

NWCG Standards for Airtanker Operations, PMS 514

DRAFT 2024

Appendix B – Table of Contents

Appendix B – Proximity Flying / Geometry 1

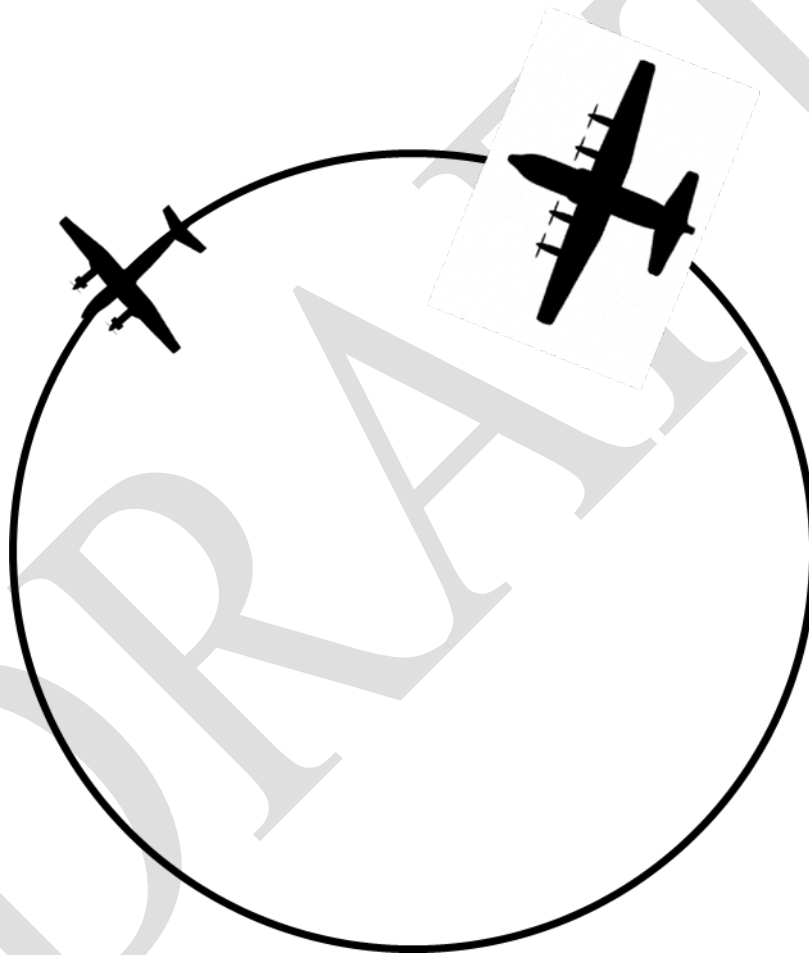
- Pursuit Curves and Intercept Principles 1
- Definitions:..... 2
- Pursuit Curves Once on the Turn Circle 6
- Using Pursuit Curves and Intercept Principles..... 8
- Pursuit Curves Once on the Turn Circle 12
- Apply Intercept Concepts to Aerial Firefighting 16
- Approaching the Orbit: Approximately 12-4 Miles..... 16
- Approaching the Orbit: 4 Miles to at Scene..... 19
- Joining the Orbit..... 19
- Orbit Spacing 22
- Lead Plane Join-Ups: From the Orbit 24
- Lead Plane Join-Ups: Straight Ahead 26
- Right Hand Patterns 28
- Lead Plane Join-Up: Right Hand Pattern..... 29
- Profiles: Show Me Profile..... 30

Appendix B – Proximity Flying / Geometry

Aircraft and Circles in images throughout this appendix are not to scale.

Pursuit Curves and Intercept Principles

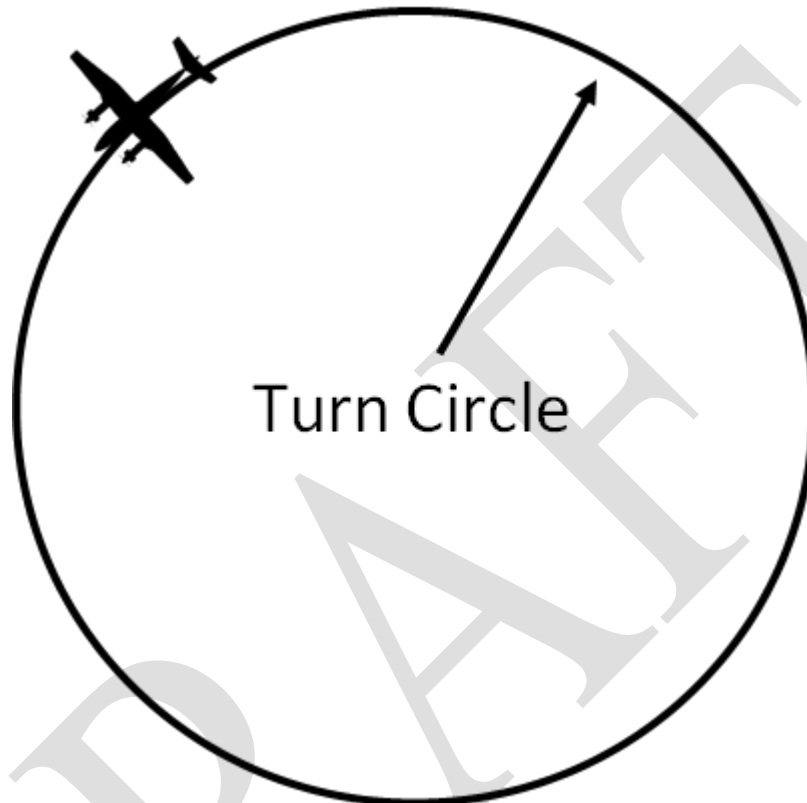
- To Join the Orbit and/or follow a lead plane, an airtanker pilot must match their flight path to that of the aircraft to follow.
- This involves entering the turn circle (orbit), reducing heading crossing angle, and setting and maintaining the spacing (range).



Definitions:

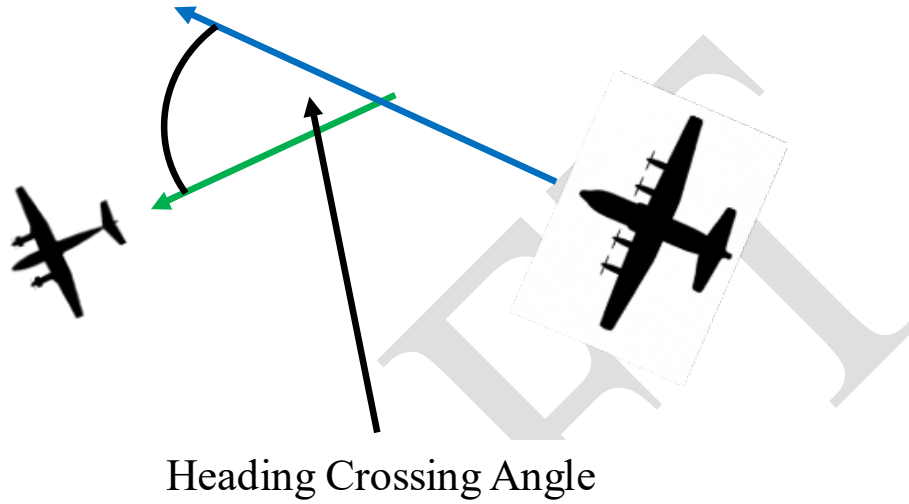
Turn Circle

- The *Turn Circle* is the flight path of the lead plane or other airtanker to follow.



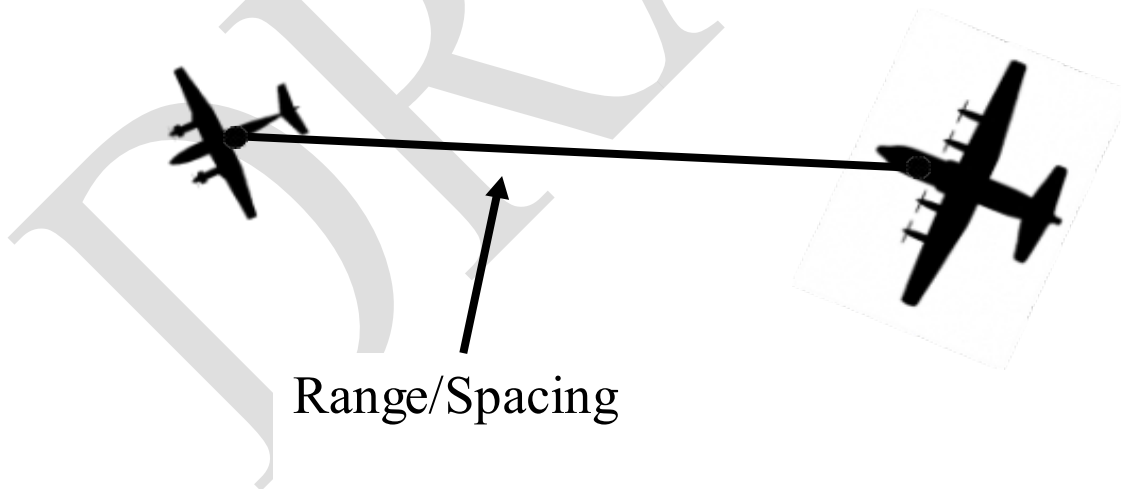
Heading Crossing Angle

- *Heading Crossing Angle (HCA)* is the difference in heading between the lead and trail aircraft.
- In the orbit following another tanker – 90-120 degrees of HCA – is normally appropriate.
- When following a lead plane in a turning pattern, 30-45 degrees HCA is typical.



