Advanced Formation Technique Review

Why Are We Here???

- Improve our formation artistry
- Airshow quality flight
- Earn an FFI card
- Better understand safety issues
- Fly with any FFI fourship in the USA
- Enjoy a weekend with some great people!

Formation Basics

Formation Training Tools

- T-34 Formation Flight Manual.
- Bonanza Type Specific Addendum.
- Darton Formation ‘The Art’ Video
- www.b2osh.org training pages
- FFI Program Manual
- No formal instruction available in GA

Formation Flying

The FAA defines FORMATION FLIGHT .. more than one aircraft which, by prior arrangement between pilots, operate as a single aircraft with regard to navigation and position reporting. A standard formation is one in which a proximity of no more than 1 mile laterally or longitudinally and within 100 ft vertically from the flight leader is maintained by each wingman

Glossary of Terms 1

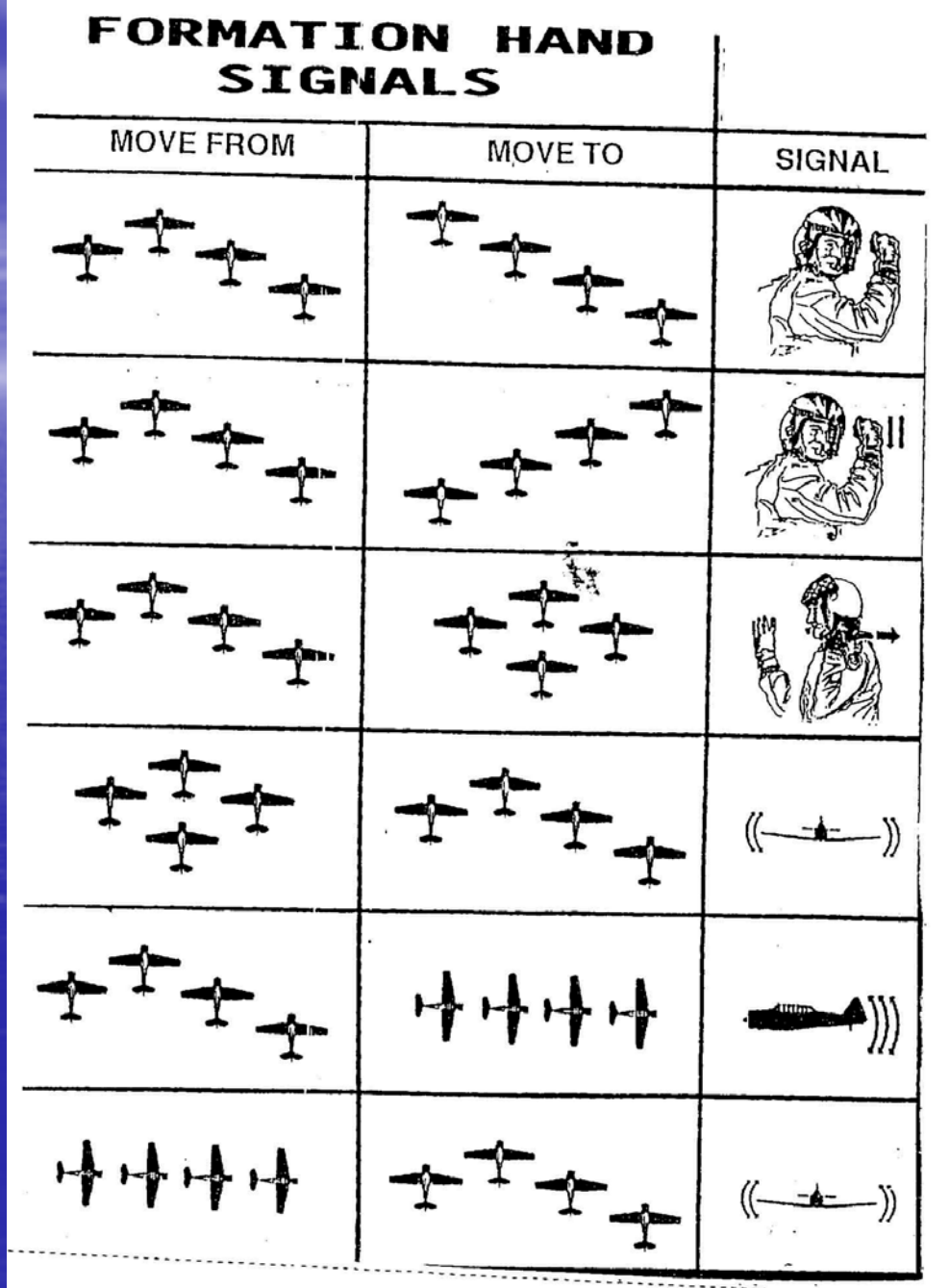
- Formation
- Gaggle
- Section or Element
- Division or flight
- Sucked
- Acute
- Nose/Tail Overlap
- Wingtip Overlap

