

REDSTAR FORMATION



FUNDAMENTAL CONCEPTS Ver 4.3

INTRODUCTION

The RedStar Pilots Association (RPA) was originally founded as the Yak Pilots Association (YPA) in 1997. The YPA was the first Formation And Safety Team (FAST) signatory organization to create and implement a signatory-specific formation manual. Since then, the YPA/RPA has continued to revise and improve the quality of its training materials. This formation manual is the RedStar Pilots Association's latest iteration and incorporates the basic teachings of the Formation and Safety Team (FAST).

This manual contains all the formation fundamentals including:

- Wingman procedures and techniques
- Operating procedures
- Contingency procedures
- Comm procedures and techniques, hand signals, and aircraft signals

NOMENCLATURE

Several conventions have been used throughout this manual. The terms he, him, his, and himself are used in a generic sense and apply to all individuals, male or female, without bias or prejudice.

The terms Lead, leader, flight leader, #1, and lead pilot are used interchangeably—all these terms refer to the same individual—the pilot in command responsible for leading an individual formation.

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PREFACE

Formation flight dates back to World War I when the military began flying in formation as a means to provide mutual support in the skies over battlefields. The military continued to develop and refine formation concepts over the years and employs these concepts, in all the militaries of the world, to this day.

The principles presented in this comprehensive formation manual are derived from these same military concepts and have been adapted to the meet the needs of the civilian aviation community.

The formation concepts presented in this manual are applicable whether you are interested in flying with like-minded pilots in the local area or you want to fly in the waived airspace typically delineated at airshow venues. Regardless of your motivation, the following priorities apply:

First—Proficiency/safety

Second—Mutual support

Third—Symmetry/aerial display

STUDENTS

Formation flying is a particularly demanding skill set. You will be flying in close proximity to other aircraft, so an error can ripple through the formation, causing harm

to other pilots. The formation student needs to approach training well prepared, both mentally and physically.

Being prepared mentally encompasses knowledge of:

- Aircraft systems
- Aircraft procedures
- Your organization's standard operating procedures
- Formation signals (hand, aircraft and radio calls)
- Formation protocols, detailed in this manual

Being prepared physically means you are:

- Physically fit for flight
- Hydrated
- Rested

WINGMAN RESPONSIBILITIES

Being a good wingman means more than just hanging on Lead's wing. The wingman is part of a disciplined team, and with that comes additional responsibilities:

- Provide mutual support
- Maintain formation integrity
- Assist in mission planning, if requested
- Keep Lead in sight at all times

- Be aware of departure, enroute and arrival routing so he can assume the lead, if required
- Monitor Lead for proper configuration and abnormal conditions
- Assist during abnormals or emergencies, as directed
- Monitor radio communication
- Trust and follow Lead's direction

SAFETY EQUIPMENT

The following is a list of equipment for formation flight. Though not all items are required, the recommended equipment adds an additional layer of safety to your operation and could save your life one day.

Recommended:

- Nomex or other fire-retardant flight suit and gloves
- Parachute
- Helmet

Required (with IP on board):

- Intercom system
- Ability for instructor to transmit/receive on radio

DEMO-DO

The onboard instructor will utilize the “demo-do” process—each task will be demonstrated and explained to the student, followed by repeated practice by the student, with the instructor providing constructive feedback and guidance.

PILOT IN COMMAND

The formation student pilot is the legal pilot in command and is ultimately held responsible for the condition of the aircraft and its safe operation. It may be in the best interest of all parties to execute a hold-harmless agreement to establish a no-liability relationship between the instructor and student prior to beginning flight instruction.

TRANSFER OF AIRCRAFT CONTROL

In the course of formation training, particularly in tandem-seat aircraft where the pilots cannot see one another's controls, it is imperative that positive control of the aircraft be maintained at all times.

Transfer of aircraft control, back and forth between instructor and student, must be performed in a positive, confirming manner. “The shaker is the taker” is a common, confirming technique. When aircraft control is passed from one pilot to the other, the surrendering pilot will state, over the intercom:

“You have the aircraft.”

The accepting pilot will shake the control stick or yoke and state:

“I have the aircraft.”

From this point on, the accepting pilot has full control of the aircraft.

Especially in the formation training environment, there is always the potential for a situation to deteriorate rapidly. If this should happen and the instructor recognizes the need to immediately take command of the aircraft to prevent a mid-air collision, “the shaker is the taker” protocol does not apply. The instructor will announce, in a forceful manner, “*I have the aircraft*” and the student will **immediately** surrender control of the aircraft.

FLIGHT LEADER RESPONSIBILITIES

Assuming the role of flight leader is a huge undertaking. In addition to being able to fly smoothly, providing a stable platform for the wingmen, Lead must monitor the wingmen, monitor the flight environment, and plan well ahead of the formation. The flight leader's responsibilities also include, but are not limited to:

- Safe conduct of flight
- Selection of wingmen
- Verification of pilots' credentials, currency and competency in type
- Mission planning
- Briefing the mission
- Debriefing the mission
- Training new formation pilots
- Endorsing Formation Proficiency Reports (FPR)
- Recommending pilots for Wing and Lead check rides

SITUATIONAL AWARENESS

Discipline and situational awareness are part and parcel to every pilot's modus operandi, but formation flight requires taking these to a higher level.

The academic definition of situational awareness is:

The continuous observation of current conditions and, along with the integration of previous knowledge, the ability to quickly form a coherent mental picture to anticipate future needs and direct future actions.

Or, in more prosaic language, “*Don't let your aircraft occupy space where your brain has not already been.*”

It is absolutely critical that every formation pilot has his “head in the game” at all times. There is little room for error and errors can propagate quickly throughout a flight of aircraft in formation.

HOW TO USE THIS MANUAL

This manual provides a comprehensive, in-depth study of fundamental formation concepts and theory.

STUDENTS

The student should begin by studying the Preface, Chapters 1 through 9, and Appendix A. This will provide the student with a solid, basic understanding of formation structure and protocols. Once the student has completed this “academic” portion of training, he should coordinate

with a qualified formation flight instructor to begin the flying portion of training.

For the flight phase of training, the student should seek to first become proficient in 2-ship formation. Once 2-ship has been mastered, the student will progress to 4-ship formation.

FLIGHT LEADERS

Flight leaders must have a thorough knowledge of the Preface, Chapters 1 through 9, and Appendix A.

There are two levels of formation flight instruction. The first level of instruction is that provided by the flight leader during the post-flight debrief. The flight leader must possess the wherewithal to critique the flight in such a manner that the what, why, how aspects of the flight are thoroughly addressed. “What” means what happened in the course of each task—this requires keen observational skill. “Why” means why was the task not performed to standard—this requires keen diagnostic skills. “How” means how do you correct the observed task to standard—this requires a deep understanding of the mechanics of the maneuver and brings into play observational, diagnostic and analytical skills to meaningfully present a solution.

FLIGHT INSTRUCTORS

The second level of instruction is that provided by an on-board flight instructor. This instructor must be capable of demonstrating and teaching all the formation tasks from takeoff to landing. In addition, this instructor must possess the wisdom and experience to recognize when it is necessary to take the aircraft from the student in order to prevent an incident or accident.

To that end, the on-board flight instructor should have thorough, in-depth knowledge of this entire manual.

WARNINGS, CAUTIONS AND NOTES

Throughout the manual, there are Warnings, Cautions, and Notes. These are defined and indicated in the manner designated.

WARNING

Warnings signify situations where injury or death may result

CAUTION

Cautions signify situations where aircraft or property damage may result

NOTE

Notes provide additional information useful to the understanding of the material



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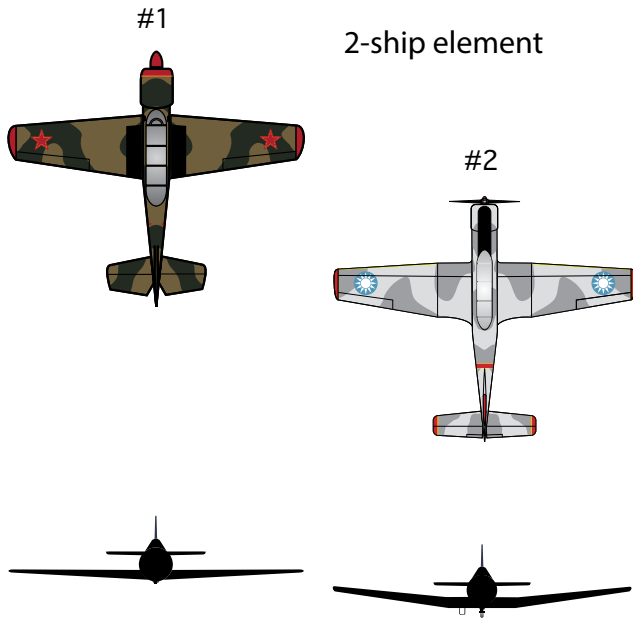
Acknowledgement:

The photographs used throughout this manual are the work of Robert Genat, a professional photographer and writer who for more than 30 years has brought his superb creative skills to bear in capturing stunning images in the realm of the automotive and aviation industries.



CHAPTER 1

FLIGHT ORGANIZATION



2-ship element

of two elements, a flight of six is made up of three elements, and so on.

In a flight of four aircraft, the aircraft positions are numbered #1 (flight leader), #2, #3, and #4. There will be two elements and therefore two element leaders. One element leader is designated as the flight leader (#1), and the other will fly the #3 position and act as deputy lead. The wing pilots will be in the #2 and #4 positions. The two elements will maintain integrity within the 4-ship flight. That means #2 will fly off #1 and #4 will fly off #3, moving with #3 whenever #3 changes position or separates from the flight.

Within a 4-ship, #1 will usually be the most experienced pilot of the group. Number 3 (deputy lead) will be the next most experienced, and preferably a lead qualified pilot. The #2 and #4 wing pilots will typically be the junior flight members.

CAUTION

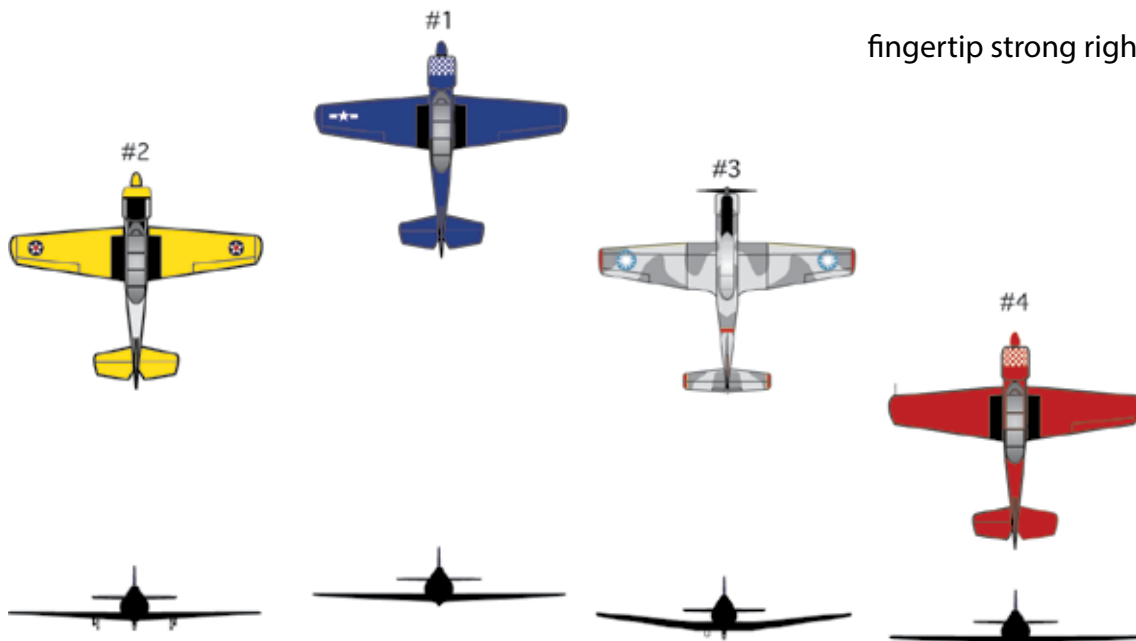
Never put a non-formation qualified or inexperienced pilot in the lead position of a formation.

TERMINOLOGY

First, we need to define some of the basic terms we use. 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 flight leader and a wingman. All flights are made up of elements. There are never more than two aircraft in an element. For instance, a flight of four aircraft is made up

FORMATION CONFIGURATIONS

There are numerous ways to arrange formations, some becoming very elaborate. A formation may fly in different configurations at different times during a flight. The basic formation configurations are fingertip, echelon, and trail. Most other configurations are variations of these.



fingertip strong right

FINGERTIP

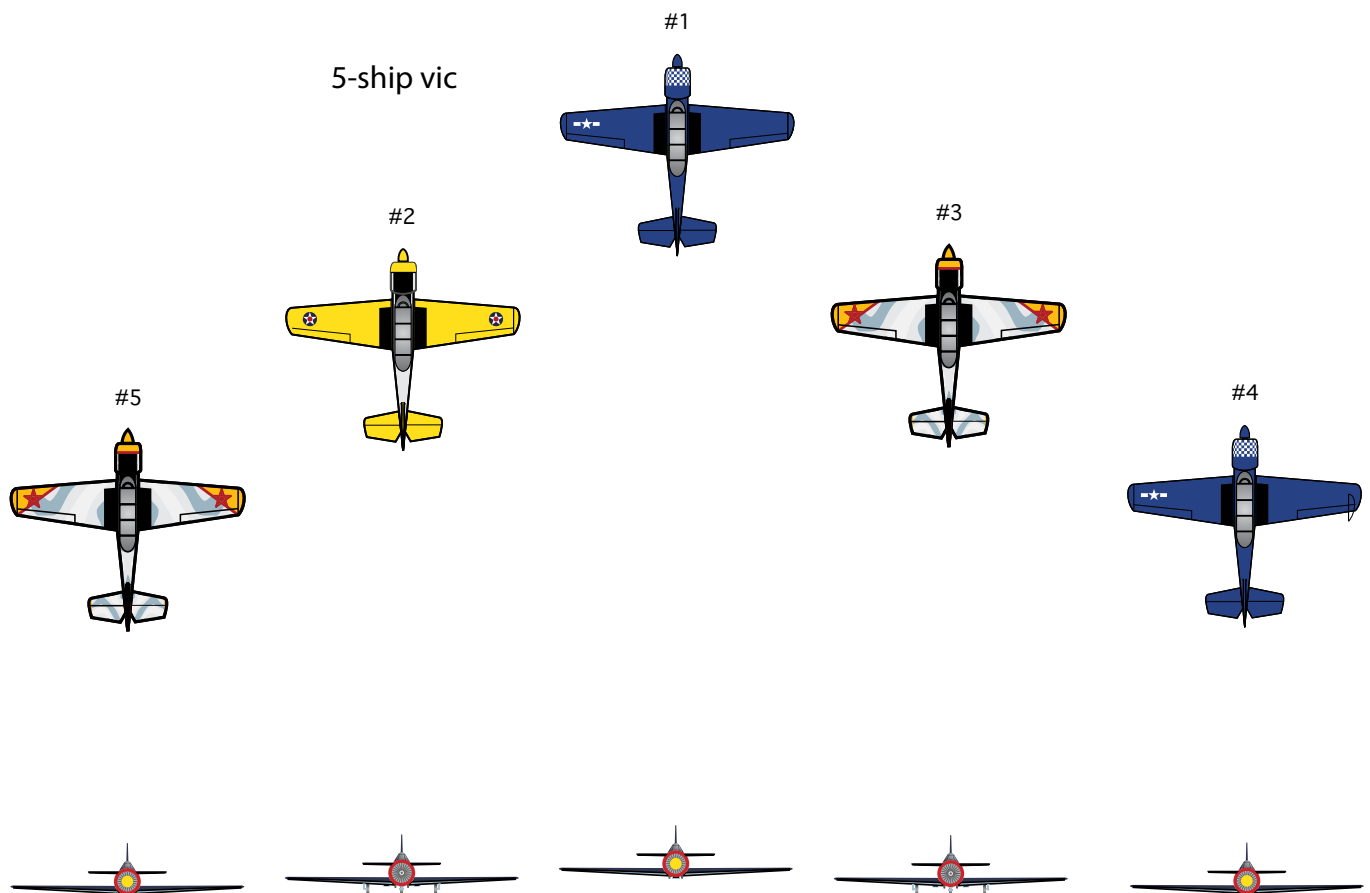
Fingertip is the standard flight configuration. It is so named because a 4-ship formation resembles the fingertips of your hand when viewed from above. “Fingertip strong left” resembles your left hand; “fingertip strong right,” your right hand. In fingertip, the wing pilot maintains a bearing line, normally in the 30° to 45° range aft of Lead, depending on the aircraft type, with slight vertical spacing from #1, as well as lateral wingtip spacing.

Formation configuration changes are executed from the fingertip position. If the flight is in a configuration other than fingertip, the flight leader will regroup the flight into fingertip before moving to a new configuration.

Vic

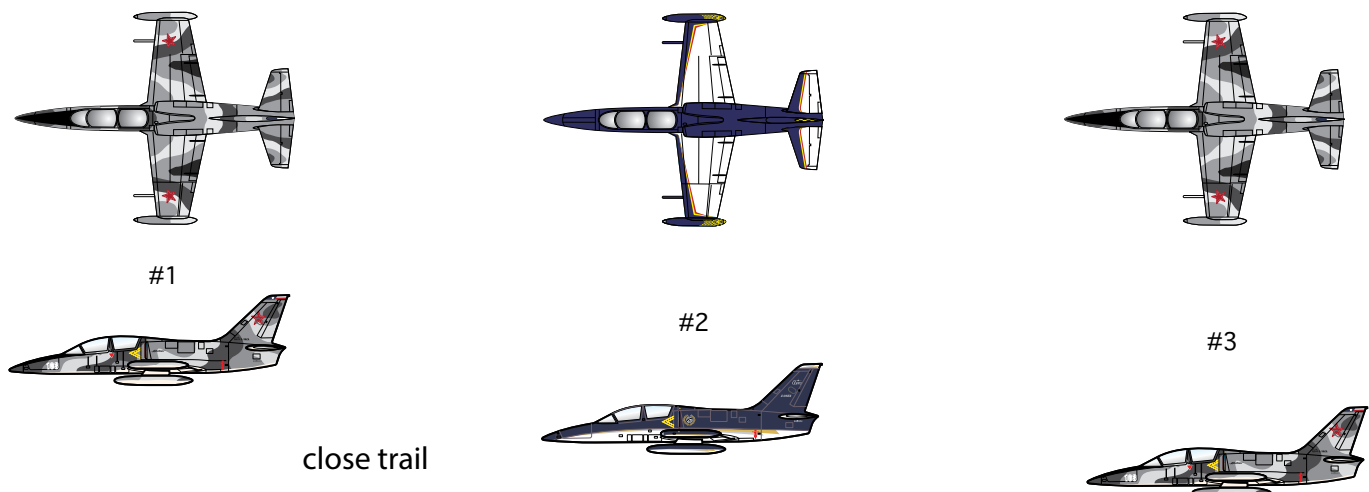
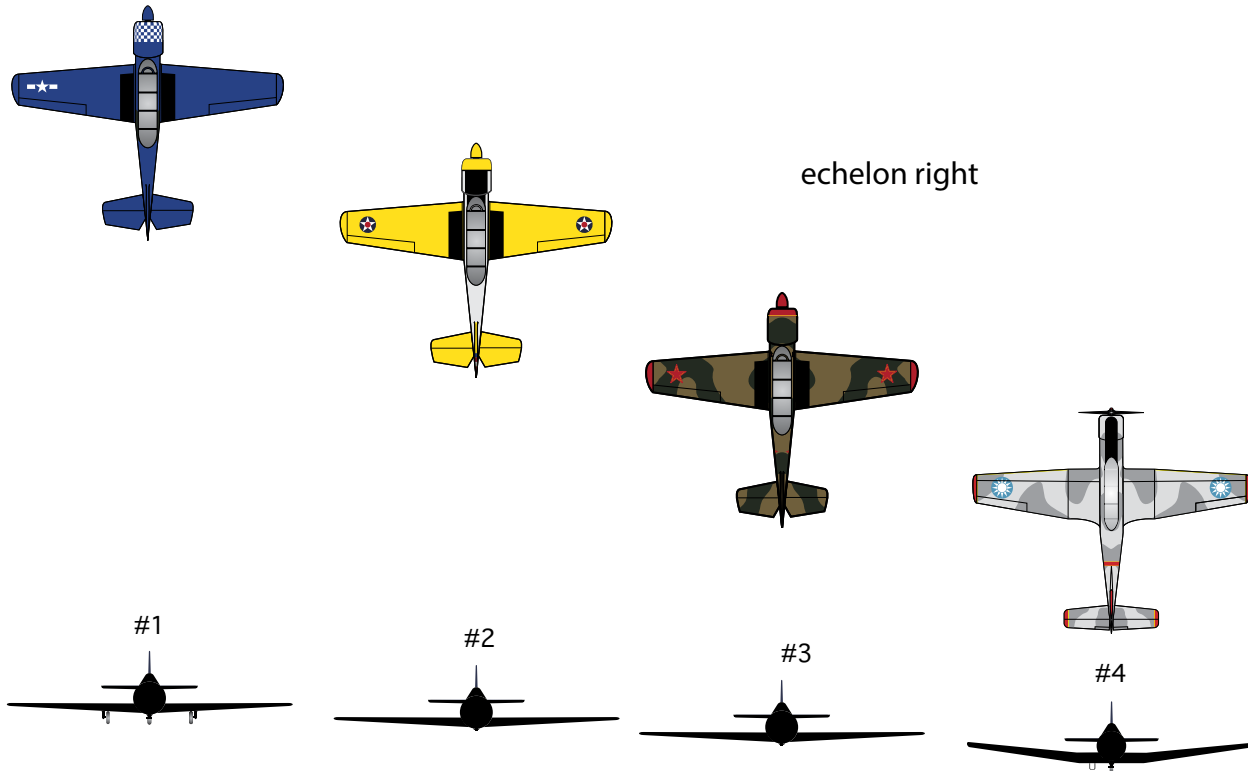
If there is an odd number in the flight, then one of the elements will contain only one aircraft. A 3-ship flight, or “Vic,” will normally utilize the concept of a “phantom” #4, meaning that in terms of signals and other formation protocol, Lead will operate as if there was a #4 on the wing of #3.

The vic, or V, can be extended with the addition of aircraft in the outboard positions to create a 5-ship vic, for instance.



ECHELON

Echelon is a configuration where all the wing aircraft are either to the right (echelon right) or to the left (echelon left), of #1. The aircraft all maintain the same relative position on the fingertip bearing line, each flying off the preceding aircraft. Echelon is used in the traffic pattern, and to position aircraft for pitchouts. Echelon is limiting in that Lead can only turn away from the flight. We will explain some other differences later.

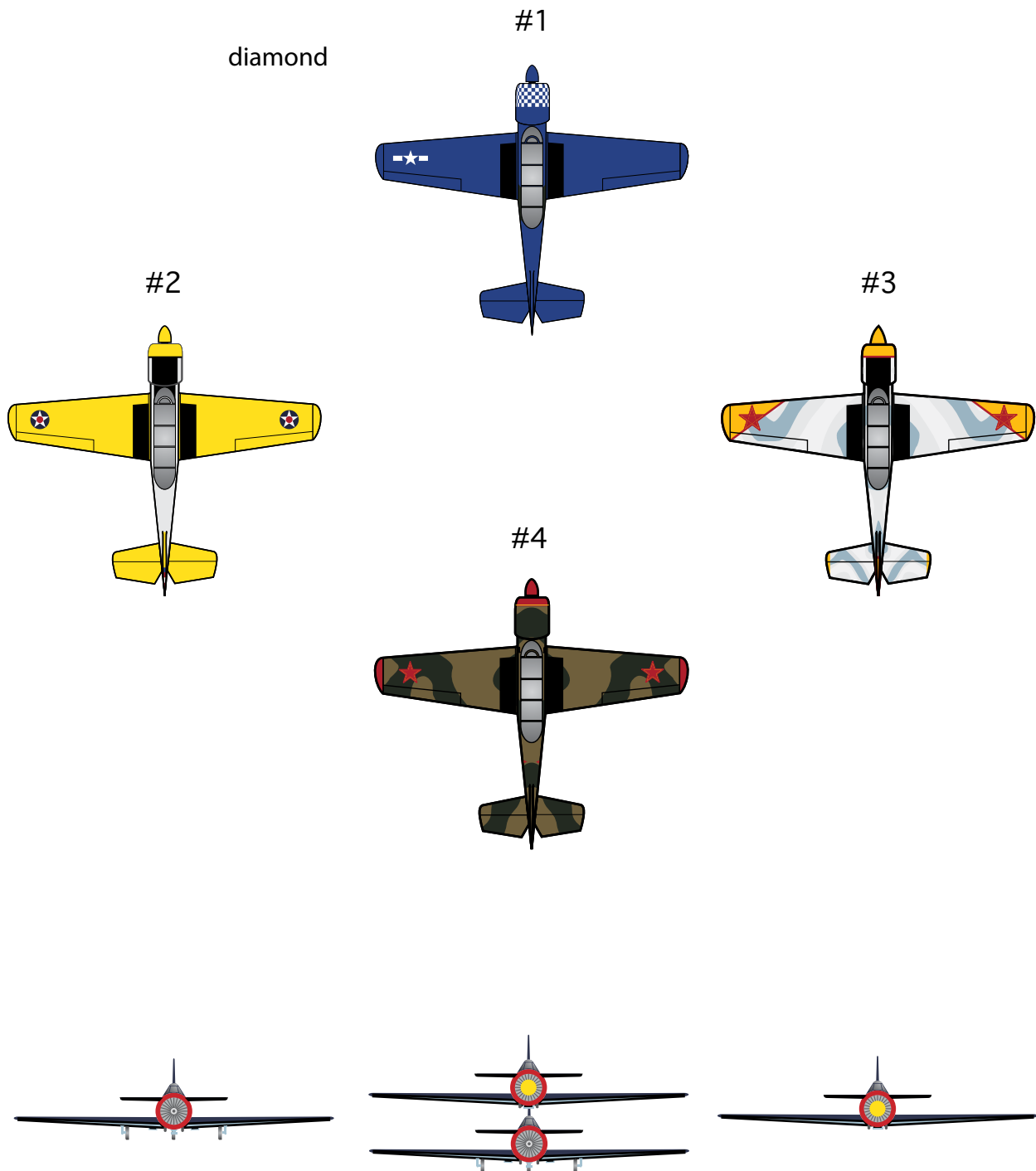


TRAIL

Trail formations are flown, as the name implies, with the wing pilots following in trail behind #1. There are two distinct types of trail formation—extended and tail chase. Tail chase can be flown in close (one ship length) or with a greater interval, as defined by the flight leader. We will discuss the differences further in the maneuvers chapter. Extended trail is generally used in situations where greater maneuverability is desired.

DIAMOND

The diamond is formed when the #4 wingman moves into the “slot” position, in trail with #1. It is a relatively compact and maneuverable configuration and for this reason is often used as a building-block to assemble mass formations.



ROUTE

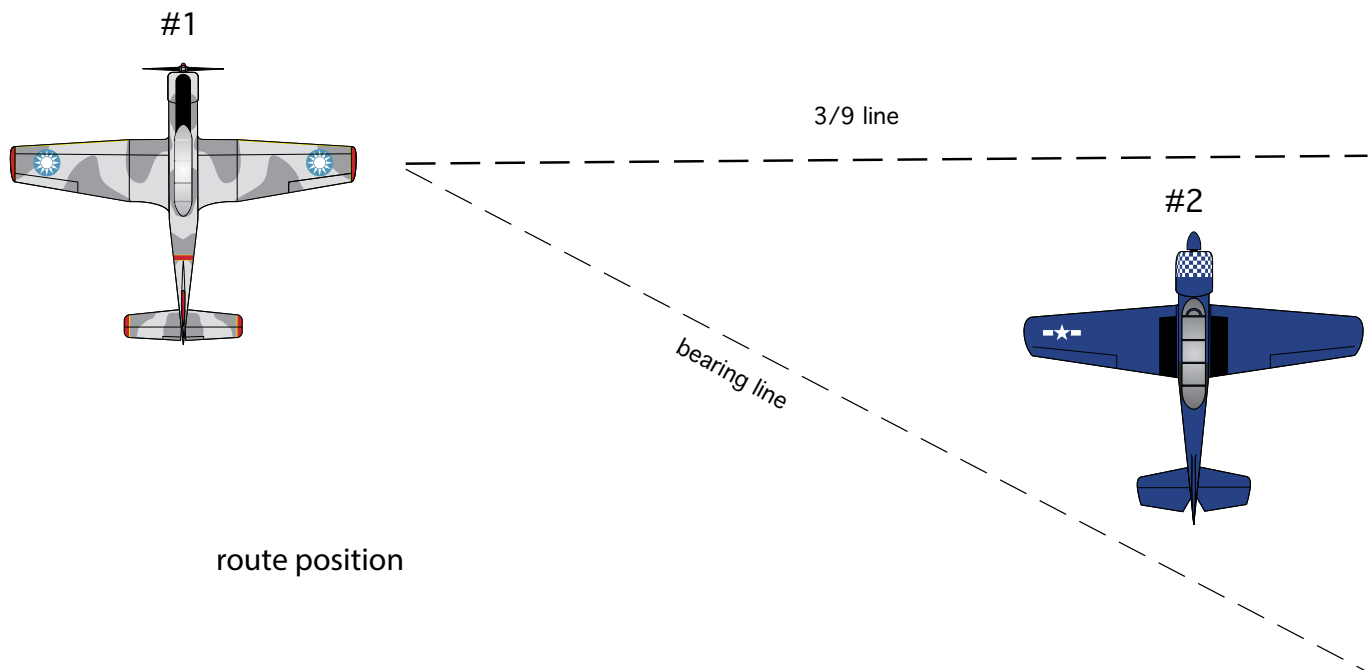
Route is a “relaxed” formation position. It allows greater spacing between aircraft and can be used to facilitate frequency changes, where the wingmen have to be momentarily “heads down” in the cockpit. It is also used to relax on cross-country flights, to give the wingmen some breathing room in high traffic areas, or to accomplish in-flight checks of systems, fuel, or other operational tasks.

The signal to send the wingmen to route is a quick rudder wag, or slight fishtail.

In route, the wingmen loosen up to a minimum of two to four ship-widths out to a maximum of 500 feet from Lead. Fore and aft, route includes an area from the 3/9 line (line abreast), aft to the bearing line.

As the wingman moves farther away from Lead in route, it becomes more important that he remain closer to the 3/9 line, as opposed to the bearing line, so that Lead can easily keep him in sight.

To tighten up and reform the flight, Lead will normally execute a wing rock.



