



Formation Flying Workshop

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Extract from the Civil Aviation Regulations:

Proximity and formation flights

91.06.6 (1) No person shall operate an aircraft in formation flight while carrying passengers for commercial purposes or, except as provided in sub-regulation (2), –

(a) in such proximity to other aircraft so as to create a collision hazard;

(b) in formation flight, except by arrangement with the PIC of each aircraft in the formation; or

(2) Formation flight in controlled airspace may be approved by an ATSU: Provided that –

(a) the formation operates as a single aircraft with regard to navigation and position reporting;

(b) separation between aircraft in the flight shall be the responsibility of the flight leader and the pilots-in-command of the other aircraft in the flight and shall include periods of transition when aircraft are manoeuvring to attain their own separation within the formation and during join-up and breakaway; and

(c) a distance not exceeding 1 km (0.5 NM) laterally and longitudinally and 30 m (100 ft) vertically from the flight leader shall be maintained by each aircraft.

(3) Formation flight for display purposes may be approved by the Director.

<p style="text-align: center;">SOUTH AFRICAN  CIVIL AVIATION AUTHORITY</p>	<p>REPUBLIC OF SOUTH AFRICA</p> <p>CIVIL AVIATION AUTHORITY</p>	<p>CAA Private Bag x 73 Halfway House 1685</p>
<p>Tel: (011) 545-1000 Fax: (011) 545-1465 E-Mail: mail@caa.co.za</p>	<p>AERONAUTICAL INFORMATION CIRCULAR</p>	<p>AIC 19-2 06-09-01</p>

GENERAL

SPECIAL AIR EVENTS

OPERATIONS AT FLYPASTS AND DEMONSTRATION FLIGHTS

Introduction

It has become increasingly clear that the procedures regarding flight operations in relation to flypasts and demonstration flights off airfields over built areas and assemblies of people are not correctly understood and therefore not always complied with in all respects. The intent of this AIC is to clarify the issue in this regard. It must be reiterated that the onus to comply with the statutory requirements rests with the operator. The risks and legal liabilities implicit to non-compliance with such requirements must be clearly understood by the organising entity.

1. In the case of general management related issues;

1.1 Requirements

The aircraft operator of the event shall -

- (a) *Apply to CAA for individual approval for the particular event.*
- (b) *Ensure that the aircrew involved meet the requirements as laid out in paragraph 1.3 below (General Rules).*
- (c) *Obtain approval from the Local Authority for the event.*
- (d) *Obtain Central Airspace Management Unit (CAMU) approval for the flexible use of the airspace.*
- (e) *Submit the approval/Request from the event organiser.*
- (f) *Submit the plan as per paragraph 1.3 (f).*

Note: *Approval documents as per paragraphs (c) to (d) are to be submitted with the application to the CAA.*

1.2 Conditions of Approval

The approval for execution of the flypast or demonstration flight shall be granted by CAA on condition that –

- (a) *The proposed plan has been submitted to the CAA for the approval as described in paragraph 1.3 below (General Rules).*
- (b) *The approval shall be a one-time approval i.e. for the particular event, at a particular venue.*

1.3 **General Rules**

2

1.3 **General Rules**

2

The organiser must note that -

- (a) *Pilots conducting such events shall be in possession of the following ratings;*
 - (i) *A valid display rating on type*
 - (ii) *For formation events, the formation leader shall be an experienced formation leader having lead a formation of similar size and complexity. The formation wingman shall hold applicable display ratings and for manoeuvring requiring more than a normal turn, shall hold aerobatic ratings on type with a display rating of 500 FT or lower.*
 - (iii) *Where possible, the formation shall operate on a separate formation frequency.*
- (b) *Single aircraft and formations are to hold at a minimum of 1000 FT above the highest obstacle (AHO) in the holding area. When planning holding areas, the pilot or formation leader is to take into account;*
 - (i) *Suitable emergency landing fields.*
 - (ii) *Run- in direction over densely populated areas.*
 - (iii) *Location of other air traffic zones in the vicinity.*
- (c) *No manoeuvring or formation position changes may be done once leaving the holding area until the flypast or demonstration flight is completed and the minimum height of 1000 FT AHO is obtained. To avoid highly populated areas or high obstacles in the run-in path, formations may plan turns of no more than 20 degrees and single aircraft may plan turns of no more than 30 degrees on the run-inn.*
- (d) *Flypast or demonstration flights shall be flown at maximum cruise power setting or higher, to ensure sufficient energy for manoeuvring or emergency landings. Formations are to fly at the maximum power settings applicable to the type of aircraft in the formation. In mixed type formations, the slowest or least manoeuvrable aircraft type should lead the formation. Fast jet aircraft are to fly at their best manoeuvring speed in compliance with ATC speed restrictions and approval, however not faster than Mach 0.90.*
- (e) *Height Limitations;*
 - (i) *Single engine aircraft and formations shall not descend lower than 500 FT AHO over the venue.*
 - (ii) *Multiple engine aircraft, capable of maintaining height with one engine inoperative and being able to climb back to a circuit height, may descend to 300 FT AHO on the run-in. Multi engine aircraft not capable of sustained level flight with one engine inoperative shall, be restricted to a minimum height of 500 FT AHO.*
- (f) *A plan showing the holding areas, run-in directions and suitable emergency landing areas is to be submitted prior to approval being given for the event.*



COMMISSIONER FOR CIVIL AVIATION



(<http://www.tigermothclub.co.za/images/DH82A%20Tiger%20Moth%2084412%20ZS-UKW%2002.jpg>)

Definition:

Formation flying, two or more aircraft traveling and manoeuvring together in a disciplined, synchronized, predetermined manner.

Close formation is to fly with one or more aircraft holding a constant, close position relative to another aircraft.

Basic Concepts

A formation is composed of a formation leader and formation members. The maximum number in a formation depends on the pilots' skill and the thoroughness of their pre-flight planning. In 1990, the Central Flying School broke the world record by flying 50 aircraft in close formation, which was equalled in 2014 by an RV formation during the NASCAR 500 in Missouri, USA.

1. The formation leader is responsible for the safety of the formation and must ensure that he manoeuvres gently and smoothly so that all the formation members can hold position without undue difficulty.
2. The formation members keep station by carefully aligning key reference points on the leader's aircraft. Changes in alignment indicate that the aircraft is drifting out of position. Position is held and regained in a logical sequence.
3. Close formation flying is a demanding exercise which will provide you with valuable experience. Both station keeping and formation leading are vital aspects that need to be mastered in order to have a safe and proficient formation.



WORKSHOP OUTLINE

This workshop is intended to provide a discussion forum where experience and expertise are shared amongst members of the Tiger Moth Club of South Africa in order to promote a safe and informed ethos around formation flying.

Attendance of this course does not provide any qualification and the organisers do not accept any responsibility for any incidents that might arise from the voluntary participation in formation flying.

THEORY

The theory and safety of formation flying will form the core of initial discussions in the same format of ground schooling. All members are encouraged to participate with questions, queries or comments.

- Overview of terms
- Safety and Airmanship
- Responsibilities of wingman / leader
- Communication
- Practicalities

PRACTICAL

Practical formation flying will take place in a number of different formats, building from elements of two aircraft to a finger four formation. Participants will practice briefings as well as being both leader and wingman. Each practical will be filmed on the ground and then feedback provided. Safety is paramount in this regard.

- Positioning of aircraft relative to each other – demonstrated on the ground
- Briefings
- Flying as elements (being a wingman and a leader)
- Feedback on the ground
- Flying as elements second round
- Flying in a larger formation
- Feedback on the ground
- Flying as a larger formation second round and departure



This section of the workshop will be broken up into the following subsections:

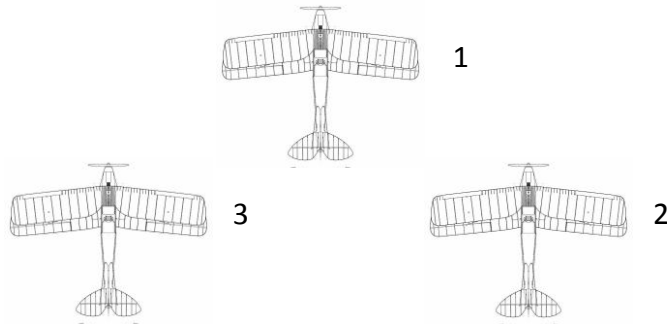
1. Standard Formation Positions
2. Terms
3. Reference Points
4. Aerodynamics and Mechanics
5. Basic Principles of Station Keeping
6. Joining and Breaking Formation
7. Formation Changing
8. Communication
9. Formation Leading
10. Guidelines for Effective Leadership
11. Sortie Profile
12. Formation Practicalities
13. Responsibilities of Leader and Wingman
14. Emergencies
15. Safety and Airmanship



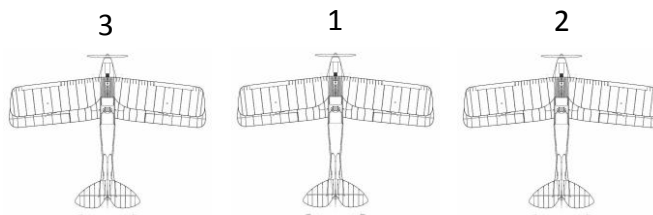
1. Standard Formation Positions.

