a larger circle than Lead and is thereby increasing the interval with Lead. In lag pursuit the visual cues will be forward LOS rate, decreasing aspect angle and increasing heading crossing angle. Lag can also be modulated—an aim point farther aft of Lead's tail will result in more accelerated separation.

Pursuit Curve	Aspect Angle	HCA	Closure	Line of Sight
Lead	Increasing	Decreasing	Increasing	Aft
Lag	Decreasing	Increasing	Decreasing	Forward
Pure	N/A	N/A	Increasing	N/A

Figure 3.10 Pursuit Curve Relationship Chart

3.2.13 Closure (V_c)

The rate of overtake the wing pilot has in relation to Lead. V_c (pronounced V sub c) can be either positive or negative. Positive closure will occur if the wing pilot has excessive speed or is flying lead pursuit, and is magnified if he/she is doing both. Negative closure will occur if the wing pilot has lesser airspeed or is flying lag pursuit, and is also magnified if he/she is doing both.

3.3 Pitchouts & Rejoins

Pitchouts are used to:

- Provide spacing for rejoin practice
- Establish spacing in the overhead traffic pattern for single-ship landings
- Expeditiously put wing pilots into extended trail/trail

Rejoins are used to:

- Expeditiously move wing pilots into fingertip formation
- Teach the concepts of closure control in a single plane of motion (POM)

3.4 Pitchout (for Rejoin Training)

Lead

Signal #2 for the pitchout (index finger pointing skyward, with rotating motion) and then hold up the number of fingers to indicate the pichout interval in seconds (normally two to five). Clear carefully in the direction of the turn and pitchout using a 30° to 60° bank, level turn, of approximately 180° heading change. Set power to achieve and maintain briefed rejoin airspeed.

Wing

Acknowledge the pitchout signal with a head nod. As soon as Lead turns away, clear ahead, then in the direction of turn.

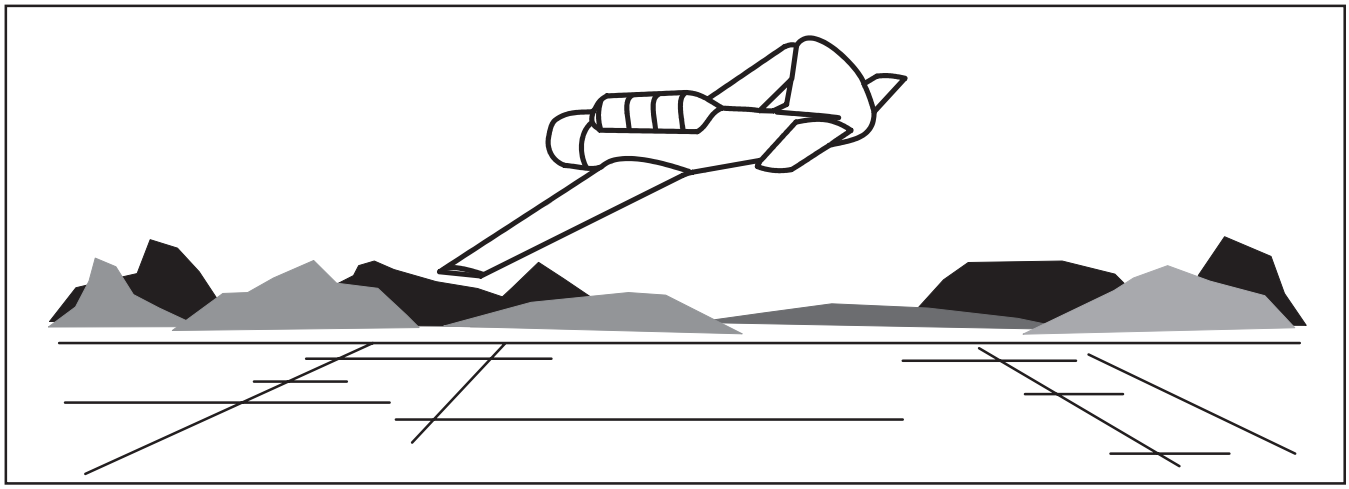


Figure 3.11 The Rejoin Sight Picture

Wait the specified interval, then make a matching turn, clearing carefully for traffic. After initiating the pitchout, set power to achieve and maintain briefed rejoin airspeed.

Approaching the rollout, modulate bank and back pressure to fall directly behind Lead with Lead on the horizon. This is an excellent opportunity to make a quick scan of the instruments and fuel to ensure all is well. Call in when level and stabilized behind Lead. ("Red 2's in").

3.5 Take Spacing Maneuver

The take spacing maneuver is used to put #2 in trail when a pitchout is not practical or desired. While the pitchout is universally applicable to four-ship training, the following maneuver is limited to two-ship only.

Lead

Direct #2 to take spacing with a radio call ("Red 2, take spacing"). Lead should add "rejoins/extended trail/trail" to this call, as applicable. After #2 acknowledges the call, Lead may accelerate, if able, to expedite the maneuver. If an interval and airspeed were not briefed for the maneuver to follow, or a specific interval is desired, provide this information in the initial radio call. When #2 calls in position, reset power and commence maneuvering.

Wing

Acknowledge Lead's instruction to take spacing, reduce power and/or use speed brakes to move aft. Once clear of Lead, you may use s-turns behind and below Lead's prop/jet wash to expedite the maneuver, using caution to keep Lead in sight. When approaching the desired interval, set power to avoid sliding farther aft and call "Red 2's in."

3.6 Turning Rejoin

Lead

After the wing pilot calls in position, initiate the rejoin with a wing rock in the desired turn direction using up to 60° of bank. Then establish a level, constant-bank turn, using up to 30° of bank. If rejoin airspeed has not been briefed, or if you are not within 10 knots (10% for high-performance props and jets) of the briefed rejoin airspeed, make a radio call announcing the airspeed. Hold that speed throughout the rejoin.

Monitor the rejoin, dividing your attention between clearing for the flight, maintaining a stable platform, and analyzing the wing pilot's altitude, aspect, and closure. If you perceive an unsafe situation developing at anytime, take positive action immediately to prevent a midair collision.

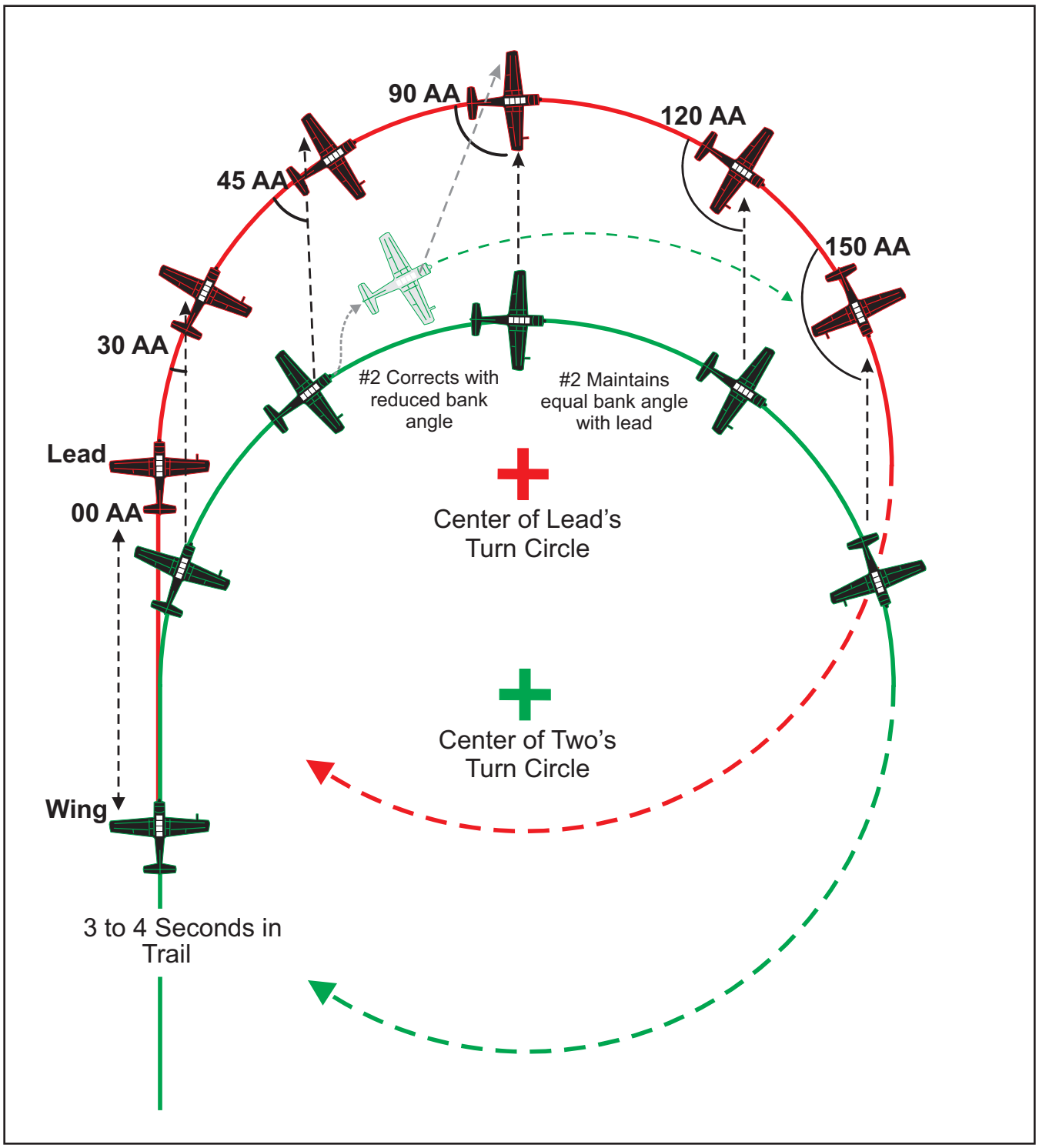
Wing

To successfully rejoin on lead, you will have to manage altitude, aspect, and closure throughout the maneuver.

> NOTE
>
> Avoid too much lead pursuit early in the rejoin (excessive aspect) because the correction for excessive aspect angle at the end of the rejoin often is an equally large correction to lag pursuit. This correction will result in excessive heading crossing angle in close proximity to lead and an unstable rejoin and possible overshoot or breakout.

When Lead enters his/her rejoin turn, begin a turn in the same direction, pulling lead pursuit to intercept the *desired* aspect angle as depicted in figure 3.5. Simultaneously adjust power to achieve up to 10% above briefed rejoin airspeed as required. Referencing Fig 3.5 again, notice how the relationship of the vertical stabilizer and the outboard wing changes in the three depictions between high, moderate (desired), and low aspect (these visual references approximate 60°, 45° and 30° AA respectively). If Lead's vertical stabilizer moves toward the wing root during the rejoin, aspect angle is decreasing and closure decreases, thus slowing the rejoin process. Alternatively, if the vertical stabilizer moves aft of the outboard wing tip, aspect angle is increasing and closure is increasing. Excessive closure will complicate the

Figure 3.12 Misaligned Turn Circles Geometry



The depiction above graphically shows how the wing pilot's aspect angle changes because of displaced, but equal, turn circles (velocity, load factor and bank angle presumed identical). During the rejoin, the wing pilot prevents excessive aspect angle by modifying his/her pursuit curve with adjustments to bank angle.

rejoin process and possibly lead to an overshoot (covered later).

Aspect angle is controlled by changing your pursuit curve (lead/lag) in relation to Lead. Vary your pursuit curve with bank angle. Shallow your bank angle (less lead pursuit) to decrease aspect angle and increase the bank angle (more lead pursuit) to increase aspect angle. As a general rule for rejoins, a bank angle equal to or greater than lead's will result in lead pursuit; a bank angle less than Lead's will decrease lead pursuit and eventually create lag pursuit. During the initial turn to establish lead pursuit, as Lead's vertical stab approaches the wingtip, reduce bank to capture this aspect angle—this visual reference equates to approximately a 45° aspect angle to Lead.

Lead should appear slightly above the horizon throughout the rejoin. As a technique, maintain approximately 10 to 20 feet of vertical separation by keeping Lead's lower wingtip on the horizon (for most low wing aircraft). If operating a side-by-side seat configured aircraft, both pilots must be visual with the lead aircraft. Avoid the common tendency to descend during the rejoin. This will complicate your task, generally slow the rejoin, and could lead to an unsafe situation.

Overall closure is facilitated by a combination of airspeed and aspect angle. As you will see, during the turning rejoin there is a constant blending of bank and back pressure to maintain altitude, modulate lead pursuit, and maintain the proper aspect angle. Use indicated airspeed and visual cues to judge closure on Lead. Adjust power and/or speed brake, as required.

As you close to approximately 300 to 500 feet, monitor your overtake carefully to ensure your closure rate is controllable. In this range, you should be able to shift your sight picture and maneuver your aircraft to utilize the normal fingertip formation references. If necessary, reduce power (and use speed brakes, if equipped) to manage closure.

In the last few hundred feet, manage bank and power closely to ensure aspect angle and closure are stabilized by the route position, and before sliding into fingertip. You know your rejoin is stabilized if:

1. Your fuselage and bank angle are nearly aligned with Lead's and the LOS rate is near zero (no fore/aft movement on the canopy).
2. You are slightly below Lead at the proper aspect angle.
3. Your closure is slightly positive with airspeed nearly matching Lead's.
4. You can stop the rejoin in route, if necessary (because of an emergency, traffic conflict, or if directed by Lead).

During two-ship formation, #2 always rejoins to the inside of the turn. If briefed/instructed to rejoin to the outside of the turn, pass below and at least one ship-length behind Lead. Stabilize in route formation before moving in to fingertip. For turning rejoins, the goal is for #2 to be joined up within 180° of turn.

3.7 Turn Circle Geometry

Using a pitchout interval that is short enough to keep you inside Lead's turn circle will not always be the case, so a thorough understanding of turn circle geometry will be helpful in executing successful rejoins from any interval or distance. This analysis will be critical as you transition to rejoining from the #4 flight position later in your training. From the moment Lead initiates the rejoin, the maneuver becomes an exercise in turn circle geometry for the wing pilot.

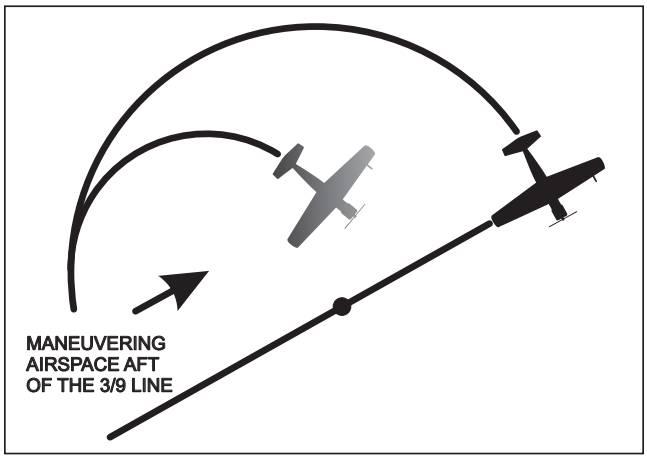


Figure 3.13 Lead's Turn Circle

There are two turn circles to consider in a turning rejoin—the lead pilot's and the wing pilot's (see figure 3.12). The wing pilot can control two characteristics of his/her turn circle—size and location. The size of the turn circle is determined by aircraft velocity, bank angle, and load factor. The location of Wing's turn circle is established initially when the wing pilot starts the turning rejoin and is altered during the rejoin by modulating bank angle.

One of the first things the wing pilot will have to determine at the start of a rejoin is his/her position relative to Lead's turn circle.

Using a two- to four-second break interval, #2 will normally be inside Lead's turn circle and aft of his/her 3/9 line when the rejoin is initiated. In this situation, #2 can immediately pull lead pursuit and maneuver to establish the correct aspect angle for the rejoin. However, what if Lead and Wing have a longer interval? There are distinct visual clues that wing pilots can use to determine their position relative to Lead's turn circle.

In general, when inside of lead's the turn circle, lead's rejoin turn results in a relatively moderate increasing aspect angle

change, but a rapidly increasing LOS rate moving across your canopy.

In comparison, if #2 is outside Lead's turn circle, he/she will see Lead's aspect angle increase rapidly, but with minimal canopy LOS rate, primarily confined near the center of the windscreen. This visual clue is based largely on your distance from the lead aircraft; farther away and the effect of rapidly changing aspect and minimal LOS rate is amplified.

To begin the rejoin, the wing pilot must position his/her aircraft inside Lead's turn circle and aft of Lead's 3/9 line (see Fig 3.13). If outside Lead's turn circle, the wing pilot should continue straight ahead until Lead's aircraft starts moving across the canopy (increased LOS rate). As #2 closes on Lead's turn circle, he/she will see the increase in Lead's aspect angle begin to decrease and the LOS rate begin to rapidly increase. At that point, the wing pilot is in position to maneuver for the proper aspect angle/visual reference for the rejoin.

In summary, if Lead's turn results in an increasing aspect angle and a relatively slow LOS rate confined near the center of the windscreen, the wing pilot knows he/she is outside of Lead's turn circle. If Lead's turn results in a relatively moderate aspect angle change and a rapidly increasing aft LOS rate across the canopy, the wing pilot knows he/she is on or inside Lead's turn circle.

3.8 Turning Rejoin Overshoot

Lead

During an overshoot, provide a stable platform for the wing pilot. However, if safety is a factor, take positive action to prevent a midair collision.

Wing

An overshoot may be caused by excessive closure, excessive aspect angle, large heading crossing angle, or a combination of these factors. The overshoot is not uncommon in training and should not come as a surprise at the end of the rejoin, but should be a planned event based on timely recognition of excessive closure. There are several definitive clues leading up to an overshoot situation:

- Rapid closure, unaffected by idle power, speed brakes, or slipping
- A significantly increasing bank angle close to Lead
- It becomes obvious that to control closure you must go belly up to Lead in an attempt to salvage the rejoin
- An exponentially growing feeling of panic
- Lead directs an overshoot

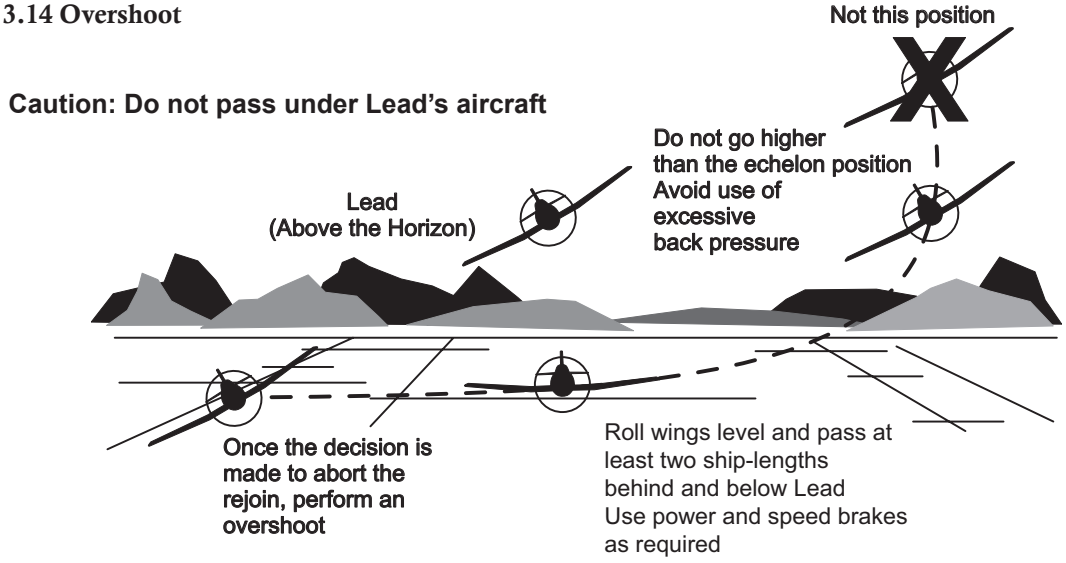
If you experience any of the above conditions, you will have to execute an overshoot. Take the following action:

- Abandon the rejoin no later than route position (the rejoin must be stabilized by route position)
- Call the overshoot on the radio
- Keep Lead in sight—pass below and behind Lead with at least one to two ship-lengths nose-to-tail separation
- Continue to the outside of Lead's turn circle but remain behind the 3/9 line and no higher than the echelon position
- Move back inside of Lead's turn, being careful not to pass under Lead

> WARNING
> Use caution not to pass directly beneath Lead if moving back to the inside. Also, if you have too much energy when moving back to the inside, another overshoot could develop.

The greater your closure rate during the overshoot, the wider to the outside you must go to prevent moving forward of Lead's 3/9 line. If you are outside Lead, in route position, you can complete the rejoin by executing a normal cross-under.

Figure 3.14 Overshoot



If you are outside and aft of Lead, you should cross back to the inside of the turn, reacquire the normal turning rejoin references, and complete the rejoin. Your instructor will demo the overshoot and allow you to practice this critical maneuver.

3.9 Straight-Ahead Rejoins

Lead

Make a radio call or rock your wings to initiate a straight-ahead rejoin. Set power to maintain the briefed rejoin airspeed or call the rejoin airspeed on the radio if not within 10 knots of the briefed speed.

