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INTRODUCTION

This is the 4th Edition of FORMATION FLIGHT, originally published in 1984.

Our intention then was to provide a level of standardization which would ensure safety and make the job of putting up big formations at Oshkosh possible in the short time allocated. The fact that this manual is being updated for the fourth time is evidence that we succeeded. In fact, formation flying has become the most popular warbird flying activity.

FORMATION FLIGHT has been adopted as the standard reference for civilian formation flying nationally, and for the first time, FORMATION FLIGHT contains information about formation flying techniques specific to other warbird types. The diversity of these types demonstrates that the basic principles contained herein are applicable to all formation flying. These basic principles remove the mystery of formation flying, and provide the foundation for **safe** formation.

Make no mistake about it, formation flying can be dangerous if you don't have a good understanding of the basic principles. Operating in close proximity to another airplane is not like driving next to another car on the turnpike! FORMATION FLIGHT will give you the foundation to build upon, but if you are a formation neophyte, make sure you spend some time with a competent and qualified formation instructor before you try it solo.

GLOSSARY OF TERMS

The language of formation flying is unique and possibly even arcane. Without a working knowledge of the terms, you will not be able to function in the flight, and will be forced to admit to your ignorance in pre- and post-flight briefings. On the other hand, diligent study of the following terms will allow you to understand what is being said.

FORMATION: A disciplined flight of two or more aircraft under the command of a flight leader, using a standardized set of signals and commands to direct the wingmen. 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**. (Also see the FAA definition of a formation in the section dealing with basic formation training.)

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

DIVISION OR FLIGHT: Four aircraft, consisting of two sections or elements, each with its own leader, but under the command of the lead element's leader, who is designated "flight lead". The flight is usually led by the most experienced pilot, with the second element leader as his deputy flight lead.

SUCKED: To fall behind the lead, or be too far out on the position bearing to be able to join up with available engine power.

ACUTE: The opposite of "sucked". To be in a position too far

forward in the formation or on a bearing (angle) that would place the aircraft too far forward during rendezvous, creating an uncomfortable closure rate and angle for the joining aircraft; vis., an "acute" rendezvous bearing as compared to a "sucked" rendezvous bearing.

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

WINGTIP OVERLAP: No lateral separation exists. A time to be smooth and concentrate if you also have nose to tail overlap.

STEP DOWN: The #2 aircraft is a couple of feet or more lower than the lead. This allows room to maneuver in case of turns into the wingman.

STEP UP: What the thinking wingman does when the leader is making low passes down the runway!

BEARING: The horizontal angle off the lead as flown by the #2 aircraft. (If the wingman were to overrun his leader and fly too far forward of a proper position, he would be on an "acute" bearing. If he is too far aft of his proper position, he is on a "sucked" bearing. Not to be confused with gentlemanly conduct, or officer-like "bearing".)

RENDEZVOUS: To join the flight onto the leader, as after takeoff. Also a gathering of pilots after a mission, wherein there may be a lot of rowdiness, drinking, and ungentlemanly bearing.

THE BREAK: The breakup of the formation over the runway when a flight does a 360 overhead entry into the traffic pattern. Also called "pitchout". A Fighter maneuver indicating an abrupt

bank and yank to accomplish a change of direction and/or altitude. It looks Sierra Hotel!

SIERRA HOTEL: Phonetic equivalent of "shit hot", used to designate anything which is outstanding, and deserving of the praise of fighter pilots.

KISSOFF: Signal passed by lead to the rest of the flight just before he slams the stick over to break, symbolically "kissing them off" as the flight breaks into individual aircraft for landing.

"GIMME ONE" "GIMME SOME": What the wingman calls to the lead when he has insufficient power to keep up, asking for lead to reduce power by one inch or more of manifold pressure.

CALL SIGN: The code word or words that designate a flight, usually selected by the flight leader for that particular mission. The flight then would be designated (In the case of a call sign of "Red Flight") as; "Red Lead", "Red Two", "Red Three", and "Red Four". In the case of large formations divided into flights, the flights might be divided as follows; Red, Blue, Yellow, etc. Or, Alpha, Bravo, etc. Any combination of names can be used, depending upon the imagination and audacity of the flight leader.

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

PARADE: Formation configuration to be used when under observation by the public, as in an airshow appearance. Parade formation is demanding, since the aircraft are in close physical proximity to each other. It requires absolute concentration on the part of the wingmen, and smooth leadership by the flight lead.