The basic formations flown are:

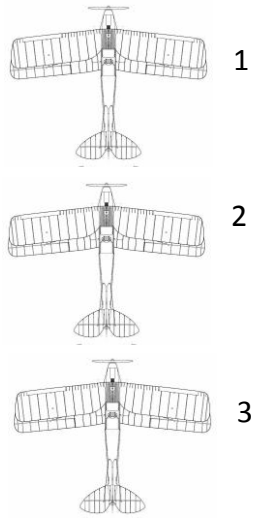
a. Vic



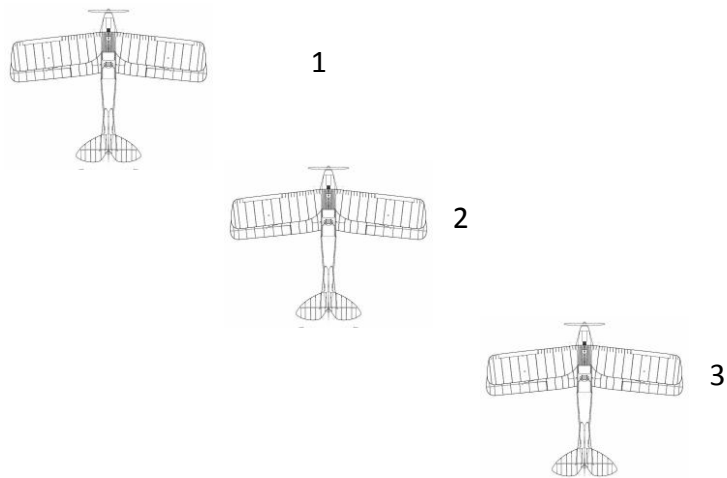
b. Line abreast



c. Line astern



d. Echelon



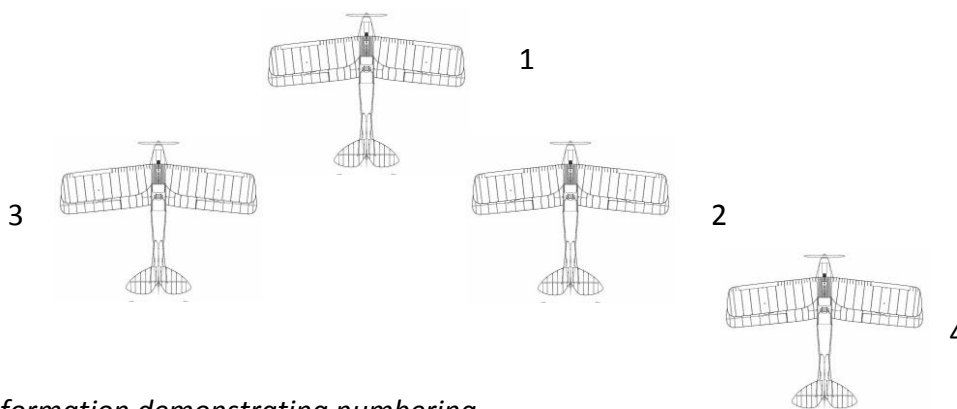
2. Terms

Station/Slot

A defined position within a formation, usually given a specific number and referred to by the formation call sign followed by the slot number. (eg. "Red three"). Once a pilot has been allocated a station, the usual convention is for that pilot to retain that number throughout the remainder of the flight regardless of station changes.

Numbering

The formation leader is always number one, then number two is to the right, three to the left, four directly behind, then five to the right, six to the left and so on.



Finger Four formation demonstrating numbering

Station keeping

The ability to hold an aircraft in a stable position in relation to another aircraft.

Visual signals

Visual or hand signals are used when using the radio is inappropriate, such as flying in a control area or a busy circuit or in aircraft not fitted with dual communications.

Separation

The distance between aircraft; guidelines given below:

"Fingertip"	about $\frac{1}{4}$ aircraft length separation
"Close"	about $\frac{1}{2}$ aircraft length separation
"Normal"	about one aircraft length separation
"Loose"	about $1\frac{1}{2}$ aircraft length separation
"Route"	200m - 300m aircraft separation

NOTE: "Fingertip" and "close" separation should only be used by experienced pilots. "Normal" is the usual separation and is used for initial instruction while "route" (the military would use "tactical") requires less concentration and is used for rest on long navigation exercises.

Stream take-off

A procedure in which two aircraft take off with less separation than permitted for aircraft not in formation, one behind the other, and join formation at some point shortly after take-off.

Stream landing

A procedure in which two aircraft separate from formation at some point and perform separate landings, with less separation than that permitted for aircraft not in formation.

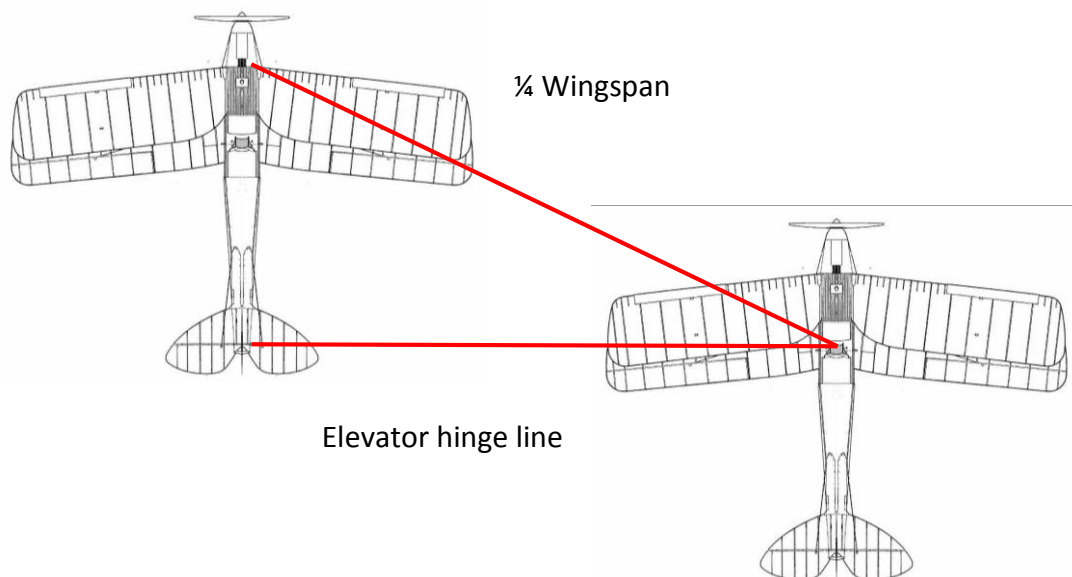
Planes of Movement

Vertical plane - up or down; longitudinal plane - forward or back; lateral plane - in or out

3. Reference Points

Reference points are parts of the aircraft that, when lined up, determine the lateral, longitudinal and vertical positions of each aircraft relative to each other. These are the focus points of the wingmen and in order to keep the correct spacing between aircraft, they must be adhered to.

We will define the reference points during the ground session. They should form a 45° angle between aircraft and take into account the three planes of movement. From personal experience, being able to see directly along the top of the elevator hinge works for me as well as lining up the streamline tube with the intake for the carburettor. Each pilot tends to find reference points that work for them personally. It is useful to have two points of reference.



Below are the SAAF Harvard guidelines for reference points:

Vic

Aircraft are on the same plane $\frac{1}{4}$ wingspan (1 elevator length) apart. The front pilot of the forming aircraft looks down the elevator hinge-line of the lead aircraft. During turns the formation members maintain their positions in the same plane as the leader.

Echelon

The same reference points as for vic in straight and level. During turns the formation members remain at the same horizontal height as the leader. The leader's helmet lies on the horizon and the propeller hub should be visible and in line with the elevator hinge line.

Line Abreast

Aircraft are in the same plane $\frac{1}{4}$ wingspan apart. Formation members are abreast of the leader. The wingtips and navigation lights are in line. In a turn, the whole formation must be managed like one huge aircraft

Line Astern

Formation members are behind and below the leader, stepped down by the same amount as the distance out. The wing tips of the aircraft ahead must appear to be touching the canopy bars in front cockpit in the dive position. The aircraft must be aware of the altitude of the last aircraft relative to the ground.

4. Aerodynamics and Mechanics.

Introduction. The following paragraphs outline the aerodynamics and mechanics relevant to formation flying.

4.1 Momentum

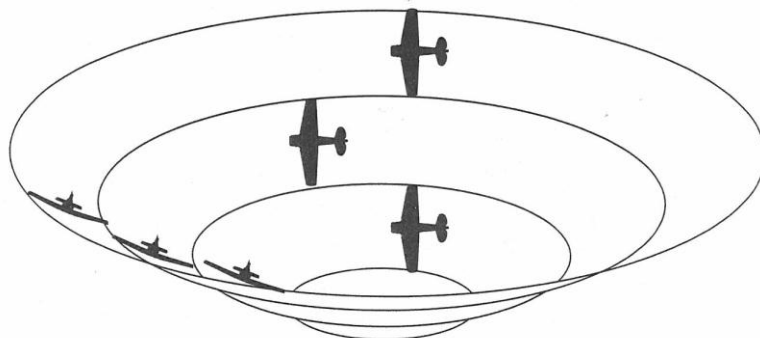
Like any mass in motion, the aircraft possesses momentum in flight. The implications are:

- When regaining station from behind, the aircraft must be accelerated above the leader's speed; this gives the aircraft excess momentum and it could overtake the leader. You must anticipate the correct position by reducing momentum BEFORE you arrive at the correct point.
- The same applies when lagging, when too far out, when too high or when too low.
- The forming aircraft will overshoot the desired position if the excess momentum is not dissipated by an opposing force.

