



RED RADIAL'S
Formation Procedures and Techniques

INTRODUCTION

This formation flying manual has been adapted from various source documents. The methods and techniques discussed here are largely based on Military techniques especially those used by the RAAF. It is intended that these procedures and techniques will be kept aligned where appropriate with RAAF procedures. The techniques described here are ideal for Warbird type close formation activities.

This manual contains all the formation fundamentals including:

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

NOMENCLATURE

Several conventions have been used throughout this manual. The terms he/she, him/her, his/hers, 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 meet the needs of the civilian aviation community.

The formation concepts presented in this manual are applicable to all formation activities. The fundamental priorities are:

1. Proficiency and safety
2. Mutual support
3. Symmetry and aerial display

DISCIPLINE

Formation flying is a particularly demanding discipline. Pilots fly in close proximity to other aircraft and 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

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

Being prepared physically means pilots 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 incidents 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
- Intercom system

Required (with a trainer on board):

- Ability for both pilots to transmit/receive on radio

DEMO-DO

The onboard trainer 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 trainer 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 trainer 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 trainer 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.” or “Handing Over”

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

“I have the aircraft.” or “Taking Over”

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 trainer 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 trainer will announce, in a forceful manner, “I have the aircraft” or “Taking over” 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, oversee 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 the flight
- Selection of wingmen
- Verification of pilots’ credentials, currency and competency in type
- Mission planning
- Briefing the mission
- Debriefing the mission
- Mentoring new formation pilots

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 their “head in the game” at all times. There is little room for mistakes, and errors can propagate quickly throughout a flight of aircraft in formation.

HOW TO USE THIS MANUAL

This manual provides a comprehensive, indepth study of fundamental formation concepts and theory.

NEW FORMATION PILOTS

The new formation pilot should begin by studying the Preface, Chapters 1 through 9, and Appendix 1 and 2. This will provide them with a solid, basic understanding of formation structure and protocols. Once the new formation pilot has read and understood the procedures in this manual its time to practice using them. Seeking a mentor who is proficient in these procedures is advisable.

Once proficient in 2 ship formation the pilot should then progress on to 3 and four ship formation work.

FLIGHT LEADERS

Flight leaders must have a thorough knowledge of the Preface, Chapters 1 through 9, and Appendix 1 and 2.

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 manoeuvre and brings into play observational, diagnostic and analytical skills to meaningfully present a solution.

INSTRUCTION

In general Red Radials operations are conducted on a “Mentoring” basis. If any basic formation training using these procedures is performed that instruction will be undertaken by pilots with the appropriate CASA instructor ratings.

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



PHOTOGRAPHERS

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CHAPTER 1: FLIGHT ORGANISATION

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 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 as well. 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.

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 sortie. The basic formation configurations are finger, echelon, and Line astern. Most other configurations are variations of these.

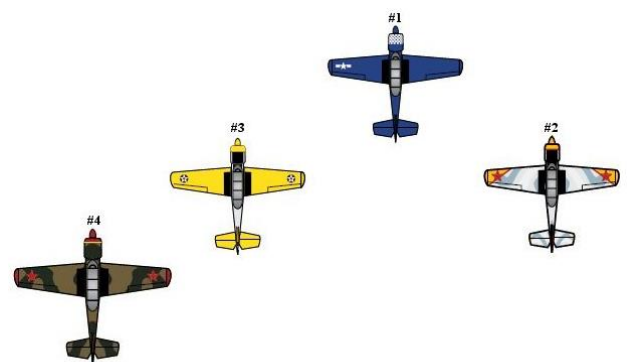
FINGER FOUR

Finger four is the standard flight configuration. It is so named because a 4-ship formation resembles the fingertips of your hand when viewed from above. “Left Hand Finger four” (LHF4) resembles your left hand; “Right hand finger four,” (RHF4) your right hand. In finger four, the wing pilot maintains a bearing line,

normally in the 30° to 45° range aft of Lead, depending on the aircraft type, as well as lateral wingtip spacing.

Formation configuration changes are executed from the finger 4 position. If the flight is in a configuration other than finger 4, the flight leader will regroup the flight into finger or Line astern before moving to a new configuration.

LHF4



RHF4



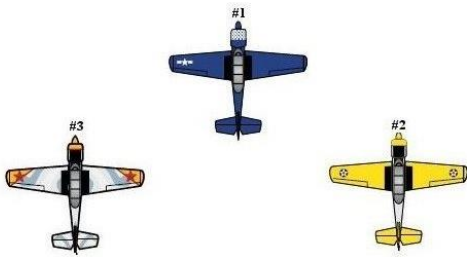
Note: No Stepdown

VIC AND REVERSE 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. In Vic, #2 will always be in echelon right. In Reverse Vic #2 is on the left

VIC



REVERSE VIC



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 bearing line, each flying off the preceding aircraft. Echelon is used in the circuit, primarily to position aircraft for pitchouts. There is no stepdown in Echelon. Sometimes echelon can be limiting. With any more than two wingmen it is generally not recommended to attempt any turns towards the wingmen.

LINE ASTERN

(Also known as “In trail”) Line Astern formations are flown, as the name implies, with the wing pilots following in line astern behind #1. There are two distinct types of line astern formation: Close and Long. 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 manoeuvres chapter. Long line astern is generally used in situations where greater manoeuvrability is desired.

BOX

(Also known as “Diamond”) The box is formed when the #4 wingman moves into the “slot” position, in line astern with #1. It is a relatively compact and manoeuvrable configuration and for this reason is often used as a building-block to assemble mass formations.

BOX



ROUTE/BATTLE 4

Route (also known as Battle 4) 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 #2 and #4 loosen up to a minimum of two to four ship-widths out to a maximum of 150m from Lead on an extended echelon/bearing line. Fore and aft, route includes an area from the 3/9 line (line abreast), aft to the bearing line.

As the #3 moves further away from the lead he should move forward but no further forward than the lead's 3/9 line. Ideally the #3 flies abeam the lead. The #3 ideally sits 600m out from the lead. This allows the lead to keep #3 and #4 easily in sight.

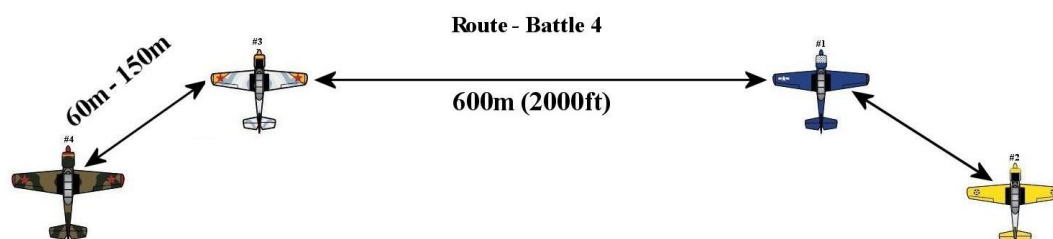
To tighten up and reform the flight, Lead will normally execute a shallow slow wing rock.

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 summarized 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 perceive 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 manoeuvre, you can anticipate as Lead turns away from you - you will have to add power and climb to stay “stacked up” in the proper echelon position. If you do not anticipate this manoeuvre 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 echelon bearing line or aft of station is referred to as being “sucked or lagging” 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 correct 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 trainer 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 finger, #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.

TURNS IN ECHELON

When Lead rolls into a turn, the manoeuvre 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 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, the wingman 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 echelon left, 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 finger) because of the greater distance from Lead.

BELLY TURNS (LOW-WING A/C)

Turns in echelon (with more than 3 aircraft in echelon) away from the flight are usually accomplished differently than in finger. As we covered earlier, in finger, everyone maintains the same position references and relative position. In belly turns, the wing pilots maintain the same lateral spacing, however they do not move up vertically to stay on the same lateral plane as the lead. This gives the wing pilots a bigger power advantage to stay with Lead. As Lead rolls into the turn, match bank angles and hold the lead aircraft's fuselage on 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 (*Red, 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., “*Red 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 “*Red, 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 and will be briefed by the lead:

- 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 takeoff” by passing the “thumbs up” signal up the line.

TAKEOFF

Takeoff can be performed in a 2-ship formation or single-ship, in stream (in trail) 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.

STREAM/TRAIL TAKEOFF

For single-ship, Stream 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 (geographic or time) 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 stream 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 centre of the runway for the takeoff roll.

FORMATION TAKEOFF

For a formation takeoff, Lead will taxi into position, normally lining up on the far side side of the runway. If the cross wind is five knots or more, the Lead will position himself downwind. The wingman will line up on the opposite side of the runway in the acute position, slightly ahead of the normal echelon 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 wingman would normally be in the centre of his side of the runway with a minimum of 3 metres of lateral wingtip clearance. However, even on wider runways, the wingman will want to approximate the 3 metres of lateral separation so that the takeoff sight picture is consistent. Depending on where the leader lines up, this 3 metres of lateral separation may have the wing pilot lined up in the centre of his half of the runway or slightly left or right of the centre position. (30m is the minimum runway width required for training.) When in position and ready to run up the wingmen will give a thumbs up to the lead, lead will then give the run up signal. The wingman will power up to the briefed power setting and check engine instruments. The wingman will then look directly at the lead and indicates he is ready for take off with a small head nod. 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 (*“Red 1, power up”*). Conversely, if the wingman is at or near full power and is having trouble keeping up, he should call *“Red 1, Revs.”*

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 keeps 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 or momentarily apply the brakes After the gear is retracted, the wingman will move into the normal echelon position.

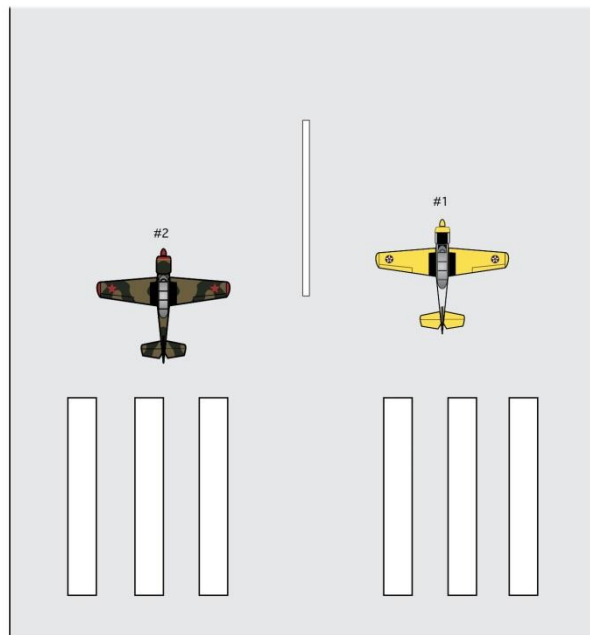
TAKEOFF ABORTS

In the event of an abort, the aborting pilot will call it out on the radio (*“Red 3, stopping”*). 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 *“Red Stop, Stop, Stop”* and all aircraft will stop. 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 centreline.

REJOIN AFTER TAKEOFF

When performing single aircraft stream 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 initially to the inside of the turn, then once stable move to the briefed position. If a straight-ahead rejoin is performed, #2 will join to the side he previously occupied, if applicable, or on the right 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.



PAIRS LINE UP

CHAPTER 4:

2-SHIP MANEUVERS

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

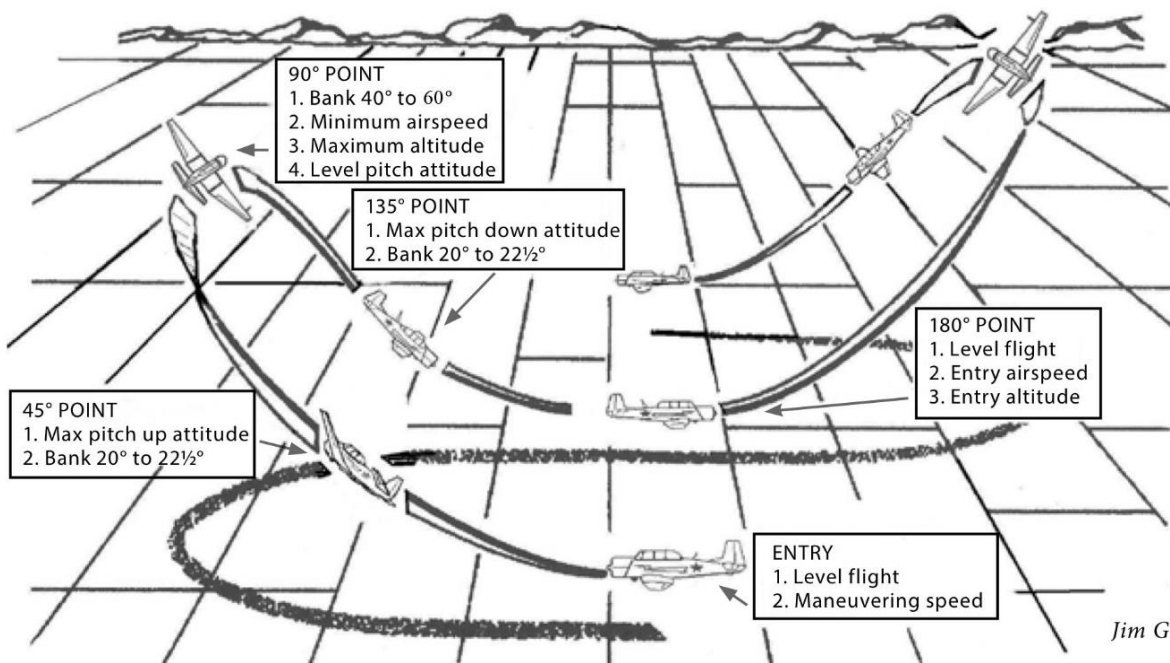
WING-WORK

One of the first manoeuvres 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 manoeuvre in formation, with the wingman remaining "welded" in position throughout the manoeuvre. 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 60° of bank. These are the parameters used in the wingman evaluation ride.