Monitor the rejoin, dividing your attention between clearing for the flight, maintaining a stable platform, and analyzing the wing pilot's altitude, aspect, and closure. If you must turn after initiating the straight-ahead rejoin, announce this to #2 and be alert for an overshoot situation.

Wing

You will rejoin to the side occupied prior to the pitchout or as briefed. If not specified, join to the left side. Set the power to establish the same minimum closure as in a turning rejoin (10% above briefed rejoin airspeed). When initiating the rejoin from beyond 500 feet aft, establish pure pursuit at Lead's low, six o'clock position. Remain slightly below Lead (Lead on or just above the horizon) at all times to avoid Lead's wake turbulence. When you have closed to approximately 500 feet, aircraft details will become visible—bank slightly away from Lead to establish an offset, two to four ship-widths out from Lead's wingtip (the route position). This offset will give you an oblique view of Lead, making depth perception and closure easier to judge. Decrease overtake with a power reduction and/or speed brakes and plan to arrive in route position at the same airspeed as Lead. If your rejoin is stabilized, move into the fingertip position.

As a technique to avoid large and excessive throttle movements as you close in during the rejoin, reduce power in proportion to Lead's LOS rate such that a slow LOS rate will result in a gradual power reduction while a fast LOS rate will result in a rapid power reduction. It will take some practice to learn your aircraft's deceleration rate.

If your closure rate is excessive during a straight-ahead rejoin, reduce power to idle, use speed brakes, slips, and S-turns, as necessary, to slow your overtake. Use S-turns with care to avoid losing sight of Lead.

If Lead must initiate a turn during a straight-ahead rejoin, transition to a turning rejoin and be alert for an overshoot situation, as you may suddenly have excessive closure because of angle (aspect) and airspeed differences.

3.10 Straight-Ahead Overshoots

Lead

Provide a stable platform for the wing pilot throughout the rejoin. During straight-ahead rejoins, 3/9 line overshoots are not uncommon and must be anticipated. Do not delay directing the wing pilot to break out or take other positive action if safety is compromised. If a break out occurs due to an excessive 3/9 line overshoot, the wing pilot will likely lose sight of you. In this situation, you must be directive in safely reforming the flight (request the wing pilot roll out on a desired heading, etc.)

Wing

A straight-ahead rejoin with excessive closure results in a pure airspeed overshoot. Use idle, speed brakes, slips, and s-turns as necessary, as soon as excessive overtake is recognized. A small (within one ship-width), controllable, 3/9 line overshoot with a parallel or divergent vector is easily manageable and can still allow an effective rejoin if visual contact is maintained, flight paths are not convergent, and #2 remains in route interval with the overshoot arrested (no aft LOS rate). If these criteria are not met, regardless of the degree of overshoot, a break-out is mandatory. As Lead begins to move forward on your canopy, anticipate the need to increase power and/or retract the speed brakes to achieve co-airspeed (no LOS rate) and prevent excessive aft movement.

If breaking out from a straight-ahead rejoin, maintain adequate lateral separation by turning slightly away from Lead and announcing the break out ("Red 2 breaking out"). Call blind in accordance with Chapter 1 of this manual if visual is lost. Lead may assign a heading to fly or request you roll out to expedite reforming the flight. With Lead's permission, resume the rejoin when Lead begins to move forward of your aircraft.

> WARNING
> When overshooting straight ahead, there is a tendency to move the control stick in the direction you are looking; that is, toward lead. If uncorrected, this action may cause your aircraft to "drift" toward Lead, creating a dangerous situation and requiring a break out.

3.11 Summary

Having a solid understanding of how to control closure though management of aspect angle and airspeed are the keys to mastering the rejoin. The concepts covered in this chapter are critical to your success as a safe formation pilot. With these concepts in hand, we will now move on to the more dynamic environment of extended trail.

CHAPTER FOUR
Fluid Maneuvers: Two-Ship Extended Trail

4.1 Introduction

Now that you have mastered pitchouts and rejoins you have demonstrated an understanding of single-plane turn circle management through the proper use of pursuit curves and the recognition of aspect angle, LOS rate and closure. You are now ready for the multi-plane (three-dimensional) maneuvering of extended trail (also known as offset trail).

With practice, these critical skills will help you become a safer, more accomplished pilot in the dynamic world of formation flight.

Extended trail will be taught in a two-ship formation initially, where the Lead Pilot can effectively observe the wing pilot and adapt the maneuvering to accommodate the learning objective. Only after the concepts have been mastered in two-ship will the student progress to the more complex three- and four-ship extended trail flights.

There is a another type of trail formation, simply called "Trail" that is used in the airshow environment, the traffic pattern, and in other situations. In Trail, the wing pilot maneuvers to maintain the same flight path as Lead, at an interval specified in the briefing. Power plays a larger role in maintaining position in Trail, while lead/lag is minimized.

4.2 Concepts and Terminology

4.2.1 Extended Trail (ET)

ET is a building-block exercise designed to teach the proper application of lead, lag, and pure pursuit options to maintain position, in and out of plane, while maneuvering in relation to another aircraft. The objective of this fluid maneuvering exercise is to train you to maintain a maneuvering position within the ET cone by solving range, closure, aspect and turning radius problems presented by a lead pilot maneuvering in single and multiple planes of motion.

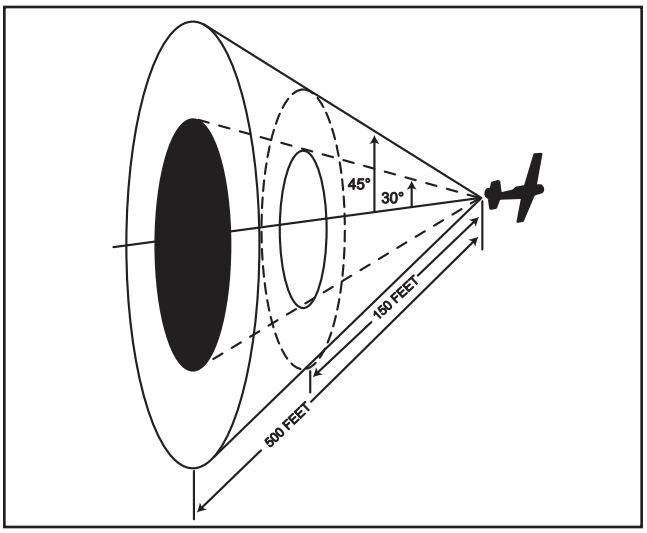


Figure 4.1 Prop Extended Trail Cone

4.2.2 Extended Trail Cone

The ET cone is a donut shaped area surrounding Lead's extended six o'clock position. For both props and jets, the donut's limits are a cone bounded by 30° on the inside and 45° on the outside. The in-trail distance limits are different for props and jets, predicated on airspeed and G-load used in the exercise.

For aircraft flying between 70 and 180 kts, the distance limits are 150 to 500 feet behind Lead. For high performance props and jets flying between 180 and 350 kts, the distance limits are 500 to 1500 feet behind Lead. These distance limits are based on the radius of the 2G to 3G turn used in ET maneuvers. At these speed and distance limits, the wing pilot should always be able to turn inside Lead.

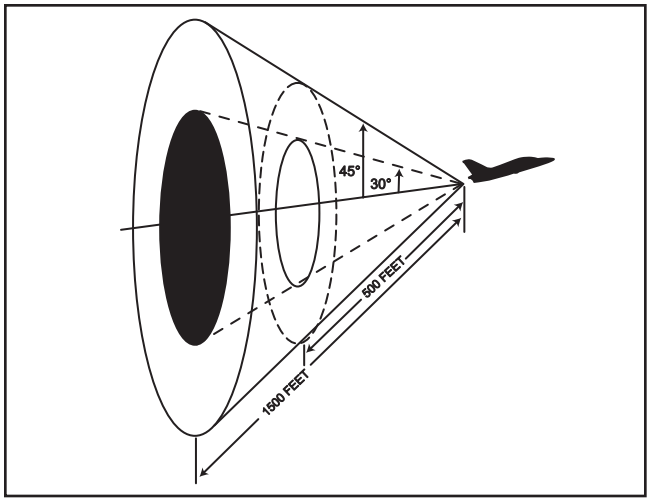


Figure 4.2 Jet Extended Trail Cone

In all cases, the minimum range limit provides a buffer from the lead aircraft. ***This buffer is a safety-of-flight limit.*** If a wing pilot flies inside the buffer, a KIO call is required. The wing pilot will break out if visual is lost.

If range is such that both aircraft do not pose an immediate collision hazard, momentarily losing sight of Lead may not require an immediate blind call or break out if Lead reappears as predicted. However, even if range is not an issue, if Lead does not reappear where anticipated, an immediate blind call is required—Lead will call KIO or direct a break out, as is appropriate.

As Lead maneuvers, he/she drags the ET cone around behind his/her aircraft. The wing pilot's goal is to manage

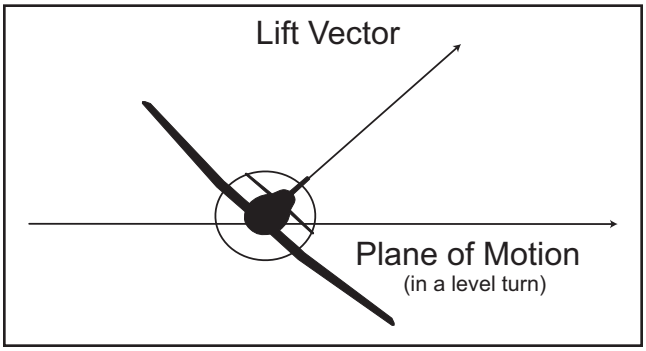


Figure 4.3 Lift Vector and Plane of Motion

nose position, lift vector and V_c to constantly remain inside this ET cone. The wing pilot will accomplish this at a fixed (briefed) power setting, using lead/lag techniques.

4.2.3 Lift Vector

An imaginary line going vertically through the top of the aircraft, representing the plane of motion in a straight pull. "Set the lift vector" or "point the lift vector" means to roll your wings to place the point you want to pull to at your 12-o'clock high position. Lift vector varies in magnitude based on G-load but is always directed straight out through the top of the canopy.

4.2.4 In Plane

When a wing pilot orients his/her turn circle in the same plane of motion as Lead, the wing pilot is "in plane." To be able to stay on or inside Lead's turn circle, in plane, the wing pilot must be able to meet or exceed Lead's turn performance (rate and radius).

4.2.5 Out of Plane

When a wing pilot orients his/her turn circle in a different plane than Lead's plane of motion, the wing pilot is "out-of-plane." Typical out-of-plane maneuvers include the quarter plane, the high yo-yo, and the low yo-yo. These maneuvers are utilized to keep the wing pilot in the ET cone and inside Lead's turn circle.

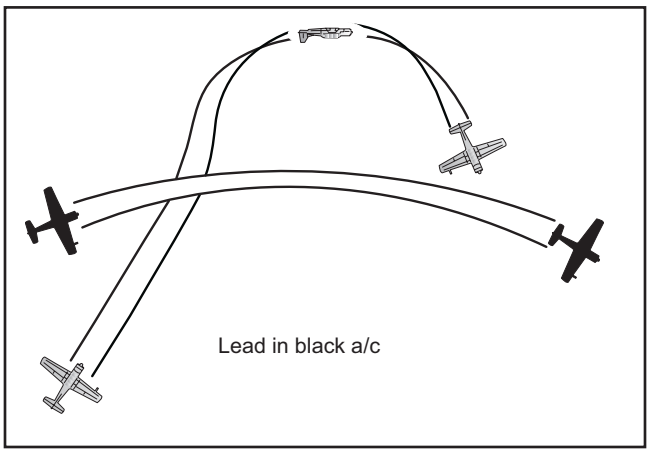


Figure 4.4 High Yo-Yo (note: roll to inverted not required)

4.2.6 Lag Reposition (High Yo-Yo)

A repositioning of Wing's aircraft that uses various combinations of pursuit and movement out-of-plane, *above* Lead's plane of motion to control closure and aspect angle due to a potential overshoot of Lead's 3/9 line.

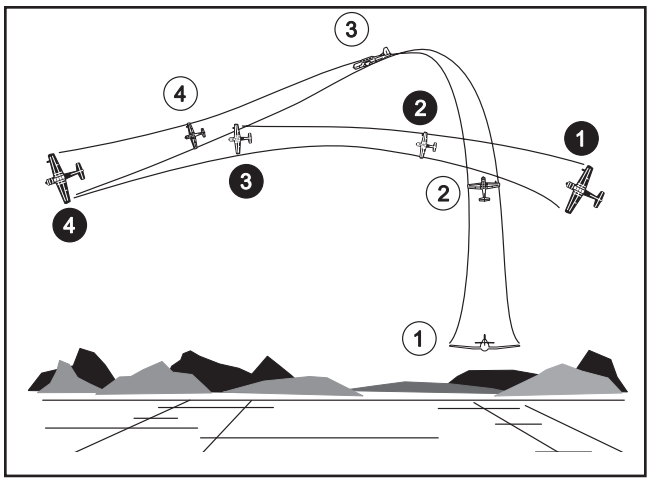


Figure 4.5 Quarter Plane

4.2.7 Quarter Plane

An aggressive, last ditch, out-of-plane lag maneuver used to control closure and aspect angle in order to maintain position aft of Lead's 3/9 line. The wing pilot will establish a POM that is 90° to Leads' POM. This situation could be the result of a late decision to execute a high yo-yo, failure to properly control aspect angle and closure, or an abrupt change in Lead's flight path.

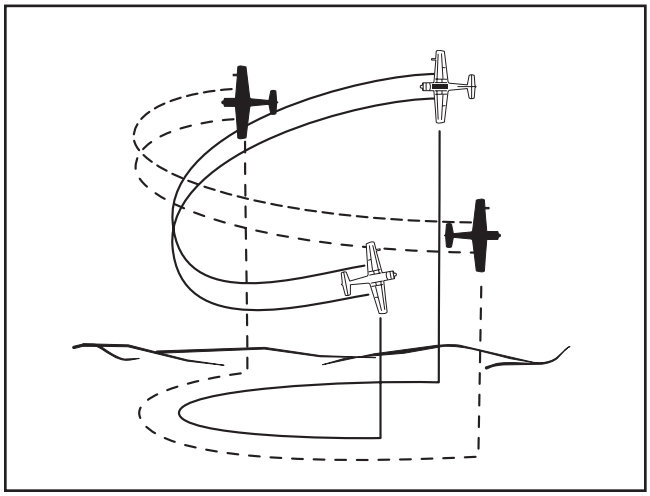


Figure 4.6 Low Yo-Yo

4.2.8 Lead Reposition (Low Yo-Yo)

A repositioning of the wing pilot's aircraft using various combinations of pursuit and movement out-of-plane *below* Lead's POM so as to increase closure and aspect angle.

4.3 ET Fluid Maneuvering Exercise

Lead

You are providing a training platform for the wing pilot—it

is incumbent upon you to maneuver commensurate with the ET level briefed. Use predictable roll rates while presenting reasonable problems to solve in range, aspect and heading crossing angle.

> WARNING
> Because of its dynamic nature, flying ET requires uncompromising flight discipline. Any pilot in either aircraft will call "knock it off" if safety is ever in question.

There are several ways to transition a flight to ET—here are two of the most expeditious: from fingertip (echelon in three- and four-ship) or route using a pitch-out, or, from close trail, straight and level, with Lead turning away from the flight and the wing pilot maintaining straight and level just long enough to achieve the desired interval, then turning to fall into position on Lead.

For new wing pilots, you may brief and use the "Take Spacing" procedure described in Chapter Three to set interval and aspect. This will allow you to point out the visual references for range and aspect limits of the ET cone.

To initiate ET, you will use a directive radio call: "Red flight, extended trail, level two, go." (see section 4.5) There is no visual signal for extended trail. Wait for the wing pilot to acknowledge before pitching out or turning away.

> NOTE
> Use a power setting applicable to your aircraft and the current conditions, such as density altitude.

For the pitch-out entry, break using up to 60° of bank and set power as briefed. The turn away entry can be accomplished in a similar manner using a moderate-rate turn of up to 60° of bank. The break or turn away to set range and aspect need not be level—if beginning the exercise below desired maneuvering airspeed, you can use a slightly oblique, descending turn to gain speed.

Wait for the wing pilot to call in position before initiating the ET fluid maneuvering exercise.

Set the briefed power and maintain it throughout the exercise. Once established in extended trail, it is important that you fly a predictable airplane that allows the wing pilot an opportunity to practice ET concepts. Depending on the type aircraft, modified lazy-eight maneuvers with a steady 2G pull work well for beginning practice. You must work to provide a continuous, curved flight path so the wing pilot can utilize lead/lag techniques to maintain position. Do not push over, or go negative G. You should not turn in one direction and immediately follow the turn with a rapid, unanticipated roll in the opposite direction.

As the wing pilot becomes more proficient, you can progress to 3G, level turns. As you fly the turns, reverse direction only after the wing pilot has flown back to the inside of your turn circle within the ET cone. Reversing the turn before you see this happen is counterproductive because you may not be able to maintain a visual on the wing pilot and thus assess his/her performance. It may also result in negative learning because the wing pilot may not get a chance to react to a predictable ET cone.

As the wing pilot becomes still more proficient, you can begin to use bank angles up to approximately 90°, and pitch attitudes up to approximately ± 30°.

Even in the more advanced, or aerobatic maneuvering, you should not unload or perform abrupt turns as this could force the wing pilot inside minimum range or forward of the 3/9 line, necessitating a break out. Remain predictable throughout the maneuvering.

You MUST monitor Wing's performance. Look over your shoulder to assess where in the donut the wing pilot is positioned. If spacing or turn geometry is approaching the limits, back off the aggressiveness of the maneuvering. This should allow the wing pilot to re-enter the ET cone. High-G maneuvers are of little value if the wing pilot is unable to maintain position. You must be constantly aware of G limits because the wing pilot is often exceeding your G loading as he/she works to regain or maintain position.

Negative learning is taking place whenever the wing pilot's capabilities are exceeded. Don't rely on wing pilots to call out of position because some won't know they are outside the cone and others won't call it because of misplaced pride. Conversely, if the wing pilot is meeting all the objectives of your current maneuver level, you have the option of calling "terminate" and setting up for a higher level of maneuvering.

> WARNING
> Be cognizant of the hard deck—your wing pilot may have very little hard deck awareness. Also, the wing pilot may be lower than your altitude during dynamic maneuvering. Call KIO if you perceive either aircraft is or will be below the hard deck.

Wing

When Lead makes the directive call to go to ET, acknowledge with your call sign: "Red 2." Lead will begin a turn or break away. Delay for an appropriate interval and then turn to establish the ET cone range and aspect. When you have maneuvered into the extended trail position, have set the

briefed power, and are ready for maneuvering—notify Lead with the radio call: "Red 2's in."

As Lead maneuvers, you will be constantly adjusting your nose position and lift vector orientation to modify your turn circle and plane-of-motion relative to Lead. You learned the following in-plane concepts from flying pitch-outs and rejoins:

1. Turning with your nose in front of Lead's aircraft (lead pursuit), increases turn rate and decreases turn radius. This produces an aft LOS rate and forward movement toward Lead's 3/9 line.
2. Turning with your nose aft of Lead's aircraft (lag pursuit), decreases turn rate and increases turn radius. This produces a forward LOS rate and aft movement away from Lead's 3/9 line.

To these in-plane concepts we will now add the following out-of-plane concepts:

1. Pulling up, at an oblique angle (less than 90°), above Lead's plane-of-motion is a high yo-yo. This will decrease closure (V_c) and airspeed relative to Lead. It is used primarily to stabilize your position at the forward edge of the ET cone while staying inside Lead's turn circle.
2. Pulling lead and diving at an oblique angle (usually from 1° to 30° nose low), below Lead's plane-of-motion, is a low yo-yo. It will increase closure and airspeed relative to Lead. It is used primarily to either stabilize your position near the aft limit of the ET cone, or to move closer to Lead by using cutoff and acceleration.
3. Pulling up and turning 90° or more off Lead's plane-of-motion is a quarter plane maneuver. It will rapidly decrease closure and airspeed relative to Lead. It will immediately produce a forward LOS rate. Initially, this LOS rate will be laterally across the windscreen then become an aft LOS rate across the windscreen as you move closer to Lead's six-o'clock position. The quarter plane is used primarily as a last-ditch effort to remain aft of Lead's 3/9 line. This maneuver usually results in a *flight path overshoot* to the outside of Lead's turn circle and will rapidly move you aft in the ET cone.
4. A flight path overshoot will place your nose in lag, outside Lead's turn circle. This will rapidly produce negative closure, aft LOS rate, and movement away from Lead toward the aft end of the ET cone. If you are too slow to transition from the flight path overshoot to a low yo-yo, you will likely fall out of the ET cone.

If Lead is flying mostly flat, mild, low-G maneuvers, as might be mandated by aircraft type or limited vertical maneuvering, you will mostly use in-plane maneuvering to remain inside the ET cone. When Lead flies more vertical, and higher-G maneuvers, you will have to use more out-of-plane techniques to remain inside the ET cone.

The following techniques will enable you to remain inside the ET cone, avoid prop/jet wash, and more easily judge separation.