ENROUTE: A much looser version of the above, applied to any formation during cross-country flight. It allows the leader to control the flight, and reduces fatigue on the wingmen. Wingmen maintain the same relative bearing on the leader, but move out to allow nose to tail and wingtip separation.

SMASH: Airspeed or Energy. Normally used to denote energy available to accomplish a snappy fighter-type maneuver, such as a pitchup to landing.

INITIAL: As in initial approach. Refers to the approach on runway heading used when doing a 360 overhead break. The leader will call his position on initial, as; "300 Sierra Hotel, flight of four T-34s on a two mile initial for a 360 overhead on runway 18."

GIB: Guy In Back, meaning your backseater.

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

NO JOY: Used to indicate that you have not visually acquired whatever it is you are looking for.

HUMMER: Any neat gadget you can't remember the name for, or which you think has been saddled with too mundane a name to use.

SLUGGER: The other general aviation airplanes, which do not participate in formation or other fun fighter pilot-type activities. Also known as "Spam Cans".

FORMATION BASIC TRAINING

FORMATION DISCIPLINE

Discipline as it is related to formation flying arises by necessity out of the very nature of the activity. Webster defines discipline as: "1. Training that is expected to produce a specified character or pattern of behavior, especially that which is expected to produce moral or mental improvement. 2. Controlled behavior 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. You have to buy into the program 100% if you expect to succeed, and that can be the toughest part of learning to fly formation. Our fundamental perspectives as pilots must shift from the self-reliant individualistic orientation of single aircraft operation to a realization and acceptance of our roles in a collective effort. Each member of the flight must fly his position properly, and if he does this, confidence will suffice the entire formation. That extends from the leader to the wingmen.....all of them. It covers the entire flight, from start-up, radio check-in, taxi, takeoff, maneuvering, arrival, and shut-down. A formation that performs in concert is a thrill to participate in, but a formation that lacks discipline will degenerate into an uncoordinated, haphazard, and dangerous gaggle of aircraft which may or may not be going the same way, on the same day.

The following basic formation training procedures and techniques will start you on the road to the Wingman Patch. As an aspiring wingman, you must first accept the authority of your leader, promptly responding to his hand signals and maintaining the proper position within the formation. Acceptance of this most basic of formation tenets is the first step towards the Wingman Patch.

BASIC CONCEPTS

We define a formation as two or more aircraft flying in close proximity with all movements coordinated. The smallest formation unit is a section or element (we consider the two terms synonymous.) of two aircraft, comprised of leader and wingman. The next basic formation unit is a division, which is made up of two elements or sections. These are basic military tactical units, created for the sole purpose of providing mutual protection in air-to-air combat. Our manual is based upon these units, but not because we expect to have to shoot down marauding Cessnas. We stick to the basic military formation because the rules provide the greatest flexibility when increasing the size of a formation. As you read further in the manual, you will note that the largest formation shown is the four-ship division. However, the resounding success of our large Oshkosh formations (up to 34 T-34s) is testimony to the validity of our basic procedures.

As a point of interest, the FAA defines formation flight as follows: "FORMATION FLIGHT-More than one aircraft which, by prior arrangement between the pilots, operate as a single aircraft with regard to navigation and position reporting. Separation between aircraft within the formation is the responsibility of the flight leader and the pilots of the other aircraft in the flight. This includes transition periods when aircraft within the formation are maneuvering to attain separation from each other to effect individual control and during join-up and breakaway.

1. A standard formation is one in which a proximity of no more than 1 mile laterally or longitudinally and within 100 feet vertically from the flight leader is maintained by each wingman.
2. Nonstandard formations are those operating under any of the following conditions:

- a. When the flight leader has requested and ATC has approved other than standard formation dimensions.
- b. When operating within an authorized altitude reservation (ALTRV) or under the provisions of a Letter of Agreement.
- c. When the operations are conducted in airspace specifically designed for a special activity. (See Altitude Reservation) (Refer to FAR Part 91)

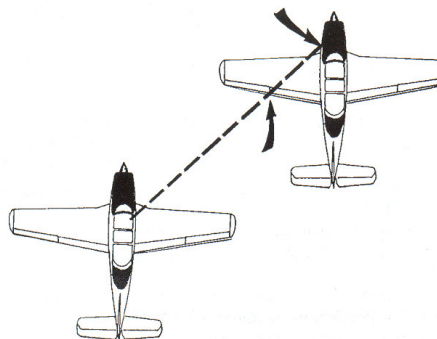
GENERAL RECOMMENDATIONS

Notwithstanding the T-34 Association disclaimer contained elsewhere in this manual, there are some general rules that should be followed prior to starting your training.