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 manoeuvre.

Lead, with power set, 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 60° 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 60° 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 manoeuvre 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 manoeuvre 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 manoeuvre, 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 to point at the wingmen then passing his hand over his head in a sweeping motion point to the new position. 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 to the Key
2. Across to the Key on the other side
3. Forward and up to echelon.

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.

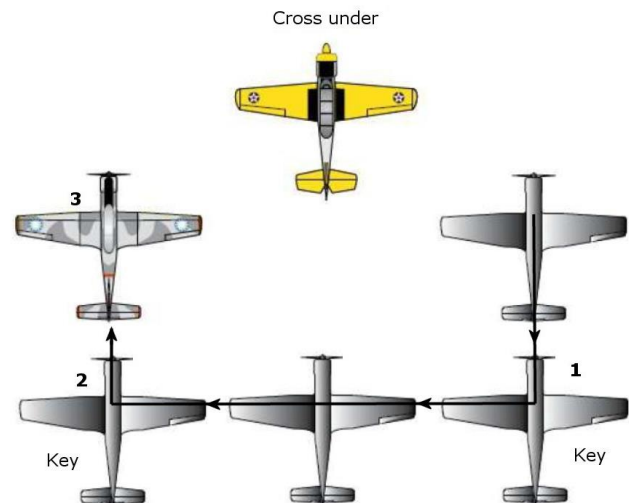
When you have wingtip clearance, return to Lead's heading. Add more power to move up and forward into the normal echelon position.

Think of the manoeuvre as having one slight power reduction followed by three big power 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 directly back from echelon to the key.
- Wingman transitions smoothly across the formation to the key on the other side.
- Wingmen moves up and forward from the key to echelon



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 echelon position

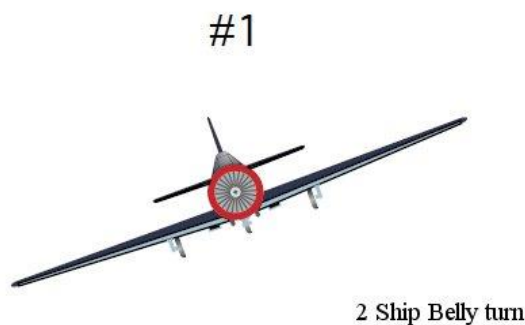
BELLY TURN

Generally, there are two occasions when the belly 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.... especially turning on to initial if 2 elects to turn in belly all turn in belly..

When turning in belly, 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 belly turns. However, there is a belly 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 belly turns.



DESCRIPTION

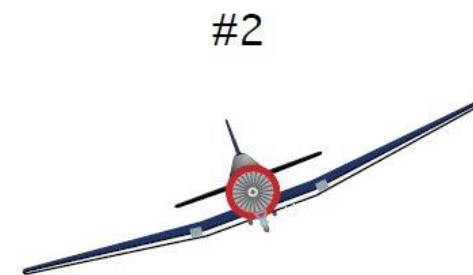
Lead rolls into a turn and the wingman simultaneously rolls with the flight leader, maintaining his position on the same horizontal plane as Lead, while matching Lead's bank angle. The fuselage of Lead's aircraft will be bisected by the horizon line. The wingman is now flying a slightly larger turn circle and will have to add power to maintain position.

PERFORMANCE GUIDELINES

- Wingman adds power, rolls into the turn and moves smoothly into the belly turn position
- Wingman maintains the correct position throughout the turn
- Wingman transitions smoothly back to echelon 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



LINE ASTERN

In line astern, the wing aircraft is directly behind Lead, stacked down, with approximately one aircraft's length. 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

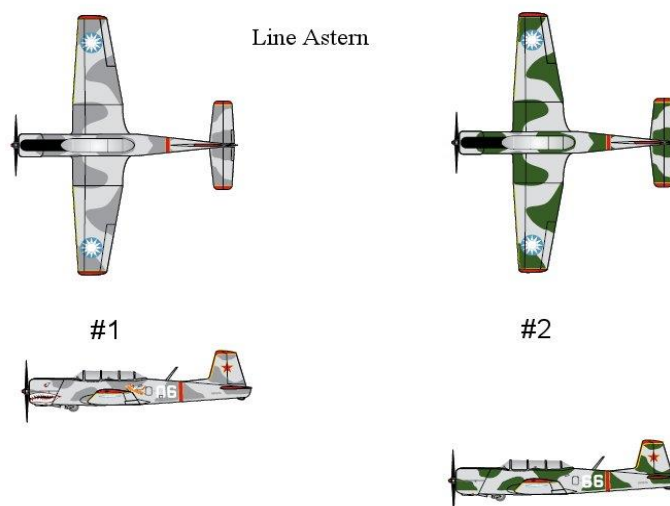
far behind, it is better to offset slightly to the side, allowing parallax to give you an oblique view of the leader to help you judge overtake.

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 manoeuvring

COMMON ERRORS

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



COMBAT

Combat is a locked-throttle manoeuvre where wingman maintains spacing within a defined manoeuvring area behind the flight leader solely by using turn geometry and energy management. It is used to teach wingmen the concepts of lead, lag, and pure pursuit. It may also be employed by a flight leader to manoeuvre around weather or in other situations where high manoeuvrability is advantageous.

SIGNAL

The flight leader will send the flight to Combat with a radio call:

“Red, Combat go”

DESCRIPTION

Lead pursuit defines both a relative 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 (V_c) 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 manoeuvre out-of-plane to prevent the overshoot.

Lead will fly a series of hard turns, turn reversals, and lazy-eight manoeuvres 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 manoeuvring 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 manoeuvres fluidly within a cone, taking advantage of turning geometry to maintain the briefed nose-to-tail spacing with Lead. Combat spacing for aircraft with manoeuvring speeds below 150 knots is normally 200 feet (60m) to 500 feet (150m), while above 150 knots, 500 to 1500 feet (150m-450m) would be used, although different intervals may be briefed. The preferred manoeuvring 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 manoeuvres 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.

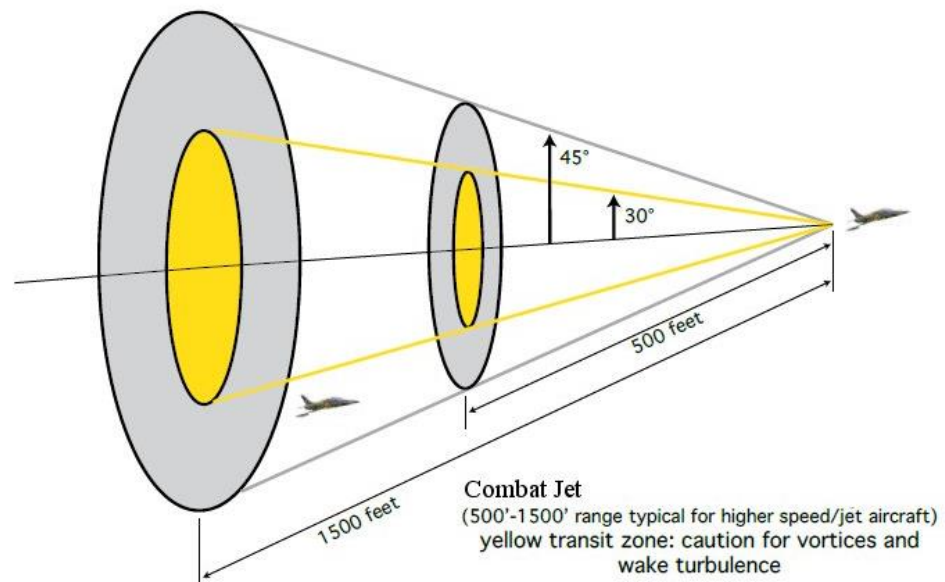
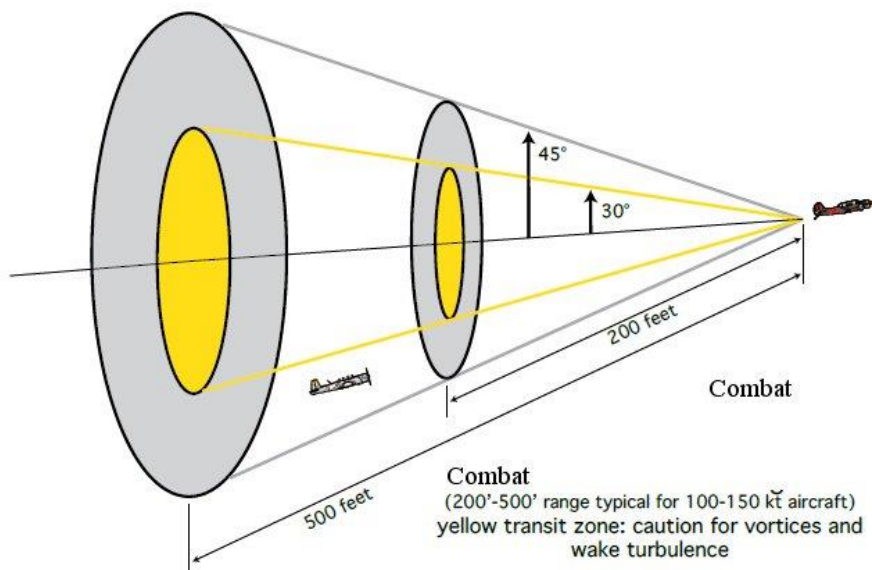
Initially, using lead, lag and pure pursuit to maintain position will be challenging. It requires practice to develop the judgment necessary to determine aspect, range and closure. If you find you are closing too rapidly, do not hesitate to reduce power or turn aggressively away from the lead aircraft.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

COMMON ERRORS

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

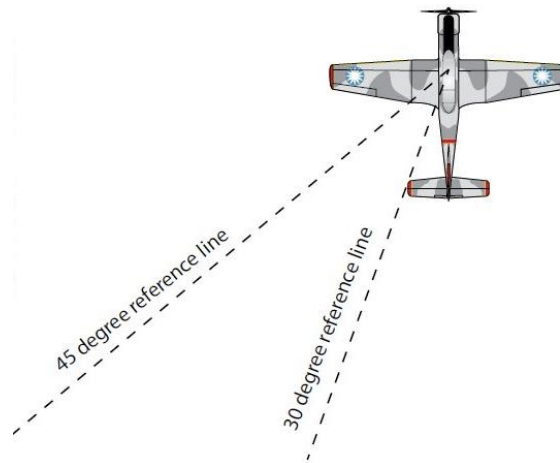
PERFORMANCE GUIDELINES

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



Combat Reference

- From leads perspective, if the wingman is between the edge of the horizontal stabiliser 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 stabiliser and a line halfway between the wing root and the inboard edge of the aileron the wingman is within the 30°/45° cone



LONG LINE ASTERN (TAIL CHASE)

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

SIGNAL

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

"Red 2, Long Line Astern go."

DESCRIPTION

Two-ship Long Line Astern differs from combat 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/60m (1000 feet/300m for jet aircraft), out to 1500 feet/450m 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 tail chase 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 trainer is paired with a student in each airplane—the trainer assumes Lead responsibility while the student in the lead aircraft observes. We don't renumber following a lead change.

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: "Red 2, Take the lead." Once abreast the lead #2 will call "Red 2 passing Left/Right taking the lead." Red 1 responds "Visual"

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 the echelon position.