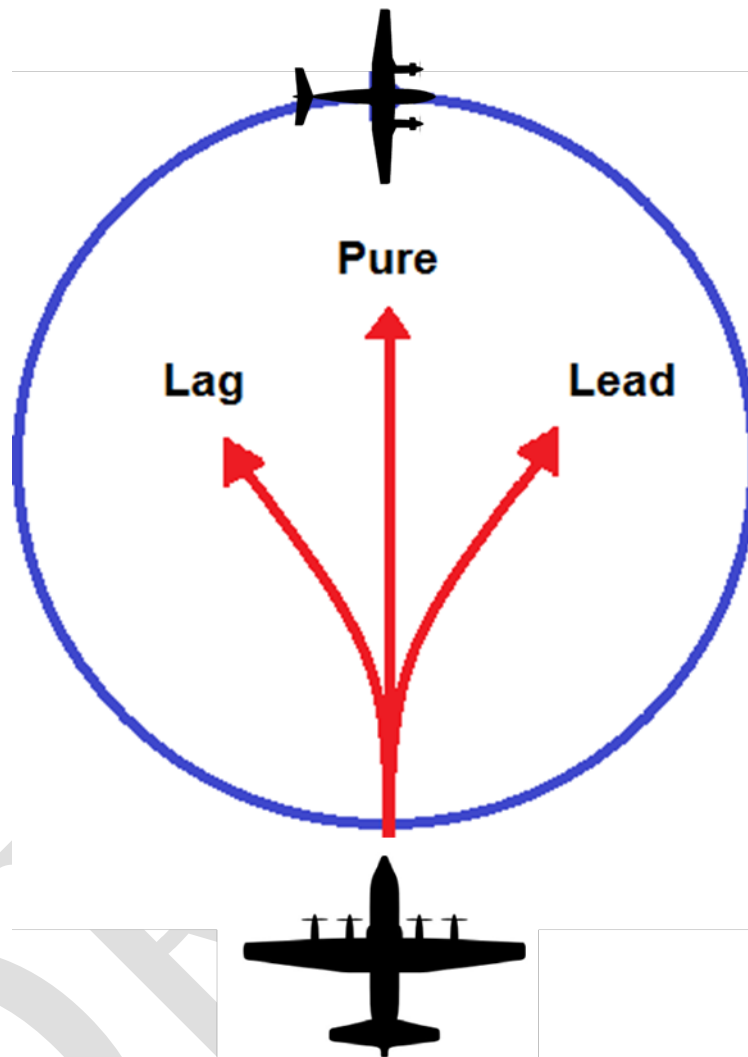
Range

- Range/Spacing is the distance between the lead and trail aircraft.



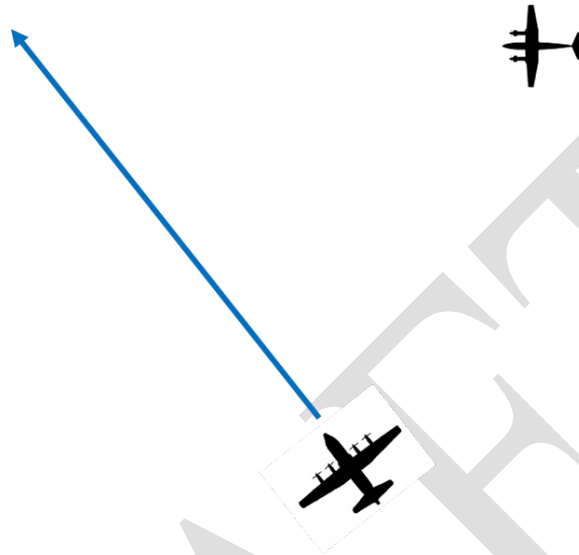
Pursuit Curves

- Pursuit curves are defined by where the trail aircraft nose points in relation to the lead aircraft.



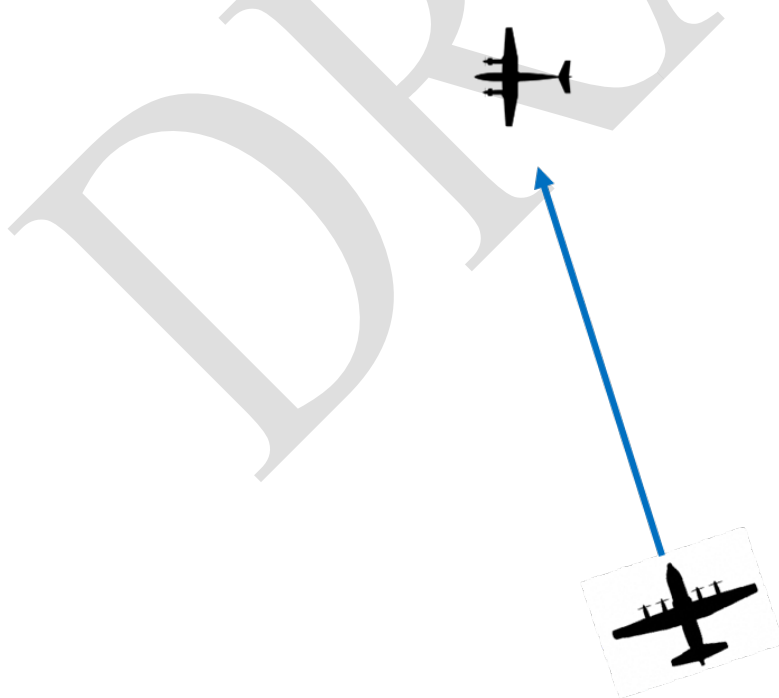
Lead Pursuit

- **Lead Pursuit = Pointing in front of the lead aircraft.**
 - Results in rapid decrease in range.



Pursuit Curves

- **Pure Pursuit = Pointing at the lead aircraft.**
 - Results in decrease in range but less rapidly than lead.



Pursuit Curves

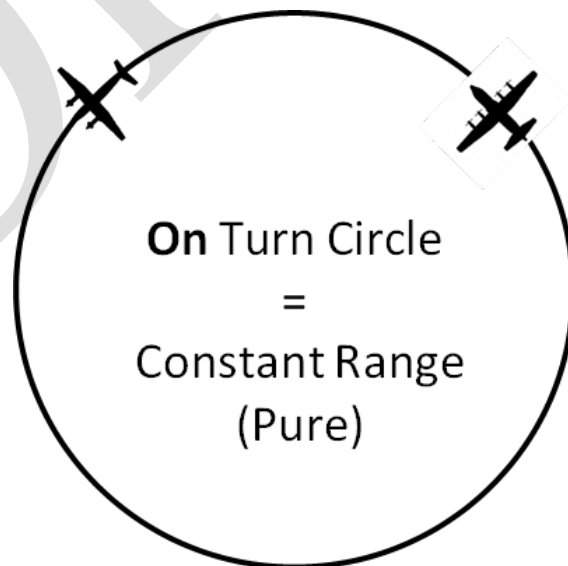
- **Lag Pursuit = Pointing behind the lead aircraft.**
 - Results in increase in range (if near the turn circle).



Pursuit Curves Once on the Turn Circle

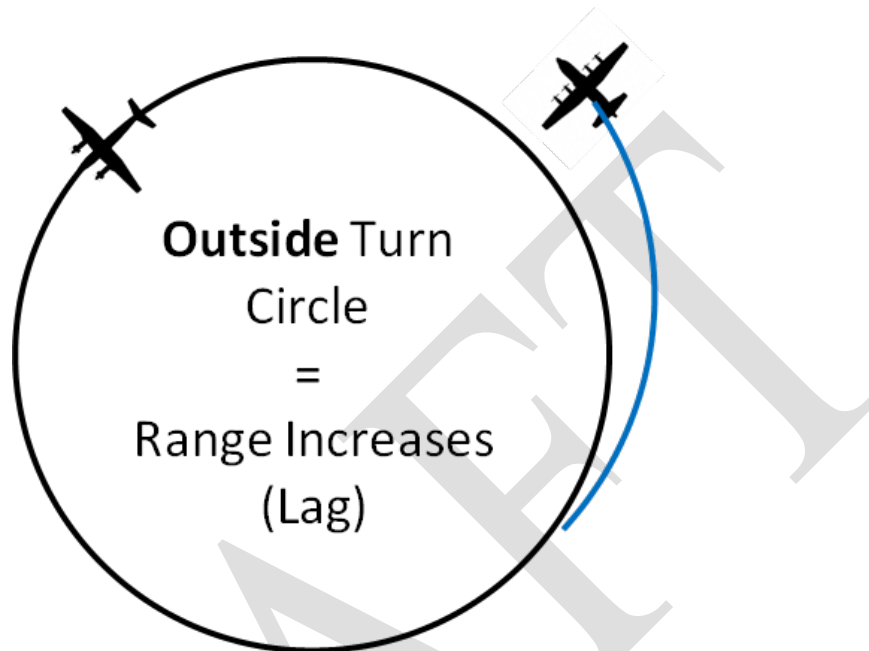
On:

- Once Established on or near the turn circle, range is adjusted by flying *inside, on, or outside* the turn circle of the aircraft to follow.
- Once established on the turn circle, matching the airspeed and bank angle of the lead aircraft will result in maintaining constant range.



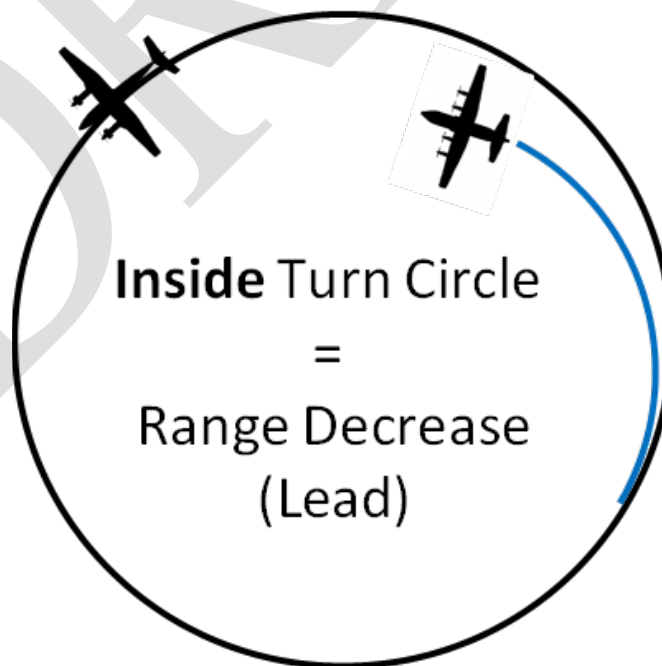
Outside:

- Establishing less bank than the lead aircraft or rolling out of the turn will result in flying outside the turn circle, causing range to increase.



