

SKY THRILLS

FORMATION TRAINING MANUAL

0459 47 43 40
www.SKYTHRILLS.com.au

THIS PAGE INTENTIONALLY LEFT BLANK

Table of contents

Chapter 1	Introduction
Chapter 2	Basic Formation Concepts
Chapter 3	Formation Turns
Chapter 4	Station Changes
Chapter 5	Close Formation Lead Changes
Chapter 6	Break-offs & Re-joins
Chapter 7	Formation Take-offs, Landings & Circuits
Chapter 8	Briefings & Debriefings
Chapter 9	Ground Operations
Chapter 10	Leading a Formation
Chapter 11	Formation Contracts
Chapter 12	Larger Formations
Chapter 13	Abnormal Situations
Chapter 14	Radio Procedures
Chapter 15	Visual Signals
Chapter 16	Formation Do's & Don'ts
Appendix 1	Formation Briefing Card
Appendix 2	Formation Knee Pad Card

THIS PAGE INTENTIONALLY LEFT BLANK

DISCLAIMER

This manual is published by SKYTHRILLS Pty Ltd in order to promote safety through standardisation in Formation flying, and to assist students of SKYTHRILLS in attaining a Formation Endorsement. The use of the procedures and signals described in this manual is entirely at the option and discretion of the Formation's pilots and any such use should be fully briefed before each flight.

The information in this manual is for reference only and the reader takes full responsibility for the use of this material. The information is presented "as is" and neither the author or SKYTHRILLS shall have any liability to any person or entity with respect to any loss or damage caused or alleged to be caused directly or indirectly by the instructions contained in this document.

Formation flying without proper training from an experienced and qualified instructor can be dangerous. Do not undertake any Formation flying without having completed a CASA approved syllabus of training with an approved flight training organisation.



THIS PAGE INTENTIONALLY LEFT BLANK

Glossary of Terms

Acute	The opposite of being "sucked." To be in a position too far ahead the correct Formation position.
Blind	When the Wingman go's into a position where he or she can no longer see the Leaders aircraft.
Break-away or Break-off	A procedure flown by a Wingman when they need to take spacing from the Formation Leader, or the Formation
Call-sign	The word and position number that designates a flight and the members in it. Usually selected by the Formation Leader for that particular flight.
Cold	Having low closure rates when conducting a Re-join, or when falling behind the Re-join line during the Re-join
Echelon Formation	A close Formation position where the Wingman is about 45° behind and off to the side of the Formation Leader.
Echelon Line	Aligning two reference features on the Leaders aircraft to create a line that extends approximately 45° behind the aircraft. Normally this would involve aligning a feature on the Wing with one on the nose of the Leaders aircraft.
Element	A Formation of 2 aircraft. Two Elements create a Section.
Formation	A disciplined flight of two or more aircraft under the command of a Formation Leader, using a standardised set of signals and commands. Not to be confused with a GAGGLE of aircraft.
Gaggle	An undisciplined group of aircraft, milling about in roughly the same piece of sky, sometimes attempting to impersonate a FORMATION.
Hot	Having high closure rates when conducting a Re-join, or when ahead of the Re-join line during the Re-join
Lead	Short for Formation Leader.
Line Abreast Formation	A close Formation position where the Wingman is directly abeam and level with the Formation Leader.
Line Astern Formation	A close Formation position where the Wingman is directly behind and below the Formation Leader.
Line Astern Line	Aligning two reference features on the Leaders aircraft to create a line that extends behind and below the aircraft. Normally this would involve aligning a feature on the tail with one on the Wing of the Leaders aircraft.
Primary Reference Line	Aligning two reference features on the Leaders aircraft to create a reference line that the Wingman uses to judge position.
Push	A term used by a Formation Leader to direct the Wingmen to change frequency
Re-join	A procedure for the Wingman to safely join a Formation
Rev's	A term used by a Wingman when they have insufficient power to remain in Formation.
Section	A Formation of 4 aircraft.
Step-down	Sitting vertically below the normal Formation position.
Step-up	Sitting vertically above the normal Formation position.
Sucked	The opposite of being "Acute." To be in a position too far behind the correct Formation position.
Tight	Where the Wingman is sitting inside the normal Formation position. In Echelon Formation this can involve laterally overlapping wingtips.

Visual	A term used by the Wingman when they have the Formation Leader in sight.
Wide	Where the Wingman is sitting outside the normal Formation position.
Wing	Short for Wingman.

Chapter 1 - Introduction

Welcome to the world of Formation Flight! This training manual is designed for students *and* qualified Formation pilots. Formation flying is the art of maintaining a stable position relative to another aircraft. The CASA Civil Aviation Regulations (CAR) 163AA defines Formation flying as 2 or more aircraft that are flown in close proximity to each other when they operate as a single aircraft with regard to navigation, position reporting and control. CAR 163AA also details the rules and regulations with respect to Formation Flight:

163AA Formation flying

- (1) A pilot must not fly an aircraft in Formation if each of the following requirements is not satisfied:
 - (a) each of the pilots in command is qualified to fly in Formation;
 - (b) the Formation is pre-arranged between the pilots in command;
 - (c) the Formation flight is conducted either:
 - (i) under the Visual Flight Rules by day; or
 - (ii) under an approval given by CASA.
- (2) Unless otherwise approved by CASA, a pilot in command is qualified for the purposes of paragraph (1) (a) only if:
 - (a) the pilot has been certified by the holder of a flight instructor rating as being competent to fly in Formation, being a rating that is appropriate to the category of aircraft to be flown in the Formation; and
 - (b) the certification is entered in the pilot's log book.
- (3) For the purposes of this regulation, 2 or more aircraft are flown in Formation if:
 - (a) they are flown in close proximity to each other; and
 - (b) they operate as a single aircraft with regard to navigation, position reporting and control.
- (4) In determining whether aircraft are in close proximity to each other, regard is to be had to the type of aircraft in the Formation and the speed of those aircraft.
- (5) In spite of sub regulation (3), aircraft are to be taken to be in Formation:
 - (a) during any period when they are manoeuvring to achieve separation from each other in order to effect individual control; and
 - (b) during join-up and breakaway.

This general CAR definition is quite broad and can be seen to include in-company, loose trail, air-touring aircraft and a range of other activities.

At SKYTHRILLS the term "Formation" is taken to mean a disciplined Formation of two or more aircraft flying in close proximity with all movements coordinated, under the command of a flight Lead and using a standard set of radio calls and visual signals. A Formation flight will have been specifically briefed by the flight Lead for the expected conditions on the day and the particular air-exercise (airex) to be conducted.

All other flights that may meet the more general CAR definition will be known as a "gaggle" and it is the aim of SKYTHRILLS to only teach and participate in Formation flying.

Formation Discipline

Formation flying is derived from the military, where it arose from a practical necessity for mutual support during tactical operations. For civilian use it is mainly for fun, convenience, safety and more fun. A large part the fun of Formation flying comes from the satisfaction of participating in a coordinated aerial activity with other like-minded pilots with whom you share a very high level of trust and respect. To maximise the fun, and to be able to conduct the activity safely, each Formation participant must set and maintain an appropriate level of discipline.

Webster defines discipline as:

- (1) Training that is expected to produce a specific character or pattern of behaviour, especially that which is expected to produce moral or mental improvement.
- (2) Controlled behaviour resulting from such training.
- (3) A state of order based upon submission to rules and authority.

The concept of discipline in the conduct of Formation flying requires a significant attitudinal adjustment. Our fundamental perspectives as pilots must shift from the self-reliant individualistic orientation of a single aircraft operation to a realisation and acceptance of our roles in a collective effort. Each member of a Formation must fly his or her position properly to the best of their ability, and this extends from the Leader to the Wingmen, regardless of experience. If this is done then trust and confidence will infuse the entire Formation.

This discipline covers the entire flight and begins at the Formation briefing extending right through to the debriefing at the end of the flight. Each of the Formation members have "contracts" and

expectations of them from the other Formation participants. A well briefed, well lead, well flown and disciplined Formation is a thrill to participate in. Being part of a Formation that lacks discipline and that degenerates into a "gaggle" is a frustrating and sometimes dangerous experience.



Discipline and Trust are essential for the safe execution of any formation flight

Formation Trust

When undertaking Formation flying, you must have 100% trust in the other members of the Formation, as they do in you. Without trust, Formation flying loses

its fun aspect, and can be downright scary. Formation flying is not the place for showboating as it can get dangerous very quickly. A Formation Leader who decides to do a 100' flypast of the local aero club will very quickly lose the trust of their Wingmen.

No matter what we write in this document, and what your instructors say to you, one day you will participate in a Formation flight with people that you don't know very well. During the briefing you will have your doubts, and you will be proven correct in the air. Your guard will be up, and the experience will not be one that you enjoy. We have all done it, as not everyone is trained to the same high standard. The best advice we can give is if you don't trust the people you're flying with, don't participate. Just because you've briefed to be part of a Formation, doesn't mean you have to remain part of the Formation if you're uncomfortable. Break out of the Formation and return home; it is the safest option.

Formation Leaders

The Formation Leader is responsible for the safe conduct of the flight and ensures all flight objectives are met. In order to ensure success, the flight Leader must in all cases be the **best possible platform** for the Wingman. This concept is called "Wingman consideration." Lead should fly so that power changes, level-offs, and roll-rates are so smooth, they are almost imperceptible to the Wingman. The pitfall to Wingman consideration, however, is to be so considerate that Lead flies sloppy parameters, i.e., climbs through a level-off altitude, overturns assigned headings, and lets the aircraft climb above an assigned altitude in turns.

Formation flying also requires proactive thinking and planning. Everything takes a little longer to accomplish in flight with common tasks like changing the radio frequency, climbing, levelling off, descending, and turning requiring more time when in Formation and Lead will have to plan accordingly. In order to manoeuvre the Formation safely and effectively within the confines of the designated Formation area, Lead must first possess a clear understanding of the area's boundaries. Additionally, Lead must be able to visualize how combinations of turns or manoeuvres can be utilized to guide the flight within those boundaries. Wind speed and direction will affect the flight's ground track and should also be considered. Finally, the Lead should be conscious of the sun's position relative to Wing and attempt to limit the Wingman's exposure to looking into the sun as much as possible.

Summary of Lead's Responsibilities:

- (1) Be a smooth, stable a platform for your Wingmen.
- (2) Keep the flight within the proper operating area and comply with local rules.
- (3) Keep the flight clear of clouds and other aircraft.
- (4) Always be aware of the position of your Wingmen.
- (5) Meet the mission objectives in a safe, efficient manner.

The Wingmen

Simply stated, the Wing's responsibility is to be in the position assigned by the flight Lead at all times and comply with Lead's instructions in a timely manner. Unlike Lead, Wing should be more aggressive, using frequent flight control or power inputs (although the magnitude of these inputs may be small) to maintain position. In other words, Wing should never accept being out of position and should always strive to achieve the perfect position.

Summary of Wing's Responsibilities:

- (1) Always maintain the position assigned by the formation Leader (echelon, line astern, etc.).
- (2) Keep Lead in sight.
- (3) Comply with all signals given by Lead and, when required, be prepared to give a timely response signal.
- (4) Maintain situational awareness of what is going on in flight and be prepared for upcoming events. In other words, be a "thinking Wingman" ready for Lead's next command.

Chapter 2 - Basic Formation Concepts

The basic element of any Formation is a pair of aircraft (also known as an element). Two elements combine to form a 4-ship section. Sections may combine to form a Formation of almost any size. This part of the SKYTHRILLS Formation Training Manual will only deal with the Formation specifics that relate to a pair or element. The specifics of Formation flying as a pair are directly applicable to 3-ship, 4-ship and larger formations.

Aircraft in Formation can be flown quite closely together (1/2 wingspan of separation) or in looser enroute or manoeuvring formations (with tens or hundreds of meters of separation). You may hear the closer Formation positions termed "fingertip", "parade" or "close Formation" and enroute or manoeuvring formations as perhaps "trail", "route" or "combat" Formations. In the civilian Formation world, the large numbers of different names are sometimes used and can become mixed up as a result of the many varied sources of origin. Many are derived from the U.S. military, as much of what has been written for civilian Formation flying has come from America (due no doubt to their very large warbird aviation sector).

Within Australia most of the corporate knowledge for Formation flying is derived from the Royal Australian Air Force. We will therefore use their Formation terms, techniques, procedures and standards. Although we as civilian pilots are not attempting to match the standards of military aviation professionals, the Royal Australian Air Force has had many many years to perfect the art of Formation flying, and have had plenty of time to make all the mistakes that we as civilian pilots can learn from. This is evident every day by the fact that Formation flying is a military way of life and flown every day with no safety issues.

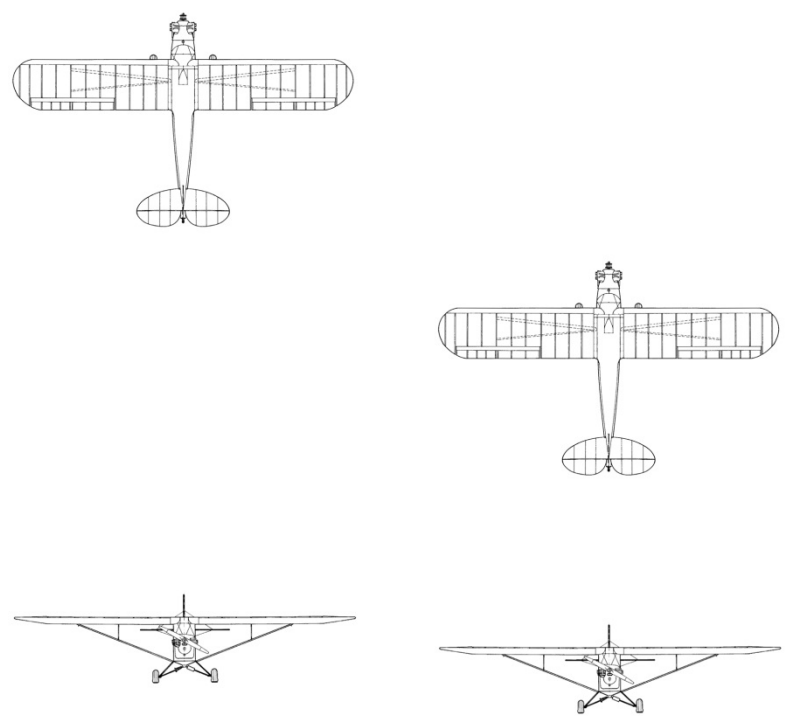
The two categories of Formation flying discussed so far (closer and more distant) will be known as "close Formation" and "combat" or "trail Formation" respectively. This section of the training manual will deal with close Formation flying.



Close Formation Positions

Echelon Formation

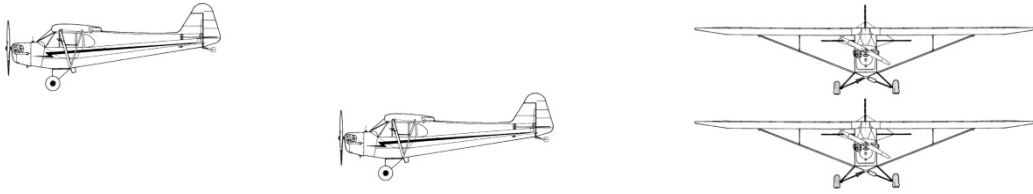
This is the most commonly used close formation position where the wingman is approximately 45° behind the leader, and slightly below.



An example of the Echelon Right Position on a Super Decathlon.

Line Astern Formation

In this formation, the Wingman is directly behind Lead with enough step-down to avoid any wake turbulence.



An example of the Line Astern Position on a Super Decathlon

Station Keeping

The essence of Formation flying is station keeping. Station keeping is defined as maintaining a defined vertical, lateral and longitudinal position reference to another aircraft.

Formation flying is going to take you back to the basic of flight. Your sense of depth perception is more important than ever because *in Formation flying, relative motion is everything*. Station keeping is control of the relative motion reference to another aircraft and to maintain position, the motion must be stopped. To manoeuvre safely in relation to another aircraft, the direction and rate of the motion is controlled. The Leader is considered to be fixed, and any movement between aircraft is movement of the Wingman. Relative movement will involve motion around any one (or more) of the three axes either up, down, forward, back or sideways.

Formation positions are denoted by lining up reference points on Lead's aircraft to define vertical, longitudinal and lateral positioning. Typically these reference points will be used to form a "primary reference line" extending away from and slightly down from the Leaders aircraft on which the Wingman positions their aircraft. For the Echelon position, these reference points will generally consist of a feature on the nose of the Leads aircraft, and a second feature somewhere along Leads wing. For Line Astern, the features are a bit easier as the Wing lines up his fuselage with Leads fuselage.

The Wingman then flies their aircraft "in" or "out" along this line to the correct to position from the Lead aircraft. To maintain an accurate and correct position in Echelon Formation, a Secondary Reference line is required on the tail of the Leads aircraft. The position in space where the Primary and Secondary Reference Lines intersect is the correct Formation position. If the Wings eyes are looking along the two reference lines, then by the simple fact that they are strapped to the seat, and the seat is attached to the aircraft will result in their aircraft being in the correct position (see Figure 2.1).

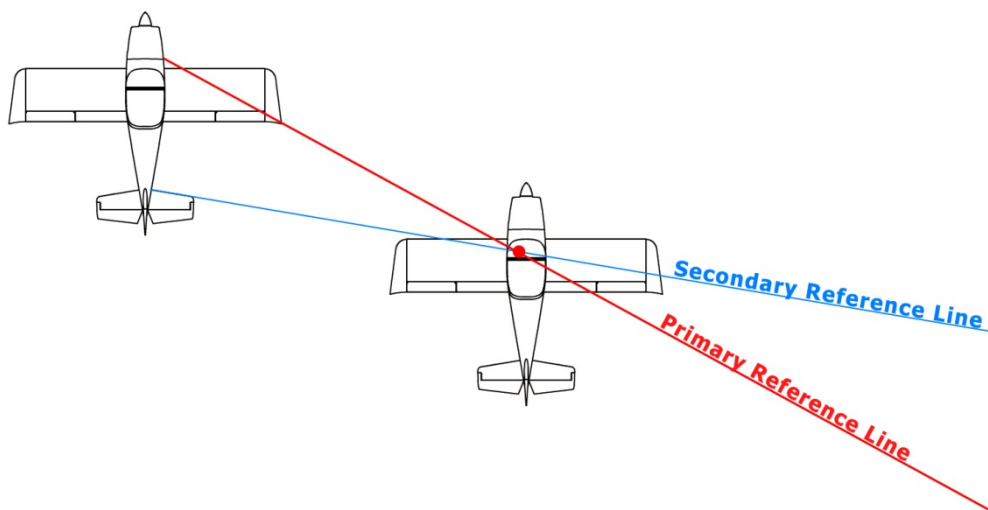


Figure 2.1 – The Primary and Secondary Reference Lines on an RV-7a. The Primary Reference Line is the trailing edge of the wing tip on the rear of the cowling. The Secondary Reference Line is the leading edge of the Horizontal Stabiliser.

For the Line Astern position, the Secondary Reference Line can be harder to judge on some aircraft as it requires the Wingman to compare the size of the horizontal stabiliser with the a feature such as the flap / aileron split on the training edge of the Wing, or possibly Wing strut attach points (see Figure 2.2) Another common procedure is to use 1 - 2 fuselage lengths.

While in practice the Wingman will maintain their aircraft on the reference line with a combination of adjustments, it is important to clearly understand what controls the aircraft in each of the vertical, longitudinal and lateral axis with respect to Lead's aircraft.

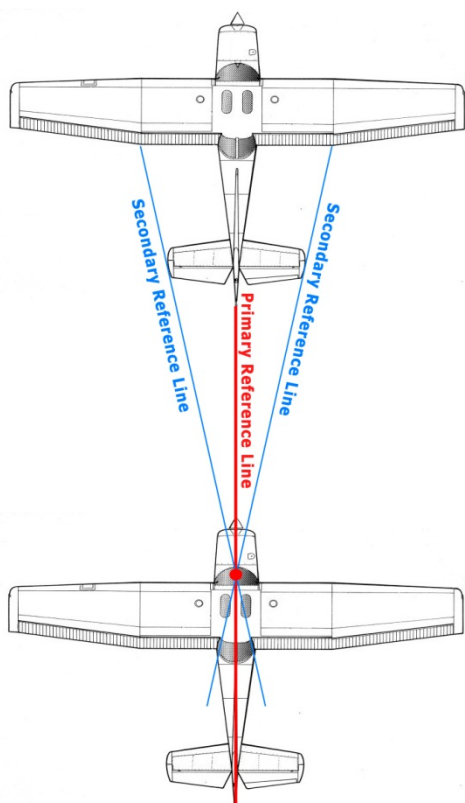


Figure 2.2 – The Line Astern Reference Lines on a Cessna 152. The Primary Reference Line is the Longitudinal Axis of the Lead Aircraft. The Secondary Reference Lines are the outer points of the Elevator the same width as the Aileron – Flap junctions.

Vertical Position

The vertical axis (or plane) is maintained by use of elevator and power. Elevator will cause the aircraft to climb and descend reference to the Lead's aircraft. This will also result in slight changes in speed reference the Lead, so small power adjustments will also need to be made. A power reduction will be required if the Wing needs to descend, and vice versa if the Wing needs to climb. The technique is to fly onto the correct "plane" and once stable trim out any elevator force. Relax and use small "pressures" on the stick to control the elevator and maintain the plane. The vertical is always adjusted or corrected first.