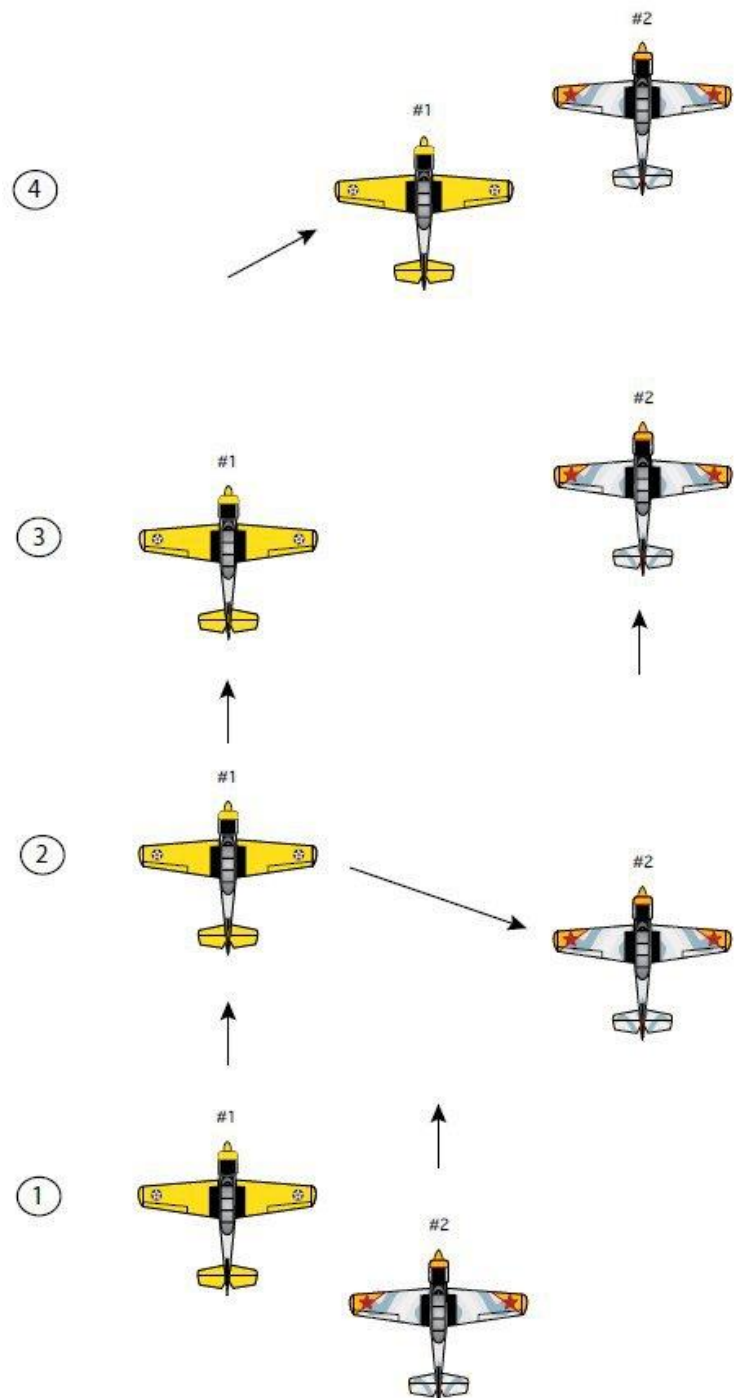
The flight lead retains his call sign during the lead change.

PERFORMANCE GUIDELINES

- Flight leader should maintain position, providing a stable platform while the new flight leader manoeuvres into position
- New flight leader should smoothly manoeuvre 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



REJOIN EXERCISE

There are two methods used to set up the rejoin exercise. The method to be used will be briefed.:

The Perch method (Preferred pairs only)

The Pitchout method. (US method)

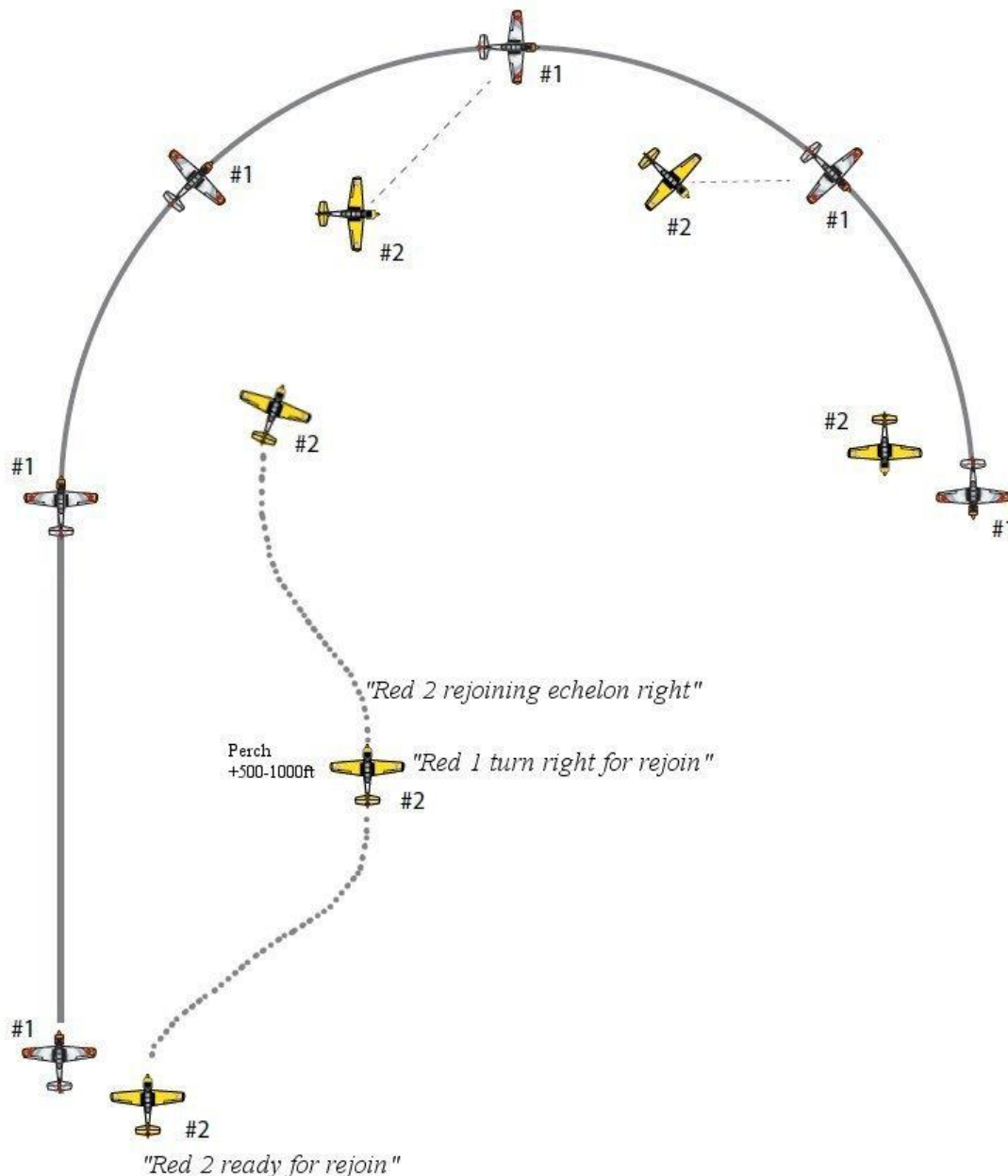
PERCH METHOD

The Perch method is a quick and convenient method used to set up a 2 aircraft rejoin practice. It commences with the wingman in echelon. When ready to start the exercise Red 2 calls *"Red 2 ready for rejoin"*. The lead clears the airspace on the wingmans side of the formation then gives the wingmen a thumbs up. The wingman increases power if required then turns and climbs away from the lead typically using 45 degrees of bank through 45 to 60 degrees of heading change gaining 500 to 1000ft of altitude then parallels the leads heading ... the wingmen is now *"on the perch"*. When ready the wingmen then

commences the rejoin. If the wingmen wants to perform a straight rejoin he points his nose use lead pursuit and says *"Red 2 rejoining Left/Right"* The lead continues on his heading and altitude providing a stable platform. Red 2 rejoins in echelon on the called side.

If the wingmen requires a turning rejoin he will in his perch call say *"Red 1 turn Left/Right for rejoin"*. The lead will then turn in the called direction using 25 to 30degrees of bank (or any specific briefed value). The wingman then performs a Turning rejoin

When done correctly there is no pause at the perch. The wingmen transits through the perch in a single flowing manner. This in most cases will have the wingmen commencing the rejoin from just inside the Leads turn circle. If the wingmen wants to practice rejoins starting from outside the leads turn circle all that is required is to delay the roll in from the perch.



PITCHOUT METHOD

The pitchout manoeuvre can be used in the traffic pattern to achieve interval spacing for landing, or in the practice area to establish extended trail spacing, or anytime the flight leader wants to break the flight up. The pitchout method is also used for used for 3 and 4 ship rejoin training.

The rejoin is used to reassemble the flight into finger or echelon.

PITCH OUT SIGNAL

The flight leader will hold his open hand up and wave goodbye to his wingman, using a twirling motion, and then pitch away from the wingman. The default pitchout interval is 4 seconds.

To initiate the rejoin, the flight leader will rock his wings, with the initial rock in the direction of the rejoin (for a turning rejoin). 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 last wingman will call "in" ("*Red 4, in*").

REJOIN TECHNIQUES

STRAIGHT REJOIN

Once the wingman has called "in," the flight leader will rock his wings to initiate the rejoin and then roll wings level. (In the case of the perch method the wingman initiates the rejoin with his radio call.) Lead will have briefed or will call out the rejoin airspeed so that the wingman has a datum 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. In the case of the Perch method the wingman nominates the side he will join on in his rejoin call. The wingman will use power/pitch 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 echelon 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.

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: Establish then keep the flight leader just above the horizon line (flight leader's lower wingtip touching horizon).
- 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. In a 4-ship, 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 overshoot, 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 overshoot is the only safe escape. Too far aft (sucked) will slow the rejoin down and create problems for the following wingmen in a 4-ship 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 echelon position parallel to Lead.

TURNING REJOIN EXECUTION

Once the wingman has called in at the six o'clock position (or at the perch), the flight leader will rock his wings, with the initial rock in the direction of turn, to initiate the rejoin (or in the perch method the wingman will call for the rejoin) and then begin a level turn 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 manoeuvres to rejoin.

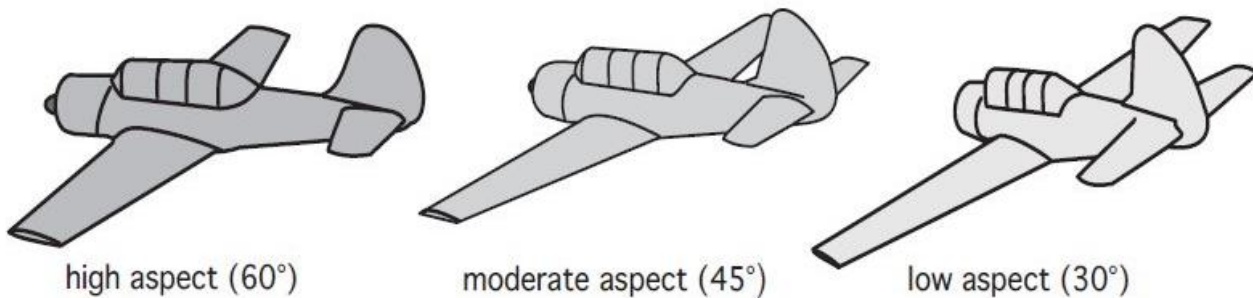
If rejoin airspeed has not been briefed, or if Lead is not within 10 knots of the briefed rejoin airspeed, Lead will make a radio call announcing the airspeed.

When the flight leader gives the rejoin signal (or in the perch method the wingman's radio call) 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 route #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 in space on the horizon where the leader started his rejoin turn and fly toward it. In the Perch method the wingman maintains Maximum continuous power lowers the nose and if inside the lead's turn circle (in most cases you will be) establishes lead pursuit on the lead. The wingman transitions to slightly below the lead.



