



Sport Class Air Racing Formation Warm Up Ground School



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Sport Class Formation Ground School Overview

- Part I: Formation Procedures
 - Normal Procedures
 - Safety and Abnormal Procedures
- Part II: Area Brief
 - Stead NCAR/SCARA Ops
 - SCARA Area Ops
- Part III: Flight Profile





SCARA Formation Introduction & Background

- SCARA Formation Warm Up is
TAILORED
- Training Philosophy & Pre-Reqs:
 - Significant Formation Experience
 - Safe for solo in 4 ship or larger formations
 - Formation experience in intended race aircraft
 - Familiarity with Sport Class SOP and Rules
 - **Specific Procedures To Support Racing**



PART I

Sport Class Air Racing Formation Concepts and Procedures



SCARA Formation

NORMAL OPERATIONS AND CONCEPTS





Familiar Terms & Concepts

- “The Formation Contract”
- Lead
- Wingman
- Station Keeping
- Bearing Line
- Fingertip
- Echelon
- Strong Left/Right
- Line Abreast
- Route
- Ops Check
- Interval Takeoff
- Rejoin
- Cross Under
- Pitchout
- In-Trail
- Overshoot/Under-run
- Blind/Lost Sight
- Extended Trail
- Overhead Pattern
- Break



“The Formation Contract”

- Flight Lead
 - Follow the SOP
 - Brief / Debrief
 - Fly stable platform
 - Control the flight maneuvers
 - Monitor flight
 - Terminate maneuvers if flight safety is compromised
 - Navigate
 - Communicate



“The Formation Contract”

- Wingman
 - Follow the SOP
 - Attend/understand briefing
 - Always maintain visual contact
 - Immediately advise lead if you do lose sight (blind)
 - Don't hit flight lead or other wingman
 - Follow briefed formations/positions/maneuvers
 - Maintain listening watch
 - Advise lead if traffic is observed
 - Have exit plan ready



COMMUNICATIONS:

- A communication plan will always be briefed
 - Use race number (Sport XX)
 - Brief all frequencies if local flying
 - Initial check-in after engine start is *generally* on CTAF
 - During FWU Freq Plan is CTAF – Company – CTAF
 - During PRS Freq plan is GND – Race Control – GND
- Frequency change protocol
 - *Use of “Go”*: Acknowledge in sequence (“check out”)
 - *Lead will check flight in on new frequency in either case*
- **Sport Class Standard at FWU and PRS – Always use “GO”**



SCARA CONFIGURATION CHANGES

- Directed with *Radio Calls*
 - Respond with Race Number (if required)
 - Optional – Pitchout Signal at RTB
 - Optional – Supplement with hand/aircraft signals
- Executed from *Fingertip/Finger Four position*
 - If in other than Fingertip:
 - Lead will regroup in Fingertip then move to a new configuration
 - Lead may brief alternative for specific training events
 - One exception is Moving to Extended Trail
 - Pitchout from Echelon to Ext Trail is Standard
 - » 3 sec spacing
 - Radio Calls
 - » Flight must acknowledge initial command from lead
 - » 4 calls "in"
 - » Must be well-briefed by Lead

Fuel Management

- **“Bingo”**
 - Fuel state at which flight must terminate to return with legal minimums or as briefed by the Flight Lead
 - *Day VFR: 30 Minutes Reserve*
 - Generally briefed in ‘Time’ - fuel remaining in minutes in dissimilar aircraft formations
 - Example report: “Sport XX is bingo plus 5”
 - ***Do not overfly briefed bingo!***



SCARA Formation

ABNORMAL PROCEDURES AND SAFETY





Abnormals Overview

- Collision Avoidance
- Lost Sight/Breakout
- Knock It Off
- May-Day
- Hard Deck
- Safety Equipment



Safety

Collision Avoidance

- Always keep lead in sight
- Always closely monitor relative motion and closure
- Always maintain separation
- Always consider prop wash and wake turbulence
- Never move ahead of your lead aircraft
- Never go “belly up” to your lead aircraft



Lost Sight/Breakout

- Breakout
 - For most SCARA procedures, Breakout is Up & Away
 - EXCEPTION: Low and Blind in the chute
- Rejoin/Departure Rejoin
 - Fly a predictable path
 - Lead will direct
 - Aircraft behind, stagnate, but stay on rejoin line
- Close Formation
 - Up and Away
 - Lead will call Knock It Off and direct lost wingman
- Echelon Enroute
 - Up and Away
 - Lead will direct lost wingman



Lost Sight/Breakout

- Extended Trail
 - Fly a predictable path – most likely wings level
 - Lead will direct flight
 - Aircraft behind, remain in formation!
 - Expect rejoin of remaining flight, and then lead direct lost wingman/men
- In the Chute (Race/PRS Scenario)
 - Low and Blind
 - Stay low, slide back
 - Lead will direct – expect remain in trail
 - High and Blind
 - Up and Away
 - Lead will direct – expect remain in trail



Safety Calls

- “**Knock It Off**” (KIO)
 - USE IT When a safety issue is *developing*
 - For **immediate hazards** to flight
 - Impending collision, etc.
 - In those cases, ***be directive first***



Safety Calls

Knock it Off

- ***“Knock It Off”***
 - Anyone can call KIO
 - *“Sport XX Knock It Off, Altitude”*
 - Lead will acknowledge the call and all flight members will mirror his/her call”
 - *“22 Knock It Off”... “39 Knock It Off”, etc.*
 - Clear your flight path and await lead’s instructions – **do not stop flying formation!**
 - Flight will terminate maneuvering, move to straight and level flight and increase spacing at KIO call





Safety Calls

Mayday

- *“Mayday”*
 - *Engine Failure, Critical Systems Failure*
Structural Failure, Midair
 - After Mayday call - Lead will Knock It Off and take control
 - No echoed KIO call for a Mayday
 - Only essential comms
 - Clear your flight path and await lead’s instructions
 - Do not stop flying formation!
 - Flight will terminate maneuvering and increase spacing at KIO call



Safety Calls Breakout

- ***“XX Blind, Breaking Out”***
 - ***Losing sight of Pace, Lead, or any racer/formation for whom a pilot has separation responsibility***
 - After breakout call, fly a predictable path
 - Lead will direct lost wingman
 - EXCEPTION: Low and Blind in chute
 - ***“XX Blind, Low”***



Safety

The Hard Deck

- ***“Virtual” ground level***
 - Minimum maneuvering altitude
 - Should be derived from current charts
 - High enough to allow reasonable chance of bailout or recovery from unusual attitude/aerobatic maneuver as applicable
 - Must be briefed on every formation mission
- ***Call KIO if penetrated***
 - *“Sport XX Knock It Off, Hard Deck”*



Aircraft / Safety Equipment Reminder

- Dual Controls
- Intercom system
- Ability to transmit from rear/right seat
- Fire Extinguisher

- **FOR PRS:**
 - Helmet
 - Gloves
 - Nomex flight suit
 - Close toed shoes

BREAK

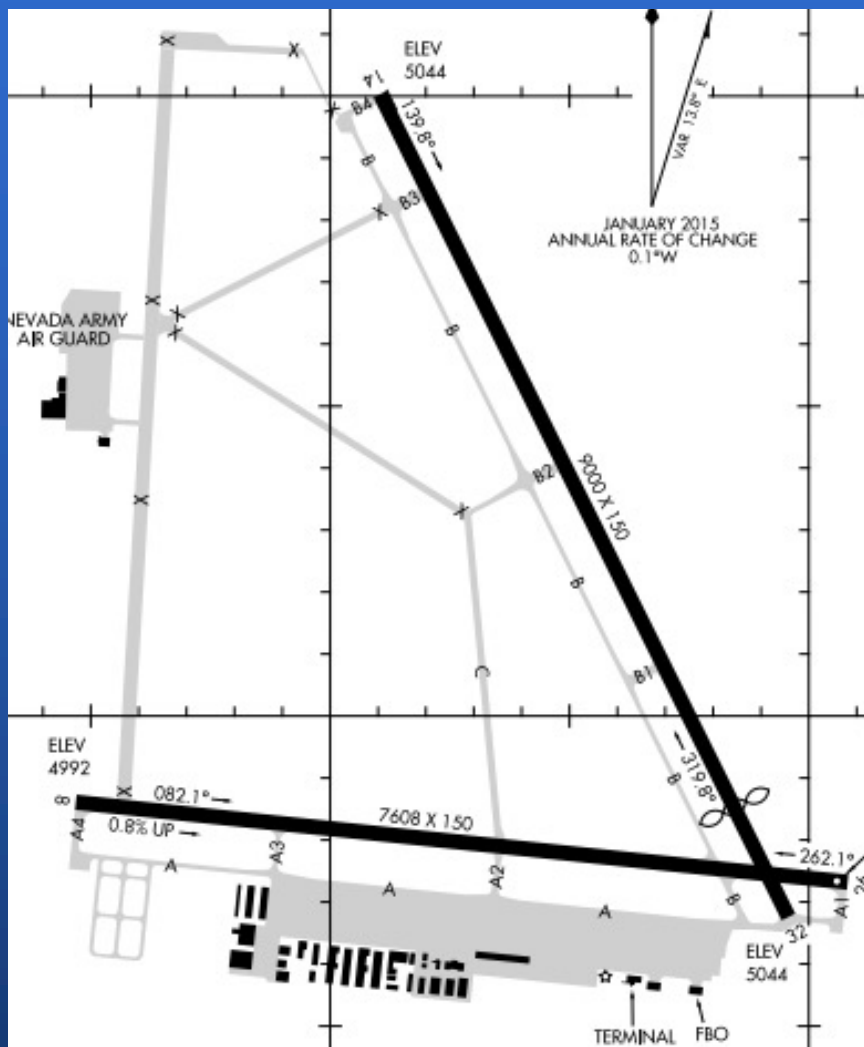




PART II

Area Brief and SCARA Formation Warm Up Procedures

Airport Diagram



Airport Elevation:
• 5050'

Frequencies:
• AWOS: 135.175
• UNICOM: 122.7



Schedule of Events

- **Brief**
 - Suggested, lead may modify
 - Lead will advise location
- **Spot**
 - Find tow driver - bribe
 - At least 20 min prior to takeoff
- **Meet**
 - 5-10 min prior start
 - At Lead's aircraft
- **Start**
- **Taxi**
 - 5 min prior takeoff rwy 08
 - 7 min prior takeoff rwy 26
- **Takeoff**
- **Course/Area**
 - Diligent about time
 - Flexibility in FWU, typically none at PRS
- **Landing**
 - Tail end charlie on deck