1. Lead's six-o'clock position, inside the 30° cone, is a transition zone only; do not stabilize there—Lead cannot see you and you won't learn anything about fluid maneuvering.
2. Try to position yourself so you can always see Lead's head/helmet through the side of his/her canopy. This reference will place you in the 30° to 45° donut. This oblique view of Lead will also make it easier to judge V_c, aspect angle (AA), and spacing because you have more aircraft mass to view, plus the advantage of parallax.
3. There is no need to precisely match Lead's fuselage and bank angle alignment. However, as in rejoins, the more in-plane and forward in the ET cone you are, the more alignment you should have. The more aft you are in the ET cone, the more misaligned you can be.
4. As long as Lead is turning, whether single plane or multi-plane, you will not be able to maintain a fixed position inside the ET cone because power is set at a briefed value. Since you are not directly in trail on Lead's turn circle, you will be constantly faced with closure and 3/9 line dynamics affecting your position inside the ET cone. Your only option if you want to stay inside the ET cone is to maneuver. The more aggressively Lead maneuvers, the more aggressively you will have to maneuver with fleeting opportunities for stabilized flight.
5. One of the few opportunities for stabilized flight will occur when Lead reaches the hard deck and opts to climb back up to the starting altitude. Once the climb begins, you will be able to match climb speed with Lead and fly a stabilized position with little or no maneuvering inside the ET cone. This is a good opportunity to relax, check engine parameters, and fuel.
6. Fly directly aft of Lead only when crossing from one side to the other. If you must cross the upper (Lead's six- o'clock high) portion of the cone, do so expeditiously because you and the instructor may momentarily lose sight of Lead. At all other times, fly in a donut around Lead's six o'clock position as depicted in figure 4.1 or 4.2. Always cross above or below Lead's prop/jet wash and relax back pressure if encountering wash to prevent an over-G. Based on the level of maneuvering, use caution during ET so as to not exceed your aircraft's normal or asymmetrical G limits.

4.4 Application of ET Techniques

Here are three case studies of ET maneuvering situations:

1. Lead starts a hard, climbing turn into the wing pilot. As Lead decelerates in the climb, the wing pilot will see an increase in aspect angle and an immediate increase in closure, combined with Lead's increased rate

of turn and decreased radius of turn. The wing pilot will quickly see a rapid movement forward toward the inner limit of the ET cone. To remain inside the ET cone, the wing pilot simultaneously raises the nose and rolls to position the lift vector behind Lead, initiating a high yo-yo. As the wing pilot pulls, the nose will move from lead to lag pursuit and V_c will begin to decrease. If the wing pilot is very close to the forward limit of the ET cone, he/she may want to continue the pull to fly outside Lead's turn circle. This will quickly decrease aspect angle and V_c. The wing pilot will see an increasing forward LOS rate and movement aft in the ET cone. If Lead continues the turn, the wing pilot will need to anticipate rolling back toward Lead, repositioning the lift vector in front of Lead, and beginning the pull to reestablish lead pursuit and positive V_c by using a low yo-yo.

2. Lead starts a hard, descending turn away from the wing pilot. The wing pilot will see an immediate decrease in aspect angle and closure. He/she will also see a rapid forward LOS rate and movement aft in the ET cone—all because of his/her position outside Lead's turn circle and his/her lag nose position. The wing pilot should immediately roll toward Lead, positioning the lift vector in front of and below Lead. As the wing pilot pulls, he/she will establish lead pursuit through this low yo-yo maneuver, quickly flying back inside Lead's turn circle. The wing pilot will see an increasing AA and V_c as well as an aft LOS rate and movement back toward the inner limit of the ET cone. If Lead continues the turn, the wing pilot must anticipate turning back toward Lead to decrease the effectiveness of this lead pursuit curve. The wing pilot may even have to execute the maneuver described above (example 1) to remain inside the ET cone.
3. You are positioned in the ET cone, inside Lead's turn circle and Lead initiates a turn reversal away from you. You will immediately be in lag on the outside of Lead's new turn circle and rapidly moving toward the aft limit of the ET cone. You should immediately reverse your turn, establish lead pursuit, and execute a low yo-yo to fly back inside Lead's turn circle. This will keep you from exceeding the aft limit of the cone and allow you to control your rate of movement back toward the center of the ET cone.

4.5 ET Fluid Maneuvering Levels

ET is divided into multiple levels of maneuvering (figure 4.7). This allows the exercise to be tailored to the student's level of experience and/or aircraft limitations. Lead will brief the level of maneuvering and announce "level one/two" as part of the ET radio call prior to commencing maneuvers. Lead will not transition to a different level of maneuvering without informing the wing pilot.

4.5.1 Flying ET Level One

Level one ET is appropriate for standard category aircraft, new formation pilots mastering pursuit curves, and instructor demonstrations of range and aspect.

	Maneuvers	Bank Angle	G Loading	Power
Level One	level to slightly descending turns	up to 60°	up to 2G	up to max continuous
Level Two	turns, modified lazy eights	up to 120°	up to 3G	up to max continuous

Figure 4.7 ET Fluid Maneuvering Levels

Lead
Fly level or near level 30° to 60° bank turns in both directions using the briefed, fixed power setting. Monitor the wing pilot's ability to manage range, aspect and closure.

Wing
With power set as briefed, use pursuit curves to explore the entire range and aspect of the ET cone. Notice how difficult it is to stay in a fixed position within the cone without maneuvering. Pay close attention to lag pursuit and its relationship to heading crossing angle.

If you exceed ET cone parameters and cannot regain position expeditiously, call "terminate." Lead will cease fluid maneuvering to allow you to regain position. When in position and ready to resume ET, call "Red 2, in." If you exceed the minimum range buffer, call "KIO," maneuver as required to maintain visual, and maneuver away from Lead. If necessary, break out.

4.5.2 Flying ET Level Two

Level two ET is appropriate for aerobatic capable pilots and aircraft. If the pilot or aircraft are not aerobatic capable, use standard lazy-eights; limiting bank angle to 60°. Level two should include exposure to out-of-plane lead and lag maneuvers (high/low yo-yo).

> CAUTION
> The pilot of any aircraft experiencing an over-G will call KIO and cease maneuvering. The other pilot will inspect the aircraft for damage or missing panels. The over-G aircraft will be escorted back to the airfield or nearest suitable airport, as required. See "Abnormals" chapter for specific inspection and chase procedures.

Lead
Monitor #2's performance, especially during out-of-plane maneuvering.

When performing modified lazy-eights (also called wing overs), allow the nose to fall to achieve your entry speed, then begin a wings-level pull until the nose passes the hori-

zon. Set the bank angle at 30° to 60° and pull the nose up (as appropriate for your aircraft, not to exceed 40°). As the airspeed decreases, expeditiously roll to 120° of bank and pull the nose down to no lower than 40° nose low. Monitor your airspeed and altitude throughout the maneuver. Roll to reset the bank to 30° to 60° and as the airspeed increases, level the wings, as needed, and begin another pull to continue the maneuver. Alternate the direction of the wing overs as you fly the level-two profile.

Wing
Attempt to predict Lead's flight path. Maneuver relative to Lead to remain in the ET cone—this requires constant analysis of Lead's plane-of-motion as well as relative range, aspect, closure, heading crossing angle, and LOS rate. Attempt to maintain the 30° to 45° aspect limits while avoiding Lead's high and low six o'clock position.

As in level-one maneuvers, if you exceed ET parameters and cannot regain position expeditiously, call "terminate." Lead will cease fluid maneuvering to allow you to regain position. When in position and ready to resume ET, call "Red 2, in." If you exceed the minimum range buffer, call "KIO," maneuver as required to maintain visual, and maneuver away from Lead. If necessary, break out.

4.6 Terminating ET and Rejoining

Lead
To complete the extended trail exercise, you must get the Wing back to a stabilized condition prior to signaling for the rejoin. Establish a level turn of up to 45° bank and maintain it until you see the wing pilot has stabilized. This technique telegraphs your intentions, allowing the wing pilot to use lead/lag to stabilize closure, LOS and AA to match your energy state. Once stabilized, signal for the rejoin, establish bank angle for either a turning or straight ahead rejoin, and adjust power and airspeed to the briefed values.

In contrast, a poor example of ET termination would be to stop maneuvering from a descending arc by simply pulling up to wings level, straight flight. In this situation, you are level and decelerating while the wing pilot is still descending and accelerating. To make matters worse, you have taken away any ability to apply lead/lag since there is no turn circle to work with. This may result in the wing pilot having to yank the power to idle and aggressively s-turn to dissipate the excessive closure. In extreme situations, the wing pilot would be forced to break out.

Wing
When you see Lead stop maneuvering and roll into a level, steady-state turn, you can anticipate that he/she is terminating the exercise and will rejoin the flight. Use lead/lag to establish a relatively stabilized energy state. When Lead signals for rejoin, use standard procedures to rejoin to fingertip.

4.7 Trail

Trail formation (also referred to as "tail-chase") is used in a number of situations—to establish an interval for single-ship landing in a traffic pattern, for airshow performances, or for a low-level mission, to name a few. The same procedures for establishing extended trail can be used for this formation with the exception that there are some instances where radio calls and responses are not appropriate to the situation—a pitch-out to downwind, for instance.

Lead
If appropriate to the situation, use a radio call to send the flight into trail: "Raven, trail, go." Set and maintain the briefed power setting or airspeed. Do not begin maneuvering until the wing pilot has called in position (if such a call is appropriate).

If the mission calls for rejoining the flight, use standard rejoin procedures to reassemble.

Wing
When signaled or directed to trail by radio, use the briefed procedure to establish the proper interval. Acknowledge being in position, as appropriate. Use power as necessary to maintain the correct interval or airspeed, as briefed. Lead/lag may be used to some extent as long as such maneuvering is not detrimental to the pilot or the mission being flown.

4.8 Summary

Extended trail is an exciting and demanding formation. It is your introduction to multi-plane, fixed power, fluid maneuvering. Trail formation is typically less dynamic and more utilitarian. Mastering the skills necessary to effectively fly lead/lag/pure pursuit curves, low and high yo-yos, and quarter-plane maneuvers are very important steps in your formation training. Aside from the fun you will have, the skills mastered here will serve as a basis for future formation training and enhance your everyday flying skills.

CHAPTER FIVE
Three- and Four-ship Formation

5.1 Introduction

Once you have become proficient in two-ship formation, you are ready to move on to the more dynamic excitement of three- and four-ship formation. The basic formation positions, references, techniques, and procedures previously covered in the two-ship chapters also apply to three- and four-ship formations.

In four-ship formation there will be two elements and therefore two element leaders. One element leader is designated as flight lead, and the other will fly the #3 position and act as deputy lead. The Wing qualified pilots will normally fly in the #2 and #4 positions. The two elements will maintain integrity within the four-ship.

Three- and four-ship formation flying requires thorough attention to detail from mission planning and the preflight briefing to the debriefing at the completion of the flight. All members of the formation will be thoroughly briefed and familiar with the mission profile.

WARNING:
Never put a non-formation qualified or inexperienced pilot in the lead of a formation.

5.2 Three-Ship Formation

There are two concepts for flying three-ship formation—the "Vic" and the "Phantom 2." The flight lead will determine which configuration is suitable to the mission objectives. Either formation can be flown as a planned mission or as a contingency mission, should one member of a planned four-ship drop out.

If flying three-ship formation because of a ground or takeoff abort, Lead will be directive and renumber the aircraft in the flight. In a three-ship formation, wing pilots may fly the normal positions for #2 and #3 (Vic), or may configure as phantom 2. Phantom 2 allows wing pilots to practice flying the #3 and #4 positions as if they were in a four-ship formation. Wing work is done with #3 and #4 on the same side.

5.2.1 Vic Formation

The Vic formation is so named because it resembles the letter V. Lead is flanked on either side by #2 and #3. The Vic is one of the basic building blocks used in airshow mass formations. (Figure 5.1)

5.2.2 Phantom 2 Formation

The phantom 2 formation is flown as if a #2 were present in the flight. Number 3 and #4 will be positioned as an element on Lead's right or left wing. The opposite wing is the position held by the phantom #2. The phantom 2 formation

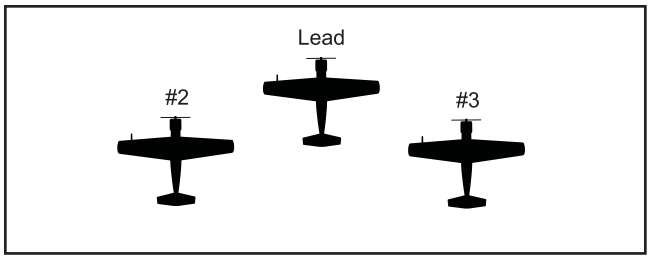


Figure 5.1 Vic

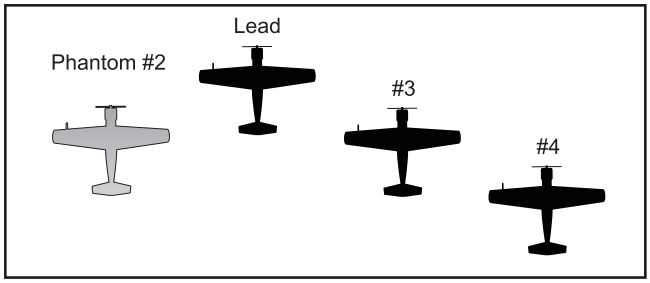


Figure 5.2 Phantom 2

is useful for training purposes when Lead wants to have the wing pilots practice rejoins to the outside. (Figure 5.2)

5.3 Four-Ship Formation

5.3.1 Fingertip

Fingertip is the standard formation configuration. There are two fingertip configurations: fingertip strong right and fingertip strong left, each modeled after the appearance of your fingertips on the respective hand. (Figure 5.3)

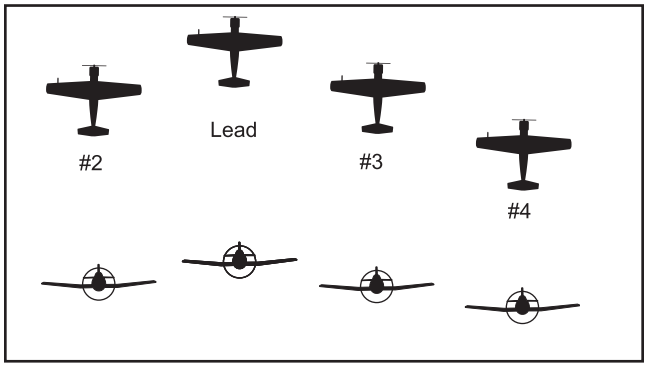


Figure 5.3 Fingertip Strong Right

5.3.2 Echelon

Echelon formation is a variation of fingertip in that it places all the wing pilots on one side or the other of Lead (echelon left or right). (Figure 5.4) Each Wing uses normal sightline references off the adjacent aircraft (#3 references #2; #4 references #3). However, if the adjacent aircraft is wobbling to the point that it difficult to maintain a stable reference, you can look "through" that aircraft and reference off Lead while

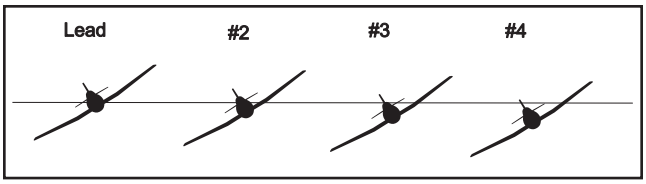


Figure 5.4 Echelon

keeping an eye on the adjacent aircraft.

5.3.3 Diamond

The diamond formation is formed when #4 crosses under to fall into a close trail position on Lead. (Figure 5.5) This formation is one of the basic building blocks used in airshow mass formations.

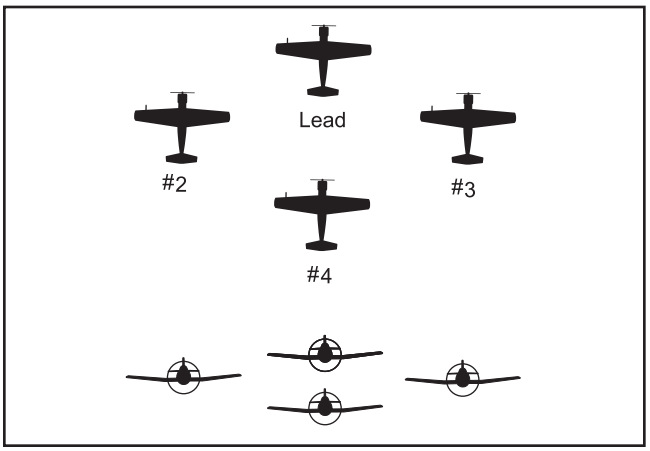


Figure 5.5 Diamond

5.3.4 Route

The purpose and parameters of four-ship route are the same as for two-ship route. For turns away from the wing pilot(s), the wing pilot(s) will fly an echelon turn instead of stacking up.

5.4 Ground Operations

5.4.1 Taxi

Lead will determine the taxi configuration. If Lead taxis on the centerline, all wing pilots will taxi on the centerline. If Lead offsets to one side of the center line, #2 will offset to the opposite side of the centerline and all subsequent aircraft will alternate opposite the aircraft ahead. Tailwheel aircraft are the exception and will taxi using normal s-turn techniques, as appropriate, to maintain maximum forward visibility.

5.4.2 Engine Run-Up

When #4 is ready to perform the run-up, he/she will pass a thumbs up to #3. When #3 is ready for the run-up, *and* has the thumbs up from #4, he/she will pass the thumbs up signal to #2. Number 2 will do the same. When Lead gives the run-up signal, all pilots will perform the run-up and all before-takeoff checklist items. When complete, pass the thumbs up signal up the line as before. As an alternative, Lead can have the wing pilots do independent run-ups and then pass the thumbs up hand signal up the line.

Lead

You should plan your turn into the run-up block so that all aircraft in your flight can be accommodated. You will give the run-up signal when all the wing pilots are in position and a "thumbs up" signal has been passed up the line from #4 to #3 to #2. At the completion of the run-up, look for the thumbs up signal to again be passed up the line to signify run-up complete; ready for takeoff.

Wing

Number 3 and #4 will pull into the run-up block parallel to #2. Because of the greater number of aircraft in the flight, pull in as close as safely possible to the adjacent aircraft without creating wingtip overlap. Parallel the adjacent aircraft so that if you should experience a brake failure during run-up, you will not strike another aircraft.

5.5 Takeoff

5.5.1 Runway Lineup

There are a number of different lineup configurations that can be used depending on the aircraft, runway width and runway length—figures 5.6 through 5.9 depict a few of the possibilities. Lead will determine the appropriate configuration and brief the flight accordingly. Lead can line up the entire flight on the runway or feed elements or aircraft on individually. When elements are lined up behind each other (Figure 5.6), 500 feet is the preferred spacing.

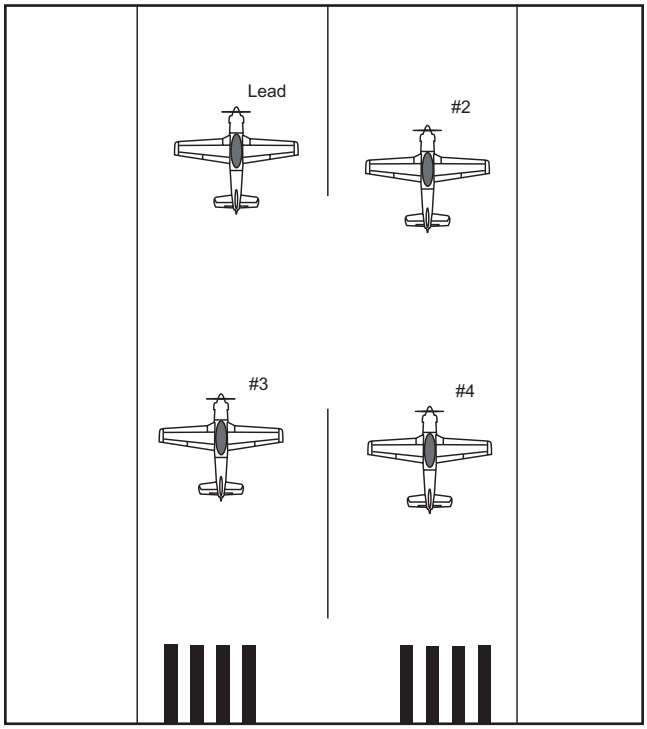


Figure 5.6 Element Lineup (narrow runway)

5.5.2 Run-Up and Takeoff

Three- and four-ship formations can accomplish single-ship takeoffs with individual rejoins out of traffic, or perform element takeoffs. When all aircraft are in position on the runway, Lead will direct the engine run-up using the same run-up procedures as in a two-ship formation. During individual takeoffs, #2, #3, and #4 may delay their run-up to allow the preceding aircraft to establish a takeoff interval. Takeoff power should be set no later than when the previous aircraft's main gear breaks ground. Brake release will not occur until the preceding aircraft or element has lifted off the runway. This ensures that if the preceding aircraft experiences an abort or other irregularity, the following aircraft will not create an even greater hazard.