4.2 Inertia

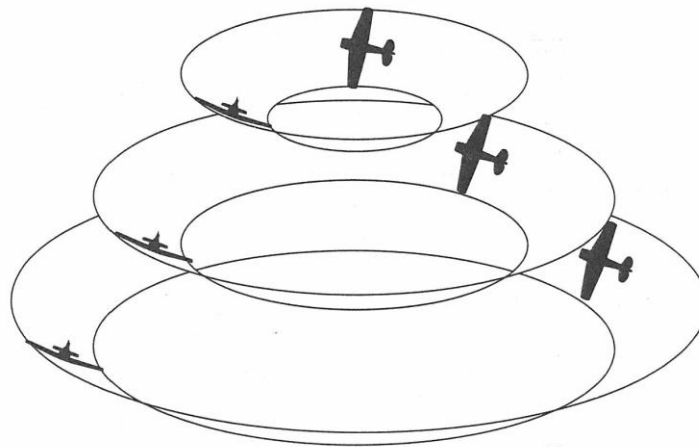
The forming aircraft will not move out of position of its own accord. It possesses inertia and will change position only when compelled to do so.

4.3 Turn Radius



This illustration shows how, during a turn in vic, line abreast or echelon formations, the outside aircraft describes a larger radius turn than the leader; similarly, the inside aircraft flies a smaller radius turn. It follows that to maintain station, the outside aircraft must increase speed relative to the constant speed of the inside aircraft. As a turn is started, the change in speed must be anticipated with an appropriate change in power. The greater the lateral distance between the leader and the forming aircraft, the greater the necessary speed adjustments. It is this factor which limits the manoeuvrability of large formations.

The figure below shows that in line astern, each aircraft flies a further distance than one above it. When flying in large formations, it becomes critical to step down as small an amount as possible.



4.4 Rolling In and Out of Turns

When a formation manoeuvres, the formatting aircraft must make significant power changes to maintain station. The further apart the aircraft are, the more the speed differential is accentuated.

4.5 Loading

During turns using 45° to 60° of bank, there will be an appreciable increase in 'g' so the formatting aircraft will need to match 'g' as well as speed.

4.6 Slipstream and Pressure Patterns

The slipstream from lead aircraft generates severe turbulence and must be avoided. Depending on your position, the pressure distribution around the lead aircraft can be sensed as a gentle pulling or pushing force. Avoid other aircraft slipstreams.

4.7 Engine Reaction Time

Compared to a jet engine, the Tiger Moth's engine responds immediately to throttle inputs, although the change in airspeed might not be as pronounced.



5. Basic Principles of Station Keeping

Station keeping in the Tiger Moth must be considered together with the characteristics of the Tiger Moth itself:

Engine Control

Piston powered: the immediate engine response gives a slow speed increase.

High drag

There is a rapid speed decrease when power is reduced.

Flight Controls

The response to control inputs is relatively slow, particularly in rolling.

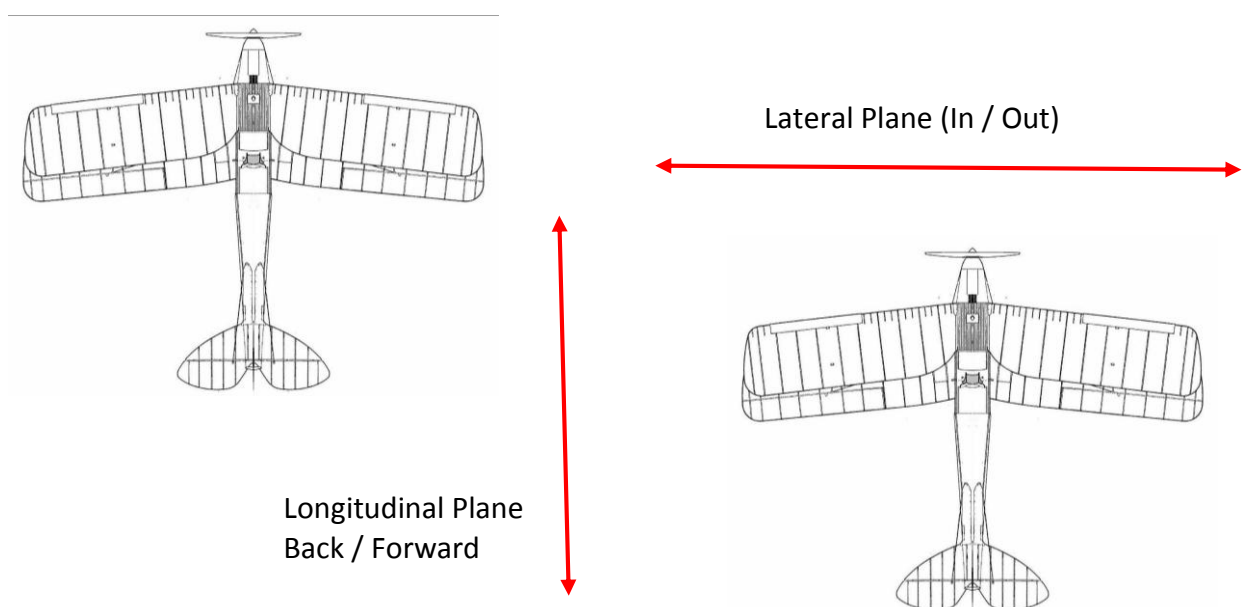
Flight Conditions

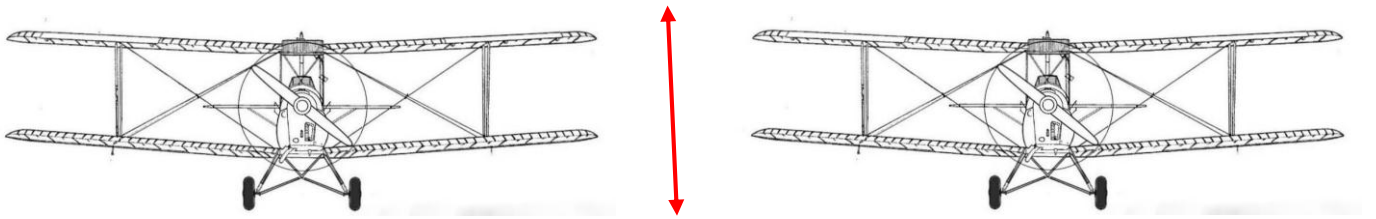
Most exercises take place at lower altitudes, where there is usually turbulence.

Planes of Movement

Accurate close formation demands that the forming aircraft are correctly positioned in the longitudinal, lateral and vertical planes. An explanation of each plane is given below:

- Lateral Plane: Movement in the lateral plane means movement in the direction of the lateral axis of the lead aircraft, in other words tighter or further apart.
- Vertical Plane: The vertical plane in formation is measured against the leader's lateral axis and 'high' or 'low' are descriptions of your position relative to the leader and not relative to the earth's surface.
- Longitudinal Plane: This simply means distance ahead or behind the leader.
- The Same Plane: When you are out of position, you must get back onto the same plane as your leader.





Vertical Plane (Up / Down)

The Same Plane (nuances)

- For vic, the same plane does not mean being at the same height; it means remaining on the lead aircraft's yawing plane, regardless of the leader's attitude.
- In echelon, being on the same plane means remaining at the same height as the leader.
- In line astern, to stay on the same plane as the leader entails remaining on the lead aircraft's pitching plane, regardless of the leader's attitude.

Control of Spacing

Vertical Spacing: Vertical spacing is adjusted using the elevators and also the throttle when large corrections have to be made.

Lateral Spacing: Lateral spacing is controlled using the ailerons. The rudder is used for fine adjustments.

Longitudinal Spacing: Longitudinal position is controlled using the throttle.

Regaining Position

You will probably spend more time regaining position than maintaining it: you may be out of position in one or all three planes of reference. **When regaining position, move only one plane at a time.** If you try to move in more than one plane at a time, you will inevitably neglect one set of references in favour of another. For example, if you try to move forward and inwards you will invariably drift far too close.

The golden rule for regaining position is:

DO NOT CORRECT MORE THAN ONE PLANE AT A TIME

Procedure for Regaining Position

To regain position in a safe and logical manner:

Step 1: Separate

If you are too close first move out to avoid collision. If you have lost sight of the leader break up and out of the formation.

Step 2: Regain the Same Plane.