Longitudinal Position

The longitudinal axis (or fore / aft movement) is controlled by relative speed and when "in position" the Wingman's speed will match the Leader's. This is impossible to do with matching power settings as small differences in weight, aircraft design and engine efficiencies will result in different power settings for Lead and Wing. This is true even for the same type of aircraft, and especially for different types. Since the Wingman will also be making more control inputs than the Leader, they will also be a small difference in drag created by both aircraft.

One of the more challenging concepts of station keeping for initial Formation Pilots is making the correct power changes to maintain position. Initially it seems like you're overworking the engine, and are making a lot of mistakes requiring large power

changes. This is actually quite normal, and even experienced Formation pilots are almost continually moving the throttle. The difference however is that experienced Wingmen will make a correction as soon as they see a deviation where novices take slightly longer to recognise and then react.

If you are behind the required position then three distinct power movements will be required to regain the correct longitudinal position (see Figure 2.3):

- (1) *Increase power to establish an overtake* - The amount of power application required to establish the overtake will be determined by how far behind the Wing is out of position, and the amount of excess power available to the Wingman. A thoughtful Leader will give the Wingman a sufficient power margin to re-establish position should they fall behind the correct position. Despite this, in lower performance aircraft, full power may be required to establish an overtake. In higher performance aircraft with larger power margins, throttle movement will be smaller. The overtake speed does not need to be excessive, but should be enough to re-establish position in a timely manner.

(2) *Approaching desired position reduce power to establish a deceleration* - In the civilian world, most aircraft have relatively low inertial (unless you're lucky enough to own a Mustang!). As the correct position is reached, a power reduction is required to match the Leaders speed. The timing of when to reduce the power is affected by the inertia and drag of the Wingman's aircraft. The lower the inertia and higher the drag, the later the power reduction will need to be. As an example, a Wingman flying a Cessna 182 will start to reduce power a few seconds before reaching the desired position, where-as a Wingman flying a Tiger Moth will wait until they are just about in the desired position. Commonly, students will over anticipate the power reduction resulting in the aircraft matching the Leaders speed before the correct position is reached. The power reduction is often too great resulting in the aircraft decelerating too much resulting in a see saw motion of the Wingman as they catch up, and then drop back again. Don't be afraid to keep the overtake going until you're in position. If you overshoot, you just bring power back a bit and re-establish position.

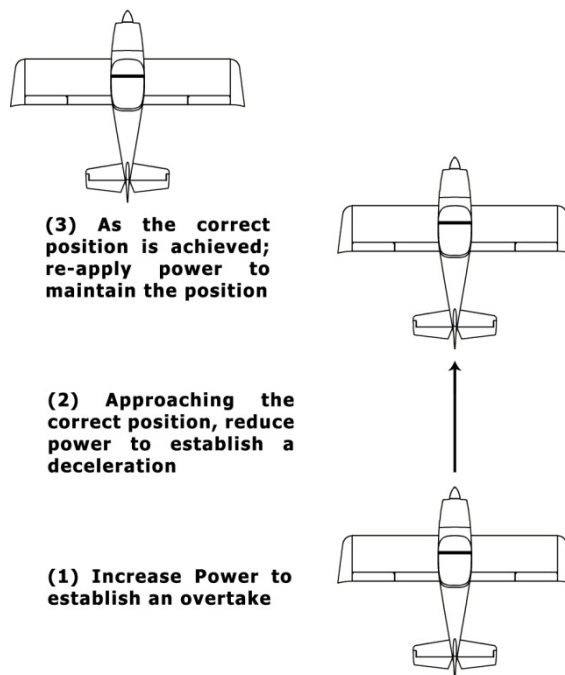


Figure 2.3 – Three distinct power movements required to regain longitudinal position

(3) *As the correct position is achieved; re-apply power to maintain the position* - The re-application of power is to stop the deceleration and match the Leaders speed. The throttle movement should be positive, but not excessive as the aircraft will continue to decelerate if power is not re-applied. If the overtake established at the start was not excessive, then the throttle position required to maintain position will be almost the same as to establish the position during the overtake. This is also a point that students find challenging, as often the re-application of power is not sufficient to match the Leaders speed.

The reverse will apply if you are in front of the desired longitudinal position. The key to maintaining the longitudinal position is to react as soon as you see a deviation from the desired position, and anticipate the need for power changes. During turns (which are explained in more detail in Chapter 3), large changes in power will be required. The amount of throttle movement will vary depending on the size of the error, but note that there are three distinct throttle movements required when correcting longitudinal position.

Lateral Position

The lateral position is controlled by heading and consequently ailerons and rudder combined. A few degrees of difference between aircraft headings will cause pronounced lateral spacing adjustments. It is important to note that it is heading, and not Angle of Bank that controls lateral position.

It is not uncommon for students learning Formation to tense up on the controls and use excessive bank, leading to rough tense Formation flying. It is also common for students to gently push on the rudder away from the Leader in a subconscious effort to get away. This reaction to close Formation flying will make holding Lateral position more challenging than required.

The correct technique for controlling lateral spacing is to use small amounts of bank for a moment, before rolling back to wings level again. This essentially changes heading by as little as a $\frac{1}{4}$ of a degree

and causes small and controllable lateral movements. The technique is to say to yourself “roll on, roll off” and adjust the bank as quickly as you say it. Once the desired lateral spacing is achieved another “roll on, roll off” adjustment is made to parallel the Leader’s heading.

Rudder is used to keep the aircraft in balanced flight so minor rudder applications should be made as you “roll on, roll off”. Rudder may be used to dampen small lateral deviations in heading and may be required in line astern however rudder should not be used to initiate lateral spacing adjustments. Use of rudder only to adjust Lateral position will result in inefficient flying and a crossed controls condition that will also need a power adjustment.

Lateral & Longitudinal Relationship

As already alluded to, in practice the reference points are thought to denote a Primary Reference Line upon which the Wingman maintains their aircraft. So far we have considered each of the Vertical, Lateral and Longitudinal station keeping techniques in isolation. In the Echelon position the vertical reference (or plane) can generally be considered and corrected in isolation. Lateral and Longitudinal maintenance can be thought of as moving in and out along the Echelon Line.

To maintain the correct longitudinal position (i.e. on the echelon line) while making a lateral spacing correction the Wingman will be required to accelerate (move closer) or decelerate (move wider). Figure 2.4 shows relative movement as thought of in a purely longitudinal/lateral sense. Figure 2.5 resolves Wingman motion with respect to the reference line. It can be seen from Figure 2.5 that power and heading are going to have to be adjusted in a coordinated fashion to maintain the echelon line and make lateral spacing adjustments “in” and “out” on the line. Being in a position on the line outside of the normal Echelon position is known as “Wide”, with the opposite position being “Tight”. Your instructor will demonstrate how to fly in and out on the echelon line on your first flight.

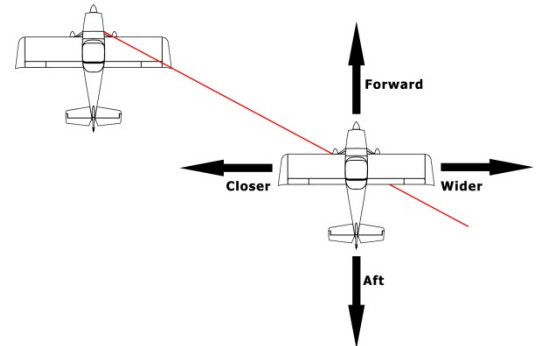


Figure 2.4 – Relative movement thought of purely in a Longitudinal and Lateral sense

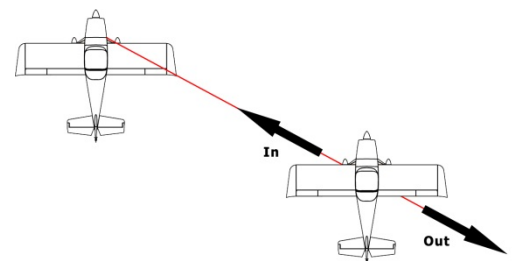


Figure 2.5 – How relative movement along the Echelon line should be thought of by the wingman

Regaining Position (error correction)

Formation flying and maintaining position involves a series of very small continuous corrections. Occasionally (typically during a series of turns or wingovers) the Wingman may find themselves significantly out of position or not able to remain stable in the desired position. This is known as Pilot Induced Oscillations. In these situations the Wingman will require a structured approach to regaining position and should use the following procedure:

- (1) *RELAX* - When out of position, most often the Wingman will be very tense and have a very tight grip on the controls. Often it will be Pilot Induced Oscillations that cause the Wingman to get out of position, essentially by over controlling. Consciously remind yourself to relax and physically relax your grip on the controls, wiggle your fingers and toes. This is especially true in turbulence.
- (2) *STABILISE* - Next, stabilise the aircraft and stop as much relative movement as you can. Allow the aircraft to stabilise anywhere, preferably Low and Wide, however it is important to ensure you stabilise in a position where you can still see the Leader’s aircraft. To increase safety, having an altitude separation between you and your Leader will mean that you can manoeuvre without any risk of collision, hence why the Wingman wants to stabilise in a

position preferably below the Leader. If you are flying a high Wing aircraft, you may consider trying to stabilise above the Leader, however if you get too laterally close to the Leader there may be visibility issues.

- (3) *UP* - The first of the three planes to fix and the most important. Being too far above the Leader can produce visibility issues possibly resulting in the Wingman going blind on the Leader. The Wingman also has the issue of having too much "energy" which may result in the Wingman overtaking the Leader as they descend, even with the power at Idle. Being too far below the Leader may also produce visibility issues for high Wing aircraft. The Wingman will also need extra power to climb, let alone move back into the correct position. This can result in a tail chase, especially in low performance aircraft. Once the aircraft has stabilised, move up or down as required to fix the plane and stabilise again on the correct plane. Although the Echelon or Line Astern reference features won't be correct, the Wingman should line the features up vertically to establish the correct plane.
- (4) *FORWARD* - Next, move forward, or in some cases backwards to meet the Primary Echelon Line. This is done through power adjustments until the Wingman can see the correct Echelon or Line Astern reference features. At this stage the Wingman should be maintaining their lateral spacing and not close towards the Leader until established on the Line.
- (5) *IN* - Once Stabilised on the correct Echelon or Line Astern Line, then move along the line to the correct position. This will require the Wingman to "Roll on, Roll off" to establish the Lateral closure, and increase power to remain on the line. Once in the correct position, "Roll on, Roll off" and adjust power to suit the Leaders speed

RELAX - STABILISE - UP - FORWARD - IN

Formation flying in general is a safe activity to participate in. A word of caution however. Any time that a Wingman is "dynamically" manoeuvring around the Leader, there is always the possibility that a closure rate may not be detected, resulting in at best a close call, or at worst a collision.

ALWAYS KEEP THE LEADER VISUAL AND STABILISE YOUR AIRCRAFT AT A SAFE DISTANCE AND IN A SAFE POSITION BEFORE ATTEMPTING TO FIX ANY ERRORS

Breaking out of Formation

If the position error or inability to stabilise is becoming dangerous then the Wingman can execute a break-out of the Formation. The break-out manoeuvre is also used to gain separation during the practice of Formation Re-joins and will be covered in greater depth in another chapter.

To perform a break-out, the Wingman rolls to a minimum of 60° AoB away from Lead and applies enough back pressure to smartly and positively separate themselves from the Leader (Figure 2.6). If the Formation contains only a Leader and Wingman at a moderate altitude then there are no further considerations for the Wingman apart from staying visual with Lead and the subsequent Re-join back into



Figure 2.6 - A not often seen formation, with the wingman performing a break-out to the right.

Formation. If the Wingman is part of a larger Formation they may need to consider other Formation members around them and go up or down to break the Formation, rather than turning away. At altitudes less than 1000 feet AGL a Wingman performing a break-out of the Formation will need to consider ground collision avoidance.

Station Keeping - Handy Hints

Smoothness is one of the most desirable characteristics in both Leaders and Wingmen, and this usually develops with time and experience. With practice you will stop the slightest relative motion between your aeroplane and that of the Leader with minimal effort. Your control movements will be so minimal that a passenger in your aeroplane may not even realize how you are maintaining position! In order to get to that plateau, you will have to master the finer points of Formation flying, beginning with:

- (1) *Relax.* Tension causes over-controlling, which will result in an oscillation that is increasing difficult to stop. Make a conscious effort to relax your grip on the stick or control column, wiggle your fingers and toes, and take your feet momentarily off the rudder pedals.
- (2) *Strive to make small, timely corrections.* Slight relative motions are hard to recognise, but easy to manage. The greater the relative motion, the more difficult it is to stabilize. Relative motion can be recognised if you are concentrating on the two reference features that make up the primary reference line on the Lead aircraft. If these two points start to diverge, then a control input is required to stop their movement.
- (3) *Trim the Aeroplane.* There are two schools of thought on this, and either one may work for you. Try them both, and then make your own decision:
 - (a) In rough air, it is sometimes better to trim the aeroplane a little nose-down, so that you are holding some tension against the stick. In theory, this will dampen out unnecessary control inputs.
 - (b) In smooth air, trim the aeroplane for one G flight, rest your arm on your leg or the side of the cockpit, and relax.

(Note that either of the above can be tried in smooth or rough air. What works for some may not work for others. The important thing is to strive to dampen out excessive control inputs which Lead to oscillations.

- (4) *Adjust your throttle quadrant friction.* This is so that you can move the throttle easily, but with enough resistance to allow you to sense the movement. Keep your hand low on the throttle lever with the heel of your hand on the throttle quadrant, or keep your index finger just touching the instrument panel. This will give you a reference as you move the throttle allowing for more precise throttle adjustments. This will be easier than if your hand was just "floating" on the throttle.
- (5) *Scanning.* The relative motion of the aircraft is detected by triangulating both the primary and secondary reference lines. Solely looking at the primary reference line will give you an idea where you are reference the correct line, however it does not give an actual position in space. Lateral movements along the line can only be detected by judging the size of the aircraft, which in close Formation can be hard to do. Keep scanning to include all the reference points to prevent "target fixation" on just the cues for the primary reference line (i.e. keep scanning to the tail cue for the correct "in/out" spacing).

- (6) *Anticipate.* All changes need to be anticipated and you'll need to stay ahead of the aircraft. Assess the result of your control inputs and be prepared to adjust. As discussed in the next chapter, approximate power adjustments are known when rolling in and out of turns, so anticipate the need to adjust power and continually assess the result.

- (7) *MMSOBYGTAST!* Ask your flying instructor!



Chapter 3 – Formation Turns

Within this chapter, we will be primarily discussing the principles of station keeping for the Wingman when flying in the Echelon position. The same principles apply when the Wingman is in the Line Astern position.

Turning in Echelon Formation produces new challenges for the Wingman as the aircraft on the inside or outside of the turn and will have a different turn radius than Lead. Radius of turn is a fundamental concept in Formation flying which must be thoroughly understood by a Wingman in order to achieve basic proficiency. In any fixed Wing aircraft, the radius of turn (the amount of airspace required to complete a turn) is a function of angle of bank and airspeed. For example, at a constant 20° angle of bank and indicated airspeed of 120 knots, a specific turn radius will result. If the airspeed is increased to 150 knots and the Angle of Bank remains the same, a larger turn radius will result. If the airspeed is decreased to 100 knots, a smaller radius will result. If the Angle of Bank is increased during a turn, a smaller turn radius will result, and vice versa when the Angle of Bank is reduced. In Summary:

- (1) With a constant Angle of Bank:
 - an increase in Airspeed will increase the radius of turn
 - a decrease in Airspeed will decrease the radius of turn
- (2) With a constant Airspeed:
 - an increase in Angle of Bank will decrease the radius of turn
 - a decrease in Angle of Bank will increase the radius of turn

These basic concepts help the Wingman to understand how to maintain position during turns in close Formation.

Turns Away from the Wingman

During turns in which the Wingman is on the outside of the turn, because of the larger radius of turn required, a small increase in airspeed is needed to maintain position. This minor difference in airspeed is achieved through a small power increase. The amount of power increase will be determined by the aircraft type that the Wingman is flying, the excess power that is available, and the Angle of Bank of the turn. Low performance aircraft such as Tiger Moth's and Gazelle's will need larger power increases to maintain position.

The Echelon or Line Astern position during a turn is exactly the same, with a change in the position of the horizon being the only visual difference. As the Leader initiates the turn, to maintain the correct position the Wingman will be required to climb to maintain position. This will put the Wingman in the same position, reference the Echelon reference lines, however in height they will be above the leader. This climb will require the Wingman to significantly increase power if they are to maintain the correct position, and not move into a sucked (aft) position. Anticipation of power application will be required by the Wingman to stay in the correct position.

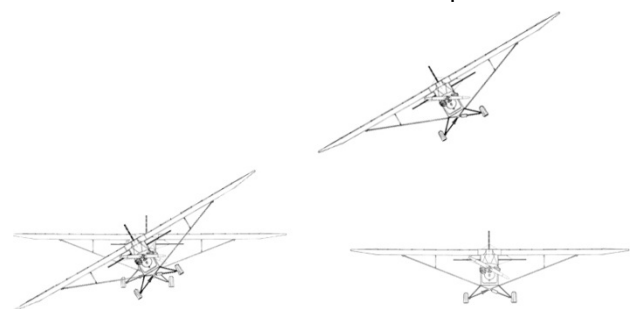


Figure 3.1 - During a turn away, the wingman will have to climb and increase power to stay in position.

During the turn, the Wingman should match the angle of bank as the Leaders aircraft. During straight and level, climbs and descent in Formation, relative heading controls lateral movement of the Wingman. In a turn however, it is Angle of Bank that controls lateral position. When the Wingman is on the outside of the turn, a slight decrease in angle of bank will result in a larger turn radius and the Wingman will move laterally away from the Leader. A slight increase in Angle of Bank will result in the opposite, and the Wingman moving laterally towards the Leader. With the lateral movement, a longitudinal movement will also result as the Wingman moves either towards or away from the Leader.

Commonly an inexperienced Wingman will not anticipate with enough power to climb and increase speed slightly, which will result in the Wingman playing catch up to try and achieve the correct position. In lower performance aircraft, this could result in the Wingman requiring full power to try and regain position. Also during an outside turn at bank angles exceeding 30° visual reference to the horizon can be lost, resulting in the feeling of “falling” in towards the Leaders aircraft. This is often subconsciously countered by the application of rudder away from the Leader resulting in a slipping turn.

To follow Lead entering a turn away, the Wingman needs to:

- Use elevator to climb and hold relative vertical position
- Smoothly increase angle of bank to match the Leaders
- Anticipate the increase in power to climb and maintain longitudinal position
- Maintain balance with rudder

Turns Towards the Wingman

During turns in which the Wingman is on the inside of the turn, because of the slightly smaller radius of turn, a slight reduction in speed will be required to maintain position and is achieved through a decrease in power. Like the turn away from the Wingman, the power reduction will be determined by the type of aircraft and the angle of bank being flown. In this instance, because of the slight descent that is also needed to remain in the correct position, higher performance aircraft such as RV's and Lancair's will need larger power reductions than their lower performance, often more 'draggy' counterparts.

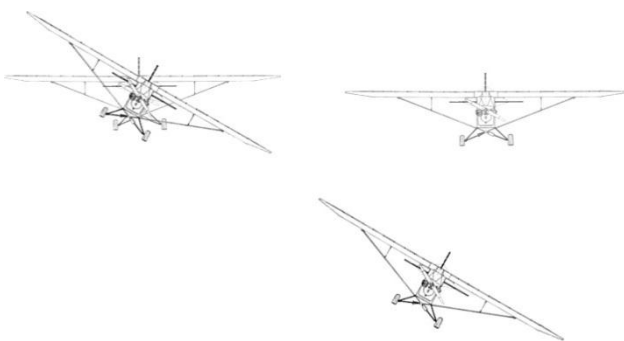


Figure 3.2 - During a turn towards, the wingman will have to reduce power and descend to stay in position

The concepts for a turn towards the Wingman are the opposite of the concepts for a turn away. To maintain position, the Wingman will need to descend to be below the Leader, and reduce speed slightly. Both of these will require the Wingman to anticipate the power reduction so they don't get acute (ahead) of the Echelon line. Angle of bank will again control lateral position with an increase in bank resulting in an increase in lateral spacing, and a decrease in bank resulting in a decrease in lateral spacing.

As can be expected, in experienced Wingman will often not anticipate the power reduction and will slip ahead of the Echelon line. In aircraft some aircraft, this can create visibility issues, especially if the Wingman is in an Echelon Left during a Left Turn. This can lead to a dangerous situation, especially in high Wing aircraft, where the Wingman loses sight of the Leader in close Formation. If the Wingman doesn't match or exceed the bank angle of the Leader, they will start to move laterally towards the Leader. In this situation, the Wingman has no other option than to break out of the Formation, usually in a downwards direction. At low power and manoeuvring during an approach to land, the Wingman might find themselves

in a situation where they are at idle power on the inside of the turn and still moving ahead of the Echelon Line. Once again, a break out of the Formation is the only safe option.

Another challenge for the Wingman during a turn in which they're on the inside, is that they will often lose sight of the horizon. On a clear day in which there are no clouds, it can appear that the Leader is "floating" and this can create disorientation. When this occurs, the Wingman should continue to fly the position as best they can, and if need be move out slightly along the echelon line to maintain a safe distance.

To follow Lead entering a turn towards, the Wingman needs to:

- Use elevator to descend and hold relative vertical position
- Smoothly increase angle of bank to match the Leaders
- Anticipate the decrease in power to descend and maintain longitudinal position
- Maintain balance with rudder

Breaking during turns

Breaking out of Formation is never a bad decision made by a Wingman, and should be encouraged by Formation Leaders if the Wingman is getting uncomfortable.