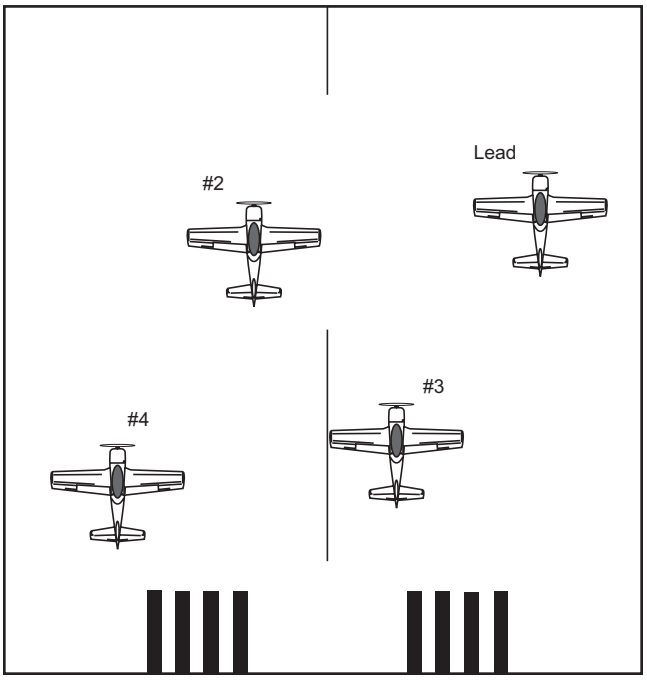


Figure 5.7 Element Offset Lineup (wide runway)

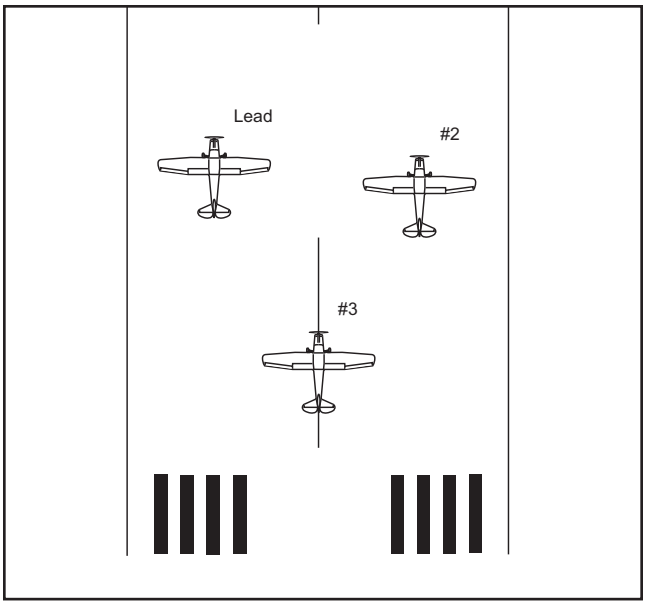


Figure 5.8 Three-Ship Vic Lineup

> CAUTION
> It is the responsibility of each element Lead, or PIC for single-ship takeoffs, to ensure there is adequate spacing between departing flights or aircraft.

5.5.3 Takeoff Aborts

Each aircraft must be prepared to react to any situation if a preceding aircraft aborts. Options available are:

1. Hold position
2. Abort
3. Continue the takeoff as safety dictates.

See the Abnormal Operating Procedures chapter for comprehensive procedures.

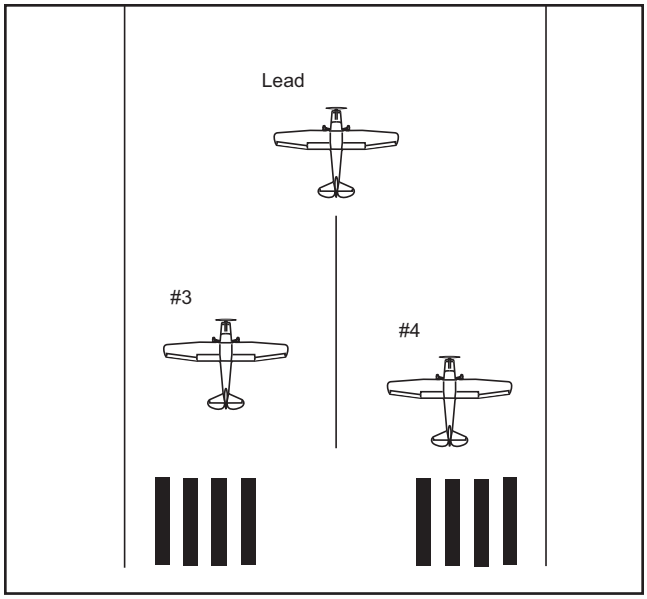


Figure 5.9 Three-Ship Phantom 2 Lineup

5.6 Departure

5.6.1 Takeoff Rejoins

The type of rejoin will depend on the local departure procedures. It may consist of a turning rejoin, a straight ahead, or a combination of both. For rejoins following element takeoffs, #3 and #4 will normally join as an element. As an option, #3 can send #4 to a route position with a minimum spacing of two to four ship-widths prior to rejoining on the lead element. Using this option, #4 will fly a position off #3 and will monitor the lead element throughout the rejoin. Number 4 will maintain two to four ship-widths of separation until #3 has stabilized in route. During all element rejoins, #3 must avoid sudden power changes and abrupt flight control inputs.

5.6.2 Turning Rejoin After Takeoff

Lead will start a turn and maintain briefed power and airspeed until the formation is joined. For single-ship takeoffs, the wing pilot will normally begin the turn no earlier than the departure end of the runway, however, for relatively long runways, the turn could occur prior to reaching the end. Following element takeoffs, Lead will ensure #2 is positioned on the inside of the turn, allowing #3 and #4 to join to the outside. Likewise, #3 will position #4 on the inside of the turn so #4 is being "dragged" up the rejoin line and is thus positioned to see all the aircraft in the flight. If required, Lead may roll out and call for a straight-ahead rejoin.

5.6.3 Straight-Ahead Rejoin After Takeoff

Lead will maintain briefed power and airspeed until the formation is joined. Lead's left side is the default position for #2 during straight ahead rejoins unless #2 is briefed or directed otherwise. Number 3 and #4 will always join to the opposite side of #2.

5.7 Wing Work

It is particularly important for Lead to be aware of the necessity of smooth, coordinated aircraft control because, in a four-ship formation, Lead's inputs can have a "crack-the-whip" effect on #4.

5.7.1 Fingertip

Lead

Monitor the wing pilots to make sure they are in a position to execute before you initiate a maneuver. Start with a "warm-up exercise" using shallow angles of bank before increasing bank angle and G-loads. Continue the exercise using modified lazy-eight maneuvers to vary airspeed, attitude, and G-load. Proficient wing pilots will be able to maintain station-keeping throughout 45° of bank in either direction combined with ±20° of pitch change.

Wing

You will use normal sightline references off Lead except #4 will determine position using the normal fingertip references relative to #3. If #3 is rough, #4 should reference Lead in order to maintain a stable position and constantly monitor #3's position

5.7.2 Echelon

Lead

Except for very gentle, shallow turns, all turns in echelon should be away from the echelon.

To reconfigure the flight from fingertip, signal for echelon by using hand signals or by dipping a wing in the desired direction.

To move the second element, signal #3 with a double pump of the arm (see Appendix C for visual signals) or dip your wing toward #2. Number 2 will hold position while #3 and #4 cross under to the echelon position on #2's wing.

To move #2, first signal #3 with a raised arm, fist clenched, to indicate that #2 will be crossing under; then signal #2 with the same raised arm, fist clenched. If using aircraft signals, dip your wing toward #3.

Wing (#2)

As #2, if Lead dips his/her wing toward you, maintain position—the second element will cross to the echelon position off your wing.

If Lead signals you with a raised arm and clenched fist, ac-

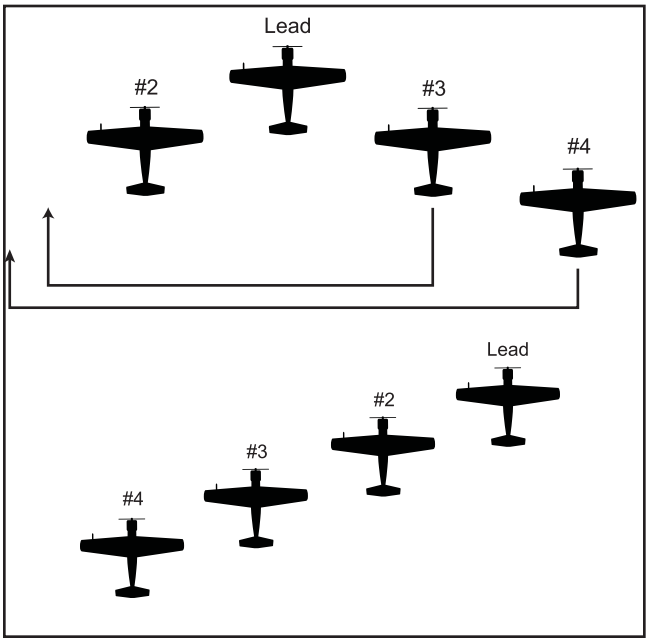


Figure 5.10 Cross-under: Fingertip to Echelon

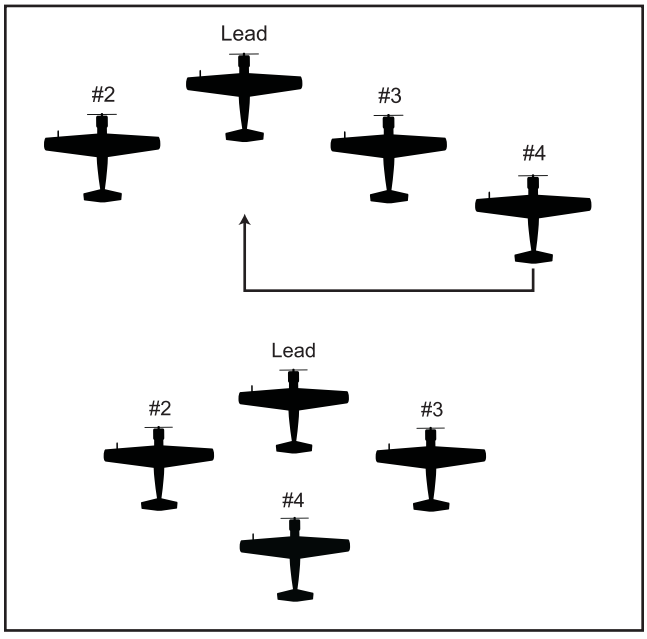


Figure 5.11 Fingertip to Diamond

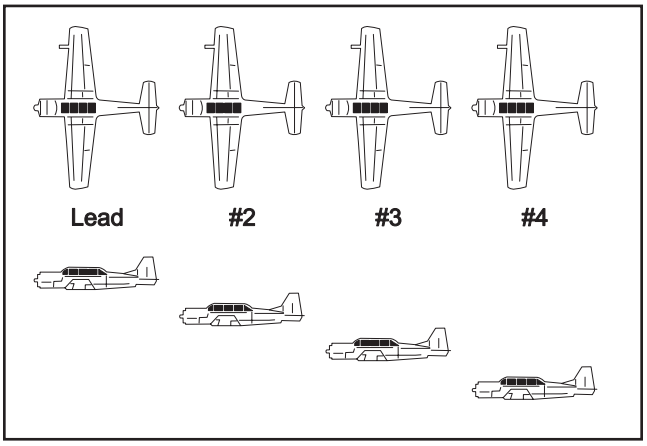


Figure 5.12 Four-Ship Close Trail

knowledge the hand signal, wait for the second element to make sufficient room for you, and then transition using normal cross-under procedures to take up position on Lead's opposite wing. Keep the element in sight until moving forward into position on Lead.

Lead may elect to use an aircraft signal to accomplish the same cross-under—if Lead dips his/her wing toward the second element, that is your signal to transition to the other side using the same procedure detailed above.

Wing (#3)
If Lead signals you with a double arm pump, move back and down (or laterally, for some aircraft), with #4 on your wing, to provide adequate clearance from the lead element. Once clear, cross the element to an echelon position on the wing of #2, maintaining safe clearances throughout the maneuver. As you cross behind Lead, #4 will cross under to the new position on your other wing.

If Lead uses an aircraft signal and dips his/her wing toward #2, transition the element to the opposite side as described above.

If Lead dips toward you, or holds up a single, clenched fist, acknowledge the hand signal, move out, back, and slightly down to make room for #2—for some aircraft, particularly those using a 45° bearing line, simply moving out laterally will normally provide adequate clearance. You and #4 will align yourselves with #2 and Lead. Smooth technique by #2 and #3 will prevent a crack-the-whip on #4.

Wing (#4)
Maintain normal sightline references on #3 at all times. When #3 is crossing the element to the opposite side, you will begin your cross to #3's opposite wing as #3 transitions behind Lead.

5.7.3 Close Trail
Four-ship close trail procedures are the same as two-ship with each aircraft flying reference off the preceding aircraft.

5.8 Three-Ship Echelon & Wing Work
Lead of a three-ship Vic formation will signal for echelon by using the same procedures as in a four-ship formation. If flying phantom 2, Lead will direct echelon turns by using a radio call: "Red, echelon turn." Since the flight is positioned for fingertip in phantom 2, if an echelon turn is not directed, #3 and #4 will maintain normal "stacked" fingertip references.

5.9 Turning Rejoins
During three- and four-ship turning rejoins, wing pilots will relay the wing-rocking signal to the aircraft behind them. In the absence of other instructions, #2 will always join to the inside of Lead's turn. Rejoin procedures for #2 are identical to the procedures described in Chapter Three. If #2 is slow to rejoin, it will complicate the rejoin for #3 and #4, who will have to decrease airspeed and/or cutoff to maintain proper spacing on the preceding aircraft. We always join "by the numbers," in numerical order. Joining aircraft will not close to less than two to four ship-widths until the preceding aircraft is stabilized in route.

Wing (#3)
You will join to the outside of Lead's turn. The basic rejoin techniques are the same as those flown by #2 except that you have the additional responsibility of monitoring #2 and being aware of #4. You should establish an aspect angle no greater than that used by #2. Accelerate to gain an airspeed advantage on Lead (up to 10% above briefed rejoin airspeed) and maintain two to four ship-width spacing (minimum) on the lead element until #2 is stabilized in route. You should plan the rejoin to pass with a minimum of nose/tail separation behind and below the lead element as you move to the outside of the turn, stabilizing in route, and deliberately moving into fingertip position on Lead. Avoid abrupt control pressure and rapid throttle movements in consideration of #4.

> NOTE
> There may be circumstances, such as a botched rejoin by #2, where it is advantageous for #4 to join on #3, forming an element—this can be done if #3 (element lead) grants #4 permission to do so.

Wing (#4)
You will also always join to the outside of Lead's turn, and basic rejoin techniques will still apply. However, you must monitor #3 as well as the lead element during rejoin, anticipating #3's power reductions and movements. After receiving the rejoin signal, begin a turn when you can place yourself inside Lead's turn circle, and then establish an aspect angle no greater than #3 or #2. Accelerate to gain airspeed advantage (up to 10% above briefed rejoin airspeed) and maintain two to four ship-width spacing on #3 until #3 has stabilized in route. Maintain this aspect angle on the lead element and #3, and plan your rejoin to pass with a minimum

of nose/tail separation behind and below the first element and #3 as you move to the outside of the turn. Stabilize in route and deliberately move into fingertip position on #3. You must monitor all aircraft in the formation as the rejoin progresses.

5.10 Turning Rejoin Overshoots

As a member of a four-ship formation, you must recognize an overshoot situation as soon as possible and make positive corrections. If an overshoot is appropriate, follow previously established procedures. In addition, the following considerations apply, based on your position in the formation:

Lead

Monitor overshoots carefully and do not hesitate to direct a break-out if the situation warrants such a call. If a break-out does occur, be directive in stabilizing the situation and establishing a plan to get the flight back together, or send the break-out aircraft back to base.

Wing (#2)

Announce your overshoot to alert #3 that you are encroaching on his/her side of Lead, "Red 2, overshooting." Clear to ensure sufficient spacing on #3 before returning to the inside of the turn and completing the rejoin.

WARNING
It is possible for #3 to lose sight of #2 when #2 overshoots. Use extreme caution and allow sufficient room on the inside of the turn to allow #2 to maneuver.

Wing (#3)

If #2 overshoots, modify your rejoin by decreasing your airspeed and adjusting your pursuit option to ensure adequate clearance if #2 returns to the inside of Lead's turn. If you extend the speed brake or remain at idle power to rapidly bleed your airspeed, notify #4, "Red 3, idle or speed brake."

Wing (#4)

Follow #3 whether #3 is overshooting or adjusting for a #2 overshoot. If #3 is overshooting, use good judgment and a combination of trail and rejoin techniques to stay with #3. Maintain two to four ship-width clearance (minimum) until #3 is stabilized in route. Depending how #2 and #3 fly the rejoin, for energy conservation or safety reasons, some situations may dictate that you fall into the six-o'clock position behind #3. This position is the safest of all options, allowing you to conserve energy and maintain a visual on all members of the flight.

5.11 Three-Ship Rejoins

When flying phantom 2, turning rejoins, wing pilots follow second element (#3 and #4) procedures, joining to the outside of Lead.

NOTE
When executing an overshoot as #3 or #4, use the same procedures as described for a #2 overshoot. However, when stabilized on the outside of the turn, you must determine whether it is more appropriate to remain on the outside of the turn, or return to the inside to complete the rejoin.

When flying Vic formation, #2 and #3 will use the standard four-ship procedures—#2 will join to the inside and #3 will join to the outside, just as if there was a #4 (phantom 4).

5.12 Straight-Ahead Rejoins

Straight ahead rejoins in four-ship employ the same procedures as in two-ship. Number 3 and #4 will close no nearer than two to four ship-widths to the preceding aircraft until that aircraft is stabilized in route position.

Lead

After completing the pitchout, signal for a rejoin by rocking your wings or making a radio call. Maintain the briefed rejoin airspeed. Monitor the wing pilots altitude, aspect, and closure as they come into your field of vision. Do not hesitate to take appropriate action if a dangerous situation develops.

Wing (#2)

Pass along the wing-rocking signal to the aircraft behind you. Rejoin to the left side unless otherwise directed.

Wing (#3)

Pass along the wing rocking signal to the aircraft behind you. Always join to the side opposite of #2, on Lead's wing, and maintain a minimum of two to four ship-widths clearance on #2 until #2 is stabilized in route.

Wing (#4)

Always join to the side opposite of #2, on #3's wing, and maintain a minimum of two to four ship-widths clearance on #3 until #3 is stabilized in route.

5.13 Straight-Ahead Rejoin Overshoots

Follow over-shoot procedures described for two-ship formation (Chapter Three) except that aircraft trailing the over-shoot aircraft will not close nearer than 100 feet to any aircraft ahead until the aircraft in sequence ahead is stabilized in route position.

5.14 Breakout

Leaving formation is the same in three- and four-ship formations as in two-ship formations, with the following exceptions:

- If #2 or #4 breaks out of fingertip formation, the re-

maining aircraft will maintain their original positions on Lead.
- If #3 leaves the formation, #4 will follow #3 at a safe distance to maintain element integrity.

Lead will direct the rejoin to the desired formation. An aircraft that has left formation will not rejoin until directed by Lead.

5.15 Three- and Four-Ship Extended Trail

The concepts and procedures discussed in two-ship extended trail (Chapter Four) apply to three- and four-ship ET but the increased dynamics of having additional aircraft in trail requires extra vigilance for all members of the flight.

Lead

You are providing a training platform for the entire flight. Be aware that with three or four aircraft in the flight there can be a "crack the whip" effect on the trailing aircraft. You also now have two or three aircraft to monitor. If your maneuvers are too aggressive for ***any*** member of your flight, decrease the intensity to accommodate that pilot.

Wing (#2)

You will follow the same procedures for two-ship ET described in Chapter Four.

Wing (#3)

You will follow the same procedures for two-ship ET except your ET cone emanates from #2. You have the additional responsibility of monitoring Lead and #2 so as to anticipate and project where #2's ET cone is likely to be as Lead and #2 maneuver.

Wing (#4)

You will follow the two-ship ET procedures except your ET cone emanates from #3. You also have the additional responsibility of monitoring Lead, #2 and #3 so as to anticipate and project where #3's ET cone is likely to be as all the aircraft ahead maneuver.

5.16 In-Flight Lead Changes

Four-ship lead changes are made from route fingertip or route echelon. Lead must thoroughly brief the planned procedures. The most commonly used method is for Lead to direct the formation to go to route with the radio call: "Red, route, go." The wing pilots will acknowledge and move to route. Lead can also direct a lead change using the hand signals detailed in 2.8.6 (Lead and Wing).

After the formation is stable in the route position, Lead will announce the lead change by stating: "Red 2 (or 3) you have the lead (on the left/right)." The new Lead will acknowledge by stating: "Red 2" (or "3"). The new Lead will move to the line abreast position and then call "Red 2 has the lead (on the left/right)," while slowly moving forward. The other aircraft in he flight will remain stable until the new Lead has pulled forward to the point at which they can pick up the normal sightline references. When the new formation is stable, the new Lead will check the flight in to confirm the new formation positions: "Red check." Once the flight has checked in properly, Lead will reform the formation to fingertip, and begin the briefed maneuvers. Lead has the option of using the original call signs or renumbering the flight.

5.17 Three-Ship Lead Change

During lead changes from route fingertip (Vic), #3 will move forward (as in a four-ship element lead change) to become Lead, using standard lead change procedures. As in four-ship lead changes, Lead has the option of retaining original call signs or renumbering the flight.