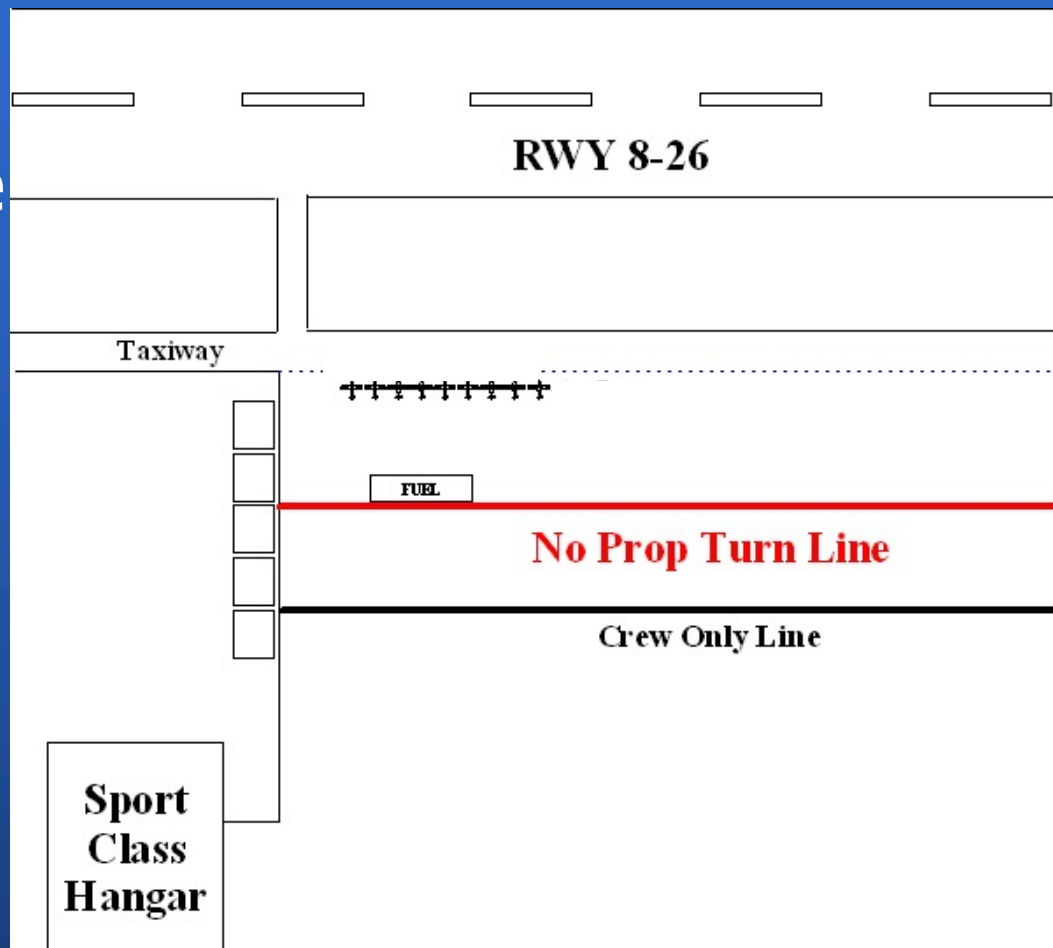
Spot & Meet Aircraft

- Find tow driver—offer bribe
- Spot At least 20 Minutes prior to Take-off
 - Spot and Start Times generally come from schedule
 - Lead may dictate
- Meet for final brief at Lead's airplane
- “No Prop Turn” line in effect
 - Do not taxi or coast across it!



No Prop Turn Line

- No propeller may be turning behind this line
- Coasting across the line is **NOT** permitted!
- Be extremely vigilant while running engines on the ramp





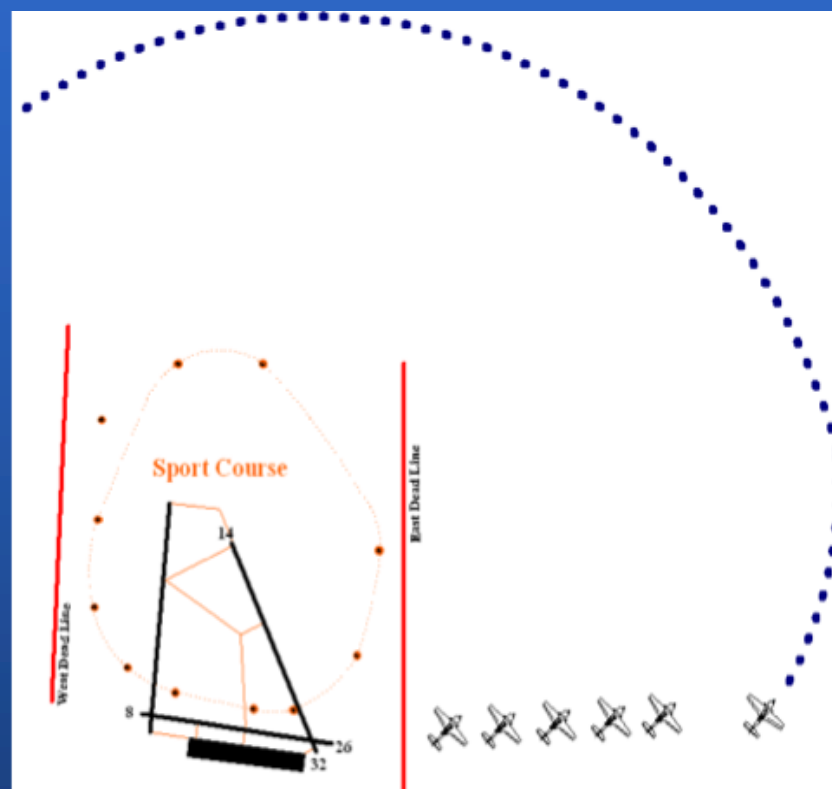
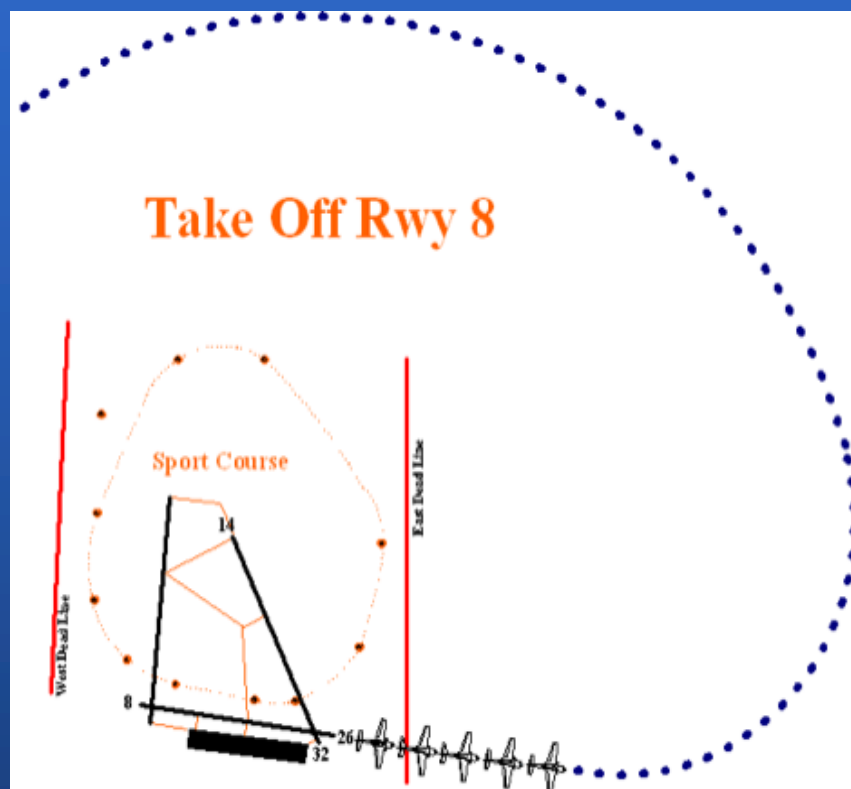
SCARA Formation