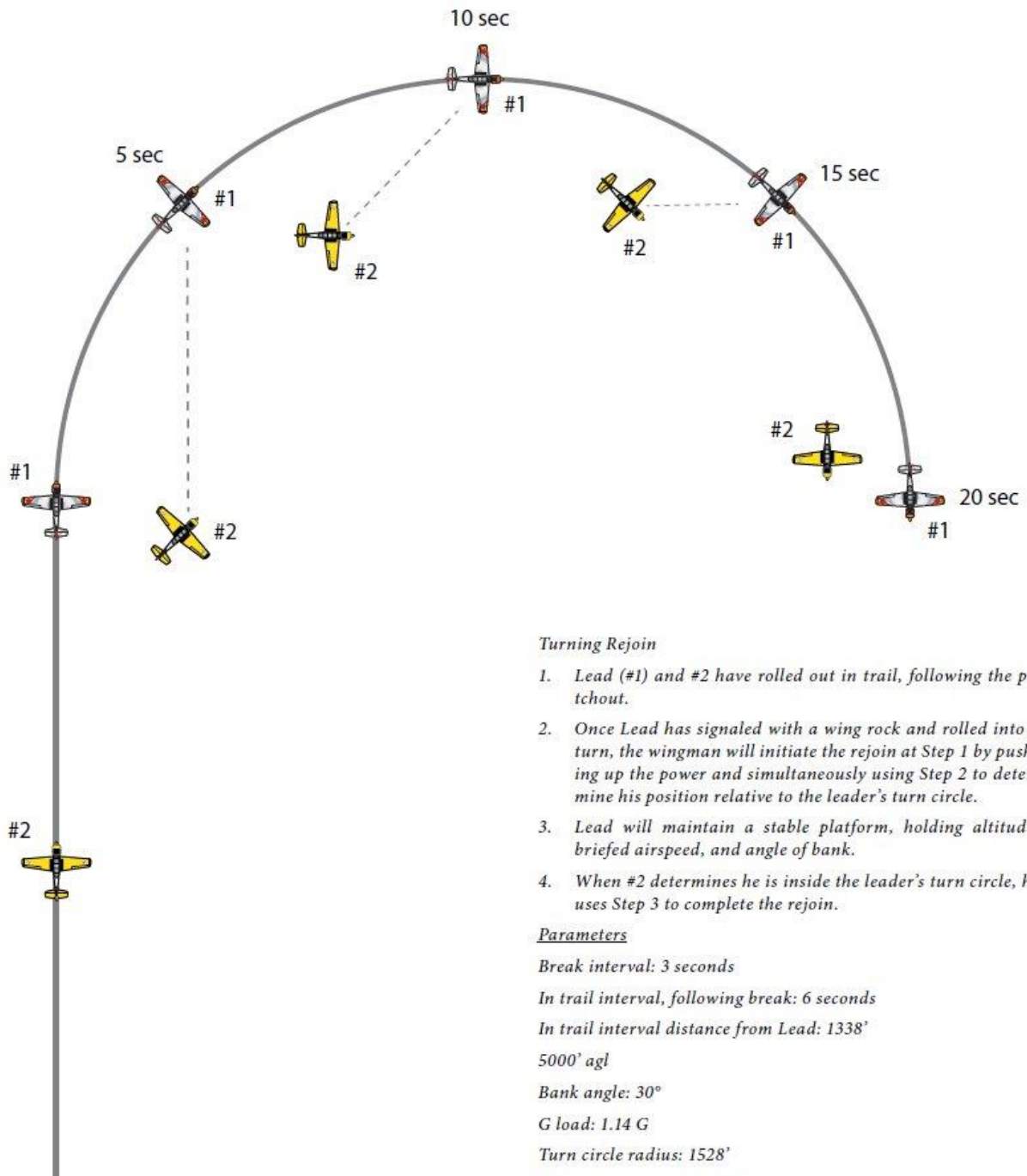
Moderate aspect with the vertical fin aligned with Lead's outboard wingtip is the sight picture you are looking for throughout the rejoin. High aspect indicates you are forward of the bearing line (acute) and your rejoin can accelerate exponentially. Low aspect indicates you are behind the bearing line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

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 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.





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.

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.

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 the key position, you must determine if your rejoin is stabilized enough to continue into echelon position. Your rejoin is stabilized if the following occur:

1. You are at the key
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 echelon

If you meet all these conditions, complete the rejoin by continuing into echelon 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, you can cross under the leader to your corresponding position on the outside of the formation if required.

Wingmen will always join to the inside of the turn. Once stabilised wingmen then move to the required echelon. Throughout the rejoin all wingmen should have all preceding aircraft in sight and on the same side. SOP is 4 avoids 3 who avoids 2 who avoids 1. 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
- Wingmen 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 TO BUGOUT

During a rejoin manoeuvre, an "overshoot" condition may develop when the rejoin becomes unstable, namely, when the rejoining aircraft becomes excessively acute and/or possesses significant overtaking speed or closure. Wingmen should not attempt to salvage an unstable rejoin if, in doing so, it would violate one of the wingman's responsibilities and create an unsafe situation. Once the overshoot condition is recognized, the corrective manoeuvre to employ is the "bugout."

The bugout is just another formation skill, and is the corrective manoeuvre to employ in an overshoot situation—the re-joining aircraft is smoothly but positively controlled to pass safely below and behind the aircraft or formation on which the rejoin is being conducted. If you religiously adhere to the "six-step" guide to flying inside the turn circle for rejoins, are well trained by your IP, and practice often, you will rarely find yourself in an overshoot condition requiring a bugout. However, blown rejoins will happen. Therefore, wingmen must learn, practice, and acquire this vital formation skill.

Think of a bugout as the formation equivalent of a go-around from an unstable or aborted approach to land. Both are designed to safely extricate a pilot from an untenable and potentially unsafe situation.

The need to execute a go-around or a bugout rarely surprises a pilot, as both often telegraph their need long before pilots reach the minimum safe execution point.

SIGNAL/COMMAND

There is no signal for executing the bugout manoeuvre. However, once the wingman recognizes the overshoot condition and begins the under-run, he will make the radio call: "*Red 2, bugging out.*" The flight leader should also be prepared, at any time, to command the wingman to execute an under-run if the wingman fails to recognize the overshoot condition and react accordingly. The flight leader will command: "*Red 2, bugout.*"

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 under-run. There are five warning signs that a rejoin is unstable and an overshooting condition is developing, 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 or correct for bearing line, 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 bearing line corrections, any or all of these conditions exist as the wingman approaches the key position, the wingman should abandon the rejoin and proceed with the bugout, while simultaneously:

1. Reducing bank angle, as required, to pass below and behind the flight leader
2. Adjusting power, as required
3. Transmitting the bugout to the flight leader (“Red 2, bugging out”)
4. Stabilizing outside Lead's turn circle, no farther forward than Lead's 3/9 line, and NOT higher than the echelon position. Keep Lead in sight
5. Remaining in this stabilized position until cleared by Lead to continue with the rejoin
6. Bugging-out, if unable to stabilize or if you lose sight

The airspace available for a bugout includes all the co-altitude airspace on the outside of Lead's turn circle as far forward as Lead's 3/9 line—in other words, no higher than the echelon position and no farther forward than abeam Lead.

Just as a prudent pilot would not rush a go-around, a wingman MUST NOT over-aggressively rush the bugout to complete the rejoin. There is no clock running, no embarrassment, and no need to create a dangerous situation by rushing. A precise execution of the bugout procedure will result in a safe, controlled rejoin.

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 close to the leader, at or slightly aft of the flight leader's 3/9 line.

This stabilized position following the bugout will look similar to a belly turn position, something all wingman are very familiar with. From here, **and only after cleared by Lead**, 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 bugout. If too much

energy is dissipated during the bugout 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, the wingman may not be able to complete the rejoin via the cross-under. Anytime this happens, after being cleared by Lead, the wingman should immediately begin a controlled move back to the inside of the flight 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 bugout procedure to gain judgment and confidence. The trainer will have him carry extra airspeed and cutoff during the rejoin to create an overshoot situation. The trick is to retain enough energy after the bugout 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 situation may be created.

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.

CAUTION

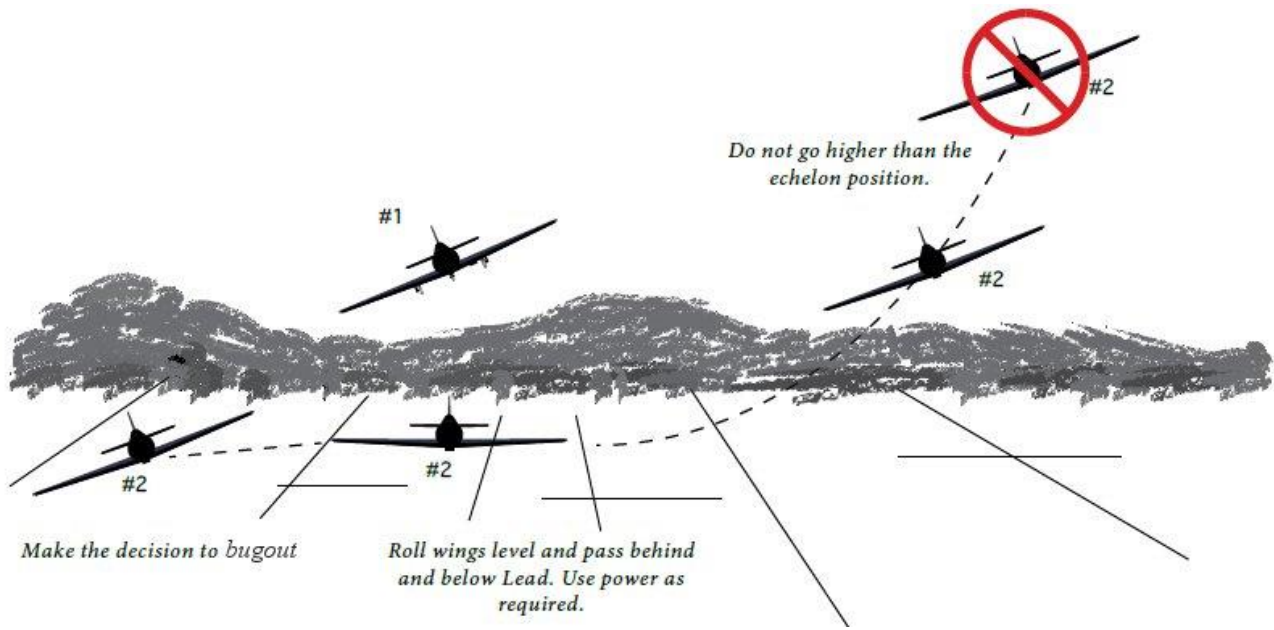
Aggressively moving inside the leader's turn circle with excess energy could result in another unstable rejoin, leading to another overshoot situation.

PERFORMANCE GUIDELINES

- Wingman will recognize excess closure and the developing overshoot situation in a timely manner, and in a smooth, controlled manoeuvre, execute the bugout
- Wingman will move to the outside of the turn **without** going forward of, or higher than, Lead
- Wingman will wait until cleared by Lead to continue before leaving the stabilized position and executing the cross-under, or regaining the bearing line inside the flight leader's turn circle

COMMON ERRORS

- Not recognizing excessive closure (the overshoot situation)
- 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 bugout (“Red 2, bugging out”)
- 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 or overshoot situation.



CHAPTER 5:

RECOVERY (RTB)

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

INITIAL AND PITCH

The Initial and Pitch is an efficient way to get a formation flight on the ground. An initial and pitch involves flying an upwind leg aligned with the landing runway centreline at a pre-briefed altitude (called “initial”), followed by a turn downwind typically executed when at mid field. The downwind leg is followed by a descending, turning base to final approach. This allows the pilot to bleed off airspeed once on the downwind leg in preparation to configure for landing, just prior to the perch point. It also keeps the aircraft relatively close to the runway.

Approaching the runway, Lead will configure the flight in echelon in preparation for the overhead pitch to downwind. The minimum pitch Interval (PI) is four seconds. Leaders may brief other PIs, as required. On initial, leaders may also change the interval by hand signal or radio call. Lead will typically pitch out at mid field but no earlier than the threshold, using a maximum of 45° of bank (less bank angle for overshooting winds), but can adjust the pitch point to compensate for winds or as needed or directed. Each pilot then takes their interval and pitches so as to roll out on downwind behind the preceding aircraft at circuit height while slowing. Lead will maintain traffic circuit altitude and airspeed on downwind until reaching the base turn position—normally 30° to 45° beyond the intended point of landing. For lateral reference, Lead will fly downwind as appropriate to their type of aircraft and the conditions. Lead will extend landing gear and flaps as he approaches the base turn point and, begin a descending turn to final.