Breaking out of a turn in which the Wingman is on the outside of the turn is easier than one in which they are on the inside. During an outside turn, if the Wingman rolls off the bank, they will immediately begin to increase lateral and longitudinal separation with the Leader. Power doesn't need to be



reduced, as the increase in radius of turn is sufficient to create the safe distance. Depending on the aircraft that you are flying, a slight climb or descent may help to maintain visibility with the Leader's aircraft.

Breaking out of a turn in which the Wingman is on the inside of the turn now creates challenges as the Wingman will have to fly a smaller radius turn to create separation. It is good practice for the Wingman to never cross underneath the Leader to break the Formation even though being on the outside of the turn is easier to manage. An altitude separation in this instance is the safest way to separate the Wingman from the Formation, and since the Wingman is already below the Leader, a descending dive away from the Leader is the safest option. This will most likely mean that the Wingman will need to bank in excess of 90° to maintain positive G during the break. If the Wingman is not comfortable doing this, then they need to be prepared to push to descend and get the altitude separation. Once safely out of the Formation, then the Wing should radio to the Lead that they have broken out of the Formation, and report their altitude so Lead can ensure the altitude separation.

In larger formations, with multiple Wingmen, a Wingman breaking Formation needs to be conscious of aircraft around them, and may need to make a positive climb or descent before adjusting bank angle.

Lead Considerations

As a Formation Leader, you need to be conscious of your Wingman's abilities. Rolling in and out of turns should be smooth and coordinated, and at a rate that enables the Wingman to remain in position. In some higher performance aircraft (RV's, Extra's, Pitts, etc.) this can be a challenge, especially in turbulence because of the fast roll rates possible.

Angle of Bank also needs to be appropriate to the Wingman's abilities, and the number of aircraft within the Formation. Whereas 30° Angle of Bank might be appropriate for a 2-ship Formation, it will be excessive for an 8-ship Formation. This is especially true when there are multiple aircraft in Echelon on the same side.

As a Leader, you don't want to be surprising your Wingmen, so a visual signal is always good to notify them of a turn that you are about to commence. At SKYTHRILLS, we use head signals in the form of a positive lookout to notify the Wingman that a turn is coming. For a turn to the Left, the Leader should clearly and positively move their head to look first to the Right, then Ahead, Above, and lastly to the Left, before looking back ahead and commencing the turn. Depending on who you fly with in the future, you may find people trained at other organisations may give a hand signal, or even a radio call to notify the Wingmen of the turn.

Lastly, a thinking Leader will always consider the position of the sun and try to ensure the Wingman is not looking into the sun. This may require a 270° turn rather than a 90° turn, or alternatively get the Wingman to move to another position before the turn is commenced. Turning can be a challenge for a Wingman, so don't be afraid to get them working and getting some benefit from practicing Formation flying.



Wingman Advice

Turning can be quite challenging for a Wingman, but with practice it will become easier. If you fly with the same people all the time, you will come to know their flying style when they are leading, as they will get to know yours. During your Formation endorsement you will look at some very gentle wingovers to refine your skills however here's some advice on making the turns easier:

- (1) *Anticipate, Anticipate, Anticipate* – As a Wingman, try to think ahead and anticipate what your Leader is going to do. If you know you're on your way back home, you know that Lead will be turning to join the circuit, so be ready for the turn before it happens
- (2) *Positive Throttle Movements* – Don't be afraid to positively move the throttle if required to maintain position. There will be instances where as a Wingman you'll need full power or idle power which is fine. As a Leader rolls towards you, make a positive movement to reduce power so you don't get ahead of the Echelon Line. As you get more practice, these power movements will get smaller as you get to know the inertia of your aircraft.
- (3) *Angle of Bank controls Lateral Movement* – During a turn, remember that it only requires small angle of bank differences to change lateral position. Stay relaxed and smoothly roll towards or away as required.
- (4) *Don't get ahead of the Echelon line when on the inside of the turn* - This can be a dangerous position to be in, especially if at approach speed and manoeuvring within the circuit area. Always anticipate the need for a power reduction and descend with the Leader to remain on the correct plane. You're always better off reducing power too much and falling behind the line slightly, rather than not bringing it back enough. Also, don't be afraid to debrief Lead if their roll rates or power settings are not appropriate for you. More about debriefs later.

- (5) *If in doubt, Break out* - If you find yourself in a position where you are having issues remaining visual with the Lead or are creeping too far ahead of the line, break out of the Formation. For safety reasons, you don't want to get into the habit of trying to fix a bad situation. If there's any doubt, there's no doubt - break out of the Formation and Re-join in your own time. There will be plenty of time to talk about it after once you are on the ground.

Chapter 4 – Station Changes

We're going to start this chapter by saying that Formation flying in general is a safe activity to participate in. The only time when it can become dangerous is when a Wingman is intentionally manoeuvring his aircraft around the Leaders. This manoeuvring can create situations where the Wingman's direction of flight is towards the Leader. If this is not detected and corrected for early enough by the Wingman, a collision risk could result. Two common situations where the Wingman is manoeuvring around the Leader are during station changes, and Re-joins discussed in another chapter.

Station Changes are used to reposition the Wingman to another position in the Formation. This can be because of an upcoming turn, positioning for a pairs landing, or simply for training of the Wingman. The station change begins with the Leader giving either a visual signal or radio call to the Wingman. A change from Echelon to Echelon is achieved in three precise steps and initially will seem quite "clunky" for the Wingman. With practice these three steps will blend into one as the Wingman moves through each position.

- (1) *Move down and back into the Station Change Key Position.* The first step of the station change is to move into a position that will ensure that a collision does not occur. This position is behind and below the normal Echelon position, and is known as the "Station Change Key Position." The position is the same lateral spacing as the Echelon position with the same Longitudinal and Vertical spacing as the Line Astern position.

The first step for the Wingman is to reduce power and move down and backwards to achieve vertical and nose to tail spacing. This power reduction doesn't have to be big, but should be enough to start a smooth but positive rearwards movement. As the Station Change Key Position is reached, a positive power application is required to stop the aircraft from moving further aft. Failing to stop the rearwards movement is a common mistake made by a new Wingman, and results in the aircraft falling so far behind that it takes a long time for the Wingman to regain the correct position.

Before moving across behind the Leader, the Wingman should stabilise his aircraft in this new position. Sometimes the Wingman can start a lateral movement across behind the Leader before achieving the correct Station Change Key Position.

- (2) *Move laterally across through the Line Astern position to the other Station Change Key Position.* To initiate the lateral movement across behind the Leader the "Roll on, Roll off" technique is used as described in Chapter 2. Remember that once again it is a heading difference that achieves the lateral movement in straight and level flight, not Angle of Bank difference. If a different Angle of Bank is used to the Leader (incorrect technique), then there will be an increasing rate of lateral movement that will be hard to control.

As the Wingman moves laterally across behind the Leader, they will also need to increase power slightly as they now have more air miles to fly than the Leader. It is another common mistake for the Wingman to not increase power as they move laterally across resulting in falling behind the Line Astern position. It is also important for the Wingman to remain below the Leader to remain clear of their wingtip vortices and prop wash. Being too low however could create visibility issues for the Wingman if they are flying a high wing aircraft.

Once the Station Change Key Position is reached on the other side, the Wingman should "Roll on, Roll off" to stop lateral movement, and adjust power to maintain longitudinal position.

- (3) *Move back into the correct Echelon Position.* The technique for moving back into position is the same as described Chapter 2. UP - FORWARD - IN. Move UP to the correct plane, FORWARD to the Echelon Line, and then IN along the line.

If the Wingman was moving from Echelon to Line Astern, they would complete steps one and two and then "Roll on, Roll off" when they get to the correct Line Astern position. If the technique used, and the power was correct, there should not be any longitudinal or vertical movement required when reaching the correct Line Astern position. Moving from Line Astern to Echelon would require the Wingman to move laterally to a Station Change Key Position, and then **UP - FORWARD - IN**.

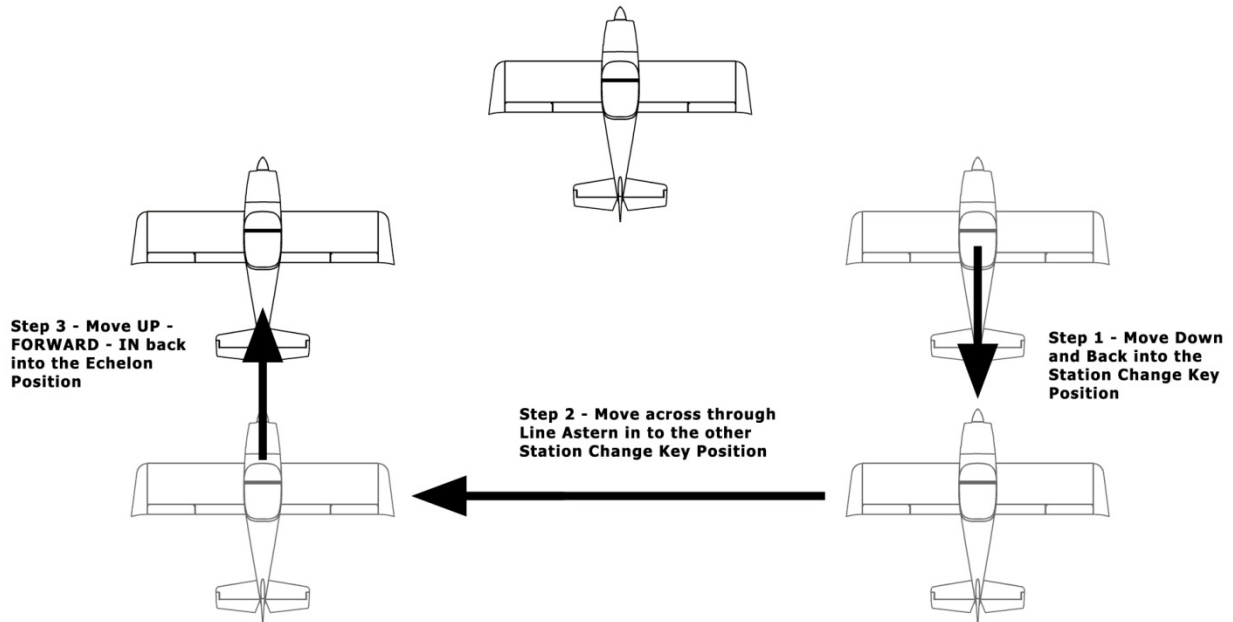


Figure 4.1 – The Station Change procedure from Echelon Right to Echelon Left



Figure 4.2 – The Station Change key position for a Super Decathlon – below and behind the normal Echelon Position

Chapter 5 – Close Formation Lead Changes

The Formation Lead (#1) may elect to have another member (#2, #3, #4, etc.) Lead the Formation for a variety of reasons such as training a new Leader, giving #1 a chance to practice flying Formation or possibly #1 may have a radio problem and require another member to lead back.

Who's responsible for the Formation

When the Lead is given to another Formation member, other than #1, the new Formation Lead is essentially temporary and is only to execute the air exercise as briefed by #1. Despite the change in positions, the Formation members always maintain their original call sign's. This prevents confusion as to who is who within the Formation.

The Formation Lead (#1) who briefed the Formation always maintains responsibility for the Formation even after a Lead change has taken place. A Formation member taking the Lead should be completely briefed on what is expected of them for the Air Exercise, and how they should manoeuvre and configure the Formation. The new Lead may be given some flexibility to make their own decisions, but if there is any confusion or safety issue, it is the Formation Leads responsibility.

When another Formation member has the Lead, #1 should not have any direct input unless they have identified a safety issue. This sometimes can be hard for a Formation Lead, especially an experienced Formation pilot, as the new Lead will probably not do things the same way as the Formation Lead. The Formation Lead should refrain from making comments over the radio, and should use the de-brief to discuss issues. Remember, nobody likes a back seat driver, especially in Formation. If #1 feels that the intent of the mission or the briefed Air Exercise is not being followed, then they can request the Lead back.

Lead Change procedure

A Formation Lead change must always be done in VMC and well clear of any other aircraft. It should be conducted in straight and level flight, normally from the Echelon Formation. The Lead change can be conducted either using the radio, or by visual signals (known as NOCOM procedures).

Radio procedure Lead change - The Leader will initiate the Lead change by calling:

"Viper 2 take the Lead"

At which point with Wingman will increase lateral spacing to between one to two wingspans and increase power to establish a moderate overtake (walking pace). As the Wingman approaches abeam the Leader they will call:

"Viper 2 passing left / right, taking the Lead"

The Leader will then look to their left / right and once they can clearly see the wingman call:

"Visual"

This should occur just as the Wingman gets abeam the Leader, so neither the Wingman nor Leader has to fly Formation looking backwards over their shoulder. It is important to note that the Wingman still has the contract of avoiding the Leader until they hear the "Visual" call. At this point #1 assumes the collision avoidance responsibility as they now become the new Wingman. Should the new Lead not hear the "Visual" call from #1, then they should repeat the radio call. If still no response, then they should move back to the original Echelon position and attempt to clarify with Lead on the radio.

NOCOM Lead change - The Leader will initiate the lead change by pointing to the Wingman and then pointing out in front of the Lead aircraft using a sweeping motion with their finger. This is described in more detail in Chapter 15. The Wingman then acknowledges with a nod of their head, and increases lateral spacing to between one to two wingspans and increases power to establish a moderate overtake (walking pace). As the Wingman approaches the abeam position the Leader will start to look out over their shoulder to sight the Wingman. The Leader is still responsible for sighting other traffic at this stage, so will have to divide their attention between looking out the front and looking for the Wingman over their shoulder. As the Wingman gets abeam the Leader, the Leader should give a big head nod at which point they assume the collision avoidance contract as Wingman. As they see the Leader give the head nod, the Wingman should smartly look straight ahead and begin looking for traffic. If no head nod is received from the Leader, then the Wingman should reduce power to avoid overtaking the Leader and remain in the abeam position until a head nod is received. If still no head nod, then they should reduce power and move back into the echelon position.

During the Lead change both pilots need to remain wings level and ensure that no heading change occurs once the wingspan of spacing and the overtake has been established. It is a common error to inadvertently “creep in” toward each other, which is the natural tendency as you look fully abeam at another aircraft.

For any Formation Lead change the precise “executive” point for the change needs to be clearly understood and observed. There can only be one Lead (fulfilling the “Lead” contract) and one Wingman (in a pair fulfilling the Wingman contract) at any one time. A good way to think about Formation Lead changes is that the Lead is relinquished by the current flight Lead rather than “taken” by the Wingman at the executive “visual” call or head nod.

Once the Lead change has occurred, #1 may elect to brief the new Lead on position of the Formation, radio frequencies, operating area, fuel status, or any other relevant information.



Chapter 6 – Break-offs and Re-joins

Once again, as described in chapter 4, when a Wingman is dynamically manoeuvring around the Leaders aircraft there is the potential for a collision if correct procedures are not followed. The procedures described in this chapter are critical to the safety of the flight as Re-joins will establish fast closure rates.

A Wingman may need to perform a Re-join for a variety of reasons such as a stream take-off, break-away or lost contact, to join up multiple elements for a larger Formation, as part of a display, etc. The skills required to perform a Re-join are distinctly different from close Formation station keeping and need to be practiced. The basics of all Re-joins is for the Wingman to establish closure on Lead, maintain de-confliction while assessing closure rate and judging when to adjust power to match Lead's speed.

Break-offs

Break-offs have already been described in Chapters 2 and 3 as a procedure for breaking out of Formation if things aren't going as planned. Break-offs are also used to separate the Formation for landing, or to practice Formation Re-joins.

As described in the previous chapters the Wingman should break a Formation by rolling smartly to at least 60° of bank and apply sufficient back pressure to turn out of the Formation. This can also be combined with a slight climb to put the Wingman above the Leader as this will help with the ensuing Re-join. Once again, other Wingmen and altitude needs to be considered, as well as cloud above or to the side of the Formation.

The break-off should encompass at least 60° of heading change, and is normally 70° - 90° of heading change. For most General Aviation aircraft (cruise at 100kts - 120 kts) this equates to 5 seconds in a 2G, 60° angle of bank turn. The time may need to be increased if the speed of the Formation is greater than 120 kts. If the Wingman does not affect enough of a heading change, then they will find themselves ahead of the Re-join line for the ensuing Re-join

A break-off for a practice Re-join is initiated by the Leader through either waving the Wingman away (as described in Chapter 15), or through the radio call:

"Viper 2, you are clear high and right, cleared to break"

Before clearing the Wingman for a break-off and Re-join, the Leader should ensure that the airspace is clear, in a suitable location, and on an appropriate heading the is clear of cloud and controlled airspace.

Line of Sight v's Re-join Line

When a Wingman starts a Re-join, they will more than likely be in a position where they will be unable to see the correct Echelon line reference features. For this reason, the Re-join line cues are different from the Echelon line cues.

Line of Sight (LOS) - Line of Sight is used when the Leader is at such distances that features on the aircraft are difficult to distinguish. The LOS refers to the position of the Leaders aircraft in the windscreen of the Wingman. The LOS position will be determined by the closure rate (speed difference) of the Wingman on the Leaders aircraft. A typical closure rate of 20 knots will result in the



Figure 6.1 – Line of Sight – when features on the Leaders aircraft are difficult to distinguish

Leader being in approximately the 10:30 or 1:30 position in the Wingman's windscreen (Figure 6.1).

If the LOS is correct for the closure speed, then the Leader's aircraft will remain in the same place in the windscreen. If Lead is moving aft in the windscreen it means that the Wingman is Re-joining to a position ahead of Lead and will eventually overtake Lead. The correction for this is for the Wingman to adjust their heading towards the Lead, and move the Lead forward in the windscreen. If Lead is moving forward in the windscreen, the opposite is occurring and the Wingman is falling into a sucked position on the Lead. This means Wing is Re-joining to a position behind Lead and will need to alter heading away from the Lead or move Lead backward in the windscreen.

The other consideration is that the faster the closure rate of the Wingman, the further forward in the windscreen the Lead will need to be. Speeds in excess of 20 kts may be appropriate if the Wingman is 2 nm away from Lead, but is not recommended when within ½ a nautical mile. To summarise:

Lead in a stationary position = Correct Re-join Line of Sight

Lead moving aft in the windscreen = Re-joining to a position ahead of Lead =
Turn towards Lead to correct

Lead moving forward in the windscreen = Re-joining to a position behind Lead =
Turn away from Lead to correct

Re-join Line - As the Wingman closes the distance between themselves and the Leader, features will start to become more obvious on the Leaders aircraft. The wings and the tail will become easier to see and should be used to establish a Re-join line. For most aircraft, putting the vertical stabiliser ½ way along the outside Wing of the Leader is a good Re-join line to use. This may not be appropriate for all aircraft it may be difficult to see the outside Wing on low Wing aircraft. An alternative feature is to put the nose ½ way along the inside Wing. Both of these are appropriate, and will result in a Re-join line that is similar to the Echelon line (Figure 6.2).

As the Wingman closes on the Leader's aircraft, heading changes for straight Re-joins or Angle of



Figure 6.2 – Re-join Line – Vertical Stabiliser ½ way along the outside wing or nose ½ way along the inside wing.

Bank for turning Re-joins will keep the aircraft on the correct Re-join line. If the Wingman starts to see the vertical stabiliser or nose of the Leaders aircraft move inwards towards the fuselage, then they are falling behind the Re-join line which is known as being "COLD". This will also result in the Leader moving forward in the windscreen in the same fashion as the LOS concept. To correct this, the Wingman must alter heading (or Angle of Bank for a turning re-join) away from the Leader to "chase" the Re-join line.

If the Wingman starts to see the vertical stabiliser or nose of the Leaders aircraft move outwards towards the wingtip, they are now ahead of the Re-join line which is known as being "HOT". This will also be evident by the Leader moving aft in the windscreen, and

can be corrected by the Wingman altering their heading (or Angle of Bank) towards the Leader. During this part of the Re-join, speed should not be altered, and the Wingman should maintain a 20 kt overtake. Heading and Angle of Bank corrections will also get smaller as the Wingman approaches the correct Re-join key position since less lateral movement is required. Once again, heading changes will be required for a straight Re-join, whereas Angle of Bank changes will be required for a turning Re-join. To summarise:

No change in the Re-join line cues = correct Re-join being performed

The vertical stabiliser or nose moving inwards along the corresponding wing = COLD on the Re-join line = Turn away from Lead to capture the Re-join line

The vertical stabiliser or nose moving outwards along the corresponding wing = HOT on the Re-join line = Turn towards Lead to capture the Re-join line

Height during the Re-join

As mentioned previously, dynamic manoeuvring when in Formation can create a collision hazard. To minimize this risk a height separation is established during a Re-join that will give adequate room should the Wingman need to bug out.

The vertical separation is established by the Wingman placing the Lead aircraft one fuselage length above the horizon. As the Wingman closes the distance on the Lead, the gap between the Lead and the horizon will get larger to maintain the one fuselage length (Figure 6.3). The Wingman will have to use their own judgement when doing this and ensure they are not too high or too low.

Re-joining with the Lead aircraft on the horizon is a very dangerous practice. The danger comes from misjudging the closure rate as the Wingman Re-joins position. If the closure rate is misjudged, then the Wingman may decide to pull and go above the Leaders aircraft, resulting in them going blind (a very dangerous way to be). The alternative is for the Wingman to push to go under the Leader which will more than likely result in negative G, and will not normally be the first choice for the Wingman. **Never conduct a Re-join with the Leader on the horizon during the Re-join.** As a Leader you should be looking for this, and de-brief your Wingman if required.