DEPARTURE PROCEDURES



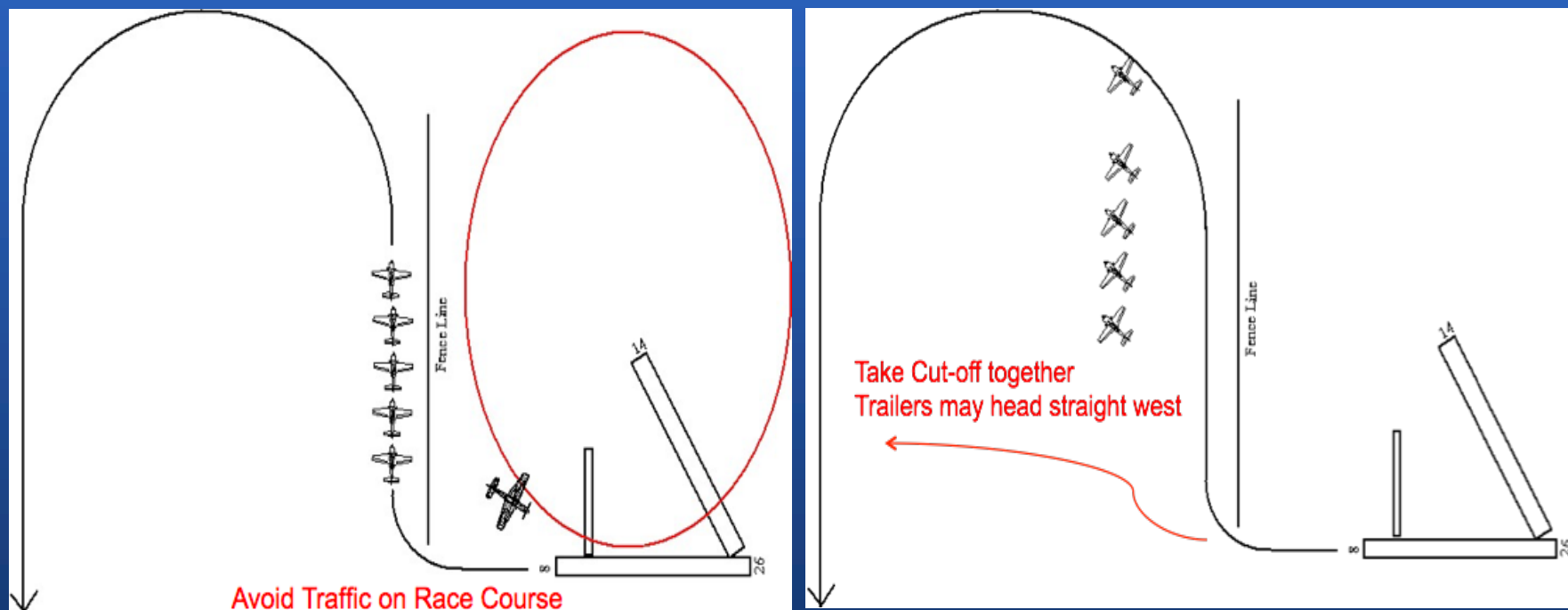
RWY 08 Depature

- Climbing left turning rejoin

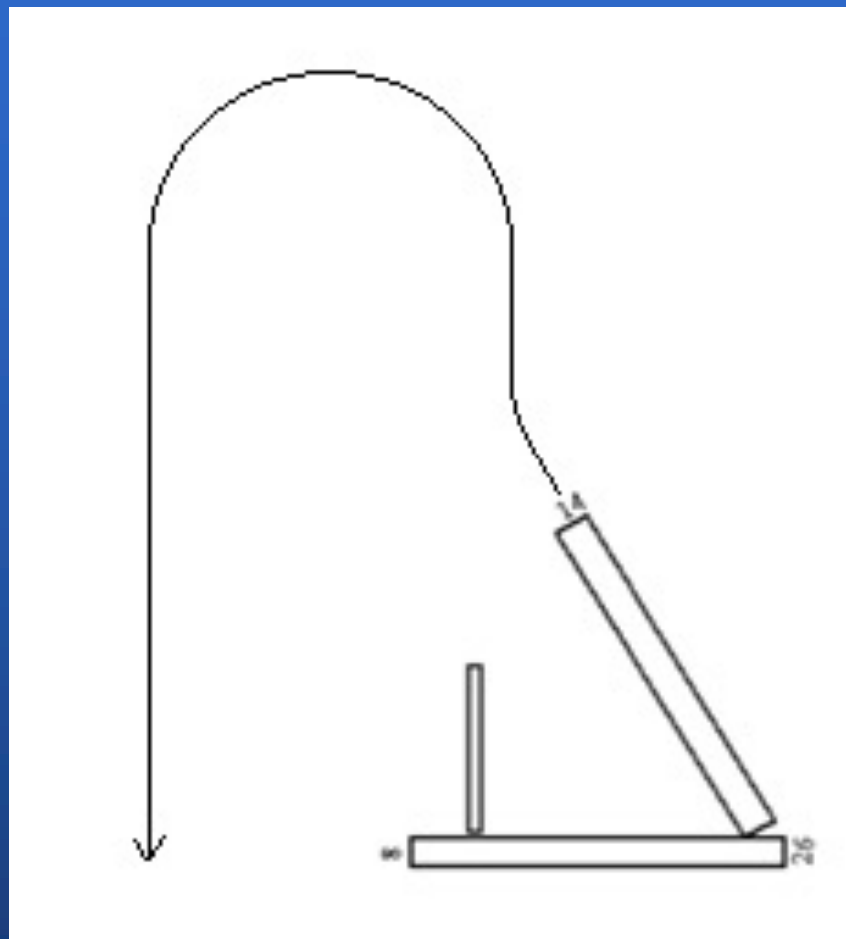


RWY 26 Departure

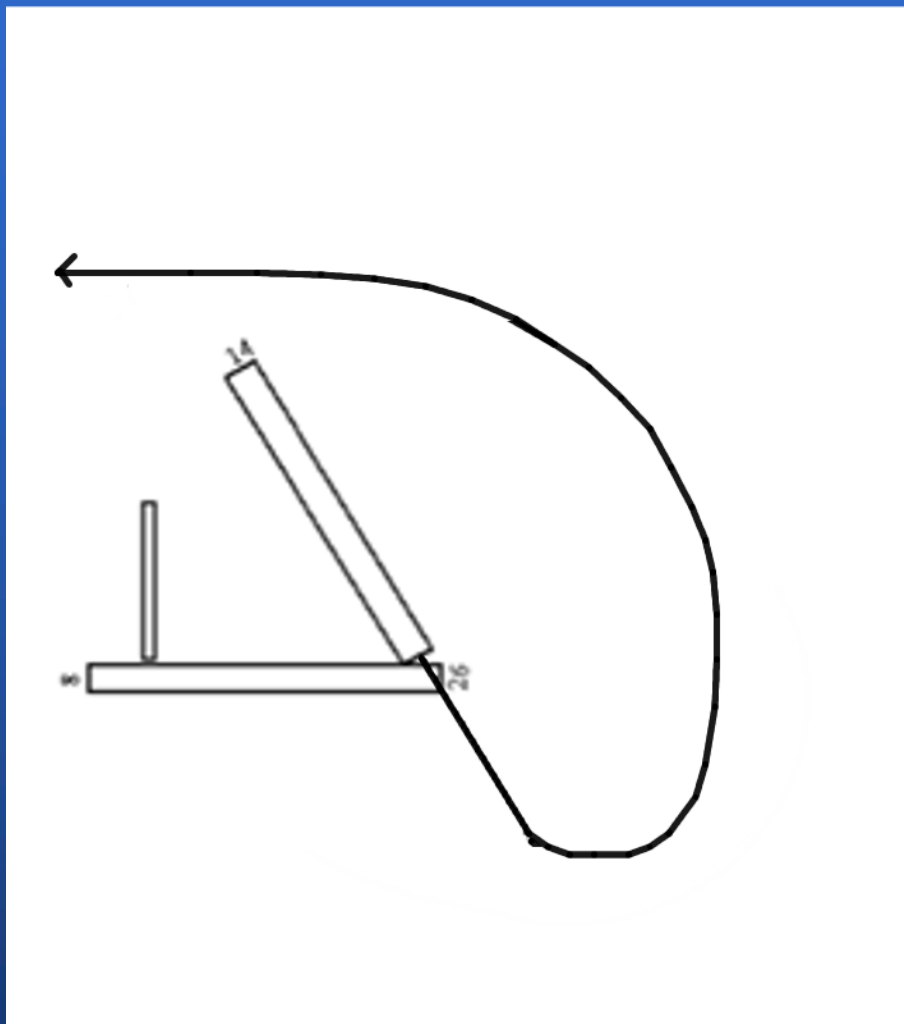
- Standard interval take off followed by:
- 90 deg in-trail turn
- THEN climbing left turning rejoin



RWY 32 Departure



RWY 14 Depature





Departure and Recovery

WORKING AREAS





WORKING AREAS

Reno MOA
Base 13,000'