Lead’s objective is to adjust the base turn point to allow for a base turn to final that results in rolling out wings level on final, ½ to ¾ of a mile from the threshold, on a 3° to 4° glide path (approximately 400’AGL).

NOTE

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

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 on the runway centreline. 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 pitch-out to maintain their target airspeed and roll out on downwind directly behind the aircraft ahead at circuit height (or as briefed). When wings-level on downwind, the wingmen will slow as appropriate (if there are wake turbulence issues, the wingmen can offset slightly to find smooth air). Wing pilots will maintain traffic circuit altitude and airspeed all the way to the base turn point and, approaching the base turn point, extend gear and flaps and accomplish the “before landing checklist.” Upon reaching the base turn point the wingman will begin a descending turn to final. The wingman will not begin the base turn unless the aircraft ahead is in sight typically at the 10 or 2 O’clock position. It is important for the wingman to positively identify the aircraft in front of them to preclude cutting an aircraft off in the final turn. Each wingman will fly their circuit 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 they fail to complete their before landing checklist!

NOTE

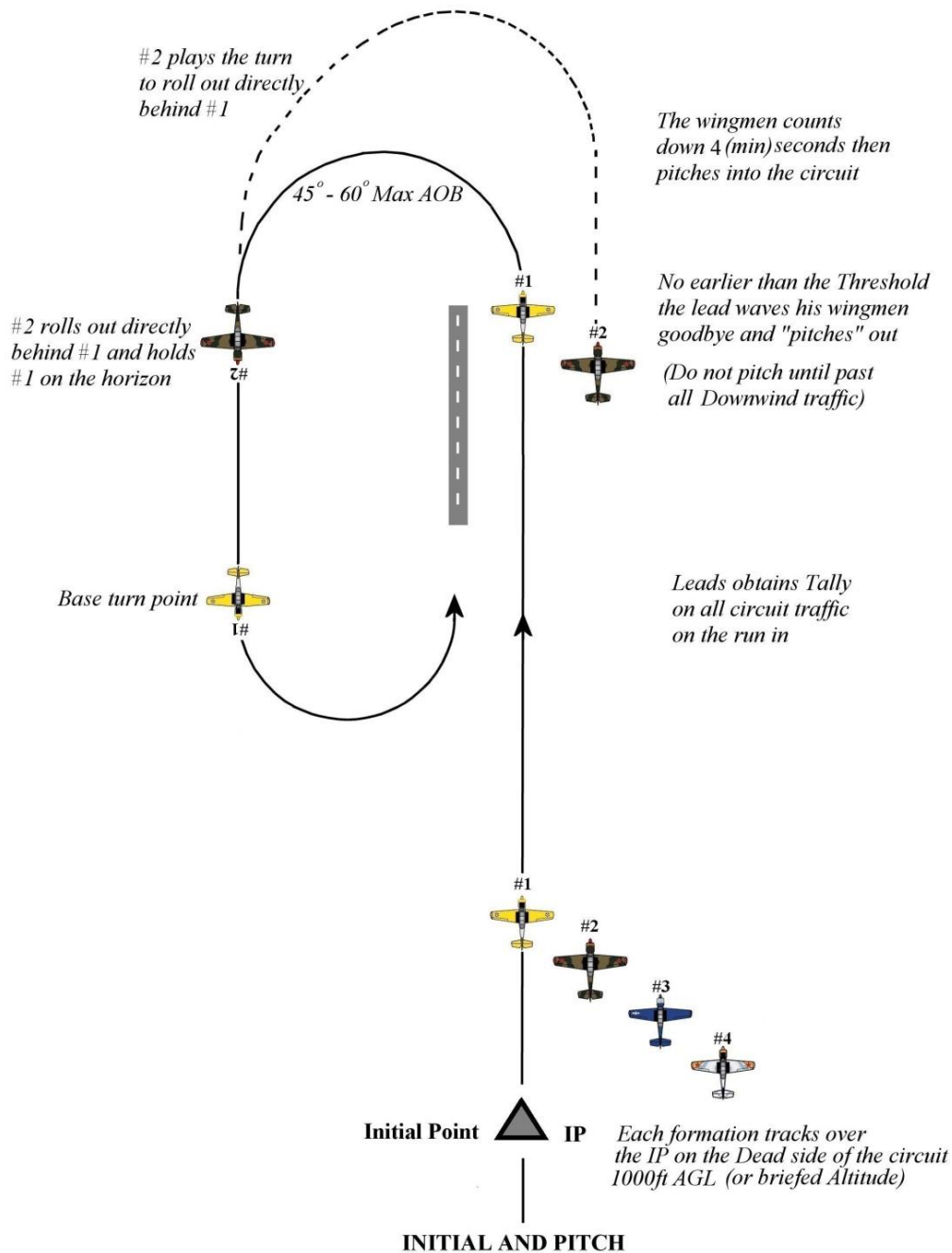
The base turn point for the wingman may not necessarily be located at the same point as Lead's base turn point, depending on the break interval. For example, a two second break would not provide adequate spacing on final if the wingman used Lead's base turn point. In this case, the wingman would have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

NOTE

The trail interval is equal to two times the break interval. Thus, a four second break will produce an 8 second trail on downwind.

The wingman's objective is to adjust their base turn to achieve a safe interval for landing --- 500metres minimum.

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



GEAR CHECK RADIO CALL

Because of the inherent distractions associated with formation flying, we add one extra component to the traffic circuit 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:

“Red 1, base, gear down/3 greens”

“Red 2, base, gear down/3 greens”

...and so on.

LANDING

Lead will normally land on the centreline then once under control move to the side of the runway that corresponds to the runway exit (cold side). Each wingman will land on the centreline and move to the cold side once under control. The outside lane (HOT lane) is then available for subsequent aircraft to use for example if they have a braking issue or need to go around.

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.

DOWNWIND PITCH

If an Initial and pitch is not feasible, another way to take spacing is on the turn to base leg. This is also known as the “downwind pitch.” Lead will configure the flight in echelon and slow the flight to normal circuit airspeed by downwind. If the downwind pitch was not pre-briefed, Lead will call:

“Reds, take spacing on the turn to base.”

Lead will turn away from the flight from downwind to base. The minimum downwind pitch interval is five seconds. After the proper interval is achieved, each wingman will turn to base. As each pilot starts the base turn they will configure for landing and complete the before landing checklist.

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 circuit. If already on the ground the pilot will call Hot lane and going round *“Red 3 Hot lane - Going round”*

PAIRS/ELEMENT LANDING (Min Rwy width 30m)

For multiple-element formations, the flight leader can break the flight into separate elements for pairs/element

landings. Each element Lead will fly a standard VFR circuit. 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, echelon position until fully configured. The wing pilot will hold 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 to 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 centreline 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: *“Red 2 Stable”*

PAIRS/ELEMENT GO-AROUND

If a go-around is required, Lead will announce his intentions on the radio (*“Reds 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 manoeuvre, 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 circuit.

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. When wingmen have completed their pre-shutdown checks, they will signal Lead with their arm held high above the canopy and a thumbs-up. Lead will then raise their hand in a similar thumbs-up and then drop it with a thumbs-down signal. The flight will shut engines down when Lead’s hand drops.

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. Debriefs are conducted under the “blameless culture” principle, where every participant in the flight is encouraged to share their opinion and critique as appropriate. Egos have no place in formation flying, and in a good debrief all participants respect this.

Lead 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, input will be solicited 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.



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 manoeuvring, 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 aircraft-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 centreline, the wingmen will follow suit (excepting S-turning tail-draggers). If Lead offsets from the centre 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

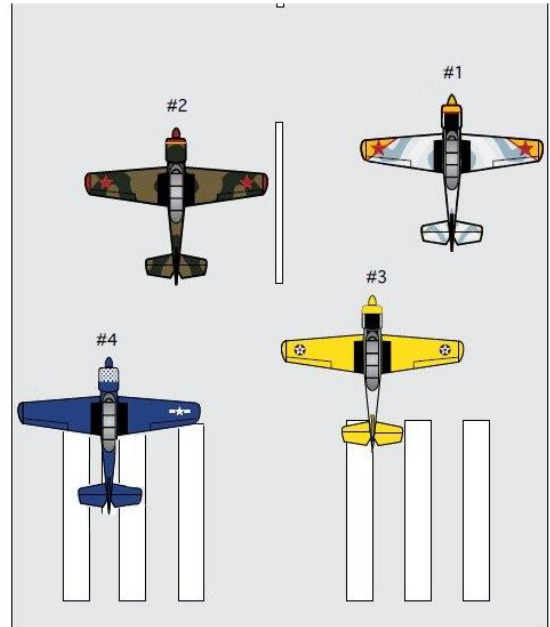
Depending on runway width, winds, weather, or local requirements, the flight leader can use one of four options:

PAIRS/ELEMENTS IN TRAIL

Used on any runway width to as narrow as 20 meters (65 feet). The trailing element is spaced from 30-150 meters back. For large piston, turboprop, or jet engine aircraft, spacing should be increased to approximately to 150 meters.

BATTLE 4/ELEMENTS IN OFFSET TRAIL

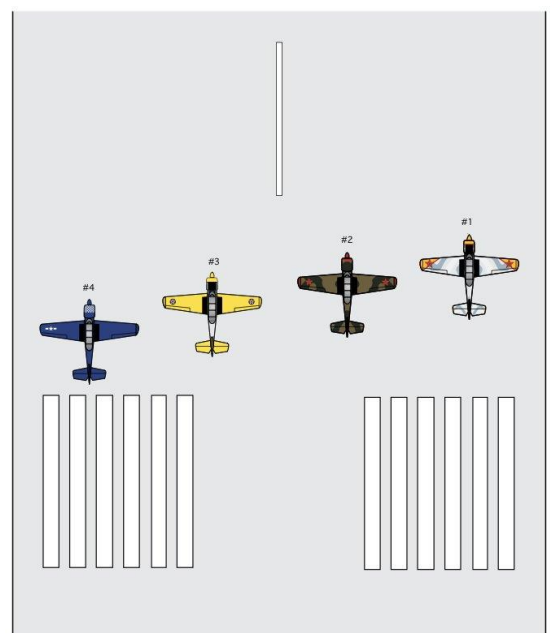
Battle 4 line up is used to get 4 aircraft lined up in a compact manner. by default the lead goes to the far side of the runway. On narrow runways the leads wingtip should be over the runway edge. #2 lines up on the near side with his wingtip on the runway centreline. #3 and #4 then line up in between #1 and #2. All wingmen to ensure sufficient nose tail separation to cater for an unexpected yaw event (loss of one brake) from any adjoining aircraft.



ECHELON

Used on any runway width 45 meters 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 echelon spacing.

When doing formation takeoffs, #2 and #4 will line up with 3 metres of wingtip separation. Number 3 lines up on #2 using normal fingertip spacing. On takeoff roll, both elements can correct to the runway centreline or as briefed otherwise.



TAKEOFF

Takeoff can be performed as Stream or **two-ship elements, as briefed.**

STREAM/INTERVAL TAKEOFF

For single-ship, stream 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, as 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 either the preceding aircraft become airborne or the minimum takeoff interval has been achieved before brake release.

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 centreline and there will be a wingman on either side of Lead. #2 on the right (crosswind limit 5 knots).

This same procedure can be executed with a 4-ship formation with #4 lining up on the centreline 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 join to the briefed position. With a second element, #3 and #4 will always join to the opposite side of #2

WING-WORK

Training in the lazy-eight manoeuvre 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 60° of bank.

DESCRIPTION

In a finger-four 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 wing-work in a variety of formation configurations, including line-astern and box.