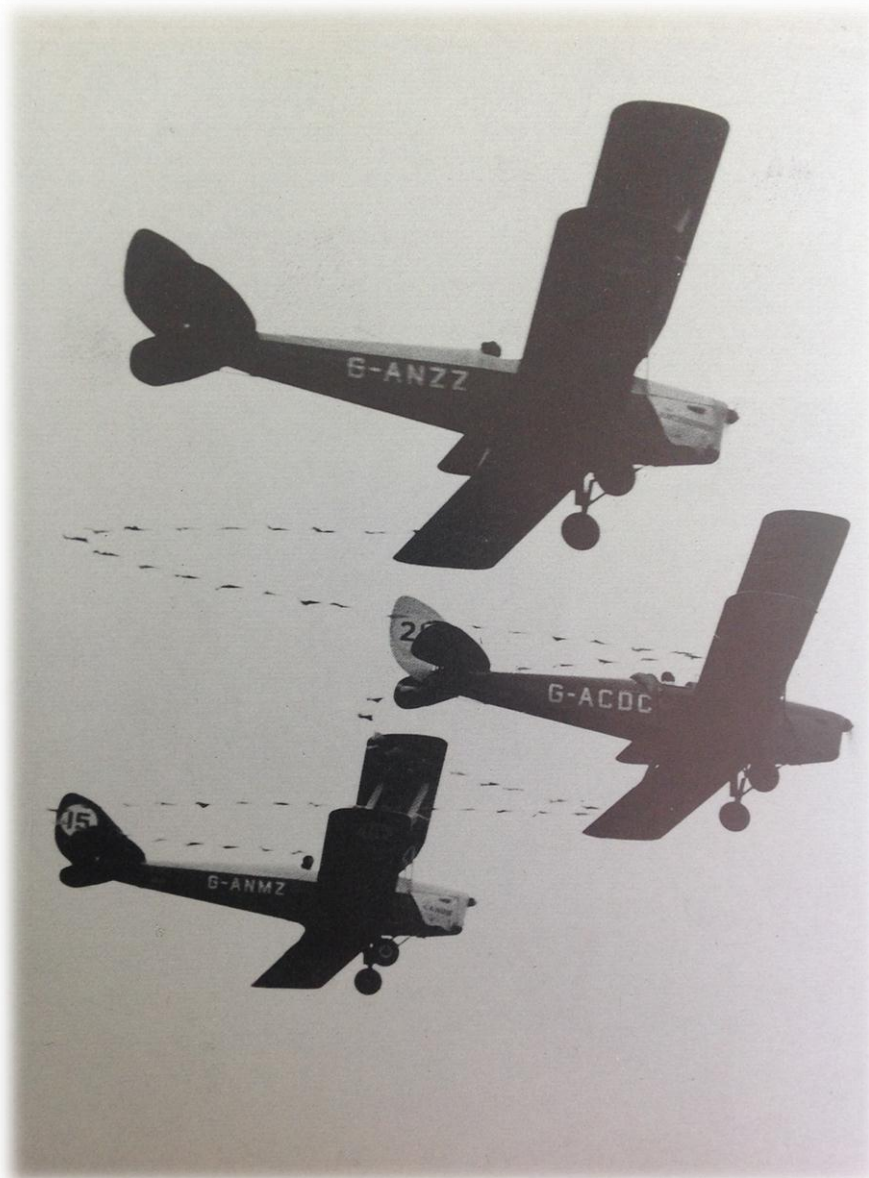
Once on the same plane, you will have a far better indication of your true vertical, lateral and longitudinal spacing.

Step 3: Regain Spacing in the Three Planes.

Depending on the formation being flown, you must regain position one plane at a time.

Make only fine adjustments to obtain the desired reference points. The usual order of regaining planes is vertical, lateral then longitudinal (up/down, then in/out, then forwards, but never backwards).

NOTE: It is vitally important to remain on the same plane as the leader. If you do not, most reference points will be lost and accurate formation will become very difficult.



6. Breaking and Re-joining

The procedure on the previous page should be used when you are out of position but still in close formation. If you become widely separated from the leader you must employ a different technique:

The Decision to Break Formation

If you lose sight of the leader, immediately break up and out of the formation. The formation can then be re-joined from a safe distance and at the same height.

Procedure for Re-joining

Do not attempt to re-join from above, nor should you try to fall back into position if you overtake the formation. Break out and start again.

- i Knowing the leader's speed and power helps you to judge your closing speed and to stabilise quickly in formation. Ask the leader his speed and height if you need to.
- ii Anticipate the requirement for large control movements when joining, because this will help to avoid over controlling.
- iii When joining, take up the correct vertical and lateral positions at about two spans distance. When settled, move into the correct longitudinal position with careful use of the throttle, aileron and rudder.
- iv Aileron inputs will cause a change of heading and so alter the lateral spacing. After closing in, some opposite bank will be necessary to restore the aircraft to the leader's heading.

Maintaining Position

You will not always be out of position. But smooth and accurate formation flying will be achieved only if you remain alert and physically relaxed. You will then detect small shifts in position promptly and, if you anticipate correctly, only small control movements will be necessary. This is not so easy to achieve at first, often because uncontrolled oscillations take place in more than one plane and this makes accurate station keeping all but impossible. If you understand the source of these oscillations, your ability in close formation will improve rapidly.

Planes of Oscillation

Oscillations can take place in any of the three planes of movement:

- a. Along the fore/aft axis, oscillating between lag and lead. This is usually caused by over controlling on the throttle, for example slamming from FULL to IDLE to FULL again within seconds;
- b. In the lateral plane, manifest as a snaking movement towards and away from the leader;
- c. In the vertical plane, oscillating above and below the leader, often because of over controlling in pitch. This form of oscillation is known as porpoising.

Longitudinal (Fore/Aft) Oscillations

Lack of anticipation and excessively large throttle movements often cause this type of oscillation.

For example, a student is flying as wingman. He begins to fall behind so he opens the throttle and his aircraft begins to accelerate. When back in position, he reduces power but the aircraft's momentum carries him forward. He reduces power to decelerate and does not increase power again until he is in position, so again he overshoots. It is not uncommon in the early sorties to find oscillating between idle and full power whilst the leader cruises sedately along at constant power.

The solution lies in anticipation and disciplined use of the throttle. The leader is probably not moving his throttle at all. Your setting should therefore always be very close to his.

Lateral Oscillation

There are two causes of this:

- a. Rudder Trim. If the rudder is incorrectly trimmed you will have to compensate by applying constant pressure on the pedal. If your attention is diverted to another task you may subconsciously relax the pressure. The aircraft will immediately start to drift. This will continue to happen until you trim the aircraft properly.
- b. Incorrect Bank. Your wings should always be parallel to your leader's wings. If you don't match the leader's bank angle you will be unable to maintain constant lateral separation without using rudder. If you try to correct the error with rudder you will end up flying with cross controls.

Pitch Oscillations

The elevator is very sensitive so it is easy to over control in pitch and start to porpoise. Relax and discipline yourself to make small control movements and keep the aircraft in trim.

Summary

To maintain a good position in close formation you must:

- a. Trim accurately or you will end up fighting the aircraft;
- b. Anticipate momentum and make disciplined use of the throttle;
- c. Match the leader's bank angle at all times.

If you don't obey these simple rules you will become tense and tension will aggravate the cycle.

Turning

Vic

At first, the sensations experienced may be disconcerting, especially on the outside of turns in vic. Take careful note of slipping - the outside aircraft is in no danger of slipping down onto the lead aircraft, so there is no need to apply top rudder.

Effects of Controls

The control movements required for keeping station are exactly the same in turns, inverted flight or any other manoeuvre. The only difference is that the horizon is displaced.

Regaining Position

The techniques for regaining position in the turn are exactly the same as for straight and level. Separate, regain the same plane as the leader, match his angle of bank and move into position one plane at a time. If you lose his plane, you lose your reference points and more effort is required to regain position.



7. Changing Formation

A sortie consists of more than one type of formation. During each flight you might change formation several times. You must do this efficiently and safely.

General

Make prompt and efficient formation changes; smooth handling and considerable anticipation with the power is required.

Change via Vic Formation

Formation changes are normally made through vic.

Sequence of Change

All formation changes should be made by moving behind and below the leader. Be careful of turbulence from the leader and other aircraft at all times.

Sequence of Change: 3-Ship

- i. When a 3-ship formation changes from vic to line-astern, the No 3 will descend and drop back but must not move into line-astern until the No 2 is in position.
- ii. When changing from line-astern to vic or echelon, the No 2 should delay slightly to give time for the No 3 to clear.
- iii. Changes from echelon port to echelon starboard are made through line astern. You must not cross directly underneath the lead's aircraft.
- iv. During all formation changes, your aircraft should not be closed onto station until the preceding aircraft appears to be settled in position.
- v. Try to be prompt with all formation changes.

Use of the Controls and Throttle

Efficient formation changes require smooth control handling and considerable anticipation of power to avoid lagging.