Area 4
7,500-9,500
123.45

Area 5
7,500-9,500
123.55

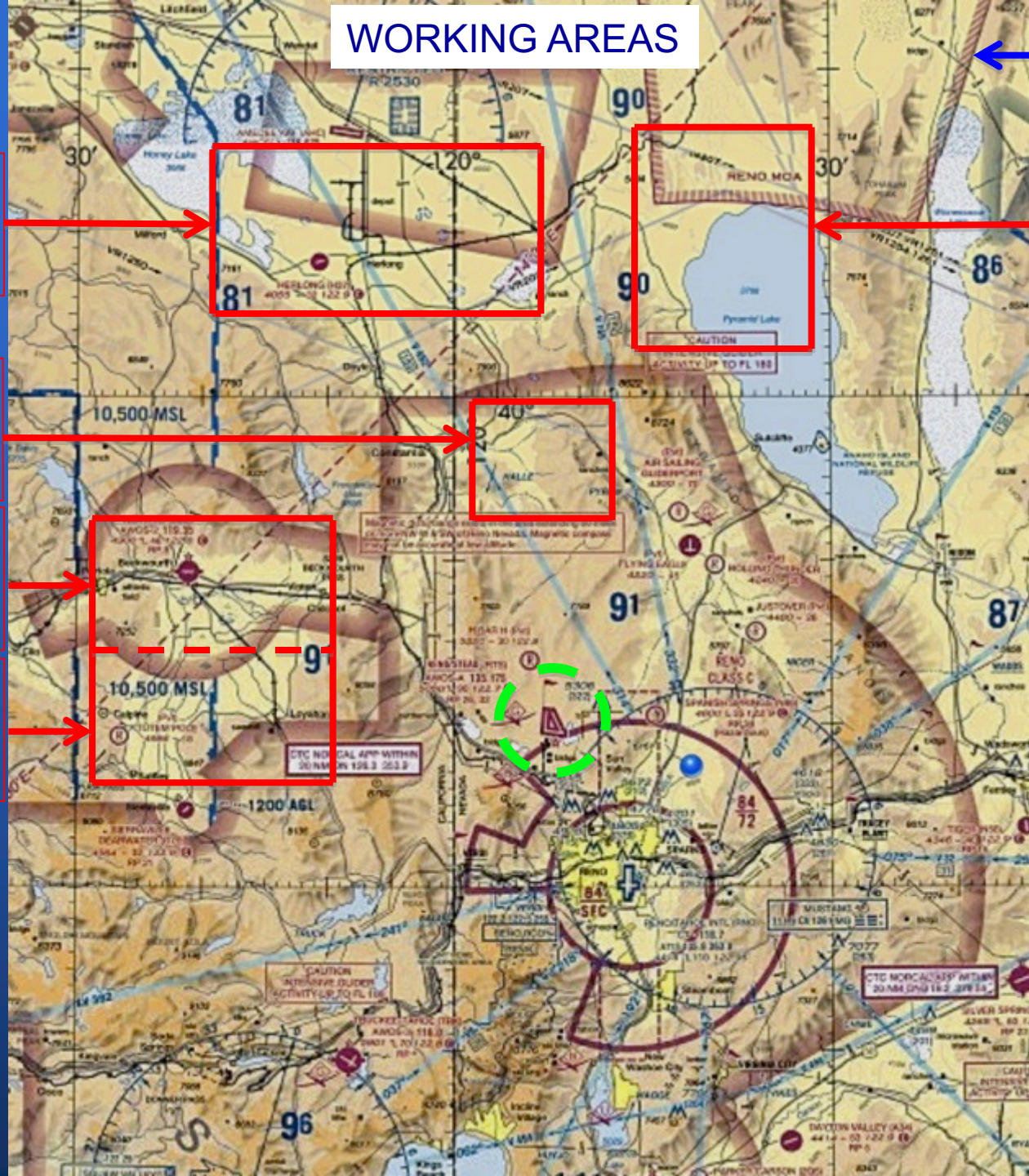
Area 3
7,500-9,500
123.35

Alternate
Freqs

Area 2
7,500-9,500
123.25

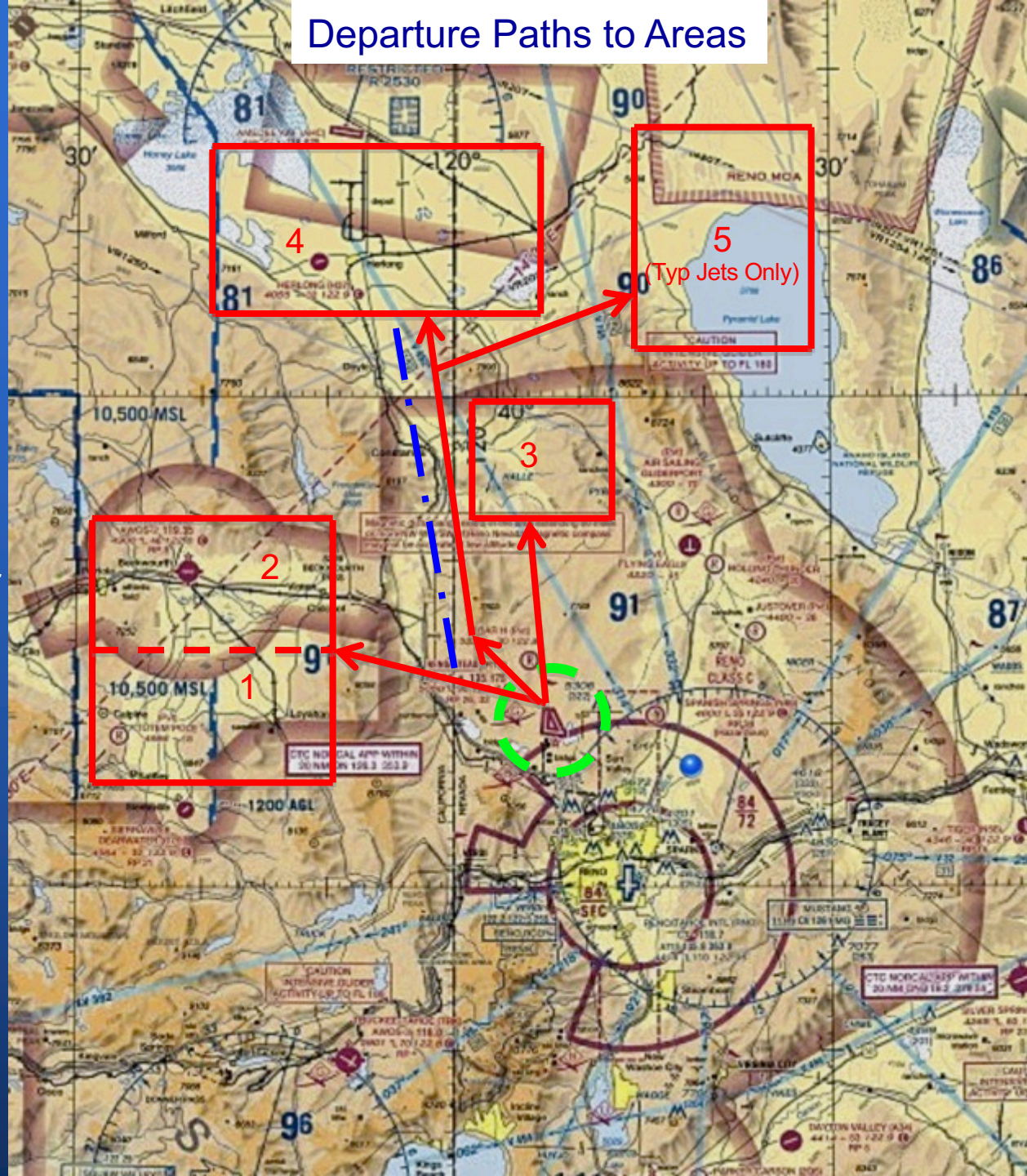
"One click up"
123.17
123.27
123.37
123.47
123.57

Area 1
7,500-9,500
123.15





Departure Paths to Areas



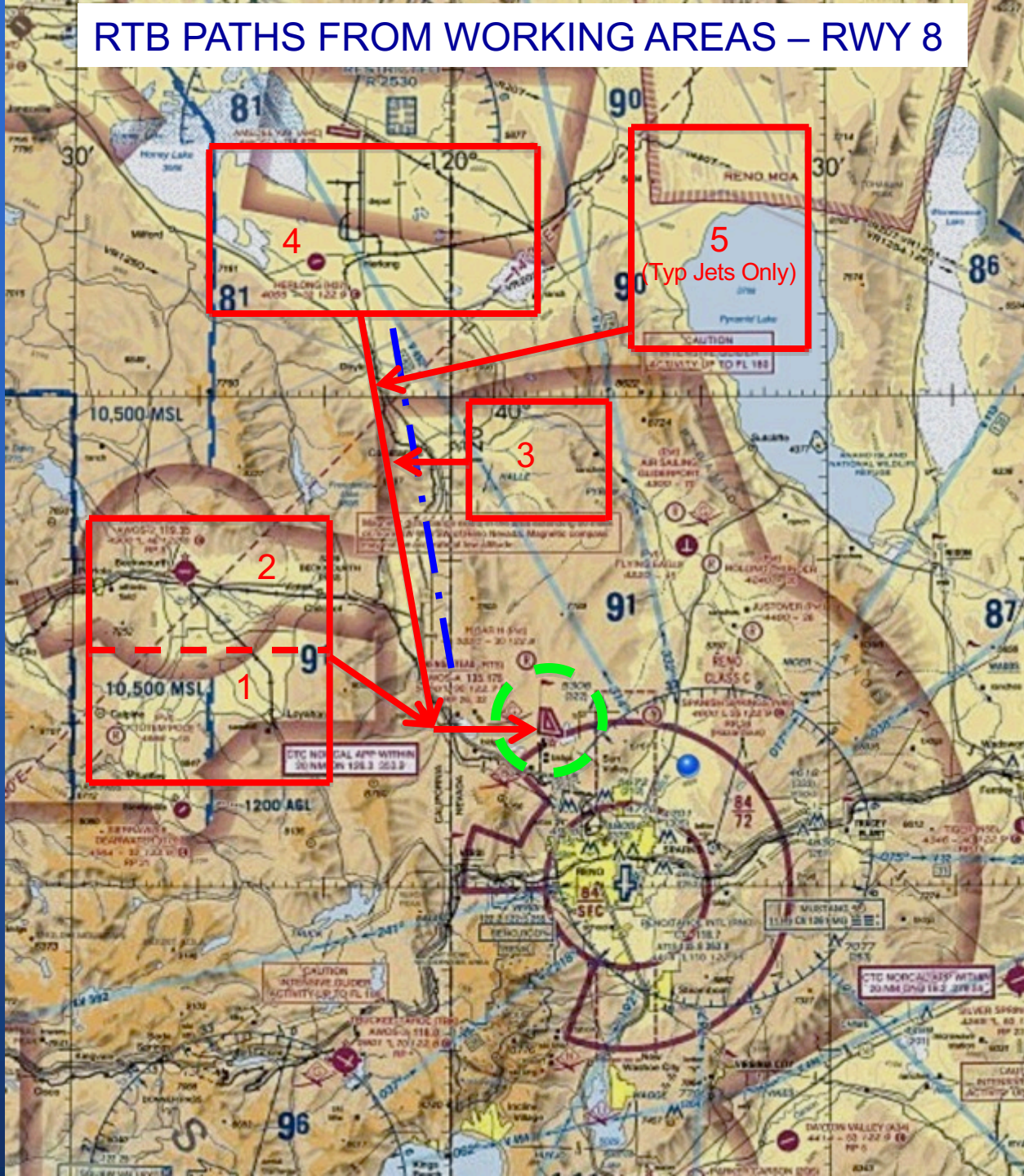
Outbound to
Areas

Dir to 1, 2, 3

Right (E) side
of 395 corridor
to 4, 5



RTB PATHS FROM WORKING AREAS – RWY 8



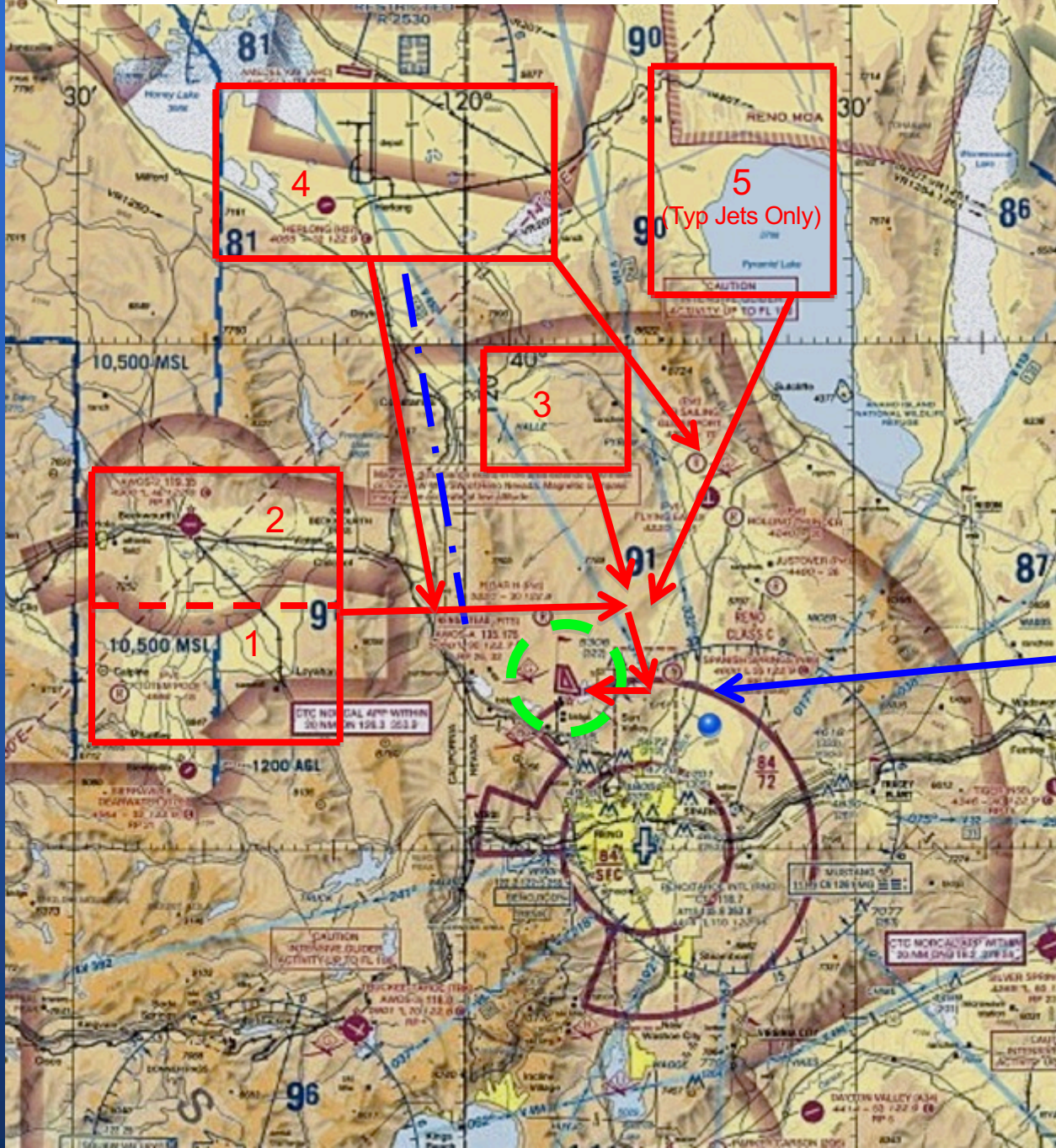
Returning to
Stead
RWY 8

1, 2
Dir to 5 mile
Initial 8

3,4,5
Right (W) side
of 395 corridor
to 5 mile Initial
8



RTB PATHS FROM WORKING AREAS – RWY 26



Returning to Stead
RWY 26

1, 2, 4
Circle 5 north,
then to 5 mile
Initial 26
(don't pinch S)