On the other side of the coin, in-experienced Wingmen may consider keeping the Leader a long way above the horizon to ensure a safe height separation. This also has its dangers as when the Wingman is a sufficient height below the Leader they now have to climb as they close the distance if they are to achieve the correct Re-join key position. This climb now results in the Wingman's energy and flight path being directed towards the Leader's aircraft. If the Wingman misjudges closure rates, then they will need to take a drastic measure to avoid a mid-air collision. This can be as dangerous as Re-joining with the Leader on the horizon.

***ALWAYS RE-JOIN A FORMATION WITH THE LEADER
ONE FUSELAGE LENGTH ABOVE THE HORIZON***



Figure 6.3 – One Fuselage Length above the horizon

Re-join work cycle

During the Re-join it is imperative the Wingman accurately monitors closure rates and height, and for this reason we use the **HEIGHT - LINE - SPEED** work cycle.

- (1) **HEIGHT** - As discussed in the previous section, it is imperative that during the Re-join a Wingman maintains the Leader one fuselage length above the horizon. This is achieved through small but positive changes in height that will get smaller as the Wingman gets closer to the Leader.
- (2) **LINE** - At this stage, the Wingman should be checking either the LOS position, or the Re-join line cues for the correct line. If behind the line, a slight turn away is required, and if slightly ahead, a turn towards is required. It should be noted during a straight Re-join that heading determines position reference the Re-join line, whereas during a turning Re-join it is Angle of Bank that determines position reference the Re-join line.
- (3) **SPEED** - Adjust power as required to maintain the correct Re-join speed. This is usually the Leaders speed +20 kts, however a different speed may be briefed by the Leader.

The Wingman must use this work cycle during the Re-join. It is not uncommon for trainee Wingmen to completely miss checking speed as they don't want to take their eyes off the Leader, despite the fact that they are ¼ of a nautical mile away.

Re-join end game

During the Re-join, the closure rate and remaining range must be closely assessed. As the Wingman closes to within 300 metres of the leads aircraft, they will notice that the Lead "Blooms" in size. This is where there is a noticeable change in size of the Leaders aircraft and it appears to get very big, very quickly. Test this concept next time you're driving down the road towards another car. You'll notice when the other car is quite a distance away, there is not really any noticeable size change as you get closer. You'll eventually get to a point where you'll notice that the car is getting bigger, and then very quickly it will grow in size as you close the last 100 metres. This is the same concept you'll see with the leads aircraft while Re-joining.

As the Lead's aircraft starts to bloom, the Wingman should reduce power, and gradually turn away from the Leader to remain on the Re-join line. The amount of power reduction required by the Wingman will be determined by the closure speed, the timing of the power reduction and the aircraft type. A high closing speed, late power reduction and a slippery aircraft will require a large power reduction that could mean idle in some situations.

At the same time as reducing power, the Wingman will need a slight bank away from the Leader to match headings for a straight Re-join or match turn rates for a turning Re-join. The Wingman should aim to stabilise in the Re-join key position, which is aft of the Echelon position, and below the Leader's aircraft. This position is the same as the Station Change Key Position. At no point should the Wingman try to Re-join straight into the Echelon or Line-Astern position.

Whilst the Wingman is stabilising in the key position, they should always maintain the vertical separation established during the Re-join (one aircraft length above the horizon). It is not uncommon for vertical "creep" to develop in this late stage of the Re-join and the Wingman finds themselves stabilised on the same plane as the Leader. Always stabilise below the Leader's aircraft, and then move into position from there.

If high lateral closure speeds are allowed to develop, large angles of bank may be required to stop the closure. **NEVER** lose sight of your Leader during a Re-join, and **NEVER** use high bank angles to try and control the closure rate (known as going belly up to Lead). This is very poor technique, and extremely dangerous. If it is not going to plan, bug-out and attempt another Re-join. As a Formation Leader, if you

see a Wingman coming towards you and all you can see is the belly of their aircraft be prepared for evasive action.

Once in the correct key position, the Wingman can either move across behind the Leader to Echelon on the far side in the same manner as performing a station change, or move UP - FORWARD - IN to the correct Echelon position on the same side. The Wingman should always Re-join to the key position on the side of the Leader they're on, and then move across to the other side if required. This is more efficient and prevents situations developing where closure rates are not detected

Straight Break-off and Re-join

To conduct a straight break-off and Re-join the following procedure should be used:

- (1) Leader initiates the Break-off and Re-join using either a visual signal (waving the Wingman away) or a radio call:

"Viper 2, you are clear high and right, cleared to break"

- (2) Roll smartly to 60° Angle of Bank, increases power and perform a 2 G level or climbing turn away from the Formation through a minimum of 70° of heading change.
- (3) Roll out and maintain wings level for at least 5 seconds. At this stage you should be looking back over your shoulder and visually spotting the Lead to maintain situational awareness. Continue to accelerate to Lead's speed +20 kts for the Re-join.
- (4) Reverse the turn and place the Leader in the 10:30 or 1:30 position and one fuselage length above the horizon.
- (5) Once established, call Lead for clearance to Re-join.

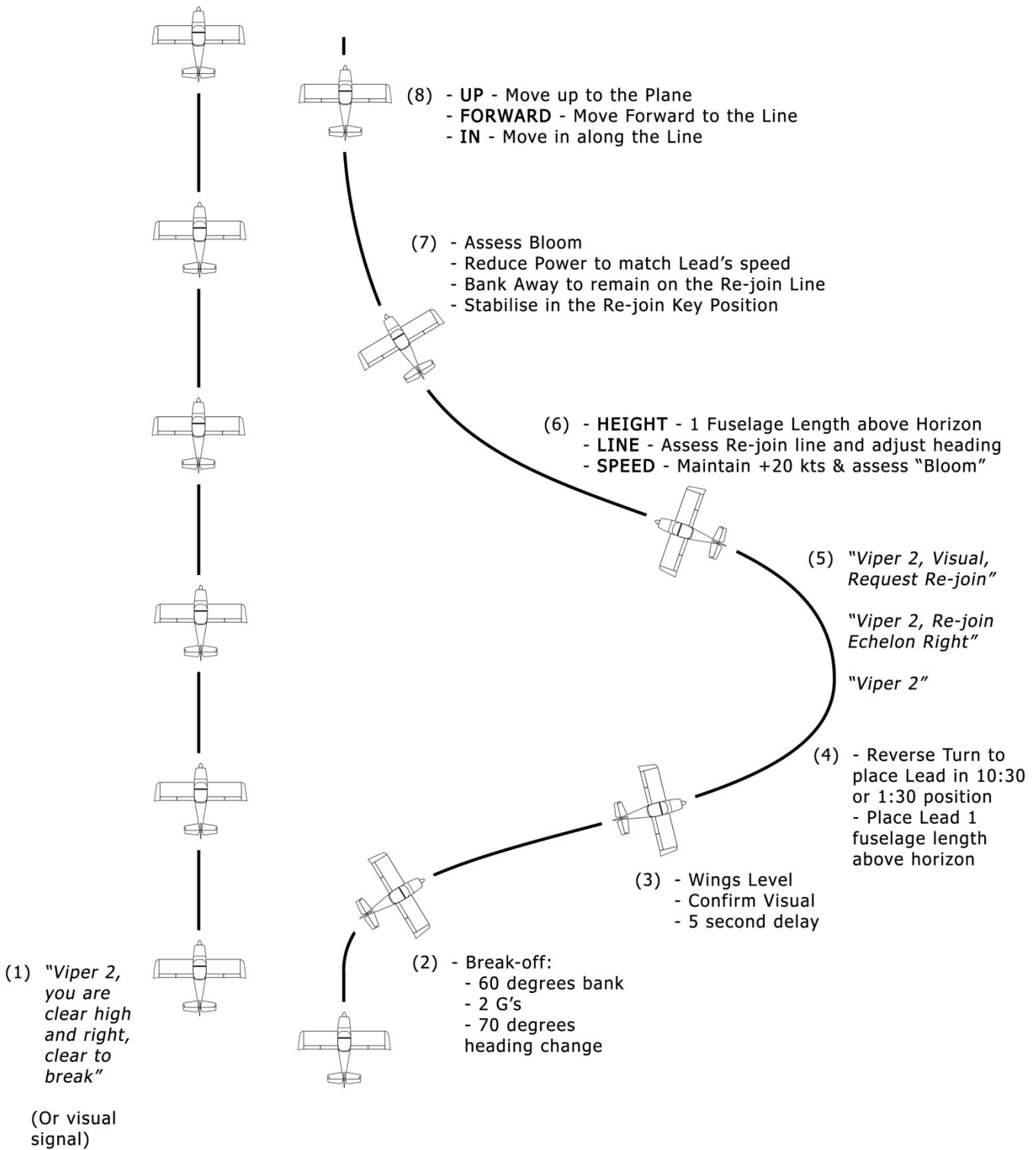
"Viper 2, Visual, request re-join"

"Viper 2, Re-join Echelon Right"

"Viper 2"

- (6) Conduct the Re-join to the nearest side using the HEIGHT - LINE - SPEED work cycle.
- (7) Approaching the "Bloom", reduce power to match the Leader's speed, bank away to remain on the Re-join line, and stabilise your aircraft in the Re-join key position (Station Change Key Position).
- (8) From here, conduct a Station Change or move UP - FORWARD - IN to get into position.

On the next page is an illustration of how to perform a straight Re-join.



Turning Re-joins

Turning Re-joins are more dynamic, and Re-join speeds tend to be higher because of both the 20kt airspeed overtake, and the geometry of the turns. Even with a matching speed, the Wingman can affect a Re-join through using geometry and essentially “cutting the corner” to close the distance with the Leader. Because the Wingman will be on the inside of the turn, angle of bank controls positioning on the Re-join line. The Re-join line and LOS cues are exactly the same, but the Re-join line is now moving as opposed to being stationary like a straight Re-join. This will require more manoeuvring by the Wingman to remain on the Re-join line. To conduct a straight break-off and turning Re-join the following procedure should be used:

- (1) Leader initiates the Break-off and Re-join using either a visual signal (waving the Wingman away) or a radio call:

“Viper 2, you are clear high and right, cleared to break”

- (2) Roll smartly to 60° Angle of Bank, increases power and perform a 2 G level or climbing turn away from the Formation through a minimum of 70° of heading change.
- (3) Roll out and maintain wings level for at least 5 seconds. At this stage you should be looking back over your shoulder and visually spotting the Lead to maintain situational awareness. Continue to accelerate to Lead’s speed +20 kts for the Re-join.
- (4) Reverse the turn and place the Leader in the 10:30 or 1:30 position and one fuselage length above the horizon.
- (5) Once established, call Lead for clearance to Re-join.

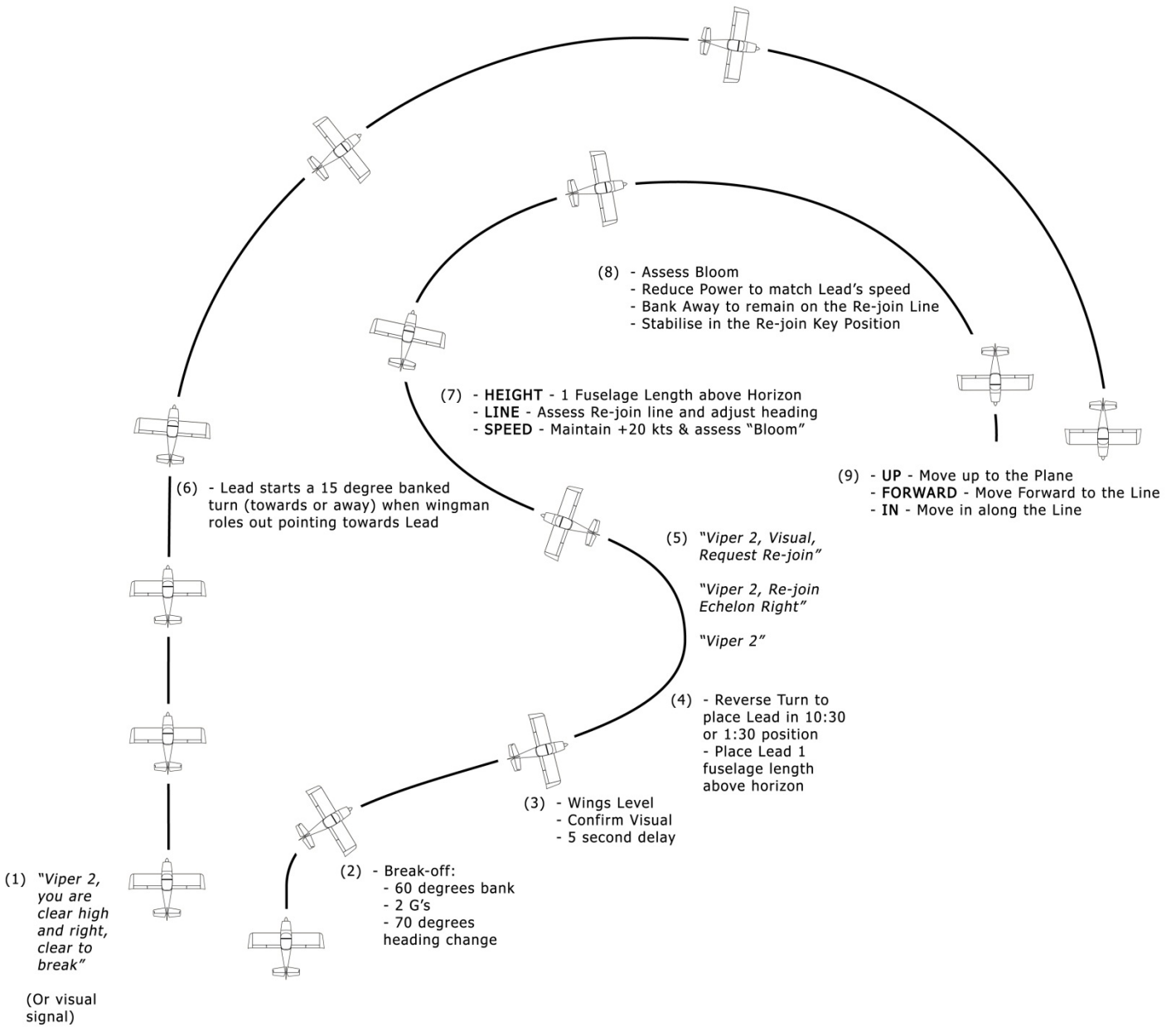
“Viper 2, Visual, request re-join”

“Viper 2, Re-join Echelon Right”

“Viper 2”

- (6) Once Lead see’s Wing roll out heading back in for the Re-join they should start a level turn of about 15° of bank either towards or away from the Wingman.
- (7) Conduct the Re-join to the nearest side using the HEIGHT - LINE - SPEED work cycle. Keep in mind that the Re-join line may be behind you and you will more than likely be HOT when the Re-join starts, and will have to bank towards the Leader before banking away.
- (8) Approaching the “Bloom”, reduce power to match the Leader’s speed, bank away to remain on the Re-join line, and stabilise your aircraft in the Re-join key position (Station Change Key Position). It is important to maintain the correct height and pass through the Leaders “plane” to establish in the correct position below the Leader.
- (9) From here, conduct a Station Change or move UP - FORWARD - IN to get into position.

Below is an illustration of how to perform a turning Re-join.



Turning Re-join - Line of Sight Picture



Turning Re-join – Re-join line features – Tail half-way along outside wing

Re-join Bug-outs

If the Wingman misjudges the closure rate, or fails to stabilise in the Re-join key position, then a bug-out should be executed. This is an important decision for the Wingman to make, as admitting that you have screwed up a Re-join is sometimes a difficult decision. If there is any doubt as to whether you'll achieve the Re-join safely, bug-out and try again. To perform a bug-out:

- (1) *Identify the need for a bug-out* - This is the most critical step of the bug-out. Look for high closure speeds, and make a decision early.
- (2) *Ensure altitude separation* - If the correct height has been maintained during the Re-join then this step is easy. Ensure you are sitting slightly below the Leader, and your direction of travel is not towards them. At this stage, radio the Leader:

"Viper 2, bugging out right"

as this will give the Leader an opportunity to also look out for you to ensure safety.

- (3) *Close the throttle and level the wings* - The next step is to pass below and behind the Leader. Closing the throttle completely will reduce forward momentum and should see you pass behind the Leader. By levelling the wings, you will ensure you don't get into a position where you are trying to bank away from the Leader to stop the closure rate.
- (4) *Stabilise the aircraft on the other side* - Now you've passed below and behind the Leader, stabilise on the other side below and behind the Leader.
- (5) *Perform another Re-join* - Re-join into the key position on the same side you're on, and then move to the correct Echelon position requested by the Leader

During a Re-join bug-out, so long as vertical separation is maintained, safety can be assured.

Chapter 7 – Formation Take-offs, Landings and Circuits

The standard Formation take-off is a pairs in echelon whenever conditions allow. Some conditions that may preclude a pairs take-off are:

- Crosswind greater than 2/3rds the limit for the aircraft
- Wind conditions gusting more than 20 kts
- Runway length marginal for a reduced power take-off
- Runway width not sufficient to allow safe wingtip clearance
- Water on the runway
- Significantly dissimilar aircraft
- Poor forward visibility during the take-off roll

This list is not exhaustive by any means, and the type of take-off should be discussed as part of the pre-flight briefing. The two most important considerations for the Leader is the Runway Width, and Runway Length. Runway width should be a minimum that will permit a safe wingtip clearance (at least a few metres), without the Wingman or Leader requiring to run their outside wheel along the far edge of the runway.

During a pairs take-off each Formation member has a contract to stay on their half of the runway. This means that under no circumstances should either the Leader or the Wingman allow any part of their aircraft to cross the runway centreline. Even in the worst case scenario, if one of the Leader's tyres should burst half way through the take-off roll, the Leader would be expected to do everything in their power to remain on their side of the centreline. This may mean full opposite rudder and brake, but this is better than being pulled into the Wingman and both aircraft being involved in an accident.

During a pairs take-off, do not cross the runway centreline under any circumstances!

Pair's Aborts

The typical runway lengths used in general aviation do not leave sufficient safety margin for the whole Formation to abort if required. This is a consideration for Lead as Wing will need time to comprehend and then react to a Formation abort situation. That is to say that a Formation abort shouldn't be attempted if the situation requires it, however the whole Formation should not abort if not essential.

Should the Leader require the whole Formation to abort, they should call "Dagger Formation, Abort, Abort, Abort!" After the radio call they should close their throttle and apply braking as required, remaining on their side of the runway. Leaders need to be conscious of aborting the take-off and then calling on the radio as they're applying brakes. Although this will be the more instinctive reaction, it will put the Wingman into a position where they will not react at the same time as Lead, and end up overtaking Lead as they brake. Now the Wingman has to divide their attention between maintaining their half of the runway, and looking back over their shoulder to avoid hitting the Leader.

There will be times when one of the members of the Formation will have to abort the take-off. This could be because of engine problems (either observed or suspected), brake issues, controllability problems or any other reason that could affect the safety of the take-off. In this case, the Formation member's priority is to maintain control of their aircraft on their side of the runway, and then calls "Dagger 2 Aborting".

The other members of the Formation should continue with their take-off, even if it is the Leader that aborts. This is due to difference in timing of reduction of power and application of brakes, and could possibly see one member of the Formation aborting at a faster speed, with insufficient runway to stop. Also, if both aircraft abort, one or the other aircraft may temper their braking in consideration for the other aircraft, and so significantly increase the ground distance required to stop.

If the element taking off are part of a larger Formation and have another element taking off behind, then the Formation member aborting should roll through to the end of the runway if it is safe to do so.

During a Pair's Take-off, NO SYMPATHETIC ABORTS!

Pair's Take-off

The element should line up in the centre of their half of the runway, with no wingtip overlap. If this is not possible, then the runway is not wide enough and a stream take-off should be flown. The Wingman should line up on the normal Echelon Line, but further out along the line as required to keep wingtip separation (Figure 7.1).

It is usual for the Lead to line up on the downwind side of the runway, however this is not essential with crosswinds less than 10 kts. With more than 10 kts crosswind, Lead should always line up on the downwind side of the runway to ensure that their prop-wash or wingtip vortices do not impact the Wingman during the take-off. This also has the additional benefit of position the Wingman's aircraft away from Lead should they weathercock into wind during the take-off. When wind is less than 10 kts crosswind, Lead may consider initial turn



Figure 7.1 – The correct Line-up position. On the Echelon Line, but further out than the normal Echelon Position

direction, or first Formation position for the Wingman when choosing which side to line-up. To avoid confusion, this should always be briefed by Lead however in the absence of discussion during the briefing, the standard position for Wing is in Echelon Right.

Once the Wingman has taxied into position, they should complete all their line-up checks and make sure they are ready for take-off. Once happy, they should look at the Leader and await the line-up signal. Lead at this stage should also complete their checks, and then look back to the Wingman. Once they can see the Wingman is looking at them, they should give the wind-up signal (Chapter 15) and run the engine up to an intermediate power setting whilst holding the aircraft on the brakes. This intermediate power setting will be pre-briefed and would be something like 1500 RPM for a C-172, 1800 RPM for a Decathlon or 3500 RPM for a Tecnam. When Formation members are flying different aircraft types, the Wingman needs to be aware that on brakes release they may need a quick power adjustment to maintain position. The purpose of this intermediate power setting is to ensure that on brakes release that both aircraft start rolling forward at the same time.

Once Lead and Wing have set the power, they should do one final check of the engine instruments to ensure that everything is good to go. If Wing is happy, then they should look at Lead and give a thumbs up signal to indicate they are ready. When Lead see's this, they should look forward tilt their head back and signal brakes release with a smooth and positive head nod. Both pilots should release brakes when the Leaders chin touches their chest.