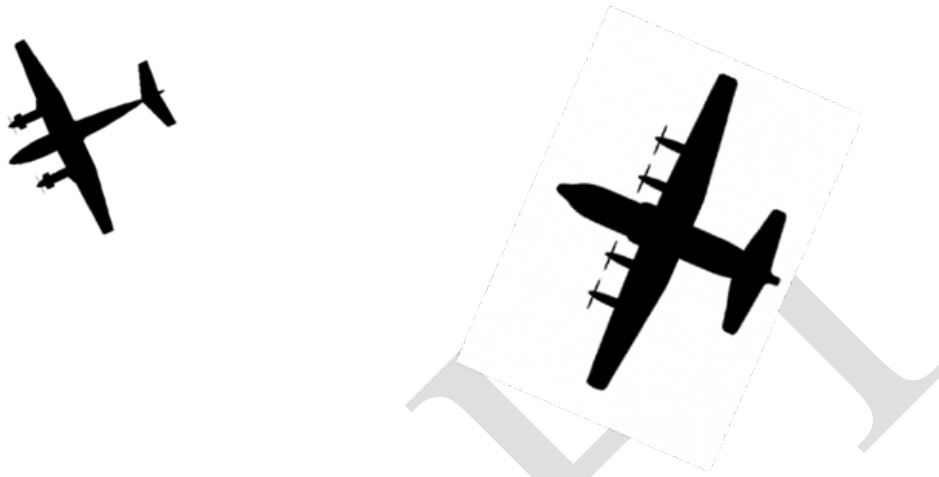
Inside:

- Establishing more bank or cutting across the turn circle will result in range decreasing.

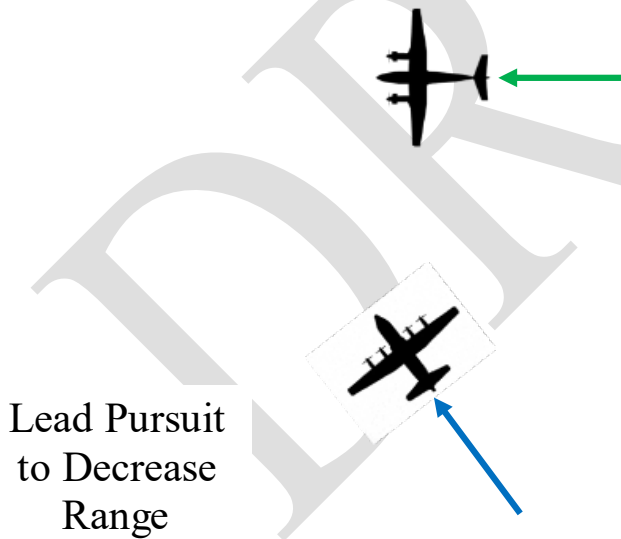


Using Pursuit Curves and Intercept Principles

- The *Pursuit Curves* are the tools to adjust *range and heading crossing angle* to achieve and maintain a position behind another aircraft.



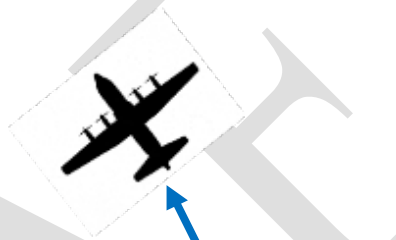
Adjusting Spacing: Decreasing Range – Step 1



IF the aircraft to follow is flying straight or you are a long way away (outside 1 mile) use **Lead Pursuit**

Adjusting Spacing: Decreasing Range – Step 2

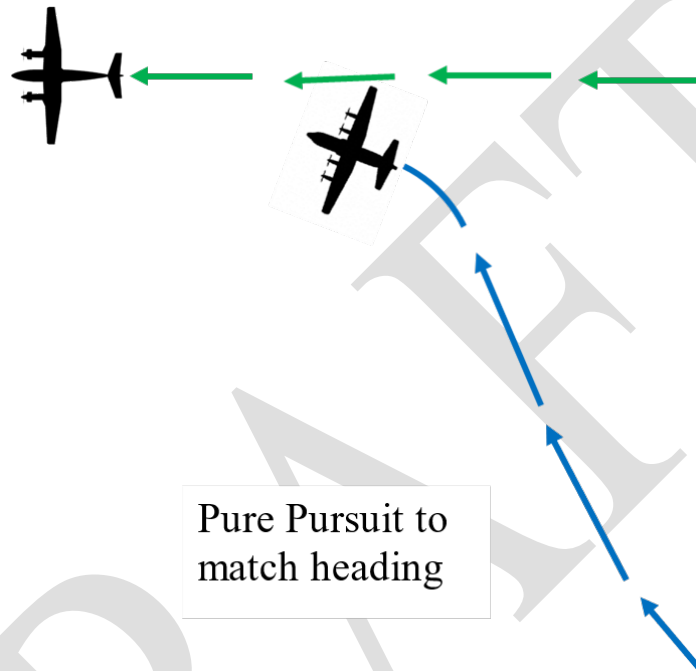
- As you get closer, you can reduce this to *PURE Pursuit*.
- As you can see, this intercept will happen with a large *Heading Crossing Angle*.



Pure Pursuit to
Decrease Range
more slowly.

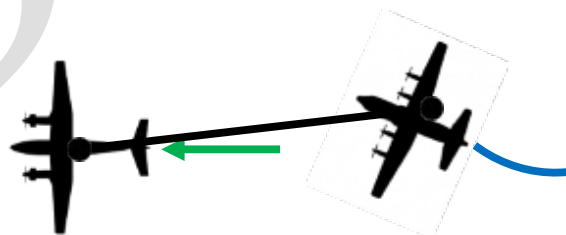
Adjusting Spacing: Decreasing Range – Step 3

- To prevent the flight path overshoot and stabilize behind the lead aircraft, heading must be matched.
- To do this, increase bank and turn the aircraft to match the lead aircraft heading.
- *This turn must be started early enough to be completed as you cross the lead aircraft's flight path.*



Adjusting Spacing: Increasing Range – Step 1

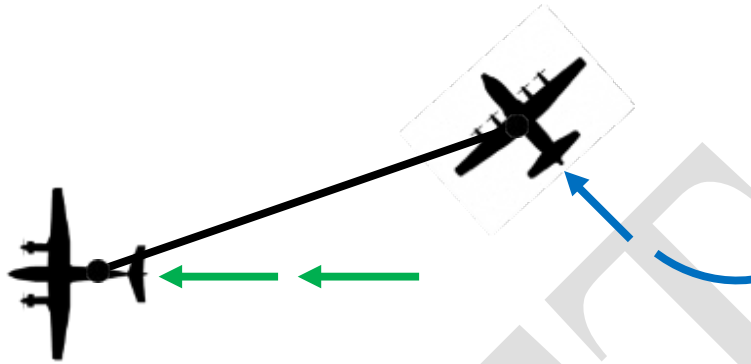
- To increase range, turn to a heading different than the aircraft to follow (20–45-degree check turn away is typical) This places your nose in lag pursuit.



Lag Pursuit
Range Increases

Adjusting Spacing: Increasing Range – Step 2

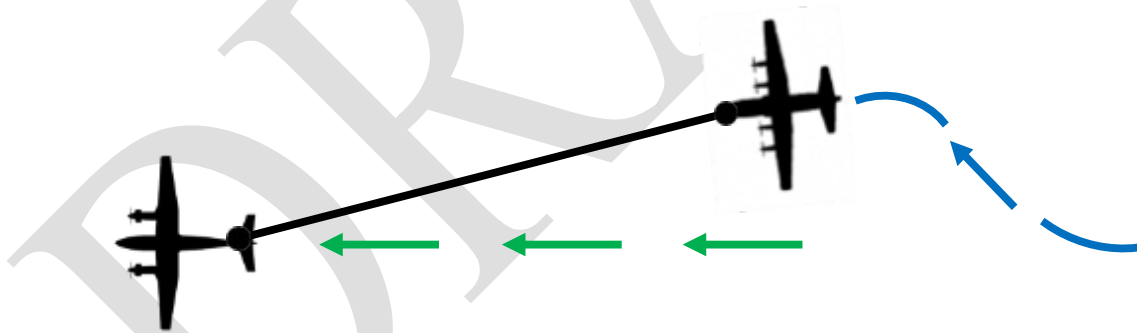
- Fly on that divergent heading until range is approaching the desired range/spacing.



Lag Pursuit
Range Increases

Adjusting Spacing: Increasing Range – Step 3

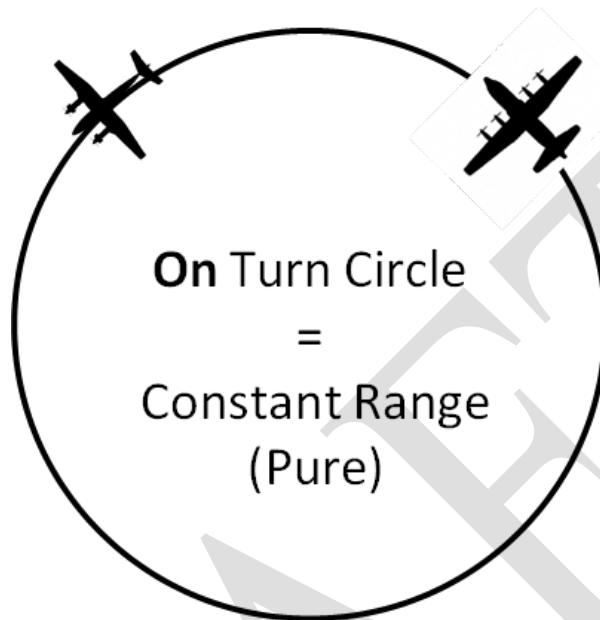
- Turn back to point at or match heading with the aircraft to follow.



Lag Pursuit
Range Increases

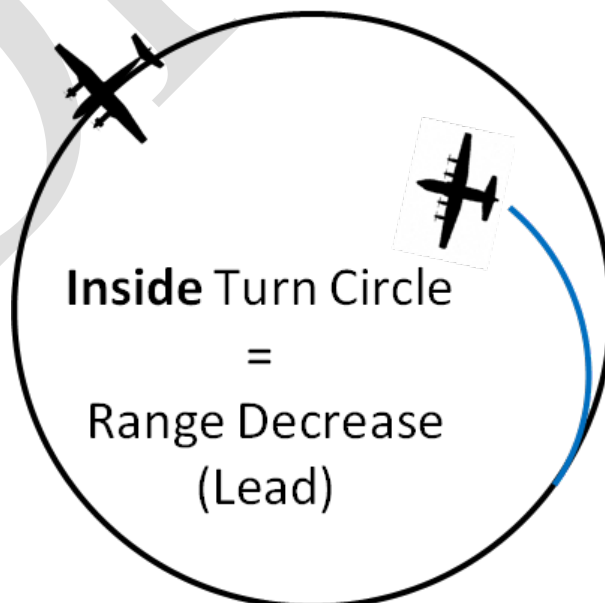
Pursuit Curves Once on the Turn Circle

- Once established on the turn circle at the correct range match *airspeed* and *bank angle* with the lead aircraft to maintain spacing.