3,4,5
Dir to 5 mile
Initial 26

(2 options
for Area 4)

Safety

Divert Fields

Beckwourth/Nervino
4900' MSL
4600' Runway
122.8

Reno INTL
4415' MSL MSL
11000' Runway
118.7

Truckee
5901' MSL MSL
7000' Runway
122.8

Carson City
4705' MSL
6100' Runway
123.0

Dayton Valley
4414' MSL
5300' Runway
122.9

Silver Springs
4265' MSL
6000' Runway
122.9





KRTS Airport & Pattern Integration

- Formation Taxiing
 - Give way when able
- Formation Takeoffs
 - Hold for arrivals or departures
 - Time the line-up and departure
- Formation Arrivals
 - Delay entry into Initial
 - Extend Upwind prior to Break
 - “Spin-it” and circle N to re-enter Initial
 - Go-around if necessary
 - Multiple go-around can get colorful!
 - **Secrets to Success – Communication and Patience!**





Recovery Comms

- Simplify Radio Calls for the overhead
 - VFR (GA) pattern aircraft are not familiar with overhead terminology
 - Sport XX Flight, 10 West, entering straight in overhead 8 (lead only)
 - Sport XX Flight, 3 mile initial, runway 8 (lead only)
 - Sport XX Flight, overhead, left break 8 (lead only)
 - Sport XX Downwind Abeam (all aircraft)
 - Sport XX Base / Gear
 - Sport XX Cold



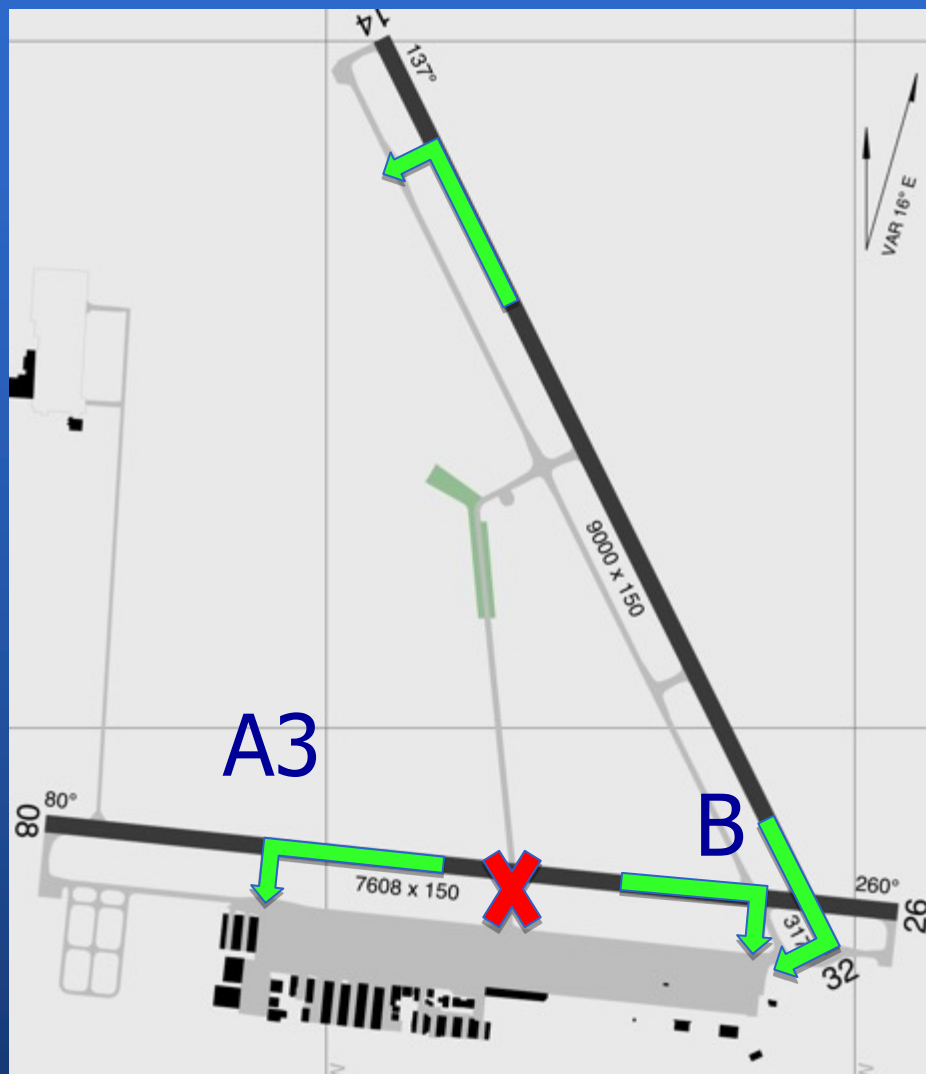
Recovery Notes

Co-existing with Local Traffic

- *Simple, Clear Comms*
- *Predictable, Consistent Overhead Entries and Patterns*
- *Courtesy to slower and/or training aircraft*
- *When in doubt of traffic interval*
 - *Ask for interval's position*
 - *Fly-through ("spin it") and re-enter, if needed*
- *Heads up for variety of skill levels and experience*
 - *Student Training common*



Runway Exit Plan

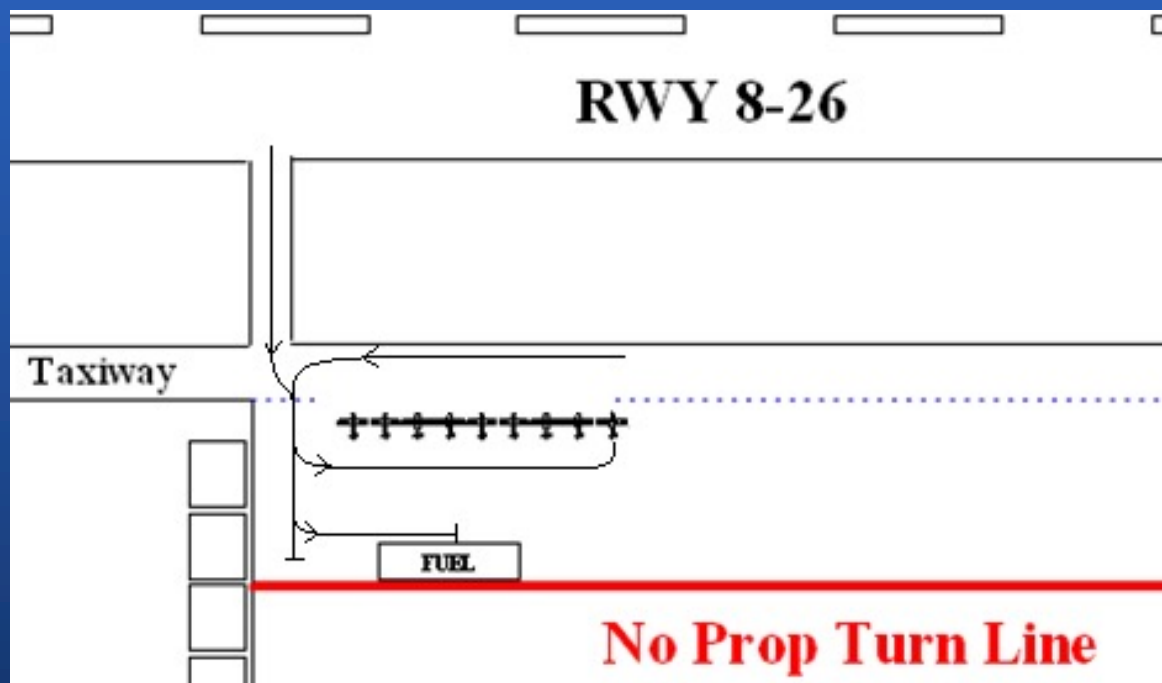


NO EARLY
TURNOFFS!



Recovery Ramp Ops

- As Briefed: Flight or Single Ship
- Follow direction of marshallers
- Marshallers will stand to side of aircraft



BREAK





PART III

SCARA Formation Warm Up Flight Profile & Description



Flight Briefing

- Critical to success of the flight
 - Sets the tone for the whole flight
 - Lead will use the Sport Class *Briefing Checklist*
 - Brief the plan
 - Listen Up / Ask Questions
 - Don't depart brief without clear picture of expectations
 - Fly the plan



Flight Briefing

- Time Hack
- Establish Mission Objectives
- Weather & Environmentals
- Sequence of Events and *standards to be used*
- Mission Specifics
 - Details on how to achieve the training objectives.
- Contingencies
- Wrap Up & Final Questions



Typical Training Profile

- Start/Check in
- Taxi out
- Run up
- Interval Takeoff
- Takeoff Rejoin
- Route Formation
- Fingertip Formation
- Wing-work (station-keeping)
- Cross-unders
- Echelon turns
- Pitch-out & Rejoins
- Extended Trail
- RTB
- Recovery (overhead)



Engine Start

- Be ready to start at briefed start time
- Ensure area is clear of all but crew
- Start when lead starts
 - If everyone in flight is turning, fire-it-up!
- Brief Non-standard Start Requirements
 - Early Starts for Radials, etc