Once both aircraft have released brakes and are rolling, Lead will smoothly but positively increase power over 5 seconds to about 80% power for the take-off. Full power is never used by Lead, unless the Wingman is flying a higher performance aircraft. The exact power setting should be briefed before the flight so the Wingman knows what to expect. By using less than full power for take-off, the Wingman has a small power advantage over Lead, and can use full power to catch up to position should they fall behind.

Something for the Leader to consider is that the reduced power take-off will increase the take-off distance required, and reduce the climb performance.

As the Leader starts the take-off roll, they should initially concentrate on maintaining their half of the runway, and setting the required power for the take-off. A quick look back half way through the take-off roll to check the Wingman is rolling with the Leader is acceptable, however the Leaders primary focus should be smooth, accurate aircraft control, with a smooth but positive rotation at the correct speed. Regardless of whether the Wingman is maintaining position or not, the Leader should continue with the

take-off and then debrief on the successful or unsuccessful aspects of the take-off after the flight.

For the Wingman, their attention will need to be divided between maintaining the correct position on the Leader, and maintaining the centre of their half of the runway. Attention should be divided 25% to the Leader and 75% to the runway. Even when looking directly ahead at the runway, the Wingman should be able to see the Leader in their peripheral vision. As the Leader rotates, so too should the Wingman. The Wingman will not need to worry about power or speed as if they are staying with the Leader then they will match what the Leader



is doing.

Once safely airborne, both Formation members should do their normal after take-off checks. If this involves raising gear or flap, then the Wingman should try to match the Leaders configuration and retract gear and flap at the same time. Visual signals can be given to retract gear and flap at the same time, however at this stage maintaining an accurate position and terrain de-confliction is more important. The Wingman may consider flying a slightly stepped-up echelon position level with the Leader until clear of the terrain and obstacles.

After re-configuring the aircraft, Lead should set their normal climb power and be on the lookout for traffic. Once established in the climb, it is important that the Wingman trim their aircraft, relax and ensure they have a light but positive grip on the controls. At this stage they should move from the slightly wide echelon position during the take-off to the normal echelon position. If the Wingman has insufficient power to maintain station, then they should call "Dragon 2, Revs". On hearing this, Lead should reduce their power by 2" manifold pressure, or 100 RPM depending on the aircraft type.

Stream Take-off

Stream take-offs are flown when existing conditions would make a close Formation take-off hazardous, eg. Strong crosswind, short runway, wet or narrow runway, very high Outside Air Temp, heavy weight, a rough runway, or loose runway surface (gravel). Conditions requiring a stream take-off will vary for different aircraft types. When participating in formations with multiple aircraft types, the Leader should always make decisions (such as pairs or stream take-off's) based on the most limiting aircraft.

The line-up on the runway is the same as for a pairs take-off, with the exception that the Lead should always be on the Downwind side of the runway. This ensures their turbulence is blown away from the Wingman during the take-off roll. Like the pairs take-off, both aircraft should complete their pre-take-off checks before Lead give the wind-up signal (Chapter 15). Once the Wingman is happy, they will give

Lead the thumbs up signal at which time Lead will look straight ahead, release the brakes and smoothly apply full power. After a pre-determined time delay, the Wingman should do the same. Lead should not give a head nod on brakes release as this would indicate a pairs take-off.

Head nod = pairs take-off. No Head nod = stream take-off

Full power should be used by both Lead and Wing to minimize ground roll and maximize obstacle clearance after take-off. As each aircraft rolls, they should gradually close towards the centreline, especially on a narrow runway.

During the pre-flight briefing, the Formation Lead should specify the required stream timing delay. There are a few considerations for both the Leader and the Wingman when considering the timing delay. The first is for the Wingman to be as close as possible to minimise the delay in Re-joining after take-off. The second consideration is for the Wingman to delay long enough so that if the preceding aircraft has to abort at any time during their take-off the Wingman will not be in a position where a collision risk could occur. If Lead aborts during the early stage of the take-off, the Wingman should still be slow enough to also abort. If later in the take-off roll, the Wingman should have sufficient distance to take-off over the top of Lead. The exact time will vary from aircraft to aircraft and if in doubt waiting longer is better than going sooner. For most general aviation aircraft, a 5 second delay is sufficient however this can be pushed out to 10 seconds.

Irrespective of which side the Wingman was lined up on for the take-off, they should always cross to the inside of the departure turn and conduct a turning or straight Re-join to that side. Lead should clearly brief their preferred plan for the Re-join after a stream take-off. One consideration for Lead is that if they have multiple Wingmen (i.e. more than one) doing a stream take-off, then they should consider delaying their crosswind turn until they're higher than 500'. By turning at the minimum 500', the last Wingman would have to start their crosswind turn at 100' or 200' so they don't lag behind. Lead may also consider temporarily levelling off at 1000' at a slower straight and level to give the Wingmen assistance to expedite the Re-join. Once all Wingmen have Re-joined, the climb may be continued as required.

Pairs Circuit

A pair's circuit is the preferred means of flying a circuit, especially with traffic already established in the circuit. Although the pair will have less manoeuvrability than if the Formation were to be split into individual aircraft, two aircraft in Formation are easier to see than individual aircraft. A Formation will also take up less space than individual aircraft at 1000' - 1500' spacing.

Pairs circuits can be flown in most aircraft, with the onus being put on Lead ensuring the correct spacing, configuration and speed with Wing simply flying the required position. Lead will need to be aware that the circuit size will have to be larger than normal due to the lack of manoeuvrability of the Formation, and the approach will be slightly shallower than normal so the Wingman has a suitable power margin. Should the circuit be too close, tight or high with the approach being too high or fast, then an overshoot will need to be flown.

On aircraft lacking drag devices (retractable gear or flaps), the power margin for the Wingman on base and finals will be quite small. Even with drag devices, the power margin can still be quite small if the Leader is flying a slightly high approach. For this reason, the Wingman must be placed in Echelon on the outside of the base and finals turn. This also gives the Wingman the option of going slightly wide around the turn if they find they're at idle and still overtaking the Leader. The Leader should remember that they cannot at any stage go to idle power, and all power adjustments should be smooth and coordinated, even in turbulent conditions.

Configuring gear and flaps within the circuit should be done at the normal points with the visual signals described in Chapter 15. Once established on finals each pilot should do their own finals checks applicable to their individual aircraft.

Initial & Pitch

Another means of joining the circuit is through an Initial and Pitch (military term). The Initial and Pitch involves the Formation joining a minimum of a 3 mile final and splitting the Formation overhead for individual landings.

The "Initial" point is a point 3 nautical miles from the threshold at 1500' AGL. When giving the inbound call, the Lead would call:

"Viper Formation, joining a 3 nm final for an Initial and Pitch Runway 29".

Depending on the experience of traffic in the circuit, Lead may elect to describe the Initial and Pitch, as an "Overhead Break" or "Upwind Join." The Lead may also specify a Left or Right circuit if there is a non-standard circuit direction at the chosen airfield. Once established at the initial point, the Lead would start a slow descent and configure the Wingman (or Wingmen) in Echelon on the opposite side to the turn into the circuit (i.e. echelon right for a left turn into the circuit).

Depending on traffic, Lead may elect to fly down to 500' above the aerodrome for a climbing break onto downwind. For higher performance aircraft, this is the better option because the climb will help to wash off speed. If there is traffic already established in the circuit, then Lead may elect to descend to 1000' for a level break onto downwind.

At the desired point over the runway (normally middle of the runway), each member breaks out of the Formation at a time interval nominated by the Leader during the Briefing (normally 5 seconds). The Leader initiates the break by waving to the Wingman, and then rolling smartly to about 60° of bank and pitching out of the Formation onto downwind.

Even though the Formation is now split into individual aircraft, they are still acting as a Formation. The Wingman should roll out on downwind behind Lead at 1000' – 1500' spacing and maintain the same spacing all the way down to landing. If the Wingman takes more spacing than other aircraft can get confused as to how many members of the Formation there are.

Pairs Landing

The standard Formation landing is a pairs landing whenever conditions allow, however the same considerations apply to a pairs landing as to a pairs take-off. Runway Width and Runway Length are the two most important considerations. Wind conditions need to also be considered with a maximum crosswind of 10 kts or 2/3rds of the maximum for the aircraft, whichever is less. Even with less than 10 kts crosswind, wind gusts and turbulence should also be considered. Essentially conditions should be good, if not perfect for a pairs landing.

To successfully conduct a pairs landing, each member is required to have a good landing technique as well as a good currency in landings for the aircraft type. This is especially the case for tailwheel aircraft. Because of the handling characteristics of most tailwheel aircraft, a stream landing is recommended for safety reasons, unless both pilots are very competent on the aircraft type.

As the pair turns finals, initially the Lead should line up with the centre of the runway. Lead should position themselves on the exit side of the runway, which may require the Wingman to change Echelon

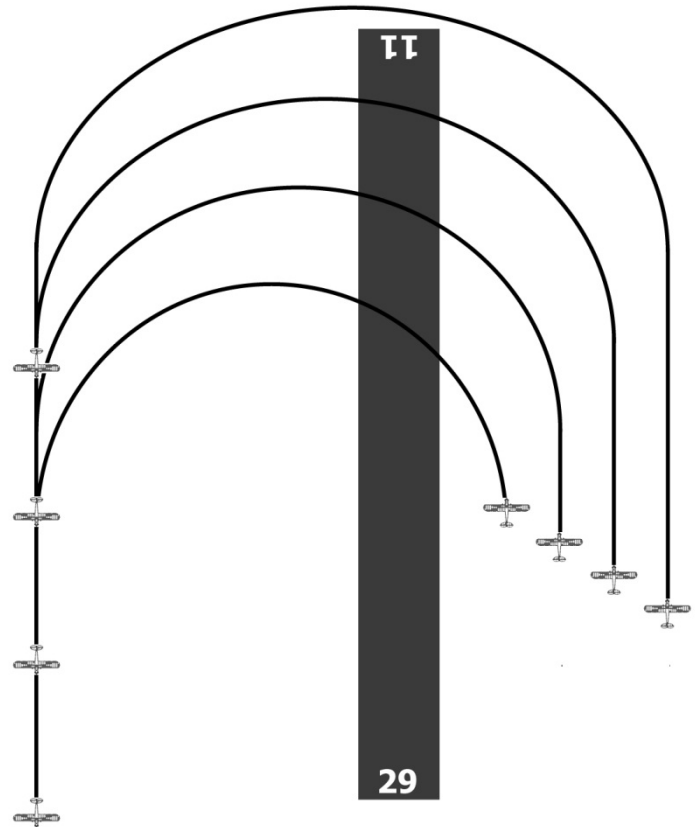


Figure 7.2 – 4-ship Initial & Pitch onto downwind for a Stream Landing

positions on finals. As the Formation gets closer to the runway then each Formation member should line up with the centre of their side of the runway. For the Wingman, this will mean staying on the Echelon line, but moving out on the line to take a slightly wider spacing.



Lead will fly a normal approach to the runway, but should use an aiming point 100 – 200 metres into the runway rather than using the threshold. This will position the Wingman safely over the threshold without landing short of the runway. Lead needs to consider runway length when conducting this approach and landing and needs to also consider that they cannot use Idle power at any stage, otherwise Wing will have no power margin over Lead.

Wing needs to fly their position very accurately on finals as they are limited in lateral movement by the width of the runway, and also limited in vertical movement by terrain clearance. Wing should also be conscious of being stepped-up, especially on short finals, as the extra height will almost certainly result in over taking Lead during the landing. Stepping-up may also create visibility issues.

When on long finals, Wing should concentrate on flying the correct Echelon position, with only occasional glances at the runway to ensure the Lead is correctly lined up. As the Formation gets closer to the runway, the Wingman should now start to dedicate more time to ensuring they are lined up with their side of the runway. As a guide:

Height	Concentrating on Lead	Concentrating on the Runway
> 400'	80%	20%
200' – 400'	50%	50%
50' - 200'	20%	80%
< 50'	5%	95%

As the Formation crosses the end of the runway, the Wingman should now dedicate 95% of their concentration to looking at the end of the runway and landing on their side of the runway. Even when looking at the end of the runway, the Wingman should still be able to see the Leader in their peripheral vision and will be able to detect movements forward or backward.

To assist in creating safe nose tail spacing trend during the landing, Lead should delay their power reduction until they have brought their aircraft back to level in the flare. Wing on the other hand, should close their throttle slightly before Lead, when assured of a safe landing. This will create a trend where the Wingman should start to drop backwards slightly during the flare.

Once both aircraft are on the ground, Lead should check back over their shoulder for the Wingman and ensure that they are falling slowly back, and if so, Lead can start to apply some light braking. If the Wingman is still in the Echelon position, then Lead should delay braking until they see Wing start to drop back. If in doubt, Lead should allow the aircraft to gradually decelerate as they roll through to the end of the runway. From Wings perspective, once they are safely on the ground, a light tap of the brakes will cause them to drop back and signal to Lead that they can start braking.

During the roll out, each Formation member should remain on their side of the runway until at a safe taxi speed. This means Wing will not run into Lead if Lead has to brake suddenly, and it also gives Wing clear runway to go-round if need be.

Stream Landing

Stream Landings are conducted when conditions are not conducive to a pairs landing. Runway width, crosswind, turbulence and differing aircraft types are the big factors affecting the decision to do a stream landing.

For a stream landing, the Wingman should be at a 1000' – 1500' distance from the Leader. This gives adequate manoeuvrability, with minimum chance of encountering wake turbulence from the Lead's aircraft.

The Leader can separate the Wingman from the Formation in a number of ways. The first option is the Initial and Pitch as described above. Secondly, the Wingman can take spacing by splitting the Formation turning base. This is similar to the Pitch as described above, with each aircraft turning base at a pre-briefed time interval. Lastly the Wingman can slide backwards on downwind, base or finals. This is initiated by a hand signal (Chapter 15) from the Lead who fly's at the normal speeds +10 kts till the Wingman has sufficient spacing. Lead can also delay their flap extension to allow Wing to create slightly more drag, and drop back faster. Once the Wingman has sufficient spacing, they match the Leaders speed, turning points and flight path to maintain the distance.

On landing each aircraft should land on the runway centreline. Once Lead has landed, they should not apply any brakes (unless essential for the safety of the aircraft), and should continue to roll through to the end of the runway. They should also move as far over to the exit side of the runway as possible to create a "Hot Lane" for the Wingman. The "Hot Lane" will allow the Wingman opportunity to conduct a go-round if required on the unoccupied half of the runway.

As the Lead gets to the end of the runway, they should vacate onto the last taxiway, or if they need to backtrack, stop on a slight angle at the end of the runway so they can observe the Wingman's roll out. Once the Wingman is under control and at a safe taxi speed, they should vacate the runway at the same taxi-way as the Lead so as to remain together as a Formation. Lead will then give a "Clear of the Runway" call when all Formation members have vacated the runway.

Overshoot / Go-Round

Go-rounds in Formation occur for the same reasons as for single aircraft operations. Lead especially needs to be aware of being too high / fast on a pairs approach and landing, and that they cannot use idle power because of the Wingman. This will most often be the cause of Formation go-round.

To initiate the Formation go-round, Lead smoothly powers up to normal climb power, and gradually raises the nose to begin climbing. Lead may call on the radio that they are going round, but time and radio chatter may not allow this. If Lead initiates a go-round from finals, then Wing should remain with the Leader as a Formation. The exception to this is if during the landing, Lead elects to go-round because of a botched landing, then Wing should remain on the ground if there are no safety issues.

Nothing prohibits Wing from performing a go-round if not happy with the approach (turbulence, speed, approach aspect, etc.) or during the landing. Wing can initiate a modified "break-away" manoeuvre at any time, however they must temper subsequent manoeuvring with the knowledge that they will have a very low situational awareness with respect to other circuit traffic.

Chapter 8 – Briefings & Debriefings

Formation Flight Briefings

The Pre-flight Formation briefing is the responsibility of the Formation Leader, and is one of safety critical items of the flight. All flights must be briefed and debriefed. Initially when you first start flying with regular Wingmen, the briefing will be more formal in nature and conducted sitting in a briefing room or around a table. Once you start to get to know your Wingman, the briefing can take on more of an informal nature as each member knows the standard procedures and what is expected of them. Despite the informal nature of the briefing and the familiarity of operations, every flight must be briefed. The Formation briefing should follow a standard format that can be found in Appendix 1 of this document.



Briefing for a Photo Shoot at the 2006 Red Bull Air Race

ALWAYS BRIEF BEFORE A FORMATION FLIGHT – NO EXCEPTIONS!

Formation Lead

For the Formation Lead, the briefing starts well before the pilots assemble. You must have a full comprehension of what you expect for the flight, including what your objectives are. To achieve this, Formation Leader's should visualize the entire flight from engine start to shut down. Based on the active runway, how will you depart for the operating area? What sequence of manoeuvres or formations will you fly? How is the local weather going to impact the mission, and what precautions can you take? How will you handle a flight member having to leave the Formation, or a radio problem, or a traffic conflict? What will your team expect to see and accomplish during the flight? Continue this process to engine shut down to ensure you know the plan thoroughly – it's your plan and your Wingmen will expect you to have the answers.

Set a professional tone early in your brief and create an environment where the flight members can focus on your plan without undue distractions. Establish early on if want questions raised "on the fly" or held until you call for them at the end of the briefing. While you should be open to suggestions that may help achieve your objectives, be wary of constantly changing or modifying the plan to appease the audience. This generally leads to confusion and poor execution.

Wingmen

It is vital that you're prepared for the Formation briefing and on time. Formation is a skill that requires above average flight discipline from all members and this starts in the briefing. Supplied with these notes are Knee Pad Cards (KPC), and these should be used during the briefing to take notes (also found in Appendix 2). If you have run out of cards, organise more before the briefing starts.

In general, if you have a question, avoid interrupting the briefing and write the question on the KPC and raise the topic when the Lead calls for questions or in the briefing wrap up. It is vital that you never leave the flight briefing with an unanswered question about the day's Formation mission, so when in doubt, ask! Offer assistance to Lead by collecting weather data, airfield information, etc., as formation flying is always a team effort.

Formation Briefing Outline

In the next part we will go through each part of the briefing and discuss the content of each section and what options Lead has. Whilst reading this, have a briefing card handy so you can read through it at

the same time. The briefing card is designed to be filled in by the Formation Lead and used with everyone sitting around the table, or under the Wing of an aircraft. In a military context, this briefing would be put on a white board in the exact layout it is on the sheet, and you may want to consider doing this if you need more space and are leading a larger Formation. You should also have received the briefing cards with this manual otherwise there is a copy of it in Appendix 1.

Formation Call Sign: The Call Sign of the Formation should be something that is easy to remember and understand on the radio. If the aircraft within the Formation are the same type, you may consider something as simple as “Cessna Formation”. You can also get more creative and use “Thunder Formation”, “Zulu Formation”, “Acro Formation” or anything else you can think of.

Time Hack: Brief on time, and develop a discipline in your Wingmen to be ready to brief on time as well. The goal of every Formation flight is the pursuit of flawless execution, and that always begins with the briefing. Introduce yourself and the Formation Call Sign and then establish the time hack immediately. Synchronizing watches is not only important to meet target times like engine start, but in our world the time hack is that singular action that symbolizes it’s time to focus on one thing and one thing only, the executing the Formation plan.

Objective: Establish what the objective of the flight is. The objective sets a clear goal so everyone knows what they’re trying to achieve. This objective can be as simple as practicing 2 ship close Formation flying for a bit of fun, or it could be more complex and involve a Formation flypast at an Airshow or event.

Crews: In this section each of the aircraft Call Signs and crews are listed. Space has been made for up to 4 Formation members, however additional can be added if a larger Formation is flown.

Weather: Give a brief overview of the expected weather including wind, cloud base, and expected turbulence. Use the TAF for the aerodrome if it is available, otherwise the Area Forecast and local observations are fine.

Timings: This part establishes when you want things to occur. Walk refers to the time you want everyone to head out to their aircraft. Normally aircraft should already be pre-flighted and refuelled before the briefing, so you may nominate a time 10 minutes after completion of the briefing that you want everyone out at their aircraft. Most times as a Formation you’ll start engines together on a signal by Lead, however there will be times that aircraft will be located on different parts of the airfield. The Start time you nominate is when you’d expect your Wingmen to be strapped in and ready for your signal to start. Take-off and Landing time works along the same lines as the Start time. If you’re doing a display, or want to be at a certain point at a certain time, you can nominate a time for this. Two points for consideration. First, it will always take slightly longer than you expect to do things, so be generous with your timings. Second, the timings are to be used as a guide by all Formation members. They should not be ignored, but they will not always be achieved.

Radios: In this part, nominate what frequencies you will be using so Wingmen can pre-program their radio’s if possible. For most local operations, you’d commonly operate on just the local CTAF or Area frequency, however you may elect to use “numbers” (123.45) as a chat frequency if you’re going to be doing a lot of talking to the Wingmen. If you have dual radio’s you may want to discuss how you’ll handle the radio’s with the Wingmen. You might want them on the CTAF or Area frequency, or you may want them on numbers, whilst you monitor the CTAF or Area frequency. Commonly you’d keep them on the CTAF or Area frequency with you to help increase their Situational awareness, but this is not a requirement.

Taxi: In this section, discuss how you want the Wingmen to taxi with you to the runway. What spacing should they be at? Which taxi-ways will you take to get to the runway? Where will you be doing run-ups? Do you want them doing run-ups before they begin taxiing?

Line-up: How do you want the Wingmen to line-up with you on the runway? Typically you'd position yourself on the downwind side of the runway, and expect #2 to line-up on the upwind side of the runway. You may want to do something different based on the runway width or the runway surface (being gravel for example).