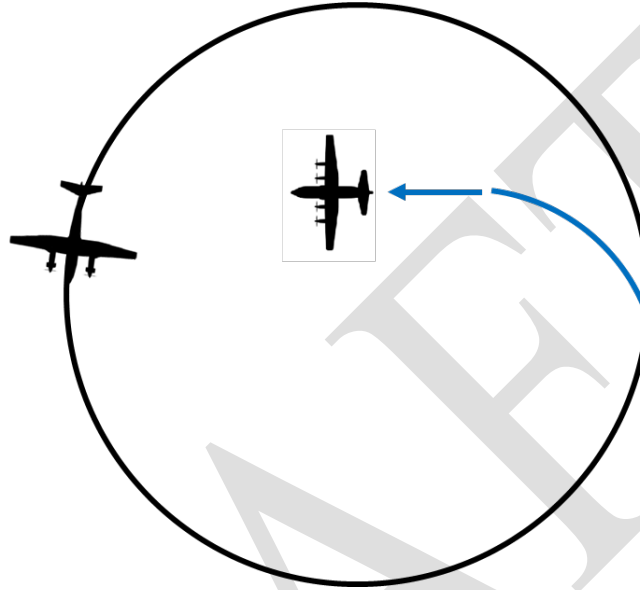
Adjusting Spacing: Decreasing Range – Step 1

- If the aircraft to follow is in a turn, you must fly a smaller diameter turn or cut across the circle to decrease range.
- Increase bank angle to tighten your turn to begin to cut across the circle. Your nose may or may not be pointing in front of the lead aircraft.



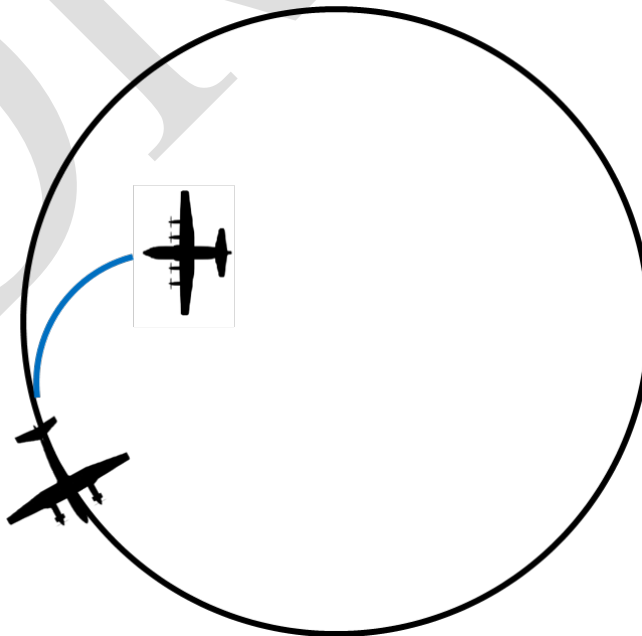
Adjusting Spacing: Decreasing Range – Step 2

- As you cut across the circle, range will *decrease*, and Heading Crossing Angle will *increase*.
- As you approach the desired range, you need to roll out, drive straight to establish lag pursuit. Range will still decrease since you are inside the circle, but the lead aircraft will drift away from your nose (to the left in this case.).



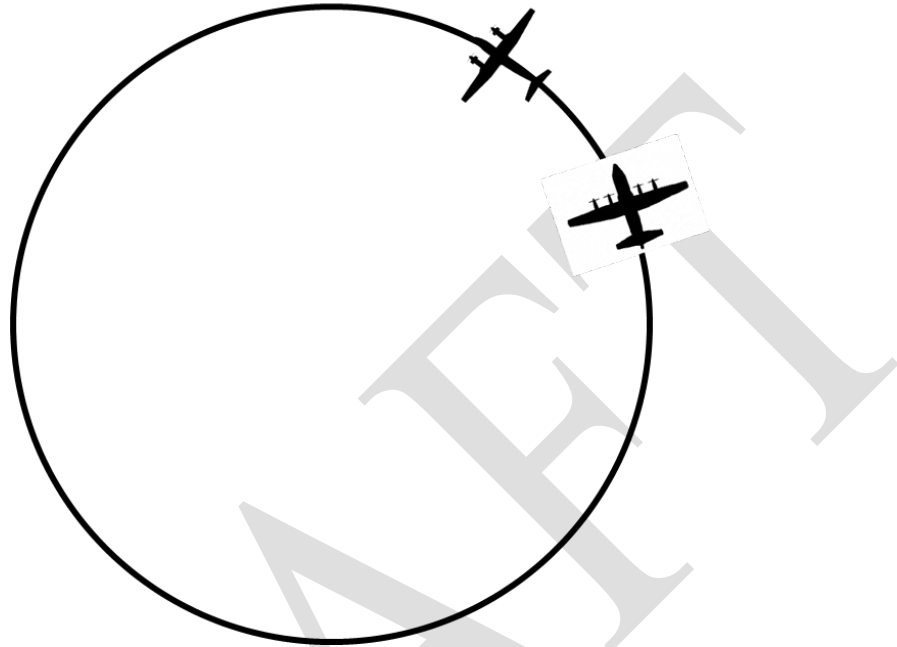
Adjusting Spacing: Decreasing Range – Step 3

- Prior to crossing the lead aircraft flight path, you must increase bank and tighten your turn to match the lead aircraft heading and roll out on their flightpath.



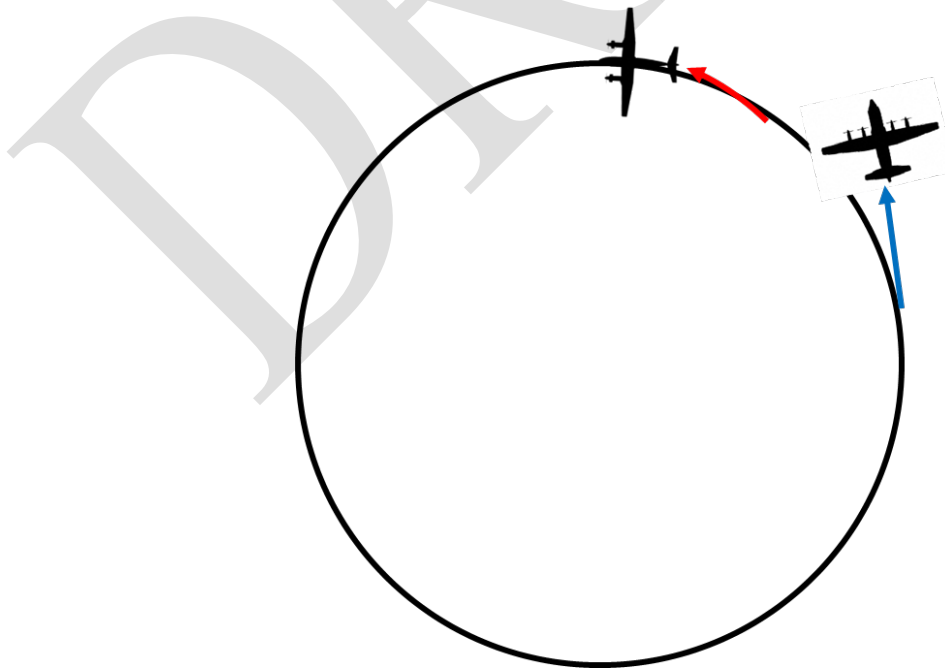
Adjusting Spacing: Increasing Range – Step 1

- To increase range, begin by rolling out or reducing bank to less than that of the lead aircraft.
 - This will result in flying outside the turn circle.



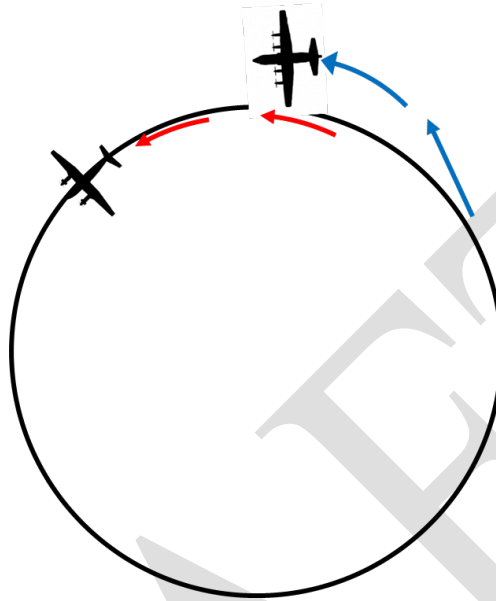
Adjusting Spacing: Increasing Range – Step 2

- As you move outside the turn circle, range will increase, and HCA will also increase.



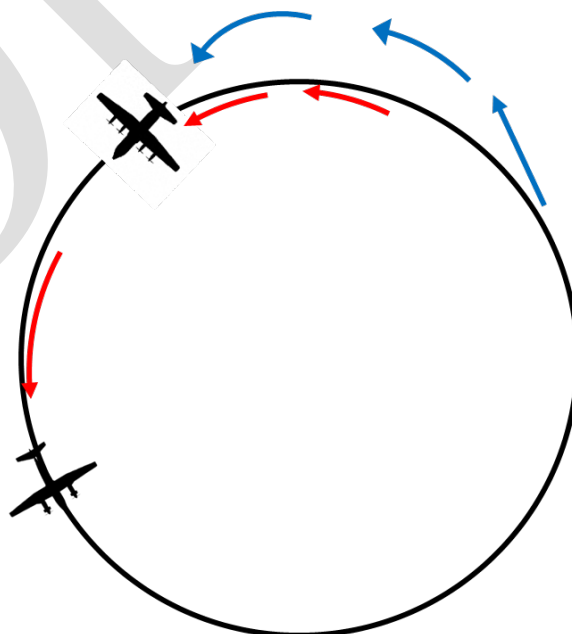
Adjusting Spacing: Increasing Range – Step 3

- As range begins to increase, you can match bank angle with the lead aircraft, but since you are outside the circle range will continue to increase.



Adjusting Space: Increasing Range – Step 4

- *Prior* to reaching desired range, increase bank angle to tighten turn and fly back toward the lead aircraft's turn circle.
- Range will continue to increase until you are established back on the turn circle.
- Common error is to wait too long and end up too far aft.