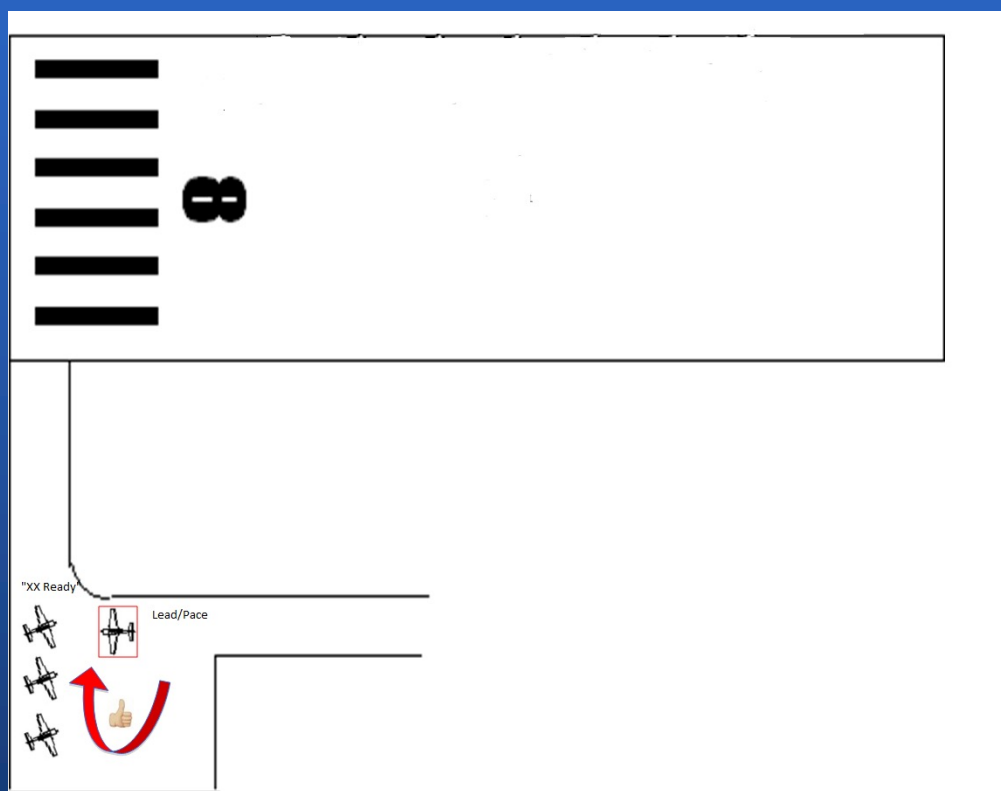


Check-in / Taxi

- Pull forward 5 feet when ready to taxi
 - FWU - Check In on CTAF with Race Number
 - PRS – Check in on Ground Control
- Taxi Sequence
 - No. 2 taxis first
 - Lead follows flight – Simulating Pace
- Spacing:
 - **BRIEF DISSIMILAR A/C or SPECIAL REQUIREMENTS**
 - In trail: *4 Ship Lengths*
 - Staggered: *2 Ship Lengths*
 - Tail Dragger: Brief NW A/C as reference or extend & weave as required

Run-Up Area Procedures

- Taxi into Pad in trail
- Angle to fit more aircraft in





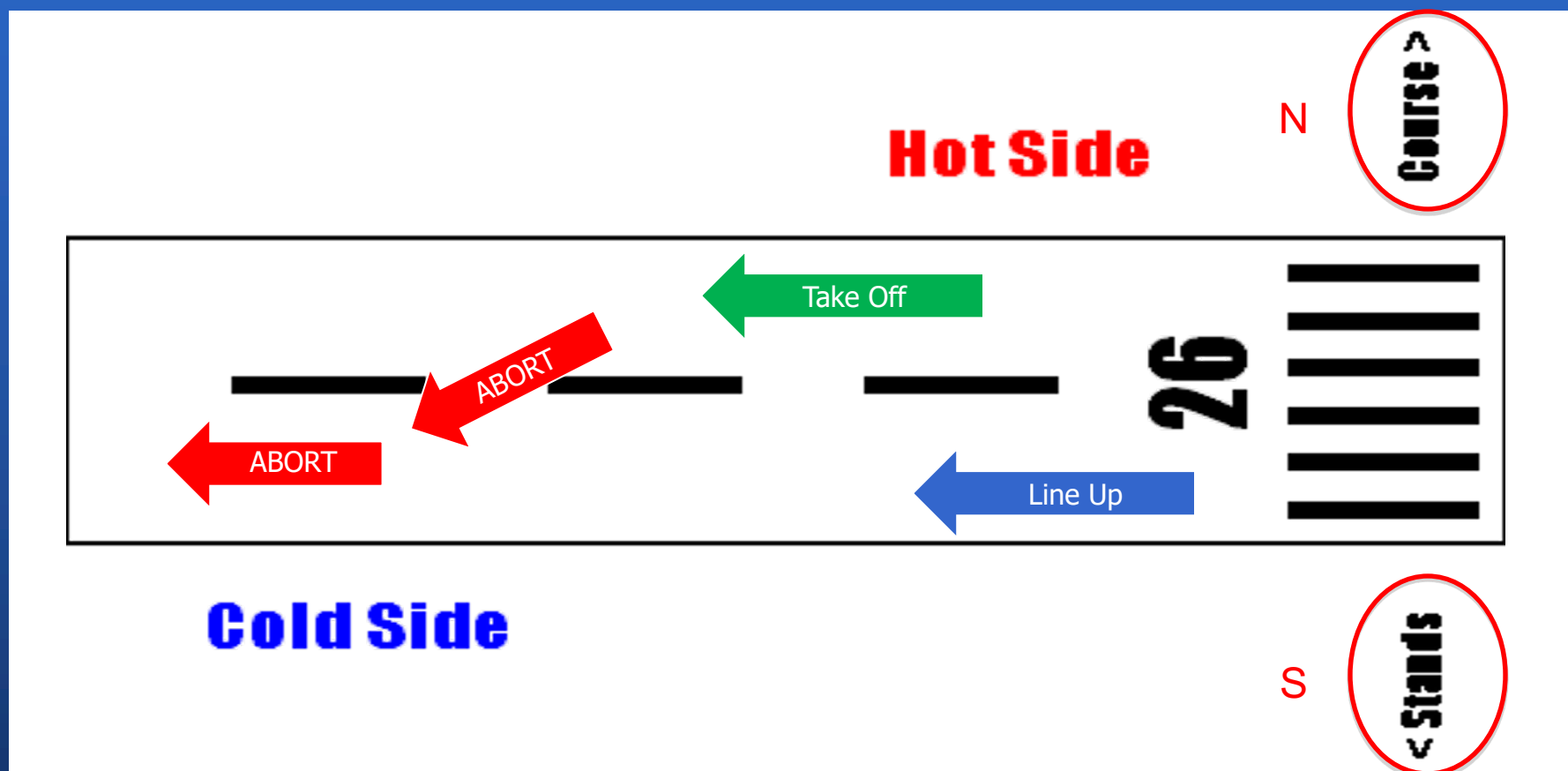
Run-up

- All Aircraft do Run-up on their own
 - No run-up signal required
- Wingmen Pass Thumbs-up back to front
- First Wingman calls “XX Ready” to Lead
- Lead switches flight to Company/Race Control Frequency (“Go”)
 - Do not auto switch
- Check-In with Race number
- Lead announces Flight’s departure on CTAF
 - Line-up and Launch using Sport Class procedures

Take Off

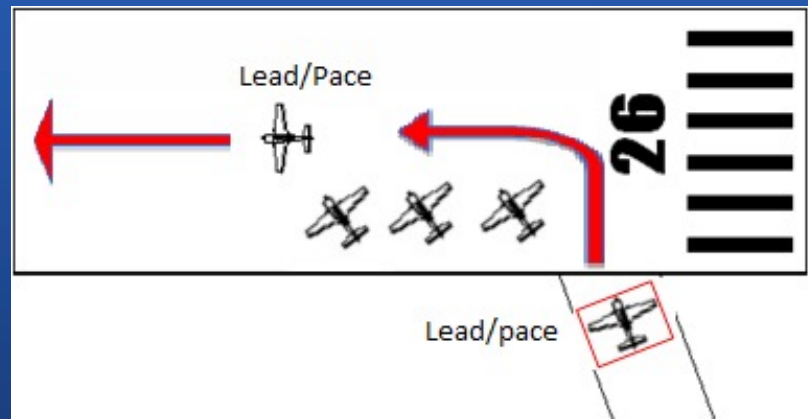
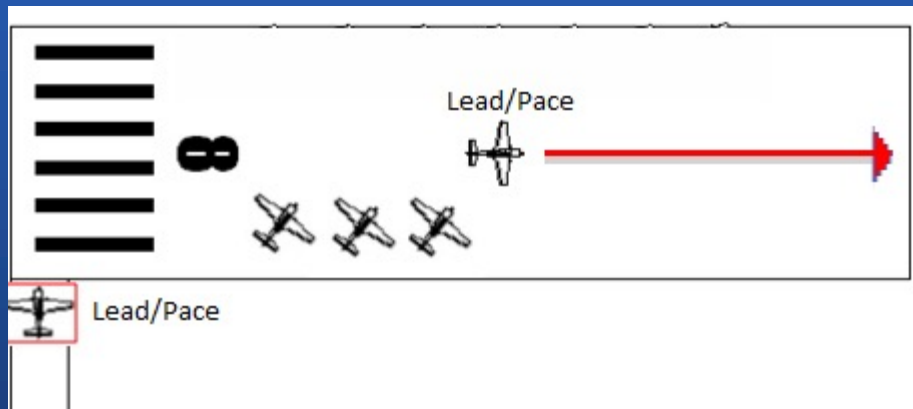
Hot Side / Cold Side

- *Cold side is exit side*



Line Up

- First Wing taxis down runway to allow all members of the flight to stop on cold (south) side of the runway
- Angle 45 degrees to the runway heading
- Lead follows flight onto runway
- When Cleared for TO, Lead taxis past all aircraft
- Racers give thumbs up to Lead/Pace





Interval Takeoff

- Lead call 60 kts
- Racers roll in order when previous racer is 1000 ft down the runway
- Last Aircraft call airborne
- Takeoff on Hot side, Abort to Cold side
 - Hot side is away from stands (N side)
 - Cold side is turnoff side (S side, towards stands)
 - Control the Aircraft
 - Call the Abort
 - Call Cold



Takeoff Aborts

Aborting Aircraft

- FLY THE AIRPLANE!
- Aircraft in control – *MOVE* to **Cold Side**
- Communicate Intentions as soon as practical

Aircraft Behind – On the Roll

- Judgment Call: Continue Takeoff roll on **Hot Side**

Aircraft Behind – Not Rolling

- Maintain position until abort is clear, then continue take off roll
- If abort cannot clear, maintain position or taxi back to ramp



Rejoins After Interval Takeoff

- Standard is a Left Turning Rejoin
 - *SCARA: ALL Rejoins in Sport Class FWU & PRS will be “Everyone Joins to the Outside of the Turn”*
- FWU Departure, PRS, and Race flight will be left rejoin turns
 - Join to right echelon
- Formation Warm Up hops may practice rejoins in both directions in working area
- Rejoins discussed in an upcoming slide



Route Formation

- WHY ROUTE?
 - Checklists and “Ops Checks”
 - Better lookout
- Signal
 - Radio Call
- Wing Pilots *move out* to maintain lateral separation.
 - 2-4 ship widths for checklists and frequency changes
- Turns
 - Wingman on the inside of the turn:
 - Fly route *welded wing* references
 - Wingman on the outside of the turn:
 - Fly *echelon* references to avoid large power req
 - (*Stack Level in turn away*)
- Use good scan of lead when doing ops checks
 - To avoid unrecognized closure