Glossary of Terms 2

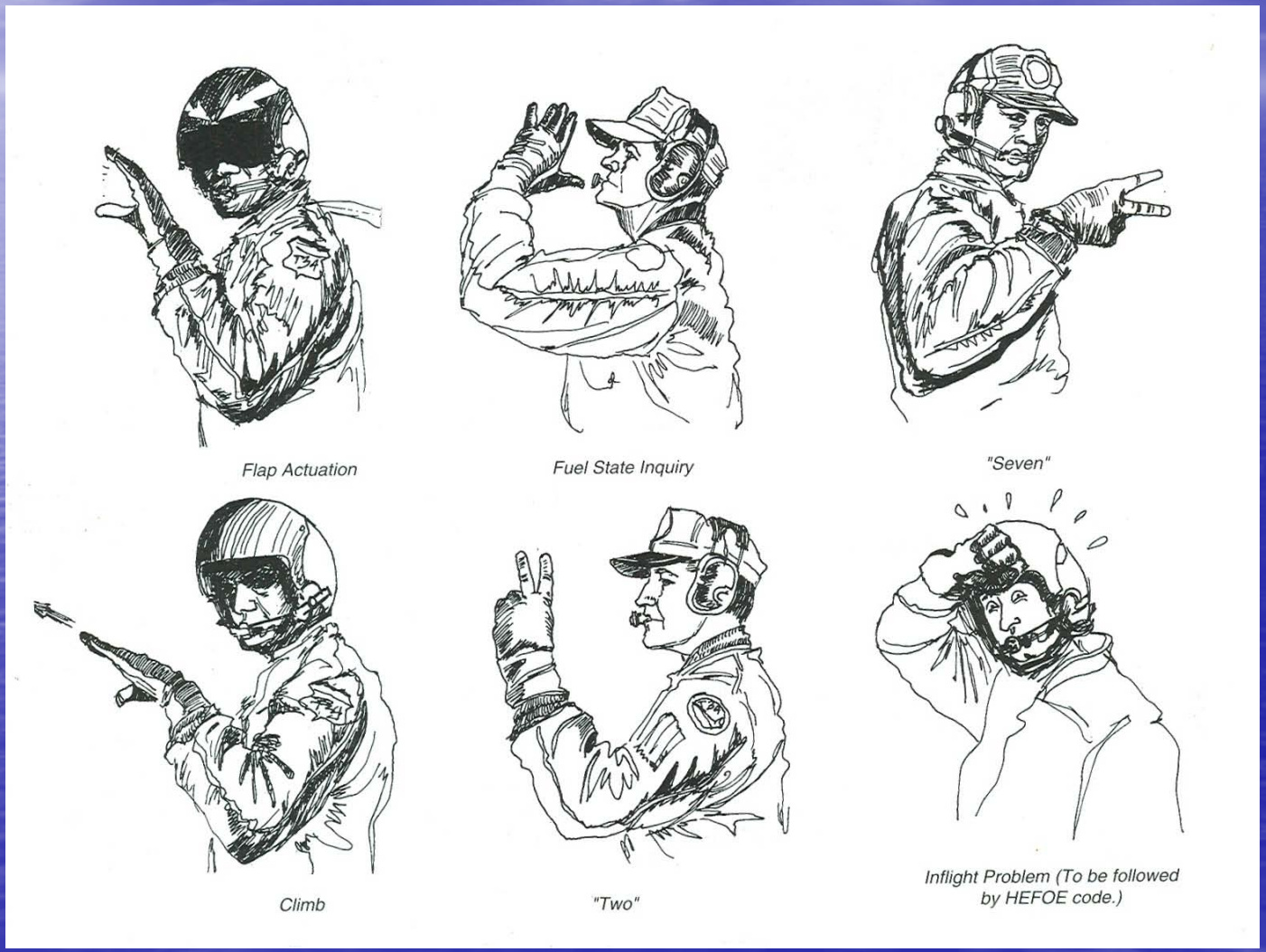
- Step Down
- Step Up
- Bearing
- Rendezvous
- The Break
- Gimmie One
- Call Sign
- Bingo Fuel
- Parade
- Enroute
- Smash
- Initial
- Gib
- Tally Ho
- No Joy
- Hummer
- Slugger
- Sierra Hotel
- Kissoff