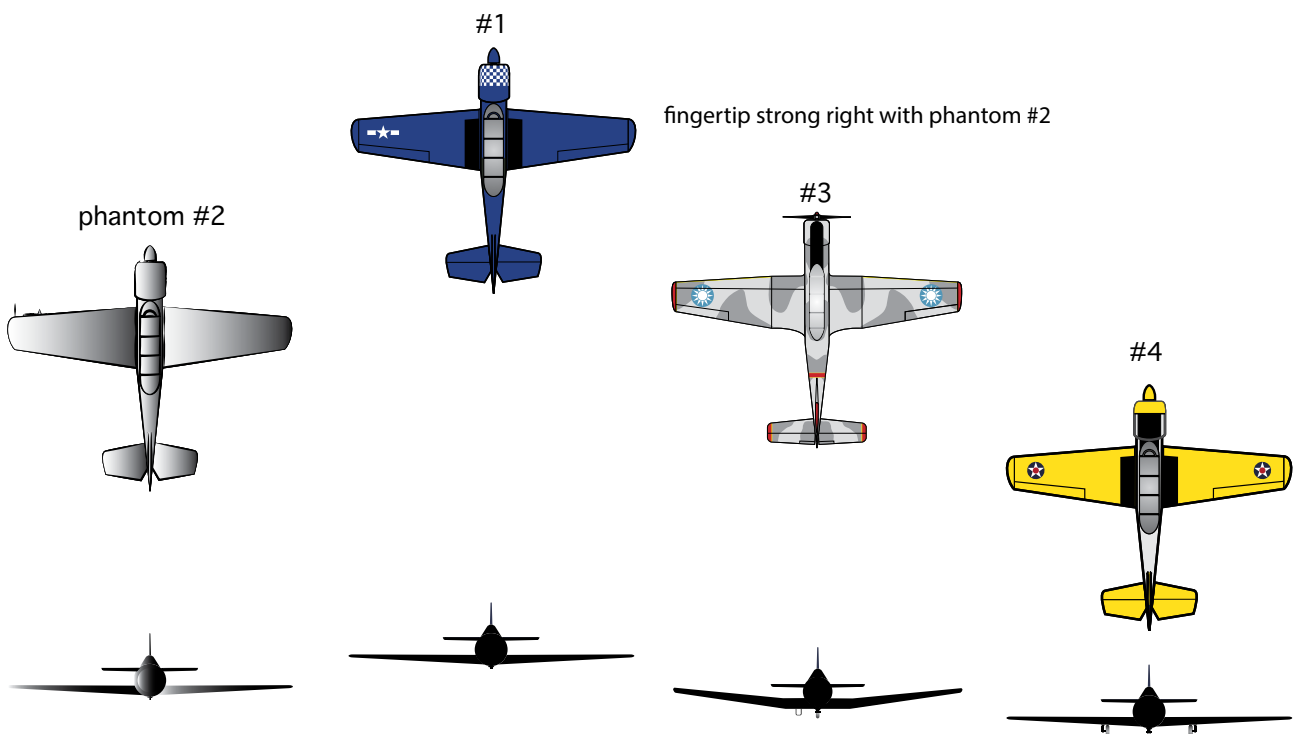
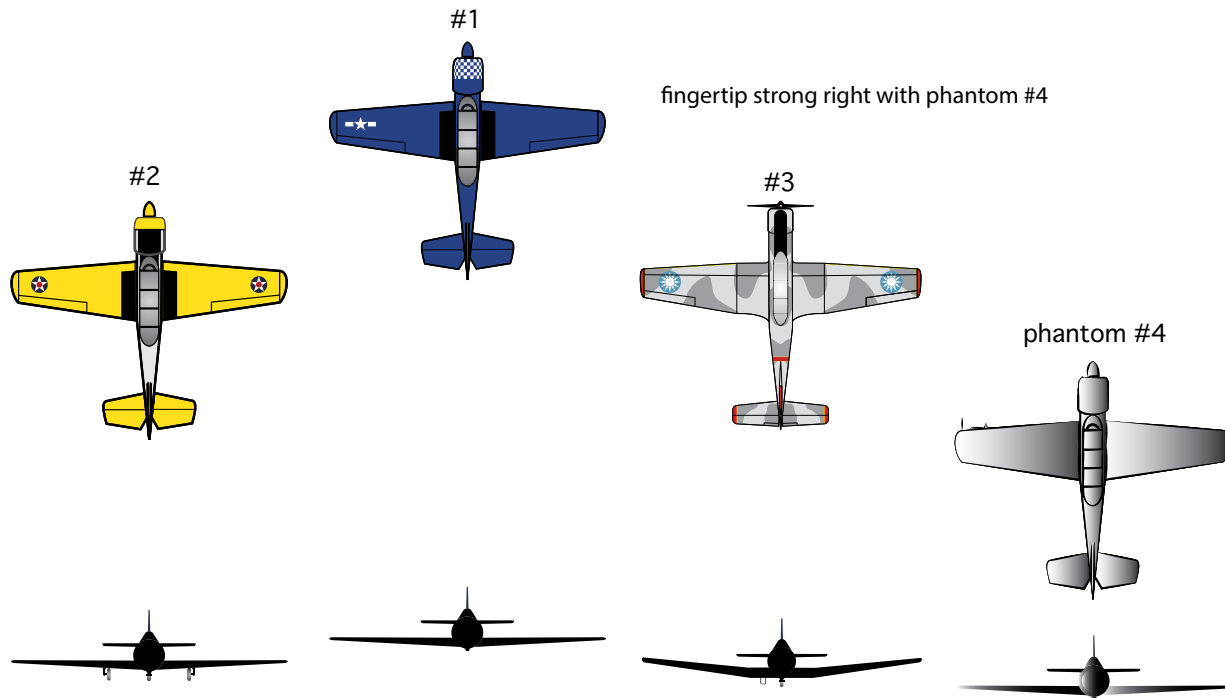
PHANTOM WINGMAN

There are times when there may be an odd number of aircraft in the flight. You might only be able to get a 3-ship together on a given day, or you could lose a wingman in the chocks because of a maintenance issue.

In a situation like this, the flight leader can elect to utilize the concept of a phantom wingman. For the purposes of

accomplishing a specific training goal, the flight leader can configure a 3-ship with a phantom #2 or #4.

With a phantom #4, the flight's pilots would behave just as if it were a standard 4-ship. With a phantom #2, the pilots would also fly as if they were in a standard 4-ship, but the two wingmen, flying in the #3 and #4 positions, would both join to the outside on a turning rejoin, even though there is no "real" aircraft in the #2 position.



CHAPTER 2

MAINTAINING POSITION

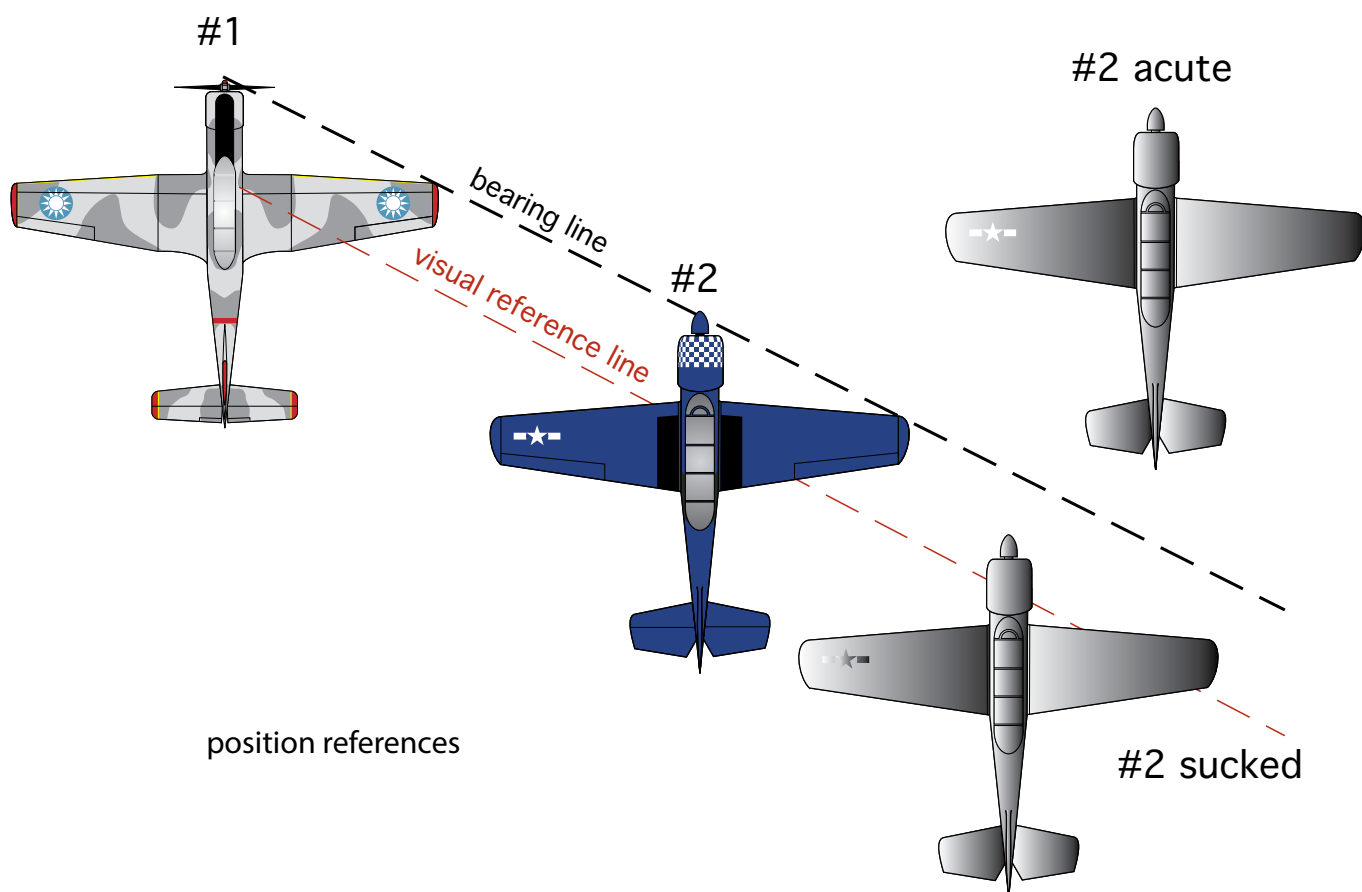
STATION KEEPING

Maintaining position, or “station keeping,” is very challenging. At first, you may wonder why the flight leader can’t seem to keep his aircraft flying straight and level only to discover in the debrief that he was rock-solid the whole time. As you progress, you will learn to judge relative motion from the leader and make small, prompt corrections to stay in position.

Good formation is the result of recognition, anticipation, planning, and always striving for the perfect position. When you do achieve perfect position, you are in a state of equilibrium with the lead aircraft where your relative motion to Lead is unchanging, even while the whole world moves around you in the background.

The key to flying precise, smooth formation can be sum-

marized in two key concepts: *recognition* and *anticipation*. Recognition means recognizing slight motion in relation to Lead and making small, prompt corrections as soon as you are out of position. The easiest way to detect motion is by monitoring fixed references on the lead aircraft. Each aircraft type has established references to help you stay in position. By using two points to triangulate off your reference 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. Keep your eyes moving; try to avoid becoming fixated on only one reference and, instead, scan all the references as well as Lead’s entire aircraft to detect relative motion and changes in position.



Anticipation means being ready for what the flight leader is going to do next and being prepared to take the appropriate action simultaneously with Lead's action, so as to not fall out of position. For example, if you are practicing a lazy-eight maneuver, you can anticipate as Lead turns away from you—you will have to add power and climb to stay “stacked up” in the proper fingertip position. If you do not anticipate this maneuver and bring the power in late, you will immediately fall out of position. Here are some pointers and techniques that you may find useful:

- Relax! Just as in basic flying, you must feel what the airplane 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 right arm on your leg to steady your hand, this will provide a stationary anchor.
- Rest your left hand on either the base of the throttle quadrant or adjacent to the prop lever to gauge movement and reduce over-controlling.

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 most likely fall behind unless you add power to maintain your airspeed.

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

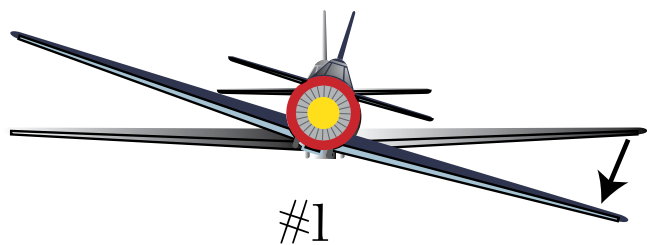
When out of position, correct altitude first, bearing line next, and finally, closeness (A, B, C). It's important to cor-

rect altitude because, if you are stacked high on Lead and he begins a turn into you, it's likely you will quickly lose sight of him. Acquiring the bearing line is important because your relative motion to the lead aircraft will always have the same appearance from that perspective. The only time you would correct for closeness first is if you have wingtip overlap, in which case it becomes critical to get some distance away from Lead before correcting anything else. Your instructor will have you practice exercises that help increase your judgment and teach you the corrections required to get you back into position. Once you become proficient, corrections will be accomplished in one fluid motion.

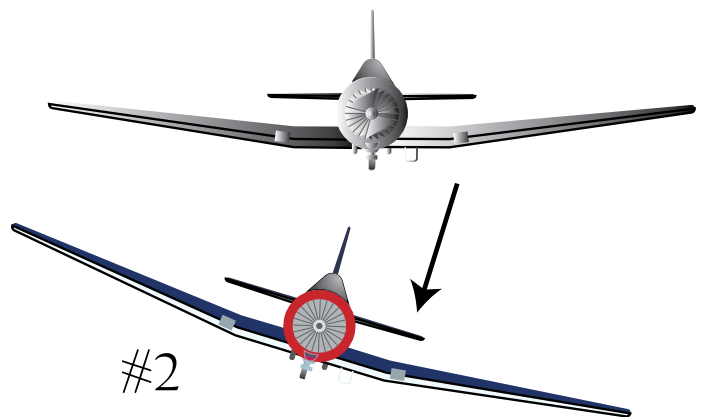
When flying in the #4 position, you will fly in reference to #3, your element leader. In fingertip, #3, in turn, maintains position on the flight leader. You will be able to see Lead “through” #3, and this will help you anticipate #3's movements, but your station keeping will normally be in reference to #3.

URNS IN FINGERTIP

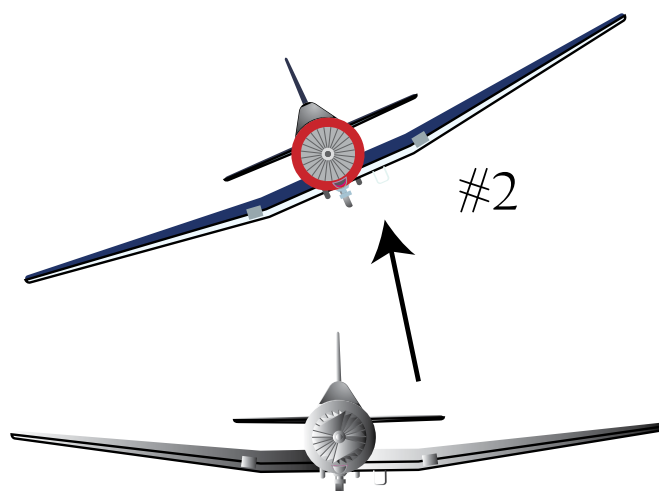
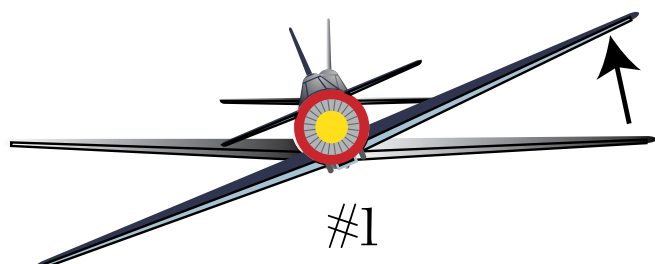
When Lead rolls into a turn, the maneuver will immediately put the wingman out of position unless he anticipates and makes the required control inputs. This occurs because the wingman is in transition from straight and level flight. Think of straight and level flight as a turn circle with an infinite radius. When on the leader's wing, the wingman is flying an identical turn circle, flying the same distance over time which requires the wingman to match the leader's speed. When the leader rolls away from the wingman, he will now be flying a larger turn circle than the leader. To stay in position, the wingman will have to travel a greater distance over time and will therefore have to fly an airspeed faster than the leader. Conversely, when the leader rolls into the wingman, he will be flying a smaller turn circle than the leader. To stay in position, he will travel a shorter distance over time and will therefore



turn into wingman



turn away from wingman



have to fly a slower airspeed than the leader. It is like a merry-go-round, where the inside horses are traveling a shorter distance while the outside horses are traveling a longer distance relative to one another. So it will be for the wingman, depending on whether he is on the inside or outside of the turn. The wing pilot maintains the same relative position while rolling into and out of bank. This means that besides rolling with Lead, the wingman will have to move vertically to stay in position and increase or decrease his airspeed. 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.

URNS INTO THE WINGMAN

Let's take the case where the wingman is #2, on Lead's left side. Lead begins a smooth roll to the left. The wingman will roll to match Lead's roll and bank angle. At the same time, he will need to descend to maintain vertical position. This descent will increase the wingman's airspeed, causing him to get ahead of Lead, unless he coordinates with a power reduction. This effect will be compounded by the fact that, on the inside of the turn, the wingman is flying a smaller turn circle and will therefore travel a shorter distance than Lead. Once Lead stops rolling and is stabilized in the bank, the wingman 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 #2, he will simultaneously reduce power, roll with Lead and apply forward pressure to stay in position. There, isn't that easy?

URNS AWAY FROM THE WINGMAN

Now, let's look at the case where Lead turns away from the wingman. In fingertip left (2-ship), Lead starts a right

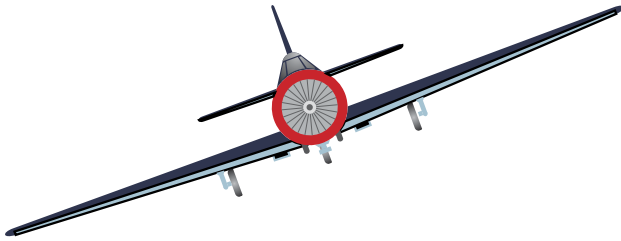
turn. The wingman will have to climb and roll to stay in position on the wing. This will require back pressure to move up vertically, and also a sizable power addition lest he lose airspeed and fall behind. Keep in mind, the wingman is also on the outside of the turn, flying a larger turn circle, and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

Here's what will probably happen on the wingman's first few "turns away." He will be a little slow to roll, which will push him out away from Lead. Thus, to stay in position vertically will require a larger climb. The wingman will probably not add enough power, which will cause him to get sucked. So, there he is, wide, below and behind Lead, with full throttle and unable to catch up. With time he may catch back up with Lead—generally about the time Lead decides to roll out. To keep this from happening, the wingman must make positive inputs as soon as Lead rolls. He should add a bunch of power, stay right with Lead's roll, and climb to stay in position. If he adds too much power initially, it is easy to correct by taking a little off. However, it is difficult to catch back up if he is shy with the power and falls behind.

Once Lead reaches his desired bank and stops rolling, ease off the back pressure, the wingman will stabilize his bank, and adjust power to maintain position. Next, he will need to anticipate Lead rolling 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.

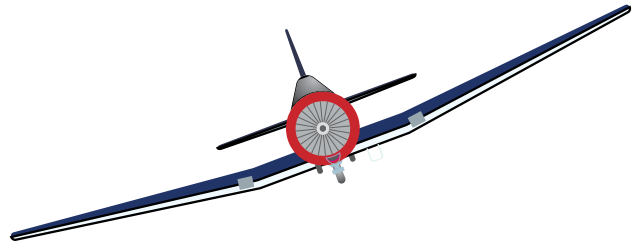
One final comment—these turning effects will be magnified even further when flying the #3 position (in fingertip) because of the greater distance from Lead.

#1



2-ship echelon turn

#2



ECHELON TURNS (LOW-WING A/C)

Echelon turns away from the flight are accomplished differently than in fingertip. As we covered earlier, 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 be on the same horizontal plane as Lead. This gives the wing pilots a bigger power advantage to stay with Lead. As Lead rolls into the turn, match bank angles and climb only slightly to split the lead aircraft's fuselage with the horizon line. Since you are on the outside of the turn, your turn circle

will be larger, you will be travelling a greater distance, and you will have to fly faster to maintain position. Add power to stay in. Maintain the same lateral spacing from Lead in the turn. When Lead starts to roll out, reduce power as you roll back out with Lead.

SUMMARY

That covers the basics of remaining in position, turns, climbs, and descents. Your first formation flights will be flown in 2-ship and will concentrate on building a strong foundation in these basics. Once you are proficient in 2-ship formation, you will be ready to move on to 3-ship and 4-ship formations.



CHAPTER 3

START, TAXI, TAKEOFF

ENGINE START

Engine starts can be initiated in one of three ways:

- Visual signals
- Radio call
- Timed start

Visual signals are best used when all aircraft are parked within sight of each other. When ready to start, the wingmen will pass the “thumbs up” signal up the line to #1. When #1 gets the “thumbs up” from #2, he will then give the signal for engine start (index finger pointed skyward, with rotating motion). In an airshow environment, where the aircraft are visible to the spectators, Lead may brief to start on an exaggerated “head nod.” When Lead’s chin hits his chest, press the start button. Complete normal start and after-start procedures.

A radio call start can be used at any time but is usually used when the pilots’ aircraft are parked out of sight of one another. To begin the start sequence, the flight lead will check the flight in on the briefed frequency (*Redstar 1, check*). All wingmen will respond, in order, with their call sign. If any wingman is not ready to start, he will state the reason and how much additional time is required to get ready. (i.e., “*Redstar 2 needs two minutes*”). This is known as an “alibi.” The flight lead will determine a course of action and then, when ready, command the start “*Redstar 1, start engines.*” Wingmen will again acknowledge with their call sign, then start engines and accomplish all before taxi checks. After allowing enough time for the start and in preparation to taxi, the flight lead will again call for a check in. Wingmen will again respond in order with their call sign and alibi, if required. Once the flight is ready to taxi, the flight lead will send the flight to the appropriate frequency, check in, call for taxi, and proceed to the runway.

Timed starts can be used at any time but are usually used when pilots’ aircraft are parked out of sight of one another and obstacles or congestion hamper the use of radio calls. At the briefed start time, all flight members will start engines and accomplish all before taxi checks. At the briefed taxi time, all flight members should be standing by on the briefed frequency and/or proceed with the briefed taxi plan.

TAXI

Using standard or briefed spacing, the wingmen will depart the chocks and taxi in order of flight position. Normally two to four ship-lengths is adequate spacing. If Lead offsets from the center of the taxiway, the wingman

will offset in an alternating pattern. To maintain forward visibility, tail draggers can s-turn on alternate sides of the taxiway, width permitting, but may have to use full width on narrower taxiways.

Run up is performed, as briefed, in one of two ways:

- Simultaneously
- Individually

Simultaneous run ups are commanded by Lead using the same visual signal used to command engine start. This is done after wingmen signal “ready” by passing a “thumbs up” signal up the line, starting with the highest numbered wingman. Individual run ups are accomplished without a flight lead signal as soon as each wingman lines up in the run up area.

Using either method, wingmen will signal “ready for take off” by passing the “thumbs up” signal up the line.

TAKEOFF

Takeoff can be performed in a 2-ship element or single-ship, interval takeoffs. Formation takeoffs are the most efficient, but may not be possible depending on runway length or width, crosswinds, gusty winds, obstacles, dissimilar aircraft, or other limiting factors.

INTERVAL TAKEOFF

For single-ship, interval takeoffs, Lead may decide to assemble the formation on the runway prior to brake release. Or, Lead may allow aircraft to roll onto the runway individually and initiate the takeoff without first assembling the elements in position. In either case, the wingman will begin takeoff roll when Lead’s aircraft is airborne or the minimum takeoff interval has been achieved, however briefed. The wingman will then proceed with a normal, full-power takeoff. See Chapter 7, *Operating Limitations*, for more information on interval takeoffs.

For narrow runways or when there are strong or gusty crosswinds, pilots who have assumed a staggered lineup on the runway, will steer to the center of the runway for the takeoff roll.

ELEMENT TAKEOFF

For an element takeoff, Lead will taxi into position, normally lining up on the downwind side of the runway. This allows the wind to blow Lead’s wake away from the wing pilot. If the wind is light, five knots or less, Lead may position himself down sun, or on the convenient side to effect the rejoin after takeoff. The wingman will line up on the opposite side of the runway in the acute position, slightly ahead of the normal fingertip bearing line.

This assures that the wingman will quickly clear Lead in the event Lead aborts or experiences directional control problems (as in the case of a blown tire).

The wing pilot would normally be in the center of his side of the runway with a minimum of 10 feet of lateral wingtip clearance. However, even on wider runways, the wingman will want to approximate the 10 feet of lateral separation so that the takeoff sight picture is consistent. Depending on where the leader lines up, this 10 feet of lateral separation may have the wing pilot lined up in the center of his half of the runway or slightly left or right of the center position. (100 feet is the minimum runway width required for training.) When the wingman signals he is in position with a head nod, Lead will give the run-up signal. The wingman will power up to the briefed power setting and check engine instruments. The wingman will then give another head nod, signaling ready for takeoff. An exaggerated head nod by Lead will signal brake release. When Lead releases brakes, he will smoothly advance power to the briefed, less than full-power setting, providing the wingman with a power advantage. The wingman will advance power to stay with Lead and modulate power as necessary to maintain the acute, takeoff position.

During takeoff roll, if the wingman has plenty of surplus power and is still able to stay with Lead, he can ask Lead to push the power up (*“Redstar 1, push it up”*). Conversely, if the wingman is at or near full power and is having trouble keeping up, he should call *“Redstar 1, gimme one.”*

Lead will only reduce power once. If the wingman cannot maintain proper position after Lead makes a power reduction, the takeoff should revert to single-ship takeoffs for both aircraft. Lead will never try to manipulate power to move “backwards” to regain element takeoff position.

If the wingman passes Lead during the takeoff roll, the pilots will revert to single-ship takeoff procedures—no attempt will be made to try to salvage the element takeoff.

Lead will accelerate to slightly above normal takeoff speed, then rotate smoothly. The wingman matches Lead’s rotation and stacks level (Lead’s head on the horizon). Lead will ensure the wingman is safely airborne and at least 50 feet agl, clear of obstacles and stabilized, and then signal for gear retraction. After the gear is retracted, the wingman will move into the normal fingertip position.

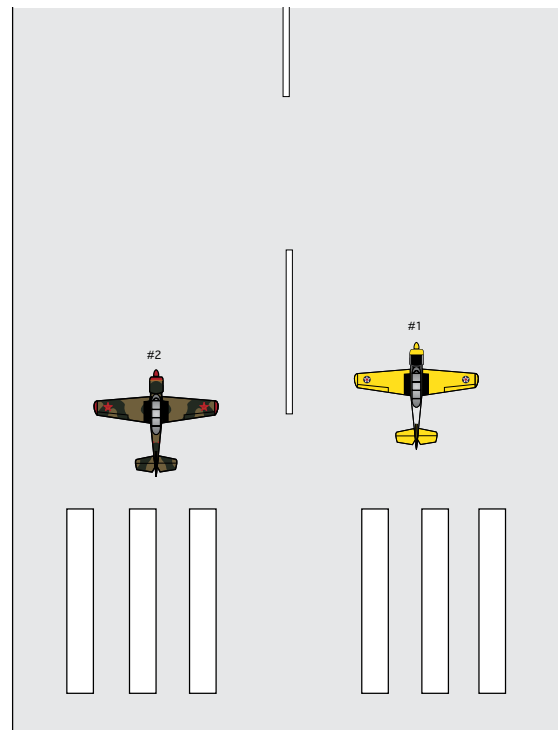
TAKEOFF ABORTS

In the event of an abort, the aborting pilot will call it out on the radio (*“Redstar 3, aborting”*). The non-aborting pilot will apply full power and continue the takeoff. If Lead decides it is imperative that the entire flight should abort, he will call *“Redstar 1 flight abort, abort, abort”* and all aircraft will abort. In this case it is very important to maintain lateral separation and normal takeoff position behind the 3/9 line. Keep directional control and do not cross over the runway centerline.

REJOIN AFTER TAKEOFF

When performing single-ship takeoffs, the formation will have to join up once safely airborne. It’s important to brief this thoroughly since local conditions and mission requirements will likely dictate the type of rejoin used. Rejoins can be done in a turn, straight ahead, or some combination of the two. A turning rejoin is much faster since the trailing wingmen can use cut off geometry as well as airspeed to complete the rejoin. If departing enroute to a destination, it might make more sense to rejoin straight ahead while Lead is wings level, on course.

When performing turning rejoins, #2 will always join to the inside of the turn. If a straight-ahead rejoin is performed, #2 will join to the side he previously occupied, if applicable, or on the left side, unless briefed otherwise. Lead will reduce power to a setting that will give the wingman a speed advantage. A detailed discussion of rejoins will be covered in the next chapter.



Two-ship runway line-up: #2 forward of the normal bearing line sight picture with a minimum of 10' of lateral wingtip separation

CHAPTER 4

2-SHIP MANEUVERS

Let's go through the maneuvers that make up a typical formation training flight. We will discuss some formation configurations, how to execute formation configuration changes, and other maneuvers.

WING-WORK

One of the first maneuvers you will be practicing falls under the heading of "wing-work." This consists of a series of turns in combination with pitch changes—a lazy-eight type maneuver in formation. Initially, you will practice at shallow bank and pitch angles, progressing to a wide variety of attitudes and airspeeds and eventually achieving up to plus or minus 20° of pitch in combination with up to 45° of bank. These are the parameters used in the wingman evaluation ride, but you will likely be able to "hang in there" with up to 60° of bank, once you become proficient.

DESCRIPTION

The lazy 8 consists of a series of 180° climbing and descending turns where the angle of bank and pitch are changing in a continuous flow. The name is derived from the fact that the aircraft traces a reclining figure 8 during the maneuver.

Lead will usually dive to gain airspeed prior to entry. From wings level, Lead will begin a gentle climbing turn so as to arrive at maximum pitch (up to 20° nose up) at 45° of turn. At the 45° point, Lead begins to decrease pitch while continuing to increase angle of bank so as to arrive at maximum bank angle (up to 45° bank) at the 90° turn point. At the 90° point, pitch will be level. Lead will continue the turn, decreasing pitch and bank so as to arrive

at the 135° point in the turn with maximum nose-down pitch (up to 20° nose down) and bank angle continuing to decrease. Lead will pull the nose up and continue to decrease bank angle so as to arrive at the 180° point wings level with level pitch. The airspeed and altitude should be the same as the entry values. At this point, without hesitation and in one, smooth action, Lead will repeat the maneuver in the opposite direction, creating a mirror image of the first 180° turn. The lazy 8 is complete at the end of the second 180° turn but Lead can continue as many cycles as necessary for training.

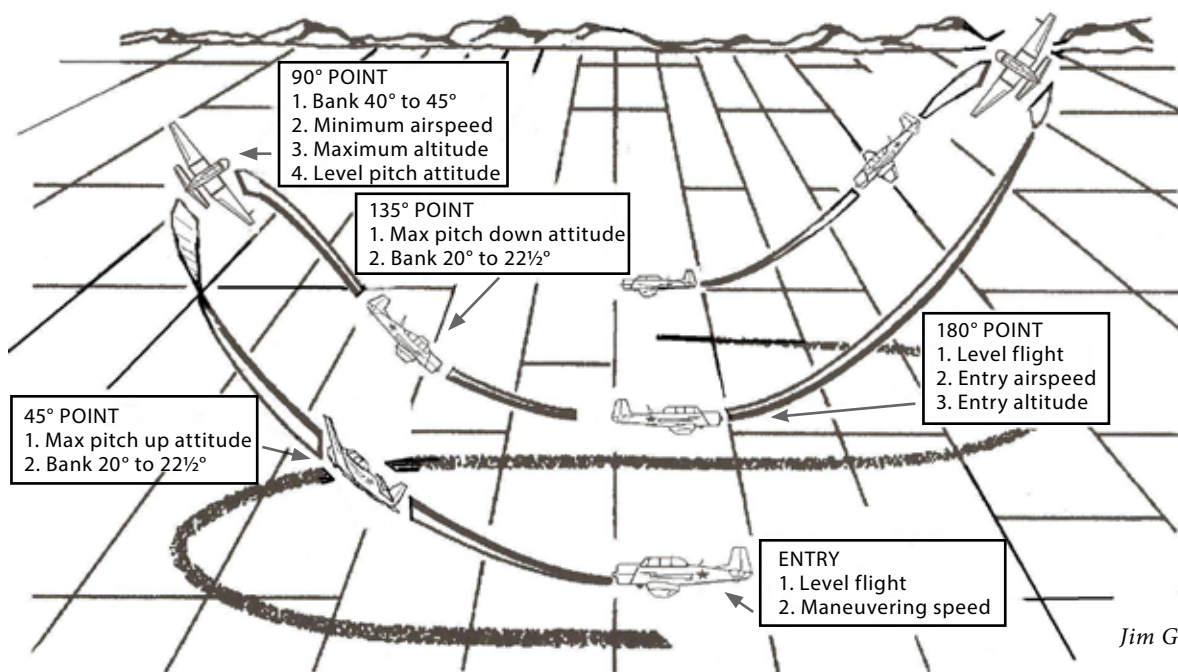
PERFORMANCE GUIDELINES

- Lead will provide a stable platform and maneuver smoothly
- Lead will not exceed the capabilities of the wingman in the flight
- Wingmen should be able to recognize when they are out of position and anticipate pitch, bank and power requirements
- Wingmen should make timely corrections to maintain position within reasonable tolerances

COMMON ERRORS

- Wingmen not recognizing when they are out of position
- Wingmen not anticipating power, pitch and bank requirements in a timely manner
- Wingmen getting sucked in turns away and acute in turns into the wingman





CROSS-UNDER

Cross-unders are used to move wingmen from one side of the flight leader to the other. Lead may want wingmen to change sides for a variety of reasons—to set up for a pitch out maneuver, to keep wingmen from looking into the sun, to help clear for traffic, or just to give #2's neck a break.

SIGNAL

The hand signal for #2 to cross-under is a clenched fist held up vertically. An alternate signal, an aircraft signal, is a precise, very rapid, very shallow wing dip away from the wingman toward the new wing position.

DESCRIPTION

Cross-unders are accomplished in three stages that, with proficiency, become one fluid movement. The three stages are:

1. Down and back
2. Across
3. Forward and up

First, reduce power slightly to start moving down and straight back. Move to a position below Lead to stay out of the wingtip vortices and prop wash. Once you have nose/tail clearance with Lead, add power to hold position. Anticipate the power increase to prevent falling behind.

To move across, change your heading only one or two degrees. Roll into a few degrees of bank (less than five), and then roll right out. This will give you the heading change you need to drift smoothly across. Do not stay in a bank, as your heading will continue to diverge from Lead and your cross-under will accelerate. Fly wings level to the other side. Add power as you move across to prevent falling behind Lead—you are flying a slightly longer flight path than Lead.