CHAPTER SIX
Abnormal Operating Procedures

6.1 Introduction
This chapter includes techniques to provide direction in an abnormal situation. The intent is not to cover every situation a pilot may encounter. It is not intended to replace or supersede procedures in the Aircraft's Operating Handbook, manufacturers procedural guidance, or sound judgment.

Your flight-mates are ready to provide support, but do not allow radio communications or other aircraft distract you from the primary responsibility of flying the aircraft. Do not hesitate to direct others to standby until able to safely provide the requested information. When making radio transmissions, be clear, concise and emphasize exactly what assistance you need.

6.2 Ground Aborts
When a flight member aborts prior to takeoff, the flight lead will normally realign flight positions to maintain a numerical call-sign sequence.

6.3 Takeoff Aborts
If an abort is necessary, maintain aircraft control, ensure separation from other aircraft and make a radio call as soon as practical. Do not sacrifice aircraft control to make a radio call.

6.3.1 Formation Takeoff Abort
Normally, during a formation takeoff, there will be no sympathetic aborts within the element (two-ship formation) after brake release. Sympathetic aborts should not be performed unless the single-ship takeoff presents a greater hazard. Sympathetic aborts can create situations where the good aircraft is aborting with an emergency aircraft and risking hot brakes, blown tires, loss of directional control, and other unforeseen complications.

During a formation takeoff abort by Lead or Wing, the other aircraft will select max/takeoff power and execute a normal single-ship takeoff and maintain his/her side of the runway.

WARNING
If flying as Wing and overtaking Lead after requesting Lead to increase power ("push it up"), this may be your first indication Lead is aborting or experiencing engine problems. If this is determined, accomplish a separate takeoff IAW this manual.

6.3.2 Element Takeoff Abort
If an element abort is necessary, because of conditions such as a fouled runway or runway incursion, Lead should transmit the flight call-sign and an abort call:

"Raven, ABORT, ABORT, ABORT"

Lead may also make a directive call, "Raven 2 ABORT NOW". Both aircraft must maintain their respective side of the runway.

6.3.3 Interval Takeoff Abort
If the Lead must abort, he/she will attempt to transmit intentions to the wing pilot, "Raven 1 aborting." Wing pilots will hold brakes and wait for Lead to clear the runway before preceding as briefed or instructed.

6.4 Airborne Emergencies
As much as possible, maintain element formation integrity for all airborne emergencies. However, should a pilot of an aircraft experience engine/power problems in close proximity to a landing field, such as immediately after takeoff, do not delay recovering the aircraft because of formation considerations. In these situations, announce your intentions over the radio.

If any aircraft malfunction occurs while in close (parade) formation, ensure aircraft separation before handling the emergency. The pilot of an aircraft experiencing an abnormal situation will advise the flight lead of the problem, intentions, and assistance required.

Lead
If possible, move the flight to route formation first, then deal with the malfunction. If the pilot with the malfunction can transmit and navigate, offer him/her the lead so you can fly support. There are some emergencies, such as simple radio failure or pitot/static failure where you should retain the lead. Attempt to follow the formation briefing instructions for contingencies, if applicable, so the wing pilot knows what to expect.

Wing
When an aircraft malfunction or emergency occurs, call "Knock It Off" and inform lead of the problem. Normally, if you are able to communicate with outside agencies and navigate, take the lead when offered. As much as possible, avoid flying the wing position with an emergency. If you must fly the wing position, fly no closer than route formation.

NOTE
See section 6.9 for specific emergency chase formation procedures.

6.5 Radio Failure

If an aircraft experiences a partial or total radio failure, defined as the inability to transmit and/or receive, the flight should be terminated as soon as practical and the no-radios (NORDO) aircraft will assume or retain the wing position and be led back to the field of intended landing, or divert as briefed.

6.5.1 Aircraft With Operational Radio

A formation approach to a drop-off on final should be performed unless safety, pilot qualification, weather or other considerations dictate otherwise. The lead pilot should inform the tower or applicable controlling agency and coordinate the go-around. Once the flight is established on final with landing clearance received, the lead pilot will give the distressed pilot the "you've got the lead" hand signal, indicating that he/she is cleared to land. The support pilot will then execute a single-ship go-around. In most cases the support pilot will accomplish the drop off at or above 300 feet AGL. The formation drop-off procedures will ensure the NORDO aircraft has clearance to land from the tower or other controlling agency.

> NOTE
> If the flight recovers to the overhead pattern, once the aircraft separate at the break the NORDO pilot must be cognizant of tower-directed light signals for landing clearance IAW the Aeronautical Information Manual or host nation procedures. Regardless of recovery procedure, heed tower-controlled lights at all times.

6.5.2 Radio Failure as Lead

Send the wing pilots to route and give the appropriate visual signal IAW appendix C, then pass the lead to either #3 or #2, as appropriate.

6.5.3 Radio Failure as Wing

While in close or route formation, pull forward to line abreast of the flight or element lead and rock your wings to attract attention and alert the flight/element lead that you require assistance. If flying in any other formation, such as extended trail, approach your flight/element lead, but do not rejoin closer than two to four ship-widths. Rock your wings to gain your flight or element lead's attention and wait for him/her to pass the visual rejoin signal before proceeding. When signaled, rejoin to route and move only as close as required to pass applicable NORDO visual signals IAW appendix C. Expect to be led back to the briefed recovery field following the procedures contained in this section.

6.5.4 HEFOE Signals

If you experience a radio failure AND another malfunction, such as a total electrical failure causing a NORDO condition, use "HEFOE" signals to communicate the particular system problem. "HEFOE" stands for:

1. Hydraulic
2. Electrical
3. Fuel
4. Oxygen
5. Engine

A HEFOE signal is given in two steps. After getting Lead's attention with the wing rock, using procedures listed in RADIO FAILURE section of this chapter, provide the flight lead with the HEFOE visual signal listed in appendix C followed by the number of fingers corresponding to the particular system problem.

> NOTE
> Some aircraft use pneumatics in the place of hydraulics, so one finger is used in these aircraft to signify a pneumatic problem.

Expect to be offered the lead to accomplish emergency checklist duties. Pass the lead back when you are ready to recover for landing IAW with NORDO procedures.

6.6 Intercom Failure

Flight training in tandem-seat aircraft produces the possibility of communication failure between instructor and pilot in command. Procedures must be in place to ensure aircraft control is positively determined at all times.

6.6.1 Preflight Briefing

When carrying a rear-seat occupant, each PIC of a tandem seat aircraft should brief the procedure for transfer of aircraft control in the event of intercom failure. The PIC should also brief specific emergency responsibilities, emergency escape, and bailout/ejection procedures.

6.6.2 Transfer of Aircraft Control

Normally, with an operable intercom, transfer of aircraft control is prefaced with "I have the aircraft" followed by shaking of the stick. This is acknowledge by the other pilot announcing "You have the aircraft" and then relinquishing all controls.

Without intercom, transfer of aircraft control can result in disastrous crew confusion if not accomplished properly. If intercom failure occurs when the PIC is not flying the aircraft, the second pilot will continue to fly the aircraft until the PIC shakes the stick. At this time the second pilot will relinquish all controls and hold up his/her hands if occupying the front seat (backseat occupants may be viewed with mirrors, if equipped).

Under normal circumstances, the PIC will retain control through the remainder of the flight. However, some circumstances may necessitate a subsequent transfer of control (emergency checklist duties, complications because of front canopy penetration from bird strike, etc.). In these circumstances, the flying pilot will yaw the aircraft with the rudders when desiring to pass control back to the other pilot. The other pilot will acknowledge by shaking the stick and looking for the PIC to show hands clear.

6.7 Lost Wing Pilot Procedures

The emphasis of this manual is on civil formation in visual flight rules (VFR) conditions. Lost wing pilot procedures are designed for formation flight in instrument meteorological conditions (IMC), whether planned or inadvertent, which has resulted in the wing pilot having lost site of lead. Lost wing pilot procedures may also be applicable to rare situations of severe spatial disorientation.

In any lost wing pilot situation, immediate separation is essential. On losing sight of the leader, or if unable to safely maintain position because of spatial disorientation, wing pilots will simultaneously execute the applicable lost wing pilot procedure and transition to instruments. Smooth application of control inputs is imperative to minimize the effects of spatial disorientation.

WARNING
The following procedures *do not* guarantee obstacle clearance along your flight path. Good judgment must be used when exercising these emergency procedures.

Lead
When informed wing pilots are executing lost wing pilot procedures, immediately perform the appropriate procedure, acknowledge the lost wing pilots' call, and transmit your altitude and heading, as required, to aid in maintaining safe separation.

NOTE
The wing pilot will notify lead, who will coordinate with the controlling agency and request a separate clearance for the wing pilot if required. The controlling agency can aid in ensuring positive separation if in a radar environment.

6.7.1 Two-Ship or Three-Ship Vic, Wings Level Flight: Climbing, Descending or Level

Wing
Turn away for five seconds using 15° of bank and inform Lead. Then resume heading and obtain a separate clearance, if applicable.

NOTE
The times used in these examples are predicated on an aircraft flying at 120 kts. For faster aircraft see figure 6.1.

6.7.2 Two-Ship or Three-Ship Vic, Turning Flight: Climbing, Descending or Level

Lead
If your wing pilot is on the inside of the turn, he/she will ask you to roll out of the turn. You will only resume the turn once separation is assured.

Wing
Outside the turn, reverse the direction of turn, using 15° of bank for five seconds, and inform Lead. Roll out and continue straight ahead to ensure separation before resuming the turn. Inside the turn, momentarily reduce power to ensure nose to tail separation and tell Lead to roll out of the turn. Maintain angle of bank to ensure lateral separation. If in a three-ship flight with both aircraft on the same side, refer to four-ship procedures.

6.7.3 Four-Ship, Level Flight: Climbing, Descending or Level

Lead
If #4 is on the inside of the turn, he/she will ask you to roll out of the turn. You will only resume the turn once separation is assured.

Wing (#2 and #3)
You will follow the procedures spelled out for two-ship and three-ship vic, above.

Wing (#4)
Because it is impossible for you to immediately determine that #3 still has visual contact with Lead, is imperative that your initial actions are based on the assumption that #3 has also become separated and is following applicable procedures. If you lose sight of #3, simultaneously inform Lead and turn away, using 30° of bank for 10 seconds. Then resume heading and obtain a separate clearance, if applicable.

6.7.4 Four-Ship, Turning Flight: Climbing, Descending or Level

Wing (#2 and #4)
You will follow the procedures spelled out for two-ship and three-ship vic, above.

Wing (#4)
On the outside of the turn, reverse the direction of the turn, using 30° of bank for 10 seconds to ensure separation from

Lead and #3. Obtain a separate clearance if applicable. Using 30° of bank for 10 seconds will generate a significant heading change from Lead. Maintain situational awareness for obstacle clearance as you separate from Lead. On the inside of the turn, momentarily reduce power to ensure nose to tail separation and increase bank angle by 15°. Tell Lead to roll out of the turn.

15 to 30° bank	approx. 45° of turn	approx. 90° of turn
120 kts	5 seconds	10 seconds
200 kts	8 seconds	15 seconds
250 kts	10 seconds	20 seconds
300 kts	15 seconds	30 seconds

Figure 6.1 Turn Times for Various Airspeeds

6.7.5 Practicing Lost Wing Pilot Procedures

Lost wing pilot procedures may be practiced in VMC conditions to prepare wing pilots for actual situations they may encounter. The flight lead assumes all responsibility for aircraft separation. For this reason, when executing practice lost wing pilot in other than two-ship formation, an instructor pilot must be on board the wing pilot's aircraft for safety. Lead directs practice lost wing pilot procedures with a radio call.

"Raven Flight, practice lost wing pilot, go"

At this time the wing pilot executes the appropriate procedure and transmits,

"Raven 2 practice lost wing pilot"

The flight lead will transmit all appropriate calls IAW this chapter for the applicable procedure. The instructor in the wing pilot aircraft will monitor Lead to ensure aircraft maintain adequate separation throughout the maneuver and request "terminate" when learning objectives have been met. The flight lead will direct a rejoin as required.

WARNING

Non-instrument rated pilots should use good judgment when executing flight with reference to instruments. In general, restrict bank angles to no more than 30° and pitch angles to no more than 10° unless the situation demands otherwise.

6.8 Spatial Disorientation

The most common form of spatial disorientation is known as "the leans." It is a condition often associated with operating an aircraft with little or no discernible horizon. The leans can occur during formation flight for a number of reasons that include illness, damage to the vestibular region of the inner ear, or environmental conditions. The following procedures will help deal with the rare episodes of extreme spatial disorientation while flying formation.

Lead

If your wing pilot informs you that he/she is experiencing spatial disorientation, cease maneuvering and establish straight and level flight while transmitting flight parameters—this may reduce the sensation of spatial disorientation. If spatial disorientation persists, consider passing the lead to the wing pilot if conditions permit. If in a flight of more than two aircraft, separate the flight into elements to more effectively handle a wing pilot with persistent spatial disorientation symptoms.

Wing

If you become spatially disorientated at any time, immediately inform Lead. Make every effort to maintain position if safe to do so. If unable to maintain safe formation position because of this condition, execute lost wing pilot procedures IAW this chapter and notify Lead.

WARNING

In cases of spatial disorientation, the time required to execute lost wing pilot procedures, transition to instruments, and recover orientation may be so great that the aircraft may have entered an unrecoverable situation.

6.9 Damaged or Abnormally Operating Aircraft

6.9.1 General Guidelines

If a single aircraft is damaged, experiences severe over-G, has indications of an unsafe gear or develops other safety-related mechanical issues in flight, the pilot will immediately request the lead after following KIO procedures IAW Chapter Two. The other aircraft will fly chase formation and provide assistance and inspection as needed.

6.9.2 Chase Parameters

Chase formation is defined as maneuvering airspace up to 45° aspect angle either side of the emergency (lead) aircraft. Fly no closer in range than required to observe the mishap aircraft without becoming a distraction, or endangering your aircraft from Lead's abrupt maneuvering because of loss of control, structural failure, or unexpected bailout/ejection. Avoid flying directly behind the lead because of falling parts or bailout.

NOTE
If both aircraft are damaged because of mid-air collision, Lead will ensure separation laterally and vertically. If part of a four-ship, the non-mishap aircraft will provide chase duties IAW this chapter. Do not delay recovery waiting on chase aircraft unless absolutely required for safe recovery. Do not fly chase between two aircraft damaged from a mid-air collision.

Lead (Emergency Aircraft)
Once the lead change occurs, use your wing pilot as an asset to help deal with the situation. When immediate emergency action items are completed, delegate tasks to the wing pilot as appropriate. Your wing pilot can read checklists over the radio if available, confirm position of alternate airports, direct navigation, or conduct airborne damage inspections. Attempt to follow your formation briefing instructions for contingencies if applicable so the wing pilot knows what to expect.

Wing (Chase Aircraft)
Fly the a proper formation chase position on Emergency Lead. Do not approach closer than route formation unless required for gear inspection or other observation assistance and requested by the emergency lead. Except for unusual circumstances, do not land in formation with a disabled aircraft; instead, fly a low approach no lower than 300 feet AGL.

The best wing pilot during an emergency is one who flies a solid chase position from which to observe Lead's aircraft, monitors key safety issues such as bailout altitudes, and otherwise remains silent unless absolutely required or requested by Lead. "Over-helping" wing pilots may distract Lead from performing critical steps in resolving his/her emergency.

WARNING
Do not fly close/parade formation unless absolutely required and coordinated with the emergency Lead for inspection (landing gear or aircraft damage, for example).

6.10 Bird Strike
Care must be taken not to cause a mid-air collision attempting to avoid an imminent bird strike. If a bird strike does occur, gain separation before handling the emergency. The most critical conditions caused by a bird strike are engine or prop failure, airframe structural damage, or cockpit penetration. Consider being led back for a wing landing if forward visibility is severely restricted.

6.11 Bailout/Ejection
If the aircraft is unsafe for continued flight or landing, it may be necessary to execute a controlled bailout or ejection. If time permits, the pilot of the emergency aircraft will inform the flight/element lead, who should ensure flight separation both laterally and vertically.

6.11.1 Crew Considerations
If the aircraft has more than one occupant, and time permits, the bailout/ejection procedures should be reviewed. When ready, the pilot in command should call over the intercom: "BAIL OUT, BAIL OUT, BAIL OUT" or "EJECT, EJECT, EJECT" as applicable to the aircraft, as the execution command. Normally, the rear occupant goes first (some ejection systems control this sequence).

WARNING
In critical situations, such as complete loss of aircraft control with insufficient altitude to recover or structural failure, if not Pilot In Command, do not delay an ejection/bailout waiting for the "BAILOUT" or "EJECT" command.

6.12 Search and Rescue (SAR)
When a formation member bails out, ejects or executes a forced landing, steps must be taken immediately to positively locate the downed aircrew and initiate rescue efforts. In many cases, the downed aircrew will suffer from shock or delayed reactions to bail out, ejection, or forced landing injuries—recovery time is critical. The following procedures are by no means complete, and may be adjusted to meet each unique situation.

NOTE
The flight lead should review basic SAR procedures during the formation briefing as applicable.

6.12.1 Specific SAR Actions
The following are suggested actions that should be made to assist in the location and recovery of a downed pilot/aircrew.

Respond
Immediately terminate maneuvering using appropriate Knock-It-Off procedures. Establish a SAR commander—normally the flight lead. Remain above the last known/observed parachute altitude until position of all survivors is determined. De-conflict other aircraft and flight members assisting in the SAR effort by altitude to preclude mid-air collision. Establish high and low SAR covering air patrol ("SARCAP") orbits, if required, to help facilitate radio com-

munications and coordination efforts.

Squawk
Squawk the emergency code to alert air traffic control.

Talk
Immediately communicate the emergency situation to the applicable air traffic control agency. Inform them of your intentions to provide airborne search and rescue support.

Mark
Mark the last known or currently observed positions of the survivors or crash site using GPS or any other means available, such as radial/DME, ATC radar positioning or ground references. Communicate this information to ATC to assist in subsequent rescue efforts.

Assess
The flight lead should attempt to assess the survivors' condition visually. This information should then be relayed to applicable controlling agencies/ATC to assist responding rescue assets.

Bingo
Revise bingo fuel and/or recovery bases as required to maintain SARCAP coverage over survivors and/or the crash site. Do not overfly bingo fuel. Relinquish SAR operation to designated rescue forces upon their arrival. Such units may consist of helicopter-born hospital units, county sheriff, EMS, or fire departments.

6.13 Summary
This chapter was not intended to address every contingency situation, but to provide general guidelines to assist in the decision making process. The application of sound airmanship, judgment and leadership will ultimately determine the successful outcome of an emergency situation. Flight leads should brief applicable contingency and emergency response plans as appropriate to their flight.

CHAPTER SEVEN
Mass Formation

7.1 Introduction
This chapter's purpose is to help prepare formation qualified pilots to fly in mass formation. Mass formations are defined as any formation of aircraft involving more than one flight of four aircraft. The purpose of mass formation flight is to demonstrate flights representative of large formations flown in typical military air operations of a bygone era. This chapter will provide background information and standards so that qualified pilots may know what to expect and be assimilated easily into mass formation.

7.2 Organization
The mass formation leader is called the "Mission Commander" (MC). MCs are highly qualified lead pilots who have experience in leading larger formations. MCs will tailor procedures to suit each particular airshow situation. The MC will determine which combinations of formations to employ based on the number of aircraft available, aircraft types, pilot qualifications, and special equipment, such as smoke systems.

MCs may designate one or more "Deputy Mission Commanders" (DMC1, DMC2). The MC may delegate DMCs to perform particular ground and airborne tasks, such as administrative details, fueling and maintenance issues, or any fall out/emergency aircraft. A DMC could be #3 in the MC's four-ship or a flight leader.

Mass formations (sometimes referred to as "the big one") are comprised of smaller flights led by their respective flight leaders. The flight leaders of these smaller formations are the key to a successful mass formation. They must be able to maneuver their flight, similar to a single ship, using smooth, judicious power management and margins so as to not lose their wing pilots. The flight leaders also need to be able to anticipate power requirements when the mass formation turns into or away from them.

7.3 Briefings
Mass formation airshow flying tends to be more complex and some procedures may vary from event to event, and from day to day, depending on numerous factors. As a result, briefings are essential tools to ensure flight safety. There are generally four briefings that play an important role in preparing to execute a mass formation. The briefings are: 1) Airshow Briefing, 2) Mission Briefing, 3) Flight Briefing, and 4) Element Briefing.

For airshows at large venues such as Oshkosh's EAA AirVenture and Lakeland's Sun 'n Fun, these briefings should be held on site whenever practicable in order to include as many qualified pilots as possible.

7.3.1 Airshow Briefing
This briefing is conducted by the Airshow Airboss and is attended by representatives from each group, team or act. This briefing will present the "big picture" with respect to all the different groups participating in the airshow—timing, altitudes, orbit patterns, launch, sequence, recovery, communications (comm) plan, and other mission details. FAA waivers, fuel reimbursement forms, and other administrative tasks may also be dealt with. With large groups, it is generally *not* desired that all pilots attend this briefing. The MC will attend and should bring to the briefing the relevant information regarding his/her group, e.g., number and type of aircraft to be flown, and special ops requirements.