Hand Signals 1

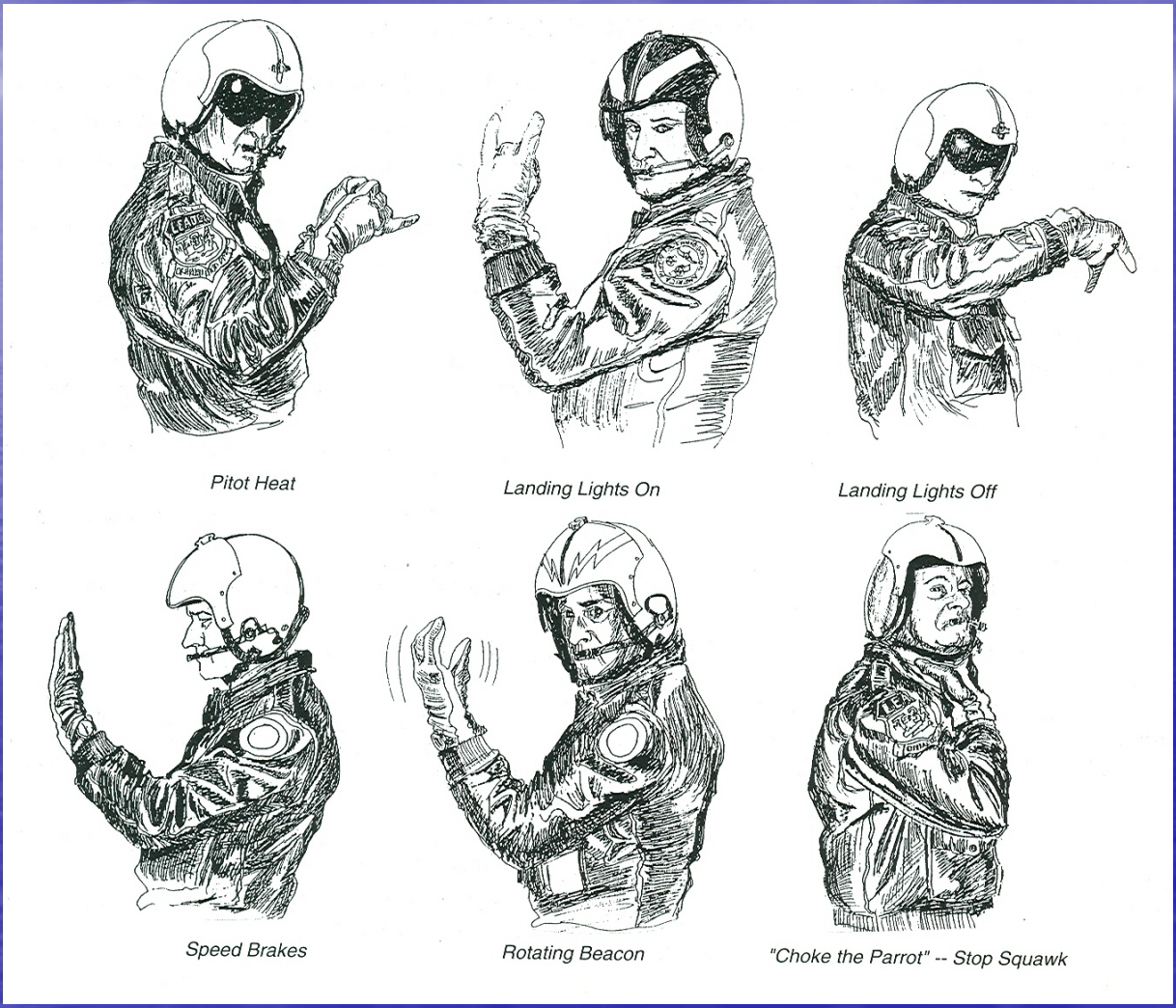
- Cross under #2
  - One hand up
- Cross under #3,#4
  - Hand pump
- Diamond
  - 4 fingers to back
  - 4 calls “4’s in”
- Back to where you were
  - Wing rock
- Kick out
  - Tail wag side to side
- Go in trail
  - Porpoise
- Break to extended trail
  - Finger in circle with # fingers
  - Break to land