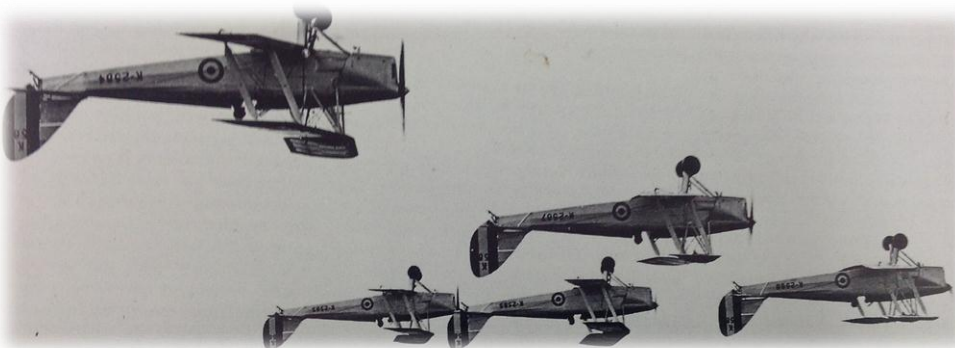
Caution and Communication

Take care to keep the other aircraft in view as much as possible during position changes. Formation changes hold the greatest risk of a mid-air collision. No change is to take place unless signalled and throughout the change adequate separation must be maintained between all aircraft.

8. Communication

To minimise the risk of collision the procedures and sequence of position changes must be briefed before flight. The radio transmissions, hand signals and sequence of changes used by the SAAF (and adopted by the Tiger Moth Club of South Africa) are described below:

FROM	TO	RADIO / HAND	ACTION
Vic	Line Abreast	"Line abreast, go!" Flat hand, palm forward, moved in a sideways motion in front of face, three times.	Open the throttle and move forward, maintaining lateral and vertical separation.
Line Abreast	Vic	"Vic, go!" Fist clenched, thumb extended. Point aft with thumb over shoulder, back and forth three times.	Close throttle, move rearwards into vic position
Vic	Line Astern	"Line astern, go!" Clenched fist held behind helmet.	Move rearward until you are the correct distance behind the lead. Obtain correct vertical separation. Move inwards in line with lead.
Line Astern	Vic	"Vic, go!" Lead rocks wings.	Gain lateral separation, move up into the correct vertical plane, then move forward into vic.
Vic	Echelon	"Echelon port/starboard go!" Clenched fist, forearm held vertical. Use the appropriate arm to indicate port or starboard.	Remain in vic, but both aircraft remain on the same level during turns.
Echelon	Vic	"Vic, go!" Fist clenched, thumb extended. Point aft with thumb over shoulder, back and forth three times.	Positioning remains unaltered, but the No 2 remains on an extension of lead's lateral axis.



Hand Signals

You will find that hand signals are emphasised and that radio calls are discouraged, particularly considering the transmission quality of an open cockpit broadcast. It is unwise to break radio silence on operational sorties, but if there is something important that must be relayed by radio, by all means do so. Also, flying a sortie with minimal radio work encourages professional planning and execution.

The following hand signals are used for formation flying:

Wind-up

A circular motion made with the forefinger and vertical forearm, signalling an increase to full power before take-off.

Climb

Hand with the palm facing down, moving from the chest at a slant forwards and upwards.

Descent

Hand with the palm facing down, moving from the chest at a slant forwards and downwards.

Increase Power

Fist held with the palm facing forwards, moving from the shoulder to the front while opening the hand at the same time.

Decrease Power

Open hand with the palm facing forward, moving back towards the shoulder and closing.

Turns

Forearm held vertically with an open hand and moving to a horizontal position in the direction of the turn.

Levelling Off

Open hand with the palm facing down and horizontal forearm moving from side to side.

Change Frequency

Twisting motion of a half-closed hand next to the ear.

Vic

A fist with an extended thumb pointing rearwards, while a vertical forearm moves backwards and rearwards.

Echelon

A clenched fist with the forearm vertical and held still.

Line Abreast

Palm facing forwards with a vertical forearm moving from side to side.

Line Astern

A clenched fist behind the head.

Indicating the Airfield

The same signal as the wind up, but followed by pointing in the direction of the airfield.

Fuel Check

Fingers closed into a fist with the thumb extended and positioned to imitate drinking.

Break

Hand held with the palm upwards and a vertical forearm while the fingers are flicked open and closed.

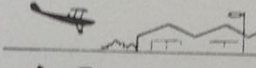
General Rules of Hand Signals

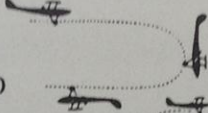
The following rules for hand signals used in formation flying must be observed:

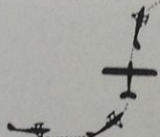
1. All hand signals are shown three times. You must react to the signal on or **after** the third time.
2. All hand signals must be clear and unambiguous.
3. In line astern the leader signals his order to change formation by rocking his wings and holding one wing low, indicating the side to which he wants the aircraft to move.

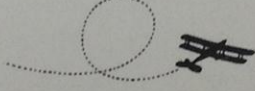
**A STANDARD
TIGER MOTH**

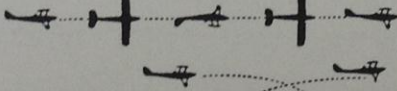
OPERATED BY NATIONAL AVIATION DAY LTD., FOR FLYING DISPLAYS
ALL OVER GREAT BRITAIN, BETWEEN APRIL 12th, 1932, AND
OCTOBER 16th, 1932, IS ESTIMATED TO HAVE COMPLETED

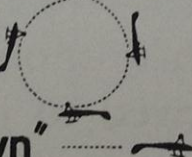
2,520 Landings 

345 Bunts (or Half Outside Loops) 

300 Upward Rolls 

1,440 Loops 

1,080 Rolls 

Inverted Loops
and approximately
90 hrs. Flying "upside down" 

THE DE HAVILLAND AIRCRAFT COMPANY LTD.
STAG LANE AERODROME, EDGWARE, MIDDLESEX
Associated Companies in Australia, Canada, India, and South Africa. Licensees, Selling and Service Agents throughout the World.

9. Formation Leading

The flight lead is ultimately responsible for the safe and effective conduct of the flight. The flight lead sees to the planning of, and briefs/debriefs the flight. The flight lead position has the authority and responsibility to ensure the flight proceeds as intended.

By upgrading to Flight Leader, you are taking on quite a responsibility. It will be you making the primary mission planning decisions, briefing the members of the flight, coordinating with air traffic control, analysing en-route weather, managing flight communications and recovering your wingman at the destination.

Once the aircraft are tied down, it's up to you to lead an effective debrief and develop the formation skills and judgment of less experienced wingmen. Take your responsibilities seriously; poor decision making on part of the Flight Leader can have negative consequences well beyond a simply bruised ego.

Formation Briefing Format

Before any formation sortie, or when two or more aircraft are planned to operate together, a briefing will be given by the leader; all participating aircrew must attend. This is compulsory. **UNDER NO CIRCUMSTANCES MUST A FORMATION FLIGHT TAKE PLACE WITHOUT A COMPREHENSIVE AND CLEAR GROUND BRIEFING.**

The brief will cover:

- a. Task: A short description of the purpose of the formation.
- b. Weather: The expected weather conditions forecast in the latest available report.
- c. Composition: Roll-call and check of aircraft numbers, aircrew and formation position. The formation call sign will be given and a deputy leader will be nominated.
- d. Timing: This includes walkout time, start-up time, taxi time and expected take-off time. The start-up and taxi time may be replaced by a suitable procedure such as radio calls.
- e. Radio: Frequency changes and their purpose, all the expected calls and also the hand signals to be used.
- f. Taxi: Order of taxi, spacing between aircraft, taxi speed.
- g. Runway: The position of each aircraft for line up and take-off will vary according to the type of take-off planned and factors such as weather conditions, wind direction and pilot experience.
- h. Take-off: Signals to indicate wind up and intervals for streamer take-off.
- i. Form-up: The leader's intentions after take-off; form-up procedure, power settings and formation positions.
- j. En Route: The likely operating altitude, levelling-off procedures, power setting, formation positions, formation changes, leadership changes and turns.
- k. Recovery: The descent procedure, joining checks, route and method of joining the circuit, formation positions and changes, radio frequencies and calls, joining initial, break onto downwind, separation and vital actions, final approach and landing (spacing, crosswind, turning off runway, taxiing, parking, etc.).
- l. Points: Under this heading any points not included in the normal sequence will be discussed. This includes minimum fuel states, reforming in event of lost leader, aircraft unserviceability before take-off, exercise limits, minimum and maximum attitudes, reporting of other aircraft, lookout,

personal equipment, maps and publications, notams and the time and place for the debrief.

- m. Emergencies: The actions in the event of the following emergencies will be briefed:
 - Engine failure;
 - Fire or overheat;
 - Radio failure;
 - Mid-air collision;
 - Landing emergencies.
- n. Time check and synchronization of watches

10. Guidelines for Effective Leadership

Good leadership is vitally important and can ease the task of the forming pilots considerably. As leader you are responsible for the overall safety of the formation. Pay particular attention to the following points:

Control and Manoeuvre

- i. All manoeuvres should be carried out smoothly and accurately, taking care to keep within the capabilities of the forming pilots.
- ii. In large formations, the aircraft farthest from the leader will have to make large changes in height and speed during manoeuvres; you must make allowance for this.
- iii. Make entries and recoveries gently and restrict bank to moderate angles.
- iv. The leader must never use maximum and minimum power settings because the forming pilots need a range of throttle movement either side of the leader's setting. In the Tiger Moths the leader tends to fly with a speed range between 65 and 70 mph.
- v. Avoid very low speeds; otherwise aircraft on the inside of turns may lose control by stalling.
- vi. Enter and recover slowly from climbs and descents.
- vii. Define all manoeuvres by being precise in control inputs

Airmanship

You must display a high standard of airmanship and in-flight planning:

- i. Planning. If the leader begins to panic and become erratic, the wingmen's workload increases dramatically. All descents, turns and speed changes must be anticipated by thorough planning.
- ii. Lookout. In close formation, the leader assumes responsibility for lookout for the entire formation. You must always bear in mind the size and reduced manoeuvrability of your formation. Fly like you are piloting one huge aircraft.
- iii. Navigation. The leader is responsible for navigation. Fuel states must be obtained periodically. Forming aircraft will suffer from higher fuel consumption than the leader. The leader must also ensure that the formation remains in the allocated sector.
- iv. Position of the Sun. Whenever possible, the leader should avoid positioning himself directly up-sun from a forming aircraft.