Ops Checks and Fuel Management

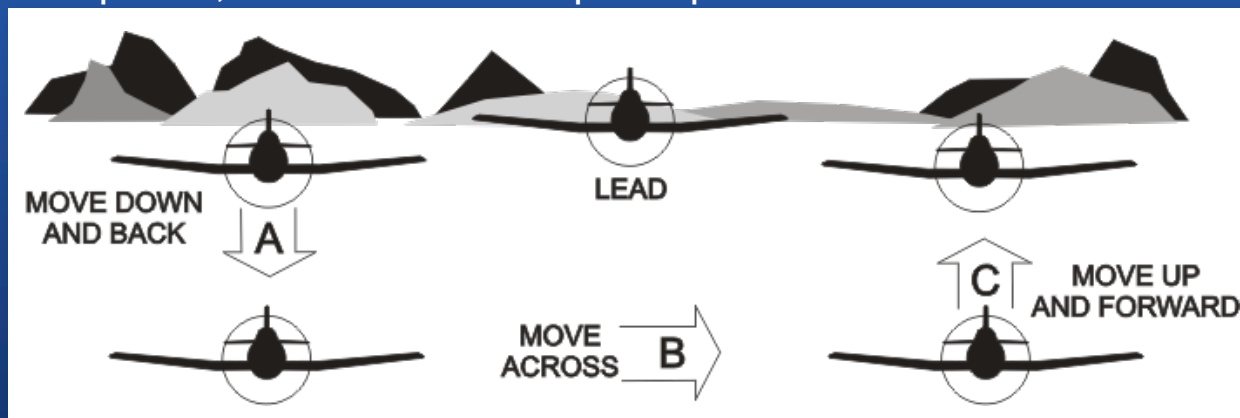
- **“Ops Check”**
 - All in-flight checks performed in route formation
 - Check fuel, fuel balance and engine parameters
 - Report parameters as required.
 - State of aircraft
 - Fuel State in hours + minutes
 - Flight Lead radio call and acknowledgment:
 - Begins with lead, then in order of flight
 - *“Sport XX flight Ops Check” ... “Sport XX, all green, 2+45”, “Sport YY, all green, 1+15”, etc*

Cross-Under

- SCARA SOP is Radio Call

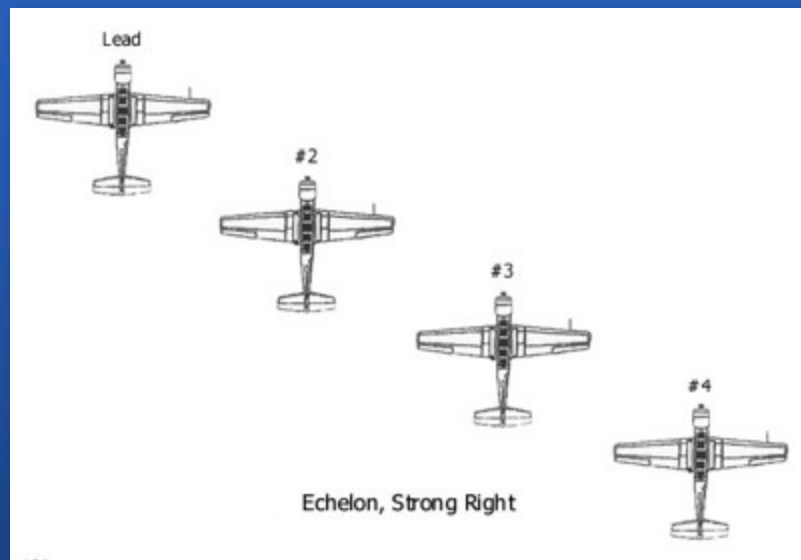
3 step process, Avoid rounding the corners

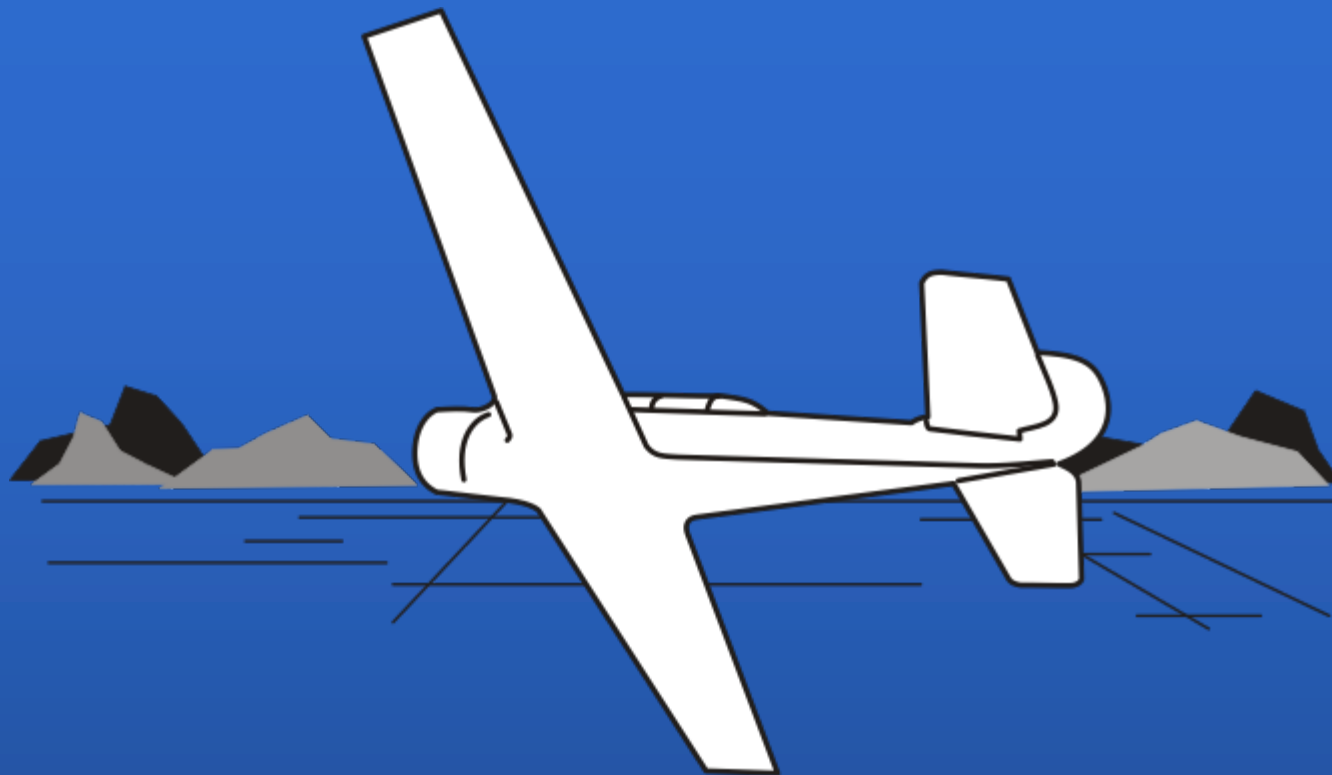
1. Reduce power, move down and back
 - Add small amount of power to stop rearward movement
2. Change heading to move across to opposite side
 - SLIGHT aileron/rudder pressure to create SLIGHT heading change
 - **NO LARGE BANK or YAW (should be imperceptible)**
 - Maintain nose to tail distance while crossing
 - SLIGHT aileron/rudder pressure to re-align heading and stop cross
3. Add power, move forward & up into position



Echelon

- All aircraft on the same side of lead
- Used for:
 - Pitch outs
 - Traffic pattern
 - Flying to the Chute





SCARA Formation

PITCH-OUT AND REJOIN



Pitch-Out Execution

- Always executed from ECHELON
- Signaled with RADIO CALL
- Level, 60° bank, 2G, 180° turn
- 3 second interval
 - Match lead's roll, G, and flight path
- "4's IN" Call
 - At completion of 180° turn (Differs from Extended Trail)
 - For Rejoins: Last aircraft calls "in" when wings-level, directly behind preceding aircraft.

Rejoin



- Rejoin is directed by radio call
- Lead establishes a steady turn (20-25 deg nominal)
- Wingman turns inside to establish LEAD PURSUIT
 - “Rejoin line” = 45 deg – vertical stab on outside wing
- Once on the rejoin line, modulate bank to *fly up the line*
 - Expect to DECREASE bank upon reaching “the line”.
- Use **BANK ANGLE**, not throttle, to control closure (but manage airspeed)
 - If acute, DECREASE bank (less lead/cutoff, less closure)
 - If sucked, INCREASE bank (more lead/cutoff, more closure)
- Stay **LEVEL** with lead – it’s an “in plane” maneuver
 - Lead ON Horizon to *slightly* above
 - Going low drives the entire flight low



Overshoot/Under-run

- Too much closure or very acute?
- **OVERSHOOT/UNDER-RUN**
 - Decrease AOB and G
 - Lower nose
 - Reduce power
 - Go below, behind and *outside*
 - Stabilize
 - Lead will direct
- **No big plays to catch overshoot!**
- **Never go belly up to lead!**



Rejoin: Finish

- Fly Bearing Line until positioned to cross
 - Think: Maintain forward motion
 - Think: Rejoin to inside, and then cross under
 - 2-3 ship-lengths
- Cross smoothly to Echelon outside of turn
 - Requires power as you move outside lead's radius
 - ~10 knots smash for -2, outside requires more
 - No big plays to outside!
 - Maintain nose to tail clearance
 - Ensure you have other wingmen in sight as you rejoin