Hand Signals 2



Hand Signals 3



Hand Signals 4

ADDITIONAL HAND SIGNALS

GO TO PRE-BRIEFED RADIO FREQUENCY: Tap ear with index finger, extend index finger. (Variations on this have been used, for example, the common signal for the T-34 frequency is an extended middle finger. It is advisable to pre-brief this signal to avoid unpleasant post-flight confrontations.)

CAN'T HEAR: Move open palm of hand past ear, back and forth.

CAN'T TRANSMIT: Move open palm of hand past mouth, back and forth.

EXTEND LANDING GEAR: Clenched fist, thumb down, downward motion, head back against headrest (viz), nod forward to execute.

RAISE LANDING GEAR: Clenched fist, thumb up, upward motion, head back against headrest, nod forward to execute.

FLAP ACTUATION: Thumb and fingers together, opening and closing.

REDUCE POWER: Palm open, facing rearward, motion to rear.

ADD POWER: Clenched fist, arm in forward motion.

INFLIGHT EMERGENCY: Clenched fist up to forehead, land as soon as possible. If radio does not work, the following number (by raised finger(s)) indicate the nature of the emergency:

1. Hydraulic
2. Electrical
3. Fuel
4. Oxygen
5. Engine

These signals are often referred to with the acronym; "HEFOE"

O.K. OR READY TO GO, IF ON GROUND: Thumbs up

LEVEL OFF: Palm flat, moved back and forth in horizontal.

ENGINE RUNUP: Clenched fist, index finger extended and rotated.

BREAKUP SIGNAL: Clenched fist, with index finger rotated. Break interval signaled with number of fingers extended after rotation.

STACK DOWN IN FORMATION: Lead extends palm of hand downward, with downward motion.

STACK UP IN FORMATION: Lead extends palm of hand upward, with upward motion.

LEAD CHANGE: Lead points to aircraft he wants to assume lead, then points to front. Pilot so designated should acknowledge this signal by patting the top of his head and pointing forward.

In all cases, the wingman should acknowledge receipt and understanding of any signal by nodding his head.

Duties of Lead

- Invites each pilot into the formation
- Plans and conducts a safe flight
- Knows capabilities of each pilot in flight
- Maintains control of flight from brief to debrief
- Maintains communications with ATC and flight
- Flies smoothly
- Slow changes in parade formation (roll, pitch)
- Think 18-wheeler, not ferrari
- Navigates and clears traffic
- Signals all flight reconfigurations
- Coaches as needed
- Efficient use of flight time

Lead Radio Procedures 1

- A good lead has good formation communication skill
- All communications must be concise and appropriate
- Lead avoids unnecessary calls, unnecessary details
- Formation flight adds many unique terms and phrases for lead
- Avoid embarassing check-in problems on public frequencies
- Practice a few check-ins and frequency changes during the brief
- Idle chatter never allowed on public frequencies. Chatter on the intraflight frequency not allowed in the terminal environment or show