Take-off: Discuss in this section how you want the Formation to do the take-off. Do you want a pairs take-off, or stream take-off? If there's more than one element, or you're doing a stream take-off, what split do you want between aircraft?

Departure: How will you conduct the departure? Which direction will you turn? What height will you climb too, and at what speed? How do you want your Wingmen to join Formation after take-off? What Formation do you want them to fly initially?

Operating Area: In this section describe the approximate boundaries of the operating area. This will help to give Wingmen a situational awareness as to where they are if they break out of the Formation. You don't have to be extremely accurate, and can simply say "5nm south of Lethbridge"

Airspeeds: Nominate what airspeeds you will be flying during each phase of flight. Even if you fly with the same Wingmen, refresh the speeds you'll be flying so everyone is on the same page. If you're flying with new Wingmen in different aircraft types, you may decide to leave this section blank and fill out the airspeeds after discussion with the Wingmen during the briefing.

Air Exercise: This section forms the main part of the briefing. What do you want to do during the flight? What formations will you want the Wingmen to fly? What operating altitude? Will you do a Lead change, and if so, what do you want the new Lead to do? What will you do for the Formation flypast if you're doing a display? You want to be detailed with this section of the briefing, however you can give a brief outline of what you want to do, and then specify exercises as required. Leaving this section blank or having little information will not help the Wingmen mentally prepare for the flight. Remember, there should never be any surprises in Formation

RTB: RTB is a military acronym for Return to Base. First part of this section is to nominate how long you want to be out in the exercise area, and what time you will start heading home. What route will you take? What runway do you expect to use, and how will you do the circuit join? What Formation will you get the Wingmen to fly?

Landing: Will the landing be a pair or stream landing? Where will you separate the Formation? What time interval do you want on the break? Any other information the Wingmen need to know about operating in the circuit (L / R circuits, local procedures)? What speeds will you be flying for the break and in the circuit?

Emergencies: In this section, you need to refresh everyone on the standard emergency procedures for the Formation. You don't need to necessarily remind people of their individual aircraft procedures such as engine failures, however you want to discuss what you are going to do, and what you expect everyone else to do in the event of formation specific Emergencies. What will you do if anyone experiences radio failures prior to departure, in the area or on the RTB? What is the hand signal for a radio failure? Refresh with the Wingmen the HEFOE signals. What do you want a Wingman to do if they lose visual contact at any stage during the Formation? How do you want to handle a mid-air collision? If desired, you can use this section as an opportunity to ask questions of the Wingmen to check their understanding and their procedures

"Viper 3, what would you do if you had a collision with Viper 1 during the Re-join?"

Other Notes: This is the final part of the Formation Briefing and is where you can make a note of any other things you wish to brief on. If you have new members of the Formation, you may decide to discuss hand signals and radio calls that you will use during the flight.

The Formation briefing card is an important document that also becomes a legal document should the flight proceed. If there is an accident, then CASA or the ATSB may use the briefing card to help determine what happened. The briefing card should be left on the ground and will also be used during the de-brief.

Formation Flight Briefing Advice

- (1) As a Lead, be prepared. Have the briefing card completed before the briefing time.
- (2) Encourage Wingmen to speak up should they have questions.
- (3) Conduct a rank-less briefing. It doesn't matter who's in the Formation, their age, or what experience they have. They are all part of the team, and should behave as such.
- (4) It is your briefing and your flight. Don't let Wingmen try to dictate what you do unless there are safety implications.
- (5) Remember, everyone is there to learn, including Lead.
- (6) Keep the briefing brief and to the point.

De-briefings

Even though the Formation flight is over, the learning hasn't. The de-briefing is as critical as the briefing before the flight as it allows everyone to learn and continually improve as Formation pilots. The de-briefing is always led by the Formation Leader, however everyone has a say during the de-briefing. The de-briefing can be done formally around the table after everyone has secured their aircraft, or it can be done out on the flight line, or more informally over a cold beer. Either way, it is Lead's responsibility to conduct the de-brief.

It is handy to have the Formation briefing card available should it need to be referred to however this is not essential. The de-briefing follows a set format that is easy to remember:

- (1) **Safety** - This is the singular most important aspect of the de-briefing. Were there any safety issues that were identified by any member of the Formation during the flight? These safety issues should be relevant issues such as a bad Re-join procedure, near mid-air collision, loss of visual contact, etc., and not something like a Wingman missing a check in after a frequency change. Safety issues must be discussed, and anyone can raise the issue.

Lead should remember that safety issues, although their responsibility, should be seen as an opportunity to learn, and not a personal attack at the Lead.

- (2) **Briefing** - Was there anything that was missed during the briefing that should have been discussed? Was the flight executed as per the briefing? Did the Wingmen have any questions that they didn't raise during the briefing that maybe they should have?
- (3) **Departure** - How well was the departure conducted? This part covers start-up through to arrival in the operating area. Were correct decisions made by the Formation Leader? Did the Wingmen join Formation in the correct manner? Was the route to the operating area the safest and most efficient?
- (4) **Air Exercise** - Was the air exercise conducted as briefed? Were there any aspects of the flight that did not follow the briefing? How well were the Wingmen doing what was asked of them by the Formation Lead? Were exercises conducted at the correct time, in an appropriate location and at the correct speed?
- (5) **RTB** - How well was the return to base conducted? Was the circuit join conducted well? Did the Lead choose the correct point to split the Formation? Was the type of landing correct for the wind conditions? Did the Wingmen follow Leads instructions?
- (6) **Any other comments?** - At the end of the de-briefing, Lead should open the floor for anyone to make comments and give feedback. How well were the Wingmen maintaining position? Can Lead offer any advice? Was everyone able to see Lead's hand signals and understand radio calls?

The questions posed in each part of this explanation are not exhaustive by any means, and Lead should ask as many questions as necessary to satisfy themselves that each part of the de-brief has been fully de-briefed.

De-brief Advice

- (1) It's your debriefing, so don't let it get out of hand or turn into a slugging match.
- (2) Always conduct a "Rank-less" de-brief. Regardless of experience, everyone within the Formation can always learn something. The goal is to improve future execution, not make ourselves look good or protect an image among peers.
- (3) Involve passengers or other pilots who were on board the aircraft during the flight. They might not be Formation endorsed, but may have seen something that was missed by everyone else.
- (4) Remember, the Formation Leader is not perfect either. Use feedback from your Wingmen to improve how you Lead the next flight.
- (5) Regardless of how well the flight was executed, always finish on a positive note with everyone. Highlight what you were happy with.

Chapter 9 - Ground Operations

In this section we will be discussing the ground operations of a Formation. We will touch briefly on the radio procedures and visual signals, however these are explained in greater detail in later chapters.

A Formation is always most visible when on the ground, and even though we are participating for our own enjoyment, the Formation will always attract attention from onlookers. Because of this we want to operate in a way that makes the whole Formation look and sound professional rather than a gaggle of aircraft going for a fly. As a general rule, Wingmen should try and match the Leader with aircraft configuration and procedures.

If you ever get a chance to watch the Royal Australian Air Force "Roulette's" you'll see that they open and close canopies at the same time. Everything is done as a Formation team. The US Navy Blue Angels even march out to the aircraft in unison. This is getting a bit over the top for a civilian Formation, but you get the idea.



Formation Engine Start

Prior to a Formation exercise, each Formation member should pre-flight, refuel and taxi their aircraft to the same starting point on the aerodrome. This ensures that everyone can start together.

Once the briefing has been completed, Lead may elect to give the Wingmen a few minutes to have a cool drink, and prepare for the flight. Lead may elect not to nominate a start time, and everyone walks out to their aircraft together. If a start time has been nominated, then Lead should expect everyone to be strapped in and ready to go by that time.

After getting strapped in and completing all necessary cockpit administration, each pilot should begin their start checks, including turning on masters and priming the engine, until all they have left to do is hit the starter. At this point they should look to Lead, and give a thumbs up in a position that Lead can see it (normally over the dash board) to signal that they are ready to start. In the event that not all Wingmen can see the Lead, then each Wingman should look to the Wingman on the outside of them, and "pass" along the thumbs up. I.e. #3 should give a thumbs up when #4 gives a thumbs up. #2 should give a thumbs up when he sees #3 give a thumbs up.

Once Lead is happy that all Wingmen are ready to start together, then he / she should give the start signal which involves holding their forefinger up and twirl it in a circle (see Chapter 15). This signal is the same as a "wrap it up" signal that you may sometimes see.

Each member of the Formation then start's their engine and runs through their normal after start checks. Once happy they have sufficient temperatures in the engine, the Wingmen give a thumbs up signalling that they are ready to start in the same manner as described above.

Before taxiing out to the runway Lead should do a radio check will all Formation members on the frequency designated during the briefing.

"Dragon Formation, Check-In"

"Two"

"Three"

"Four"



Taxi Spacing for a pair of Super Decathlons – two to three fuselage lengths

Formation Taxiing

As Lead begins to taxi out, each Wingman should follow in the correct order. Taxi spacing should be close enough so that it is obvious that the aircraft are a Formation, however not so close that a collision could occur should Lead have to stop for some reason. Typical taxi spacing would be around two to three fuselage lengths, however Wingmen should take more spacing if forward visibility is an issue (i.e. tail-draggers).

If Lead has nominated during the briefing that the run-ups will be done at the end of the runway, then they should aim to stop on the taxiway at a

minimum of a 45° angle so they direct their slipstream away from the Wingmen. Lead should be conscious as to the manoeuvrability of the other aircraft in Formation, and try not to park at an angle or in a position that the Wingman may have trouble taxiing away from. Each Wingman should try to park as close as comfortable and at the same angle as the Lead.

Individual run-ups and pre-take-off checks are done at this stage, with the Wingmen giving a thumbs up when ready to go. Once Lead is happy that everyone is ready, they give the appropriate radio calls, and depart the airfield as briefed.

After Landing and Shutdown

After landing, each Formation member should taxi clear of the runway and perform their after landing checks. If the airfield has a taxi-way running parallel to the runway, then the Wingmen should vacate the runway at the same taxiway as the Leader and follow them back to parking. If a runway back-track is required, generally the last member of the Formation would Lead the Formation back to the parking area, and this should be briefed beforehand by Lead. Either way, once Lead is satisfied that the runway is clear, then they should give the normal clear of the runway call on behalf of the Formation.

Once in the parking area, each of the Wingmen should do their shutdown checks to the stage where they are ready to pull the mixture to idle, or turn the magneto's off. They should then look to Lead for the shutdown signal. When ready, each Wingman should put their hand held palm open vertically at the top of the canopy, or over the dash board where Lead can see. Lead will do the same and when they can see everyone is ready, Lead will take their hand out of sight and shut down the engine. Wingmen should do the same when they see Leads hand disappear, and all aircraft should shut down at the same time. Now it is time for the debrief and a cold drink.

Chapter 10 – Leading a Formation

Good Formation leadership is something of an art that can only be perfected with experience. For this reason, the Formation Leader should be the most experienced Formation pilot within the team, the exception being during training and practice exercises. As a Formation Leader, like your Wingmen, you will be in a continual learning process. When you do fly as a Wingman, observe your Formation Lead, and attempt to identify and adopt their successful attributes. Often with an experience Formation Lead, these attributes will be subtle, and it will be the small things they do that make a Wingman's life easier. No matter what our experience we all observe and learn things that can improve our performance.

A good Formation Leader is more than just a good "stick and rudder" guy (or girl). A good Leader is one who is conscious of each individual Wingman's experience and abilities, is disciplined in their approach to Formation flying, and is one who has the trust of his or her Wingmen.

To gain trust, the Formation Lead should set the tone early in the flight as to the standards and discipline they expect, with the obvious starting point being the briefing. Be prepared, understand the objectives of the flight, and know how you're going to execute it. Consider also the backgrounds and "standardisation" of the team as a whole. Do not spend time briefing standard numbers, signals or procedures if all the participants have good Formation currency, and a common training background.

Be clear and concise throughout the brief and ask for questions at appropriate junctures throughout the briefing. If there is a digression in the brief simply cease it if it is not relevant to the flight (and discuss it during the de-brief if appropriate) or confirm understanding and achieve common ground, then re-brief the relevant area to confirm the specific details as decided.

During the flight, work hard to be "ahead of the aircraft" and anticipate flight path and speed / power changes. Continually plan what you're going to do and when you're going to do it, and remember that as a Formation Lead, you're now as manoeuvrable as a Commercial Airliner. Plan how you're going to join the circuit, where you're going to turn, and how you want to split the Formation. You may have traffic and weather to deal with, so your original plan may need to be changed.

It is ok to change the flight plan from what you briefed the Wingmen, so long as you keep your Wingmen informed. Each Wingman is expected to acknowledge the new plan.



"Gazelle Formation, change of plans. We'll be changing to a stream landing, 5 second split turning base"

"Two"

"Three"

"Four"

In-flight, be smooth and positive with your control inputs. Strive to be the most stable you can be for your Wingmen, but without over controlling. Ensure changes in pitch and roll are smooth but positive. Maintain a very diligent lookout; the Formation Lead is the eyes and ears of the Formation. As Lead, your contract is to manage the flight path and parameters of the element. Be disciplined to be at the heights and speeds you brief.

While you should always strive to consider the Wingman as much as possible, this should not be to the detriment of positioning the Formation, exceeding operating limitations or not flying your preferred flight path. Lead's job is always to Lead the Formation. If Wing cannot maintain position, then they should either drop back slightly and then catch up when possible, or break out of the Formation. The De-brief can be used to establish how Wing became out of position, and a possible solution.



It is Lead's responsibility to conduct the de-brief. Wingmen will appreciate honest feedback on how they can improve their flying, just as Lead should be open to improving their leading skills. Lead must maintain control of the debrief process, and make sure that others inputs are gained and acknowledged, but the Formation Lead is responsible for keeping it on the rails.

A good Formation Leader is prepared, on time, assertive, calm, smooth and positive. A good Formation Lead has a very good understanding of their aircraft and Wingman's abilities as well as the Formation standards. A good Formation Lead clarifies and simplifies (vice confusing and complicating).

Chapter 11 – Formation Contracts

Lead – Lead

As you've probably gathered by now, the Formation Leader is responsible for much more than just flying in a straight line. In the author's opinion, Leading is harder than flying as a Wingman as it involves more thinking and planning.

At the core of responsibilities, the Formation Leader is responsible for Flight Path, Navigation and above all, Safety of the entire Formation. At its most basic, this is ensuring terrain avoidance, and that all members of the Formation remain clear of other aircraft. It generally includes however, complying with all rules and procedures, airspace adherence, radio calls, fuel management and in-flight aircraft operating limitations.

Leader's contract therefore is to Lead the Formation, regardless of what Wingmen are doing around them. If two of your Wingmen have a mid-air collision, you must leave them to handle their situation on their own. You have a responsibility to Lead any other members of the Formation back to base and ensure they land safely.

Wing – Be There!

This simple statement doesn't necessarily mean to maintain Formation position at all costs; rather, "Being there" actually involves completing the following tasks in priority order:

- (1) *Fly the aircraft*
- (2) *Maintain collision avoidance*
- (3) *Remain visual with Lead*
- (4) *Maintain correct Formation position*
- (5) *.... Other tasks*

At first glance, this short priority list looks to be stating the "bleeding obvious" and for normal operations it is, however when things start going wrong, it is a powerful mental model to have in mind. The idea of a priority list is to "shed tasks" from the bottom up.

The highest priority for the Wingman is for them to fly the aircraft. Formation flying is an optional activity, and if there are any issues with controllability or aircraft system, the Wingman should depart the Formation and concentrate on managing the problem. Flying the aircraft also encompasses making sure that you have sufficient airspeed and height. Even though these are Lead's responsibility, if you are flying different aircraft types, you must make sure you're not in a position where you are stalling whilst in Formation. If this is the case, break out of the Formation and fly the aircraft.



Second on the list is to maintain collision avoidance with Lead and other Formation members. In an Element, #2 avoids #1 whereas in a Formation of 4 aircraft #4 avoids hitting #3, #2 and #1, #3 avoids #2 and #1, and #2 avoids #1. You as a Wingman have a contract not to hit other aircraft. If you have broken out of Formation, it is your responsibility to maintain an altitude separation from Lead and the rest of the Formation to ensure you don't collide

Thirdly, if you can maintain collision avoidance, you must then ensure you keep Lead visual. Lead is concentrating on managing the Formation and will not be necessarily looking out for the Wingmen.

Fourth, if you can keep visual, maintain the correct Formation position. Sometimes in turbulence this may not be possible. It is advisable for a Wingman who is struggling to maintain position either because of conditions or because Lead is manoeuvring, to move out of Formation slightly and maintain a position where they are still visual with Lead, but not necessarily in the correct position.

The lowest priority for the Wingman is any other tasks that they have to do. For example, radio frequency changes, switching on lights, programming a GPS, etc. If Lead is manoeuvring hard, it may be taking all of the Wingman's capacity to maintain position. That is not the time to be programming a GPS to warn Lead of airspace 5 miles ahead.

The point is that "Being there" doesn't mean clenching the teeth and staying in close when things are going wrong. On the other hand, if conditions are such that the exact Formation position can't be safely maintained (turbulence or Wingman skill) the Wingman is not to "give-up". Instead, ease out of position slightly, stabilise (relax), maintaining collision avoidance and then move back into position when conditions allow.

Human Factors / Crew Resource Management

The members of a Formation can be considered a "crew" in the "multi-crew" cockpit sense, with #1 as the captain. It can therefore be seen that Crew Resource Management and other similar human factor issues and techniques are applicable to Formation flying. Like any good co-pilot, the Wingmen should seek to "back-up" their Formation Lead without interfering or (particularly in formations) talking too much. While it is hard to articulate the appropriate balance, the extremes of the spectrum can be easily imagined. On the one hand there is the old school military view that the Wingman should not say anything on the radio except "2" and "Lead you're on fire". At the other extreme is the Wingman that is constantly on the radio querying every decision and offering unsolicited advice (or noting every minor flight deviation). The balance clearly lies somewhere in the middle. A good strategy or guide for the Wingman to begin with is to speak up only when there is misunderstanding or a significant degradation in the safety of the Formation. Minor and non-flight critical observations, misunderstandings or confusion can be left until the debrief.

Examples of this principle might include a scenario where the Wingman notes that the Formation is pointing at an airspace boundary 3 miles away at the commencement of a straight re-join. If it is a "soft" boundary (edge of the training area) then nothing might be said. If it was a "hard" boundary (active controlled airspace) the Wingman would speak up. Another example might be that if Lead was over transmitted by another aircraft as the Formation was safely outbound from the airfield and switching to the area frequency, the Wingman may say nothing and just switch the new frequency. On the other hand in the situation where there was some over transmitting or some confusion in the Wingman's mind about whether the Formation had been cleared to take-off by Air Traffic Control as Lead gave the run-up signal they should query Lead.

"Zulu 1, confirm we're cleared for take-off?"

While not exhaustive, these examples are perhaps indicative of the balancing act the Wingman needs to adopt to support their Lead.

Chapter 12 – Larger Formations

Formations of any number of aircraft are possible once the basic Echelon and Line astern positions are mastered. At events like Oshkosh Airshow in the United States, it is not uncommon to see formations of 40+ aircraft. In this section, we will discuss some of the common 3 and 4 ship formations that are used.

At the basic level, Larger formations are just combinations of 2 ship elements. #1 in most cases will be the most experienced Formation pilot, with #2 being their Wingman. In the second element, #3 is normally the second most experienced Formation pilot and is also known as the deputy Lead, with #4 being their Wingman. #2 and #4 will generally be the least experienced Formation pilots.



Lead considerations

As you should have already gathered by now, for a Formation exercise to be successful, Lead must plan ahead and be thinking well in front of the aircraft. This is no different with leading a larger Formation, however Lead should keep in mind that Formation changes will now take longer to occur than a simple 2 ship element.

As part of the planning process for the flight, you should be thinking about each member's experience, and how they will best fit into the Formation. Leading a second element (i.e. #3), should be an experienced Formation pilot who can also be responsible for a Wingman (#4). #3 has more responsibility than the other Wingmen, as they are the deputy Lead and responsible for ensuring a safe re-join of their element, as well as assuming the Formation Lead should #1 have any problems.



A Larger formation of Boeing Stearman's, complete with wing walkers!

Manoeuvrability in larger formations is also reduced, especially if you have 2 or 3 Wingmen on the same side. If you have more than 2 Wingmen in echelon on the same side, try to plan your turns to all be away from the Wingmen. For the Wingmen, especially those on the outside of the Formation increasing power and climbing on the outside of a turn is easier than reducing power and descending. When the Formation is slower than normal cruise (i.e. manoeuvring in the circuit), turning towards the Wingmen can result in #4 having to reduce power to idle to maintain position.

As formations become larger than 4 aircraft, manoeuvrability is severely limited, and Lead must limit their turns to 15° of bank. If the Formation is such that 10+ aircraft are involved for a flypast or other event, Lead would consider keeping separate elements, or 4-ship sections, until established 5 miles from the fly over point. At this stage they would assume straight and level, and allow all the elements or formations to assume their

position. Lead would not manoeuvre, maintain straight and level, and after the flypast coordinate the break-off of individual elements or sections. In the Royal Australian Air Force, special permission is required for formations of greater than 4 aircraft. Larger formations are no more dangerous, but you must have a very experienced Lead to ensure safe execution.

Wingman considerations

Wingmen, when participating in larger formations, need to keep in mind that they will have other Wingmen around them that they need to be conscious of. In a 2-ship Formation, if turbulence moves the Wingman out of position, it is easy to take some spacing, settle the aircraft and then move back into position in your own time. This becomes more challenging when there is another Wingman looking at your aircraft to maintain position. Should a Wingman need to break out of Formation, the only option is to go up or down, rather than take lateral spacing.