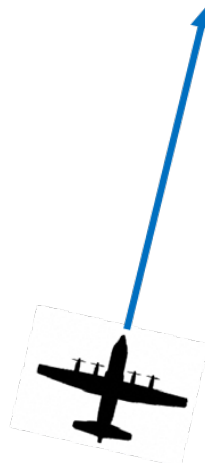
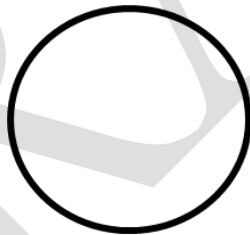
Apply Intercept Concepts to Aerial Firefighting



Approaching the Orbit: Approximately 12-4 Miles

- Applicable to small fires, work areas on large fires, and holding at IPs.
- Approaching the fire or work area, fly toward a position wide of the right side of the orbit.
- The arriving tanker is responsible for separation from all tankers established in the orbit.
- Attempt to gain sight of all aircraft in the orbit and determine which tankers are to follow.

Orbit



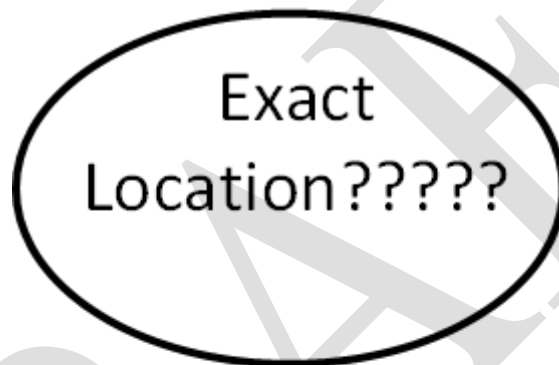
Approaching the Orbit: Approximately 12-4 Miles

- Aim extra wide if unsure of exact location or size of the orbit.
- Widen even further if unable to gain sight of all aircraft by about 4 miles.
- IF unable to gain sight you may make a radio call announcing:

Flight lead: "T-89 arriving at scene 4 miles southeast looking for Tanker 131 and MAFFS2."

- The tankers at scene or aerial supervisor may see you and be able to give you a position report of the other resources in relation to your aircraft.

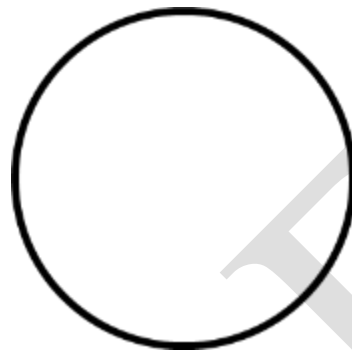
Orbit



Approaching the Orbit: Approximately 12-4 Miles

- The Bus Incident Mid-Air in 2001 occurred in the area marked with an X when a tanker in the orbit widened the pattern and an arriving tanker was pointed directly into the right edge of the orbit.

Orbit

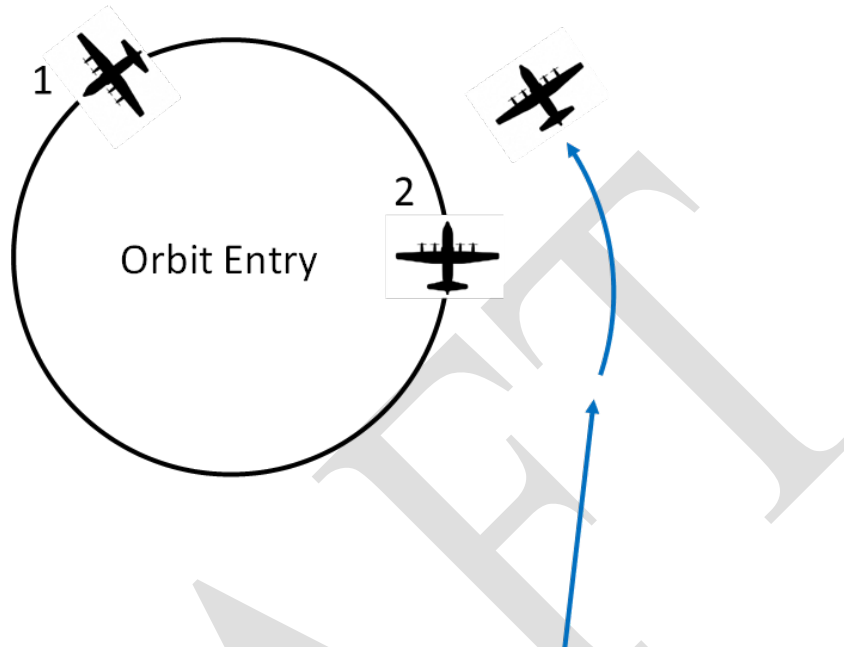


X



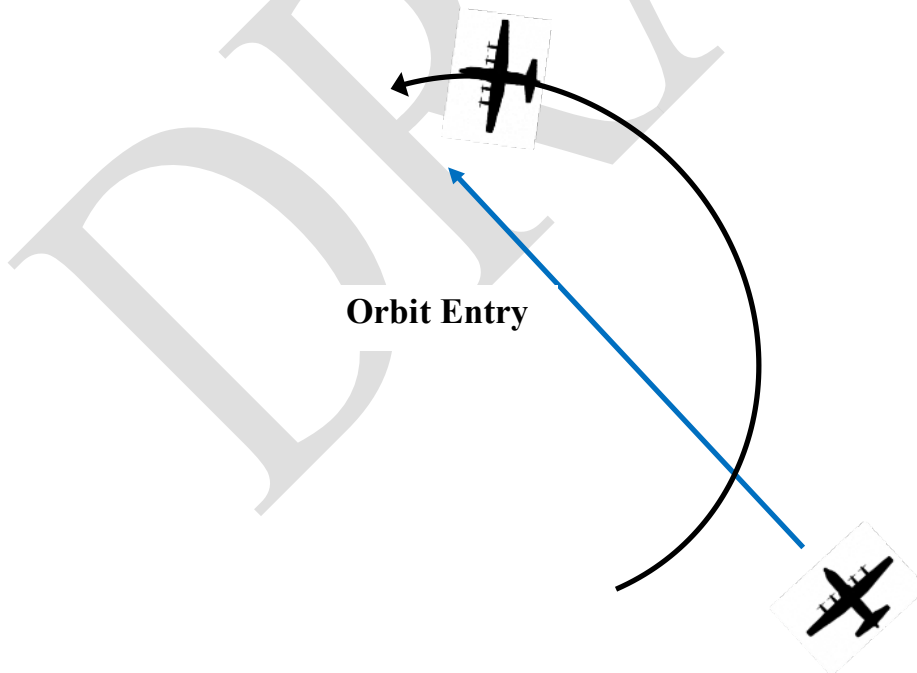
Approaching the Orbit: 4 Miles to at Scene

- If unable to gain sight of *all* aircraft, stay wide of the orbit and arc around while gaining sight of everyone and determining which aircraft you are to follow.



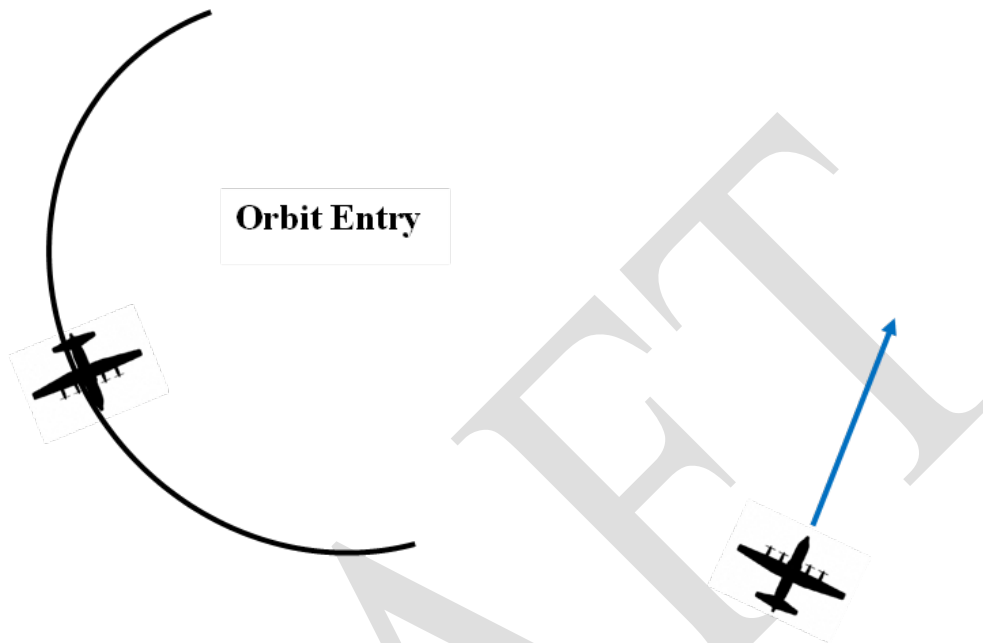
Joining the Orbit

- If the aircraft to follow in the orbit is generally on the right half of the orbit and thus pointing away from you, utilize *Lead or Pure Pursuit*. This will reduce range.