Radio Procedures 2

- T34 and FFI standard method
  - Everyone in flight talks and listens on the same frequency.
  - Lead moves flight to each new frequency
  - “Go” – [go through the whole procedure] acknowledged command to change to a new frequency. Entire flight must acknowledge in sequence before moving to new frequency. Lead checks in flight on new frequency after a complete acknowledgment sequence is heard on the old frequency. Lead must “find” unacknowledged wingmen for safety.
  - “Push” – [just push the button] unacknowledged command to change from a congested frequency to a new frequency. Lead’s option to check flight in on new frequency. Good for congested frequencies or very large flights and avoids embarassing mistakes in acknowledgment and check-in. Makes it possible that someone is not on frequency and won’t hear something vitally important for flight safety.

Duties of Wingmen

- MAINTAIN SEPARATION FROM LEAD/OTHERS 100% OF TIME
- LOOK AT YOUR REFERENCE PLANE 100% OF TIME WHEN CLOSE
- Be safe
- Be slow/smooth if you have someone on your wing
- Follow lead's commands
- Match lead's attitude and velocity at all times
- Maintain exact station by precise reference point alignment
- Initiate corrective action as soon as you diverge
- Come back TO reference point, not THROUGH reference point
- Move farther away if you need to adjust things, request a kickout if you have something that needs a lot of attention
- Check in reliably, acknowledge commands, don't acknowledge info
- Maintain discipline

Coming back “to”, not “through”

- “through” leads to pilot induced oscillation
- Correction Process:

A. Recognize a deviation from proper position, attitude, and/or velocity

B. Choose a proper sequence of inputs to correct the problem
   - Initial correction generates closure toward where you want to go
   - Secondary input initiates deceleration as you get close to where you want to be
   - Third input restores attitude and power to correct state to be stationary relative to lead at the proper flying position

Tips for Wingman Smoothness

- Rest hand on throttle quadrant, or touch finger to throttle wall (precision)
- Rest yoke arm on thigh or armrest (stability)
- Hold yoke lightly with fingertips (precision)
- Eliminate pilot-induced oscillation
- Use push/pull on throttle rather than vernier
- Fly straight and level while relaying a signal. (Use throttle hand to make the signal, don't twitch yoke hand. Don't twist torso)
- Use small relative bank angles or rudder in close
- Fly straight and level before pitchout, no "lean"
- Master your plane

Duties of #2

- Sets geometry for flight – step down, step back, step out
- Adjusts spacing for safety – bumpy air, twitchy lead, aggressive maneuvers, traffic avoidance
- Holds a stable position without variation
- Sets a position that everyone can hold
- Establishes 45° join line for #3 and #4