When you have wingtip clearance, return to Lead's heading. Add more power to move up and forward into the normal fingertip position.

Think of the maneuver as having one slight power reduction followed by three big power

With a single, raised fist, Lead signals #2 to cross under, from right to left, to the opposite side.

additions. To fly good cross-unders, you must anticipate each power change and make the smallest possible changes in pitch and bank. Cross-unders may be performed in turns when you are proficient. Use caution to stay clear of wingtip vortices and prop wash. Do not fly directly under Lead. Always maintain nose/tail separation.

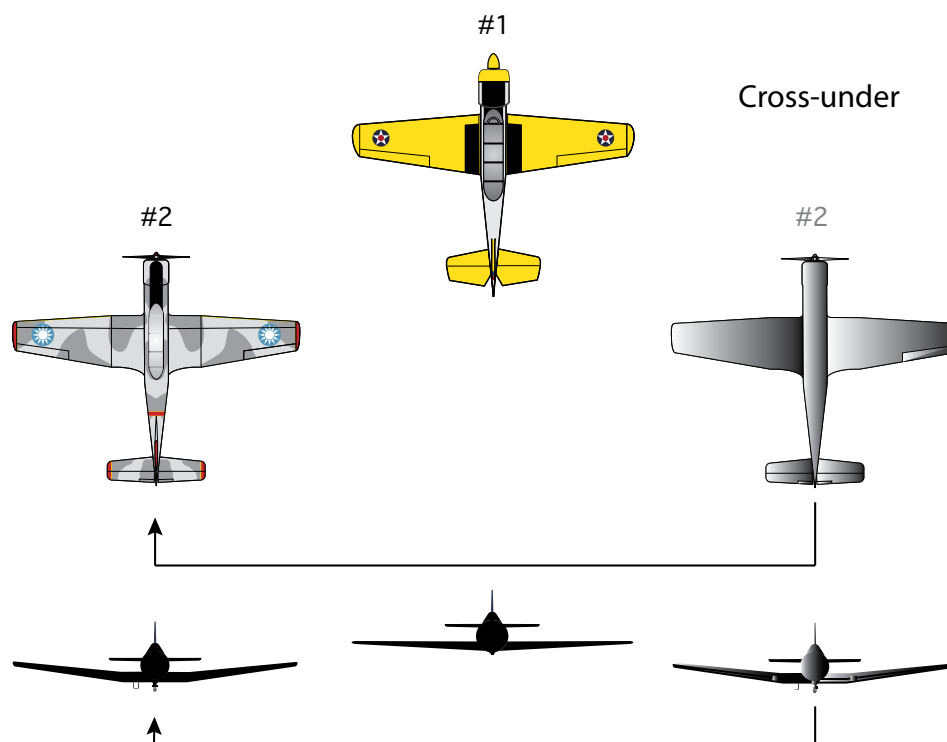
One final point to remember as you become proficient—the cross-under is not a race to the opposite side, it is a deliberate, controlled and precise repositioning of your aircraft.

PERFORMANCE GUIDELINES

- Wingman moves down and back no greater than one ship-length distance from the aircraft ahead
- Wingman transitions smoothly and deliberately to opposite side
- Wingman moves up and forward to the correct fingertip position

COMMON ERRORS

- Falling too far behind
- Descending too low
- Not descending low enough to avoid Lead's vortices or prop/jet turbulence
- Not anticipating power requirements
- Being too aggressive—crossing rapidly to opposite side
- Not crossing far enough, thereby compromising wingtip clearance, when moving forward into the fingertip position



ECHELON TURN

Generally, there are two occasions when the echelon turn is employed: 1. When in echelon—that is, when all the wingmen in a 4-ship, or 3-ship with a phantom #4, are configured in echelon or, 2. When an element is in the traffic pattern.

When turning in echelon formation, all turns will be away from the wing aircraft. 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.

SIGNAL

When there are three or more aircraft configured in echelon, there is no need to signal for echelon turns. However, there is an echelon turn signal—fist raised, with forefinger and pinky finger extended upward, that can be used by the flight leader in situations where an echelon turn would not normally be called for. For example, in a 2-ship, out in the practice area, Lead may want his wingman to practice echelon turns.

DESCRIPTION

Lead rolls into a turn and the wingman simultaneously rolls with the flight leader, climbing just slightly to posi-

tion himself nearly on the same horizontal plane as Lead, while matching Lead's bank angle. The fuselage of Lead's aircraft will be bisected by the horizon line. The wingman is now flying a slightly larger turn circle and will have to add power to maintain position.

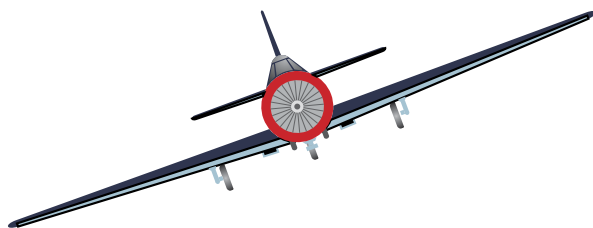
PERFORMANCE GUIDELINES

- Wingman adds power, rolls into the turn and moves smoothly into the echelon turn position.
- Wingman maintains the correct position throughout the turn.
- Wingman transitions smoothly back to fingertip at the completion of the turn.

COMMON ERRORS

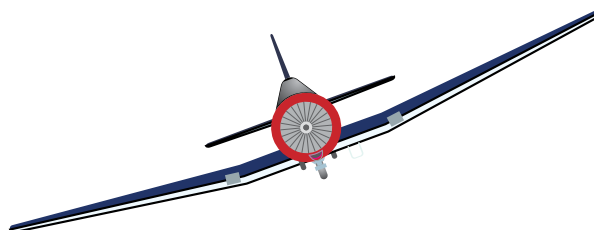
- Not adding enough power to maintain position during the transition into the turn.
- Sliding aft and becoming sucked during the turn.
- Not climbing or descending during the turn—falling out of position.
- Becoming laterally spaced too wide on Lead.

#1



2-ship echelon turn

#2



CLOSE TRAIL

In close trail, the wing aircraft is directly behind Lead, stacked down, with approximately one ship-length spacing. The wing aircraft is “welded” to the lead aircraft as it moves, matching bank angles and remaining in a fixed position relative to Lead.

SIGNAL

Lead will motion to the rear, with fist held up and thumb extended. As an alternative, aircraft signal, Lead may use the elevator to porpoise his aircraft.

DESCRIPTION

The wingman should match bank with Lead to remain directly behind. Use power to maintain the correct nose/tail distance. A note of caution: It is more difficult to judge depth perception when looking only at the rear of Lead's aircraft. If you fall far behind and need to create some overtake in order to move back into position, you may not see excessive closure developing. If you do fall far behind,

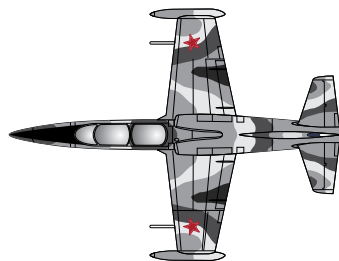
it is better to offset slightly to the side, allowing parallax to give you an oblique view of the leader to help you judge overtake.

PERFORMANCE GUIDELINES

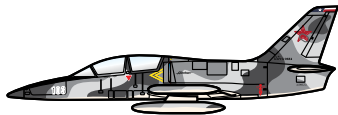
- Wingmen is capable of moving into position without compromising proper separation
- Wingman is able to maintain proper nose/tail distance and fixed position throughout the range of maneuvering

COMMON ERRORS

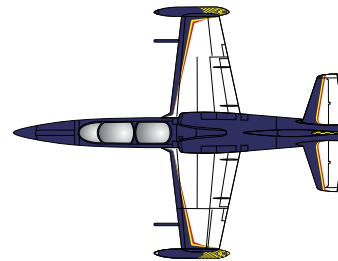
- Falling too far behind when maneuvering into position
- Getting sucked while maneuvering
- Stacking too low
- Not maintaining position directly behind aircraft ahead



#1



Close trail



#2



EXTENDED TRAIL

Extended trail is used to teach wingmen the concepts of lead, lag, and pure pursuit. Also, since it is a very maneuverable configuration, it may be employed by a flight leader to maneuver around weather or other situations where high maneuverability is advantageous. The objective is to remain within a defined maneuvering area behind Lead using lead, lag, and pure pursuit to maintain proper position.

SIGNAL

The flight leader will typically send the flight to extended trail with a radio call:

“Redstar 1, extended trail, go”

DESCRIPTION

Lead pursuit defines both a nose position and a pursuit curve. To achieve both of these, point your nose in front of the leader and keep it there as long as required. This puts you on a smaller turn circle than the leader, flying a shorter distance, and creating geometric overtake. If you are at least co-speed with the leader, you will also have some airspeed overtake on the leader as well. Your velocity of closure (Vc) will have both a geometric and an airspeed component. Together, both components support closure and will efficiently produce a decreasing distance to the leader.

Lag pursuit nose position and pursuit curve occurs when you fly your nose to a position behind the leader and keep it there as long as required. This puts you on a larger turn circle than the leader eliminating all geometric closure. If you are co-speed with the leader, you will quickly lose all airspeed closure when you fly outside the leader's turn circle. Both produce separation and create increasing distance from the leader.

Pure pursuit nose position and pursuit curve occurs when you fly your nose to point directly at the leader and keep it there as long as required. You will close on the leader, but as you do, you will have to pull more and more G to keep your nose on Lead. Once you reach your G limit, you will automatically revert to lag pursuit and, in all probability, overshoot the leader's flight path and begin separating from him unless, prior to overshooting, you maneuver out-of-plane to prevent the overshoot.

Lead will fly a series of hard turns, turn reversals, and lazy-eight maneuvers with the angle of bank not to exceed 90°. This will provide the wingman with the geometry to practice the lead, lag and pure pursuit techniques. Lead's and the wingman's power are set at the beginning of the exercise so that closure and extension are purely the result of maneuvering geometry, and energy management.

Wingmen should expect the in-trail gap to close when Lead climbs and to extend when Lead descends. This spacing change occurs because of the change in Lead's

speed as Lead increases or decreases pitch. Since this is a dynamic, fluid exercise, you will be continuously alternating between lead, lag and pure pursuit to maintain your desired position, relative to Lead.

The wingman's power is fixed to match the flight leader's power. The wingman maneuvers fluidly within a cone, taking advantage of turning geometry to maintain the briefed nose-to-tail spacing with Lead. Extended trail spacing for aircraft with maneuvering speeds below 150 knots is normally 200 feet to 500 feet, while above 150 knots, 500 to 1500 feet would be used, although different intervals may be briefed. The preferred maneuvering area behind Lead is defined by an inner, 30° boundary cone measured from Lead's six-o'clock position (known as 30° aspect) to an outer boundary cone of 45° aspect. The wingman will transit the entire cone behind Lead as he maneuvers to maintain relative position in the donut formed by the inner and outer cones.

For low, straight-wing aircraft, 30° aspect angle visual reference is defined by a line from the outside edge of the horizontal stabilizer to the front cockpit pilot's head. The 45° aspect angle visual reference is defined by a line from a point midway on the trailing edge of the wing between the wing root and the inboard edge of the aileron to the front cockpit pilot's head.

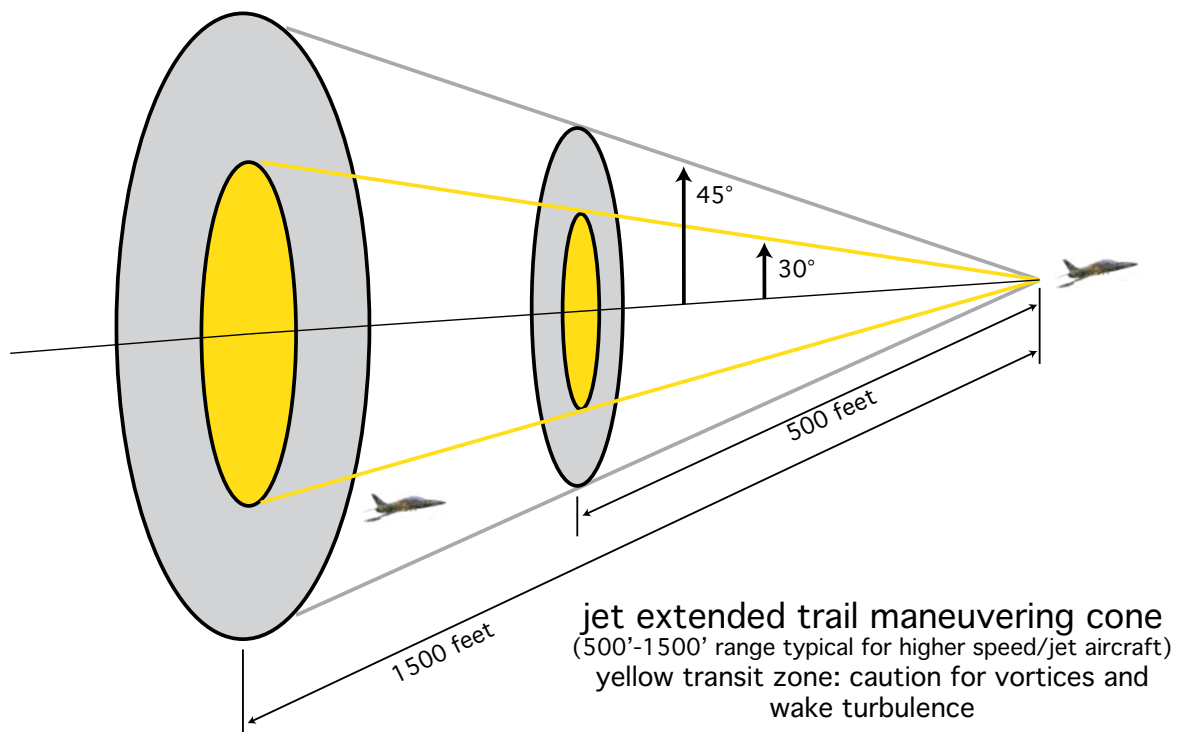
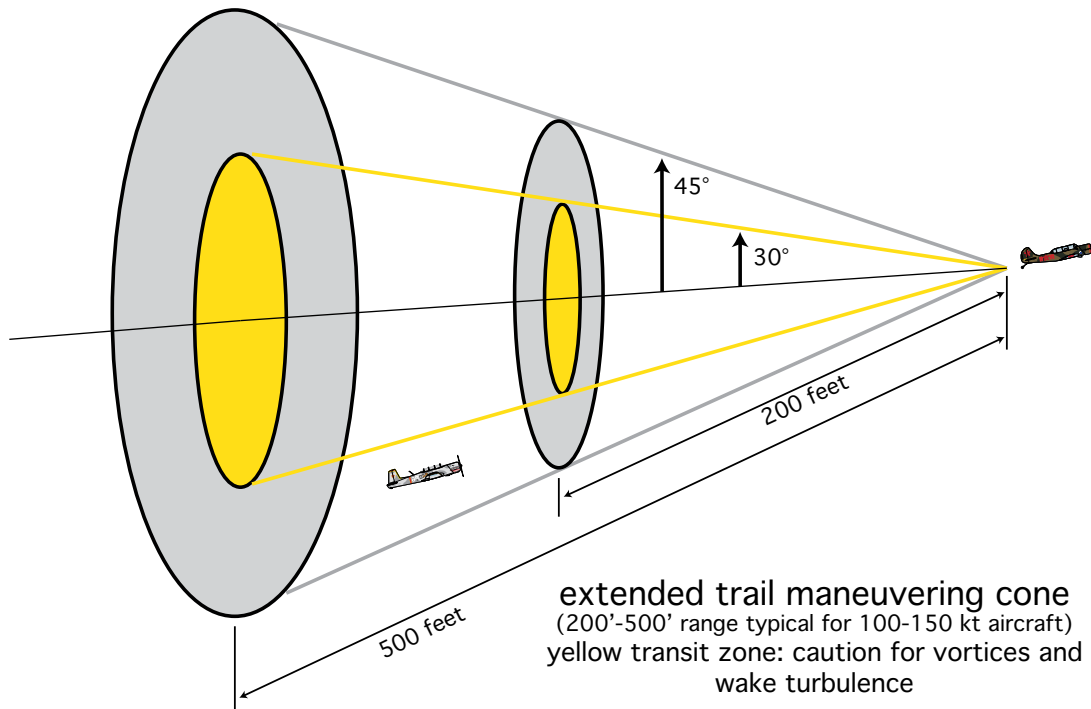
Initially, using lead, lag and pure pursuit to maintain position will be challenging. It requires practice to develop the judgment necessary to determine aspect, range and closure. If you find you are closing too rapidly, do not hesitate to reduce power or turn aggressively away from the lead aircraft. Break out of the formation if necessary.

PERFORMANCE GUIDELINES

- Wingman calls “in” when stabilized in position
- Wingman maintains proper lateral position within the donut
- Wingman maintains proper interval range throughout maneuvering, using lead/lag techniques, without adjusting power

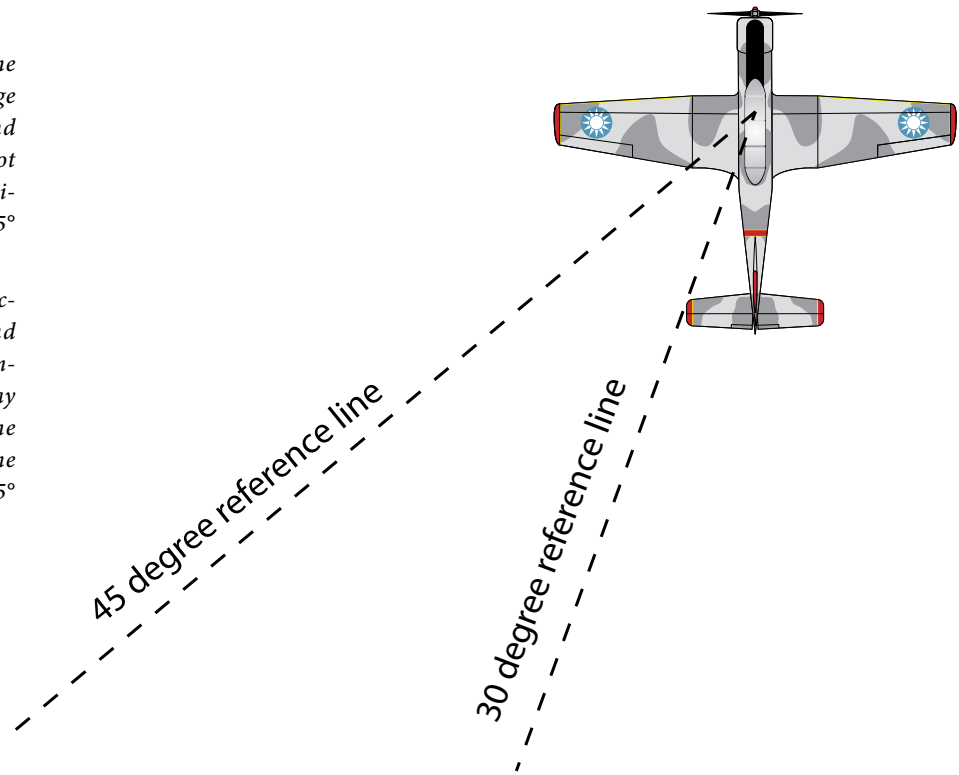
COMMON ERRORS

- Failure to call “in” when in position
- Getting sucked, falling outside of the proper maneuvering range
- Maneuvering in the six o'clock position instead of maintaining proper lateral offset within the donut



Extended trail references

- From Lead's perspective, if the wingman is between the edge of the horizontal stabilizer and halfway between the wing root and the inboard edge of the aileron, he is within the 30°/45° cone
- From the wingman's perspective, if he can see Lead's head between the edge of the horizontal stabilizer and a line halfway between the wing root and the inboard edge of the aileron, the wingman is within the 30°/45° cone.



TAIL CHASE

Tail chase is a configuration where the wingman is, essentially, flying in Lead's flight path, primarily using power to maintain a fixed interval.

SIGNAL

The flight leader will typically send the flight to tail chase with a radio call:

"Redstar 1, tail chase, go"

DESCRIPTION

Two-ship tail chase differs from extended trail in three respects:

1. The throttle is the primary means of maintaining interval
2. The wingman is extended behind Lead from a minimum of 200 feet (1000 feet for jet aircraft), out to 1500 feet or whatever distance the flight leader has briefed.
3. The wingman can also fly in Lead's six o'clock position—think of the Aeroshell T-6 team when they fly in Lead's smoke trail during their routine. In addition to using power, if power alone will not suffice, the wingman can also use lead, lag and pure pursuit, as necessary, to maintain the interval.

PERFORMANCE GUIDELINES

- Wingman calls "in" when in stabilized in trail position
- Wingman uses power as the primary means and geometry as the secondary means to maintain the briefed, fixed interval on Lead
- Wingman remains predominantly in Lead's six o'clock position

COMMON ERRORS

- Failure to call "in" when in position
- Failure to consistently maintain briefed, fixed interval on Lead

LEAD CHANGE

There will be times when the flight leader will swap positions and transfer control of the flight to #2. This is common in training situations where a back-seat instructor is paired with a student in each airplane—the instructor assumes Lead responsibility while the student in the lead aircraft observes.

SIGNAL

The flight leader will point to #2 and then point straight ahead, indicating, “You have the Lead.” Number 2 will acknowledge with a head nod, move out to route position, push the power up and, when passing line abreast with Lead, tap the top of his head with an open palm and then point directly forward, indicating, “I have the lead.”

A Lead change can also be directed with a radio call: “Redstar 2, you have the lead.”

DESCRIPTION

To minimize risk, the “stable platform” concept must be used when transferring positions. The pilot surrendering the Lead position will maintain his power setting and position, providing a stable platform. Number 2 will move to the route position, add power and move forward. As #2 passes the former flight leader (line abreast), the former flight leader will pick up the wingman references and move into fingertip position.

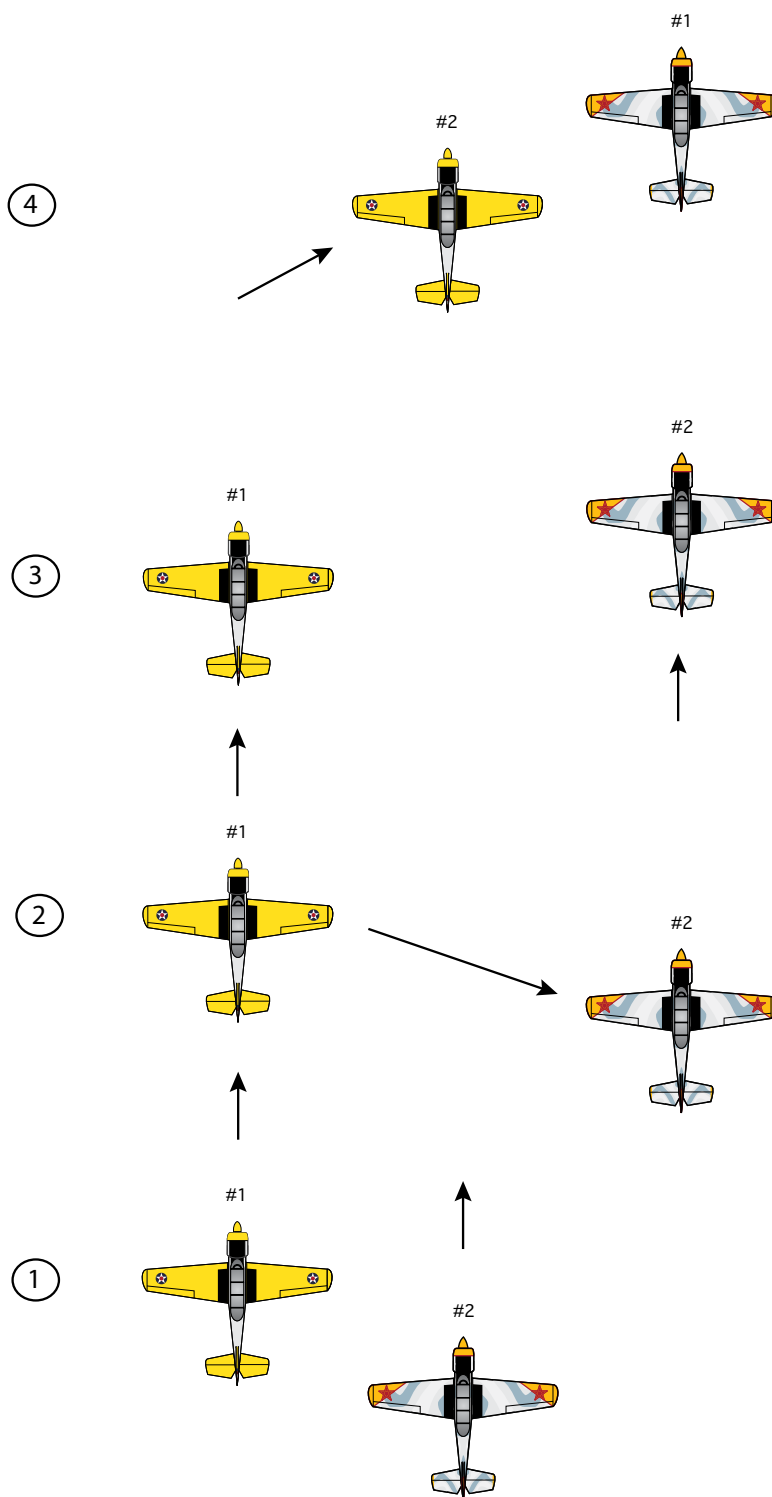
The flight lead has the option of retaining call signs during the lead swap or changing them to correspond to the new formation positions. At the completion of the Lead change, the new flight leader will make a radio call to check the flight in. The wingman will respond with the callsign of his new position, as appropriate.

PERFORMANCE GUIDELINES

- Flight leader should maintain position, providing a stable platform while the new flight leader maneuvers into position
- New flight leader should smoothly maneuver to route and then execute the lead change

COMMON ERRORS

- Not thoroughly briefing Lead change
- Failure to have wingman check in at the completion of the Lead change
- New leader assuming lead responsibilities before passing the old leader’s 3/9 line



PITCH OUT AND REJOIN

The pitchout maneuver can be used in the traffic pattern to achieve interval spacing for landing, in the practice area to establish extended trail spacing, or anytime the flight leader wants to break the flight up.

The rejoin is used to reassemble the flight into fingertip.

SIGNAL

The flight leader will extend his index finger upward, using a twirling motion, and then hold up the number of extended fingers that correspond to the number of seconds to be used in the pitch out. Number 2 will acknowledge with a head nod.

To initiate the rejoin, the flight leader will rock his wings. After the wing rock, the flight leader will roll wings level for a straight-ahead rejoin or roll into a turn for a turning rejoin.

DESCRIPTION

The flight leader will signal, clear in the direction of the turn and then break away from the flight using 45° to 60° of bank. He will roll wings level after approximately 180° of turn. The wingman will modulate his turn so as to roll out directly behind the flight leader. The wingman should roll out at Lead's six o'clock, with Lead positioned just above the horizon. After a quick ops check and when ready for the rejoin, the wingman will call "in" ("Redstar 2, in").

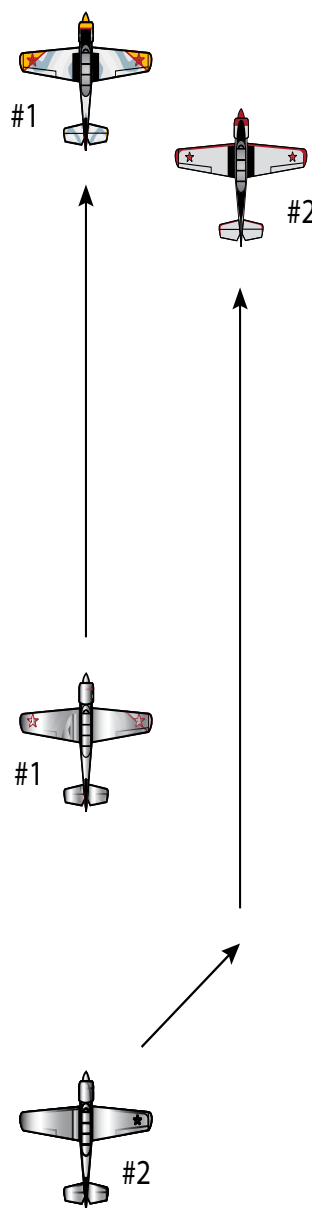
STRAIGHT AHEAD REJOIN

Once the wingman has called "in," the flight leader will rock his wings to initiate the rejoin and then roll wings level. Lead will have briefed or will call out the rejoin airspeed so that the wingman has an index speed to use for the rejoin. For straight ahead rejoins, #2 will rejoin based on the following priority: 1. to the side directed by Lead, 2. to the side previously vacated, if applicable, 3. to the left wing. The wingman will use power as necessary to gain an airspeed advantage of +10 knots or +10%, minimum. The wingmen will monitor closure and, after ensuring closure is stabilized, slide into fingertip position. Wingman should offset to the side because it is very difficult to judge distance and overtake looking at the knife edge view of Lead's aircraft from the dead 6 o'clock position.

Offsetting to gain an oblique view of Lead's aircraft equal to the very familiar distance of route position works very well. Select an aim point on the horizon equal to 2-4 apparent wingspans of Lead's aircraft and fly towards it. As the wingman closes, he should continuously update the aim point to correct for the apparent increase in Lead's wingspan. Doing so will place him at the normal route position distance giving him the familiar oblique view of Lead's aircraft.

If closure rate is excessive during a straight ahead rejoin, the wingman should reduce power, slip the aircraft, or do both to slow the overtake. If an overshoot is imminent,

the wingman will turn slightly away from Lead, keeping Lead in sight. The wingman will resume the rejoin when Lead begins to stop moving backwards across the canopy. If the overshoot will result in losing sight of Lead, the wingman will break out of the formation—clearing and turning away from the flight.



Straight Ahead Rejoin

1. Lead (#1) and #2 have rolled out in trail, following the pitchout.
2. Once Lead has signaled with a wing rock and rolled wings level, #2 picks an aim point on the horizon equal to two to four apparent ship-widths on the rejoin side of the leader and flies toward that aim point.
3. Lead will maintain a stable platform, holding altitude and briefed airspeed.
4. The wingman will monitor closure and offset to achieve a stable rejoin approaching route position.
5. If #2 determines his rejoin is stable, he then continues flying into the fingertip position.

TURNING REJOIN

There are four variables to master for the turning rejoin:

1. Altitude
2. Bearing line
3. Airspeed
4. Alignment

From the rejoining wingmen's perspectives, the references are:

- Altitude: keep the flight leader just barely above the horizon line.
- Bearing line: align the top of Lead's vertical stabilizer with the tip of Lead's outboard wingtip
- Airspeed: accelerate to rejoin airspeed plus 10 knots (or 10%)
- Alignment: align your fuselage with Lead's fuselage

Being below altitude during the rejoin (Lead too far above the horizon line) will have several detrimental effects. You will be performing a climbing rejoin, which requires more energy. You will force the wingmen behind you to fly even lower, in order to keep you in sight. Your flight path vector will be directed at Lead which complicates an under-run should one become necessary.

If you are forward of the bearing line (acute) the rejoin geometry is such that your rejoin can be accelerated to the point where an under-run is the only safe escape. Too far aft (sucked) will slow the rejoin down and create problems for the following wingmen as they try to slow down their own rejoins.

Of the two factors that control closure, G and true airspeed, your G is pretty much constant so airspeed becomes your controlling variable. Increasing your airspeed to rejoin plus 10 knots will expedite your rejoin.

Alignment is important because it is necessary for your aircraft to arrive at the fingertip position parallel to Lead.

TURNING REJOIN EXECUTION

Once the wingman has called in at the six o'clock position, the flight leader will rock his wings to initiate the rejoin and then begin a turn in either direction, using approximately 25° to 30° of bank. The flight leader will maintain a constant bank, a constant airspeed, and a constant altitude while the wingman maneuvers to rejoin.

If rejoin airspeed has not been briefed, or if Lead is not within 10 knots of the briefed rejoin airspeed, Lead will make a radio call announcing the airspeed.