11. Sortie Profile

Pre-flight Inspection, Start-up and Check-in

Pre-flight inspections are done individually. When they are complete, the pilot stands behind his aircraft until all members have completed their checks. If the formation is spread across the front and rear lines, the pilots on the rear line should stand in front of their aircraft.

The formation leader will give a thumbs up when everyone is ready, indicating that all members may now strap in, start up and do the warm-up and pre-taxi checks. During the warm-up, the check-in frequency must be set on the radio.

When the pre-taxi vital actions are complete, the formation leader carries out a radio check with his formation. The relevant frequencies are checked sequentially in descending numerical order. When the check is complete, the leader will request taxi clearance for the formation.

Taxiing

Aircraft must taxi in number order.

Aircraft taxi in the normal zigzag taxi pattern and automatically change to the appropriate frequency on leaving the dispersal area. When the last aircraft leaves the dispersal area, the formation leader makes a radio check on the new frequency. Aircraft should maintain a spacing of three aircraft lengths during taxiing and should zigzag alternately, so that all aircraft can be kept in sight and all pilots must be vigilant about downhill taxiways, using the grass to slow down where necessary.

At the runway, pre-take-off vital actions are done individually. When they are complete, the formation members give a thumbs up to the leader.

Line-up and Take-off

When the formation leader has received take-off clearance he will taxi onto the runway and stop to allow the rest of the formation to line up in whatever formation has been briefed (ie. stream take-off, vic, etc.) To avoid the risk of a ground collision the wingmen must keep the leader in sight throughout their manoeuvring. In 2-ship formations the leader takes the left side of the runway. When the last aircraft is in position each member gives a thumbs up to signal that he is ready.

When the leader signals the wind-up, the formation carries out the following procedure:

- a. Check oil pressure.
- b. Align compass with runway.
- c. Formation members indicate their readiness with a thumbs up signal.

The leader signals full throttle and all aircraft open up simultaneously.



After Take-off

The formation leader maintains runway heading and flies a wide crosswind. After take-off vitals are performed by each pilot. The leader checks visually to confirm that all aircraft are airborne and safely clear of the ground.

If a formation take-off has not been carried out, the leader maintains a wide circuit, allowing opportunity for the rest of the formation to 'cut the corner' in order to catch up with the leader. The formation should aim to be formed up mid-downwind and therefore 'cutting the corner' can take place on crosswind and downwind.

All aircraft check in on the radio once in position, in numerical order. Wingmen now focus only on the leader and their reference points, carrying out brief scans of the instruments. Flying as a wingman needs a great deal of trust, so as a wingman, you must trust the leader for appropriate speeds, navigation, radio calls, etc.

Departure for the General Flying Area

When the formation has left the circuit the leader signals to change to the appropriate frequency. He then checks the formation in on approach and makes the "Circuit outbound" radio call. Each member checks in on the new frequency and the leader carries out all radio calls.



12. Formation Practicalities

When practicing formation flying, the following should be focus points:

- a. Keeping station
- b. Breaking and re-joining formation
- c. Regaining position
- d. Holding station in turns

Turns

Except for line astern, all turns are indicated with hand signals. For safety reasons, echelon turns should be performed away from the formation members, that is, to turn left all members must be to the right of the leader.

Changing Leadership

To change lead, the procedure is:

- a. The leader indicates the direction of the airfield;
- b. He gives the signal for a fuel check. The other members check their fuel and indicate a thumbs up if there is enough fuel to continue the sortie;
- c. The leader then indicates himself as No 2 and the new leader as No 1. The new leader acknowledges by indicating the old leader as No 2 and himself as No 1. The new leader looks straight ahead, signifying that he is no longer forming. This can be done through hand signals or on the radio;
- d. The lead has now changed and the new leader immediately assumes all responsibility for the formation;
- f. The new leader signals the other aircraft into vic formation then signals power setting

Returning to the Airfield

Before the leader requests joining instructions, he will:

- a. Signal the formation into vic;
- b. Signal the direction of the airfield to the rest of the formation;
- c. Do the joining checks for the formation, he will also change frequency and indicate to the rest of the formation to change frequency as well;
- d. Formation leader then checks that the formation is on approach frequency;
- e. Formation leader requests joining instructions;
- f. Formation leader confirms that forming members have received the joining instructions by looking for a thumbs up;
- e. Formation leader calls and flies to the normal joining point for the runway. During the approach to the downwind leg, the leader may signal the formation into line astern to facilitate manoeuvring – keeping numerical order.
- f. Downwind is flown wider than normal to facilitate spacing.
- g. For non-stream landings, the leader calls for the disbanding of the formation, and every pilot is then responsible for his own aircraft.

The Break

If required, the leader makes the "On the break" call just before the point where he wishes to break. On receiving the clearance, the leader signals the break and breaks according to what was decided during the pre-flight briefing.

Usually formation members break in the same direction, following at 3-second intervals, each aircraft keeping the one in front on the horizon, irrespective of whether he loses or gains height.

Stream Landings

On rolling wings level downwind, the leader makes the downwind call. The downwind vital actions are carried out individually.

A continuous descending turn is flown from downwind onto the final approach. The base leg vital actions are carried out as soon as the turn begins.

The leader makes the "Final approach" radio call. He acknowledges the landing clearance and states which side of the runway he is going to land on. In crosswinds, the leader will land on the downwind side. If there is no crosswind he may land on either side of the runway (ie. "Cleared to land 13, leader landing Right.")

The formation members acknowledge the leader's decision on tower frequency by calling alternate sides of the runway; for example, if the leader is landing right, No 2 will land left, No 3 right and so on. In this example, the No 2 will call "No 2 landing left."

All except the last aircraft will execute wheel landings on alternate sides of the runway. The last aircraft should carry out a 3-point landing as close to the threshold as possible. When the last aircraft clears the runway he makes the "Vacated" radio call.

Once vacated, the aircraft are no longer in formation. The after-landing vital actions, return to dispersal and shutdown are done individually.



13. Responsibilities of Leader and Wingman

Leader	Wingman
Select wing pilots for the flight	Maintaining position in the formation
Brief and debrief each mission	Mutual support
Oversee the planning of all missions	Formation Integrity
Verify pilots' credentials, currency and competency in type	Managing own aircraft
Manage radio transmissions	Focus should be solely on the aircraft on which the wingman is forming
Communication with the formation	
Navigation	
Practicalities of manoeuvres	
Managing formation checks	
Lookout for other traffic	

Do not allow time pressures to affect your judgement or thoroughness when it comes to any aspect of formation flying. Formation flying is the ultimate act of teamwork and trust; therefore, remember how your decisions directly impact upon other aircraft, both in the formation, and those not involved in the formation. Flying in a formation does not automatically give priority over other aircraft. Doing everything as a unit together is the aim of a formation; from start-up to shut-down.

14. Emergencies

- Radio Failure:** If there is a failure of transmission or reception, the pilot will point to the affected component (the earphone or microphone) and signal a thumbs down. If the lead aircraft suffers a failure, leadership is handed over to the deputy leader who will then lead the formation back to base. Under no circumstances will leadership be handed to an aircraft with radio failure.
- Precautionary Landing:** If an emergency landing or precautionary landing becomes necessary, the unaffected member will break away and act as a relay for search and rescue purposes. Under no circumstances are you to descend for a low-level inspection. Return to base when required.
- Collision:** If aircraft touch during formation, all aircraft are to break away and carry on at a safe altitude in the approach configuration. These checks must be done high enough to abandon the aircraft safely if it becomes uncontrollable. The leader has the option of returning individually or in loose formation, depending on the extent of the damage.
- Clearing the Formation:** When leaving the formation for whatever reason, the departing aircraft must signal their intentions to leave the formation, obtaining permission from the leader and then break formation by flying upwards and outwards. If in an emergency, the aircraft still moves up and out of formation, maintaining awareness of the position of the other aircraft in formation.

15. Safety and Airmanship

Safety and airmanship are the foundations of everything that has been written in this guide.