PERFORMANCE GUIDELINES

- Lead will provide the wingmen with a stable platform and manoeuvre as smoothly as possible
- 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

CROSS-UNDER

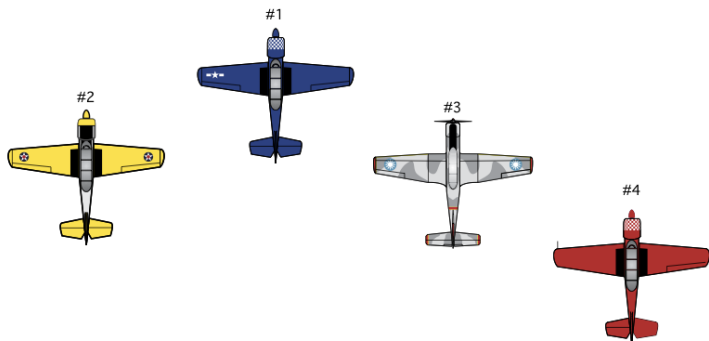
ELEMENT CROSS-UNDER

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

#2 CROSS-UNDER FROM FINGER 4

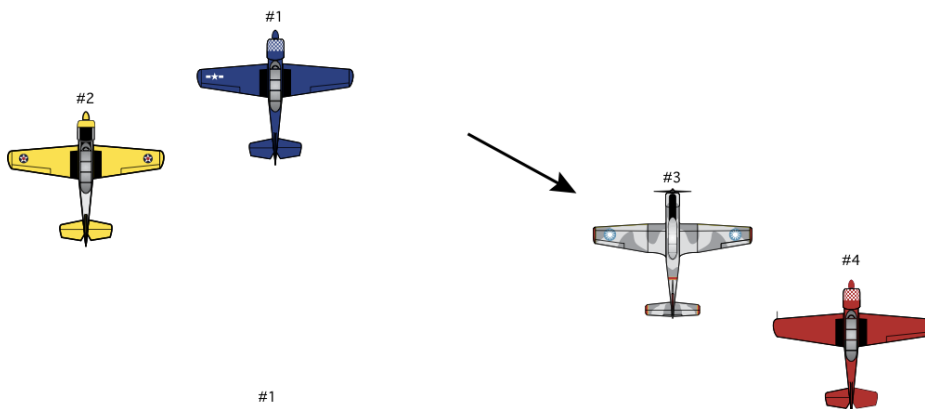
There are 3 basic means to perform a cross-under from Finger.

- If the lead simply wants to move #3 and #4 to the other side he commands the formation to the desired echelon or uses the Change sides Hand signal. #3 and #4 slide back in unison. #3 performs a standard cross over. #4 performs the same on #3 aiming to pass through #3's six O'clock as #3 passes through #1's six O'clock.
- If the lead wants to move #2 across into echelon he must first get #3 to make a space for #2. To do this Lead signals #3 with an open palm pushed outward toward #3. #3 then moves outward to make the space. When the space is made Lead then signals #2 to cross under into the other echelon. #2 performs a standard cross-under. Once #2 is in #3 and #4 move into to echelon.
- The alternative method to move #2 across to echelon is for the lead to call the formation into line astern then when #4 calls in the lead can call the formation to the desired echelon (or Finger if desired)

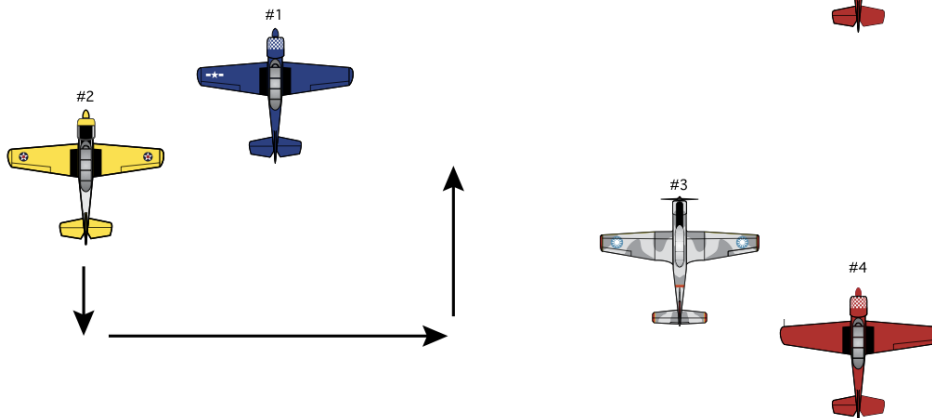


#2 Cross-Under

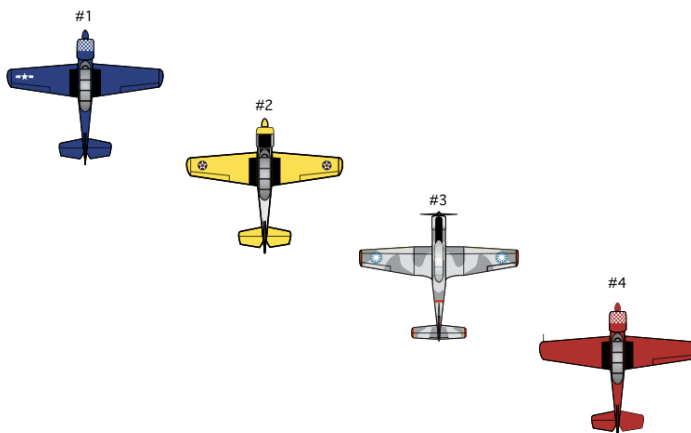
1. RHF4 to echelon right. Lead signals #3 to make space for #2 by using the open palm push away hand signal



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



3. Having confirmed the space for #2 has been made Lead then signals #2 to change sides using the standard hand signal



4. #2 performs a standard cross under. once #2 is in, #3 and #4 close up to Echelon right.

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 a 2-ship formation, the cross-under is not a race to the opposite side. Instead, it is a deliberate, controlled and precise repositioning of aircraft.

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)

BOX

The box is used when the flight leader wants to configure a 4-ship into a tight, manoeuvrable, symmetrical formation. By default #2 is on the right. Reverse Box has #2 on the left.



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 line-astern references. Then, #4 should begin to cross check #2 and #3 and adjust position by establishing a normal fingertip position on the bearing lines off of #2 and #3. When stabilized, #4 will call in position ("4's in").

When Lead signals with a brief but firm wing rock, #4 will rejoin to the original finger-four 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 finger-four position 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

BELLY TURN

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

SIGNAL

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

DESCRIPTION

Lead rolls into a turn and the wingmen simultaneously roll with the flight leader. 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.

LINE-ASTERN

In 4-ship line-astern, 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 it is following.

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.

When #4 is in position and stabilized, they will call “4’s in”.

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 manoeuvring
- #4 calls “4’s in” when they are in position and stabilized

COMMON ERRORS

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

COMBAT

In 4-ship combat, 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: “Reds, Combat - Go.”

DESCRIPTION

Four-ship combat is flown using all the procedures and techniques described in 2-ship combat. Number 3 maintains position within #2’s cone and #4 maintains position within #3’s cone. Remember, this is a locked-throttle, energy management exercise. Just as in 2-ship combat, all wingmen will be using lead, lag, and pure pursuit to remain in the 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.

CAUTION

4 Ship combat is very dynamic and needs to be briefed carefully. no matter what the avoidance rule, #4 avoids #3 who avoids #2 who avoids #1 remains sacrosanct. Each aircraft must ensure Nose Tail separation from the aircraft ahead of him. Leads should no be to aggressive when conducting this exercise

PERFORMANCE GUIDELINES

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

COMMON ERRORS

- Failure to call “in” when in position
- Getting sucked, falling outside of the proper manoeuvring range
- Manoeuvring in the six o’clock position instead of maintaining proper lateral offset within the donut
- Attempting to match #2’s interval

LONG LINE ASTERN 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: “Red Flight, Long Line astern - Go.”

DESCRIPTION

Three or four-ship tail chase differs from Combat 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 and bearing to home or nearest divert field (“*Red 3, heading 360, 5,600 feet, southeast corner of area 1, home is 010, 7 miles. Red 3 take the lead*”). Number 3 adds power, looks around to orient himself, and as he passes line abreast, transmits “*Red 3 passing right/Left taking the lead.*” Red 1 responds “*Visual*”

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 echelon position.

Formations will NOT renumber in flight.

Lead changes are typically executed from the finger 4, 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 manoeuvres into position
- New flight leader should smoothly manoeuvre to route and then execute the lead change
- Flight should move from route to close formation when directed to do so by the new Lead (wing-rock or radio call)

COMMON ERRORS

- Not thoroughly briefing the lead change
- Moving back to close formation (either finger-four or echelon) before directed to do so by the new Lead

PITCH OUT AND REJOIN EXERCISE

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 finger-four configuration.

SIGNAL

The minimum pitch interval is 4 seconds. If required this can be changed by briefing or on the radio. Before initiating the Pitch out the lead will wave goodbye to his wingmen. Subsequent wingmen will count the pitch interval and pitch at the appropriate time after the aircraft preceding them. 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 pitch away from the flight using 45° to 60° of bank. He will roll wings level after approximately 180° of turn. The wingmen will each pitch, 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 operational check as able, they will call in position (“*Red 2 in, Red 3 in, Red 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 right 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 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 call an overshoot (“Red 3, overshoot”), break out of the formation, and turn away from the flight. They may rejoin when cleared to do so by Lead.

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 manoeuvre 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 finger 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 rejoins to the corresponding finger-four position on the opposite side to #2. 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.

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
- Not recognizing and/or reacting changes in bearing relative to Lead
- Getting too low
- Becoming sucked and/or acute
- Not monitoring airspeed

OVERSHOOT TO BUG-OUT

The bug-out (under-run) manoeuvre for #2 in a 2-ship is explained in Chapter 4 “2-Ship Manoeuvres.” However, in a 4-ship a bug-out manoeuvre executed by #2, #3, or #4 creates a more complex situation, given that with a 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, and #3 will not join on Lead until #2 has joined. This allows #2 to bug out if required, and gives #3 and #4 time and space to react to this while preserving their ability to complete their own rejoin (the same applies to #3 if he bugs out).

SIGNAL/COMMAND

There is no signal for executing the bug-out manoeuvre. However, once any wingman recognizes the overshoot condition and begins the bug out, he will make the radio call: “Red (2, 3, or 4) *bugging-out*.” The flight leader should also be prepared, at any time, to command any wingman to execute a bug-out if any wingman fails to recognize the overshoot condition and react accordingly. The flight leader will call: “Red (2, 3, or 4) *bug-out now*.”

If closure becomes excessive and an overshoot situation exists, **any wingman can use, or be commanded to execute, the bug-out manoeuvre** to safely correct, stabilize, and rejoin, or reacquire the bearing line to affect the rejoin. **Numbers 3 and/or 4 must also remain in their stabilized position after executing a bug-out until**

cleared to rejoin by Lead. Number 4 does not complete his rejoin by crossing over until #3 completes the rejoin.

If #2 bugs out, what #3 and #4 do depends on how severe the overshoot situation is, and how much time it takes for #2 to complete the bug-out manoeuvre and then rejoin into position.

If #2's bug-out is completed expeditiously, #3 and #4 may only need to stop their rejoins by decreasing airspeed slightly and maintaining the bearing line. Once #2 completes their rejoin, #3 and #4 can accelerate and continue their rejoins along the bearing line.

If #2's overshoot is severe, the bug-out manoeuvre is time consuming, and maintaining the bearing line becomes difficult for #3 and #4, a practical option is to fly a co-speed, in-trail position on the flight leader's turn circle. This way, #3 and #4 can easily keep all formation aircraft in front of them in sight and give #2 plenty of room to manoeuvre. 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 excessive closure and an overshoot situation exists, a bug-out manoeuvre should be executed. Number 3 should stabilize on the outside of Lead's turn as per the bug-out manoeuvre. Once cleared to continue the rejoin by Lead, the wingman may then manoeuvre into the finger-four position. Depending on the distance away from Lead, the wingman may need to stabilize in route position and then move into finger-four. Number 4 should not complete the rejoin until #3 is in finger-four. Number 4 can use the same procedure if an overshoot situation exists on his rejoin. Number 3 and #4 must not be overly aggressive when dissipating energy, and should use the same care when completing their rejoins as #2

does when executing the bug-out procedure. In a training environment, Lead may direct #3 or #4 to cross back to the inside of the radius of turn and complete a normal rejoin from there.

PERFORMANCE GUIDELINES

- Wingman will recognize excess closure and the developing overshoot condition in a timely manner, and in a smooth, controlled manner, execute the bug-out
- Wingman will move to the outside of the turn **without** going forward of, or higher than, Lead
- Number 3 and/or #4 will delay their rejoins, as required, to keep #2 and/or #3 in sight, giving time and space to complete the rejoin via the bug-out manoeuvre
- Wingman will wait until cleared by Lead to continue, before leaving the stabilized position and executing the cross-under, regaining the bearing line inside the flight leader's turn circle (#2), or directly into fingertip (#3 or #4)

COMMON ERRORS

- Not recognizing excessive closure (overshoot situation)
- Flying to a lateral position forward of Lead's 3/9 line
- After overshooting as #2, flying to an elevation position higher than Lead
- Not making a radio call advising Lead of the bug-out ("*Red [2, 3, or 4], bugging-out*")
- Failing to stabilize the under-run, allowing excessive nose/tail separation to develop
- Prematurely and aggressively crossing under, moving to the inside of the flight leader's rejoin turn circle, or to fingertip, resulting in another unstable rejoin or overshoot situation



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.