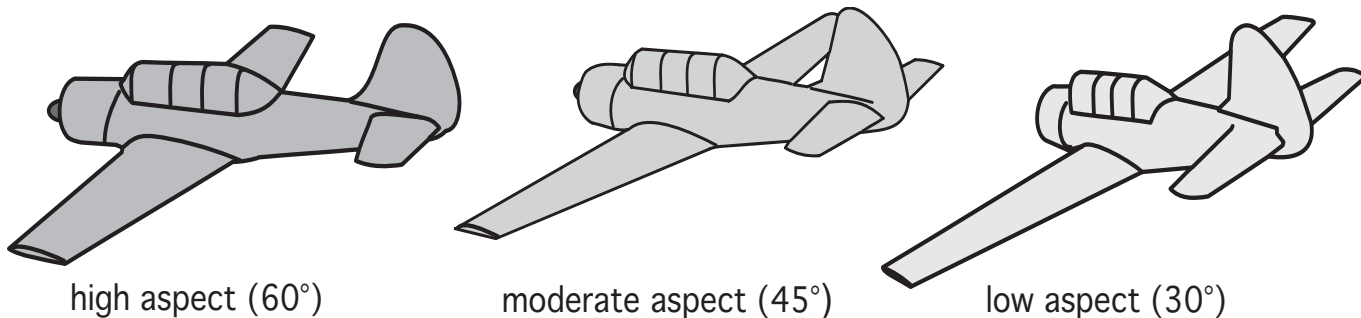
When the leader gives the rejoin signal and establishes the rejoin turn, execute as many of the following six steps, as required, to complete the rejoin. Flight leads should brief a break interval placing new #2 trainees inside the rejoin turn circle. However, extended break intervals, slow wingman counts, slow wingman pitch outs and mismatched speeds can place #2 outside the rejoin turn circle. For these reasons, new #2s must learn to start all rejoins at Step 1 and logically proceed through the 6 Steps. Prematurely pulling lead before getting inside the rejoin turn circle WILL quickly result in high aspect angle and an acute position relative to the bearing line. Continuing this rote #2 rejoin practice when starting from outside the rejoin turn circle will result in #2 having a fairly flat learning curve, a high frustration level, poor rejoin sight pictures, and poor outside the turn circle rejoins.

STEP 1

Push the power up to accelerate to +10 knots or 10% minimum, above the rejoin airspeed. Pick an aim point on the horizon where the leader started his rejoin turn and fly toward it.

STEP 2

Simultaneously, determine your position relative to the leader's turn circle (TC). To successfully and expeditiously complete a rejoin, you must get inside the leader's TC before beginning the rejoin. By observing the Leader's aspect angle, you can quickly and precisely determine your position. As the leader turns, if you see more and more of

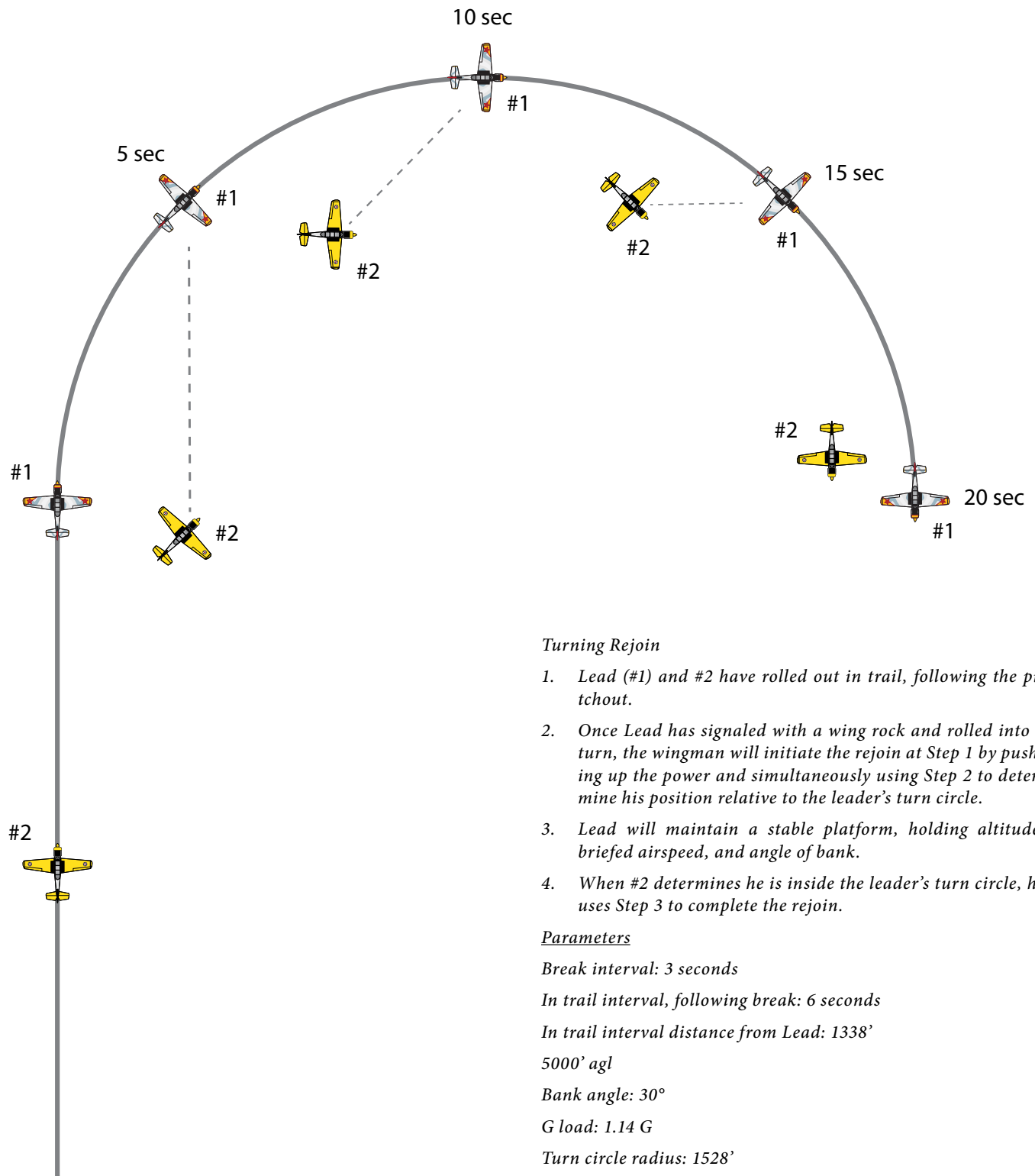


Moderate aspect, with the vertical fin aligned with Lead's outboard wingtip is the sight picture you are looking for throughout the rejoin. High aspect indicates you are forward of the bearing line (acute) and your rejoin can accelerate exponentially. Low aspect indicates you are behind the bearing line (sucked) and will delay your rejoin as well as the rejoins of the wingmen following.

the side of his aircraft, and a slow line of sight (LOS) rate, you are outside the TC. If you see a stabilized, low aspect angle (between 10° and 30°) and an increasing LOS rate, you are inside the leader's TC.

STEP 3

If you are inside the turn circle, begin the rejoin by rolling into the direction of Lead's turn and pulling your nose ahead of him into lead pursuit. Simultaneously, monitor your altitude to keep the leader slightly above the horizon throughout the rejoin.



Turning Rejoin

1. Lead (#1) and #2 have rolled out in trail, following the pitchout.
2. Once Lead has signaled with a wing rock and rolled into a turn, the wingman will initiate the rejoin at Step 1 by pushing up the power and simultaneously using Step 2 to determine his position relative to the leader's turn circle.
3. Lead will maintain a stable platform, holding altitude, briefed airspeed, and angle of bank.
4. When #2 determines he is inside the leader's turn circle, he uses Step 3 to complete the rejoin.

Parameters

Break interval: 3 seconds

In trail interval, following break: 6 seconds

In trail interval distance from Lead: 1338'

5000' agl

Bank angle: 30°

G load: 1.14 G

Turn circle radius: 1528'

120 knots KIAS / 132 KTAS

Note: the times given here are approximations intended to give you a sense of the flow of the rejoin.

Your lead pursuit turn will fly you toward the proper rejoin aspect angle and bearing line of 45°. Simultaneously, the leader's AA will also increase. For conventional straight wing aircraft and most jets, the 45° bearing line is reached when the leader's fin overlaps his outboard wing tip.

When this overlap occurs, adjust your bank and pull to stabilize yourself on this bearing line/rejoin aspect angle. Now, check airspeed and adjust power to maintain your desired rejoin airspeed. As you close on the leader, continue to bank, as required, to control the bearing line. For example, if a gap opens up between the fin and wing tip, you are pulling too much lead, you are going acute and the leader's AA is increasing. To fix this, decrease your lead pursuit by rolling into the leader/towards the bearing line, as required to move the fin back over the outer wing tip. Conversely, if the fin moves down the outer wing toward the wing root, you are not pulling enough lead, you are going sucked and the leader's AA is decreasing. To fix this, roll away from the leader and pull your nose more into lead pursuit as required to move the fin back up the outer wing to the overlap position. In both cases, anticipate the need to begin reducing your correction before you recapture the bearing line. This will prevent overshooting the proper bearing line position which would require another correction. Remember, bank controls the bearing line and you will always roll toward the bearing line to properly correct to it.

As you approach route position, you must determine if your rejoin is stabilized enough to continue into fingertip position. Your rejoin is stabilized if the following occur:

1. You are stabilized on the rejoin bearing line/aspect angle
2. Your bank angle is the same as the leader's
3. Your fuselage is aligned with the leader's
4. Your rate of closure is slow enough that you could either stop the rejoin or continue into the fingertip position

If you meet all these conditions, complete the rejoin by continuing into fingertip position.

STEP 4

If you are outside the turn circle, get inside the turn circle. Do this by continuing to fly toward the horizon aim point determined in step 2.

STEP 5

Once you determine you are inside the turn circle using the clues discussed in step 2, do an inside the turn circle rejoin as discussed in step 3.

STEP 6

If you are #3 or #4 in the formation (or are practicing #3 or #4 rejoins), as you approach route position and determine your rejoin is stabilized, cross under the leader to your corresponding position on the outside of the formation.

Number 2 will always join to the inside of the turn unless briefed otherwise. From a starting position inside the leader's 25°-30° bank turn circle, a proficient #2 should be able to complete the rejoin within 180° of turn.

PERFORMANCE GUIDELINES

- Flight leader will provide a stable rejoin platform by maintaining a constant altitude, airspeed, and bank angle.
- Wingmen will maintain proper airspeed, altitude, bearing line, and alignment throughout the rejoin

COMMON ERRORS

- Flight leader not maintaining a stable platform
- Wingman getting too low
- Wingmen becoming sucked and/or acute for prolonged periods of time because of inadequate corrections to the bearing line/rejoin aspect angle
- Wingmen not monitoring airspeed
- Wingmen failing to align their fuselage with Lead's

OVERSHOOT

An overshoot is just another formation skill. It is used when a wingman determines his rejoin is unstable and, in trying to salvage it, would violate one of the wingman's responsibilities. If you religiously adhere to the six-step guide to flying inside the turn circle rejoins, are well trained by your IP, and practice often, you will rarely need to fly an overshoot. However, blown rejoins will happen. Therefore, wingmen must learn, practice, and acquire this vital formation skill.

Think of an overshoot as the formation equivalent of a traffic pattern go around. Both are designed to safely extricate a pilot from an untenable situation.

The need to execute a go around or an overshoot rarely surprises a pilot. Both telegraph their need long before pilots reach the minimum safe execution point.

SIGNAL

There is no signal for an overshoot. However, once the wingman executes the overshoot he will make a radio call announcing the overshoot, when able (*"Redstar 2, overshooting"*).

DESCRIPTION

Recall that as wingmen approach route formation, they must evaluate the stability of their rejoin to determine if they will continue the rejoin, or overshoot. There are five warning signs that a rejoin is unstable, and these will be evident long before reaching route position:

1. Excessive closure, usually because of being too acute or having too much airspeed, or both
2. An excessively prolonged acute position relative to the rejoin bearing line
3. A noticeable misalignment of fuselages and/or bank angles
4. The need to excessively over bank into the rejoin turn in an attempt to align fuselages and reduce Vc, resulting in a high probability of losing sight of the leader.
5. A panicky, rushed feeling accompanied by hair standing up on the back of the wingman's neck

If, despite aggressive power reductions and corrections toward the bearing line, any or all of these conditions exist as the wingman approaches the route position, the wingman should abandon the rejoin and proceed with the overshoot. Simultaneously:

1. Reduce bank angle, as required, to pass below and behind the leader
2. Adjust power, as required
3. If/when able, transmit the overshoot to the leader (*"Redstar 2, overshooting"*). This is the only radio call required. Wingmen do not need to request permission to rejoin unless they break out of formation.

The airspace available for overshoot use includes all the co-altitude airspace on the outside of the leader's turn circle up to his 3/9 line—no higher than the echelon position and no farther forward than abeam Lead.

Just as a pilot would not rush a go-around to prematurely get back to final, an overshooting wingman **MUST NOT** over aggressively rush the overshoot to complete the rejoin. There is no clock running, no embarrassment, and no need to create a dangerous situation by rushing. A controlled, precise execution of overshoot procedures always results in a safe, expeditious rejoin.

CAUTION

Aggressively moving inside the leader's turn circle with excess energy could result in another unstable rejoin, leading to another overshoot.

The wingman will get the most expeditious rejoin by simultaneously controlling power and position outside of the leader's turn circle, dissipating the overshoot energy, and stabilizing as close to the leader as possible—at or slightly aft of the leader's 3/9 line.

This stabilized position will look similar to an echelon turn position, something all wingman are very familiar with. From here, the wingman can smoothly move to the echelon position, keeping in mind that as lateral spacing is reduced, power must also be reduced to move aft to the echelon position and reduce airspeed to slightly above Lead's. Once stabilized in echelon, the wingman now performs a cross-under back to the inside to complete the rejoin to the #2 position.

There are situations where using the cross-under technique is not the most expeditious way to rejoin. This is determined by the wingman's position relative to Lead, and energy state, following the overshoot. Wingman can dissipate too much energy during the overshoot by reducing power too much, or going too far outside Lead's turn circle, or ending up too far aft of Lead's 3/9 line. This would result in the wingman not being in a position, and without enough energy, to complete the rejoin via a cross-under. Anytime this happens, the wingman should immediately begin a controlled move back to the inside of the leader's turn circle, adjust airspeed as required, and recapture the bearing line to complete a normal, inside the turn circle, rejoin.

During training, the wingman will practice the overshoot procedure to gain judgment and confidence. The instructor will have him carry extra airspeed and cutoff during the rejoin to make the overshoot realistic. The trick is to retain enough energy after the overshoot to move back to the inside of the turn without getting sucked. The wingman should use caution, though, not to pass directly beneath Lead when moving to the inside. If he has too much

energy when moving down and to the inside of the turn, another overshoot may be necessary.

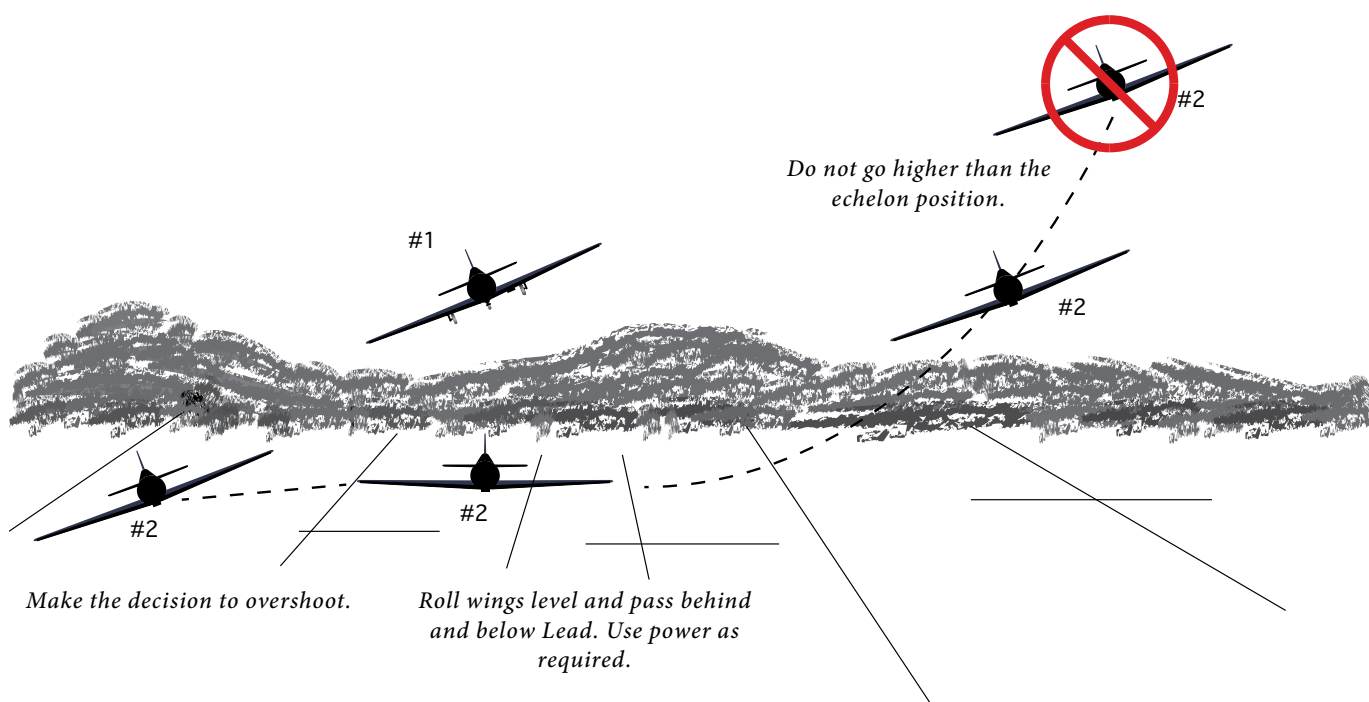
If the rejoin stagnates and/or the wingman gets sucked prior to getting into position, he will move back to the inside of Lead's turn, advance power as necessary, and get back on the bearing line to complete the rejoin.

PERFORMANCE GUIDELINES

- Wingman will recognize the excess closure in a timely manner and in a smooth, controlled maneuver, execute the overshoot.
- Wingman will move to the outside of the turn without going forward of, or higher than, Lead

COMMON ERRORS

- Not recognizing excessive closure
- Flying to an elevation position higher than Lead
- Flying to a lateral position forward of Lead's 3/9 line
- Not making a radio call advising Lead of the overshoot
- Failing to stabilize the overshoot allowing excessive nose/tail separation to develop
- Prematurely and aggressively moving to the inside of the leader's rejoin turn circle resulting in another unstable rejoin and overshoot



CHAPTER 5

RECOVERY

Formation recoveries are performed as either single-ship landings or element landings.

SINGLE-SHIP, INTERVAL LANDING

Single-ship, interval landings may be necessary on a narrow runway, in strong crosswinds, or in other situations. If traffic, or bird activity, is a factor, Lead may decide to put the flight in route or trail for safety. As there are several ways a flight can take appropriate spacing in the pattern, this is normally pre-briefed. We will cover a few of the methods.

360° OVERHEAD PATTERN

The 360° overhead pattern is an efficient way to get a formation flight on the ground. An overhead pattern involves flying an upwind leg aligned with the landing runway centerline at pattern altitude (called “initial”), followed by a level “break” turn (pitch-out) to the downwind, typically executed when over the runway numbers. The downwind leg is followed by a descending, turning base to final approach. This pattern allows the pilot to bleed off airspeed once on the downwind leg in preparation to configure for landing, just prior to the perch point. This also keeps the aircraft relatively close to the runway.

Approaching the runway, Lead will configure the flight in echelon for the traffic pattern in preparation for the overhead break. For Yak/CJ, or other similar piston engine aircraft, Lead will fly initial at 1000’ agl and 120 knots. The standard break interval (BI) is five seconds. Leaders may brief other BIs, as required. On initial, leaders may also change the BI by hand signal or radio call. Lead will typically break over the numbers, using a maximum of 45° of bank (less bank angle for overshooting winds), but can adjust the break point to compensate for winds or as directed by a tower controller. Each pilot then takes his interval and breaks so as to roll out on downwind behind the preceding aircraft at 1000’ agl, while slowing to 90 kts (Yak/CJ type aircraft). Lead will maintain traffic

NOTE

The perch position is the point on downwind, at traffic pattern altitude, at which Lead starts the descending turn to final. The perch position can shift upwind, downwind or laterally, depending on wind conditions, traffic congestion or other mitigating factors. In a no-wind condition, the perch will typically be located 30° to 45° beyond the runway threshold. With increasing headwinds, the perch will shift closer to a point abeam the numbers. Overshooting crosswinds will shift the perch position farther away from the runway.

pattern altitude and airspeed on downwind until reaching the “perch” position—normally 30° to 45° beyond the intended point of landing. For lateral reference, Lead will fly downwind such that the nearest edge of the runway cuts across the inboard wing approximately $\frac{1}{3}$ inboard from the wingtip, but no less than $\frac{1}{2}$ inboard from the wingtip. Lead will extend landing gear and flaps as he approaches the perch and, at the perch, begin a descending turn to final.

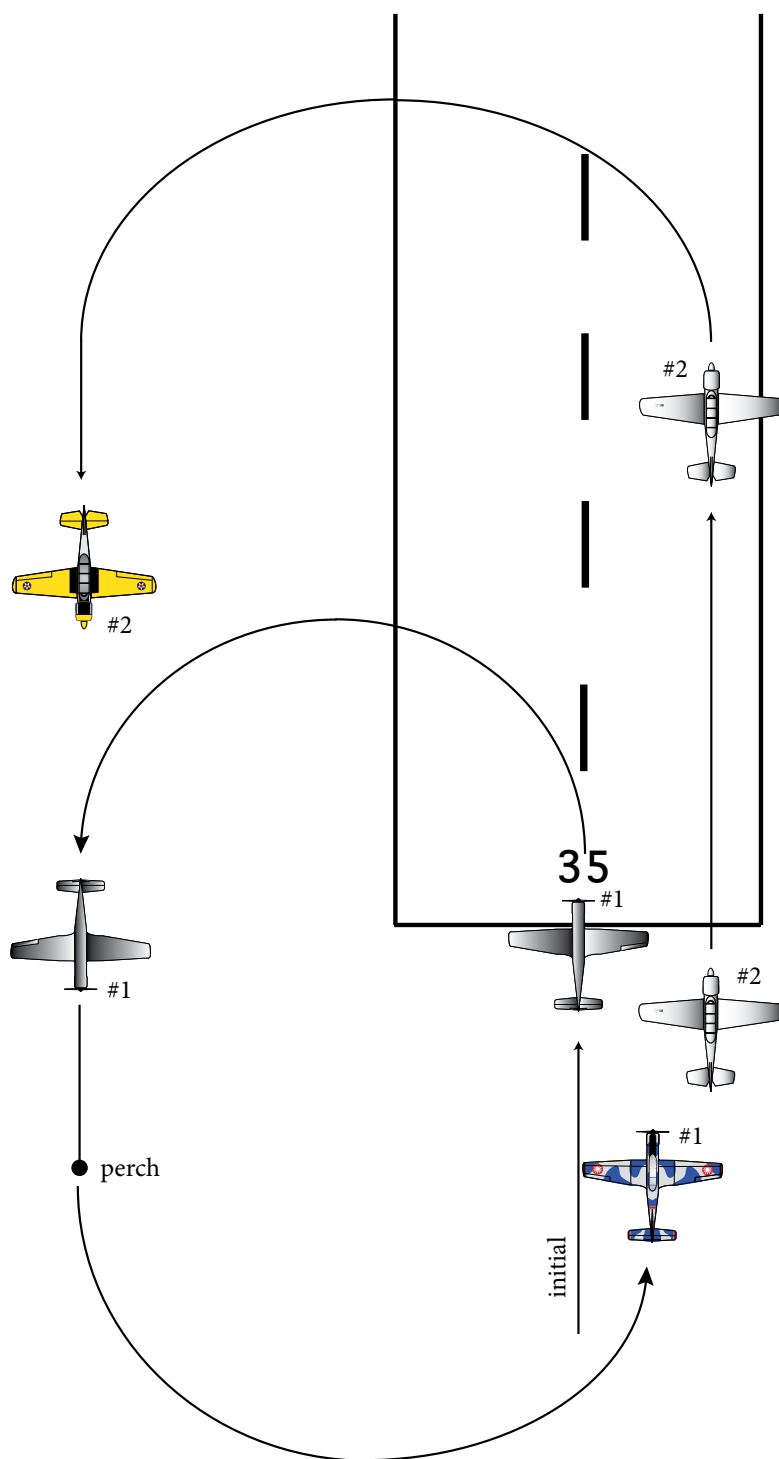
Lead’s objective is to adjust the perch point to allow for a base turn to final that results in rolling out wings level on final, $\frac{1}{2}$ to $\frac{3}{4}$ of a mile from the threshold, on a 3° to 4° glide path (approximately 150’ to 250’ agl).

Lead will vary the pitchout bank angle, downwind leg position, downwind crab angle and turn to final to compensate for misalignment on initial, cross winds, and high density altitudes. Lead will roll out on final, lined up on the center of the side of the runway of intended landing. The bank angle in the final turn should not exceed 45° of bank and, if it does, especially in the last 90° of turn, the pilot should seriously consider going around. In this situation, do not worry about ground track—it is more important to increase stall margin than to roll out in line with the runway.

WARNING

With overshooting crosswinds, the danger of inducing an accelerated stall is significantly increased if the pilot attempts to salvage an overshoot of the runway during the base turn.

Each wingman will adjust power in the break to maintain 120 knots and roll out on downwind directly behind the aircraft ahead at 1000’ agl. When wings level on downwind, the wingmen will slow to 90 knots (if there are wake turbulence issues, the wingmen can offset slightly to find smooth air). Wing pilots will maintain traffic pattern altitude and airspeed all the way to the perch and, approaching the perch, extend gear and flaps and accomplish the “before landing checklist.” Upon reaching the perch, the wingman will begin a descending turn to final. The wingman will not begin the base turn unless the aircraft ahead is in sight. It is important for the wingman to positively identify the aircraft in front of him to preclude cutting an aircraft off in the final turn. Each wingman will fly his pattern based on the interval established by #2 but in no case will they land with less than the minimum safe interval. The wingman should not become so distracted that he fails to complete his before landing checklist!



NOTE

The perch position for the wingman may not necessarily be located at the same point as Lead's perch position, depending on the break interval. For example, a two second break would not provide adequate spacing on final if the wingman used Lead's perch point. In this case, the wingman would have to extend his downwind to a perch point three seconds or more beyond Lead's perch.

360° Overhead Pattern

Lead

1. Lead (#1) flies 120 knots on initial at 1000' agl. Using a 5-second break, Lead pitches out to downwind, using a maximum of 45° of bank (less bank for overshooting crosswinds).
2. Lead rolls out on downwind, at traffic pattern altitude and slows to 90 knots, placing the runway under the wing, approximately $\frac{1}{3}$ inboard from the wingtip (no closer than $\frac{1}{2}$ inboard). Approaching the perch, Lead extends landing gear and flaps.
3. At his perch point, Lead begins the descending, turning, base to final turn.
4. Lead rolls out on final $\frac{1}{2}$ to $\frac{3}{4}$ mile from the threshold on a 3° to 4° glide path (approximately 150' to 250' agl).
5. Lead lines up on the center of the half runway that corresponds to exit side (cold side).
6. Lead lands, rolls out either to an appropriate intersection or the end of the runway.
7. Once clear of the runway, Lead stops and waits for wingman for taxi back, if appropriate.

Wingman

1. Wingman (#2) continues tracking straight ahead until reaching his break interval time.
2. Wingman pitches out to downwind, adjusting bank angle so as to roll out directly behind Lead, at 1000' agl, and slows to 90 knots.
3. Wingman maintains traffic pattern altitude and airspeed and, approaching the perch, extends landing gear and flaps.
4. At the perch point, the wingman begins the final turn if he has the preceding aircraft in sight and has the proper minimum/desired spacing.
5. Wingman rolls out on final at the appropriate interval from Lead and lines up on center of opposite half of runway from Lead.
7. For hot/cold side procedures, the wingman slows to taxi speed and then moves to the cold side (exit side of runway).
8. For staggered landing procedures, in 3-ship or 4-ship, each wingman will slow to taxi speed and, those on the non-exit side, will wait for radio clearance from the aircraft behind before crossing to the cold side (call from Bigdog 3: "Redstar 2, cleared to cross").

NOTE

The trail interval (TI) is equal to two times the break interval. Thus, a five second break will produce a ten second trail interval on downwind.

The wingmen's objective is to adjust their base turn to achieve a safe interval for landing—1500', minimum, 2000' desired. This equates to 10 seconds, minimum, 14 seconds desired, for aircraft with a final approach speed of less than 100 knots. For aircraft with approach speeds exceeding 100 knots, 3000', minimum, is the recommended interval (15 second spacing).

If the wingman does not have adequate spacing, he will execute a go-around.

L-39 Traffic Pattern Speeds

downwind/gear	180 kts
flaps	160 kts
base	140 kts
final	120 kts
touchdown	100 kts

GEAR CHECK RADIO CALL

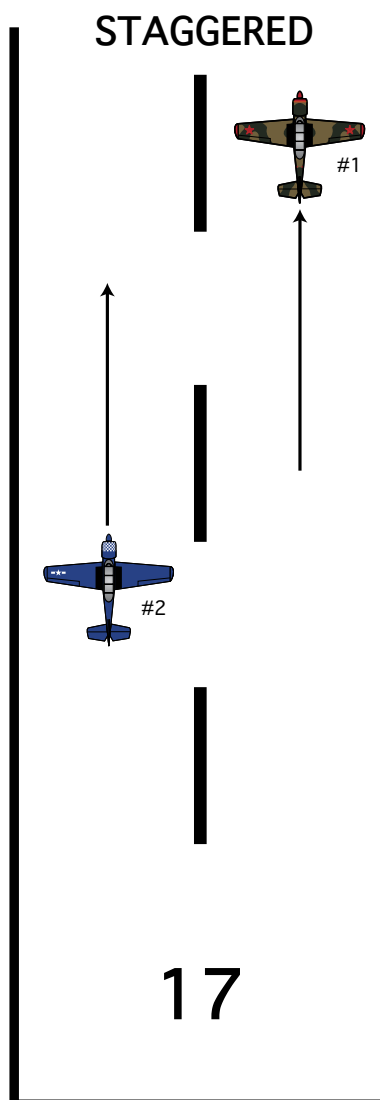
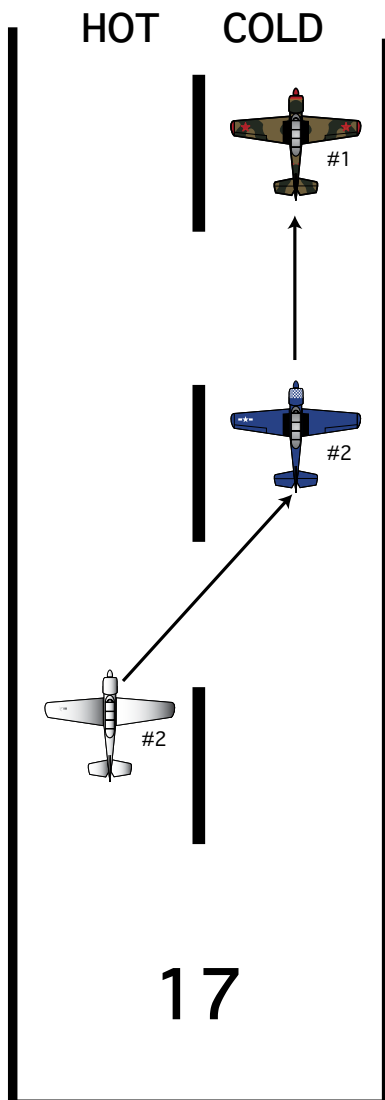
Because of the inherent distractions associated with formation flying, we add one extra component to the traffic pattern call that provides us with an extra layer of safety. To the standard call that identifies who we are, where we are and what our intentions are, we insert a gear check. Once the pilots have confirmed that they are fully configured for landing, they will make a confirming radio call:

"Redstar 1, left base, gear down, full stop runway 35"

"Redstar 2, left base, gear down, full stop runway 35"

HOT/COLD LANDING

For "hot/cold" side landings, Lead will normally land on the side of the runway that corresponds to the runway exit (cold side). Each wingman will land on the opposite side from Lead (hot side) and, once slowed to a reasonable taxi speed, cross over to the cold side.



HOT/COLD

1. Lead (#1) will typically land on the exit (cold) side of the runway.
2. The wingman will land on the opposite side, the hot side, and once slowed to a safe taxi speed, transition to the cold side for exit behind Lead.

STAGGERED LANDING

1. Lead (#1) will typically land on the exit (cold) side of the runway.
2. The wingman will land on the opposite (hot) side of the runway from Lead.
3. The wingman will slow to a safe taxi speed and once he has reached the exit point, will exit the runway behind Lead.

NOTE

The spacing achieved in the break from initial to downwind will not always be the desired interval for landing. If this occurs, wingmen will maintain the downwind airspeed and create the desired landing interval by adjusting the turn from downwind to final.