Duties of #3

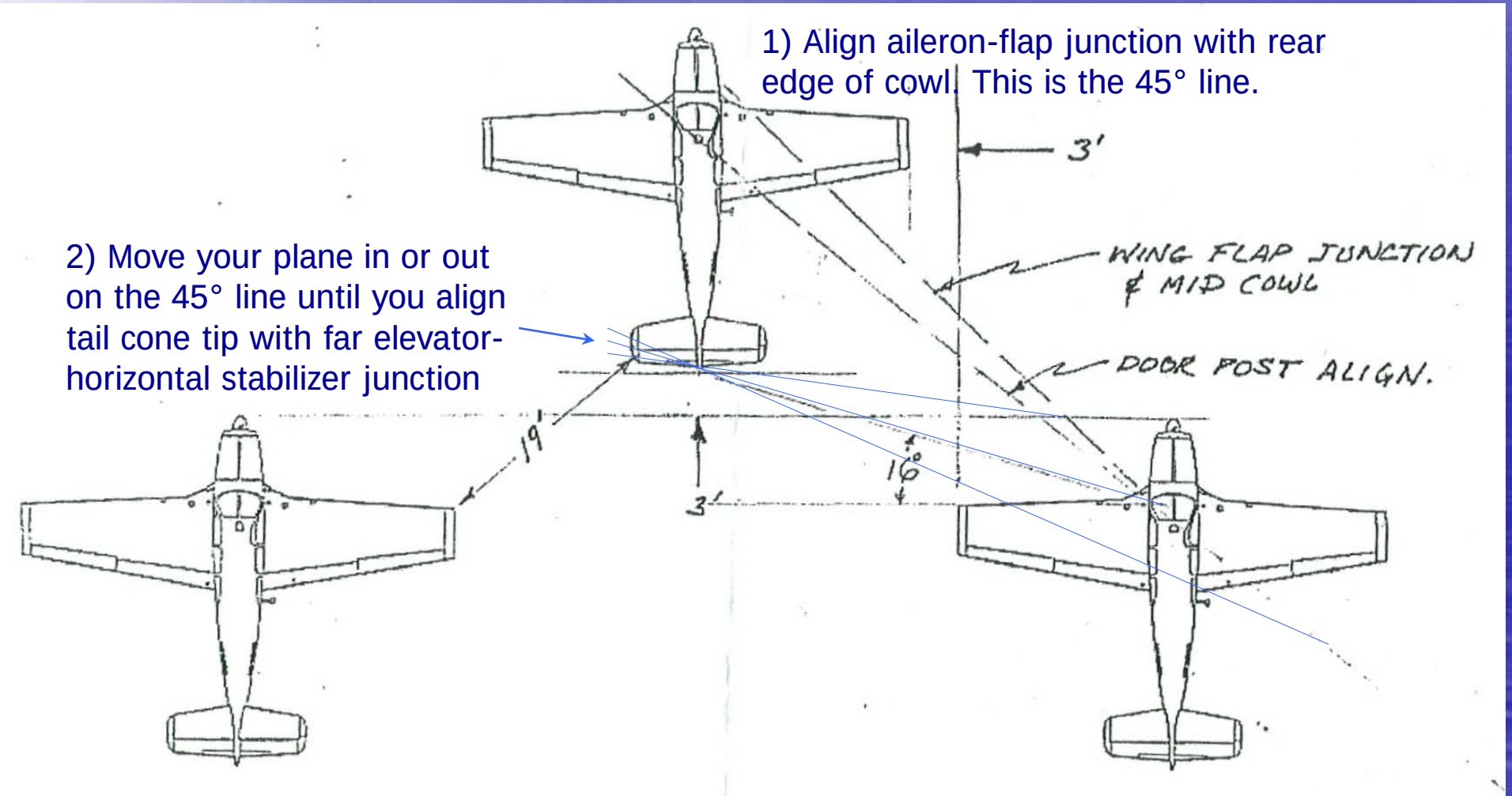
- Dual reference on lead and #2
- Matches #2 geometry exactly – level with 2, wingspars aligned, same angle to lead, or, puts #2's head on lead's head
- Leads #4 when broken out as separate element

Duties of #4

- Put #3's head blocking lead's head
- Match interplane spacing
- Make the formation look pretty
- Wide angle vision in slot – 3 planes collision hazard, deal with obstructions (glasses, posts)
- Longest distance to travel in rejoin
- Be wary of sudden moves and instabilities

Wingman Position - Top View

- 3’ step out, 3’ step back happens when reference points are simultaneously aligned at cowl and empennage



Wingman Position – Step Down

- In parade formation, top edge of near wing should be barely visible or barely not visible

Standard Formation Turn

- Maintain sight picture
- Add power and go up for outside
- Reduce power and go down for inside
- 1 to 3 kts speed difference in close formation
- 54’ vertical spread at 30° bank in fingertip
- Lead’s slow roll rate allows wingmen to maintain welded wing

Echelon Turns

- Maintain same altitude (not welded wing)
- Keep adjacent plane's lower wingtip on horizon
- Roll out should be in position
- Plane #2 shown is high
- Beware collision hazard on rollout

Instability in Turns

- Do not move in/out on the 45 in turns
  - On inside moving down, you need to reduce speed while descending which may rapidly move you acute
  - On outside moving up, you need to increase speed while ascending which may rapidly move you sucked
  - Instead, move in/out a little bit on 45 if needed then make any further movement parallel with lead