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 adequate 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. No wing overlap is permitted.

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.

Timed intervals should not be executed under the following conditions:

- Initial training of unqualified pilots
- 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 manoeuvring exercises, such as Combat or Long Line Astern are intended to teach and practice lead, lag and pure pursuit concepts, in the case of Combat, and how to maintain position using only power in the case of Long Line Astern. 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 manoeuvring, 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 manoeuvring.

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 adequate 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 adequate 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).

Runway width permitting, once the aircraft is under control, move to the exit side of the runway to allow for a Hot Lane. Leading aircraft in a pairs/element landing

will not cross the centreline until cleared to by the aircraft behind. A call off "Stable" implies that the lead can cross the centreline to the exit side of the runway if required. The trailing aircraft accepts collision avoidance responsibility.

In Stream landings Aircraft land on the centreline then when under control smoothly move to the exit side of the runway (Cold lane). This then frees up the far side of the runway as a HOT lane for any following aircraft to use in the event of a braking issue or a Go Around is required.

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 (HOT lane) side or executing a go-around.

GO AROUND

If a wingman cannot maintain a 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.

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.



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. In this case a formation renumber may be appropriate.

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: “Reds STOP, STOP, STOP.” 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, STREAM/INTERVAL TAKEOFF ABORT

When using single-ship, stream/Interval takeoff procedures, the aborting aircraft will announce the abort to warn following pilots: “Red 2 stopping.”

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 manoeuvre 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 manoeuvring 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.

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 trainer will determine if it is best for the student or the trainer 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 manoeuvring 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 manoeuvring 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 manoeuvring, 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, Red 3 recognizes an impending violation of the briefed hard deck:

“Red 3, knock-it-off, hard deck”

“Red 1, knock it off”

“Red 2, knock it off”

“Red 3, knock it off”

“Red 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 manoeuvring.

If a KIO occurs in a mass formation or tactical employment scenario, flight members of individual flights will comply with the above procedures.

TERMINATE

The term “Terminate” is used to cease the manoeuvring 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.

“Red 2, terminate, outside the cone”

“Red 1, terminate”

“Red 2, terminate”

Red 1 flies a predictable flight path allowing Red 2 to fly back inside the cone. Red 1 instructs Red 2 to call in when ready to recommence manoeuvring. Red 2 calls “in” and Red 1 recommences combat manoeuvring.

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 manoeuvring 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.

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:

“Red 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

“Red 2, visual on 1. Red 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.

“Red 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

“Red 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 combat.

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:

“Red 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:

“Red1, visual, Red 2, the visual is your right, two o’clock high, 700 feet”

In this situation, Red 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 counter-productive 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 manoeuvring 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.



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CHAPTER 9: COMMUNICATION

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

1. Voice
2. Aircraft Signals
3. Hand 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.

TRANSPONDER

Only the lead will squawk a transponder code. If the lead changes the transponder squawk will stay with the original lead unless briefed differently.

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. Less is best!

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.

"Merlin ..." (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:

"... Line astern go"

Step 2, If it is a formation change, the acknowledgment is the movement of the wingman to the new position. If it's a frequency change the acknowledgement is the check in on the new frequency. If it is a call that requires a response 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.

"Merlin 2, say again"

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

"Merlin 2"

"3"

"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:

"Merlin 1, Merlin 4, Rev's"

"Merlin 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 check-in, within the flight and in sequence, will respond with position number. Subsequent wingmen will check in in sequence with their number only. If responding out of sequence, or if separated from the flight, revert to full call sign use to avoid confusion.

"Red Push 121.8"

The entire flight switches to the new frequency. The Lead will then initiate the check-in, with the wingmen responding sequentially with position numbers.

"Red 1"

2

3

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. If a wingman fails to check in the lead will resolve the issue and get the wingman on Frequency.

In the Form Brief radio frequencies and procedures will be briefed. 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 based on the wingman's capabilities and frequency congestion.

If a wingman does not respond to repeated radio calls, the wingman may be experiencing radio equipment failure or has simply misunderstood the frequency. 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 close formation wingmen can move out to a comfortable position, stabilize and proceed with the channel change. Once the frequency change has been accomplished, the wingmen will move back into position.

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

PUSH VERSES SWITCH

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

"Merlin, push 121.7" or "Merlin switch 121.7"

When the term push is used, it is as described above.

The term "switch" may be used if the lead does not want the wingmen to acknowledge. The command simply means switch to the new frequency and listen out. An example of when this may be used is landing at a controlled airfield and the lead switching the form to Ground and saving congestion on the frequency. In this case if a member of the formation missed the frequency change it doesn't matter.

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.

"Melbourne Ground, Merlin, formation of four, request taxi, received Bravo."

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

"Merlin, taxi to runway 27"

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.

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 Left hand finger 4, 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 Left hand finger 4, 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 LHF4 or RHF4).

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

ATTENTION IN THE AIR

Execute rapid, shallow wing rock.

LINE ASTERN GO

Leader gently porpoises his aircraft.



GO AROUND

There may be situations where a go around is necessary but the flight leader does not have time to transmit. Just fly for formation and look for the gear and flap movement/signals.

OPS/FUEL CHECKS

Airmanship dictates that in-flight checks be carried out. This is a pilot's normal responsibility. The flight lead will brief how fuel states will be reported, such as total time, or total fuel on board.

When requested Lead will expect wingmen to acknowledge with total fuel remaining in time (hours/minutes), or total fuel on board, however briefed.

"Merlin 2, 45 Litres"

This simple call indicates to Lead that the wingman's ops check is normal and that he has 45 Litres 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.

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:

“Merlin 2, joker”

Lead will acknowledge the “joker” call and prioritize any remaining manoeuvres, 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 overflowed, 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 litres. If an aircraft reaches bingo fuel, the required call is:

“Merlin 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 litres 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 litres—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 aircraft in the same formation:

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 manoeuvring as a single formation
3. Flight rejoins following a pitchout manoeuvre
4. Flight rejoins following a break out manoeuvre
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 (RV)

This term will apply to aircraft or formations departing from different airfields or at different times and briefed to join up. They will rendezvous and then rejoin as briefed.

HANDSIGNALS

Pilots should be proficient in the use of all Handsignals. At a minimum the essential hand signals as shown in [Appendix 1](#).



HAND SIGNALS (ALL)

Hand signals can be used to communicate most of leads 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 signals communication the 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 the receiving pilot will nod his head. If the hand signal is not understood the wingman will remain looking at the lead and maintain his current position.. The lead will then repeat the hand signal or revert to the radio. Once the wingman understands the hand signal he will comply with the leads command.

Exaggerated Head Nod

Used by the lead as an executive to initiate the sequence commanded by the hand signal.



Engine Start/Run up

Extend arm over head and make a circular motion with the hand with index finger pointing upward.



Ready for Takeoff

After run-up the wingman will look intently at the lead. (If he is not ready he will look at the instrument panel).

Start of take off roll

Once all wingmen have indicated ready the lead will look to the front and perform an Exaggerated to Head nod. Brakes are released as the leads head reaches his chin.

Gear Up

The leads will indicate gear retraction by a short application of wheel brakes followed by a head nod.

Gear Down

Clenched fist Chain pulling motion up and down. Head nod to execute



Flaps UP/Down

Thumbs and fingers together open and closing. Head nod to execute



Frequency Change

Tap you ear with fingers extended. Extend fingers vertically for the digits 1 through 5, horizontally for 6 through 9. Hand is pulled down out of sight between digits. Signal 0 with a clenched fist.



Frequency change to pre-briefed Freq

Tap ear with your index finger then indicate the Stud/Tac number required . e.g 2 fingers to switch to Stud/Tac 2



Change sides

Used to move elements from one side to the other. Lead points to the wingman then using a sweeping motion over the head points to the other side of the formation.



Finger to Line Astern

Fist with thumb extended pointed to rear.



Finger to Long Line Astern

Fist with thumb extended smartly forward and aft



Loosen Formation

Open hand pushing out. Can also be used to allow wingmen to deploy to a pre briefed position



Pairs Landing

Usually used by wingman to indicate that he needs to land on the wing. Open hand patting shoulder.



Finger to box

Leads Arm bent 90, thumb tucked in 4 fingers raised. Fist then clenched with thumb extended rearward. Move hand backwards and forwards



Belly turns

Used in 2 aircraft formations if lead requires turns away to be made in Belly. Forefinger and little finger extended, middle fingers folded.



Stack Down

Palm of hand facing down .. move in downward motion.



Stack Up

Palm of hand facing up ... move in upward motion.



Pitch Out

Lead waves wingmen good bye.

Hand open fingers extended. Wave hand forward and aft.



Power up

Clenched fist, arm in forward motion.



Reduce Power

Palm open facing rearward, motion to rear



Speed brakes

Hand up palm forward. Head nod to execute



Lead change

The flight lead will point to the deputy lead and then point straight ahead, indicating, "Take the lead" the deputy lead will acknowledge with a head nod, 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 ahead indicating "I have the lead.



Climb

Palm flat, motioning in a forward and upwards direction



Descend

Palm flat moved back and forth in a horizontal motion.



Level Off

Palm flat, moved in a horizontal motion



Go Around

Clenched fist arm in forward motion



Pitot heat on

Little finger extended out from clenched fist



Transponder Off

Hand clutched to throat like strangling.



Rotating beacon On

Hand held Up, fingers together, thumb apart in cupping shape, rotate hand and wrist.



Cannot Transmit

Point to mic then thumbs down



Cannot Receive

Point to ear then thumbs down.



Oxy Check

Cup hand over mask, followed by query of an "OK" sign.

Thumbs up response for ok

Thumbs down response if not



Fuel Check

Clenched fist thumb extended in drinking motion.

Wingmen response.

1 finger = 10-20mins,

2 fingers 20-30 mins

3 fingers 30-40 mins

4 fingers 40-50 mins

Thumbs UP = Bingo +

Thumbs Down = Bingo



System Failures HEFOE

Hold clenched fist to forehead .

Then hold fingers up to indicate system failed/degraded.

1 Finger Hyd/Pneumatic

2 Fingers Electrics

3 Fingers Fuel

4 Fingers Oxy

5 Fingers Engine



You are on fire

Indicate to victim he is on fire by using index finger in a throat cutting motion



Aircraft Signals

Lead can also use gentle aircraft motion to indicate formation changes.

Line Astern Go

Lead porpoises aircraft



Route Formation Go

(From Close formation)

Lead gently yaws aircraft

Finger/Echelon Go

(From Route)

Lead wing waggles. Rejoin in last or briefed formation.

Change Sides

Brisk wing drop towards the side to change to

Knock it Off (KIO)

(In Route or Combat)

Rapid wing waggle

GLOSSARY

3/9 LINE OVERSHOOT

When your aircraft moves ahead of the leader.

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.

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.

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.

BEARING LINE

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

BELLY

As in Belly turn, in plane turn with wingmen looking at leads belly (Echelon turn in US terms)

BINGO FUEL

The fuel state at which the flight must return to base. A predetermined fuel figure remaining in gallons, litres, 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.

BLIND

I cannot see any member of the formation

BOGEY

A visual contact who's identity is unknown.

BOX

A four ship formation in a diamond shape. By definition #2 is on the right. If #2 is required on the left the formation is called Reverse box. #4 is always line astern of #1

BUGOUT

1. A manoeuvre 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

Formation configuration flown at the closest, most demanding physical proximity. It requires absolute concentration on the part of the wingmen and smooth precise leadership by the flight leader.

CLOSURE RATE

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

COMBAT

Manoeuvre position in cone behind lead.

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

CONTINUE

Directive instruction to continue manoeuvring.

DASH ONE, TWO, THREE, FOUR

A term to refer to successive wingman in a flight, written as #2,#3,#4 etc

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 backup on routine flights with radio or equipment malfunctions in addition to moral support and good company.

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.

FINGER 4

Formation of 4 aircraft whose position is similar to 4 fingers. Two variants Left hand Finger 4 (LHF4) and Right Hand Finger 4 (RHF4)

FLIGHT INTEGRITY

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

FLIGHT

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

GO

Used to direct the flight to initiate the action commanded.

HEADING CROSSING ANGLE

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

INITIAL

The Initial point is downwind of the airfield at an appropriate distance depending on aircraft performance. It is flown on runway heading to the desired pitchout point, usually located on the dead side of the runway.

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.

KEY

A position immediately behind the echelon position 1 aircraft's length behind the lead and stepped down (abeam the line astern position)

The Key is the aimpoint for all formation rejoins. The Key is a transition position during formation changes.