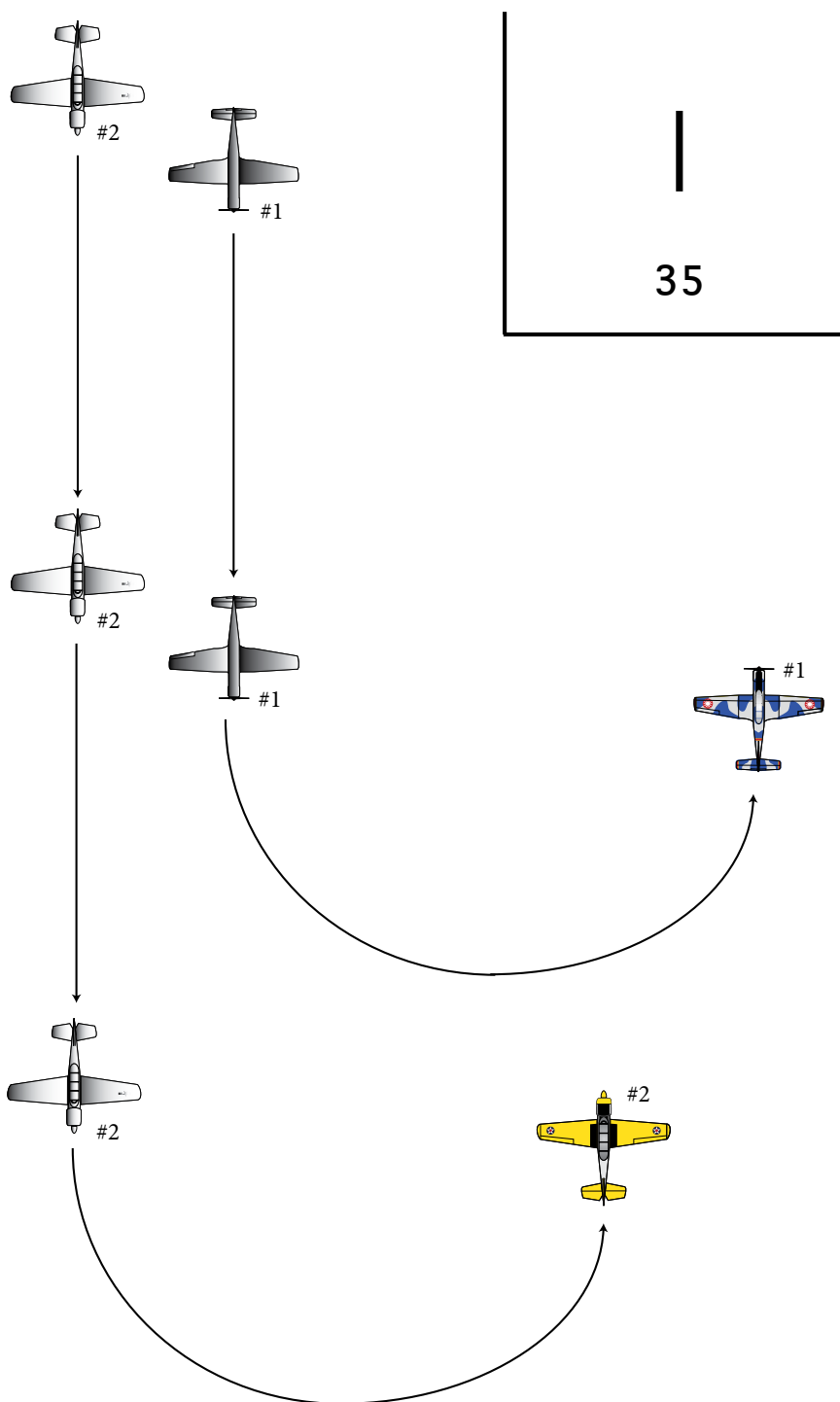
STAGGERED LANDING

For staggered landings, Lead typically lands on the exit (cold) side of the runway and exits at an appropriate intersection or at the end of the runway. Each wingman lands on alternating sides of the runway and then taxis to Lead's exit point, unless otherwise briefed. Wingmen will not cross in front of a following aircraft until cleared to do so by that aircraft. For example, if #4 was on landing rollout, under control with adequate spacing and at a safe

speed, he would call "Redstar 3, cleared to cross" and #3 would know it is safe to cross in front of #4.

DOWNWIND BREAK

If a 360° overhead is not feasible, another way to take spacing is on the turn to base leg. This is also known as the "downwind break." Lead will configure the flight in echelon and slow the flight to normal pattern airspeed by downwind. If the downwind break was not pre-briefed,



Downwind Break

Lead

1. Lead maneuvers the flight onto the downwind leg and configures the flight in echelon, if not already in echelon.
2. Lead signals for the break interval.
3. When Lead has appropriate spacing on the runway, he turns away from the flight, configures for landing, and lines up on final.
4. Lead descends so as to roll out $\frac{1}{2}$ to $\frac{3}{4}$ mile from the threshold on a 3° to 4° glide path (approximately 150' to 250' agl).
5. Lead lines up on the center of the half runway that corresponds to the exit (cold) side.
6. Lead lands, rolls out as briefed to an appropriate turn off, or to the end, and exits the runway.
7. Once clear of the runway, Lead stops and waits for the wingman for taxi back, as appropriate.

Wingman

1. Wingman maintains downwind altitude and airspeed until signaled interval elapses.
2. At the signaled interval, the wingman executes a turn to final, adjusting bank angle so as to roll out lined up on center of opposite half of runway (hot side) from Lead.
3. Wingman maintains traffic pattern altitude until he intercepts a 3° to 4° glide path to landing.
4. After landing, wingman slows to taxi speed and then moves to the cold side (exit side of runway).
5. For staggered landing procedures, in 3-ship or 4-ship, each wingman will slow to taxi speed and, those on the non-exit side, will wait for radio clearance from the aircraft behind before crossing to the cold side (call from Redstar 3: "Redstar 2, cleared to cross").

Lead will call:

“Redstar 1, take spacing on the turn to base.”

Lead will turn away from the flight from downwind to base, when appropriate—the minimum downwind break interval is five seconds. After the proper interval is achieved, each wingman will turn to base. As each pilot starts the base turn he will reduce power, lower the gear, extend the flaps and complete the before landing checklist. Wingmen will land on alternating sides of the runway or use the hot/cold procedure, as briefed, following the same procedures used in the 360° overhead pattern.

360° OVERHEAD GO-AROUND AND DOWNWIND BREAK GO-AROUND

If any pilot has to execute a go-around, that pilot is considered to be single-ship and no longer part of the formation. The pilot will follow normal go-around procedures, clear for traffic and re-enter the traffic pattern.

ELEMENT LANDING

For multiple-element formations, the flight leader will break the flight into separate elements for element landings. Each element Lead will fly a standard, VFR, rectangular pattern. If conveniently aligned, a straight-in approach may also be flown.

The flight leader will normally position the wingman on the upwind side of the runway when crosswinds are greater than five knots. If wind is not a factor, the wingman should be placed on the outside of the turn, in the event of a go-around. If neither of these apply, Lead can place the wingman on the side opposite the runway exit point so Lead does not have to cross in front of the wingman.

Lead will turn base, allowing enough distance to turn a one to three mile final. Upon turning final, the flight leader will line up on the appropriate side of the runway.

Lead will slow the aircraft on final to configure with gear and flaps for landing and then fly a stable, on-speed approach to the flare.

Lead will intercept a 3° final approach path to a touchdown point 500' to 1000' beyond the runway threshold.

The wingman will stay in the standard, fingertip position until fully configured. The wing pilot will then move up to stack level with Lead (Lead's head on the horizon), move out to establish a minimum 10' wingtip separation and move forward to the same acute position utilized for formation takeoffs. When the wingman sees the overrun, other runway end identifiers, or the runway itself in his peripheral vision, he should take one quick glance to make sure he will land on the runway. With this confirmed, the wingman must then concentrate 100% on flying perfect formation off the lead. The wingman must be ready to match lead's flare and power reduction. He must

be ready for the touchdown ensuring he maintains directional control, a minimum of 10' wingtip separation, and remains behind the lead's 3/9 line. The only way to make consistent, safe formation landings is concentrate on lead and fly formation.

If the wingman has any doubt about landing on the runway, he should immediately execute a normal, single ship go around. In the flare, Lead will make a smooth power reduction to just above idle power. During rollout, Lead will use normal braking techniques to gradually slow the element to taxi speed.

The wingman will continue to fly off Lead during the flare and landing. The wingman should touch down slightly before, or at the same time, as Lead. If the wingman touches down after Lead, it is likely that he will “float” past Lead on the runway. After touchdown, the wingman will maintain relative position on his side of the runway and begin normal braking. If the wingman does pass Lead on the runway, he will immediately look forward, continue straight ahead and maintain his side of the runway and make no attempt to slide back into position behind Lead.

If Lead must cross the runway centerline in front of the wingman to exit, #2 must ensure that he has safe spacing, safe speed and is under control before making the call:

“Redstar 1, cleared to cross.”

ELEMENT GO-AROUND

If a go-around is required, Lead will announce his intentions on the radio (*“Redstar 1, flight of two, going around”*), smoothly advance power to a setting that is appropriate for the go-around, yet still allows a safe margin for the wingman. When stabilized and no longer descending, Lead can call or signal for flap retraction, as appropriate to aircraft type. When a positive rate of climb is established, Lead can call or signal for gear retraction.

The wingman, upon hearing the go-around call, will anticipate the maneuver, add power and take appropriate measures to maintain a normal element takeoff position, reconfiguring the aircraft as directed by Lead.

Maintaining aircraft control is more important than maintaining position. If the wingman cannot maintain formation position, he should fly a single-ship go-around, while being careful to maintain separation from Lead and other aircraft in the pattern.

TAXI IN AND SHUTDOWN

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

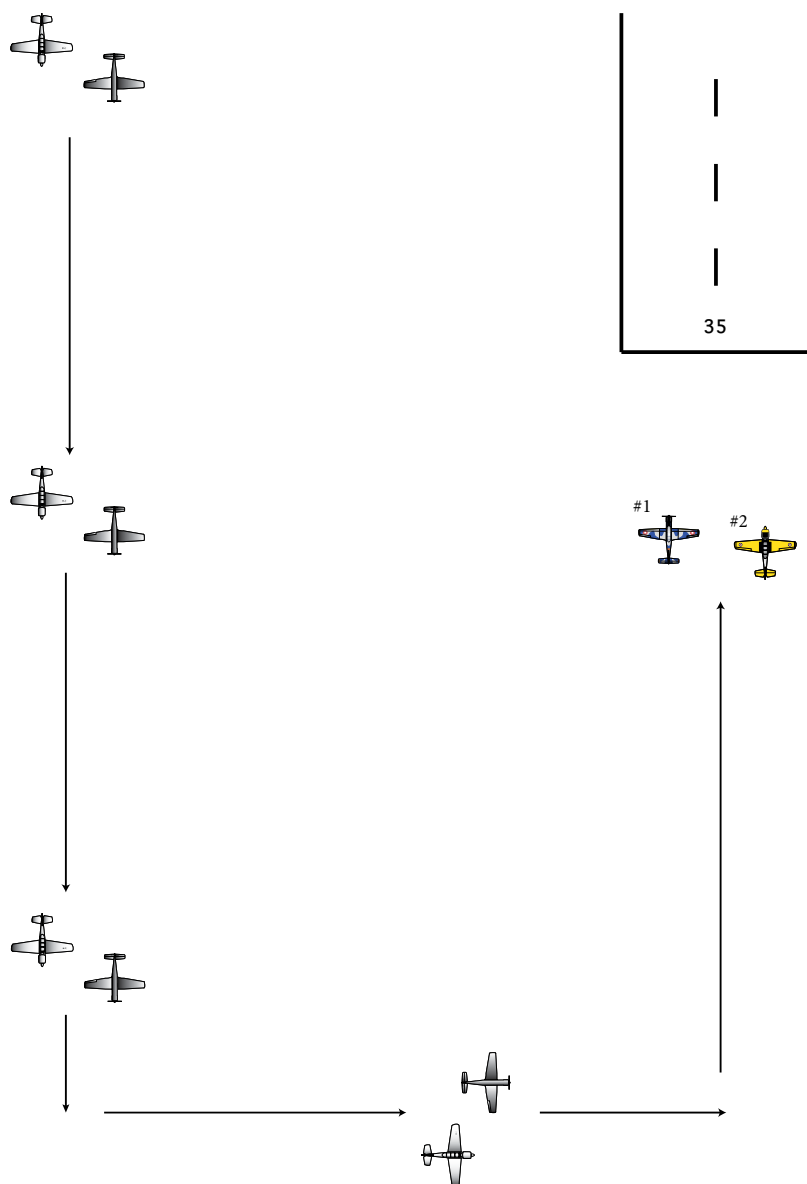
If parking together, the flight can shut down together. If conditions permit (i.e. no aircraft, people, or obstructions behind the formation), Lead will signal to perform

the pre-shutdown run-up, if required. On Lead's signal, run power up to the briefed power setting (radial engines). Reduce to idle on Lead's signal (hand held up, palm open, motioning rearward). Lead will then give a slashing sign across the throat followed by an exaggerated head nod. Wingmen will shut engines down when Lead's chin hits his chest.

DEBRIEF

The flight members will assemble for the debrief at the appointed time and place. The goal of the debrief is to improve safety, performance, communication, and understanding.

Lead (or the Check Pilot) will direct the debrief. The debrief should be instructional with emphasis placed on the "what, why and how"—what happened, why it happened and how to improve performance. All aspects of the flight are critiqued. Following the flight leader's analysis, he will solicit inputs from the individual flight members. Lead cannot possibly observe every single aspect of the entire flight so it is important to hear everyone's perspective. Make sure all questions are answered and uncertainties are resolved. Although seldom will a formation flight go as well as hoped, learning will always take place.



Element Approach

Lead

1. Lead flies a standard, VFR, rectangular pattern and maneuvers the flight onto the downwind leg.
2. Lead turns base allowing enough distance to provide for a one to three mile final.
3. Lead lines up on the appropriate side of the runway.
4. Lead slows the formation and signals for gear and flap extension.
5. Lead flies a stable, on-speed approach to the flare.
6. Lead intercepts a 3° final approach path to a touchdown point 500' to 1000' beyond the runway threshold.
7. In the flare, Lead makes a smooth power reduction to just above idle.
8. During rollout, Lead uses normal braking techniques to slow the element to taxi speed.

Wingman

1. Wingman maintains standard fingertip position until fully configured.
2. Once configured, the wingman moves out, minimum 10' lateral wingtip separation, forward to the acute position and stacks up, level with Lead.
3. Over the overrun or with runway end environment in sight, take one quick look ahead to confirm runway alignment. Then, concentrate 100% on flying perfect formation on the leader.
4. The wingman will match the leader's flare and power reduction to land with him maintaining a minimum of 10 feet wingtip separation. wingman will typically touchdown slightly ahead or at the same time as the leader.
5. During the rollout, use normal braking to maintain relative formation position and minimum wingtip separation.
6. If Lead must cross the runway centerline in front of the wingman to exit, #2 must ensure that he has safe spacing, safe speed and is under control before making the call "Redstar 1, cleared to cross."

CHAPTER 6

4-SHIP MANEUVERS

When you move into 4-ship formation, there is a significant change in the dynamics of the flight—far more than you might expect would occur by simply adding additional aircraft. Everything, from communication to maneuvering, becomes more complex. Be prepared to ramp up your flight discipline and situational awareness another notch or two.

ENGINE START

Three or 4-ship flights will use the same engine start procedures as a 2-ship flight.

TAXI

Using uniform spacing, wingmen will depart the chocks and taxi, as briefed, behind the preceding aircraft, in flight order. Normally two to four ship-lengths is adequate spacing. Number 2 will set the spacing behind Lead with #3 and #4 matching #2's interval. If Lead taxis on the centerline, the wingmen will follow suit (excepting S-turning tail-draggers). If Lead offsets from the center of the taxiway, wingmen will offset in an alternating pattern (except tail-draggers).

Reaching the run-up area, wingmen will try to line up in echelon, or in a position where they are visible to Lead. The flight performs the run-up either simultaneously on Lead's command (same visual signal as for start) or individually, as briefed. When ready for takeoff, pass a "thumbs up" signal up the line to Lead.

RUNWAY LINEUP

Depending on runway width, winds, weather, or local requirements, the flight leader can use one of four options:

ELEMENTS IN TRAIL

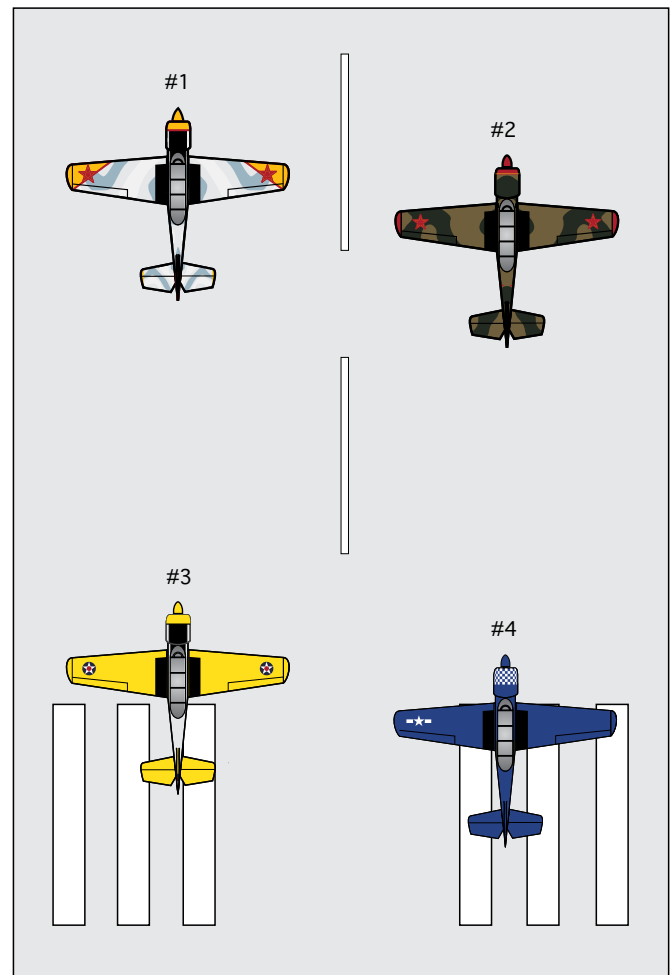
Used on any runway width to as narrow as 65 feet. The trailing element is spaced from 100-500 feet back. For large piston, turboprop, or jet engine aircraft, spacing should be increased to approximately to 500 feet.

ELEMENTS IN OFFSET TRAIL

Used on any runway width 75 feet or greater. The trailing element is spaced from 100-500 feet back. For large piston, turboprop, or jet engine aircraft, the spacing should be closer to 500 feet if the offset is close to in-trail with the first element.

NUMBER 4 IN THE SLOT

Used on any runway width 100 feet or greater. The trailing element is displaced slightly aft of the normal fingertip position, offset from #2. The leader lines up as close to the runway edge as comfortably possible. Number 2 lines up with the normal 10 feet wing tip separation. Number 3 lines up on #2, slightly aft, in normal fingertip posi-



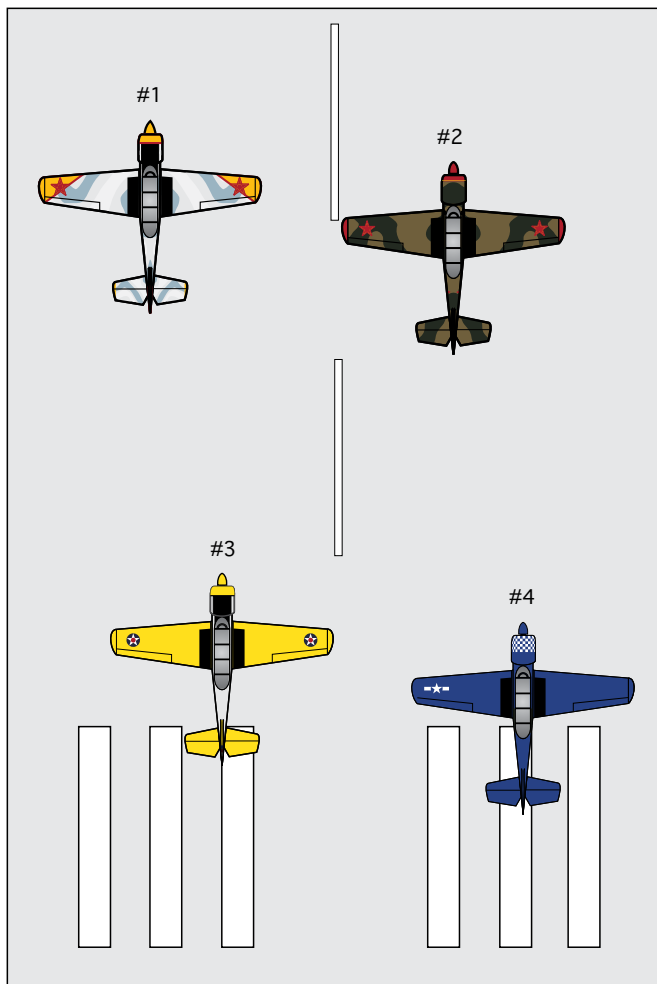
*Elements in trail, 100' to 500' spacing between elements
Single-ship takeoff for runways less than 75' wide*

tion. Number 4 lines up in the slot between #1 and #2 in normal formation takeoff position on #3. Number 4 must ensure the pilot in #3 is in sight.

ECHELON

Used on any runway width 150 feet or greater when doing single ship takeoffs. The leader lines up as close to the runway edge as comfortably possible. All aircraft line up using normal fingertip spacing. On takeoff roll, all aircraft correct to the runway centerline.

When doing formation takeoffs, #2 and #4 will line up with 10 feet of wingtip separation. Number 3 lines up on #2 using normal fingertip spacing. On takeoff roll, both elements correct to the runway centerline.



Elements in offset trail, used on runways 75' or wider, the trailing element is spaced from 100' to 500' behind the lead element

TAKEOFF

Takeoff can be performed in two-ship elements or single-ship, interval takeoffs.

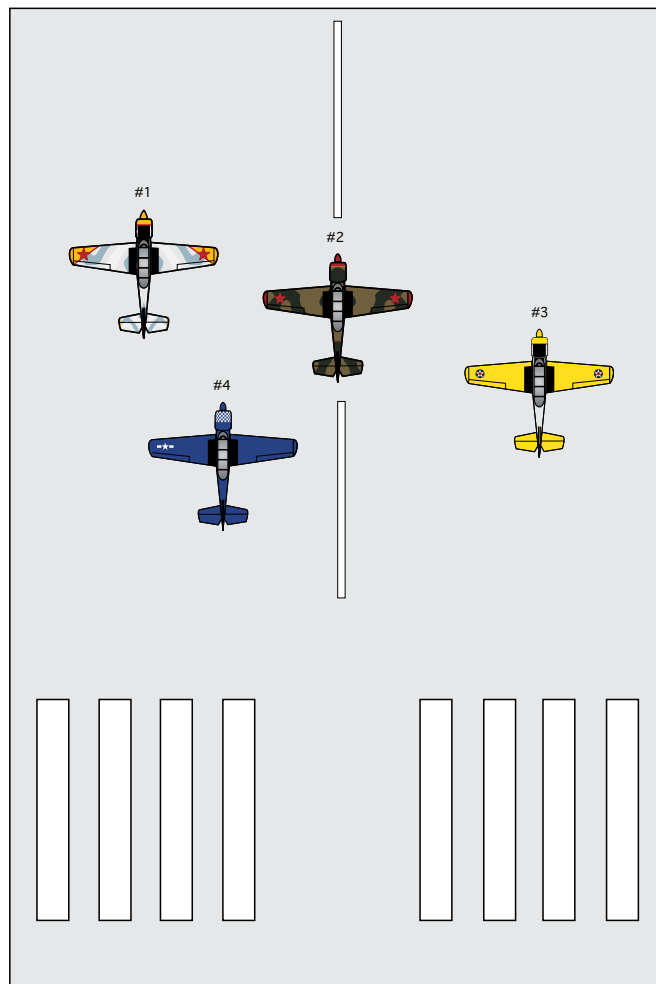
INTERVAL TAKEOFF

For single-ship, interval takeoffs, Lead may decide to assemble the formation on the runway prior to brake release or allow aircraft to roll onto the runway individually and initiate the takeoff without first assembling the flight in position. In either case, wingmen will begin takeoff roll when the preceding aircraft is airborne or the minimum takeoff interval has been achieved, however briefed. The wingmen will then proceed with a normal, full-power takeoff.

ELEMENT TAKEOFF

For an element takeoff, Lead will taxi into position, allowing enough room for the following element. The takeoff procedures are identical to those described in the previous chapter for 2-ship element takeoffs.

Subsequent elements will perform individual formation takeoffs. Element leaders will wait until the preceding aircraft become airborne, or the minimum takeoff interval has been achieved, before brake release.



Number 4 in the slot, used on runways 100' or wider

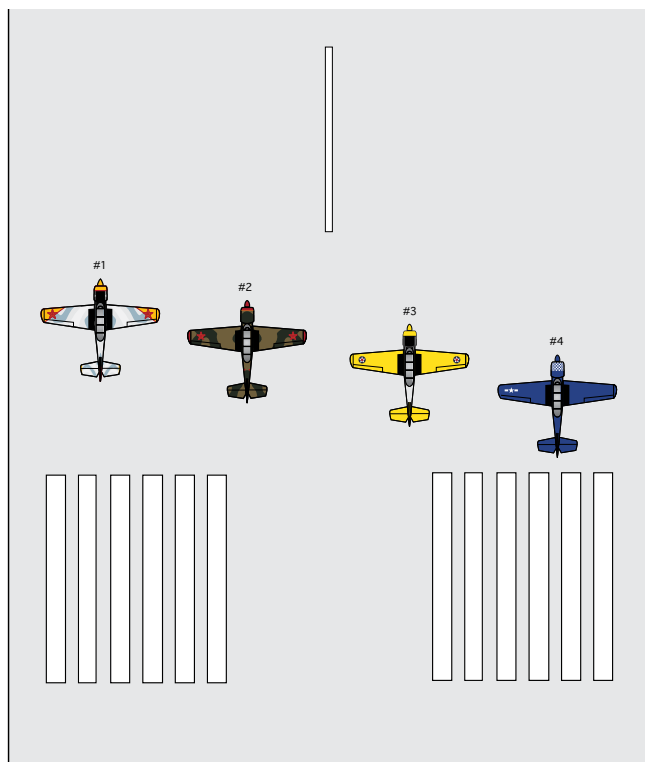
If the runway is wide enough, a 3-ship vic takeoff can be performed. The procedure is identical to an element takeoff, except Lead will line up on the centerline and there will be a wingman on either side of Lead.

This same procedure can be executed with a 4-ship formation with #4 lining up on the centerline, behind Lead. The 3-ship vic will takeoff and then #4 will follow, using the briefed takeoff interval.

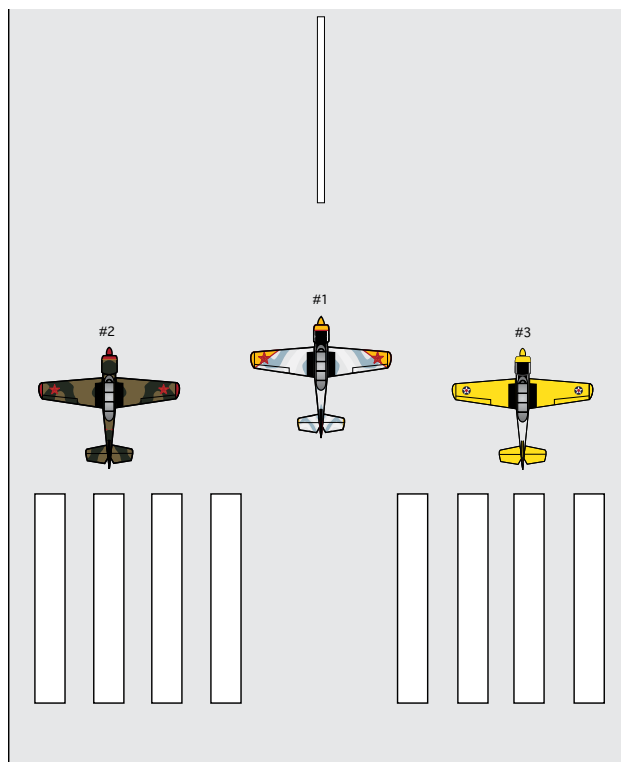
REJOIN AFTER TAKEOFF

Whether performing single-ship or multiple-element takeoffs, the formation will have to join up once safely airborne. It's important to brief this thoroughly since local conditions and mission requirements will likely dictate the type of rejoin used. Rejoins can be done in a turn, straight ahead, or some combination of the two.

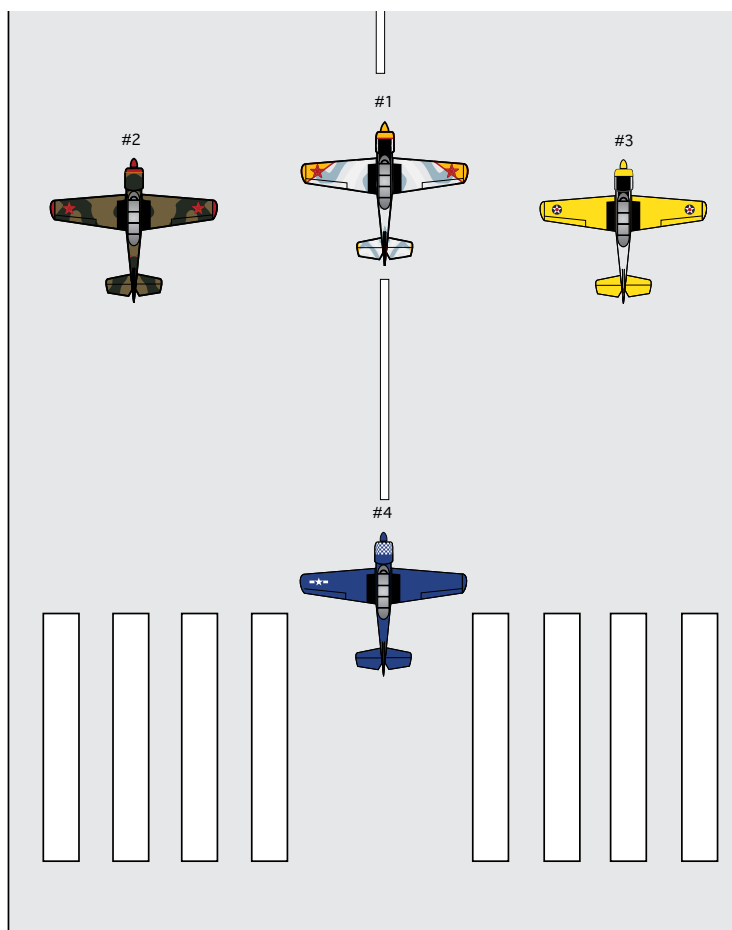
When performing turning rejoins, #2 will always join to the inside of the turn. With a second element, #3 and #4 will always join to the opposite side of #2, on the outside of the turn.



Echelon lineup, used on runways 150' or wider



3-ship vic runway lineup



Three-ship vic runway lineup with #4 in the slot. Once the vic has lifted off, #4 will begin its takeoff roll.

WING-WORK

Training in the lazy-eight maneuver will continue in 4-ship. As with 2-ship, initially, you will practice at shallow bank and pitch angles, progressing to a wide variety of attitudes and airspeeds and eventually achieving up to plus or minus 20° of pitch and up to 45° of bank.

DESCRIPTION

In a 4-ship fingertip turn, with aircraft on both sides of Lead, the outside aircraft will stack up while the inside aircraft will stack down. You will also practice wingwork in a variety of formation configurations, including close trail and diamond.

PERFORMANCE GUIDELINES

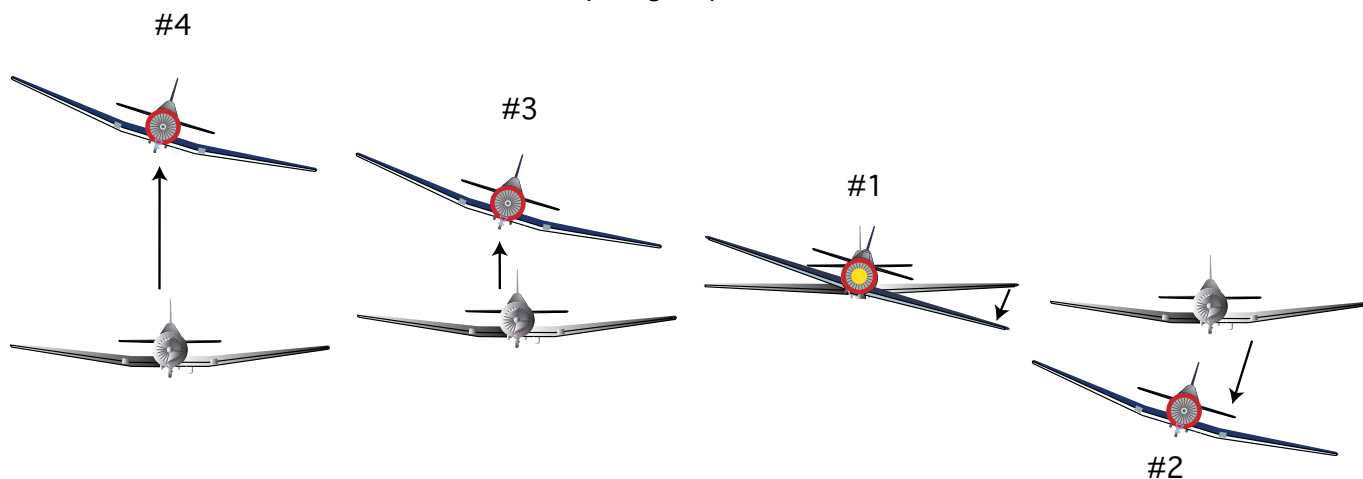
- Lead will provide the wingmen with a stable platform and maneuver smoothly
- Lead will not exceed the capabilities of the least proficient wingman in the flight
- Wingmen should be able to recognize when they are out of position and anticipate pitch, bank and power requirements

- Wingmen should make timely corrections to maintain position within reasonable tolerances

COMMON ERRORS

- Not recognizing when out of position
- Not anticipating power, pitch and bank requirements in a timely manner
- Getting sucked in turns away and acute in turns into the wingman
- Stacking too low
- Stacking too high

4-ship fingertip turn into #2



CROSS-UNDER

Executing a cross-under from 4-ship fingertip will result in an echelon configuration.. Element integrity is always maintained, so #4 will stay with his element Lead, #3, during the cross-under.