Locking Down Unstable Formations

- Some formations seem to wiggle and wave, can't get steady
- Likely problem is wingmen are flying on the adjacent plane instead of the lead.
- Flying on the adjacent plane amplifies oscillations as they progress from 1 to 4. This can create unsafe situations, especially in larger formations.
- Stay far enough away from the adjacent plane so that you can fly on lead and let your neighbor oscillate freely inside his "bobble box"
- Maintain safe separation from the adjacent plane at all times
- If you can't reference position simultaneously on your neighbor and lead, be sure to maintain separation from the adjacent plane first
- If you see people not flying on lead or oscillating excessively, call "lock it down"

Dissimilar planes

- Flying dissimilar planes requires detailed review of the entire sequence of flight to verify compatible operations
- The greater the dissimilarity, restrict formation flight to simpler maneuvers like straight and level flight
- Even similar planes (Bonanzas) have quite a bit of variation from model to model
- Check weight and stall speeds. A36 lands with approach flaps with J35 having no flaps to best match landing speeds.
- Beware possible bounced landing or stall on landing flare or varying lift off speeds – all exacerbated by type differences on takeoff/ldg
- Descent and climb profiles need extra review
- Allow turbos more time to shut down
- Gear speeds, landing speeds, stall, takeoff, cruise, slipperiness, max speed, flap speeds

Runway Air

- Lots of dirty air in formation at the runway
- Land and takeoff 5 to 10 kts faster for more control authority near ground
- Consider half or no flap landing for more stable transition from air to ground
- Pitch control critical to avoid bounces

Pitchout and Rejoin Procedures

Pitchout Procedure

- Break from echelon
- Signal - circle finger then show # of seconds. 3 seconds beginner, 5 seconds advanced (10 seconds hazardous)
- Snappy precise 45° degree bank to extended trail in 180°
- #2 sets the break interval. Don’t lean into turn
- When all four planes in straight line at same altitude, #4 calls “in”

Rejoin

- Difficult to do efficiently, artistically, safely
- Fighter pilots train to do it a million ways
- A common procedure is covered here – from 1 mile long trail to parade fingertip in 360°

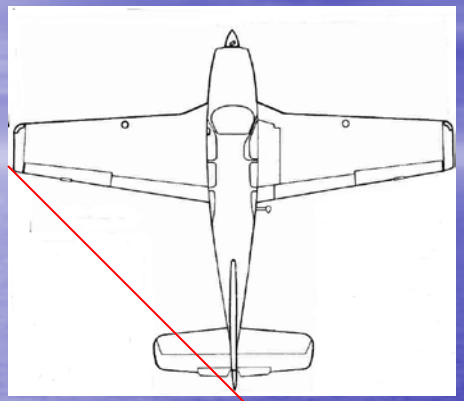
Basic Rejoin Strategy

- 2, 3, and 4 cut inside lead's turn to catch up
- When getting close to catching the lead, 2, 3, and 4 safely approach the lead by
  - Intercepting the 45° join line in order with adequate extra spacing to stabilize
  - Riding up the 45° join line until joined in fingertip

Use Angular Cutoff for Advantage

- Bid to the inside of the turn
- Head directly to a spot where you can join expeditiously
- Reduce time on the join line for faster rejoin
- Stay inside of planes ahead to gain on them
- Leave room at end to turn your plane to align the fuselage
- While cutting off lead, keep your nose ahead of lead – not behind
- Don't go so far inside as to
  - have a head-on collision, or
  - have a difficult time getting turned onto the 45 degree join line, or
  - join ahead of the planes in front of you, or
  - have a hard time seeing all planes at once
- Expect a big angle of bank when you finally turn to the join line
- When banking hard, don't lose sight of anyone ahead under the glare screen! Left hand turns very tough!! Drop another 20 feet if needed to give more visibility over glare screen.