Extended Trail

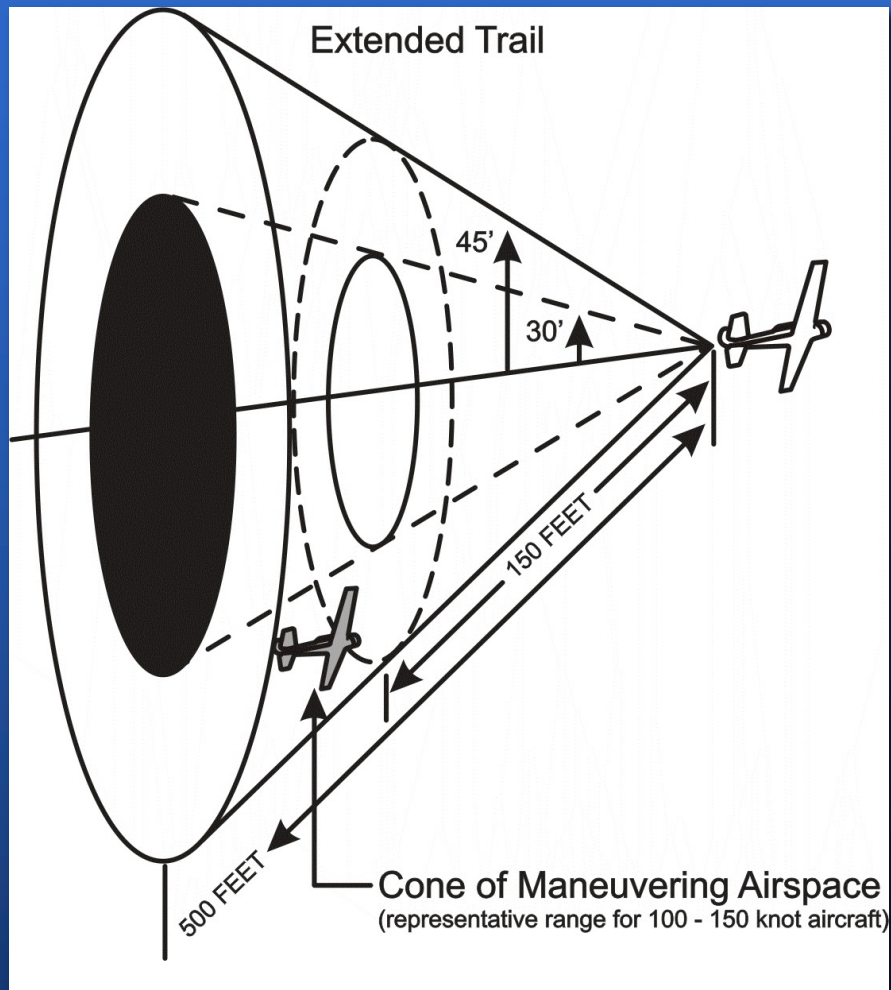
- Exercise to manage nose to tail with lead/lag
 - Use pursuit curves, not power to:
 - Control Nose to Tail
 - Control Closure
 - Manage Aspect
 - Fluid position
 - 500' - 1000' Nose to Tail
 - No closer than 200 feet or KIO/breakout
- Evaluated using wingovers, max bank angle 90 degrees
- Lead may brief and fly greater or lesser angles based on exp
- Operational Applications:
 - Rejoins and Landing Interval
 - Confidence Builder!



Entering (Separating to) Extended Trail

- Entered from Echelon
- Flight Lead Brief procedures in detail
- Use Voice call to initiate
- Standard 3 second pitchout
- “4’s In” Call
- **For Extended Trail:** Last aircraft calls in when achieving the desired spacing and ready for maneuvering
- **Differs from PO/RJ in this respect**
 - (no need to wait for 180° of turn)
- **Lead begins maneuvering on “4’s In” call**

Flying Extended Trail



Lead

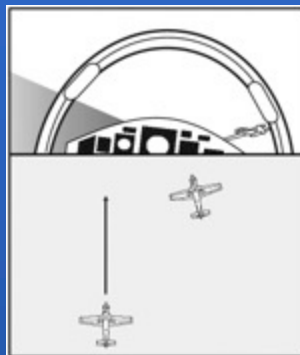


Figure 3.8 Lead Pursuit (two perspectives)

Pure

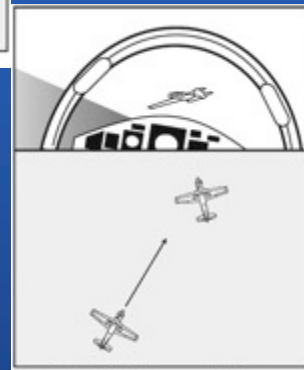


Figure 3.7 Pure Pursuit (two perspectives)

Lag

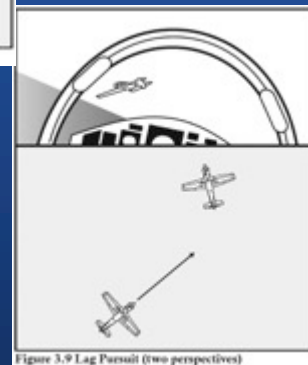


Figure 3.9 Lag Pursuit (two perspectives)



Rejoin from Extended Trail

- Flight Lead flies S&L for short period
 - Radio Call
 - Turn for rejoin
 - Standard Rejoin Procedures



Line Abreast Formation

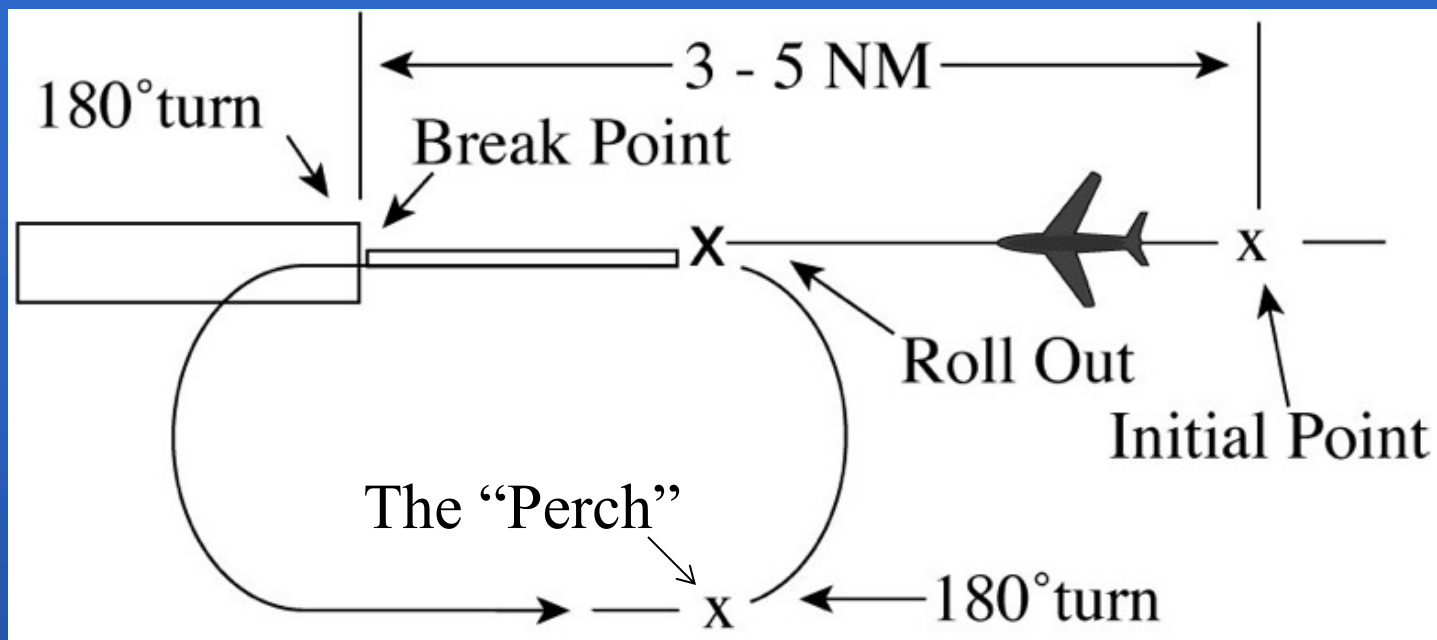
- Flown in the Start Chute
 - Will be practiced in the working area
- Maneuver begins from Echelon Right
 - *"Sport Flight XX, move it up Line Abreast"*
- Flown on 3/9 line, stacked level, lead to the left
 - Wing tip to wing tip
 - No step down
 - Route spacing (2-4 ship widths)
- Lateral Spacing (in/out) is challenging
- Banking causes spacing difficulties
- Tendency is to roll where you look (so don't!)





Lost Sight/Break Out

- Lead will pre-brief the formation, timing and technique they will utilize for this exercise
- Lead will only give the Breakout call to one Wingman at a time
- Lead will initiate the exercise with a call such as, “*Sport XX, Breakout*”, or “*Sport XX, you have Lost Sight, Breakout*”, or “*Sport XX, you are Blind*”, or similar
- The Wingman so directed, will:
 - Clear the break out area
 - Initiate an immediate Breakout, as described previously
- After the Breakout Wingman recovers the aircraft to straight and level from the Breakout, the Lead will direct the Wingman back into the formation



SCARA Formation

RECOVERY



Overhead Pattern Execution

- Lead configures flight in echelon prior to Initial
- Normal Radio calls alert wingmen to upcoming pitchout
- Lead Signals pitchout and 5 sec interval (only hand signal we use)
- Pitchout at 1000' AGL (6000' MSL @ RTS)
 - Fixed Gear A/C - Level pitch to 6000' DW
 - RG A/C - Pitch up to 6500' DW
 - **Sport Class Standard is 5 sec Interval for Landing Pattern**
 - Alternate interval may be briefed by lead
 - Creates ~1,500' interval on downwind
 - Interval about 90° ahead in approach turn
 - Know your interval and aircraft ahead of it



Landing Pattern Execution

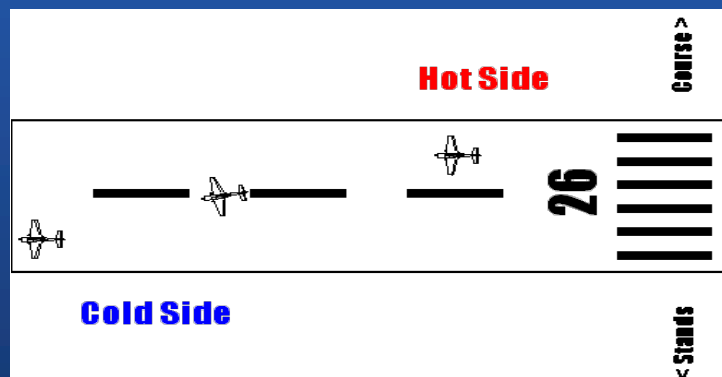
- Wing Pilots match aircraft ahead
 - Speed and configuration...aircraft type differences permitting
- Coming Off the Perch
 - Continuous descending turn to final
 - Use same turn point off perch
 - Adjust turn point as needed for aircraft type (speed differential)
 - Do not descend early on downwind
 - Don't chase lead down...forces entire pattern down
 - Keep interval(s) in sight
 - Adjust interval as needed with turn (lead/lag)
 - 90° behind aircraft ahead, 2000' spacing +/-



Landing Pattern

Hot-Cold Landing Procedure

- Lead lands long on hot side (or centerline of runway if conditions warrant), then moves to cold side (ramp exit side)
 - Each Wing Pilot does the same
 - **CONTROL YOUR CLOSURE ON INTERVAL BEFORE GOING COLD**
 - 2000' +/- spacing at threshold
 - <100 ft wide runway: No clear lane, increase interval
 - RWY 18 @ RTS
- All aircraft roll to briefed exit to clear
 - **No Early Turnoffs**





Taxi In/Shutdown

- Lead assembles flight clear of runway, or
- Individual Taxi OK – As briefed by lead
- **CAUTION entering ramp!!**
 - Other Flights and their crew
 - Do not taxi or coast across No Prop Turn Line



Debrief

- Lead Pilot directs the debrief
 - Wingmen get their shot when called
- Critique all aspects of flight, as required
 - Examine the *“what, why and how”* of the sortie
- Wingmen should not leave debrief with unanswered questions or concerns
- **Remember: Egos checked at the door**
 - **Goals: Safety, Mutual Support and Constant Improvement!**



Questions? – *Let's Fly!*