SIGNAL

The hand signal for the second element to cross-under is a double pump, up and down, of a clenched fist. The aircraft signal is a distinct, rapid, shallow wig dip away from the element, in the direction of the cross-under.

The hand signal for #2 to cross-under is a clenched fist held up vertically. Lead will first signal #3 with a raised, clenched fist to signal #3 to make room for #2. The aircraft signal is a distinct, rapid, shallow wing dip away from #2 in the direction of the cross-under.

DESCRIPTION

The element cross-under is executed by #3 with #4 on his wing. As #3 crosses Lead's six o'clock position, #4 will cross #3's six o'clock position and continue the cross-under into position. This allows #4 to keep all the other aircraft in sight as he executes the cross-under. As with the 2-ship cross-under—the cross-under is not a race to the opposite side, it is a deliberate, controlled and precise repositioning of aircraft.

Element Cross-Under

1. Fingertip, strong right: Lead signals #3 with the double pump of a clenched fist or wing dip, indicating to #3 that he should cross his element to the opposite side.

2. #3 moves his element down, back and across—#4 moves to #3's six o'clock position as #3 moves to Lead's six o'clock position.

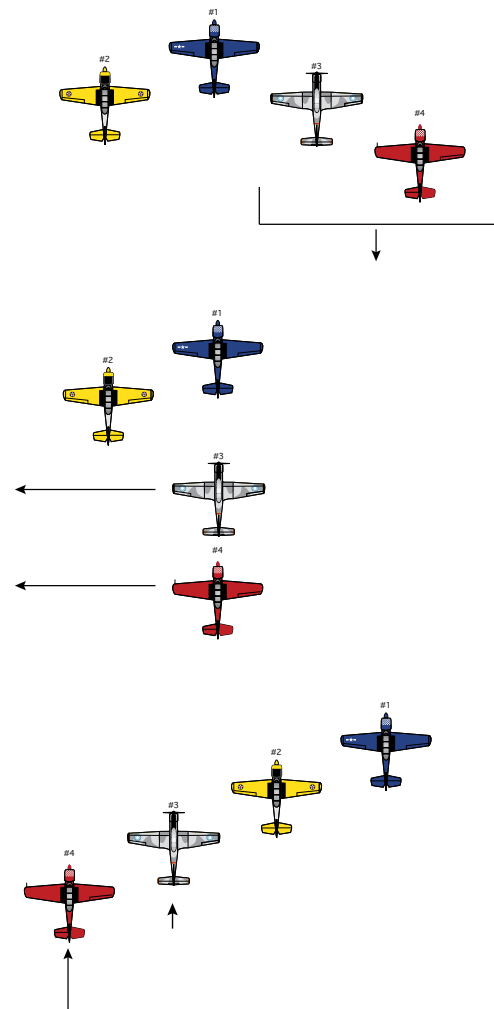
3. #3 moves forward and up into the fingertip position—#4 continues the cross-under and then moves up into the fingertip position.

PERFORMANCE GUIDELINES

- Wingman or element Lead moves down and back no greater than one ship-length distance from the aircraft ahead
- Wingman transitions smoothly and deliberately to opposite side
- Wingman moves up and forward to the correct fingertip position

COMMON ERRORS

- Falling too far behind
- Descending too low
- Not descending low enough to avoid Lead's vortices or prop/jet wash
- Being too aggressive—crossing rapidly to opposite side
- Not crossing far enough, compromising wingtip clearance when moving forward into fingertip
- Flight leader failing to signal #3 first, before signaling #2 to cross to #3's side (into echelon)



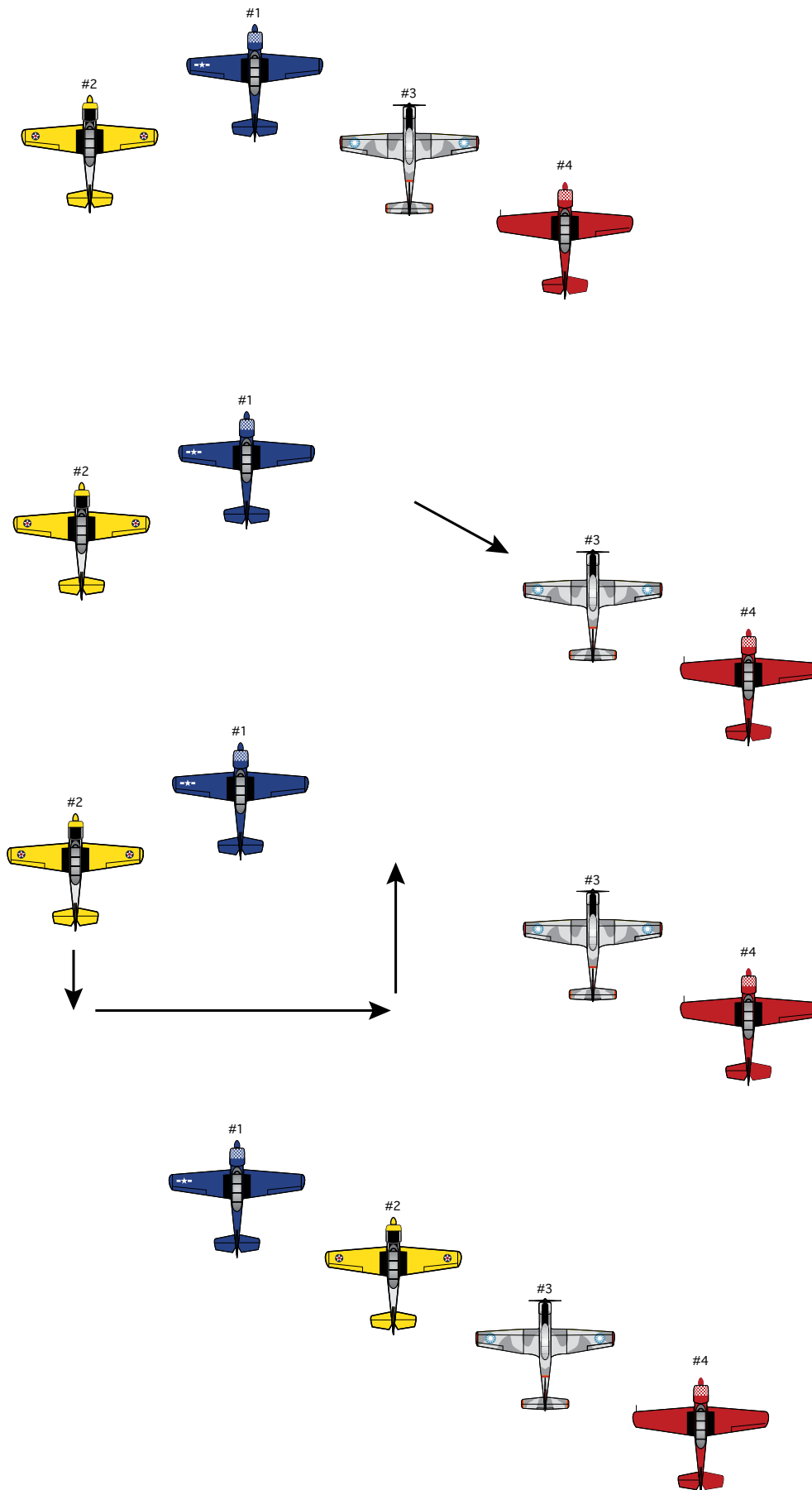
#2 Cross-Under

1. Fingertip, strong right: Lead signals #3 with a single, raised fist or wing dip, indicating to #3 that #2 will be crossing under and over to his side, so #3 needs to move out to make room for #2 to pull up into the gap. (The wing dip also indicates to #2 that he should cross-under once #3 moves out to create space for #2.)

2. Number 3 moves his element out on the bearing line to make room for #2

3. With a single, raised fist, Lead signals #2 to cross under—#2 crosses under and moves up and forward into the fingertip position

4. Cross-under complete, the formation is configured in echelon right



DIAMOND

The diamond is used when the flight leader wants to configure a 4-ship into a tight, maneuverable, symmetrical formation.

SIGNAL

The flight leader will first hold up four fingers and then gesture aft with a raised fist, thumb extended. Without taking his eyes off Lead, the deputy lead (#3) will pass the same signal to #4. If #4 does not see the signal and does not move, Lead will repeat the signal to #3.

DESCRIPTION

When #4 has received the signal, he will perform a partial cross-under, stopping directly behind Lead, in the slot position, using close trail references. Then, #4 should begin to cross check #2 and #3 and adjust his trail position by establishing a normal fingertip position bearing line off of #2 and #3. When stabilized, #4 will call in position.

When Lead signals with a wing rock (aileron flutter), #4 will rejoin to the original fingertip position on #3's wing.

PERFORMANCE GUIDELINES

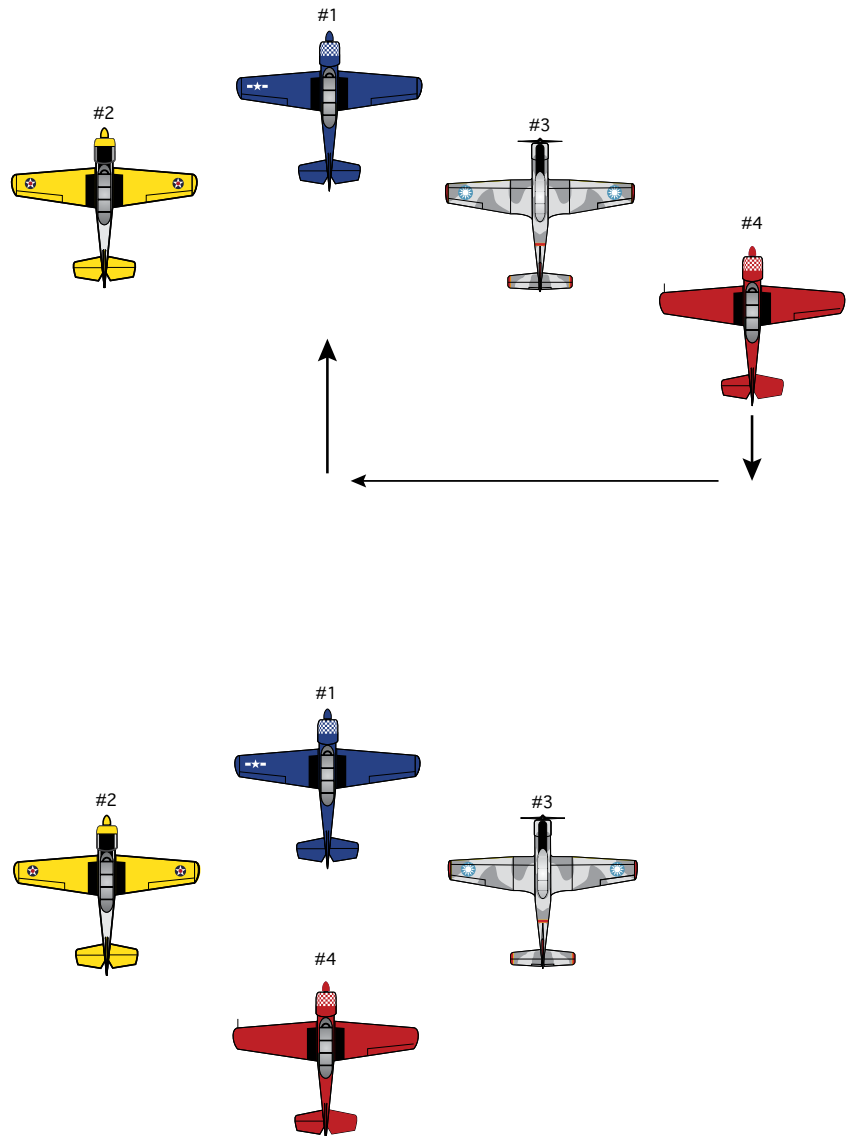
- Wingman transitions smoothly from fingertip to the slot position
- Wingman calls in position
- Wingman transitions smoothly back to fingertip when signaled

COMMON ERRORS

- Falling too far back during the cross-under to the slot position
- Getting too low during cross-under
- Not pulling forward far enough into the slot position
- Not calling in position when stabilized

Transition to Diamond

1. Lead signals #3—four raised fingers followed by gesturing aft with thumb.
2. Number 3 passes the signal to #4, without taking his eyes off #1 and not looking at #4 for acknowledgement
3. Number 4 executes a half cross-under and moves up and into the slot using close trail references
4. In order to achieve symmetry, once established in the slot, #4 should begin to cross-check #2 and #3 and adjust position to establish a normal fingertip bearing line off #2 and #3



ECHELON TURN

Four-ship echelon turns are executed just as they are in 2-ship.

SIGNAL

There is no need to signal for an echelon turn when configured in 4-ship echelon formation—the echelon turn is the standard in this configuration.

DESCRIPTION

Lead rolls into a turn and the wingmen simultaneously roll with the flight leader, climbing just slightly to position themselves nearly on the same horizontal plane as Lead, while matching Lead's bank angle. The fuselage of the aircraft ahead will be bisected by the horizon line. Each successive wingman is now flying a larger and larger turn circle and so each will have to add incrementally more power to maintain position.

PERFORMANCE GUIDELINES

- Wingmen add power, roll into the turn and move smoothly into the echelon turn position.
- Wingmen maintain the correct position throughout the turn.
- Wingmen transition smoothly back to fingertip at the completion of the turn.

COMMON ERRORS

- Not adding enough power to maintain position during the transition into the turn.
- Sliding aft and becoming sucked during the turn.
- Failure to climb or descending during the turn, falling out of position.
- Getting laterally spaced too wide on the aircraft ahead.

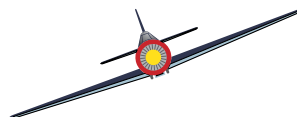
#1



#2



#3



#4



CLOSE TRAIL

In 4-ship close trail, each wingman will fly directly behind the aircraft ahead in the formation, with approximately one ship-length spacing. Each aircraft is “welded” to the aircraft ahead as it moves, matching bank angles and remaining in a fixed position, relative to the aircraft ahead.

SIGNAL

Lead will motion to the rear, with fist held up and thumb extended—first to #2 and then to #3. Number 3 does not pass the signal to #4. As an alternative signal, Lead may porpoise his aircraft.

DESCRIPTION

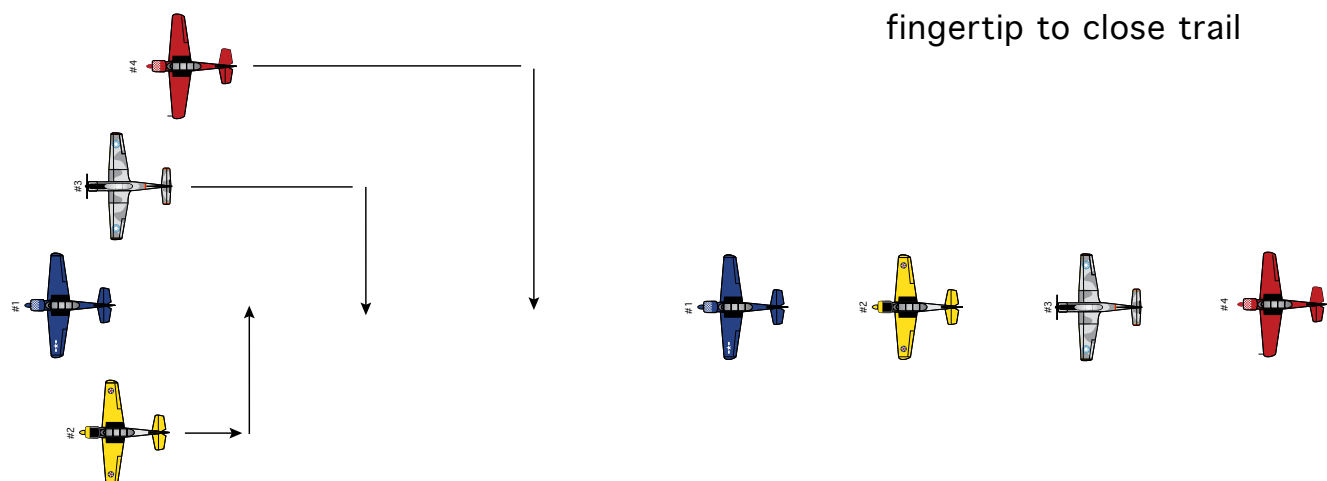
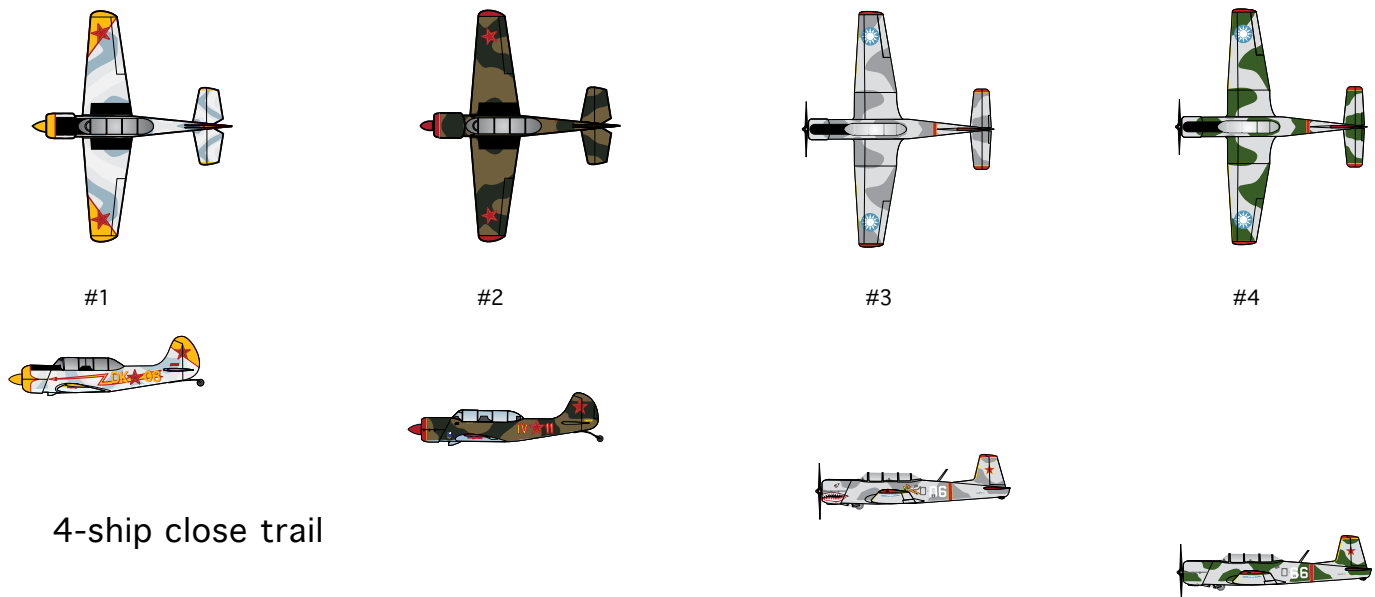
Wingmen should match bank with the aircraft ahead to remain directly behind. Use power to maintain the correct nose/tail distance.

PERFORMANCE GUIDELINES

- Wingmen are capable of moving into position without compromising proper separation
- Wingmen are able to maintain proper nose/tail distance and fixed position throughout the range of maneuvering

COMMON ERRORS

- Falling too far behind when maneuvering into position
- Getting sucked while maneuvering
- Stacking too low
- Not maintaining position directly behind aircraft ahead



EXTENDED TRAIL

In 4-ship extended trail, the same techniques are used in terms of lead, lag and pure pursuit. The difference is that although #2 continues to fly in reference to Lead, the #3 and #4 wingmen will fly in reference to a 30°/45° cone emanating from the aircraft directly ahead.

SIGNAL

The flight leader will typically send the flight to extended trail with a radio call: "Redstar 1, extended trail, go."

DESCRIPTION

Four-ship extended trail is flown using all the procedures and techniques described in 2-ship extended trail. Number 3 maintains position within #2's ET cone and #4 maintains position within #3's ET cone. Remember, this is a locked-throttle, energy management exercise. Just as in 2-ship ET, all wingmen will be using lead, lag, and pure pursuit to remain in the ET cone and out of the dead six o'clock position of the preceding aircraft. Therefore, a fixed spacing and position will be impossible to maintain.

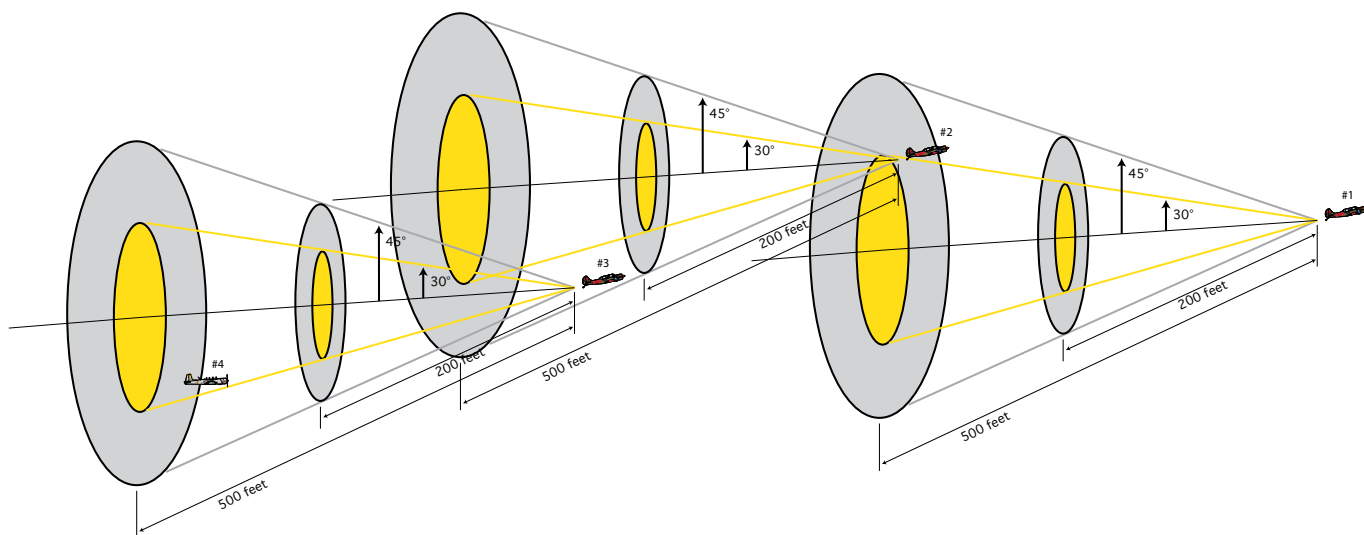
Wingmen should make no attempt to match #2's spacing. Pilots should also be aware that increasing G forces and variations in airspeed and altitude will be amplified down the line.

PERFORMANCE GUIDELINES

- Wingmen call "in" when stabilized in position
- Wingmen maintain proper lateral position within the donut
- Wingmen maintain proper interval range throughout maneuvering, using lead/lag techniques, without adjusting power

COMMON ERRORS

- Failure to call "in" when in position
- Getting sucked, falling outside of the proper maneuvering range
- Maneuvering in the six o'clock position instead of maintaining proper lateral offset within the donut
- Attempting to match #2's interval



4-ship extended trail

- Lead, lag and pure pursuit are the primary means of maintaining position (power is fixed)
- Each wingman maneuvers to stay within a 200' to 500' range of the aircraft ahead (piston aircraft, 120 knot speed range)
- The wingmen transit the six o'clock position (yellow area) as they maneuver within the donut but do not linger there

TAIL CHASE

Tail chase is a configuration where the wingmen are, essentially, flying in Lead's flight path, primarily using power to maintain a fixed interval.

SIGNAL

The flight leader will typically send the flight to tail chase with a radio call:

"Redstar 1, tail chase, go"

DESCRIPTION

Three or four-ship tail chase differs from extended trail in four respects:

1. The throttle is the primary means of maintaining interval
2. Number 2 sets the interval and the other wingmen match that interval
3. The wingman is extended behind Lead from a minimum of 200 feet (1000 feet for jet aircraft), out to 1500 feet, or whatever distance the flight leader has briefed.
4. The wingmen will fly in the six o'clock position of the aircraft ahead—think of the Aeroshell T-6 team when they fly in Lead's smoke trail during their routine. In addition to using power, the wingman can also use lead, lag, and pure pursuit, as necessary, to maintain the interval.

PERFORMANCE GUIDELINES

- Wingmen call "in" when in stabilized in trail position
- Wingmen use power as the primary means and geometry as the secondary means to maintain the briefed, fixed interval on the aircraft ahead
- Wingmen remain predominantly in Lead's six o'clock position

COMMON ERRORS

- Failure of wingmen to call "in" when in position
- Failure to consistently maintain briefed, fixed interval on Lead, as set by #2



LEAD CHANGE

There will be times when the flight leader will swap positions and transfer control of the flight to another lead-qualified pilot in the flight.

SIGNAL

The flight leader will point to the pilot he wants to designate as the new Lead and then point straight ahead, indicating, “You have the lead.” The newly-designated lead will move out to route position, push the power up and, when passing line abreast with the former leader, tap the top of his head with an open palm and then point directly forward, indicating, “I have the lead.”

A lead change can also be directed with a radio call. The leader will move the formation to route position. He will then transmit a situation awareness briefing to the new lead which includes heading, altitude, position in the working area, and distance to home plate or nearest divert field (“Redstar 3, heading 360, 5,600 feet, southeast corner of area 1, home plate 010, 7 miles. You have the lead”). Number 3 adds power, looks around to orient himself, and as he passes line abreast, transmits “Redstar 3, has the lead.”

All flight members will remain in route position until the new flight leader rocks them back into close formation.

DESCRIPTION

To minimize risk, the “stable platform” concept must be used when transferring positions. The pilot surrendering the lead position will maintain power setting and position, providing a stable platform. The pilot accepting the flight leader position will move to route position, add power and move forward. As the new Lead passes the former flight leader (line abreast), the former flight leader will pick up the wingman references and move into fingertip position.

At the completion of the lead change, the pilots have the option to retain their original call signs or modify their call signs to match their new flight position. The new leader should check the flight in to confirm all wingmen understand their new position/callsign. The primary flight lead will designate the chosen option in the flight briefing.

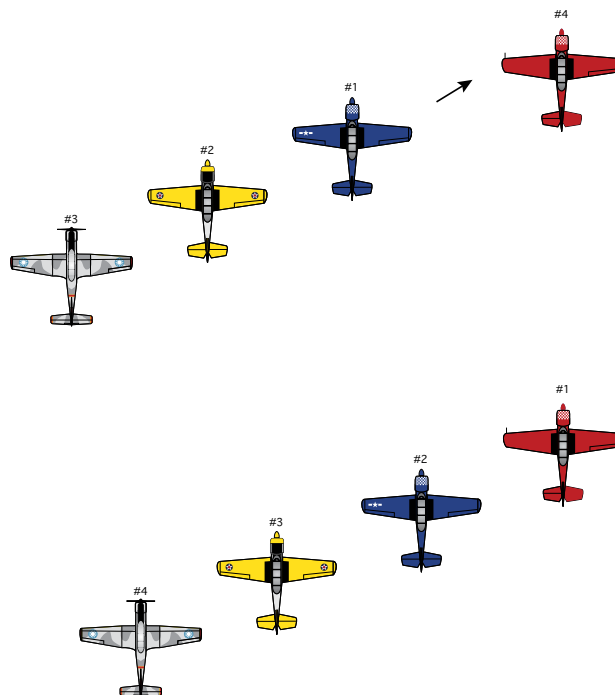
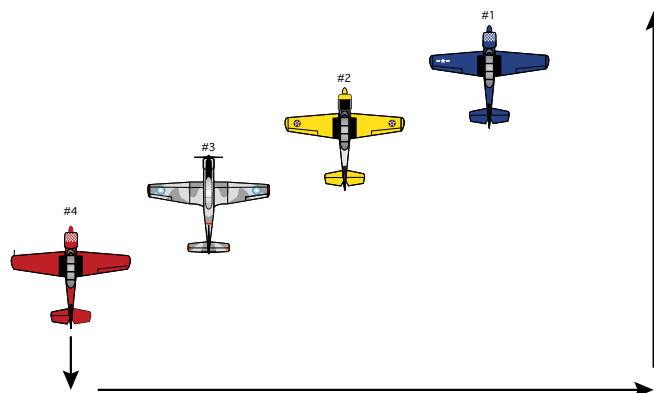
Lead changes are typically executed from the fingertip strong right or left configuration, with the deputy lead (#3) assuming the lead. However, there are many ways to transfer lead—for instance, the transfer can take place from an echelon configuration, with #4 being designated as the new flight leader. No matter what technique is used, it is critical that the lead change be thoroughly briefed and the stable platform concept be employed.

PERFORMANCE GUIDELINES

- Flight leader should maintain position, providing a stable platform while the new flight leader maneuvers into position
- New flight leader should smoothly maneuver to route and then execute the lead change

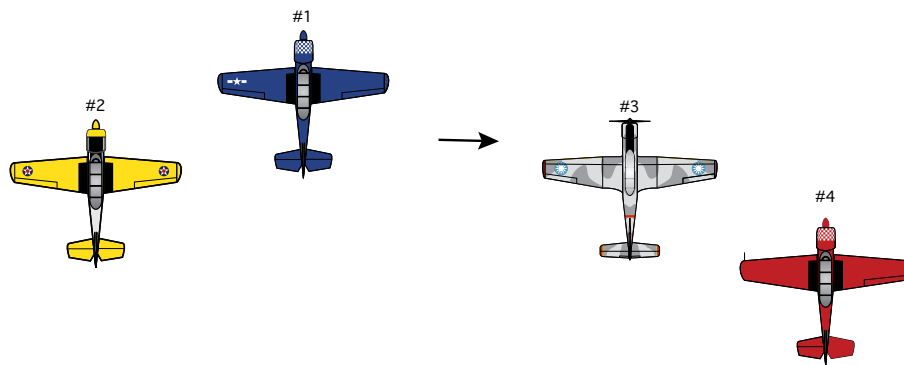
COMMON ERRORS

- Not thoroughly briefing the lead change
- Failure to have wingmen check in at the completion of the lead change

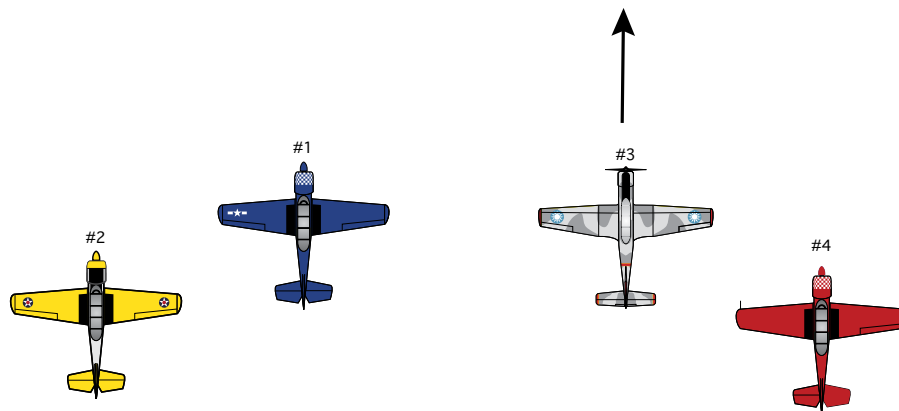


Lead change executed from echelon

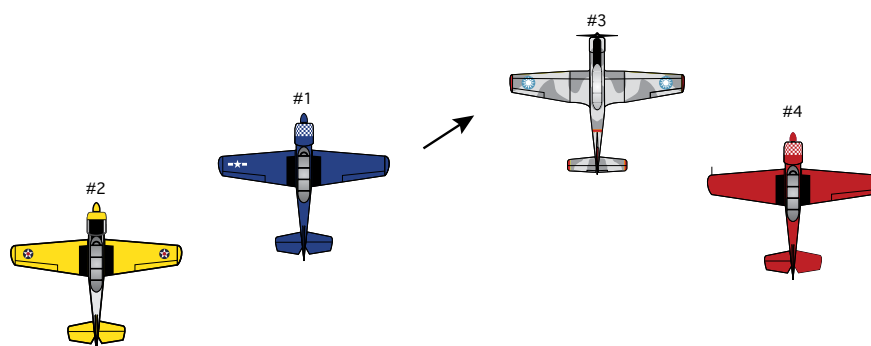
Number 4 performs a cross-under and then maneuvers forward into the route position. As #4 passes abreast, the surrendering lead picks up the normal wingman visual cues and moves into fingertip position.