When flying a large or small formation, be cognisant of the affects that your operation might have on other aircraft, both on the ground and in the air. The following offer a guideline that is specific to Tiger Moth operations:

- Briefing:
- i. Try to ensure that the briefing takes place close to the aircraft so that you might be able to familiarise yourself with the leaders aircraft, etc;
 - ii. Plan timeously, allowing for delays, such as one member having problems swinging the prop;
 - iii. Plan according to the slowest aircraft;
 - iv. Ensure that your aircraft is in 'tip-top' condition;
 - v. Use knee boards for notes where necessary.
- Start-up:
- i. Try to park in numerical order to facilitate an easy start-up;
 - ii. Ensure the start-up area is clear;
 - iii. Do not prop swing any aircraft without the pilot being present in the cockpit;
 - iv. Be mindful of other aircraft parked behind you.
- Taxi:
- i. Allow sufficient spacing for downhill runways/taxiways;
 - ii. Assess the activity of the airspace and circuit operations.
- Airborne:
- i. Until the formation has formed up, keep a good look-out for other aircraft;
 - ii. Be predictable in your control movements;
 - iii. Do not fly in excess of your capabilities; formation flying is not about ego;
 - iv. Smooth and gentle flying is the order of the day;
 - v. Trust the leader;
 - vi. Do not overstress the engine;
 - vii. Try to avoid cross-controlling the aircraft;
- Landing:
- i. Ensure that you plan your landing roll to accommodate other aircraft;
 - ii. Rather go around than carry out an unsafe landing;
- Shut-down:
- i. Be mindful of other aircraft in the area;
 - ii. Wait for the entire formation before shutting down;

BEING METHODICAL, TIMEOUS AND HAVING AN AWARENESS OF WHAT YOUR IMPACT HAS ON OTHER AIRCRAFT IS PARAMOUNT. ALWAYS STICK TO THE PLAN AS BRIEFED.



16. Conclusion

Formation flying is a team operation and it requires concentration, precise techniques and coordinated cooperation from every member of the team. The safety of each pilot and his aircraft depends on the accuracy of every other member. It is especially important to remember the golden rules:

Brief thoroughly all aspects of the sortie before flight and adhere to the briefing in the finest detail

And

When in doubt, up and out

Formation flying is also great fun, so enjoy yourself, learn as much as you can and most of all, be safe.



EXTRACTS FROM 'PLANE AND PILOT'

Formation Flying

The risks and rewards of flying wing

Bill Stein

I've seen few things in my lifetime as beautiful as looking down on other planes in flight while on the top of a wingover. Multiple airplanes acting as one require a significant amount of discipline, dedication and practice. Even after more than 3,000 hours of flying within 20 feet of other airplanes, I know that this is an extremely risky activity that should never be attempted without considerable ground and flight training. I carry a Formation and Safety Team (FAST) card as well as the Statement of Aerobatic Competency card that's required for flying formation aerobatics at air shows in the United States and Canada. I'm also an FAA-designated Aerobatic Competency Evaluator (ACE) for formation aerobatics.

The FAA defines formation flying requirements in FAR section 91.111: "Operating near other aircraft. (a) No person may operate an aircraft so close to another aircraft as to create a collision hazard. (b) No person may operate an aircraft in formation flight except by arrangement with the pilot in command of each aircraft in the formation. (c) No person may operate an aircraft, carrying passengers for hire, in formation flight." For me, the definition of formation flying is operating aircraft relative to one or more aircraft.

The formation flight briefing is usually done by the lead pilot and includes all aspects of the flight profile such as weather, airport and communications information, potential issues (e.g., dissimilar airplanes), take off and join-up procedures, flight route, manoeuvre profile, landing operations and emergency procedures. Communications are extremely important to safely conducting a formation flight and must be understood by all flight members.

This article is a description of techniques I employ on formation flights—it isn't a substitute for training. Flying formation is an easy way to die, and engaging in a formation flight without proper dual instruction is unthinkable!

I've seen few things in my lifetime as beautiful as looking down on other planes in flight while on the top of a wingover. Multiple airplanes acting as one require a significant amount of discipline, dedication and practice. Even after more than 3,000 hours of flying within 20 feet of other airplanes, I know that this is an extremely risky activity that should never be attempted without considerable ground and flight training.

Wing's responsibilities are to maintain position and separation from lead and other lower-numbered members of the flight, and to alert other flight members of problems and emergencies. The act of maintaining position relative to lead's airplane is called "station keeping"; to do this well, you must use lead as your horizon and as the only reference that you use for flying. One skill that requires extensive dual instruction is the ability to see closure toward lead. Remember, you can only tie the record for flying close to lead!

Flying Wing

When I was with the Red Baron Squadron (and now with the Collaborators Formation Team), we used a technique called "three-axis control": Use ailerons to match wing bank with lead, elevator to match fuselage pitch, and rudder to move laterally in and out from lead. The throttle is used to move forward and backward relative to lead. This allows us to maintain a stable position and eases



the load of the outer wingmen in formations larger than two-ships. When flying wing, it's essential to know exactly where your perfect position is relative to lead. It's best to use triangulation with at least two sets of points for your sight picture: one set for the bearing (or 45-degree) line and another for lateral spacing. For example, when I'm flying my Globe Swift with friends to visualize my sight picture, I "connect" the lead Swift's innermost aileron hinge with the front of lead's cowl. This serves as our bearing line. I "touch" lead's tailwheel to the outer edge of the aileron on lead's far wing to get my target position. If we're on our bearing line and there's space between the tailwheel and the aileron, I know I'm too far forward (and too close) to lead; if lead's tailwheel touches the wing inside of the far wingtip, I need to move forward (and also in). One of these should cover vertical alignment.

Wing makes constant small corrections using all flight controls to keep the wings matched in bank and the fuselage matched in pitch, and to stay in the same relative position. The throttle, stick and rudder are almost always moving during station keeping. One trick: After making a power change, take half of it away as soon as you see it start to have an effect. This helps to smooth out the cycles of forward/back from lead.

When you're just starting to train, you'll work hard to open up your vision to "see" the entire lead airplane. This comes with experience, and if you're not able to do this, you should continue training before you fly solo as wing. Wing pilots must always keep sight of and maintain separation from lower-numbered flight members. If you're #2, you must keep sight of and maintain separation from lead. If you're #3, you must keep sight of and maintain separation from both lead and #2.

Once you can fly straight and level with airplanes matched, you need to be able to fly turns in formation. When lead turns toward wing, wing reduces power, descends slightly and banks to match lead. After everything is stable in the turn, wing returns to the process of making constant corrections with all flight controls. When lead begins to level out, wing will likely need to add some power while keeping the wing bank matched. When lead stops the rollout, wing will slightly reduce power because the small climb back to lead's altitude is achieved. The converse is true for turns away from wing: Wing will need to add power and climb slightly while banking to match lead.

But before you can do any of this, you have to join up with the formation. This is most efficiently done while lead is in a turn so that the geometry of a shorter path allows wing to catch up and establish position, instead of a throttle-only tail chase. The general mechanics of a join-up turn are as follows: Get inside the arc of lead's turn; get close to the same altitude as lead (put lead just above the horizon); get on the 45-degree line (for most planes this sight picture has lead's far wingtip touching the front of the vertical stabilizer); reduce power as you get closer to lead (400 to 800 feet); and slowly slide into position. The description is pretty simple, but in practice it can be very challenging. For me, a well-conducted re-join is one of the most gratifying moments of any formation flight.

The Airplane

Some airplanes are fun to fly in formation; some are okay; and some are terrible. The biggest issue is visibility. High-wing planes have very limited visibility, which can turn a small error into a full-blown emergency. High-wing aircraft shouldn't be used for formation flights. Certain low-wing aircraft also have reduced visibility. The Mooney owners club advises its members not to fly formation in its airplanes because of visibility, and that can be generalized to many popular planes, such as the Bonanza or Pipers. I agree—pilots should develop expert-level skills before flying formation in a limited-visibility airplane. One of the reasons that I love my Globe Swift (with its bubble canopy mod) is that its visibility is excellent.

When Things Go Wrong

If something goes wrong in a re-join, it can go very wrong! Brief your overshoot procedures, and make sure you're very experienced in re-joins and overshoots before your instructor gets out of the plane. There are several strategies for pilots of low-wing airplanes who overshoot. If the flight is



turning, go under formation to keep it in sight; if the flight is flying straight and level, stay on your side below the flight to maintain sight of formation. Communicate by radio that you're overshooting, then call in when stable. If you're unable to keep continuity with the flight, call "out" while maintaining separation, and then request permission to re-join.

If you can't see the flight (very scary!), then you're having a real in-flight emergency because you're unsure where the other members of the formation are. One way to manage this is to call, "out, no joy," and indicate where you are ("level at 3,000 feet heading west"). Lead should tell you where the flight is ("lead is at 2,500 feet heading north"). Use altitude for separation until you find the others, and then request to re-join.

It's a very good idea not to do anything in a hurry. When people make a big error in formation training, they often want to fix it as quickly as possible, causing them to fly erratically. If you're lucky enough to survive an "out, no joy" situation, then you probably owe the other flight members a cold beer, as well as an apology. High-wing airplanes are prone to no-joy situations, and I recommend that you never conduct formation flights in them, especially if you don't have considerable formation experience.

Exiting the formation can be done two ways. When lead breaks off first (as in a break to land), lead signals the break, then splits off away from wing, and wing maintains level flight. After the proper amount of time, wing then breaks and follows lead. When lead has wing break off first, lead must ensure that there's nothing in wing's way. It's smart to make sure lead is correct—when I'm waved off from a formation, I'll start my exit slowly until I'm able to verify that I'm headed toward unoccupied air.