Banana the Formation

In situations where a Formation of 3 or 4 aircraft are in Echelon, #2 in the Formation should fly slightly low (only 3 – 4 feet lower) in the normal echelon position to allow the other Wingmen to see any visual signals from Lead. This is known as bananaring the Formation (Figure 12.1).

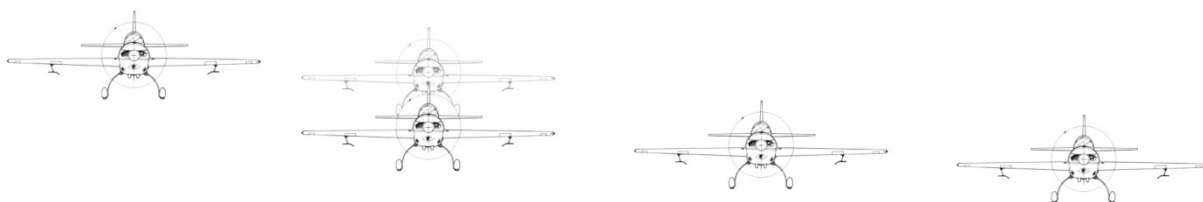


Figure 12.1 – By #2 stepping down slightly, #3 and #4 can now see any visual signals from the Leader

Echelon Formation

Echelon Formation can be flown as an Echelon Left or Echelon Right. Unless briefed otherwise by Lead the Formation would normally be positioned according to position numbers #1 - #4. Each Wingman should fly the normal Echelon position on the aircraft inside of them with the exception of #2 who positions slightly low. (Figure 12.2 and 12.3)

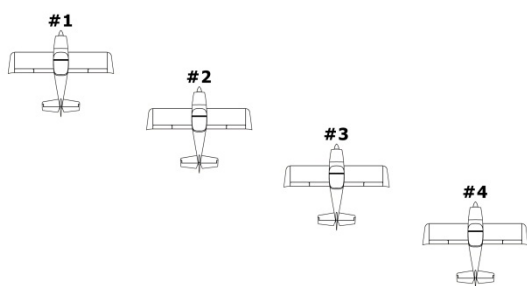


Figure 12.2 – 4-ship Echelon Right

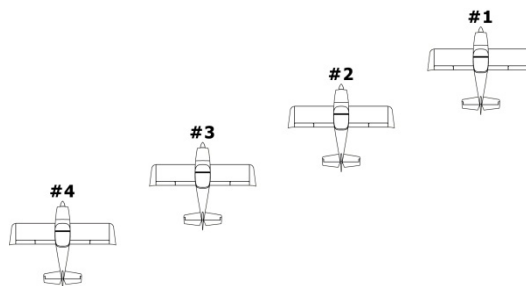


Figure 12.3 – 4-ship Echelon Left

Line-Astern Formation

Line-Astern, like Echelon is normally flown with each Wingman in a position corresponding to their numbers (#1 - #4). If required, this can be modified by the Formation Leader. (Figure 12.4)

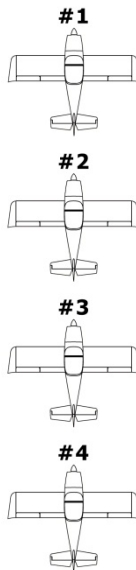


Figure 12.4 – 4-ship Line Astern

Vic Formation

Vic Formation is a standard 3 ship Formation, with a Wingman on either side of the Leader. The standard Formation is for #2 to be in Echelon Right, with #3 in Echelon Left. (Figure 12.5)

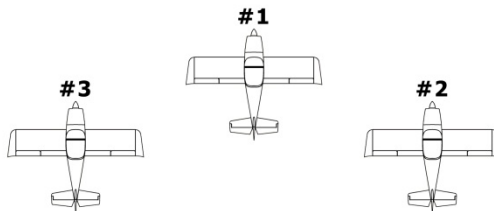


Figure 12.5 – 3-ship Vic Formation

Finger 4 Formation

Finger 4 Formation gets its name from the position of your fingertips on your left or right hand. Left-hand Finger 4 is the standard Formation, however Right-Hand Finger 4 can be flown at the discretion of Lead. If you hold your left hand, palm down, you'll see that the Lead is your middle finger, #2 is your index finger, #3 is ring finger, and #4 as your pinkie finger. (Figure 12.6 and 12.7)

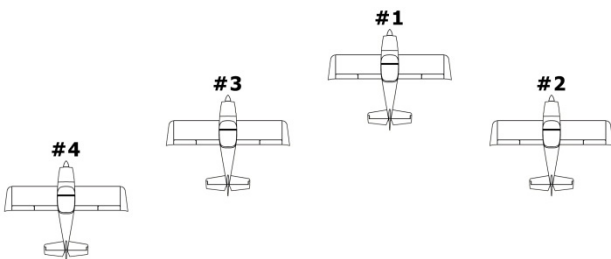


Figure 12.6 – 4-ship Left Hand Finger 4

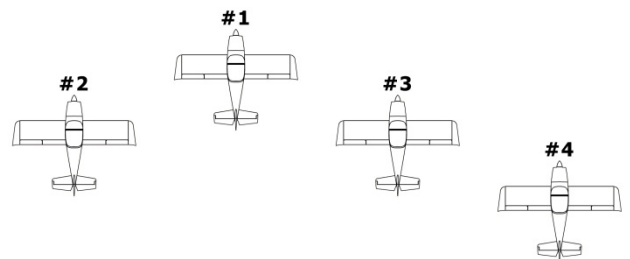


Figure 12.7 – 4-ship Right Hand Finger 4

Box Formation

Box Formation, is a Vic Formation with #4 in the Line Astern Position on Lead. (Figure 12.8)

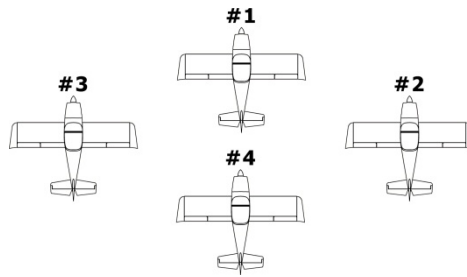
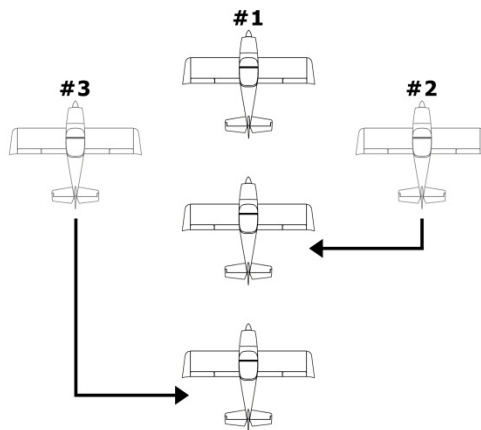


Figure 12.8 – 4-ship Box Formation

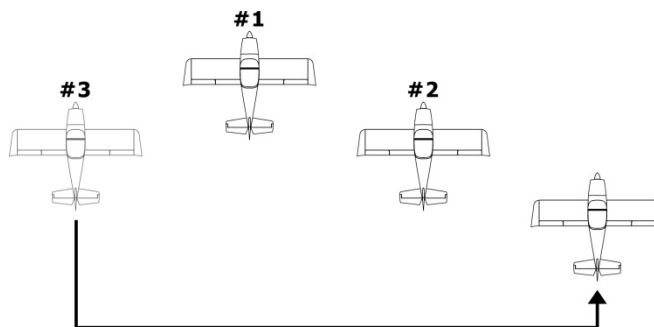
Changing between formations

When changing between Formations, Lead needs to be conscious of how Wingmen are going to move around each other. For example moving Wingmen from a Left-hand Finger 4 to a Right-hand Finger 4 would result in Wingmen having to still fly Formation, and try and avoid hitting each other as they cross behind. A smarter way of changing between these Formations is to get the Formation into Line Astern, and once stable in line astern, then move into a Right-hand Finger 4. Below are some other idea's.

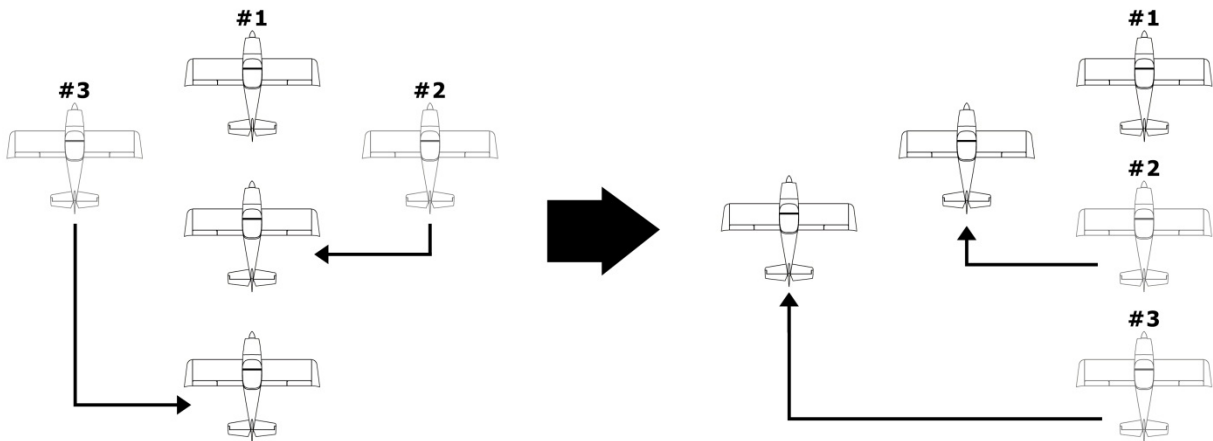
Vic to Line Astern



Vic to Echelon Right

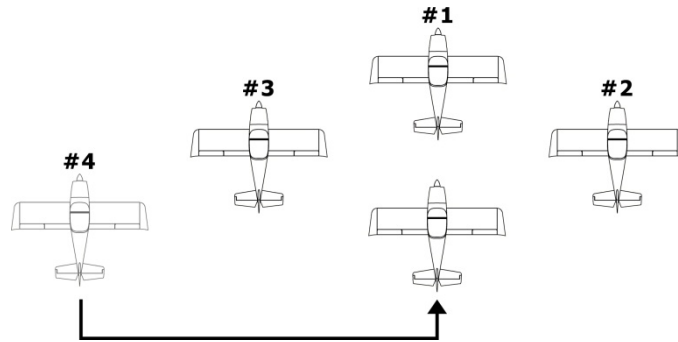


Vic to Echelon Left

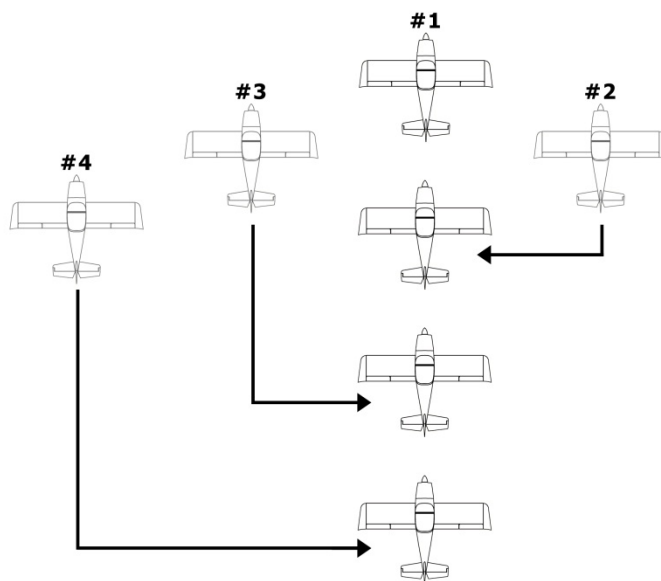


First configure Vic to Line Astern, then Line Astern to Echelon Left

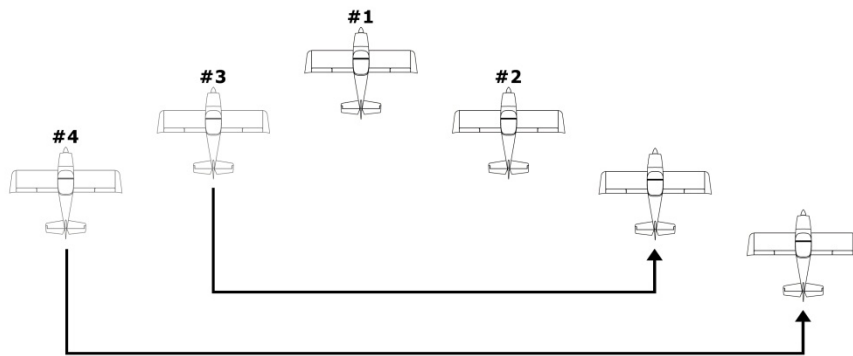
Left-hand Finger 4 to Box



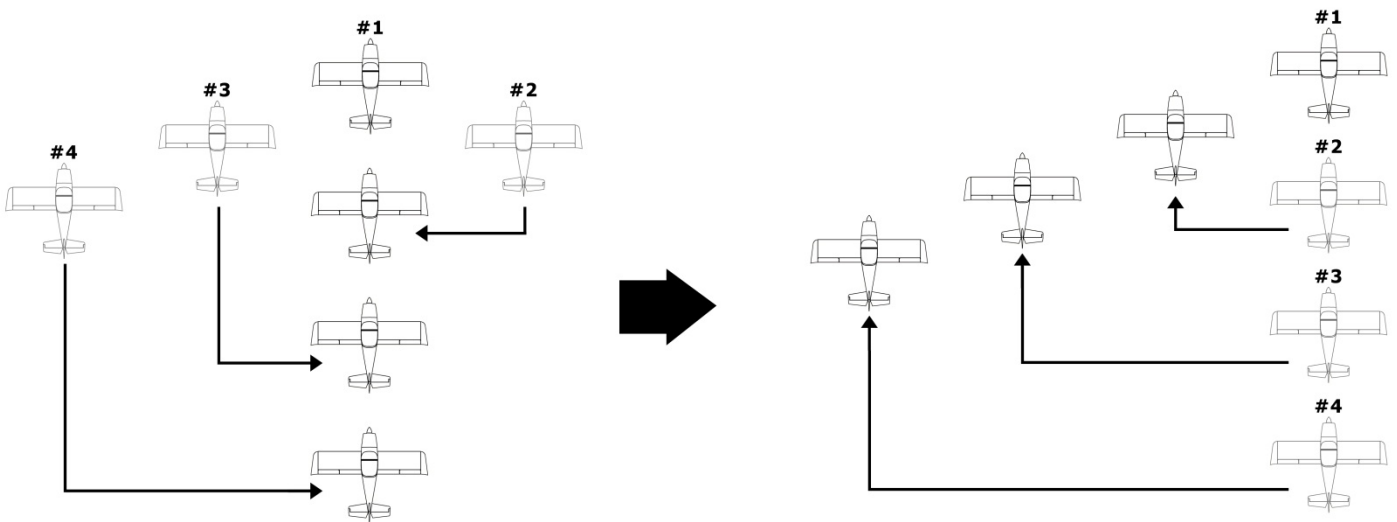
Left-hand Finger 4 to Line Astern



Left-hand Finger 4 to Echelon Right

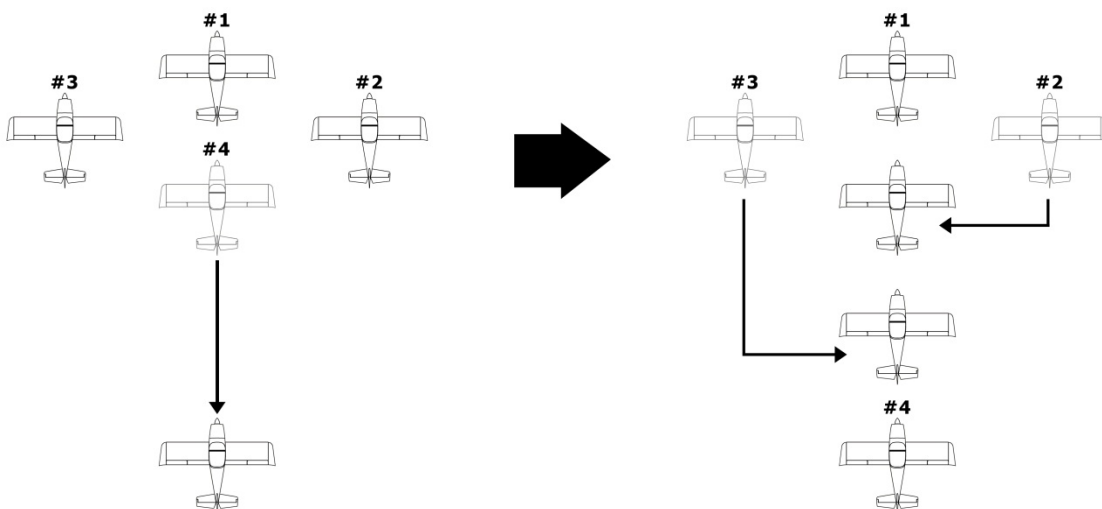


Left-hand Finger 4 to Echelon Left



First configure LH Finger 4 to Line Astern, then Line Astern to Echelon Left

Box to Line Astern



When the call to Line Astern is made, #4 reduces power, drops back and calls “#4’s clear”. On hearing the call from #4, #2 and #3 can move into position

Chapter 13 – Abnormal Situations

General Abnormal Situation Considerations

All the abnormal situations that can occur to a single aircraft can occur to aircraft in Formation. If handled well, being in Formation can provide the aircraft with the abnormal situation mutual support and greatly ease the workload of the incident pilot or crew. If handled badly, being in Formation can exacerbate an abnormal situation with additional tasks and coordination etc.

The first step is to ensure collision avoidance. Immediately after the occurrence (irrespective of which aircraft has the abnormal situation) the Wingman must maintain collision avoidance. Once the abnormal situation is identified a decision must be made as to whether it would be better to be on the Wing or in the Lead (in order for Wing to divulge the collision avoidance responsibility). In most cases (especially for engine / airframe issues) the Wingman will want to request the Lead before “working the problem”. In some cases it may be better for the emergency aircraft to be on the Wing (typically minor avionics / navigation instrument issues).

Once the aircraft with the abnormal situation has the Lead, the supporting Wingman should fly a loose Formation as the new Lead may need to make significant power or configuration changes. The supporting Wingman should also remain in the same configuration as the new Lead. If the emergency aircraft has to lower the undercarriage or deployed flaps it is best for the supporting Wingman to do the same in order to stay in a similar power and drag condition.

Even though the emergency aircraft may have the Lead for collision avoidance purposes it may be required that the supporting Wingman makes the appropriate radio calls or fulfils the navigation monitoring tasks.

“Melbourne Centre, Red Dragon Formation. Dragon 2 has suffered a partial engine failure. Dragon Formation is overhead Geelong 3000ft tracking direct to Lethbridge, on descent, request flight following”

“Dragon 2, if able come right 30 degrees for Lethbridge, we’ll have to start descent in 5 miles”

In some cases it may be better for the aircraft with the abnormal situation to be on the Wing (typically minor avionics or navigation instrument issues). For example if #1’s avionics failed completely they may communicate this by use of a hand signal to their Wingman. #1 would then maintain their heading for a period and “work the problem” while they have the Lead and therefore no collision avoidance responsibilities. Once #1 has attempted to fix the problem and been unable to rectify the problem, they may then direct #2 to take the Lead for the remainder of the flight.

In some cases the abnormal situation may be significant and time critical. In these cases the aircraft may have to “break-out” of the Formation in a clear direction and track as required conducting actions as required. The other Formation member may be simply fly “chase” and assist where possible. For example, if the Wingman has an electrical fire and/or significant smoke in the cockpit then they will not be in a position to fly Formation nor make any radio calls. In this case Lead would simply take up a loose Formation and follow the Wingman passing ‘advisory’ calls to ATC.

“Arrow 2 has a serious electrical problem and is trailing smoke; we’re turning left on to an Easterly heading and descending through 2500ft; standby for further”

“It appears as if Arrow 2 is tracking for Barwon Heads for an emergency landing; Arrow Formation is on descent through 1500ft, switching Barwon Heads CTAF, call on the ground or by time 25”.

As can be envisaged from this brief discussion, there are almost an infinite combinations of emergencies and scenarios that could occur. Some of the worst and more likely can be identified and prepared for (“What if ...?”). The general principles of ensuring collision avoidance, establishing who is best

to Lead and who to be on the Wing, and being clear about who is to do what tasks should be considered during an abnormal situation in Formation.

There are two emergencies that have unique Formation considerations; aborts on the runway and inter-formation collisions. The take-off abort scenario has previously been discussed in the section on take-offs and landings (no sympathetic aborts).

Airborne Collision

First and foremost, an airborne collision should never happen as Wing should always maintain visual with Lead. Wing must always maintain a safe spacing that is appropriate for the conditions, and always maintain height separation when doing Re-joins.

A “touch” or collision in close Formation however is likely quite survivable. There is likely to be some sort of airframe damage but generally this will be minimal if the Wingman has not been dynamically manoeuvring around Leads aircraft.

Should this ever occur, then the following procedure should be followed.