1. You should have at least a Private Pilot License.
2. You should have a qualified instructor. (The T-34 Association and the North American Trainer Association designate check pilots who may be available for instructional purposes.)
3. You should always wear a parachute and be thoroughly briefed on it's use.
4. You should be psychologically prepared to use the parachute if it becomes necessary.
5. You should wear appropriate flight gear, to include helmet, flight suit, and gloves.
6. All formation flights must be briefed prior to takeoff.

STATION KEEPING

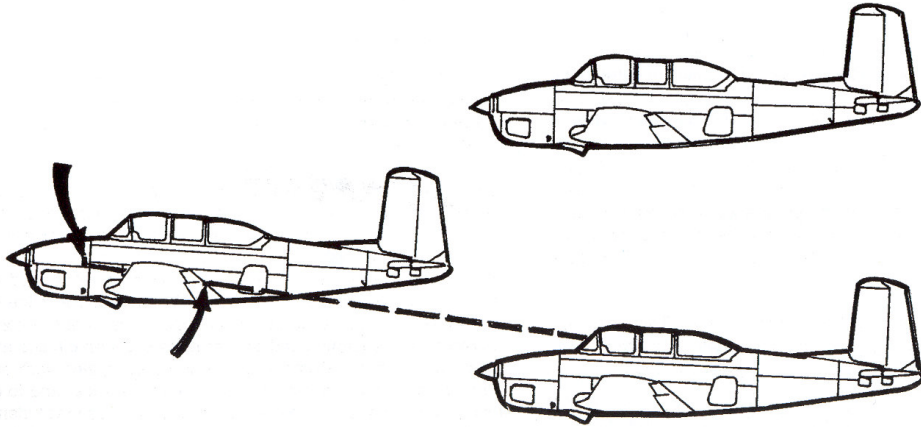
When you began flying, there was a heavy emphasis on the physical skills required to control the aircraft. You were now dealing with another dimension, which required a new awareness on your part. Landings were particularly difficult, since they required you to fine-tune your sense of depth perception. Once you had mastered this phase of your flight training, the emphasis



Sight line of wingman passes through aileron-flap junction at trailing edge of wing to last cowl latch on the T-34.

shifted to "head work", and the more you advanced, the more emphasis was placed on numbers. FAR's, aircraft performance figures, navigation, weather, and defining personal limits became the most important elements of flying. The actual control of the airplane was relegated to the status of riding a bicycle.....once you know how, you never forget.

Formation flying is going to take you back to basics. Your sense of depth perception is more important than ever because *in formation flying, relative motion is everything*. Station keeping...maintaining position on the leader.....is control of the relative motion between your airplanes. To maintain your position, the motion must be stopped. To maneuver 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 motion will involve movement around any one (or more) of three axes, up, down, or sideways. Fore and aft motion is controlled by



Nose to tail separation should be maintained. Normal step-down and step-up positions are shown.

use of the throttle, while vertical displacement is controlled by the elevator. Horizontal motion is controlled by coordinated use of aileron and rudder (mostly rudder). Movement of any of these controls will affect station keeping, and a new awareness of aerodynamic principles is bound to result once you become attuned to station keeping.

Smoothness is a most desirable characteristic in both leaders and wingmen. This is usually developed with time and experience. Eventually, practice will enable you to sense and stop the slightest relative motion between your airplane and that of the leader. Your control movements will be so minimal that a passenger in your airplane may not even realize how you are maintaining such perfect position! But 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 increasingly difficult to stop.
2. Strive to make small, timely corrections. Slight relative motions are hard to recognize, but easy to manage. The greater the relative motion, the more difficult it is to stabilize. Relative motion can be recognized if you are concentrating on two points on the lead aircraft. When flying on a T-34, we suggest you line up the flap-aileron junction with the last cowl latch. If these two points begin to diverge, do something to stop their motion. (If the cowl latch disappears, you are going low. If it moves forward, you are getting sucked. If it moves back, you are acute.) Other types will have different refer-

ence points, but it is imperative that you establish two reference points on the target aircraft so that you can sense and correct relative motion quickly.