KNOCK IT OFF

Terms used to cease manoeuvring.

LAG

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

LEAD

A 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.

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 ASTERN

In line astern the wing aircraft is directly behind the lead, stacked down, with approximately one aircraft's length interval. The wingman's aircraft is "welded" to the lead aircraft as it moves matching bank angles and remaining in a fixed position relative to lead.

LINE OF SIGHT (LOS)

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

LONG LINE ASTERN

Long Line Astern is a manoeuvre where the wingman is essentially flying in the leads flight path or smoke trail primarily using power to maintain a fixed interval.

LOS RATE

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

MMSOBYTAST

Mustard Mud S... Or Blood Grit Your Teeth And Stay There

NO JOY

I cannot see the other aircraft (not associated with the formation) that you are referring to

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.

OPS CHECK

Periodic check of aircraft systems and fuel state.

PERCH

The point in an overhead pattern where each aircraft initiates the final turn I.e. the base turn point. Or in a Turning rejoin the position from where the wingmen commences the rejoin.

PLANE OF MOTION

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

POWER UP

Used by the wingmen to request the lead to increase power slightly to help the wingmen maintain his position.

PURE

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.

PUSH

Command to select a new frequency

REJOIN

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

RENDEZVOUS (RV)

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.

REV's

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.

ROUTE

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

SOP

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

STOP

Used by a member of a formation to command an aborted a take off. Usually repeated three times.

STOPPING

Used by a wingman to indicate they are aborting their takeoff.

TACTICAL FORMATION

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

TALLY HO OR TALLY

Used to indicate that you have visually acquired whatever it is you were looking for. Typically other aircraft not associated with the formation. The term Tally can also have a number like Tally 3 meaning I see 3 aircraft not associated with the formation.

TERMINATE

Used to cease manoeuvring in a specific flight when learning objectives have been achieved

THE BREAK/PITCH

The breakup of the formation over the runway when a flight does a 180 turn onto downwind with a briefed spacing. Also called a "pitch".

TURN CIRCLE

The circumference of an aircrafts turn

TURN RADIUS

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

TURN RATE

The rate of heading change by an aircraft.

VIC

A V formation of aircraft by Definition #2 is on the right. If required for #2 to be on the left the formation is called Reverse Vic

VISUAL

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

WINGTIP OVERLAP

No lateral separation exists.

APPENDIX 1

ESSENTIAL HANDSIGNALS



Engine Start/Run up

Extend arm over head and make a circular motion with the hand with index finger pointing upward.



Exaggerated Head Nod

Used by the lead as an executive to initiate the sequence commanded by the hand signal.



Frequency Change

Tap you ear with fingers extended. Extend fingers vertically for the digits 1 through 5, horizontally for 6 through 9.

Hand is pulled down out of sight between digits.

Signal 0 with a clenched fist.



Change to Pre Briefed Frequency

Tap ear with your index finger then indicate the Stud/Tac number required. e.g 2 fingers to switch to Stud/Tac 2



Lead Change

The flight lead will point to the deputy lead and then point straight ahead, indicating, "Take the lead" the deputy lead will acknowledge with a head nod, 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 ahead indicating "I have the lead".



Gear Down

Clenched fist chain pulling motion up down head nod to execute

Flaps Up/Down

Thumbs and fingers together open and closing head nod to execute



Line Astern Go

Thumb pointed to rear.



Long Line Astern Go

Fist with thumb extended smartly Forward/aft



Cannot Transmit

Point to mic, then thumbs down



Cannot Receive

Point to ear, then thumbs down.



Loosen Formation

Open hand pushing wingman out. Can also be used to allow wingmen to deploy to a pre briefed position



Change Sides

Used to move elements from one side to the other. Lead points to the wingman then using a sweeping motion over the head points to the other side of the formation.



Pitch Out

Lead waves wingmen good bye.

Hand open fingers extended.

Wave hand forward and aft.



System Failures HEFOE

Hold clenched fist to forehead Then hold fingers up to indicate system system failed/degraded.

1 Finger Hyd/Pneumatic

2 Fingers Electrics

3 Fingers Fuel

4 Fingers Oxy

5 Fingers Engine



APPENDIX 2

Formation SOPs Summary

LEGALS – CAR 163AA

An aircraft must not be flown in Formation unless:

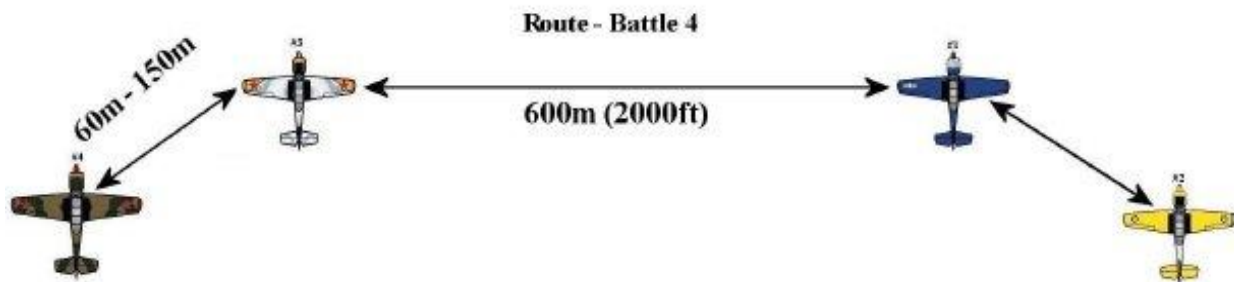
- each of the pilots in command is authorised to fly in formation
- the formation is pre-arranged between the pilots in command, and
- the formation flight is conducted either:
 - under VFR by day, or
 - under an approval given by CASA.
- Two or more aircraft are flown in formation if they are flown in close proximity to each other and they operate as a single aircraft with regard to navigation, position reporting, and control.

BASIC FORMATIONS – UP TO 3 SHIPS:

- Echelon
- Line Astern (last in calls “In”)
- VIC SOP #2 on the right
- Reverse VIC, #2 on the left

ADVANCED FORMATIONS

- 4 Ship - RHF4 and LHF4
- Box
- Route / Battle 4 a transit formation



CHANGING FORMATIONS

- The SOP way to change formation is via the Cross Under Method
- Signals are given either by Hand or Radio
- All changes are to be square
- Complex changes like LHF4 to RHF4 are done via Line Astern.

URNS

- Echelon
- Belly Turns (only for turns away)

CHANGING LEAD

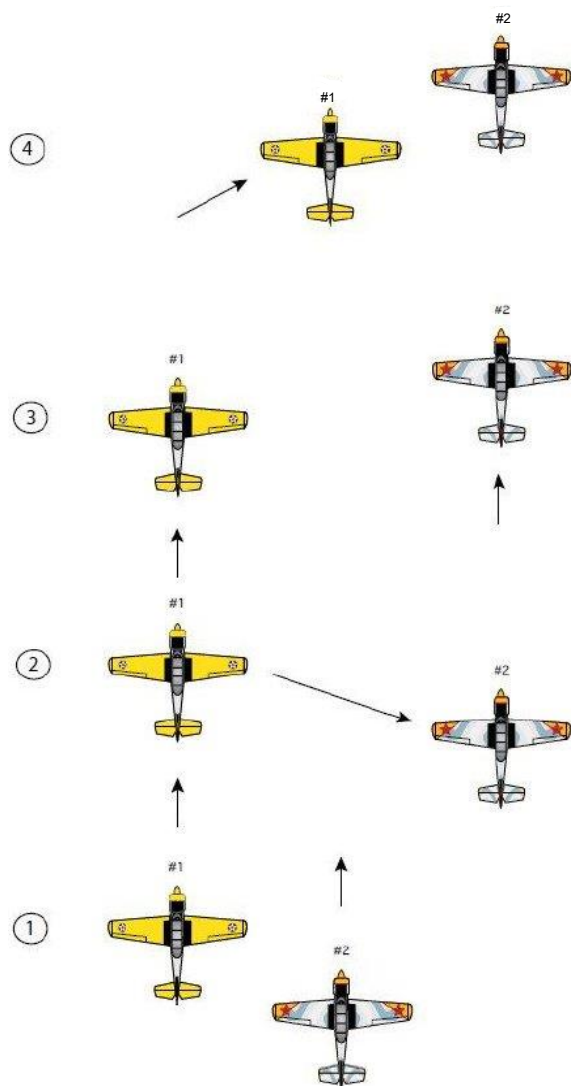
RADIO OR HANDSIGNAL

Radio

"Red 2 Take the lead"

"Red 2 Passing L/R Taking the lead"

"Visual"



No Re numbering.

RE-JOIN EXERCISES

General

- 2 avoids 1, 3 avoids 2, 4 avoids 3
- All re-joins are to be flown to avoid collision course between elements until the joiner is so close no significant closure rate can develop
- Two distinct parts:
- Out of plane manoeuvre - bring elements to the

“Key” position

- Movement in a controlled manner from the “Key” or “Waiting” position into formation
- Movement from the “Key” position - FWD, UP, IN (or UP, FWD, IN as briefed)
- Breakout if ever closure or speed is excessive, or a collision risk exists
- Scan LOOKOUT - LEADER - SPEED during the re-join

Perch Method

- *“RED 2, Ready for Re-Join”*
- Lead clears airspace, thumbs up / wave off
- 45° AOB through 45-60°, aim for 500ft “perch”
- Straight Re-join - *“RED 2 Joining Left / Right”*
- Turning Re-join - *“RED 1, Turn Left / Right”*
- Lead = 25-30 AOB
- Bugout *“RED 2, Bugging Out”*
- Lead ordering a Bugout = *“RED 2, Bugout”*

START, TAXI, AND TAKEOFF

Start Initiation:

- Visual, Radio, or Timed

Taxi

- Consider Anti-Fod Order
- Can stagger on Wide taxi ways

Takeoff

- Formation – 2 ship is SOP
- 32m min runway width for VIC (based on wingspan of 10m)
- 22m min runway width for Pairs (based on wingspan of 10m)
- Consider and Brief minimum width for other types

Pairs / VIC Take-off

- Elements line up slightly forward of references in their own half/third of runway, wingman thumbs up
- Leader gives wind up signal
- Once Elements are "Ready" -give lead small head nod
- Lead will execute the take-off roll via an exaggerated head nod
- Aborts call *“Stopping”* other aircraft continue take off in your half.

RECOVERY

- Initial and Pitch, Downwind Pitch, Pairs Landing from Straight in Approach.

Initial and Pitch

- The minimum pitch interval = 4 seconds (brief if a different interval is required e.g for TW aircraft)
- Max AOB on final = 45° - consider a go around if above 45°
- Individual Base Calls with Gear - *"RED 1, Base 3 Greens, Full Stop, (Touch and go or Overshoot)"*
- Interval for landing ~ minimum 500m/1500'
- Land on Centreline then move to Cold lane
- Exit side of runway = COLD LANE
- Outside lane = HOT LANE
- When last aircraft is at taxi speed he calls *"RED X, Stable"*
- If you need to use the HOT LANE call it *"RED 4 HOT LANE"*

Downwind Rejoin

- If Initial and Pitch is not feasible - Lead formation to end of D/W point
- *"REDS, take spacing on Downwind"*

Pairs Straight in approach

- Min Runway width = 30m (based on 10m wingspan)
- Brief either Gear and Flap or Gear then Flap
- Leader will fly normal approach, add a few knots (5) and aim slightly in the runway (500-1000ft)
- Wingman - sit slightly high to see only top surface on Lead's wing (alternatively Leader's head on the horizon) below 500 ft
- Below 100' - wingman increases scan of runway,
- #2 touchdown slightly before leader, commence deceleration ASAP.
- Centreline is a brick wall - **NEVER CROSS** until cleared to do so if ahead of another element
- If lead needs to cross ahead of #2 after landing to vacate - *"C/S 2, Stable"*
- Go-Around *"REDS, Going Around"* or just follow the leader

TAXI IN AND SHUT DOWN

- Last element to vacate the active runway - *"RED X, Runways Vacated"*

DE-BRIEF

- Proper de-Brief is essential - to include SAFETY POINTS

COMMUNICATION

Standard Radio Check In:

- (used for initial check in or a missed check in etc) *"Red Check"*
- *"Red 2"*
- *"3"*
- *"4"*

Radio Frequency Change

- *"RED, PUSH 121.8"*
- Lead initiates Check in using his callsign, wingmen respond with number only *"RED 1", "2", "3"*

Handsignals and Aircraft Signals

see in **APPENDIX 1**. Essential and HAND SIGNALS (ALL) Pg 43-46