The Real Risks

If you lack significant training in formation flight operations, then stay on the ground. The right way to get formation training is to go through the FAST organization (www.flyfast.org). They use military techniques, and their communications standards come from the T-34 formation manual. FAST has many signatory organizations, including Sport Class Air Racing, Swift, Red Star Pilots and various warbird clubs. There are also flight schools such as the Tutima Academy of Aviation Safety (www.tutimaacademy.com), where I teach, that provide formation training.

Due to their limited visibility, it's very risky to fly formation in high-wing aircraft. I feel a responsibility to warn aviators about photo flights because they represent the biggest risk. By definition, a photo flight is a formation flight, but many pilots don't even consider this. As a result, pilots with zero formation experience will still fly a photo mission. This leads to an unorganized process where briefs are often poor and not followed. In the air, pilots will attempt things beyond their skill level, because of photographer requests or because the camera pointed at them minimizes their situational awareness. Other complications include dissimilar aircraft with very different flight characteristics and a constantly changing formation, with aircraft moving in and out of formation to be on- or off-stage. Don't be tempted by the photos on these pages—everyone involved has extensive formation training. Make sure you get the same.



Formation Flying

The cognitive challenges of flying lead

Bill Stein

Formation flying is a dangerous and, for me, compellingly beautiful and engaging experience. It requires a significant amount of discipline, dedication and practice, and should never be attempted without considerable ground and flight training. My experiences and training have made me firmly believe that formation flying is primarily about the proper attitude toward safety, in addition to training and discipline.

Lead Is A Cognitive Job

As lead, you're responsible for all aspects of the flight from pre-flight briefing to managing all in-flight operations and the post flight debrief. This isn't to say that lead should be an autocratic dictator when it comes to setting goals and objectives for a flight, but once the group has decided on its objectives, it's time for lead to step up and manage the process going forward.

Lead is responsible for doing the thinking and planning for the formation. In the air, lead is expected to be a smooth and consistent platform for the wingmen to fly off of. Lead should assess the skill levels of the wingmen in the flight, and be able to sense what kind of day each of the wingmen are having to gauge whether they can be helpful, keep the entire formation within their capabilities and safely complete the mission.

It's generally agreed that lead should be the best pilot in the formation and should definitely have the most formation flight experience. A lead pilot must have excellent wing skills so that he or she can understand and anticipate what the wingmen will need for a successful flight.

Pre-Formation Flight Planning

A formation of airplanes is a complex thing to be responsible for. Not only are there multiple pieces of machinery but also multiple personalities with different capabilities. The lead pilot has to provide a tight enough framework for the flight to operate in so that everybody has a clear plan and can relax and enjoy the flight.

The formation flight briefing is usually conducted by the lead pilot and consists of all aspects of the flight profile such as weather, airport and communications information; pilot positions within the flight; potential issues such as dissimilar airplanes in formation (taxi routes, type of take-off and join-up procedures); flight route; the manoeuvre profile; all potential landing operations; and emergency procedures (including lost-sight procedures). Communications are extremely important for safely conducting a formation flight; this must be known and understood by all flight members. If a flight member has formation flying experience, but lacks a thorough knowledge of the standards that are to be used, then the person has no business being in the flight and should remain on the ground until he or she is familiar with all operating procedures.

A good ground briefing includes all of the previously mentioned items and a review of all the pertinent standards that apply to the specific flight. Plane & Pilot and Pilot Journal photo flights, particularly when flying some of the new light jets that are entering the market, can be an extreme example of briefing dissimilar planes in formation. Flying a jet at the very low end of its operating speed range, with seemingly almost no drag, off of a Bonanza is a challenging experience that deserves considerable discussion about join-ups, each manoeuvre in the flight profile and especially outs. We review all commands and procedures to try to ensure that no surprises raise their ugly heads during the flight.

To me, one of the best safety planning strategies is to perform a ground briefing and discuss as many potential issues as possible before taking off so that everybody you're flying with develops a similar problem-solving approach. If members of a team share similar approaches to solving problems, then they'll become predictable in their reactions to situations. If a team member hasn't done this kind of foundation work, then he or she might seem erratic when "stuff" happens. I believe that members of the Collaborators—the aerobatic formation team that I'm a part of—have spent about twice as much time on the ground (talking about potential problems that we could encounter) as we've spent flying.

Lead Runs the Formation

From the moment the team gets to the airplanes, the formation flight has started and lead runs the operation. Lead's first challenge after start up is to taxi the team to the run-up areas. To do this, you must have a very good idea of how large the formation is (so that everybody can fit into your selected run-up area) and how fast it can safely move on the ground.

Once in the air, lead is the one giving commands. Lead needs to be clear and decisive; if lead isn't, then the wingmen will become confused and frustrated, and start to ponder what should be going on instead of what they need to do to play their parts. As John Bowman, lead pilot for the Red Baron Stearman Squadron that I was a part of, always said: "A thinking wingman is a liability." A personal example of not being completely clear happened on a recent four-ship flight of Globe Swifts that I was leading. Even after giving the signal to my wingmen to follow my break from an echelon formation at four-second intervals, my departure from the flight was so gentle that the wingmen didn't know if I was leaving or initiating a turn. I confused the flight and they started to follow me into the turn.

There has been a lot of focus on cockpit resource management (CRM), and there's an analogous component that I call formation resource management (FRM). Lead doesn't have to do all of the tasks associated with the flight; he or she can assign wingmen to do things like calling Flight Watch to get the en route weather or looking at the sectional chart to identify alternate airports in case the weather closes in. Lead can also consider reducing the number of tasks that happen concurrently. Anybody who has ever had lead cross under an element while calling for a frequency change and starting to roll out of a turn will know what I mean. It's much safer and more comfortable to anticipate the need for all of those things in advance, and to plan to execute them one at a time.

In the same way that it's wise to consider all of the "what ifs" as you fly solo, it's also prudent to prepare for any in-flight issues that can occur with multiple airplanes in the formation. The possibility of a mechanical issue is not only greater, but so is the loss of situational awareness from one of the pilots in the group. If a minor mechanical issue (like lost communications) occurs, your standard procedures should allow you to communicate and complete the flight in an orderly fashion. If an emergency or major mechanical problem happens, then you need to do whatever you can to help the flight member having the emergency (e.g., helping to select a reasonable landing or bail-out location, flying cover to aid in communications, or identifying obstacles and hazards). It's something that should be covered in brief, and one wingman to help the crippled airplane is probably better than a crowd (because of the manoeuvring space needed for the crisis). Situational awareness problems can range from wingmen on the wrong frequency to outs, out-no-joys and lost wingmen. I've seen instances where a wingman starts to fool around on a cloudy day cross-country and can't reacquire the rest of the flight. You have to identify a way to ensure separation, most likely by altitude, and then work with the wingman to re-join the flight.

Flying Technique

The lead pilot needs to employ flying technique to be a predictable and consistent platform for the rest of the formation to fly off of. One basic concept is to fly formation on the earth's horizon and make all of the same continuous and small corrections to be stable and smooth. If you're looking at a point on the horizon, you'll be able to use all flight controls to immediately return to your flight path whether turbulence bumps you up and down, or yaws you left and right. If you fix these flight



path deviations right away, then your wingmen won't have to decide if you're starting a turn or if, maybe, you're just going to fly one wing down for a while.

Wingmen have needs that lead has to accommodate. A power advantage needs to be available for wingmen to make corrections and fly on the outside of turns. A slow and smooth roll into and out of turns is important in order for wingmen to look good and stay safe. It's almost impossible to roll too slowly, especially when you have more than two planes together. When the air is bumpy, it's sometimes helpful to keep bumping or nudging the stick to continue a smooth roll rate.

Post flight Debrief

Lead usually runs the post flight debrief, where the focus is on reviewing and discussing issues on the flight so that everybody continues to develop skills and to enhance safety. It's important to remember that everybody will make mistakes on the flight and that the issues discussed aren't personal. To that end, all flight members should be sure to check their egos at the door. Debrief should thoroughly address all significant flight issues while maintaining a respectful atmosphere and some amount of tact. As discussed earlier, this is an important opportunity for all flight members to learn to problem-solve in the same way.



- South African Formation Training Manual (adapted by Jeff Earle for EAA Formation Training Course)
- <http://global.britannica.com/EBchecked/topic/1403296/formation-flying>
- <http://www.tigermothclub.co.za/images/DH82A%20Tiger%20Moth%2084412%20ZS-UKW%2002.jpg>
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- https://www.google.co.za/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0CC4QFjAD&url=http%3A%2F%2Fwww.zapper.orconhosting.net.nz%2Ffraafsims%2Fdownloadable_files%2Fformation_flying.DOC&ei=-WjUVLnmHoaX7QaDroHIAQ&usg=AFQjCNFW1huUi0hxXFA2d7sYxBNTp6k4FQ&sig2=4Lp2Tdy_FHV0_bDAFN4yVA&bvm=bv.85464276,d.d24
- The Formation Pilot's Knowledge Guide Version 1.2 by Drew Bhlanick
- The Tiger Moth Club of South Africa
- The Tiger Moth by Stuart McKay
- Plane and Pilot Magazine