7.3.2 Mission Briefing
This briefing is conducted by the Mission Commander. All mass formation pilots are required to attend. The MC will brief the weather, NOTAMS, FAA waiver information, and other pertinent information from the airshow briefing. The MC will make position assignments for each pilot, then will detail DMC's and flight lead pilots' responsibilities, departure and recovery procedures, formation configurations to be flown, the comm plan, altimetry, contingency plans, and emergency plans. Safety will be emphasized throughout the briefing. The MC will ensure that every pilot understands their role and individual position in the mass formation, as well as when and how configuration changes will be performed.

The briefed information should be germane and concise—too much information can be counterproductive to the mission.

A "walk-through" of the mass formation is an essential component of the mission briefing. The MC will have all the participating pilots line up in the order that they will assemble for taxiing to the runway. This allows each pilot to coordinate with the pilot they will follow to identify their aircraft and determine where they are parked. The MC will then have the individual flights walk through the post-takeoff join-up. Once the join-up is complete, the MC will discuss and walk through the planned mass formation configurations and the means to transition from one configuration to another. Finally, a walk through of the recovery plan will be conducted. The walk through should be repeated until everyone is confident that they have a clear understanding of how and when the entire mission will be accomplished.

7.3.3 Flight Briefing
This briefing is conducted by each flight's lead pilot and attended by that flight's pilots. This briefing is essentially the same briefing we use every time we fly in formation with the exception that the relevant mass formation information is factored into the plan.

7.3.4 Element Briefing
This briefing is conducted by each element's lead pilot and is the same element briefing we conduct on our routine formation sorties. Of particular importance is coordinating takeoff procedures and highlighting aircraft differences.

Only formation-qualified pilots will fly in waivered airspace. After the mission has been briefed, there will be no additions to the formation and no stingers added.

No pilot, regardless of qualification, should participate in a mass formation in waivered airspace unless that pilot has logged previous mass formation time or mass formation practice.

7.3.5 OSH Briefing
Pilots participating in the Oshkosh AirVenture airshow for the first time must attend a "first timer's" briefing prior to flying. This briefing is normally conducted by the airboss or his/her designate.

7.4 Altimetry
The MC will brief the altimeter procedures in the mission briefing. Within the confines of waivered airspace and the airshow environment it usually enhances situational awareness to set altimeters to zero on the ground. All in-flight altimeter readings will then be height above field level. During run-up, the MC can remind the wing pilots of the "zero" altimeter by passing the "OK" sign down the line (hand raised, with thumb and index finger in the shape of a zero).

7.5 Comm Plan
The comm plan for most airshows is generally straightforward; however, with as many as one hundred or more aircraft in the air at the same time, radio discipline is critical. The MC will develop a comm plan that meets the mission requirements. It is essential that all pilots understand all the details of the comm plan.

Frequencies used will vary depending on the type of airshow. For most local shows, all aircraft will fly the show on the briefed airshow or "Airboss" frequency, also referred to as the "external" frequency. If flying with other large groups, such as the Warbird Show at Oshkosh, it will be best to have the MC monitor/communicate with the Airboss on the primary frequency and communicate with the members of the mass formation on their own discrete frequency, also referred to as the "internal" or "tactical" frequency. The airboss and tactical frequencies should have a backup in case they become jammed or otherwise unusable.

In mass formations where all aircraft are equipped with dual radios, the MC has the option of having the pilots tuned to the internal frequency while monitoring the external frequency on the second radio. This enables the MC to keep all pilots informed of the progress of the show without interfering with communications on the airboss frequency. Keeping the pilots informed can help them manage fuel status and ease the tension of flying in the airshow.

The overall mass formation will have its own call sign. The individual flights within the mass formation will each have a unique call sign. Situational awareness can be enhanced by identifying these smaller flights using sequential flight call signs, such as, Alpha, Bravo, Charlie and so on, to identify their position within the mass formation.

After engine start, the MC will typically check all the pilots in on the briefed frequency—this may be the ramp, ground, Airboss, or discrete frequency. This check-in/out may be the only time when all pilots acknowledge a radio call. During this initial check-in the MC will advise the formation of the weather/ATIS, remind pilots to "zero" their altimeters, and communicate any changes. Normally, on subsequent frequency changes, only the individual formation flight leads will acknowledge. The MC can initiate this option by making the radio call "Red Leads, check in," indicating that only the individual lead pilots should check in. (In this case the overall mass formation call sign is "Red" flight)

On all subsequent radio calls participants should refrain from using calls such as "lead" or "two" because there are many pilots to whom the call would apply. The use of full call signs ("Alpha one", "Alpha two") will eliminate ambiguity and maximize situational awareness.

There may be times when pilots are required to switch frequencies on their own, automatically— for instance, switching to ground once clear of the warbird ramp, or changing to tower when approaching the runway. This will be briefed as part of the comm plan.

A default frequency, normally a discrete tactical frequency, will be briefed. The purpose of the default frequency is to provide a frequency for the confused/lost pilot to monitor until retrieved by a lead pilot. The flight lead of the lost pilot will automatically initiate retrieval procedures. The flight lead can either retrieve the lost pilot or designate another flight member to do so. If the lost pilot can't be found on the default frequency, use standard hand signals to get him/her on the right frequency.

Once airborne, radio calls will be kept to an absolute minimum. If specific, directive radio calls have to be made, i.e., "Red, smoke on, now" it is better to have the affected pilots on a discrete frequency. Comm or other problems will normally be handled within flights by the individual flight lead pilots. The MC, if capable, will monitor the tactical frequency on his/her second radio so that flight members can contact him/her if necessary.

In a distress or emergency situation, the affected pilot needs to communicate the situation immediately on the briefed

frequency. In the event of a catastrophic emergency, the Airboss must immediately be informed so that all efforts can be channeled toward the safe recovery of the emergency aircraft. If the distressed aircraft is unable to make the call, the MC, the pilot's flight lead, or an aiding wing/chase pilot should coordinate. If the situation is less critical, and does not require the recovery of the distress aircraft, it may be possible to handle the event within the flight on the discrete, tactical (tac) frequency.

7.6 Passenger Policy

The FAA waivers that airshows operate under generally do not allow passengers. Only required crew members may fly while the waiver is in effect. An exception may be allowed for a pilot who is new to the airshow environment and requires indoctrination. With the approval of the Airboss and FAA, a qualified instructor may be allowed to accompany the new pilot. This approval will be on a case-by-case basis, prior to each airshow.

For non-waivered airspace sorties, such as practice sessions, it is normally standard operating procedure (SOP) that all passengers must be approved by the MC and the event organizer, for sponsored events.

7.7 Safety

You are operating in an airshow environment, so you are "on display." It is important that every move you make, from engine start to shutdown, be carried out with the understanding that safety is still paramount, in spite of the pressures and excitement of the airshow. The welfare of potentially thousands of people is entrusted to each pilot in the show.

7.8 Ground Operations

Each individual pilot must take responsibility to ensure their aircraft is serviced and ready to go on time. Engine start will be accomplished using standard procedures, either using hand signals or a briefed start time.

After engine start, the MC will wait approximately three minutes to check the flight in. Pilots not ready to taxi should give the MC their reason for delay and expected taxi time. For cold starts, more time will be allotted to minimize delays.

Particular attention will be paid to taxi speed and interval since the taxi-out is part of the show. The MC will taxi at a moderate pace—taxiing too slowly forces excessive brake use and can result in brake fade. The MC will specify the taxi interval desired, but it will be up to each pilot to make the interval look uniform. Adjustments to the interval may be briefed if tailwheel aircraft are in the formation.

Standard run-up procedures are generally used; all aircraft will line up and pass signals up and down the line to run-up simultaneously. To expedite the run-up, the MC may brief everyone to run-up on his/her own. When the last pilot in the formation is ready for takeoff, he/she initiates the passing of the "thumbs up." If hand signals cannot be passed up the line due to lack of visibility, reverse order radio calls may be necessary.

7.9 Takeoff

Standard takeoff procedures will be used. Takeoff will be accomplished in a manner that will most efficiently and expeditiously get all the aircraft airborne. With runway widths of 150 feet or more, three-ship vics can be launched (winds and other conditions permitting). The MC will thoroughly brief the runway lineup and takeoff procedures. Regardless of which method is used, the last aircraft or element will call when airborne.

7.9.1 Element Takeoff

Field conditions, weather and the airport configuration will dictate how the element takeoff will be executed. All the possibilities cannot be detailed here, but the following are effective for most standard operations.

- Line up as many elements on the runway as possible. However, make sure the lead element has adequate usable runway available for takeoff/aborts. With a large formation, the MC does not have to wait for all elements to line up before starting the take off roll.
- If all the elements cannot be lined up on the runway, as the lead element starts its takeoff roll, subsequent elements will taxi forward, in turn, to the runway position occupied by the lead element. Those elements holding short will then be able to feed onto the runway as each element moves forward.
- On shorter and/or narrower runways another option is for elements or single aircraft to feed onto the runway and do a rolling takeoff.

7.9.2 Single-Ship Takeoff

- On runways less than 75 feet wide, use standard formation single-ship takeoff procedures.
- On wider runways, runway length permitting, the aircraft can be lined up on the runway using standard procedures prior to initiating the single-ship takeoff roll.
- If starting from the hold short line, all aircraft can roll onto the runway using staggered taxi spacing. The MC will start the takeoff roll as soon as he/she is lined up. The wing pilots continue to roll down their half of the runway at a slow taxi speed until starting the takeoff roll. Takeoff roll will be initiated when the previous aircraft has lifted off. If a flight member is approaching 3000 feet of runway remaining, he/she should control taxi speed so as to start the takeoff roll prior to the 3000-feet-remaining point; stopping only if the preceding aircraft is not yet airborne. The objective is to keep all aircraft taxiing onto and down the runway in a tight

staggered formation, never stopping unless approaching 3000 feet remaining.

7.10 Assembly

If the goal is to assemble over the airfield, the MC will generally extend the departure leg straight out to allow the trailing aircraft to position for the rejoin. Depending on the number of aircraft and spacing, a racetrack pattern, a large teardrop, or two 270° turns can be used to assemble the mass and quickly get it in position over the show line.

If the rejoin is going to take place away from the field, the MC will maintain the briefed altitude and airspeed enroute to the assembly point. Those aircraft that can will rejoin straight ahead enroute; those aircraft that are not able to rejoin enroute will execute a turning rejoin at the rendezvous point. The MC will maintain an airspeed that both allows for an expeditious rejoin and allows for adequate engine cooling.

7.11 Airshow Patterns

Airshow patterns will typically be flown as a racetrack or dog bone. The MC will direct the configuration changes as planned. The changes will normally occur when the mass formation is maneuvering away from the crowd or during the return to show center. Some configuration changes may look interesting from a crowd perspective and can be accomplished over show center but most changes simply look like an unorganized clump to the average observer so discretion is advised.

There are a few techniques that will help while maneuvering a large formation. In turns, the MC should use relatively shallow-banked turns if there are many aircraft spread out laterally and ***roll rate is a critical factor*** when maneuvering large formations. In some formation configurations, such as the "Diamond Vic" (Figure 7.4), flight leads on the outside of a mass formation turn will fly echelon off their reference (leading) flight. In this situation, wing pilots can fly normal, "stacked" references. In other configurations, such as the "Arrow" (Figure 7.6), aircraft on the outside of the turn will use echelon, as opposed to stack-up, to aid in maintaining position. This also reduces the vertical space used by the group. Aircraft on the inside of the turn can fall into trail, if necessary, to help maintain position. In all cases, situational awareness is paramount during configuration changes.

Maintaining the normal stack-down reference is even more important when flying in mass formations; as the numbers of aircraft increase, more and more vertical space is occupied by the formation. This can be a factor when you are restricted to a block altitude to de-conflict with other mass formations. Flight leads for trailing formations should stack down only enough to keep the flight clear of the preceding flight's wake turbulence.

7.12 Symmetry

Maintaining symmetry is critical to the appearance of the formation. All pilots will fly the standard references, precisely. In addition, to assure balance and symmetry, the following techniques are employed.

7.12.1 Line Up the Heads

This means that all pilots looking up the bearing line will line up the pilots' heads of the preceding aircraft. These pilots will move slightly as needed to make sure all preceding pilots heads are in perfect alignment fore and aft.

7.12.2 Dress Right

All pilots will "dress" across the formation to the right. This means that aircraft on the right set the spacing. Aircraft on the left will crosscheck to the right across the formation (perpendicular to the flight path) to line up with aircraft to the right.

7.12.3 Dress Forward

Aircraft following in trail of other aircraft should crosscheck forward to ensure that they are directly in line, longitudinally, with all preceding aircraft.

7.12.4 In-Trail Spacing

Maintaining symmetrical intervals between in-trail formations within the mass is difficult to gauge. Index marks, placed on lead pilots' windscreens can help judge intervals. These marks, applied with grease pencil or thin tape, correspond to the aircraft ahead's wingspan. The lead pilot adjusts fore and aft spacing so the preceding aircraft's wingspan appears to be the same width as the desired interval mark. As an example, the following index marks correspond to an aircraft with a 33-foot wingspan:

1 ¼ inches = 1000 feet
3 inches = 500 feet
4 ¾ inches = 250 feet

There will be some variation in the dimensions of the index marks depending on seat position and aircraft wingspan. Lead pilots will have to experiment to tailor the exact dimensions to their aircraft.

7.13 Recovery and Landing

Getting the mass formation on the ground is usually viewed as part of the show and, if so, will be carefully choreographed by the MC. Normally, mass formation recoveries will be accomplished by pitchouts to single-ship landings, or by element landings. The greater number of aircraft involved makes it important to keep proper intervals between aircraft. Wake turbulence is also an increased risk.

7.13.1 Pitchout to Landing

There are many variations of the overhead pattern that may be briefed. Spacing between flights and break interval may vary. Pitch-up breaks may be used for visual effect. In all

cases, though, the MC will configure the mass formation in echelon flights, trailing one another, prior to short initial.

Spacing between the flights will depend on the MC's goal. If pitching out and landing in front of the crowd, the spacing between flights can be kept close (as close as 100 feet) to keep the break interval the same between succeeding flights' aircraft. This procedure strings out the pitchouts along the show line for a nice visual effect, but results in later aircraft flying successively longer downwind legs to the perch.

Alternately, a larger interval between echelon flights may be used (up to one mile) to keep the overhead pattern tight. In this case, the lead pilot of succeeding flights will strive to break when the last aircraft of the proceeding flight is at the perch.

The break interval between aircraft should be three to five seconds. As an example, at 140 MPH, this results in 600 to 1000 feet of spacing between aircraft and allows all aircraft to roll off the perch at the same place. Each pilot will strive to fly their pattern the same as the preceding aircraft. Keep in mind that if the break interval is five seconds, all aircraft should be touching down within ten seconds of the preceding aircraft.

Pitch-up breaks add to the visual impact of the recovery and can help aircraft to slow to configuration speed quickly. The MC will adjust the altitude depending on the number of aircraft in the formation, because of the stack down of aircraft. With larger formations a pitch-up break may not be feasible and the break will be performed at pattern altitude.

There are some common errors that tend to string out the pattern that must be avoided. The first error is getting low on downwind and/or at the perch. If a pilot gets low, he/she forces all following aircraft even lower lest they lose sight of the preceding aircraft. It is important to crosscheck altitude on downwind.

The next error is being wide and/or long at the perch. This error can go unnoticed in a four-ship, but is amplified in larger formations, resulting in a wide, extended, distorted pattern. To keep the pattern tight, it is important to roll out on downwind, directly behind the preceding aircraft, at pattern altitude.

Finally, it is also important to fly the briefed traffic pattern airspeed to prevent the "accordion" effect created by mismatched speeds.

If wake turbulence becomes a problem, the pilot will aggressively maneuver out of the wake and adjust the pattern as necessary. In severe cases a breakout and go-around may be necessary.

7.13.2 Element Landings

Element landings can facilitate a quick recovery and may be used by the MC. In this case, the MC will specify how the flights will separate and take spacing. Two-ship, three-ship, and even four-ship "diamond drop" landings may be executed, depending on conditions and pilot experience. Element spacing should be increased to reduce the changes of wake turbulence encounters while in fingertip at approach speeds. Three-ship landings may be performed with sufficient runway width (150 feet, minimum) and favorable winds. Four-ship "diamond drop" landings will only be performed by pilots practiced in this procedure. In the "diamond drop," a four-ship approaches in diamond configuration with the lead pilot planning a long landing. Approaching the threshold, the #4 slot pilot drops out of the diamond and lands first, well short of the remaining three-ship.

7.13.3 Low Pass Prior to Landing

The following techniques can be employed to execute a single-ship pass after the initial break, prior to landing.

1. The MC's three-ship or four-ship can fly a 300 to 500 foot AGL initial. Pitch-up spacing should be two seconds. To execute the pitch-up, pull up, wings level, to your desired pitch angle. Unload to hold this climb angle for two seconds. Briskly roll to 35° to 45° of bank, depending on the crosswinds, and then pull up to downwind at 800 feet AGL. Maintain your power setting. For the pass, roll off the perch abeam the threshold approximately 400 feet behind the preceding aircraft, or as briefed. Fly the low pass and pull up to downwind again as briefed. Landing lights and/or smoke looks good and aids following flights in de-conflicting. Fly this second pitch up to an 800 foot downwind like the first but this time, pull up and use the techniques previously discussed to complete the landing.
2. To provide adequate spacing for the passes, use the following timing: allow one minute of spacing for each aircraft in the flight you are following—three minutes if following a three-ship; four minutes if following a four-ship.
3. All trailing flights should fly their first initial at 1000 feet AGL to pass above preceding aircraft in their final turn for their full stop landing.
4. If the mass formation lands together, it will be necessary to land long to provide spacing for subsequent, landing aircraft—pick an aim point at an appropriate spot on the runway and fly a normal pattern as if the threshold were located at that aim point.
5. If the aircraft ahead of you doesn't land long enough and forces you down early, you have two choices—you can keep your taxi speed up or keep power on and fly a few feet above the runway at just above touchdown airspeed (termed "hover taxi"). Reduce power and land as necessary.

6. Taildraggers (TDs) can be mixed anywhere within the formation. Some TDs can easily hover-taxi to minimize time on the runway. Since they can't see over the nose once the tail comes down, expect them to maintain their side of the runway until turning off. If they do cross to the cold side (the exit side of the runway), expect them to S-turn taxi, if necessary, to clear in front prior to exiting the runway.

7.13.4 Runway Turnoff

Normal runway turnoff procedures will be used. If the runway length and location of exits permits a safe turnoff, the MC may brief an exit prior to the end of the runway. The MC will normally stop well clear of the runway to allow all aircraft to land and exit, prior to performing a mass taxi-in.

7.14 Post-Flight Ground Ops

Standard procedures will be used. The MC will brief whether all aircraft in the flight will shut down together or individually.

Debriefings and ground servicing may need to be deferred to a later time if the group is expected for autograph signing or other show-related duties. Use care to secure all aircraft properly prior to leaving the area.

7.15 Contingencies

The mission should be flown as briefed, of course, but that is not always the case. Events can occur at the airshow that may alter the original plan. In the Mission Briefing, the MC will brief some of the possible contingencies, such as changes brought about by one or more aircraft dropping out prior to takeoff or after airborne. The MC should also be prepared to divert the entire mass formation to an alternate airport should the airshow airport close down. The MC has to have the ability to completely disassemble the mass formation to the point of performing single-ship landings, if necessary.

It is impossible to plan for every possibility so some flexibility is required if an alternate plan must be executed. In all cases, safety will dictate the plausibility of any alternative plan.

One approach is to brief a "fall back" plan where any individual flight that experiences the loss of an aircraft (or more than one aircraft), simply falls back to the end of the mass formation. If the MC has to abort, the MC's flight can fall back in trail behind the mass formation. The Deputy Mission Commander would then assume responsibility for the mass formation. This technique simplifies the reorganization and transfer of command of the mass formation.

7.16 Emergencies

A catastrophic emergency while in the midst of a dozen aircraft presents a very unique situation. Each pilot's actions will vary depending on the conditions—situational awareness and an effective plan of action will determine the outcome. The variables that will have to be considered in the decision making process will include, but are not limited to: the nature of the emergency, position within the formation, energy state, position relative to the airfield, position relative to spectators, and altitude.

In some situations it may be prudent to pull up and away from the formation, in others it may be better to push down, and in still others it may be best to simply hold position for as long as possible. Remember, as the dynamics of the variables change, you will have to adjust your game plan.

The MC will brief whether or not emergency aircraft leaving the mass formation will have a chase plane. That decision will, in part, be predicated on where the emergency occurs. If in a holding pattern away from the airfield, for instance, a chase plane could aid the emergency aircraft in a recovery to an alternate field. If directly over the airshow airfield, the emergency aircraft could recover without a chase. If a chase aircraft is briefed, in the MC's and DMC's flights, they will designate either #3 or #4 to accompany #2, should #2 have a problem—this allows the MC and DMC to remain with the mass formation.