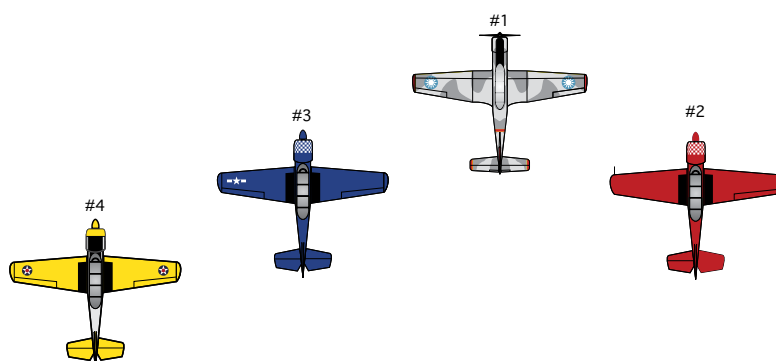
1. The flight leader signals #3 to assume the lead. Number 3 moves out to the route position.



2. Number 3 moves forward while the sur-rendering lead provides a stable platform by maintaining a fixed position.



3. As #3 passes abeam, the former flight leader picks up the standard fingertip visual cues and moves into position.



4. The new flight leader checks the flight in so that everyone understands their new position in the rearranged flight.

PITCH OUT AND REJOIN

The 4-ship pitchout is executed in the same manner as is 2-ship, however, there are some differences in the rejoin. The 4-ship rejoin will reassemble the flight to the fingertip configuration.

SIGNAL

The flight leader will extend his index finger upward, using a twirling motion, and then hold up the number of extended fingers that correspond to the number of seconds to be used in the pitch out. Number 2 will acknowledge with a head nod. There is no passing of the signal down line—the #3 and #4 wingmen simply count off and mimic the interval established by #2 when he breaks after the flight leader.

To initiate the rejoin, the flight leader will rock his wings. After the wing rock, the flight leader will roll wings level for a straight-ahead rejoin or roll into a turn for a turning rejoin.

DESCRIPTION

The flight leader will configure the flight in echelon, signal, clear in the direction of the turn, and then break away from the flight using 45° to 60° of bank. He will roll wings level after approximately 180° of turn. The wingmen will each break, in sequence, duplicating the flight leader's turn. As each wingman rolls wings level, stabilizes in trail directly behind and at the same altitude as the flight leader, and completes a quick ops check, he will call in position (*"Redstar 2 in, Redstar 3 in, Redstar 4 in"*).

STRAIGHT AHEAD REJOIN

Once all the wingmen have called in position, the flight leader will rock his wings to initiate the rejoin and then roll wings level. Lead has the option to reduce power to give wingmen an airspeed advantage. Lead will brief or call out the rejoin airspeed so that wingmen can monitor their overtake. For the straight ahead rejoin, #2 will rejoin based on the following priority: 1. To the side directed by Lead, 2. To the side previously vacated, if applicable, 3. To the left wing. The second element will take the opposite side. Using the same procedures described in 2-ship straight ahead rejoins, wingmen will use power as necessary to gain an airspeed advantage and fly offset to the side to which they will rejoin, so as to arrive in the route position. Wingmen will monitor closure and, after ensuring closure is stabilized, slide into fingertip position.

If closure rate is excessive during a straight ahead rejoin, wingmen will reduce power, slip or use a combination to slow the overtake. If an overshoot is imminent, the wingman will turn slightly away from Lead, keeping Lead in sight. The wingman will resume the rejoin when Lead begins to stop moving back across the canopy. If the overshoot will result in losing sight of Lead, the wingman will break out of the formation—clearing, and turning away from the flight.

TURNING REJOIN

Once all the wingmen have called in position, the flight leader will rock his wings to initiate the rejoin, and then begin a turn in either direction, using approximately 25° to 30° of bank. The flight leader will maintain a constant bank, a constant airspeed and a constant altitude while the wingmen maneuver to rejoin.

If rejoin airspeed has not been briefed, or if Lead is not within 10 knots of the briefed rejoin airspeed, Lead will make a radio call announcing the airspeed. Once the rejoin has been initiated, wing pilots can expedite the rejoin by accelerating and holding up to 10 knots or +10% of additional airspeed.

When the leader signals the rejoin and establishes the rejoin turn, all wingmen should use the six-step procedure previously described in 2-ship turning rejoins and summarized here:

STEP 1

Push up the power. The goal is to add a minimum of 10 knots or +10% of the leader's rejoin airspeed as expeditiously as possible.

STEP 2

Determine position inside or outside of the leader's turn circle (TC). If the leader's AA remains stable with an increasing LOS rate, the wingman is inside the TC. If the Leader's AA continues to increase with a low LOS rate, the wingman is outside the TC.

STEP 3

If inside the turn circle, start pulling lead pursuit to capture and maintain the rejoin bearing line. Check airspeed and stay as close to the leader's altitude as possible. If the rejoin is stable approaching route position, continue into fingertip to complete the rejoin.

STEP 4

If outside the turn circle, get to the TC ASAP by flying toward the reference point on the horizon where the leader started his rejoin turn. This will preserve turning room and prevent an uncontrollable, very acute rejoin.

STEP 5

When the leader's AA stabilizes and the LOS rate starts increasing, the wingman is inside the turn circle. Now, the wingman should proceed with Step 3 and complete an inside the TC rejoin.

STEP 6

Number 3 and #4 must complete their rejoin to the corresponding fingertip position on the outside of the leader's turn circle. If these wingman approach route position with a stabilized rejoin, they should maintain their overtake and simply perform a cross-under to their corresponding position. As the overtake rate increases, wingman should cross-under farther back to give themselves more time outside the leader's turn circle to dissipate excessive overtake.

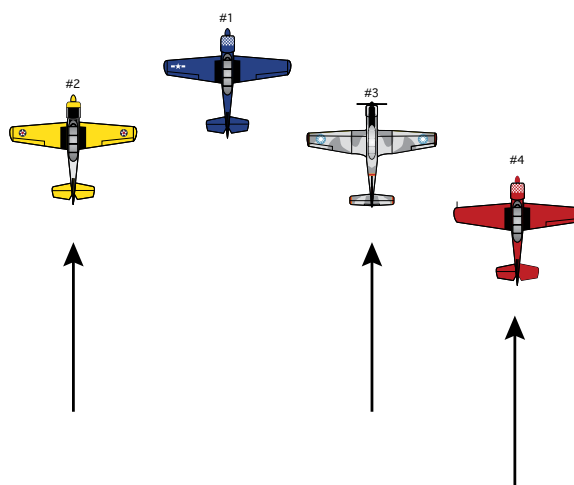
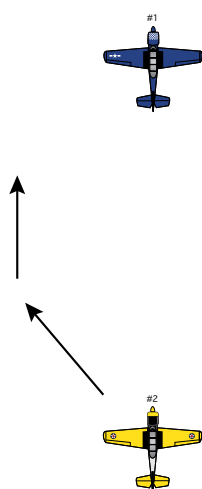
Number 2 will always join to the inside of the turn. Number 2 should be able to complete the rejoin within 180° of turn (when using a three second break interval).

PERFORMANCE GUIDELINES

- Flight leader will provide a stable rejoin platform by maintaining a constant altitude, airspeed and bank angle.
- Wingmen will maintain proper airspeed, altitude, bearing line and alignment throughout the rendezvous

COMMON ERRORS

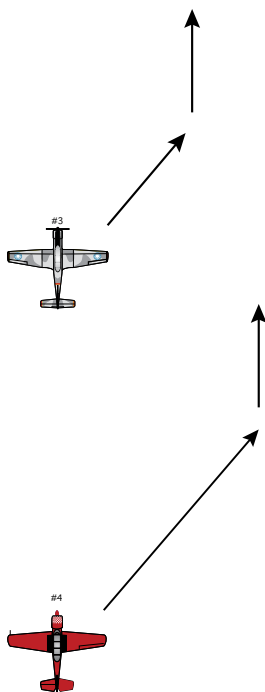
- Flight leader not maintaining a stable platform
- Getting too low
- Becoming sucked and/or acute
- Not monitoring airspeed



Straight Ahead Rejoin

Left: Once Lead has signaled with a wing rock and rolled wings level, the wingmen will initiate the rejoin. Number 2 moves ahead and left, to return to the same side he vacated before the formation was configured in echelon for the pitchout. Numbers 3 and 4 will join to the opposite side.

Above: Wingmen move back into the original fingertip formation.



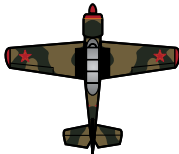
#1



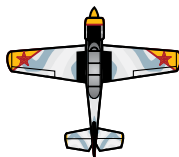
1528'



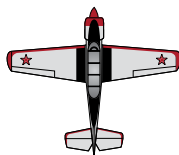
#2



#3



#4



Turning Rejoin

Once Lead has signaled with a wing rock and rolled into a turn, #2 will fly an inside the turn circle rejoin, when able. Number 3 and #4 will evaluate their position relative to the leader's turn circle. If outside, they will accelerate to get inside the TC as soon as possible and, to preserve turning room, fly toward the point where the leader started his turn. Once inside the turn circle, #3 and #4 complete an inside the turn circle rejoin to the route position. Then, they complete a cross-under to their corresponding position on the outside of the leader's turn circle.

Parameters

Break interval: 3 seconds

In trail interval, following break: 6 seconds

In trail interval distance from Lead:

- #2 = 1338' in trail (inside Lead's turn circle)
- #3 = 2676' in trail (outside Lead's turn circle)
- #4 = 4014' in trail (outside Lead's turn circle)

Bank angle: 30°

5000' agl

G load: 1.14 G

Turn circle radius: 1528'

120 knots KIAS / 132 KTAS

OVERSHOOT

With the 4-ship rejoin, there are two additional aircraft in motion, moving up the bearing line toward Lead. When executing individual rejoins, such as after a pitchout, the wingmen will “join by the numbers.” In other words, each wingman will join on Lead, in turn. As an example, #4 will not join on #3 before #3 has rejoined with Lead. This allows #2 to overshoot, if required, and gives #3 and #4 time and space to react to this overshoot and preserve their ability to complete their own rejoin.

SIGNAL

There is no signal for an overshoot, however, the wingman will make a radio call to advise the flight leader that he is executing the overshoot (“Redstar 2, overshooting”).

DESCRIPTION

Number 2 should be the only wingman who needs to use the overshoot/under-run option because he is rejoining to the inside. The #3 and #4 rejoins include a controlled overshoot to their corresponding position on the outside of the leader’s turn circle, but if closure becomes excessive any wingman can use the overshoot to safely correct, stabilize, and then reacquire the bearing line to effect the rejoin. Number 4 does not complete his rejoin by crossing over until #3 completes the rejoin.

If #2 overshoots, what #3 and #4 do depends on how severe the overshoot is and how much time it takes for #2 to overshoot, and then complete his rejoin.

If #2’s overshoot is not too severe and is completed in a very short amount of time, #3 and #4 may only need to delay their rejoin by decreasing airspeed slightly and lagging off the bearing line to a sucked position leaving space for #2 to reacquire the bearing line. Once #2 completes his rejoin, #3 and #4 can speed up their rejoins by re-accelerating and pulling lead to reacquire the bearing line and complete their rejoins.

If #2’s overshoot is severe and time consuming, the best position for #3 and #4 to fly to is a co-speed in trail position on the leader’s turn circle. This way, #3 and #4

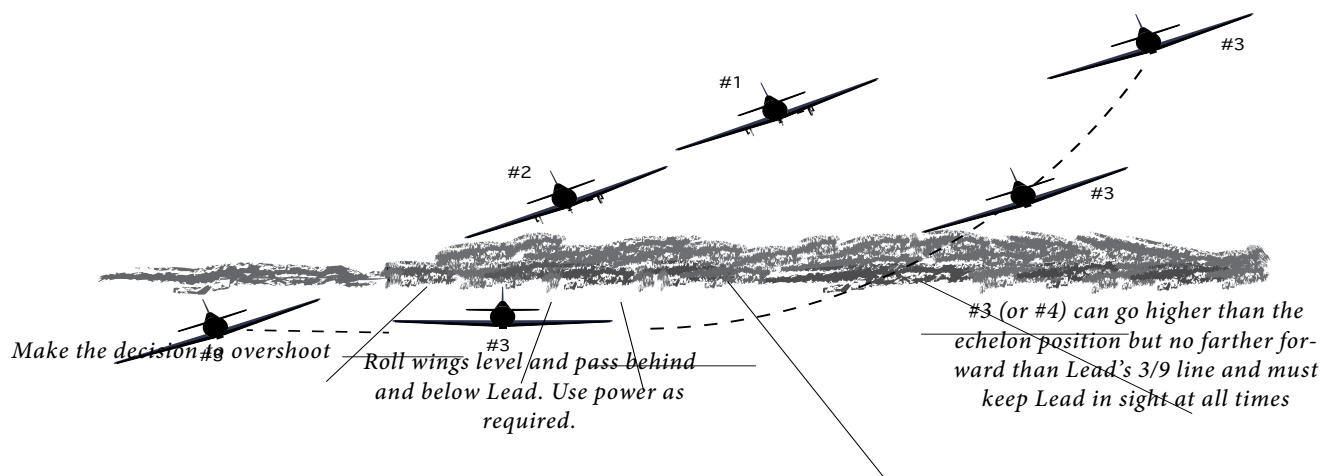
can easily keep #2 in sight and give him plenty of room to maneuver. Once #2 has completed the rejoin via the overshoot, #3 and #4 can recommence their rejoins. Both should pull lead to reacquire the bearing line, push up the power, and place Lead on the horizon, just as in any other rejoin. Now, they both complete their rejoins by flying Step 5 and 6. If #3 has excess Vc and cannot move directly into the fingertip position on the outside of the turn, he can use reduced power, speed brakes, and fly a wider echelon or fingertip position until his Vc allows him to slide into normal fingertip position. Number 4 should not complete his rejoin until #3 is in fingertip. Number 4 can use the same procedures if excess Vc needs to be dissipated. Number 3 and #4 must not be overly aggressive dissipating Vc and hurry to get into position. They must use the same care completing their rejoins as #2 does when using overshoot procedures.

PERFORMANCE GUIDELINES

- Wingman will recognize the excess closure in a timely manner and in a smooth, controlled maneuver, execute the overshoot.
- Number 3 and #4 will delay their rejoins, as required, to keep #2 in sight and give him time and space to complete the rejoin via the overshoot.
- If #3 and/or #4 need to dissipate excess Vc, they will do so in a controlled fashion on the outside of the leader’s turn.

COMMON ERRORS

- Not recognizing excessive closure
- Flying to a lateral position forward of Lead’s 3/9 line
- After overshooting as #2, flying to an elevation position higher than Lead
- After overshooting as #2, not making a radio call advising Lead of the overshoot
- Number 3 and/or #4 not giving #2 enough time or space to complete the rejoin via the overshoot.
- Number 3 and/or #4 dissipating excess Vc on the outside of the turn in an overly aggressive manner.



CHAPTER 7

OPERATING LIMITATIONS

The dynamic nature of formation flight generates its own particular operating limitations. In this chapter, some of the more routine limitations are detailed.

Every situation cannot possibly be envisioned or anticipated and not every potential scenario is presented here. As always, it remains the responsibility of the pilot-in-command to exercise judgement and take the necessary action to deal with whatever may arise.

WARNING

The following are only suggested guidelines—environmental conditions, aircraft limitations or pilot proficiency may dictate more restrictive protocols.

TAKEOFF

The flight leader must evaluate runway conditions to determine what type of formation departure will be executed.

RUNWAY LENGTH

For element takeoffs, the element leaders will be using less than normal takeoff power. The resulting, longer takeoff roll must be factored into the runway calculation. Also, with multiple elements positioned on the runway, the lead element will be displaced farther down the runway, thereby diminishing available runway. Based on these factors and, depending on pilot technique, an element takeoff can lengthen takeoff roll by 20%, or more.

Single-ship, interval takeoffs are not impacted as much as element takeoffs, since all pilots are using normal takeoff power. However, if the flight leader has elected to position the formation on the runway prior to takeoff, the lead elements will be displaced down field, reducing available runway length.

RUNWAY WIDTH

For formation, element takeoffs, the runway must be wide enough to provide a minimum of 10 feet of lateral wingtip separation between aircraft when they are in position on the runway. In addition, there must be adequate clearance so that, in the event of an abort, the non-aborting aircraft has a clear lane to pass the aborting aircraft.

For most aircraft with wingspans in the 33' range, a 100' wide runway will provide adequate clearance for 2-ship element operations. A 150' wide runway will normally ensure adequate clearance for 3-ship vic operations.

TAKEOFF INTERVALS

There are two established protocols for determining spacing between departing formation aircraft—lift-off interval and timed interval.

LIFT-OFF INTERVAL

The fail-safe procedure for establishing spacing between departing aircraft is lift-off interval. Formation aircraft will not begin takeoff roll until the preceding aircraft has lifted off (daylight under the main gear).

TIMED INTERVAL

If the pilots are sufficiently proficient and there is adequate runway width to provide for a clear, safety lane, a safe, timed interval may be accomplished, but only for aircraft with adequate forward visibility. The safety concept behind timed interval takeoffs is that preceding aircraft, already in motion, are accelerating at a greater rate than the trailing elements just releasing their brakes. This creates a telescoping effect, providing an ever-increasing distance between departing elements.

The minimum recommended timed takeoff interval between nosewheel aircraft during staggered, single-ship takeoffs, is six seconds.

For element takeoffs, there is no clear lane available, therefore, the minimum recommended timed interval between formation elements is ten seconds. The ten-second interval provides enough time for the following element leader to recognize and react to an abort by the element ahead.

Timed intervals should not be executed under the following conditions:

- Initial training of unqualified pilots
- Tailwheel aircraft, because of limited over-the-nose visibility
- Widely dissimilar-powered or configured aircraft because of variations in acceleration
- Runways not sufficiently wide enough to conduct element takeoffs
- Less than optimal braking action
- If the procedure was not briefed, to include abort procedures
- If the departure is altered after the briefing has taken place (i.e. #4 aborts in the chocks for maintenance)

CROSSWINDS

The flight leader is responsible for determining the acceptable crosswind limits for an element takeoff. He must factor in environmental conditions, aircraft limitations, runway constraints and the wingman's capability. Element takeoffs are not recommended if gusty winds or windshear are reported. If in doubt, the flight leader should revert to single-ship, interval takeoffs.

FLUID MANEUVERING

Fluid maneuvering exercises, such as extended trail (ET) or tail chase (TC) are intended to teach and practice lead, lag and pure pursuit concepts, in the case of ET, and how to maintain position using only power in the case of TC. As such, aerobatic flight is not required and should not be performed if the formation pilots are not proficient in aerobatics, spin training and unusual attitude recovery.

Flight leaders need to be cognizant of the fact that there is a crack-the-whip effect, during fluid maneuvering, where the forces experienced by #1's aircraft are magnified progressively with each succeeding wingman. Because of this phenomenon, wingmen are subjected to higher G loads, both symmetric and asymmetric, as well as greater variations in airspeed and altitude, with #4 at most risk.

In addition to closely monitoring airspeed and G loads, the flight leader should always brief a hard deck to provide for adequate clearance from terrain and obstacles, and for inadvertent spin recovery during fluid maneuvering.

LANDING

The same runway considerations used to determine adequate runway for takeoff, apply to the landing calculation.

RUNWAY LENGTH

During the landing phase, the telescoping effect seen during takeoff is reversed and a compression effect occurs, creating less and less spacing as the aircraft ahead decelerates to taxi speed. In addition, for element landings, and for single-ship landings on narrow runways, there is no clear lane between landing aircraft.

Available runway length will be also be reduced for any aircraft or element landing long.

The flight leader must consider all these factors when determining where and how to recover the flight.

RUNWAY WIDTH

The runway must be wide enough to provide a minimum of 10 feet of lateral wingtip separation between aircraft when they land on opposite sides. In addition, there must be adequate clearance so that, in the event a preceding aircraft is disabled upon landing, the following aircraft has a clear lane to pass the blocking aircraft.

For element landings, the runway must be wide enough to accommodate both aircraft, side by side on the runway with a minimum of 10' of lateral wingtip spacing. There must also be enough clearance such that a clear lane is available to both pilots should one of the aircraft become disabled upon landing (i.e. collapsed gear).

Generally, a 100' wide runway will provide adequate spacing during 2-ship operations for aircraft with wingspans in the 33' foot range. For 33' wingspans, a 150' foot wide runway will normally provide adequate spacing for 3-ship vic landings.

MINIMUM LANDING INTERVAL

To compensate for the collapsing distance between landing aircraft, minimum landing intervals are necessary to provide a safe margin. Landing intervals are usually measured between aircraft as they cross the threshold.

The landing interval must provide enough spacing such that pilots of in-trail aircraft have enough time to recognize an abnormal situation on the runway and react by either passing on the clear lane side or executing a go-around.

For aircraft with approach speeds in the 90 knot range, 1500' is the minimum threshold crossing interval for hot/cold or staggered operations, with 2000' desired. For narrow runways with no clear lane option, 3000' is the minimum recommended threshold crossing interval.

Landing Intervals: 90 knot Approach Speed

pitchout interval	5 sec	7 sec	10 sec
in-trail interval	10 sec	14 sec	20 sec
threshold crossing distance	1500'	2000'	3000'

For larger or turbine aircraft, with approach speeds exceeding 100 knots, 3000' is the minimum recommended threshold crossing spacing for hot/cold or staggered landing operations. When landing on narrower runways that do not provide the option of a clear, passing lane, 6000' feet is the recommended minimum threshold crossing spacing.

Landing Intervals: 120 knot Approach Speed

pitchout interval	7½ sec	10 sec	15 sec
in-trail interval	15 sec	20 sec	30 sec
threshold crossing distance	3000'	4000'	6000'

GO AROUND

If a wingman cannot maintain the minimum acceptable threshold crossing interval or if, at any time, the wingman loses sight of the aircraft ahead, a go around is mandatory.

TAILWHEEL AIRCRAFT

The limited over-the-nose visibility in tailwheel aircraft presents these pilots with a few constraints in the interest of safety.

During takeoff, it is recommended that tailwheel pilots utilize the liftoff interval procedure (daylight under the main gear) so that the runway ahead is clear of traffic prior to beginning the takeoff roll.

Element takeoffs can be performed safely in a tailwheel aircraft but tailwheel element landings are not recommended. Tailwheel landing operations should be conducted with enough of an interval between aircraft to ensure an unobstructed landing and rollout zone is available, particularly after the tailwheel is lowered to the ground and forward visibility becomes restricted.

The minimum break interval for hot/cold or staggered landing procedures on runways 75 feet wide or greater is five seconds. On runways less than 75 feet wide, consider using a break interval of 10 seconds.



CHAPTER 8

ABNORMAL PROCEDURES

This chapter is designed to provide some guidance for potential abnormal situations. Every possible scenario cannot be detailed here, but the material presented may provide a basis for forming solutions to other unique situations.

GROUND ABORT

If one or more wingmen abort prior to takeoff, the flight leader will normally reassign flight positions and check the flight in under the new configuration.

If the flight leader aborts, the deputy lead, #3 will normally assume control of the flight.

TAKEOFF ABORT

Takeoff aborts require prompt, coordinated action to prevent the situation from becoming more dangerous. In an abort situation, the critical actions are to maintain aircraft control, maintain separation from other aircraft and communicate intentions.

ELEMENT ABORT

During element takeoffs, normally when one pilot aborts, the other pilot will advance the throttle to the takeoff power setting and continue the takeoff. Two aircraft simultaneously aborting can complicate the situation, as both pilots attempt to maintain aircraft control and steer clear of the other aircraft.

If both Lead and the wingman must abort because of an obstructed runway or other circumstance, Lead will announce the element abort over the radio and include the term “flight” to indicate that the entire flight is directed to abort: “Redstar 1 flight, abort, abort, abort.” Following such a call, Lead’s wingman and all following elements in the flight will hold position or, if in motion, abort the takeoff.

SINGLE-SHIP, INTERVAL TAKEOFF ABORT

When using single-ship, interval takeoff procedures, the aborting aircraft will announce the abort to warn following pilots: “Redstar 2 aborting.”

If operating from a narrow runway, with no clear lane to allow for passing, all following pilots will hold position or, if already in motion, abort the takeoff.

If operating from a runway that is wide enough for passing, pilots behind the aborting aircraft will hold position or, if already in motion, abort, unless continuing the takeoff in the clear lane is the safer course of action.

AIRBORNE EMERGENCIES

There are some circumstances, such as an engine failure immediately after liftoff, where a pilot will act independently of the formation element. Normally, however, it is in the best interests of the distressed pilot to maintain element integrity, so as to benefit from mutual support.

The nature of the emergency will determine what support is required and which aircraft will be in the lead position and which aircraft will be flying chase.

As a general rule, if the pilot of the emergency aircraft can talk, squawk, navigate, needs to spend time inside the aircraft to deal with the situation, or has a partial power loss, he should lead. If the pilot of the emergency aircraft can’t do the above or has pitot/static problems, making the performance instruments unreliable, he should fly as the wingman.

The pilot of a distressed aircraft will advise Lead of the nature of the emergency, his intentions, and the assistance required. The flight leader will configure the flight to provide maximum support and bring the emergency to a safe conclusion.

If there is more than one element in the flight, the flight leader will normally separate the elements. The leader will direct the emergency element to return to base (RTB) and clear the non-emergency element to either continue with an alternate mission, RTB, or fly in a support role for the emergency element.

If the flight leader is flying the distressed aircraft, he may elect, depending on the circumstances, to hand off responsibility for the flight to the deputy lead, or other flight member.

In all emergencies, it is imperative to ensure separation between aircraft, before becoming distracted and engrossed in solving the problem.

RADIO FAILURE

If an aircraft loses the capability to transmit or receive—“no radios” (NORDO), the flight leader will determine if the mission can continue, be abbreviated, or be terminated.

If it becomes necessary for a NORDO wingman to gain the attention of lead following radio failure, he should maneuver into route position and rock his wings to signal “attention in the air.” The wingman can then use the appropriate hand signals to convey the radio failure alert.

If the wingman is flying in extended trail or is otherwise not in close proximity to Lead, wait until the flight leader has rejoined the flight before maneuvering into route and attempting to gain Lead's attention.

If the flight leader loses the ability to transmit/receive, he should use the appropriate signals to convey the radio failure and then transfer control of the flight to another pilot, using lead change procedures.

A formation landing or an approach to a drop off on final, at or above 300 feet agl, should be flown with the NORDO aircraft in the wing position, unless circumstances dictate otherwise. The leading pilot will make all appropriate radio calls and coordinate the go-around, if required.

If using a formation landing to recover the NORDO aircraft, use standard formation landing procedures. If using drop off procedures, on final, once the distressed aircraft is in a position to execute a safe landing and has received landing clearance, (for towered airport), the leading pilot will use the "you have the lead" hand signal to indicate to the distressed pilot that landing clearance has been received. The leading pilot will then execute a go around and re-enter the traffic pattern. The distressed aircraft will land or, if unable, will also execute a go around and, if necessary, rejoin on the leading aircraft for another attempt.

If the approach is executed from a 360° overhead pattern at a towered airport, the NORDO pilot should be alert to landing clearance as indicated by light signals from the tower controller.

INTERCOM FAILURE

Intercom failure is not normally a significant issue. In an instructional flight, however, when communication is lost between student and instructor, the issue becomes more significant because of the necessity for positive transfer of aircraft control, particularly in tandem-seat aircraft.

The instructor will determine if it is best for the student or the instructor to fly the aircraft, based on the circumstances. The "shaker is the taker" method can be used to transfer aircraft control. To surrender control of the aircraft, the surrendering pilot should yaw the aircraft to alert the other pilot that he wishes to transfer control. The taking pilot can then use the "shaker is the taker" protocol to establish positive transfer of control.

RECOVERY

There are other situations, such as with an aircraft experiencing loss of reliable airspeed indications, where the same escort and drop-off procedure used for NORDO aircraft would be appropriate.

SYSTEM FAILURES—HEFOE

If a pilot is NORDO, and experiences another major system failure, the HEFOE signals will enable the pilot to communicate the emergency to another pilot in the flight.

The HEFOE signal is **only used when radio communication is not possible** and is given in two steps. First, hold a clenched fist up to your forehead and, second, hold up the number of fingers corresponding to the condition:

- Hydraulic/pneumatic = one finger
- Electric = two fingers
- Fuel = three fingers
- Oxygen = four fingers
- Engine = five fingers

KNOCK-IT-OFF (KIO)

The term "Knock-it-off" is used to cease the maneuvering of all aircraft in the flight, mass formation, or tactical scenario when safety of flight is a factor or doubt or confusion exists.

EXAMPLES OF SAFETY OF FLIGHT FACTORS

- Loss of situational awareness that can't be regained
- Violation of briefed area boundaries
- Flight through minimum altitude has or is about to occur
- Weather below minimums required to safely conduct the mission
- Aircraft malfunction affecting safety of flight
- Recognized radio failure
- Non-briefed/non-participating aircraft/flight enters the working area and is detrimental to the safe conduct of the mission
- Over G/exceeding briefed flight parameters
- Bingo fuel is reached

KIO PROCEDURES

KIO is normally initiated over the radio. Aircraft with radio failure will signal KIO with a continuous wing rock (altitude and airspeed permitting). Pilots observing a continuous wing rock will transmit the KIO and standby to assist as required. ANY flight member can initiate a KIO. When possible, the pilot initiating the call will state the reason for the KIO.

Upon hearing the KIO call or observing a continuous wing rock, the flight leader will do the following:

1. Cease maneuvering and establish a stable, predictable flight path that will enable all wingmen to maintain visual contact and remain in their relative position.
2. Initiate a KIO call and get a positive response from all wingmen either on the radio or through a wing rock. If required, repeat the call until all wingman have positively responded.
3. Positively determine the reason for the KIO. If possible, use corrective action to eliminate the reason for the KIO then, resume the mission profile if desired.

4. If the reason for the KIO cannot be eliminated (such as an aircraft emergency, deteriorating weather, or changing airfield conditions), determine the proper course of action to render assistance as required and RTB in an appropriate manner.
5. In all cases, be directive to the wingmen.

Upon hearing the KIO call or observing a continuous wing rock, the wingmen will do the following:

1. Cease maneuvering, clear their flight path, and maintain current relative position.
2. Acknowledge the KIO call in order when the flight lead initiates the call.
3. If a wingman makes the initial KIO call, give the flight lead the reasons for the call when asked.
4. If any wingman loses sight of preceding aircraft, call “blind” and execute a break out, as required.
5. Provide directive calls to other flight members. These include position, heading, altitude, roll and push/pull calls to help them reacquire/maintain a visual, deconflict flight paths, and avoid ground contact.
6. Acknowledge and comply with all flight lead directions to resume the mission profile or deal with the KIO situation.

In the following example, Redstar 3 recognizes an impending violation of the briefed hard deck:

“Redstar 3, knock-it-off, hard deck”

“Redstar 1, knock it off”

“Redstar 2, knock it off”

“Redstar 3, knock it off”

“Redstar 4, knock it off”

To recommence the flight profile, the flight leader will climb the flight to an altitude above the hard deck, advise the flight, get an acknowledgement, and then recommence maneuvering.

If a KIO occurs in a mass formation or tactical employment scenario, flight members of individual flights will comply with the above procedures. The Mission Commander and flight leaders will then comply with Air Boss instructions or other special instructions (SPINS).

TERMINATE

The term “Terminate” is used to cease the maneuvering of all aircraft in a specific flight when learning objectives are achieved or are not achievable. Terminate is used when safety of flight is not a factor.

TERMINATE PROCEDURES

Terminate procedures are normally initiated over the radio. In tactical scenarios, the terminating aircraft will also add a wing rock to the radio call when airspeed and altitude permit. The procedures are identical to the above

listed KIO procedures.

In the following 2-ship example, Redstar 2 has fallen out of the extended trail cone and is unable to get back inside.

“Redstar 2, terminate, outside the cone”

“Redstar 1, terminate”

“Redstar 2, terminate”

Redstar 1 flies a predictable flight path allowing Redstar 2 to fly back inside the cone. Redstar 1 instructs Redstar 2 to call in when ready to recommence maneuvering. Redstar 2 calls “in” and Redstar 1 recommences extended trail maneuvering.