Flying the 45° Join Line

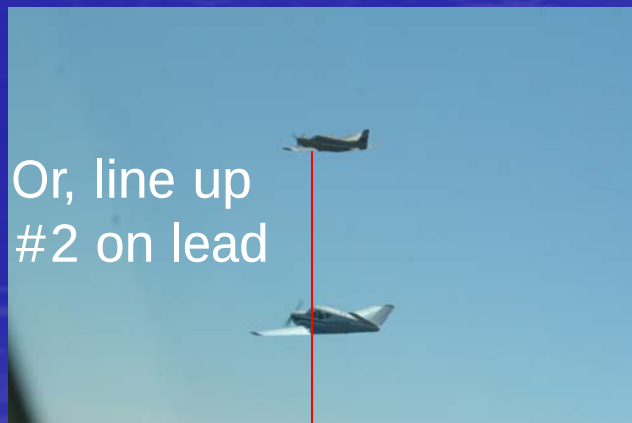


To fly the join line, put the lead's tail cone underneath the far wing tip. Use it as your CDI. Turn your plane as needed to cleanly intercept the line and hold it. Those who can't see clearly can just line up #2 on lead (if #2 can maintain position on the rejoin line!). The join line is defined by lead's plane only.

Acute, turn left

Sucked, turn right

Just right.
Hold it here



Or, line up
#2 on lead

Changes in Altitude during Rejoin

- Don’t change altitude
- Keep the lead on the horizon
- When close enough to tell, stay 20’ below the plane in front of you until stable
- Don’t ride up the normal 45 degree sight line (wing walk barely visible) or you will be WAY TOO LOW. If you do, keep speed and power up!
- Significant change in altitude interferes with airspeed stability and slows the rejoin

A Detailed Rejoin Procedure

- Starts with 5 second pitchout interval from echelon to trail
- Lead rocks wings to signal start of rejoin
- #2, #3 & #4 sharply turn 20 to 25 degrees to cut off lead
  - Use angular cutoff to gain on the plane(s) ahead
  - Keep lead on the horizon, stay in order (2, 3, 4), always be able to go below and behind all planes in front of you
- Adjust that heading to optimize interception of the 45° join line
- No need to touch the throttle until close.
- #2 joins on inside
- #3 & #4 join on outside into fingertip formation
- Don't join tightly on the plane in front of you until it is established in formation with lead
- If overtaking too fast, go to outside of turn by passing below and behind planes in front of you
  - Don't go belly up to inside of turn, very unsafe

Play Rejoin Simulation Here

Real life Rejoin #1

- #2 is low and acute
- #3 is on the 45 but a little above #2
- #4 has lead on horizon but risks a safety hazard being above #3 and #2. He must not lose them under glare screen or be unable to fly under and behind them

Real life rejoin #2

- Sweet 45 degree join line
- Better if lead is on horizon

Ways to expedite the rejoin

- Fly a more acute join line than 45 degrees
- Increase airspeed - lots far away, gradually bleed it off when getting close
- Fly more direct to the join up point - intercept the 45 join line as close to others as safely possible
- Get #2 joined faster so #3 and #4 can take a more aggressive line to lead
- Delay interception of join line a bit while staying inside to gain on the plane ahead of you
- Avoid hazard and risk, adjust technique slowly

Climbing and Element Rejoins

- Use 10° bank angle for climbing rejoin
- For element rejoin, #4 starts inside #3 and automatically crosses under as #3 passes behind #2 and #1.

Rendevous Rejoin

- Pre-brief via phone or email
- Fly to prebriefed navigation point
- Using radio and GPS distance to waypoint to determine order of join
- First one there circles the point at specified altitude and direction
- Use the radio, skywatch and/or smoke to help maintain separation – don’t rely on visual plane acquisition to prevent a collision
- Second plane approaches the navigation point at least 500’ below first plane until lead plane in sight
- Fly to inside of lead’s circle, find the 45° join line and join
- Subsequent joining planes stay in a known clear area, distance, or altitude until all planes ahead are in sight

Final Rejoin Safety Notes

- Always keep all planes in front in sight
- Be able to pass behind and under any plane in front on your way to the outside
- When making a big turn to intercept the rejoin line, be sure to stabilize heading and speed away from other planes
- DO NOT GO BELLY UP & LOSE SIGHT OF LEAD