NOTE

The T-34 Association has done extensive experimentation with simulated engine failures in mass formation. They have found that it is best for an aircraft in the middle of a mass formation to pull up out of the formation and acquire best glide speed. The following, stacked-down aircraft were able to fly out from under the distressed aircraft before it began its descending glide. Pilots for each aircraft type should determine what procedure works best for them based on aircraft performance, glide speed and drag index.

The emergency procedures that we normally brief will be used. Some malfunctions, such as an airborne radio failure need not interfere with the completion of the mass formation. More serious emergency situations require timely resolution. As an example, if an aircraft within a formation experiences a partial power loss, that aircraft's element (if chase is appropriate) will separate from the mass formation to deal with the emergency. The distressed pilot will declare an emergency on the Airboss frequency. The Airboss will coordinate the emergency recovery to the airfield. The MC will determine if it is prudent and possible to safely adapt to a new plan. It may be necessary to direct the mass formation to one of the alternate airfields or to a holding pattern pending recovery.

7.17 Emergency Scenarios

The most serious emergency for the individual pilot and the

mass formation would be some type of catastrophic engine failure. Listed below are some suggestions for dealing with various situations.

7.17.1 Emergency Aircraft

The initial indications of serious engine failure could include unusual sounds (or no sound—that's a dead giveaway), vibration, fire, and the inability to maintain power. It is important to note that it is incumbent on each pilot, as pilot in command, to monitor fuel and engine instruments whenever it is safe to do so. Loss of oil pressure or high temperatures could be a harbinger of pending power loss or engine failure.

If a sudden power loss occurs, continue to fly the aircraft. If possible, make a radio call to alert the airboss and warn other aircraft. Smoothly maneuver the aircraft clear of the mass formation. Control movements to climb, descend and/or turn should be smooth, not abrupt. If you are in the lead or middle of a formation, abrupt movements could cause a massive formation disruption or a mid-air collision.

In our mass formations we are generally at a relatively medium energy state; if unable to maintain position, usually the best place to go is up. You may only need to climb 20 to 50 feet to clear aircraft in your flight and the next trailing flight since they are all stacked below you. If you are toward the front of the formation, don't delay climbing—the sooner you clear the mass formation, near the mass formation's speed, the smaller your effect on trailing flights. If you are on the outside of the mass formation, turn away enough to clear the formation. Turn only if on the outside of the formation.

Keep in mind that an abrupt pull-up that "loads" up the wing will result in a rapid speed reduction, bleeding off energy unnecessarily.

Once clear of the mass formation, achieve best glide speed, point toward an emergency field, and perform your emergency procedures.

When able, declare an emergency and inform the MC and airboss of your problem and intentions (this would be accomplished simultaneously with a radio call on the airboss frequency). The MC may coordinate a chase ship if there is not one already assigned to you. The airboss will coordinate ground assistance and your recovery to the airport.

For non-catastrophic emergencies that require an air abort, maintain position and inform the MC of your problem and intentions (on the internal/tactical frequency). The MC will inform the airboss and may coordinate a chase ship. When directed, follow instructions from the MC or airboss to clear the formation, hold until airshow completion, or recover as directed. You may be given a discrete frequency to use to work through your problem with your chase pilot.

7.17.2 Mass Formation Aircraft

If possible, maintain formation position, heading, and altitude to allow the emergency aircraft to clear the formation. Unnecessary maneuvering dramatically drives up the possibility of a mid-air collision. However, if necessary to maneuver to avoid a collision, climbing will provide the fastest separation in most cases. If you do climb, you may only need to climb 20 to 50 feet to clear a descending aircraft. If unable to maintain a visual on your leader, use standard breakout procedures to clear the mass formation, reacquire visual contact, and rejoin when granted permission by the MC.

If the emergency aircraft descends directly in front of you, and a collision is possible, descend as necessary to keep the emergency aircraft in sight. As soon as you are clear of the formation and can turn laterally to avoid the emergency aircraft and other formation aircraft, SMOOTHLY do so. Remember, there may be other formation aircraft below and in trail with you. Rapid, abrupt maneuvering dramatically drives up the possibility of a mid-air collision.

Pilots will use Mission Commander briefing directives to determine who will chase the emergency aircraft.

7.18 Mass Formation Training

The MC has to have a complete understanding of what he/she can do with the mass formation. No matter how large the formation, the MC must be capable of assembling and disassembling the entire mass. Practicing this is necessary in preparation for any contingency and it builds confidence in each participant.

Whenever possible, practice over an airfield. This will give MCs the ability to practice timed arrivals at show center, dog-bone turns at each end of the runway, and experience in turning large formations and reconfiguring them prior to arrival over the runway. It will also give wing pilots a chance to practice cross-unders in a turn—something they don't do on a regular basis. Practicing over an airfield also allows a ground spotter to critique the formation from a crowd perspective.

In ALL of our formation training, flight leads MUST hold all flight members to the highest performance standards. If all pilots know and fly the standard formation positions all the time, then putting a mass formation together is nothing more than positioning three-ship and four-ship formations together. All pilots must resist the urge to fly too tight. It only takes one flight flying too tight to degrade the symmetry of a mass formation.

An airborne spotter can provide additional feedback for making corrections to the symmetry of the flight. The best technique is to have a "back seater" in the spotter aircraft so that the spotter pilot can concentrate on clearing and flying while the spotter provides feedback. Low-wing, spotter aircraft can gain the best perspective by flying below the mass

formation, moving with the formation. With obstructions and terrain in mind, brief a hard deck for the spotter aircraft if it is going to be positioned below the mass formation. High-wing, spotter aircraft may have a better perspective when flying above the mass formation. An airborne spotter can be used in the airshow but must be positioned two to three thousand feet above the mass formation. The spotter needs to be aware of all the other participants in the airshow so as not to conflict with their patterns. Single (or stinger) aircraft near the mass formation look out of place, destroy formation symmetry, and distract the crowd.

Listed below are some MC techniques all flight members will benefit from knowing.

1. For column formations, use bank angles up to 45°.
2. For echelon formations with more than two aircraft on either side of the MC, use bank angles of 30° or less.
3. The race-track pattern over the show line is the easiest to fly but it significantly reduces the time over the crowd.
4. The dog-bone pattern is more difficult to fly but it maximizes the time over the crowd. The initial dog-bone turn direction will be determined by traffic, airspace, wind, and/or FAA/airshow directives.
5. The fastest dog-bone turn back to the show line starts with a 90° turn left or right. Roll out for X number of seconds as needed for wind correction. Then turn 270° right or left to line up on the show line for the next pass.
6. To change to a new formation, use a 90° left or right turn: Roll out for wind correction as described above. Turn 90° right or left and roll out. Direct the formation change then turn 180° left or right to line up on the show line for the next pass. Formation changes can also be accomplished on the inbound leg as long as some time is built into the outbound leg after the second 90° turn described above.

7.19 Mass Formation Configurations

There are an infinite number of ways to "build" a mass formation—you are only limited by your imagination and the capabilities of the aircraft and pilots involved. Some sample formations are depicted on the following pages. The majority are depicted as one flight—multiple flights can be formed into groups in the same mass formation or a mix of any depicted formations can be used.

In many formations, the individual three- and four-ships are separated by one to two ship's length/width. This makes it easier to fly because bobble is dampened by the additional separation. Also, spotter observation confirms it to be a very good-looking formation.

These formations are adaptable to a mix of three- and four-ships as well as all three-ships or all four-ships. They can also have additional flights added to them.

Generally speaking, it makes the mass formation building process easier when four-ship flights are utilized instead of flights of lesser numbers. Utilizing three four-ships verses four three-ships, for example, would reduce the number of maneuvering flights as well as the number of lead pilots with which to communicate and coordinate.

Safety of flight must never be compromised in an attempt to achieve symmetry or to expedite maneuvers. The mass formation configurations should be designed with the following considerations in mind:

- Emergency disengagement of any single aircraft
- Ease of assembly and split up
- Ease of morphing from one configuration to another configuration
- Ability to turn within the airshow airspace

Smaller configurations involving two to three flights are capable of being morphed into a variety of configurations. The MC has a lot of flexibility in designing configurations that can be quickly reconfigured from one configuration to another.

Medium-sized formations of four to five flights present increasing logistical challenges—changing from one configuration to another becomes more difficult and more airspace is required to accomplish the change.

Giant configurations of six or more flights ratchet up the complexity to a whole new level. Situational awareness becomes paramount. Properly executed, a giant formation is a thing of beauty; photographed and remembered for years. The 1995, 50th anniversary, World War II commemoration, using a 50-ship, T-6 formation at EAA AirVenture at Oshkosh was a perfect example.

With each increase in the level of complexity comes a commensurate increase in the sophistication of planning required to safely and successfully execute the mass formation. The 1995 T-6 formation required months of planning and days of practice prior to successful execution.