3. Trim the airplane. There are two schools of thought on this, and either one may work for you. Try them both, then make your own decision.
 - A. In rough air, it is sometimes better to trim the airplane a little nose-down, so that you are holding some tension against the stick. In theory, this will damp out unnecessary control inputs. (It is worth noting that the Blue Angels have adopted this practice, and they use A LOT of nose-down trim.)
 - B. In smooth air, trim the airplane for one G flight, rest your arm on your leg, and relax. Your control movements will smooth out, and formation flying will become easier.

(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 damp out excessive control inputs which lead to uncontrollable oscillations.)

4. Adjust your throttle quadrant friction knob so that you can move the throttle easily, but with enough resistance to allow you to sense movement. Keep your hand low on the throttle lever, heel of hand on the quadrant.

FORMATION EXERCISES

The 45 degree off position, as defined above, is the standard wingman position in the T-34 Association. This position, with the appropriate visual references, should be demonstrated to the student formation pilot by his instructor. Other variations on this position which can be demonstrated include:

1. Stack up on the lead airplane.
2. Level with lead

(Note that neither one of these positions is ever assumed by the slot man in the diamond formation, and the level position should only be demonstrated as visual reference, but never flown as a standard position.)

Once the student has established himself in position, he should practice moving out and in on the imaginary 45 degree line that runs from his airplane to that of the leader. This exercise will demonstrate the importance of coordinated use of all controls. If this maneuver is properly executed, the relative positions of the two aircraft do not change, only the distance between them varies. This exercise should be practiced until the student is able to recognize separation and closure rates between the aircraft and stabilize them. Common errors to guard against include excessive throttle movement, which causes exaggerated fore and aft movements and target fixation, which blinds the student to closure or separation rates. Large pitch changes should also be avoided, though they tend to be much more dramatic and are easily and quickly recognized. If at all possible, the instructor should demonstrate these errors to the student, along with the appropriate corrective measures.

Radius of turn is a fundamental concept in formation flying which must be thoroughly understood 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 its angle of bank and airspeed. For example, at a constant 20 degree angle of bank (AOB) and indicated airspeed of 120 knots, a specific radius of turn will result. If the airspeed is increased to 150 knots and the AOB remains at 20 degrees, a larger radius of turn will result. If the airspeed is decreased to 100 knots, a smaller radius will result. If the AOB is increased, the radius of turn will decrease. A combination of increased AOB and de-

created airspeed will result in an even smaller radius of turn. (Until the airplane stalls.) In Summary:

- A. With a constant bank angle (AOB):
 1. Increasing IAS will increase radius of turn.
 2. Decreasing IAS will decrease radius of turn.
- B. With Constant Indicated Airspeed (IAS):
 1. Increasing AOB will decrease radius of turn.
 2. Decreasing AOB will increase radius of turn.

This is a basic flight training concept which should be reviewed and thoroughly understood by a formation student. It's importance will become immediately evident in preflight discussions concerning join-ups.

Understanding the effect of angular relationships between aircraft is essential for proper control of relative motion between aircraft in formation. Generally speaking, any change from a parallel relationship between the axes of leader and wingman will result in a change in relative motion and a consequent displacement of the relative flight paths of these aircraft. Depending upon the direction of displacement, aircraft separation will decrease or increase. This becomes graphically clear when flying in relatively close formation, when a small displacement creates an immediate position change. What is less obvious, but no less critical, is the change that takes place when the flight is separated, and attempting to rejoin.

In order to demonstrate this, put yourself a few hundred yards in trail behind the lead aircraft. Ask the leader to begin a constant rate turn. When he turns, match his turn immediately, placing his aircraft at 45 degrees angle off your nose. If you turn at the same

time, and stop his relative motion in your field of view, you will join up on the lead aircraft, quickly or gradually, depending upon the angle of bank chosen. If you wish to remain in trail, you must wait until you reach that spot in the sky at which the leader began his turn. Note that, if you turn when he does, your view of his airplane changes from the 12 o'clock position to a few degrees either side of dead ahead, and you will begin to join up on him. Now, if you are far enough back, and his angle of bank is shallow enough, you may not notice this action taking place right away, but it is happening!