If the “Terminate” call is made in a mass formation or tactical scenario, all affected aircraft/flights will comply with the Terminate procedures. Additionally, they will:

1. Cease maneuvering with the terminating aircraft, flight, or signatory.
2. Deconflict flight paths and, as required, climb/descend to a safe altitude (1000 feet AGL minimum) or assigned altitude or altitude block.
3. Comply with Air Boss instructions or other SPINS.

BREAK OUT

The purpose of a break out is to ensure immediate separation and to avoid a mid-air collision.

A wingman must break out of the formation if:

- He loses sight of his reference aircraft
- He is unable to rejoin or stay in formation without crossing directly under or in front of Lead
- He feels his presence in the formation constitutes a hazard.
- When directed to do so by Lead

If you have lost sight, clear, then break in the safest direction away from the last known 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:

“Redstar 2, breaking out, climbing to 4500 feet.”

After gaining safe separation, you should confirm that Lead is, or is not, in sight and transmit this information to him. If you have visual contact, maintain it and fly to remain in your current formation position. Then, transmit as much of the following information, as required, to help the leader reacquire his visual:

1. Position
2. Elevation

3. Distance away

“Redstar 2, visual on 1. Redstar 1, the visual is at your left 8 o’clock, slightly high, 2000 feet”

If the leader replies with *“visual,”* follow his instructions to either rejoin the flight or RTB.

If he replies *“blind,”* maintain your relative position and transmit another visual call. If environmental factors or look angles are hampering the leader’s visual ability, direct him to turn so you can establish a near line abreast and parallel position.

“Redstar 1, check 45 left. The visual will be your left 9 o’clock, slightly high, 1000 feet”

Continue doing this until the Leader reacquires the visual.

If the wingman is blind, he should establish an orbit pattern and transmit the following information, as required, to give the leader SA:

1. Position
2. Altitude

“Redstar 2, blind, over the racetrack, 4,500’, left turning pattern”

If the leader calls *“visual,”* follow his directions to either RTB or rejoin.

If the leader calls *“blind,”* follow the procedures in the “Both Aircraft Blind” section.

If the flight is a 3-ship or 4-ship, any wingman who has the visual on the leader and the break out aircraft should be ready to direct “blind” aircraft, as required, to expeditiously reacquire visual contact and enable the leader to rejoin the flight.

LOST SIGHT

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

THE BLIND AIRCRAFT

If the other aircraft is not in sight when anticipated and proximity does not warrant immediate breakout, you will notify the flight using the term “blind,” and state altitude:

“Redstar 2, blind, 5500 feet”

In some cases, heading information may be useful but avoid long transmissions or descriptions. If visual contact is regained, do not rejoin until directed to do so by your flight or element leader.

THE VISUAL AIRCRAFT

If Lead has not lost visual with the wing pilot, he will help the wingman reacquire visual contact by transmitting his position from the wingman’s perspective, using the previously discussed format:

“Redstar 1, visual, Redstar 2, the visual is your right, two o’clock high, 700 feet”

In this situation, Redstar 2 simply needs to look to his two o’clock high to attempt to reacquire Lead. In all cases, Lead should be directive and ensure altitude separation, if required. Lead will then decide on the appropriate course of action.

BOTH AIRCRAFT BLIND

Both pilots will use the previously discussed procedures to pass SA in their respective “blind” calls. If the leader briefed a no-sight rejoin ground reference point, he can direct all blind wingman to proceed to this point to rejoin the flight. If a no-sight ground reference point was not briefed or to expedite the rejoin, the leader can anchor the flight by either establishing an orbit over a prominent ground reference point, or directing the wingman to do so. All blind wingmen then proceed to the reference point at their de-conflicted altitudes to rejoin the flight as directed by the leader.

Directing a wingman to RTB single-ship is also an option.

COORDINATION & SUPPORT FOR DAMAGED OR DISABLED AIRCRAFT

Any number of situations can result in an aircraft becoming partially or significantly disabled—mid-air collision, bird strike, and mechanical failures are examples. If an aircraft is damaged or experiences a failure that could compromise the controllability of the aircraft, the pilot will make the “knock it off” call with an explanation and then request the lead position. The second pilot will assume the chase position and provide whatever support is needed, such as navigation, communication, and emergency checklist response. If the pilot flying the disabled aircraft can talk, squawk, navigate and has reliable pitot-static systems, he should be given the lead.

FLYING CHASE

The pilot providing coordination and support to a distressed pilot will fly a chase position, maneuvering in a route position, offset up to 45° aspect angle either side of the leading, distressed aircraft. Since the distressed pilot may be subject to loss of aircraft control, aircraft structural failure or bailout/ejection, it is critical that the chase pilot fly only as close as is necessary to provide observation and support without creating a further hazard or distracting the distressed pilot.

CHASE PILOT RESPONSIBILITIES

The chase pilot can provide a wide variety of support functions, some of which are listed below:

- Coordinate radio communication
- Coordinate emergency recovery
- Coordinate emergency rescue equipment
- Provide emergency checklist guidance
- Provide emergency landing guidance
- Provide visual inspection and feedback

WARNING

The chase pilot must avoid “over-controlling” the distressed pilot—this can be distracting and counterproductive to a successful outcome.

BIRD STRIKE

In case of imminent bird strike, it is important not to compound the problem by maneuvering into another aircraft while attempting to avoid the bird. If a bird strike does occur, the pilot will make the “knock-it-off” call and request the lead position—unless the pilot’s visibility is restricted because of windscreen penetration. With limited visibility it may become necessary to lead the damaged aircraft for a drop-off landing.

BAILOUT/EJECTION

If an aircraft is damaged to the point where it is no longer controllable or cannot be safely landed, it may be necessary to bailout or eject. Time permitting, the pilot will notify Lead so he can ensure separation and provide subsequent support. The pilot will then follow the bailout/ejection procedures prescribed for his aircraft.

If there are additional pilots or passengers onboard, the PIC should issue the bailout or eject command over the intercom:

“BAILOUT, BAILOUT, BAILOUT,” or

“EJECT, EJECT, EJECT”

COORDINATION & SUPPORT FOR BAILOUT, EJECTION OR FORCED LANDING

SEARCH AND RESCUE (SAR)

When a member of the flight has to bailout, eject or make a forced landing, timely communication is critical.

RESPONSIBILITIES OF THE SAR COMMANDER

The SAR commander, normally the flight leader, will initiate the SAR effort. The following action items, though not necessarily appropriate for every emergency, should be considered as part of the response effort:

- **Respond:** Terminate maneuvering using KIO procedures. Establish a SAR commander. Remain above the last known position of the downed airman, using altitude separation to de-conflict with other SAR aircraft. Establish a high and low covering air patrol (SARCAP), if required to enhance radio communications.
- **Squawk:** select the emergency transponder code (7700) to alert air traffic control
- **Talk:** Communicate with the most suitable agency to initiate the SAR effort. In some instances this will be an air traffic controller and in other instances it will be a radio call to a local airport to advise local emergency rescue squad personnel via phone.
- **Mark:** Establish, as accurately as possible, the location of the downed airman using GPS, nav aids, a radar fix, or ground references.
- **Assess:** Try to determine the condition and needs of the downed airman—relay this information to the rescuing agency.
- **Bingo:** Be cognizant of fuel state. Bingo fuel can be revised to a lesser amount if there are recovery fields that are closer than those originally planned. In any case, do not compound the emergency by flying beyond the minimum acceptable bingo fuel.

CHAPTER 9

COMMUNICATION

Communication is the glue holding all formations together. In formation, there are three forms of communication:

1. Voice
2. Hand Signals
3. Aircraft Signals

Many of the commands and messages can be given using any of the above three options. Some can only be done using one option.

All three forms of communication are based on a two-step process:

- Step 1 is the command or the message
- Step 2 is the acknowledgement

This chapter will cover all three forms of communication in detail.

VOICE COMMUNICATION

Voice is the primary means of communication between the flight leader and other flight members. 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.

TWO-STEP MESSAGE PROCESS

Step 1 in voice communications is a two-part command or message process. The first part of any radio call is the attention or preparatory portion. This part serves to alert the listener that a message is coming and to specify to whom the call is directed. The attention part should always be the receiver's full call sign regardless of who initiates the call.

"Redstar 1..." (call sign for entire flight)

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

"...extended trail, go"

Step 2, the acknowledgement, depends on whether the message was understood or not. If it was, the wingmen will acknowledge, in order, with just their call sign. If it was not understood, wingmen should, again, acknowledge in order with their call sign and a request for clarification.

"Redstar 2, say again"

The flight members should acknowledge with full call sign, or position only, as briefed, and any information requested.

#2: "Redstar 2"	Or,	#2: "2"
#3: "Redstar 3"		#3: "3"
#4: "Redstar 4"		#4: "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. The flight member the call was addressed to will acknowledge with his full call sign. For instance:

"Redstar 1, Redstar 4, gimme one"

"Redstar 1"

FREQUENCY CHANGE & CHECK-IN PROCEDURE

All flight members must maintain the capability to communicate with one another. Check-in and frequency switching procedures are critical to achieving this objective. When acknowledging simple instructions such as a frequency change or check-in, within the flight and in sequence, wingmen may respond with position number only, unless briefed otherwise. On the other hand, if responding out of sequence, or if separated from the flight, revert to full call sign use to avoid confusion.

#1: "Redstar 1, 121.8, go"

#2: "2"

#3: "3"

#4: "4"

With all pilots responding, the entire flight will then switch to the new frequency. If one or more pilots do not respond, the pilots who do respond will do so, in sequence, after a pause for the non-responding pilot. The responding pilots will then switch to the new frequency. It is Lead's responsibility to sort out the comm problem—once this is accomplished, he will then initiate the check-in, with the wingmen responding sequentially with position numbers or full call signs, as briefed.

#1: "Redstar 1, check"

#2: "2"

#3: "3"

#4: "4"

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

NOTE

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

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

If a wingman does not respond to repeated radio calls, the wayward wing pilot may be experiencing radio equipment failure, simply misunderstood the frequency, or mis-channelled the radio. In these situations, Lead should pass the frequency to him, via hand signals. Once all the wingmen are established on the correct frequency, Lead will check the entire flight in on the radio.

If Lead calls for a frequency change in flight without moving the flight to route, wingmen should move to route position, stabilize and proceed with the channel change. Once the frequency change has been accomplished, the wingmen will return to fingertip at the direction of Lead, unless briefed otherwise.

The flight leader speaks for the flight to all agencies until the flight splits up.

NOTE

The flight leader will include the number of aircraft in the flight and his tail number on initial contact with air traffic control, unless tactical callsigns have been previously approved:

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

GO VERSES PUSH

The flight leader has the option of using the term "go" or "push" when directing the flight to change frequency.

"Redstar 1, tac 2, go" or, "Redstar 1, tac 2, push"

When the term "go" is used, all wingmen will acknowledge with their full callsign or position, as briefed, prior to switching to the new frequency. The flight leader will then check the wingmen in on the new frequency.

When the term "push" is used, the wingmen will *not* acknowledge the command and will simply switch to the new frequency. The flight leader will then check the wingmen in on the new frequency.

CALL SIGN TERMINOLOGY

There are other methods that can be used to identify a flight. Lead may elect to use the military protocol, where a two-digit callsign is assigned to the flight and each member of that flight. The first digit is part of the flight's identification and the second digit identifies the pilot's position in the flight. In this example, the flight callsign is Redstar 31.

Redstar 31 = #1
Redstar 32 = #2
Redstar 33 = #3
Redstar 34 = #4

To direct a frequency change, the flight leader call and wingmen's responses, if using full callsigns, would be:

"Redstar 31, tac 2, go"

"Redstar 32"

"Redstar 33"

"Redstar 34"

If abbreviated callsigns were in use, the call would be:

"Redstar 31, tac 2, go"

"2"

"3"

"4"

If dealing with a controlling agency or making traffic pattern calls, the flight leader would call:

"Easton tower, Redstar 31, flight of four, six miles north information bravo"

AIR TRAFFIC CONTROL CALLS

Whenever the flight lead talks to an ATC facility for the first time, he should include the number of aircraft in the flight. This will maximize ATC's situation awareness.

"Easton Ground, Redstar 1, flight of four, west ramp, taxi with Bravo."

On subsequent calls to the same facility, the flight lead can drop the *"flight of four"* and just use the flight call sign.

"Redstar 1, taxi to runway 22"

The use of the word "flight," as part of the callsign, is optional, at the discretion of Lead, at all other times, but its use is not necessary.

HAND SIGNALS

Hand signals can be used to communicate most of Lead's instructions during a formation sortie. However, radios should be used if there is an emergency, time is critical, or if hand signals are creating confusion. Any non-standard hand signals will be thoroughly briefed before they are used. All members of the flight must be familiar with the hand signals to be used. Normally, aircraft malfunctions or safety related issues will be communicated over the radio.

In step one of hand signal communication, the flight leader will strive to make hand signals easy to see. Hand signals will be placed in the cockpit against a contrasting background to make them as visible as possible.

In step two, if the hand signal is understood, acknowledgement is accomplished with an exaggerated head nod. The head nod must not be so vigorous or exaggerated that the wingman loses sight of the leader or bobbles his aircraft. If the hand signal is not understood, the wingman should maintain current position and continue to stare at the leader. The leader will then either repeat the hand signal or use the radio to avoid any further confusion. Once the wingman understands the signal, he should comply with the leader's command.



Exaggerated head nod

Wingmen should not hesitate to use the radio to avoid confusion.

ENGINE START

Extend arm over head and make a circular motion with the hand

ENGINE RUN-UP

Extend arm over head and make a circular motion with the hand



Engine start or engine run-up

READY FOR TAKEOFF

After run-up, flight/element lead looks at wingman—wingman nods head yes or no

START TAKEOFF ROLL

Lead places head back toward head-rest and nods head for brake release

GEAR UP

Clenched fist, thumb up, upward motion of hand—head nod to execute

An additional, alternate signal—Lead looks at the wingman, then makes a distinct, upward head nod



Gear Up

GEAR DOWN

Clenched fist, thumb down, downward motion of hand—head nod to execute



Gear down

FLAPS UP/DOWN

Thumb and fingers together, opening and closing—head nod to execute



Flaps up/down

CHANGE FREQUENCY

Tap ear with fingers extended—extend finger(s) vertically for the digits one through five, horizontally for six through nine, pulling hand down out of sight between digits. Signal zero with a clenched fist.



Change frequency

CHANGE TO PRE-BRIEFED FREQUENCY

Tap ear with index finger, extend fingers to correspond to the number of the pre-briefed frequency (tac 1, tac 2)

Change to pre-briefed frequency



CROSS-UNDER

Cross #2 (2-ship)—Lead's arm bent 90°, fist clenched

Cross #2 (4-ship, fingertip to echelon)—Lead first signals #3 with arm bent 90°, fist clenched to indicate that #3 must out to make room for #2. Lead then gives #2 the same signal.

Cross #2 (4-ship, echelon to fingertip)—Lead signals #2 with arm bent 90°, fist clenched

Cross-under, #2



Cross #3/#4 (second element)—Lead's arm bent 90°, fist clenched, two arm pumps. If in echelon, Lead signals #2 and #2 relays the signal to #3 without taking his eyes off Lead

Cross-under, #3 and #4 (second element)



CLIMB

Palm flat, motioning in a forward and upward direction

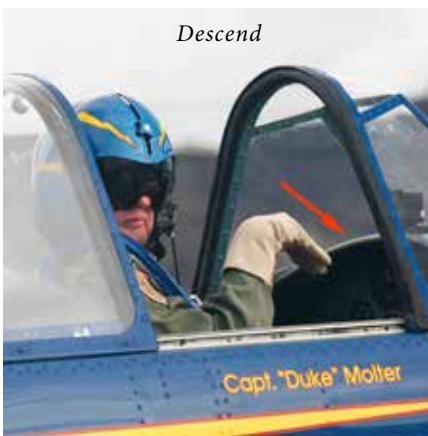
Climb



DESCEND

Palm flat, motioning in a forward and downward direction

Descend



LEVEL OFF

Palm flat, moved back and forth in a horizontal motion

Level off



ADD POWER

Clenched fist, arm in forward motion

Add power



REDUCE POWER

Palm open, facing rearward, motioning to rear

Reduce power



STACK DOWN

Palm of hand facing downward with downward motion



STACK UP

Palm of hand facing upward with upward motion



ECHELON TURNS (2-SHIP)

Forefinger and pinky finger extended from clenched fist, held up for each echelon turn to be performed



FINGERTIP TO TRAIL

Lead motions aft with clenched fist, thumb extended rearward



SPEED BRAKES

Hand up, palm forward, with head nod for execution



FINGERTIP TO DIAMOND

Lead's arm bent 90°, fist clenched, four fingers extended upward, followed by closed fist with thumb extended rearward, motioning aft. Number 3 relays this signal to #4 without taking his eyes off Lead. Number 4 calls in position.



#4 to diamond (second signal)



PITCHOUT

Clenched fist, with index finger held up and rotated, followed by number of fingers raised to indicate break interval in seconds



Pitch out, 5 seconds (second signal)



KISS OFF

Optional salute or other similar signal given by Lead just before he initiates a pitchout, symbolically “kissing them off” as the flight separates into individual aircraft



LEAD CHANGE

The flight leader will point to #2 and then point straight ahead, indicating, “You have the lead.” Number 2 will acknowledge with a head nod, move to route, push the power up and, when passing line abreast with Lead, tap the top of his head with an open palm and then point directly forward, indicating, “I have the lead.”



Lead change, accepting pilot (1st signal)



Lead change, accepting pilot (2nd signal)



FUEL CHECK

Clenched fist, thumb extended toward mouth in a drinking motion

Fuel check



FUEL REMAINING (IN RESPONSE TO FUEL CHECK)

Use up to five fingers to indicate each ten minute increment of fuel remaining as follows:

One finger = 10 to 19 minutes, fuel remaining

Two fingers = 20 to 29 minutes

Three fingers = 30 to 39 minutes

Four fingers = 40 to 49 minutes

Five fingers = 50 to 59 minutes

OXYGEN CHECK

Cup hand over mask, followed by query in the form of an OK sign (circle formed by touching ends of thumb and forefinger, other fingers extended)

Oxygen check



PITOT HEAT ON

Pinky finger extended out from clenched fist

Pitot heat on



ROTATING BEACON ON/OFF

Hand held up, fingers together, thumb apart in cupping shape, rotate hand at wrist

Rotating beacon on



LANDING LIGHTS ON/OFF

Pinky and index finger extended from clenched fist—upward for lights on, downward for lights off



STOP SQUAWK (TRANSPONDER OFF)

Hand clutched to throat in a choking motion



OK OR READY TO GO (ON GROUND—NOT ON ACTIVE RUNWAY)

Thumbs up



GO AROUND

Clenched fist, arm in forward motion



CAN'T HEAR

Move flat palm back and forth across the ear



CAN'T TRANSMIT

Move flat palm back and forth across mouth



SYSTEM FAILURES—HEFOE

The HEFOE signals are only intended for use when NORDO.

Hold clenched fist up to forehead and then hold up the number of fingers corresponding to the condition:

Hydraulic/pneumatic = one finger

Electric = two fingers

Fuel = three fingers

Oxygen = four fingers

Engine = five fingers

HEFOE (first signal)



NOTE

When airborne, there are two situations where a wingman will pass a hand signal down the line. When Lead wants to send #4 into the diamond, slot position, he will signal #3 who will then pass the signal to #4. The second situation is when Lead wants to reposition the second element (#3 & #4), from an echelon to fingertip—Lead will signal #2 with a double pump and #2 will repeat the signal for #3. Wingmen will not look away from the leader when passing a signal and will never look for an acknowledgement from other wingmen.

AIRCRAFT SIGNALS

Step 1—the flight leader signals by moving his aircraft.

Step 2—if the wingmen understand the signal, they will move their aircraft to the commanded position. There are no head nods in acknowledgement, just aircraft movement. If the wingmen don't understand the signal, they will not move. They will stay in the current position, and stare at the leader. The leader will either repeat the signal, use a hand signal, or use the radio to eliminate all confusion.

GO TO ROUTE

Lead will yaw/fishtail the aircraft

REFORM/TIGHTEN FORMATION

Rock wings smartly

CROSS-UNDER

The wing dip signal is a single dip of Lead's wing and only applies to the aircraft or element on Lead's wing, immediately adjacent to Lead.

In 2-ship, to cross #2, Lead executes a quick, distinct wing dip in the direction he wants the wingman to cross.

In 4-ship, fingertip strong left, a wing dip to the left would direct #2 to cross to the left side (to echelon left). The deputy lead (#3) would move the element out to make room for #2 to move into place.

In 4-ship, fingertip strong left, a wing dip to the right would direct the element (#3 & #4) to cross to the right side (to echelon right).

From echelon left or right, a wing dip away from the echelon would move #2 to the opposite side (to fingertip strong left or right).

From echelon left or right, to cross the second element (#3 and #4), a radio call is required.

FINGERTIP TO TRAIL

Lead gently porpoises aircraft several times

ATTENTION IN THE AIR

Execute rapid, shallow wing rock

GO AROUND

There may be situations where a go around is necessary but the flight leader does not have time to give the go around hand signal. The flight leader will attempt to transmit the go-around call but wingmen should be alert to the possibility of a go around on every approach, and follow through with Lead if the situation arises.

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.

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

“Redstar 2, 45 minutes”

This simple call indicates to Lead that the wingman's ops check is normal and that he has 45 minutes of fuel remaining. If the wingman's ops check is other than normal, he will notify Lead immediately of the problem and state his fuel remaining.

After the check is complete, Lead will rock the wingmen back into their original positions.

FUEL MANAGEMENT

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

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:

“Redstar 2, joker”

Lead will acknowledge the “joker” call and prioritize any remaining maneuvers, as briefed, and plan to recover the flight not later than bingo.

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 could 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 should brief bingo fuel in time remaining instead of pounds, gallons or liters. If an aircraft reaches bingo fuel, the required call is:

“Redstar 2, bingo”

Lead should carefully plan the sortie to determine appropriate joker and bingo fuel. Lead will consider briefed forecasts and current conditions, as well as other factors that may require additional fuel. In formations consisting of one aircraft type, Lead 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 this situation, it is advisable to reference fuel reporting in time rather than gallons or liters—given as total time remaining until out of usable fuel. If any flight member calls bingo, Lead will acknowledge the “bingo” call and immediately cease area work and begin recovery to the planned destination.

The wingmen 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, each wingman has the responsibility of monitoring fuel state. Wingmen will always inform the flight leader, even if already on the recovery, when reaching joker or bingo and get an acknowledgment.

REJOIN VERSES RENDEZVOUS

In order to align these terms with military protocols, eliminate confusion, and maximize situation awareness, the following definitions will apply:

REJOIN

This term will apply to all within visual range formation assemblies including:

1. Rejoins after takeoff for members of a single flight using single ship, element, and/or vic takeoff procedures
2. Rejoins after takeoff for multiple flights departing from the same airfield forming up into a mass formation maneuvering as a single formation
3. Flight rejoins following a pitchout maneuver
4. Flight rejoins following a break out maneuver
5. Flight rejoins following an overhead traffic pattern resulting in a go-around for one or more flight members and a desire to fly a follow-on overhead traffic pattern

RENDEZVOUS

This term will apply to all beyond visual range formations intending to assemble using a geographic, latitude/longitude, or VOR radial/DME reference point:

1. Single/multiple flights or mass formations of aircraft departing from the same or different airfield(s) with no intention of maneuvering as a single formation but intending to start an air show, mission, or tactical employment scenario from a common starting point.
2. Single/multiple flights or mass formations of aircraft departing from the same or different airfield(s) intending to maneuver as a single mass formation starting an air show, mission, or tactical employment scenario from a common starting point.
3. Single/multiple flights or formations departing from different airfields with the intention of assembling and then proceeding cross-country to another destination airfield.



APPENDIX A

GLOSSARY

ACUTE

In normal flight, forward of the standard or briefed position. In turning rejoins, forward of the desired bearing line and at a high aspect angle.

ASPECT ANGLE

The angle from the leader to the wingman, measured from the leads six o'clock. Wingman heading has no bearing on AA. Flying directly aft of lead is zero degrees aspect, abeam is 90 degrees and directly in front is 180 degrees AA.

ANGLE OFF (AO)

Also called Heading Crossing Angle (HCA). The angular difference between the longitudinal axis of leader and wingman. The difference in headings between aircraft.

ABORT

Directive to cease current operation or inform others of your intentions, such as during an aborted formation takeoff.

ALPHA CHECK

Request for a bearing and range to a described point, such as the home airfield:

"Redstar 2, request alpha check to field."

BOGEY

A visual contact who's identity is unknown.

CONTINUE

Directive instruction to continue maneuvering.

BUTTON

Term describing a preset frequency, as in:

"Redstar 1, button 2, go."

BEARING LINE

The line angled off the lead's nose as flown by the wingmen.

BINGO FUEL

The fuel state at which the flight must return to base. A predetermined fuel figure remaining in gallons, pounds, or minutes which will allow return to base plus sufficient overhead reserve. When the wingman signals bingo fuel, the leader acknowledges and heads for base.

CALL SIGN

The word and position number that designates a flight and the members in it. Usually selected by the flight leader for that particular mission, such as "Redstar 1." During flight, the leader and wingmen are referred to by their position numbers—"Redstar 1, Redstar 2, Redstar 3."

CROSS-UNDER

A maneuver to change the position of a wingman from one side of lead to the other.

CLOSURE RATE (V_c)

Relative velocity of one aircraft in relation to another. Contains both a geometric and airspeed component. Can be a positive, negative, or zero value.

DASH ONE, TWO, THREE, FOUR

A US Navy term to refer to successive wingman in a flight.

EXTENDED TRAIL

A 2-, 3-, or 4-ship formation designed to teach the use of lead, lag, and pure pursuit procedures to stay within a prescribed maneuvering cone behind a preceding aircraft. To enhance this training, all aircraft match engine power then lock throttles. Maneuvers include hard turns, turn reversals, and lazy-eights.

ELEMENT

A flight of two aircraft. The section is the basic fighting element and is self-supporting covering each other's six o'clock in combat (real or otherwise), and providing back-up on routine flights with radio or equipment malfunctions in addition to moral support and good company. US Navy historically refers to this as a Section,

ENERGY (Ps)

A term describing the current state of conditions with regard to altitude and airspeed of an aircraft. Altitude reflects an aircraft's potential energy, while airspeed reflects kinetic energy. Either may be transferred between the two as required.

FLIGHT INTEGRITY

The ability of the wingman to maintain proper relative position while the flight is maneuvering.

FLIGHT

Two or more aircraft flying under the direction of a designated flight leader.

FLUID MANEUVERING

The opposite of Parade/Close/ Fingertip formation. Aircraft fly defined range and offset parameters, but maneuver relative to one another. Extended Trail and Tail Chase are Fluid Maneuvering formations

FLUID FOUR

A formation consisting of four aircraft in which the element leads fly a tactical position off one another and the wingmen fly extended trail position off their respective element leaders.

FIGHTING WING

A 2-ship formation using the same maneuvering cone as extended trail. In tactical formation, it provides mutual support and maximum maneuverability. Maneuvers include hard turns, turn reversals, lazy-eights, loops, rolls, cloverleaves, Immelmans, and the split S.

“GIMME ONE”

What the wingman calls to the lead when he has insufficient power to keep up, asking for lead to reduce power by one inch or more of manifold pressure/reduce EGT, RPM or burner setting in jets as applicable.

GO

Used to direct the flight to switch to a new frequency after acknowledging with call sign and or position number, in-sequence. See also “Push”.

HEADING CROSSING ANGLE (HCA)

Also referred to as ANGLE OFF (AO). The angular difference between the longitudinal axis of leader and wingman.

HI YO YO

A maneuver performed out of plane with respect to another aircraft to control excessive closure, decrease aspect and prevent an overshoot.

INITIAL

The first leg in a 360° overhead traffic pattern. It is flown on runway heading to the desired pitchout point, usually located over the landing runway threshold or runway numbers.

IN-TRAIL

A multi-ship fluid maneuvering formation where each aircraft follows the other. See also Tail Chase.

JOKER

The fuel state at which formation time must be prioritized to meet mission objectives. Joker will be briefed by the Flight Lead and may be in time or volume.

KNOCK IT OFF/TERMINATE

Terms used to cease maneuvering.

LAG ROLL

A rolling maneuver executed from a trail position, performed in the opposite direction of the leader/target's turn in order to maintain sight, reduce aspect angle, and control closure.

LIFT VECTOR

An imaginary plane going vertically through the top of the aircraft, representing the plane of motion in a straight pull. “Set the lift vector” means to roll the aircraft to set the point you want to pull to at your 12 o'clock high.

LINE OF SIGHT (LOS)

A line from the pilot's eye to the object being viewed, usually the flight leader or a target.

LOS RATE

A viewed object's rate of motion across the windscreen/canopy.

LEAD PURSUIT

A pursuit course that will, if not properly controlled, cause the wingman/attacker to fly in front of the leader/target. It supports decreasing separation, increasing AA, and increasing closure.

LAG PURSUIT

A pursuit geometry that will cause the wingman/attacker to fly behind the leader/target. It generates opening separation decreasing AA, and decreasing closure.

PURE PURSUIT

A pursuit geometry causing the wingman/attacker to fly directly at the leader/target. It decreases separation and increases closure, but not as great as lead pursuit.

LOW YO YO

A maneuver flown in an oblique plane, usually below the leader/target's plane of motion. It uses a combination of increased power, geometry, and gravity to decrease distance, increase aspect angle, and increase closure.

NOSE TO TAIL OVERLAP

As viewed from above, the nose of the #2 aircraft is farther forward than the tail of the #1. Naturally, as long as there is lateral separation between aircraft, no danger exists.

NO JOY

Used to indicate that you have not visually acquired whatever it is you are looking for.

BLIND

Call when you have lost sight of the lead or reference aircraft.

OPS CHECK

Periodic check of aircraft systems and fuel state.

OVERSHOOT

1. A maneuver flow by a wingman (#2) to salvage an unstable rejoin by crossing below and behind the leader, dissipating excessive closure and/or Aspect Angle on the outside of the leader's turn circle, and completing the rejoin to the #2 position when under control.
2. The end result when an attacker's turning room required exceeds the turning room available.

CLOSE FORMATION (FINGERTIP, PARADE)

Formation configuration flown at the closest, most demanding physical proximity. Aircraft are “welded” together and fly as one unit. It requires absolute concentration on the part of the wingmen and smooth precise leadership by the flight leader.

PLANE OF MOTION

An imaginary plane defined by the aircraft's flight path.

PUSH

A flight lead verbal command directing all wingmen to silently change radio frequency without acknowledging the command.

PADLOCKED

Informative term used when the pilot cannot take his eyes off another aircraft/ground target without losing sight.

PERCH

The point in an overhead pattern where each aircraft initiates the final turn.

REJOIN

The airborne assembly of collocated flights/mass formations intending to operate under the direction of a single flight lead or mission commander.

RENDEZVOUS

The airborne assembly of flights/mass formations departing from non-collocated locations. The flights/mass formations may or may not be operating under the direction of a single flight lead or mission commander.

ROUTE

A looser version of fingertip. Lateral separation extends from two ship-widths out to 500'. Bearing references extend from line abreast to the standard 30° or 45° line.

ROE:

Rules of Engagement. The agreed upon rules the members will operate under.

SPINS

Special instructions.

STEP DOWN

The standard vertical stack placing wingman below the leader.

STEP UP

A non-standard vertical stack placing the wingmen above the leader. It is used in photo shoots and low altitude parade passes.

SUCKED

In normal flight, aft of the briefed/desired position. In turning rejoins, aft of the rejoin bearing line and at too low of an aspect angle.

SOP

Standard Operating Procedures. Those procedures that should be understood and used unless briefed differently by the flight lead.

TACTICAL FORMATION

Two or more aircraft flying either in line abreast, approximately one turn radius apart or in fighting wing.

TALLY HO

Used to indicate that you have visually acquired whatever it is you were looking for.

TAIL CHASE

A trail formation flown at a fixed distance behind and on the turn circle of the preceding aircraft. In multi-ship formations, #2 sets the spacing and all trailing wingmen primarily use power to maintain the spacing.

THE BREAK

The breakup of the formation over the runway when a flight does a 360 OVERHEAD. Also called a "pitch out." A fighter maneuver indicating an abrupt bank and pull to accomplish a change of direction and/or altitude.

TURN CIRCLE

The flight path described by an aircraft in a turn. The size of the turn circle is based on relative G and TAS.

TURN RADIUS

The distance from the aircraft to the center of his/her turn circle.

TURN RATE

The rate of heading change by an aircraft.

VISUAL

Radio call or situation when the pilot has the leader or reference aircraft in sight.

3/9 LINE OVERSHOOT

When your aircraft moves ahead of the leader.

WINGTIP OVERLAP

No lateral separation exists.