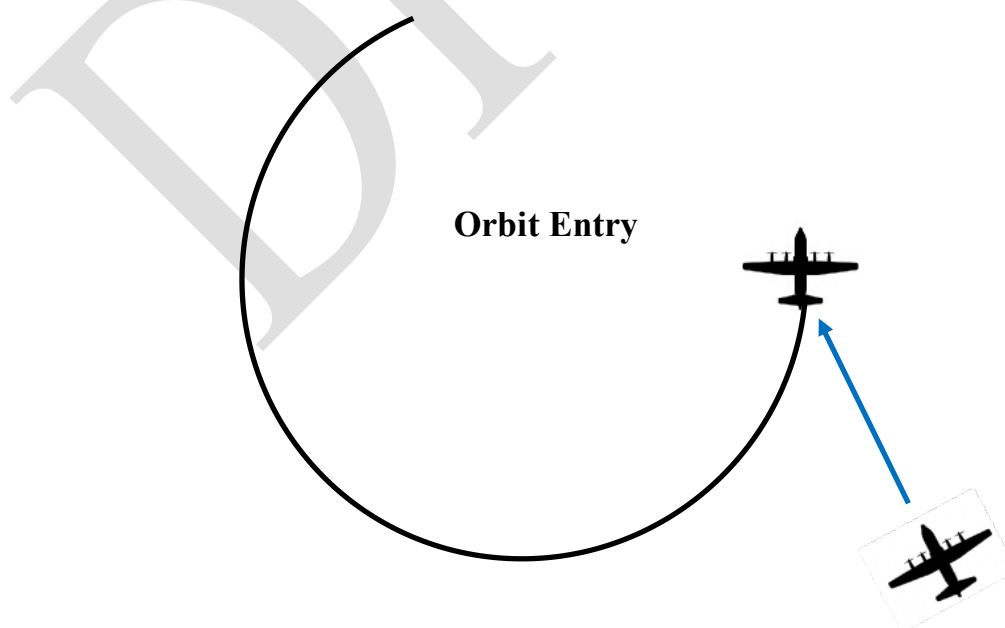
Joining the Orbit

- If the aircraft to follow in the orbit is generally on the *left half* of the orbit and thus pointing toward you, *point to a position outside the right side of the orbit and let the aircraft pass you.*



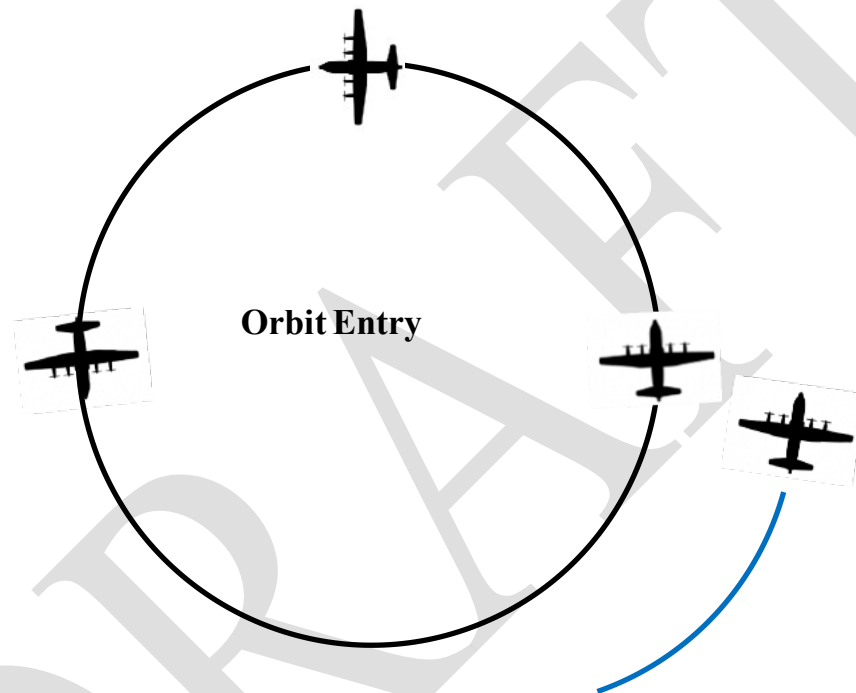
Joining the Orbit

- Once the aircraft to follow has passed, you use pure and lead pursuit to enter the orbit and adjust spacing.



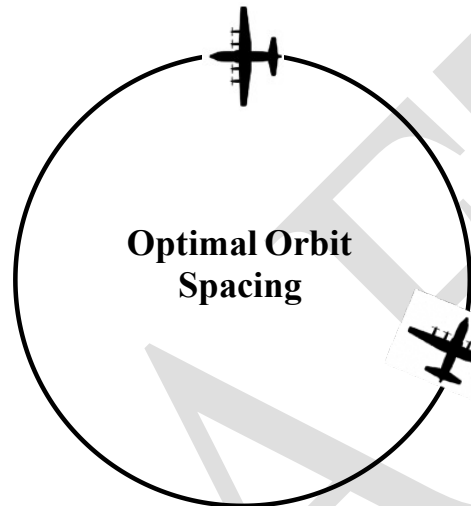
Joining the Orbit

- If there are multiple aircraft in the orbit, arc wide of the orbit until the aircraft to follow passes, then cut back into the orbit to fall in the trail of the correct aircraft.
- The most recent to join the orbit is responsible for separation from everyone.
- All aircraft will maneuver predictably and communicate any unusual or unexpected maneuvers as well as visually clearing their own flight path.



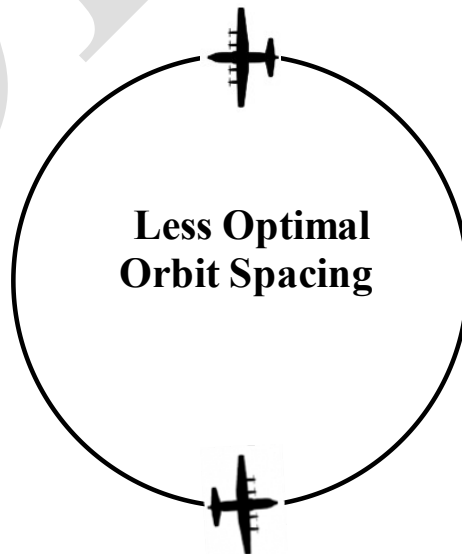
Orbit Spacing

- Normal spacing in the *orbit* is about ½-1½ miles.
- It is commonly set by being 1/4 to 1/3 of the way around the orbit from the preceding aircraft.
- Second aircraft has primary responsibility for separation.
- Allow first aircraft more flexibility to maneuver.
- Make it easy for additional arriving aircraft to determine who to follow.



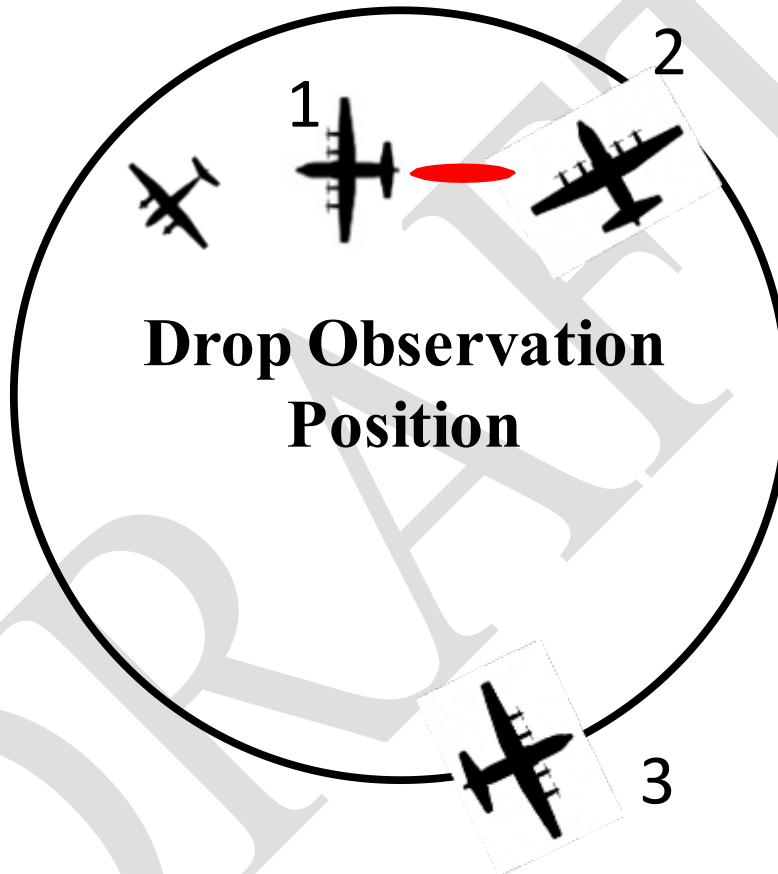
Orbit Spacing

- First aircraft must worry about position of second while preparing for drop.
- Other arriving aircraft have difficulty determining which aircraft to follow.
- Spacing will need to be reduced if more aircraft arrive.



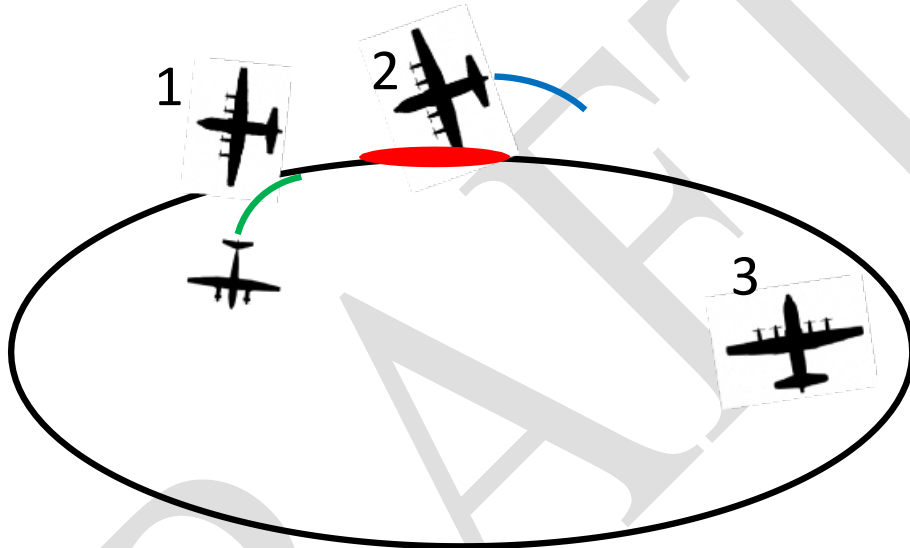
Orbit Spacing Once #2 to Drop

- When you are number 2 to drop, maneuver to a position above and behind the tanker that is dropping.
- Maintain orbit altitude and a left-hand pattern but reduce the spacing so as to arrive above and about 1/4 mile behind the dropping tanker.
- This position above and 1/4 mile aft is also one correct place to follow a lead plane during a “show me.”