A quick join-up is effected by assuming the normal wingman position on the lead aircraft. That is, by positioning the lead aircraft at the 2 o'clock or 10 o'clock position from your airplane. Line up those two points of reference on his airplane that we talked about earlier as soon as you are close enough to distinguish them. If he remains in the turn, you will cut him off and join up, simply because your turn radius is smaller than his. Simple geometry will show you that it is much easier to achieve a snappy joinup if you maintain a position that guarantees you will cut off the lead airplane. That means turning inside of him. Keep that in mind, and your joinups will happen more or less quickly. Remember that if you exceed the "ideal" 45 degrees angle-off joinup position (becoming acute), you will be faced with a possible overshoot. The key to a smooth joinup is achieving the ideal 45 degree angle off, then holding the lead airplane stationary in your field of view. Any movement of the lead will result in an overshoot or undershoot.

The overshoot usually comes as a complete surprise to the student, whose eye is not trained to recognize the increasingly rapid rate at which the target airplane is growing. Just make damn sure you overshoot *under* the target, stabilize to the outside of the turn, then turn inside again to complete the joinup. If it looks as though you might stop the overshoot by increasing your angle of bank dramatically.....DON'T! This usually leads to a situation where the target disappears under that lifted wing,

which prevents you from seeing if you actually did stop the overshoot. This can be hazardous to the health of everyone involved. NEVER go belly-up or lose sight of the leader! Having given this admonishment, it is also necessary to caution against being too low on the joinup. Many a perfect joinup has been blown by the wingman coming in 50 or 100 feet too low, then rolling out on the same heading as the leader and, as he pulls up into position on the leader's wing, he falls back because he has expended his reserve energy on the pull-up.

Having less than the desired angle-off will result in your falling behind (getting sucked). You can tell when you are getting sucked if the joinup does not happen. You just keep going around and around in a turn, never seeming to close on the target airplane. (A good rule of thumb is that experienced wingmen should join up within 180 degrees of turn, while a novice should be able to join up within 360 degrees of turn.

POWER MANAGEMENT

.....is one of the most important aspects of formation flying. When flying in parade formation, you will probably be making continuous throttle adjustments in order to maintain position. This is where alignment of those two points on the target airplane becomes so important. Concentrating on those points allows you to make *minute* throttle adjustments. If you try to concentrate on the whole airplane, you will find yourself making large adjustments in order to control relative motion which is erratic and dramatic.

In a perfectly executed joinup, you should not have to make any throttle adjustmentstheoretically. (Since you will be matching the leaders turn rate and radius when you joinup, you should only have to also match his power setting in order to achieve perfect harmony.) However, we all know it is not a perfect world, and leaders have been known to A.) turn into wingmen at the critical moment of joinup, in order to induce an overshoot. or B.)

Increase power, rate of climb, or angle of bank during joinup. Any of these will require power adjustment. Don't be afraid to use whatever power setting is required in order to maintain or achieve position! Formation flying requires the coordinated use of all controls, including the throttle.

In the case of the T-34 and the T-28, it is possible to get radical power mismatches within the same formation. T-34s are currently flying with 225HP, 285HP, 300HP, 400HP, 420HP, and 550HP engines. (The latter three are turbines.) The T-28s face similar mismatches between A, B, C, and Fennec models. When a formation is assembled with aircraft of diverse power, it is necessary to know the capabilities of all aircraft, and the power settings which will allow enough margin for the slowest aircraft to keep up.

CROSS-UNDERS

The proper cross-under is done in several steps. The practiced and proficient wingman will do it in one smooth, continuous motion. The fundamental, by-the-numbers method is: The wingman, when given the signal to cross under, will acknowledge the signal with a head nod, then reduce power very slightly so as to slide to the rear and down to a position which gives nose-to-tail separation and stepped down far enough (probably at least 10 feet) to avoid propwash as he crosses under. Power is added to stabilize the rearward movement. The cross under is accomplished with coordinated use of the controls, with the wingman completing the maneuver in the same relative position on the other side of the lead airplane. Note that as you cross under, you will have to add power to keep from getting sucked, and to move back up into position. When a second section is moving across under the first section, the wingman in the second section (#4) will also, simultaneously and automatically, without being signaled to do so, move further across his section leader so as to