- (1) *Separate aircraft* - The incident aircraft are to “breakaway” into clear airspace. No further attempt to maintain or re-establish close Formation should be made as the Formation flight for the aircraft involved is now over. If visual is going to be lost during the breakaway, then separate altitudes should be nominated to ensure a safe de-confliction
- (2) *Assess handling / controllability* - Each aircraft involved should conduct individual assessment of handling and flying qualities. A decision to do an immediate forced landing may have to be made.
- (3) *Coordinate RTB* - The aircraft involved in the collision should be careful to coordinate their RTB's to make sure they remain de-conflicted. In most instances the most damaged aircraft should land first, however if there is only one runway, this could create issues with blocking the runway. A decision may be made for the least damaged aircraft to land first, or the least damaged aircraft (and any others) land at another airfield.

If as part of a larger Formation, then the other Formation members should remain together as a Formation and provide mutual support to the aircraft involved in the “touch”. The other Formation members may have to coordinate who is leading back if the Formation Lead has been involved. These other members, should maintain an appropriate separation from the aircraft involved in the “touch” as they may need to manoeuvre randomly if situations dictate.

Radio Failures

The Formation Lead should, during the briefing, explain the procedure they want followed in the event of a radio failure on the ground or in the air. On the ground, if a Wingman has a radio failure, Lead may still continue to do the flight and use visual signals. For Lead, if they have a radio failure on the ground, then they are best to cancel the whole Formation flight as briefed, and allow the Wingmen to re-brief if they elect to go flying.

For Lead, a radio failure in the air can be handled in one of two ways. If operating as a 2 ship element, the easiest option would be for the Formation Leader to relinquish the lead to the Wingman and have them lead the Formation home. In larger formations however, this becomes more of a problem as which Wingman position does Lead fly? If leading a larger Formation, it may be easier to remain as Lead, and have your deputy Lead (#3) make the required radio calls.

HEFOE Signals

If you experience a radio failure AND another malfunction, you can communicate it to your Lead (or Wingmen if leading) through using the HEFOE signal. HEFOE stands for:

- (1) Hydraulic
- (2) Electrical
- (3) Fuel
- (4) Oxygen
- (5) Engine

The HEFOE signal is given in two separate steps. After getting Lead’s attention with a Wing rock, you hold your hand in a fist with the top of your hand touching your forehead. Then, you hold up the number of fingers corresponding to your problem.

Lost visual procedures

If the Wingman loses visual with the Formation Lead at any stage during the flight, it is Wing’s responsibility to maintain a safe separation and minimize any collision hazard. The following procedure should be used:

- (1) *Ensure safe separation* – the safest way to ensure separation is attain at least 500’ altitude difference above or below Lead. In a two ship Formation, this can be combined with a turn away at the same time, however in larger formations the Wingman must go up or down first, before turning.
- (2) *Call on the radio* – Once you’ve assured that safe separation from Lead has been attained, then call on the radio that you’ve lost visual. This will allow Lead to also keep their eyes out and although you may not be able to see them, they may be able to see you and can help assure safe separation

“Dragon 2 lost visual, breaking right descending to 2500 feet”

- (3) *Lead Coordinate Re-join* – From this point Lead should coordinate the Wingman’s Re-join back into the Formation. If Lead cannot see the Wingman, then they can specify an altitude for the Wingman to maintain and a position to track over until both Wing and Lead are visual with each other.

“Dragon 2, negative visual, maintain 2500 feet and track overhead Lethbridge until you have us visual. We will maintain 3000 feet”

Bird strike

Care must be taken not to cause a mid-air collision whilst attempting to avoid an imminent bird strike. If a bird strike does occur, gain separation from the rest of the Formation before handling the emergency. The safest option is to conduct the same procedure as a mid-air collision with the affected aircraft(s) leaving the Formation for individual landings.

Knock-It-Off

There may be times during Formation flights, especially when practicing manoeuvring in Formation when the Leader or Wingman may identify potential safety issues. The term “Knock-It-Off” can be used by any member of the Formation to direct all aircraft to cease manoeuvring and is used when a safety issues is identified.

Following a “Knock-It-Off” call, the Formation should return to Straight and Level, and any Wingmen conducting Re-joins or dynamic manoeuvring should stabilise their aircraft in the position where they are (unless safety is an issue), and proceed as directed by Lead. A “Knock-It-Off” call may be made if the following situations occur:

- A dangerous situation is developing
- Loss of situational awareness that can't be regained
- Violation of briefed area boundaries, or flight through minimum altitudes has or is about to occur
- Non-briefed or non-participating aircraft enters the area and is a potential hazard to the flight
- Exceeding briefed flight parameters or briefed manoeuvres

This list is not exhaustive, and essentially the main parameter is safety.

Chapter 14 – Radio Procedures

As a Formation, all members should be familiar with the radio procedures, and what is expected of them. Most of the time, Wingmen will simply need to acknowledge Lead's radio calls. Poor radio discipline often results in frustration and a poor showing for the flight. Likewise, excellent radio procedures are often the trademark of skilled Formation pilots.

Each of the flight members are identified by a unique call sign that also identifies their position in the Formation (Raven 1 = Lead, Raven 2 = Wingman). Even when the Lead calls for a Formation change or relinquishes Lead to a Wingman, each member retains their original Formation number. This avoids confusion as to who is who.

Use of Full Call Sign in Formation

Full call signs should be used by the Lead whenever they are directing a specific flight member to take a specific action. If there is another Formation flight on the same frequency, then the use of the full call sign will improve changes that the proper Wingman will respond.

"Vampire 2, Line Astern, Go"

The Wingman should then acknowledge with their full call sign.

"Vampire 2"

If the Lead is talking to the whole Formation and providing information or checking in on a new frequency, then the Wingmen can simply use their number as opposed to the full call sign.

"Vampire Formation, we'll be doing a downwind join, runway 29, 10 second split between elements for a pairs landing"

To which the Wingmen would be expected to respond:

"Two"

"Three"

"Four"

Another way for the Wingman to think of it, is if Lead uses your individual call sign, then you should use it to respond. If you are acknowledging a call, or checking in then your number is all that is required.

Furthermore, announcing your independent actions at all time, use your full call sign:

"Vampire 3, lost visual, breaking right, climbing to 3000'

Frequency Change & Check-In procedures

To initiate radio frequency changes, Lead uses the term "Push" to tell the Wingmen to change onto a new frequency. The term "Push" comes from Military flying and originated from the design of radio's in military aircraft.

Lead should always brief the radio frequencies that they will be using during the flight, so there is minimal chance of confusion with the Wingmen. When Lead wishes to change the radio frequencies, the following call should be made:

“Jabiru Formation, Push 123.45”

The Wingmen are not required to acknowledge this call, and simply change onto the new frequency. As the Wingman's attention will be divided between the radios and flying the correct position, they may consider moving out slightly whilst changing frequency. If the Wingman has a digital radio with a stand-by frequency, they should set the next frequency before they leave the ground.

Once a sufficient timespan has elapsed (10 – 15 seconds) Lead should check in the Formation on the new frequency.

“Jabiru Formation, Check-In”

“Two”

“Three”

“Four”

If a Wingman misses a check-in, then Lead should wait a few seconds, and then call the Wingman directly.

“Jabiru 3, Check-In”

“Three”

If the Wingman still doesn't respond to Lead's calls, then Lead may have to go back to the previous frequency and see if they can contact the Wingman who may have missed the frequency change. If this doesn't work, then Hand signals may be used to direct the Wingman onto the correct frequency.

Knock-It-Off

Whenever a “Knock-It-Off” call is made by any member of the Formation, all Wingmen are expected to acknowledge the call. The call begins with the Formation call-sign, contains the phrase “Knock-It-Off” and finished with a brief description of the reason for the call.

“Pioneer Formation, Knock-It-Off, Traffic 2 o'clock ½ a mile”

“Pioneer One, Knock-It-Off”

“Pioneer Two, Knock-It-Off”

“Pioneer Three, Knock-It-Off”

“Pioneer Four, Knock-It-Off”

Standard Formation Radio Call's

A lot of civilian aircraft only have one radio. In these cases, radio calls are best kept to a minimum at a busy airfield like Lethbridge. This table of radio calls is representative of a Formation operating at Lethbridge and whose aircraft have only one radio.

Reason for radio call	Lead (Vampire 1)	Wingman (Vampire 2)
Initial Check in prior to Taxi (on CTAF frequency)	“Vampire Formation, Check-In”	“Two”
During taxi give a Formation taxiing radio call	“Traffic Lethbridge, Vampire Formation is taxiing runway 36 for a local flight, Lethbridge”	
Departure Call	“Traffic Lethbridge, Vampire Formation is lining up and departing runway 36 for a local flight, Lethbridge”	
Switching to Operating Frequency	“Vampire Formation, Push 123.45”	

	"Vampire Formation, Check-In"	"Two"
Change Formation positions	"Vampire Two, Echelon Right, Go"	"Two"
Wingman has insufficient power to remain in position		"Lead, Rev's"
RTB brief	"Vampire Two, tracking inbound to Lethbridge shortly. Expecting runway 36 for arrival. Overhead join, pairs landing."	"Vampire 2"
Switching to CTAF	"Vampire Formation, Push 127.65"	
	"Vampire Formation, Check-In"	"Two"
Inbound Call	"Traffic Lethbridge, Vampire Formation is 5 miles south, passing 3500' on descent inbound Lethbridge"	
Circuit Joining Call	"Traffic Lethbridge, Vampire Formation is joining crosswind, runway 36, Lethbridge"	
Turning Base Call	"Traffic Lethbridge, Vampire Formation is turning base, runway 36, Full Stop, Lethbridge"	
Clear of the Runway Call	"Traffic Lethbridge, Vampire Formation is clear of all runways, Lethbridge"	

For aircraft with two radios initial check-in after start, in-flight station changes, configuration changes, fuel checks and general inter Formation chatter is conducted on second radio which remains on the Formation common frequency throughout the flight. This will need to be briefed by the Lead.

Chapter 15 - Visual Signals

Visual signals are often used in close Formation for Formation changes, configuration changes, and Lead changes. It is often said that a good Formation is a quiet Formation however nothing should prohibit any member of the Formation from using the radio if essentially required. On the other side of the coin, a Formation that is continually talking on the radio becomes annoying for other aircraft, and blocks the radio frequency. Initially during your Formation training there will be a lot of chatter on the radio as instructors talk to each other and request different exercises. By the last flight, there will be almost no radio calls between aircraft, and everything will be done by visual signals.



Depending on the aircraft, you may have to give a hand signal numerous times to make it clear and obvious to the Wingmen. In some aircraft, it may even be better giving a radio call, if Wingmen are having trouble seeing you.

Lead should ensure before flight that all Wingmen are familiar with the visual signals used. If a Wingman has come from another training background, it is important to discuss visual signals so there is no confusion. Below are the SKYTHRILLS standard close Formation visual signals.

Action	Lead / Wing	Description of Signal	Action to be taken by Wingman at
Start Engine	Lead	Hand raised, forefinger extended upwards and revolve in horizontal plane. ("Wind up" signal)	Commencement of signal
Ready to taxi	Lead / Wing	Thumbs up	
Engine run-up complete	Lead / Wing	Thumbs up	
Run-up to intermediate power setting for pairs take-off	Lead	Hand raised, forefinger extended upwards and revolve in horizontal plane. ("Wind up" signal)	Commencement of signal
Engine power set for take-off and ready for brakes release	Lead	Thumbs up	Commencement of signal
Brakes release for pairs take-off	Wing	Head tilted back then single downward movement of head nod to chin on chest	Chin on chest
After take-off checks		No signal	Wingman to complete after take-off checks as required (retractable undercarriage aircraft – Wingman may see wheels stop rotating on brakes on/off or gear doors opening as first sign to retract undercarriage)
Flaps 'up' or 'down'	Lead	Hand horizontal, fingers facing forwards, flapping movement of the thumb in the vertical plane	Head nod
Switch radio frequency to the operating frequency (normally 123.45 – "the	Lead	Raised fist with fingers extended one at a time in order (i.e. 1, 2, 3, 4, 5)	Cessation of signal

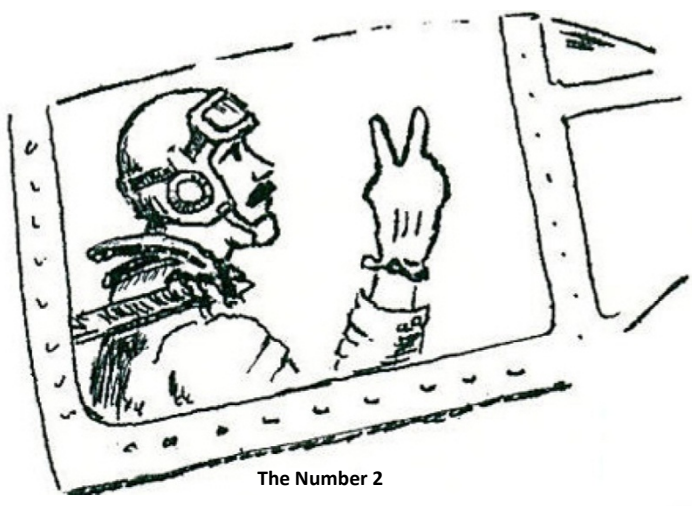
numbers")			
Re-join close Formation in Echelon (to the inside of the turn)	Lead	Rocking of the wings, then start a gentle turn	Cessation of signal, Wingman joins to the inside of the turn.
Take-over as Lead	Lead	Lead points to Wingman in echelon with forefinger and then sweeps finger forward to be pointing straight ahead	Cessation of signal
I am relinquishing Lead and adopting Wingman role & collision avoidance responsibility	Lead	As the Wingman moves forward (at the abeam point) the relinquishing Lead nods head	
I am accepting the Lead of the Formation	Wing	Move head smartly from looking at the #1, to looking straight ahead	As #1 gives a head not passing abeam
I am about to turn Left or Right	Lead	Positive movement of the head to look, Left, Ahead, above then Right for a Right Turn. The opposite for a Left Turn	Cessation of signal
Go echelon left or right	Lead	Point to the aircraft concerned then hand moved across face to point at the new position	Cessation of signal
Go line astern	Lead	Clenched fist with thumb extended horizontally placed at back of head	Cessation of signal
Request a practice Re-join	Wing	The Wingman requesting the Re-join raises a flat hand palm down and "weaves it" away from Lead and back toward Lead in a representation of a breakaway and Re-join.	Cessation of signal
Break away and conduct a straight / turning Re-join back to this echelon position	Lead	Back of hand with fingers extended forward (flat hand) used to "wave away" the Wingman	Commencement of signal
Request your fuel state	Lead	Make a drinking motion with open hand and the thumb extended toward the mouth	Cessation of signal
Response to fuel state request	Wing	See note 1	
Extend undercarriage	Lead	Clenched fist pumped up and down vertically	Head nod
Radio failure	Lead / Wing	Tap microphone or earphone and give thumbs up or down as appropriate	
Take spacing for stream landing	Lead	Hand held in fist and pumped rearwards, with thumb out pointing backwards	



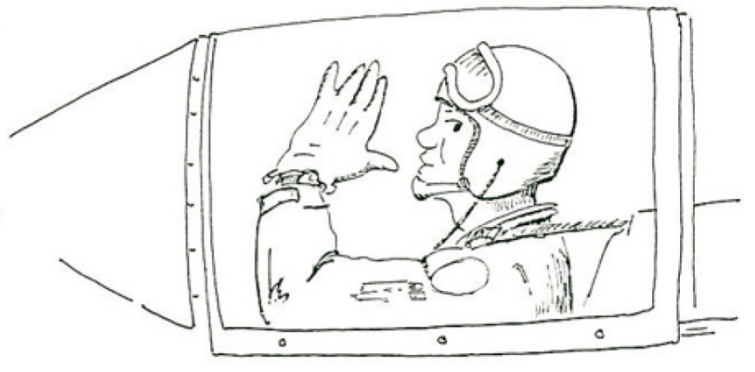
Start-up or Wind-up hand signal



Gear Up or Gear Down followed by a head nod



The Number 2



Fuel State Inquiry



HEFOE signal followed by a number 2 would indicate an Electrical Problem

Note 1: The procedure for indicating how much fuel remaining uses the standard hand signals for communicating numbers. The fuel remaining is generally rounded down to the nearest number only needing two digits to communicate (zeros assumed for the magnitude and unit of measure of fuel carried in that aircraft type – for example in larger military aircraft 1000s of pounds; a signalled 4 and 7 would be 4.7k pounds (4700lbs) In military training aircraft typically 100s of pounds is used; a signalled 7 and 5 would be 750lbs of fuel.

In General Aviation Aircraft the unit of measure of fuel is litres. Two signalled digits would be for actual fuel on board (a 7 and 2 would indicate 72 litres, a 5 and 0 would be 50 litres etc.)

Hand signals for numbers

- (1-5) One through to five is indicated by the number of fingers held vertically
- (6-9) Six through to nine is indicated by the number of fingers extended horizontally plus 5
- (0) Zero is indicated by a clenched fist

Each digit of a number is communicated one hand signal at a time. For example if you want to communicate 280; raise hand in loose fist with first two fingers vertically for the first digit (2). Re-clench fist loosely and lower hand slightly then re-raise hand with three fingers extended horizontally for the next digit (8), re-clench and lower and then raise a firmly clenched fist to indicate the zero.

Tip – if two digits are communicated “out of the blue” then it is likely to be fuel quantity. If 4 or 5 digits communicated “out of the blue” then it is possibly a new radio frequency to change to.

Chapter 16 - Formation Do's and Don'ts

DO:

- ✓ Know your mission, your aircraft and yourself
- ✓ Brief every mission thoroughly
- ✓ Use an instructor or safety pilot on all training missions
- ✓ Learn and practice the manoeuvres that are the easiest first, then proceed to the more difficult manoeuvres
- ✓ Know your aircraft emergency procedures thoroughly
- ✓ Plan well ahead if you are leading a Formation
- ✓ Be extra smooth on the controls if you are leading a flight
- ✓ Know the hand and aircraft signals used in Formation
- ✓ Keep alert for, acknowledge, and relay all signals in Formation
- ✓ Work constantly to achieve and maintain the ideal Formation position
- ✓ Ensure adequate clearance before starting cross-overs
- ✓ Know switch locations and proper directions to move switches by feel alone
- ✓ Keep the windscreen and canopy clean at all times
- ✓ Use the clock code when calling traffic
- ✓ Stay loose and flexible

DON'T:

- ✗ Go below the minimum altitude established for the flight
- ✗ Fly a mission if there are restrictions to visibility in the area of operations
- ✗ Continue the mission below minimum fuel requirements
- ✗ Talk unnecessarily on the radio
- ✗ Fly with a known or suspected malfunction
- ✗ Leave the briefing with questions unanswered
- ✗ Attempt any manoeuvres that were not briefed for that flight
- ✗ Forget to plan ahead when leading a flight
- ✗ Check in on a new frequency out of turn
- ✗ Attempt a Re-join with excessive overtake or rate of closure
- ✗ Take your eyes off the aeroplane you are flying Formation on, except for the **briefest** of instants to check cockpit instruments or perform normal cockpit administration
- ✗ Try to impress everyone by flying too close
- ✗ Change sides in the Formation without permission of the Leader
- ✗ Anticipate Leader's moves and react prematurely
- ✗ Bunch up in the circuit area, especially on finals
- ✗ Give a frequency change to a the Formation in a turn

Appendix 1 – Formation Briefing

FORMATION CALL SIGN _____

TIME HACK _____

OBJECTIVE: _____

CREWS

#1	_____	_____ / _____
#2	_____	_____ / _____
#3	_____	_____ / _____
#4	_____	_____ / _____

WEATHER _____

TIMINGS WALK

START	_____
T/O	_____
DISPLAY TIMINGS	_____
LAND TIME	_____

RADIOS

CHECK-IN	_____
EXERCISE AREA	_____
ENROUTE	_____
RTB	_____
TRANSPONDER	_____

TAXI _____

LINE-UP _____

TAKE-OFF

X-WIND <10KTS PAIR
 X-WIND >10KTS STREAM TIME SPLIT: _____sec

DEPARTURE

(route, height, speed, Formation join)

OPERATING AREA

AIRSPEEDS

CLIMB: _____ kts	RE-JOIN: _____ kts
CRUISE: _____ kts	DESCENT: _____ kts
BASE: _____ kts	APPROACH: _____ kts

AIR EXERCISE

RTB T/O + _____
 (route, height, Formation)

LANDING

X-WIND <10KTS PAIR
 X-WIND >10KTS STREAM
 BREAK FORMATION _____
 TIME BREAK _____sec

EMERGENCIES

ABORT

No sympathetic
 Radio Calls

RADIO FAILURE

(Lead / Wing; before departure / area / RTB)

RADIO FAILURE + HEFOE

1. Hydraulics
2. ELECTRICAL
3. FUEL
4. Oxygen
5. ENGINE

LOST CONTACT

Separate
 Radio Transmission
 De-confliction (Altitude)
 Formation Re-join

COLLISION

Separate
 Individual Controllability checks
 Mayday / Pan
 Individual RTB (de-confliction)

OTHER NOTES

Appendix 2

FORMATION KNEEPAD CARD (KPC)

CALL SIGN _____

WEATHER / ATIS:

AIRCRAFT #1 _____ #3 _____
 #2 _____ #4 _____

TIMINGS WALK _____ START _____

T/O _____ DISP _____ LDG _____

FREQUENCIES CHECK-IN _____ EXERCISE AREA _____

TRANSPONDER _____ ENROUTE _____ RTB _____

TAKE-OFF PAIR STREAM _____ sec split

DEPARTURE _____ **OPERATING AREA** _____

AIR SPEEDS CLIMB _____ kts RE-JOIN _____ kts CRUISE _____ kts

AIR EXERCISE

RTB T/O + _____

RECOVERY

LANDING PAIR STREAM BREAK FORMATION _____ _____ sec BREAK

OTHER NOTES