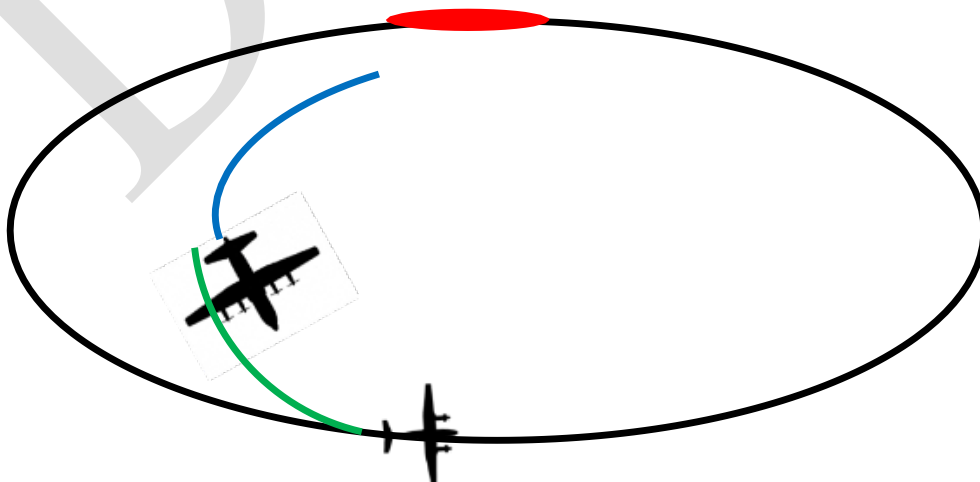
Lead Plane Join-Ups: From the Orbit

- As the #1 tanker drops and exits, the lead plane will normally execute a tight turn to the crosswind to observe the drop.
- As the number 2 tanker remains at orbit altitude, deconflict from other tankers in the orbit while beginning to maneuver to a position behind the lead.
- Third and/or fourth tankers in the orbit will maneuver to stay behind or out of the way of second tanker.
 - May widen orbit or cut in behind second tanker.



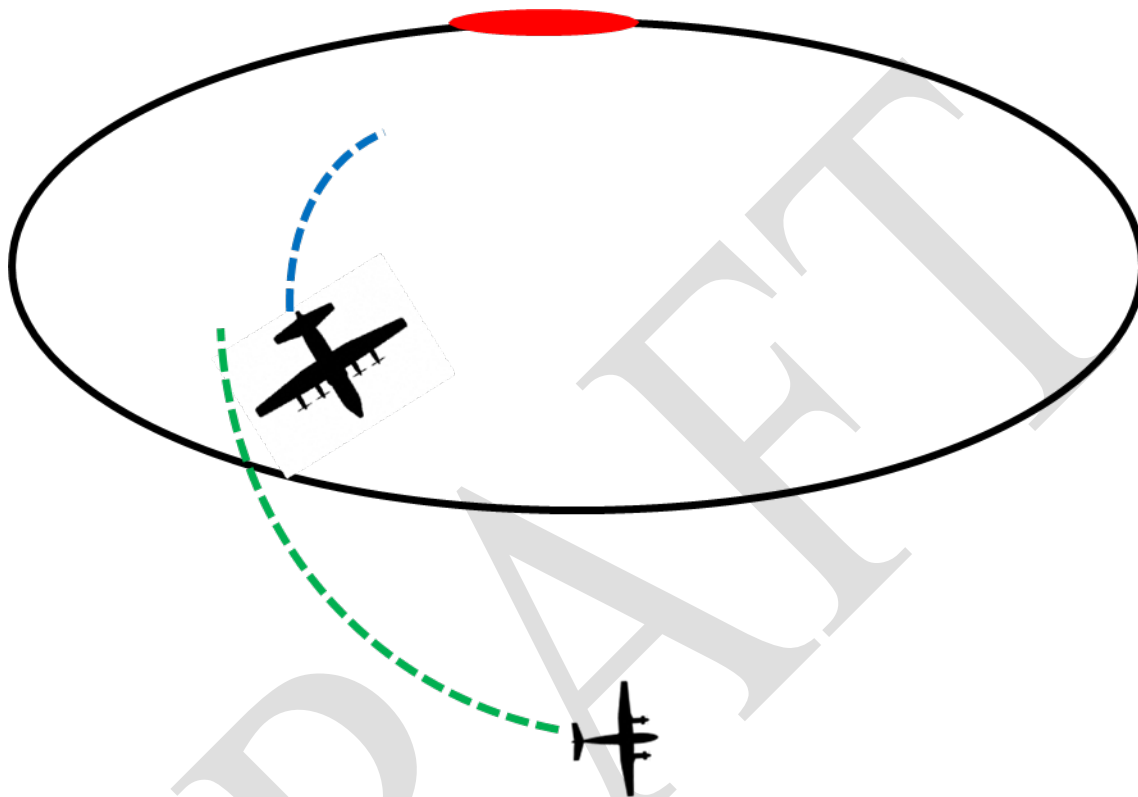
Lead Plane Join-Ups: From the Orbit

- Use intercept geometry to establish range of 1/4 miles and heading crossing angle of 30-45 degrees.
- Do not descend until cleared by the lead plane.



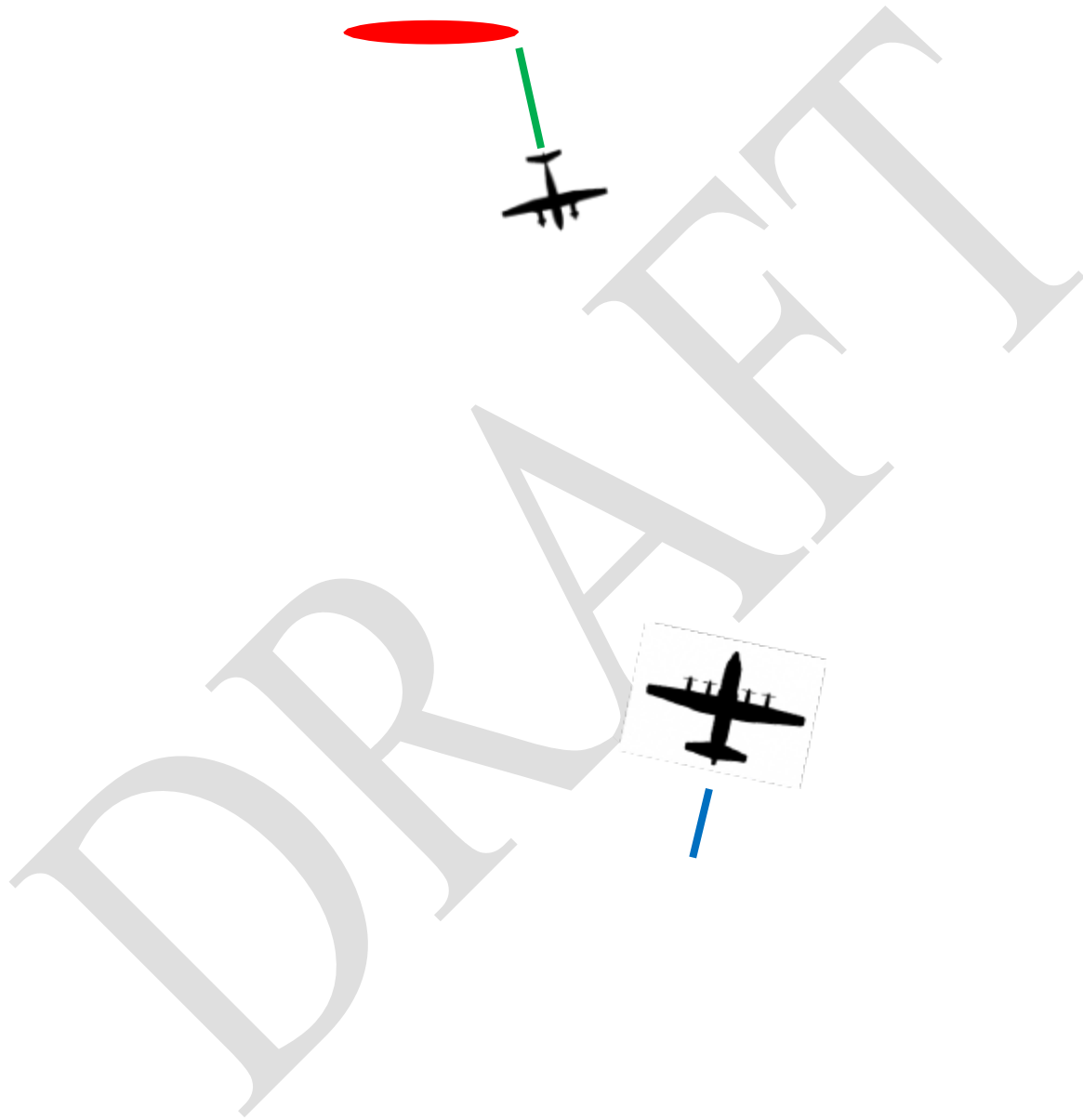
Lead Plane Join-Ups: From the Orbit

- If out of position, request to have the lead plane extend the pattern to allow you to use lead pursuit or cut inside the turn circle to reduce range.
- Try to establish spacing prior to turning base but no later than base final turn.