Figure 7.1 Fingertip Trail

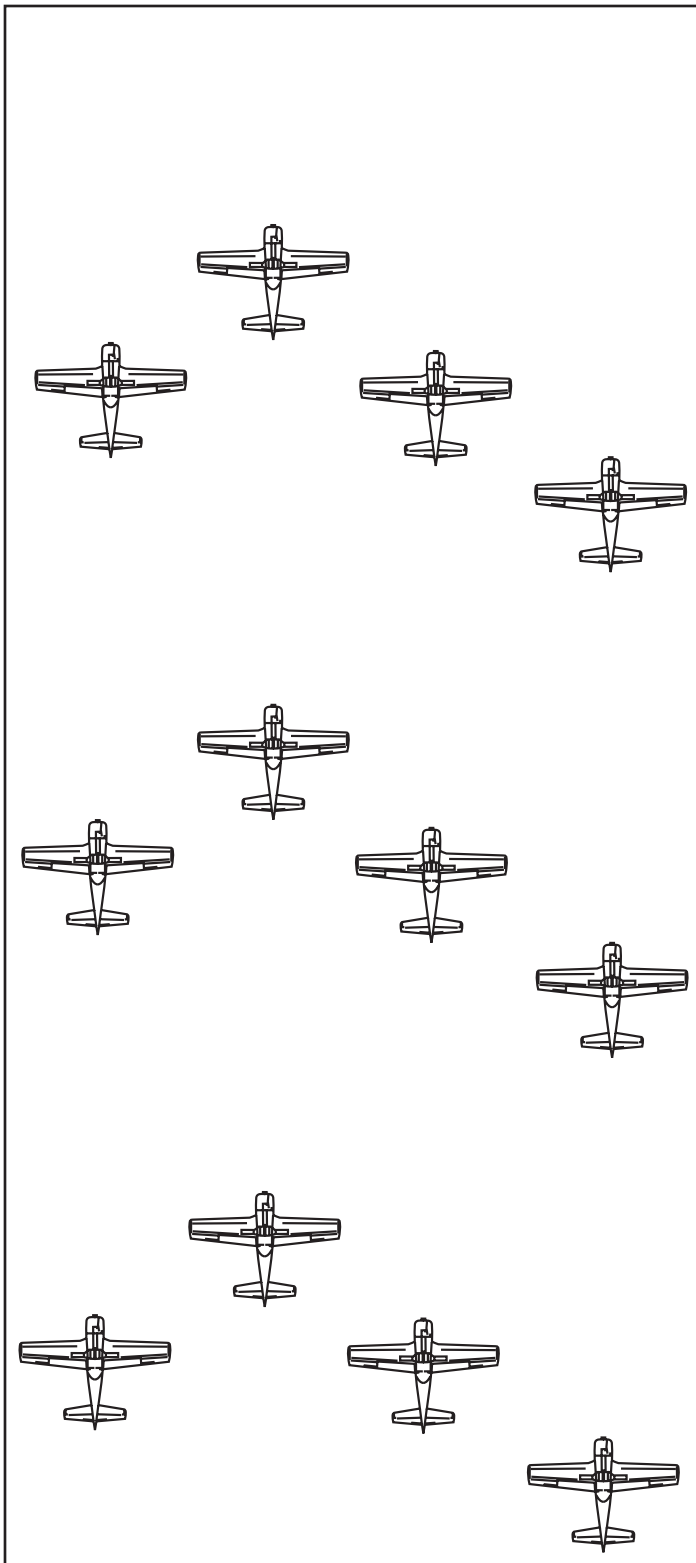


Figure 7.2 Diamond Trail

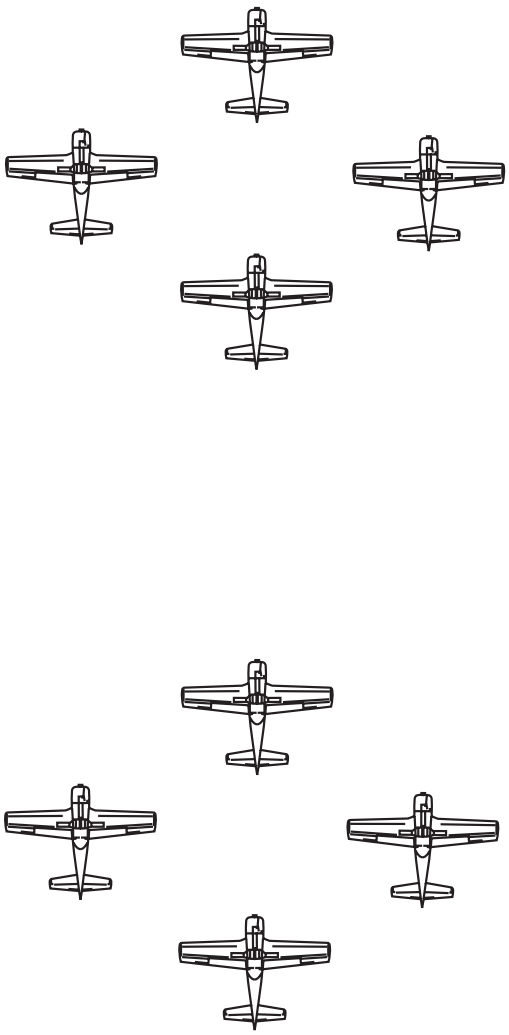


Figure 7.3 Double Diamond

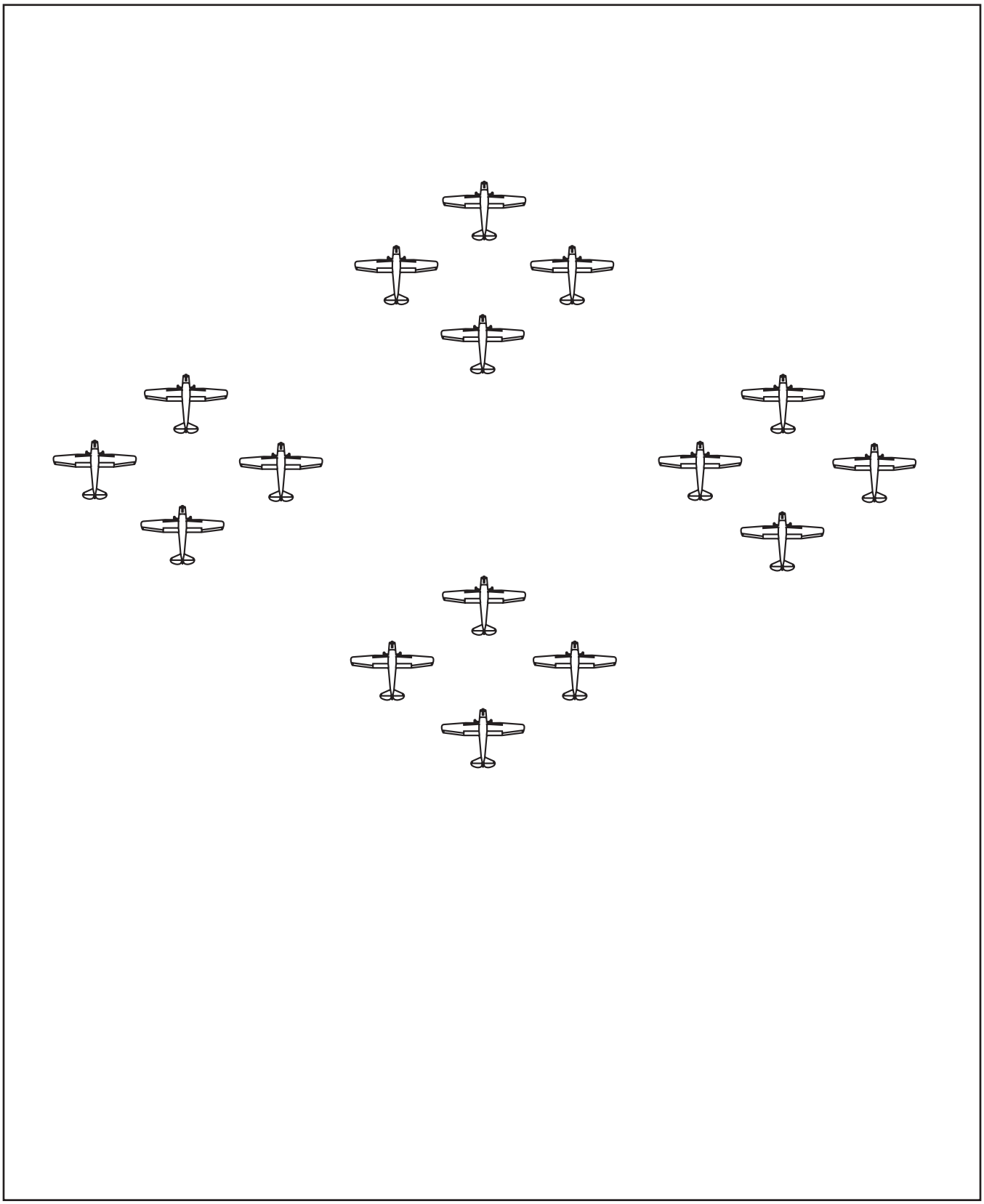


Figure 7.4 Diamond Vic

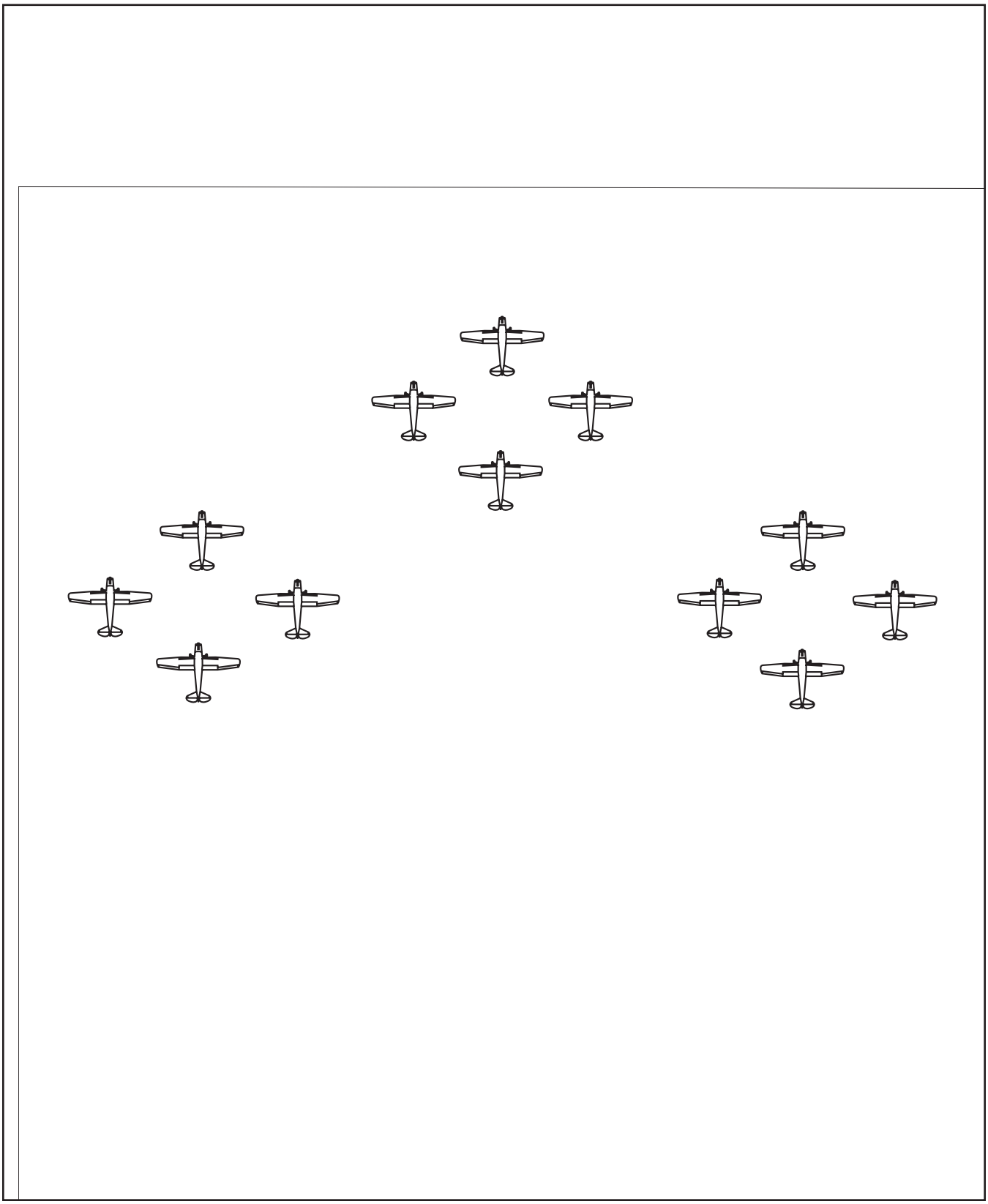


Figure 7.5 Dog Paw

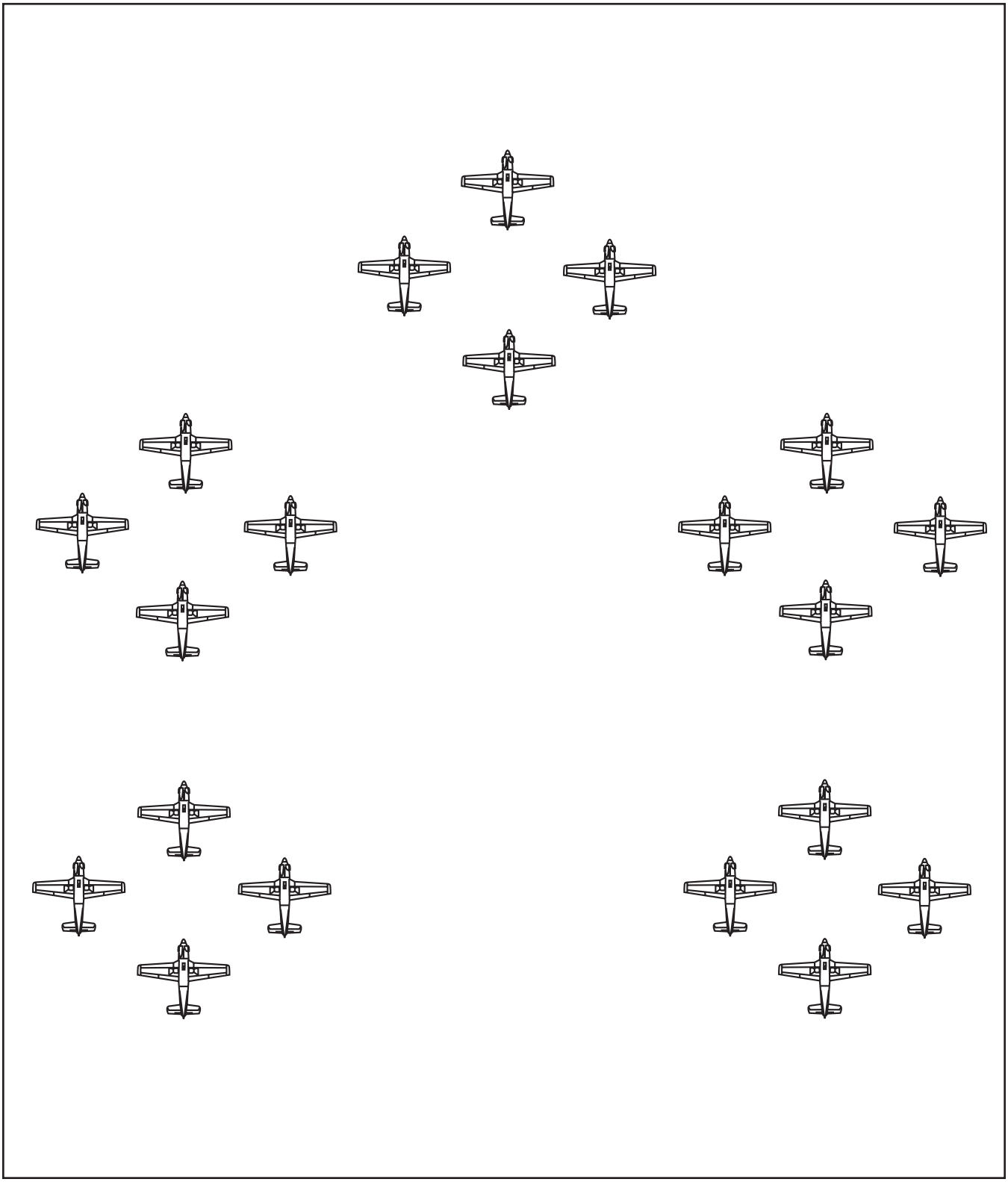


Figure 7.6 Arrow

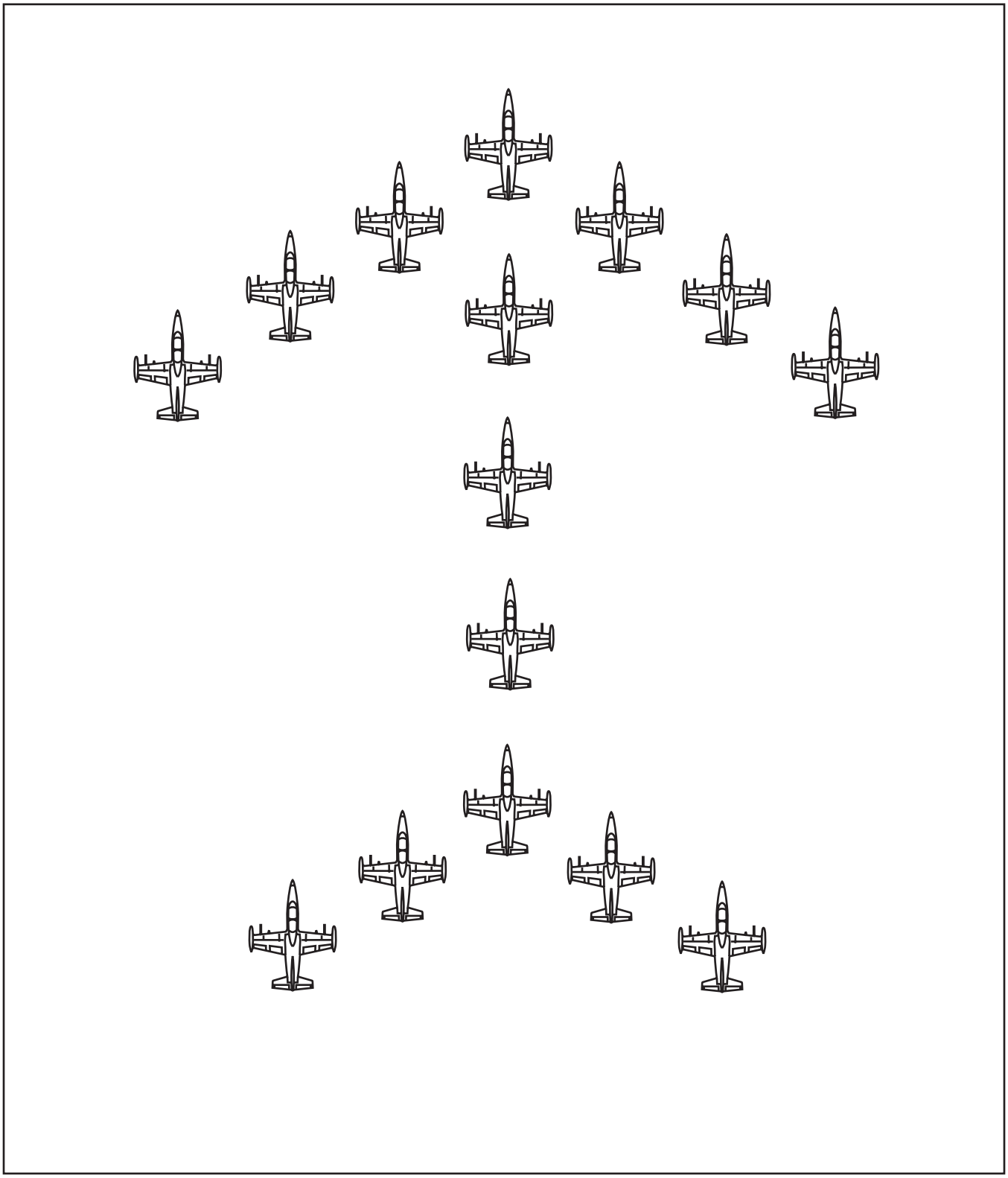


Figure 7.7 Christmas Tree

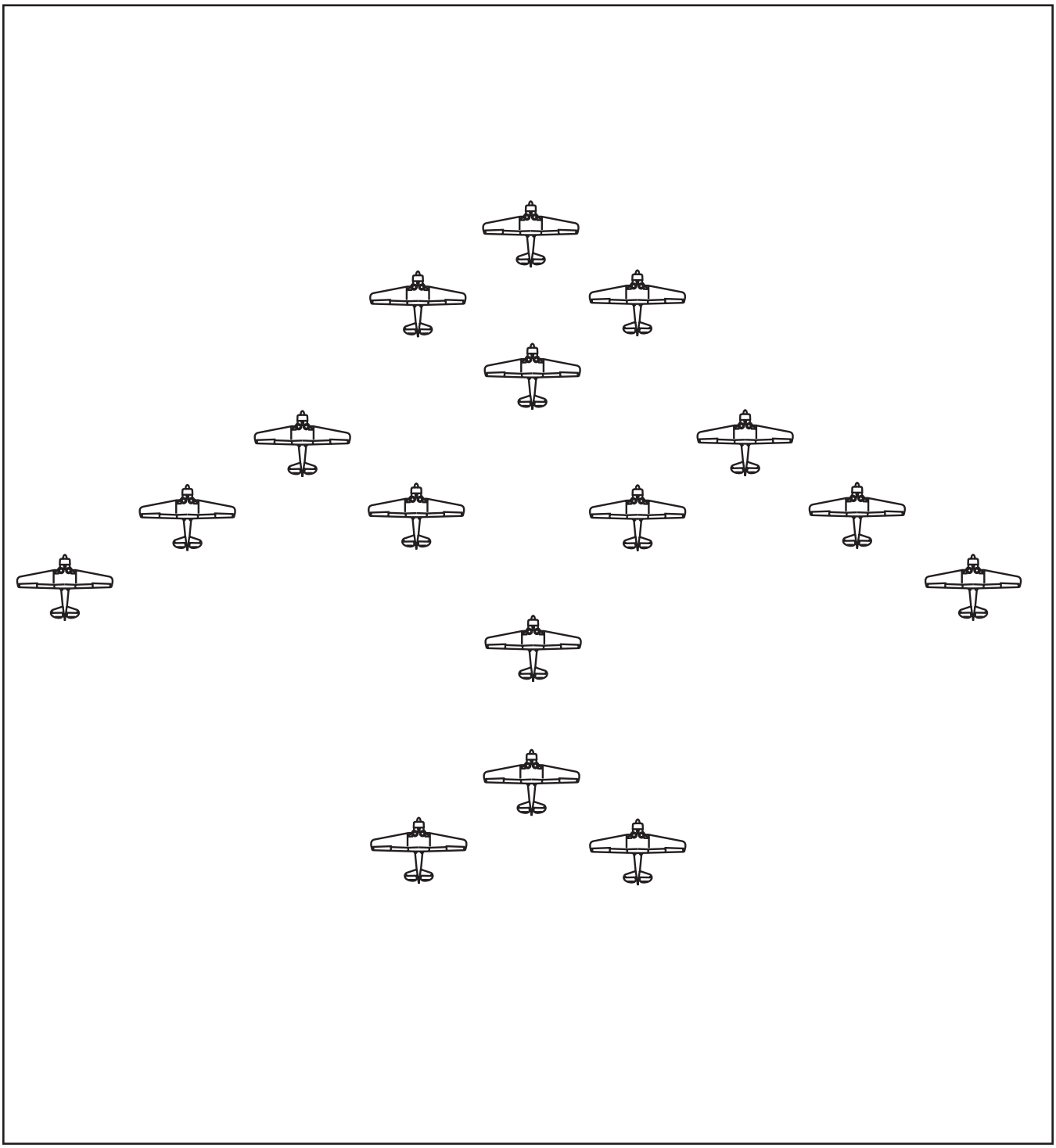
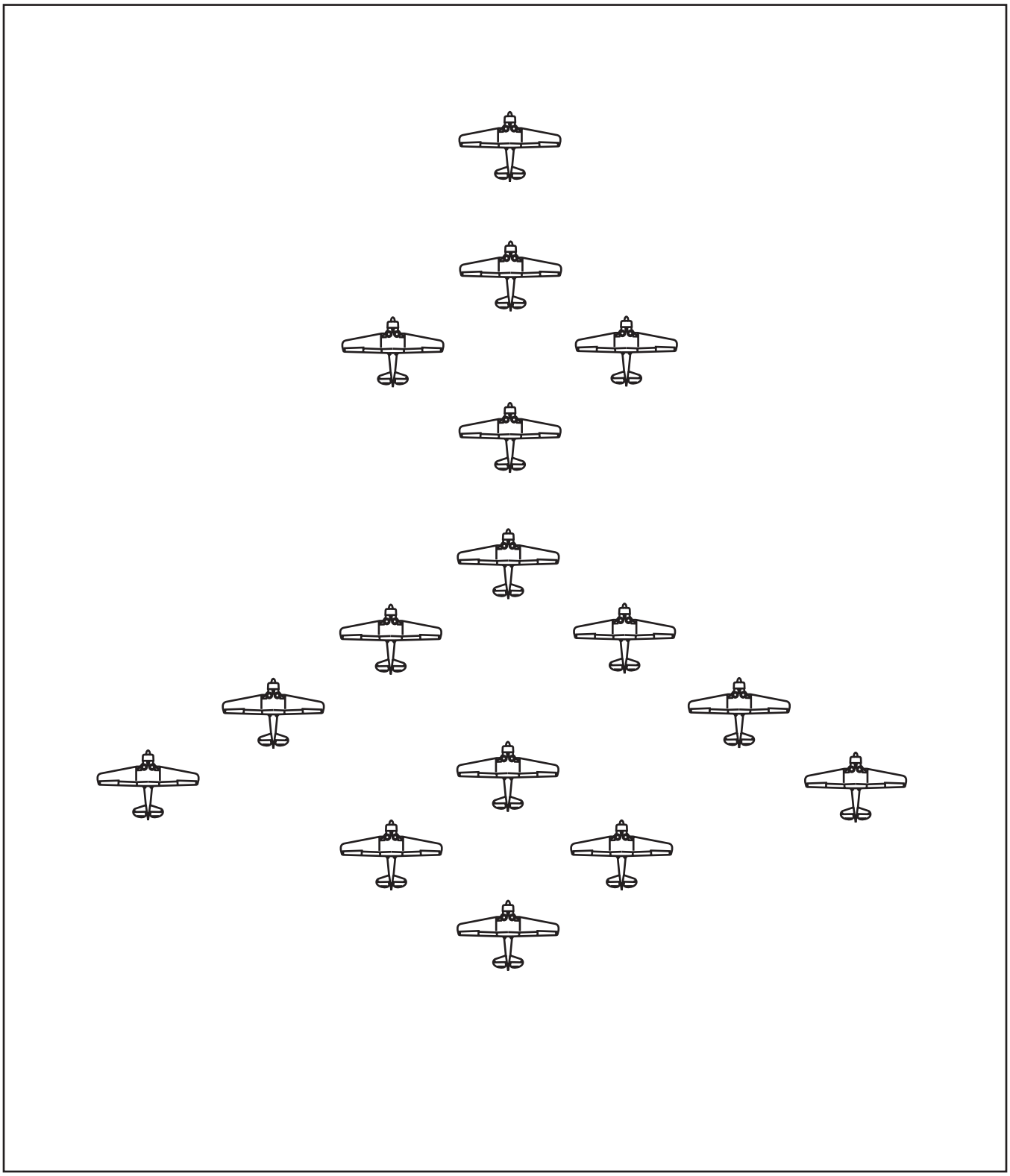


Figure 7.8 Starship



CHAPTER EIGHT
Ceremonial Formation Flights

8.1 Introduction

Participating in a formal ceremonial formation flight, specifically the missing man formation, is an honor and a privilege which should be held in the highest regard by pilots and crew. The first ceremonial fly-bys are reported to have taken place during WWI. Major General Oscar Westover, head of the U.S. Army Air Corps may have been honored with the first "Memorial Formation" fly-by in September of 1938 during his burial at Arlington National Cemetery. The "Missing Man Formation" as we know it today probably had its beginning during the Korean War in the early 1950s when Air Force General Hoyt Vandenberg was buried at Arlington. General Vandenberg received "a fly-over of jet aircraft with one plane conspicuously missing from the formation" in lieu of the normal horse-drawn artillery caisson. (Flying Tigers: www.warbirdforum.com/missing2.htm).

Ceremonial formation flights can be classified into three major categories based upon the tribute being paid and the number of aircraft configured for the flight.

8.2 Categories

8.2.1 Category One

Missing Man Formation

- Funerals and memorial events
- Number three pulls to a create gap

8.2.2 Category Two

Missing Man Formation

- Funerals and memorial events
- Pre-configuration with a gap

8.2.3 Category Three

Ceremonial Formation Flight

- Sporting events, dedications & parades
- No missing man or gap

8.3 Definition and Use

8.3.1 Category One and Two

The most revered of the ceremonial flights, these are the Missing Man Formations. These flights are solemn procedures, typically a funeral or memorial parade event, requiring the highest level of professionalism and reverence. Study why you are honoring the deceased or the event. Always wear your flight uniform and fly, look and sound your best. You are representing yourself, your organization and all of your fellow pilots.

Maintain the high honor of Category One and Two flights by using them only for those who have participated in the defense or service of our country or in the aviation community, either military or civilian. The aviation community consists not only of pilots, but of all the people who either support aircraft, such as mechanics, and avionics technicians, and/or work with the flight crew, such as aviation medical and rescue personnel. (Used as partial reference: AFI 11-209 04052006 Aerial Event Policy and Procedures 3.6.2.3 & 4)

8.3.2 Category Three

This formation flight is flown for all other non-memorial ceremonies. These flights are often used for sporting events, grand openings and dedications and are generally less solemn by their nature. The same professionalism noted above applies here also. For flights that do not meet the criteria for Category One or Two, use Category Three.

8.4 Detailed Guidelines

8.4.1 Category One: #3 Pulls To Create a Gap

1. Verify the exact ceremony location. If possible, place coordinates into a GPS. Calculate your holding area based upon three minutes to the target.
2. Research airspace restrictions, if any, in the entire flight area, including the flight holding area near the target.
3. Verify all altitude, airspace and FARs that may affect the flight and plan for compliance. The best altitude, subject to the above, should be 800 AGL unless the FARs would require a higher altitude.
4. Consider giving advance notice of the flight, time and flight path to affected airspace controllers to allow them to accommodate your mission. A call to the local police authority is often appreciated and allows everyone the opportunity to explain away possible citizen noise complaints.
5. Make arrangements to have a ground control person with an aviation transceiver tuned to the flight's discrete frequency to provide Lead with precise target timing.
6. Brief the ground controller on proper use of the ra-

dio. Also, as the flight is approaching the target, the ground controller can suggest to Lead slight heading adjustments to place the flight precisely over the target and to inform Lead when the flight is overhead.

7. All members of Flight must be formation rated.
8. The flight must always be fully briefed.
9. This flight works best with four aircraft flown in fingertip right or left. However, it can be flown with more than four aircraft in formation. It is always recommended that #3 be the missing man.
10. Prior to departure, call the ground controller and verify the time line.
11. While enroute to holding area, communicate with the ground controller to verify communications and obtain an updated time line.
12. Arrive at the briefed holding area with enough time to establish ground references, holding pattern, and calculated time to target. You can make your timing calculations easier by flying airspeeds that can be divided by 60 (120 mph / 60 = two minutes). Get several updates from the ground controller, and use computed ground speed and distance to target to compute minutes and seconds to the target. Establish your final holding pattern circuit to compensate for exact arrival time over target.
13. When airspace and obstacle clearance allow, position the flight to arrive over the memorial on a heading that allows #3 to pull up to clear the flight and make a right turn to the west (this is preferred but not mandatory).
14. Just prior to the arrival at target, Lead, while keeping in mind #3's flight path during the pull up and separation, will scan the area for any air traffic or obstacles which may create a hazard.
15. At the target site, Lead will do final obstruction scans and clear #3 for the departure procedure stating: "*#3 your current heading is ____. The traffic is clear...On my command, pull up and turn right… PULL UP….. **NOW**."* Number three performs a smooth but deliberate straight pull up climb for 200' then a gradual climbing turn until out of visual range of target. If #3 has smoke, Lead has the option to call smoke on just prior to clearing #3 from the flight. Only #3 should smoke. "*SMOKE ON...PULL UP….**NOW**."*
16. After #3 has cleared the flight, the remaining flight will continue level in formation, maintaining the gap created by #3's departure until out of view of the memorial. While approaching and departing the target area, Lead should maintain constant cruise power settings to keep a steady, even engine sound. Only #3, if necessary, should add power over the target area (this is to maintain the solemnity of the event).
17. As previously briefed, proceed back to base as a three-ship or, when in visual contact, Lead can clear #3 to rejoin the flight.

8.4.2 Category Two: Configured with a Pre-Established Gap

This formation is flown the same as Category One, except there is no #3, and hence no "pull." Just prior to leaving the holding area, Lead will configure the flight with a gap in #3's position. The flight will maintain this gap until passing over the target and out of visual range. Category Two works well if you only have three aircraft available for the flight. However, you can use Category Two with three or more aircraft.

8.4.3 Category Three: Ceremonial Flights

This formation is flown the same as Category One and Category Two, except there is no missing man. The flight will ***not*** be flown with a gap or pull up for the missing man. One or more aircraft can be used. This is considered a fly-by or fly-past.