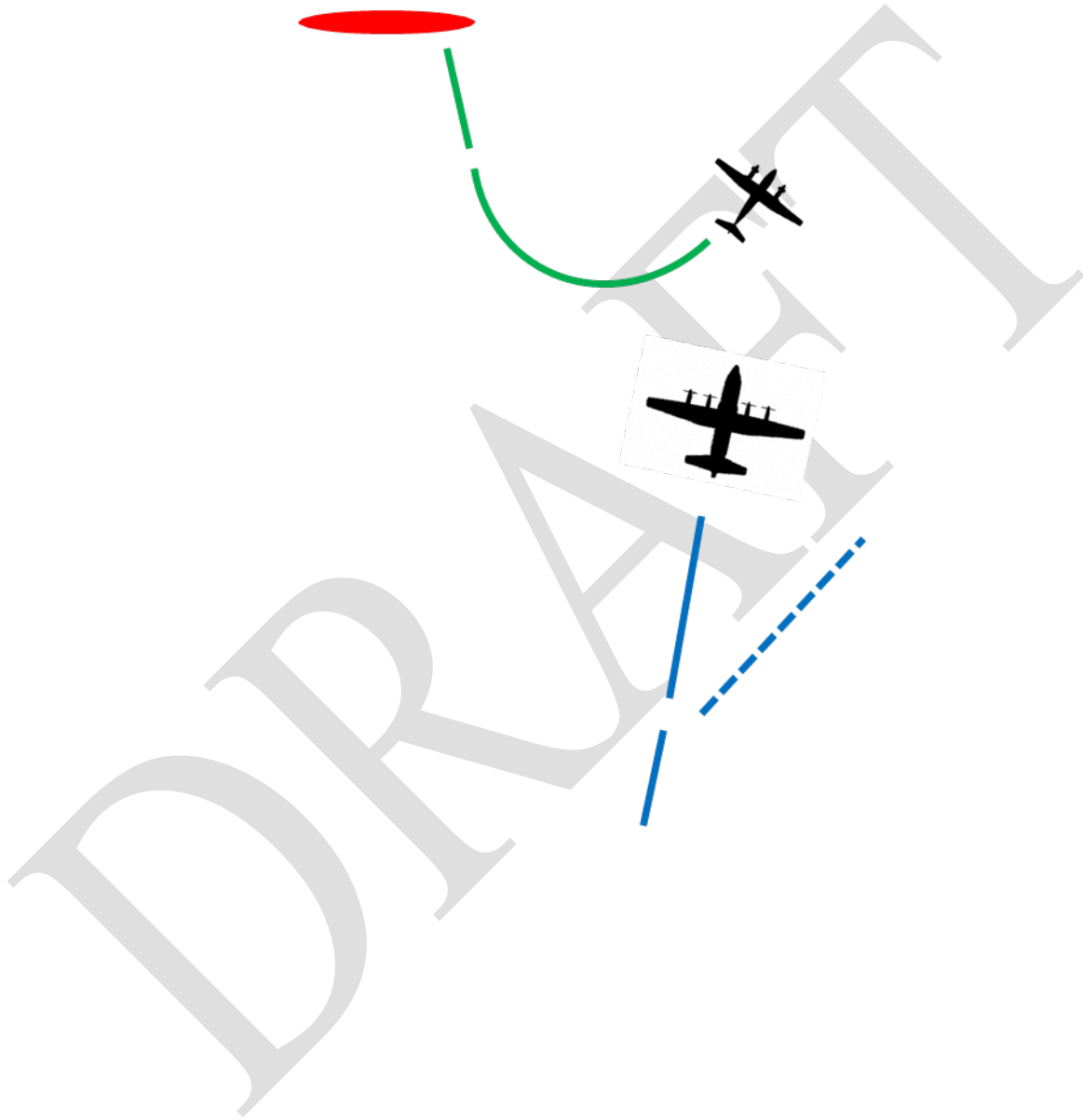
Lead Plane Join-Ups: Straight Ahead

- If arriving at a fire as the first tanker on scene or if conditions are difficult, the lead may fly out to meet the tanker for the join-up.
- The lead will be 500' below orbit altitude and fly toward the inbound tanker.
- Each pilot will attempt to gain sight and talk the other's eyes on.



Lead Plane Join-Ups: Straight Ahead

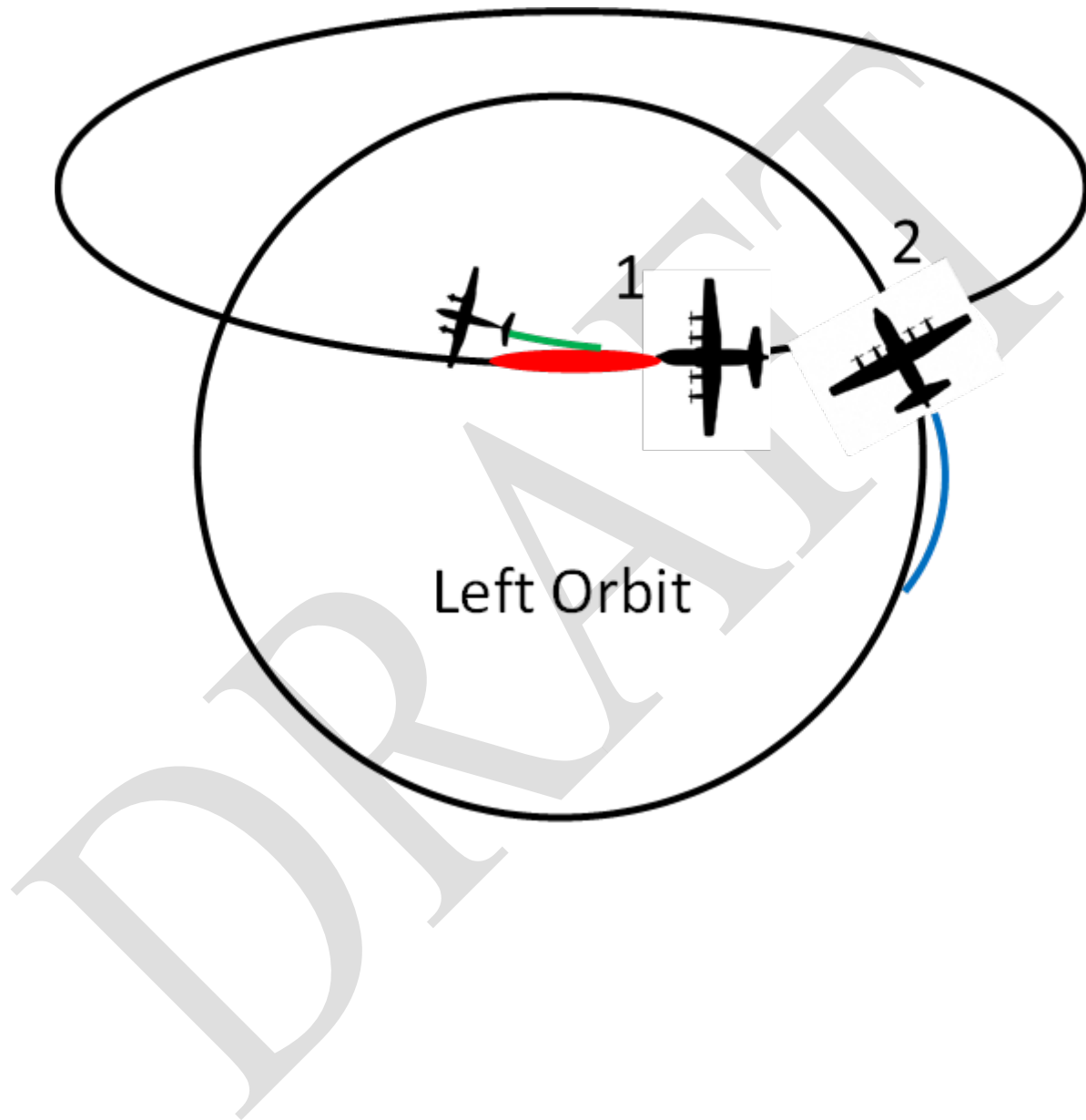
- The lead plane can “pop smoke” to aid in visual detection.
- Approximately 2 miles in front of the tanker, the lead plane will begin a turn back toward the drop area to roll out 1/2 to 1 mile in front of the tanker.
- If the lead plane rolls out too close in from of you, use lag to increase range.



Right Hand Patterns

- When dropping from a right pattern, only the tanker maneuvering will be in a right pattern.
- Observe the previous drop from a left turn above and behind the tanker dropping.

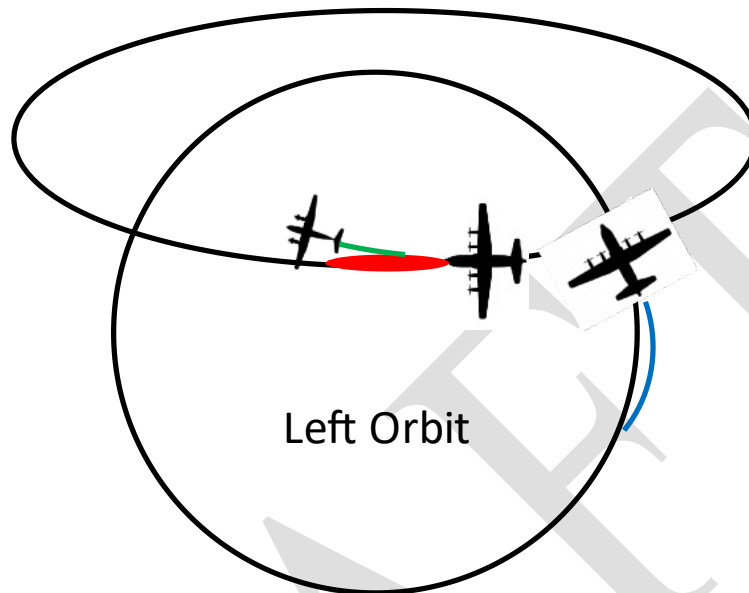
Right Drop Pattern:



Lead Plane Join-Up: Right Hand Pattern

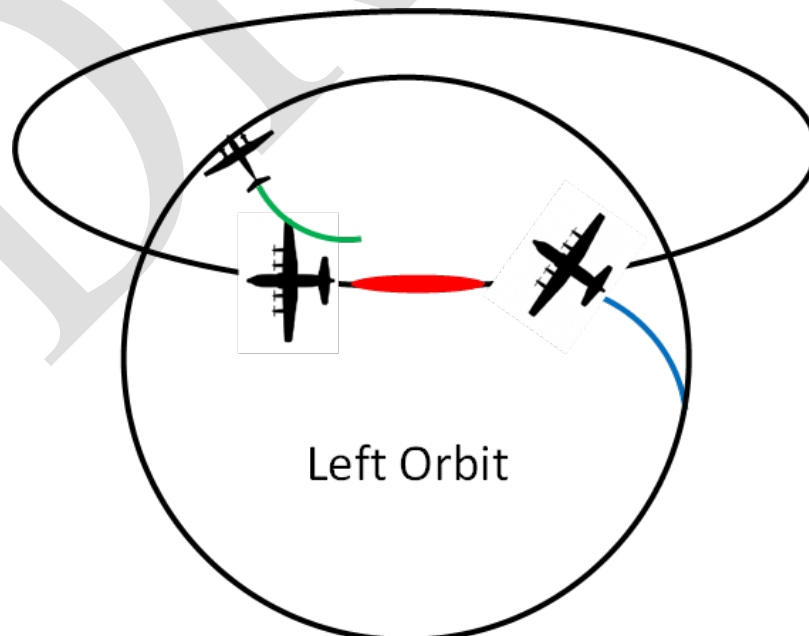
- As the previous tanker drops, deconflict from their exit while maintaining sight of the lead plane.

Right Drop Pattern:



Lead Plane Join-Up: Right Hand Pattern

- Use intercept geometry (normally lead pursuit) to begin a rejoin on the lead plane.
- Do not descend until cleared by the lead plane.
- Do not enter a right turn until 500' below maneuvering altitude.



Profiles: Show Me Profile

- Tanker remains at orbit altitude unless cleared lower by the lead plane.
- The tanker can follow the lead plane through the drop pattern approximately 1/4 mile aft and slightly outside the orbit. Same as being #2 and watching first tanker drop.
- The lead may also perform a show me while the tanker is in another position as long as the tanker can see the lead and the target.

