



Navigation & Flight Planning

Overview

WHAT

- The process of planning and executing cross country flights (> 50 nm distance)
- Procedures for different situations that may arise during flight

WHY

- Integral to safely flying from point to point
 - Time, fuel requirements, prevent getting lost, etc.
- Make planning flights easier and more organized

CONTENT

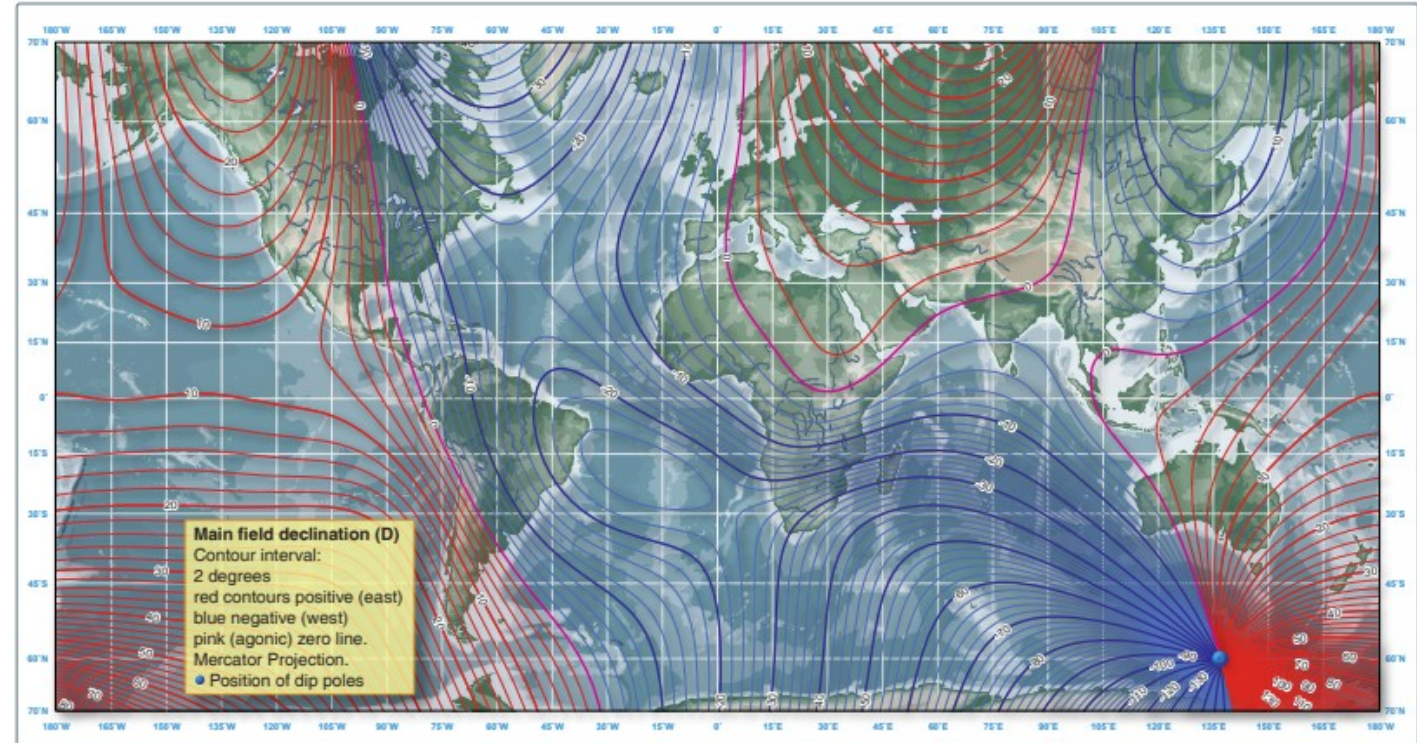
- Terms
- Aeronautical Charts & Chart Supplement
- Navigation
- Flight Planning & Nav Logs
- VFR Flight Plan
- Weather Check
- GPS Navigation
- Diversion to an Alternate
- Lost Procedures
- Flight Following & Intercept Procedures



Terminology

Navigation Terms

- True North
 - Geographic north pole
- Magnetic North
 - Magnetic north pole
- Variation
 - Angular difference between true & magnetic north
 - Isogonic lines on charts



Terminology

Navigation Terms

- True Course
 - Direction of flight measure clockwise from true North
- True Heading
 - Direction of longitudinal axis with respect to true North
- Magnetic Course
 - True course corrected for magnetic variation



Terminology

Navigation Terms

- Magnetic Heading
 - Magnetic course corrected for wind
- Compass Heading
 - Aircraft heading read from the compass
- Deviation
 - Compass error due to magnetic disturbances from in the airplane
 - Correction is displayed on the compass correction card



Terminology

Atmospheric Terms

- Standard Pressure: 29.92" Hg at sea level
 - Standard Lapse Rate: Pressure decreases 1" Hg per 1,000'
- Standard Temperature: 15° C / 59°F (at sea level)
 - Standard Lapse Rate: Temp decreases 2° C (3.5° F) per 1,000'



Terminology

Altitude Terms

- Indicated Altitude
 - Read directly from the altimeter when set to the current altimeter setting
- Pressure Altitude (PA)
 - Height above the standard pressure level (29.92")
 - $1,000(29.92 - \text{Alt}) + \text{Elevation}$
- Density Altitude (DA)
 - Pressure altitude corrected for nonstandard temperatures
 - Approximation:
- True Altitude
 - Vertical distance of the aircraft above sea level
- Absolute Altitude
 - Vertical distance of the aircraft above the surface of the earth (AGL)



Terminology

Airspeed Terms

- Indicated Airspeed (IAS)
 - Speed of an aircraft shown on the airspeed indicator
- Calibrated Airspeed (CAS)
 - IAS corrected for installation and instrument errors
- Equivalent Airspeed (EAS)
 - CAS corrected for adiabatic compressible flow for the altitude
- True Airspeed (TAS)
 - Speed at which an aircraft is moving relative to the surrounding air
 - CAS corrected for density altitude
- Groundspeed (GS)
 - Speed of the aircraft in relation to the ground
 - TAS corrected for wind



Aeronautical Charts

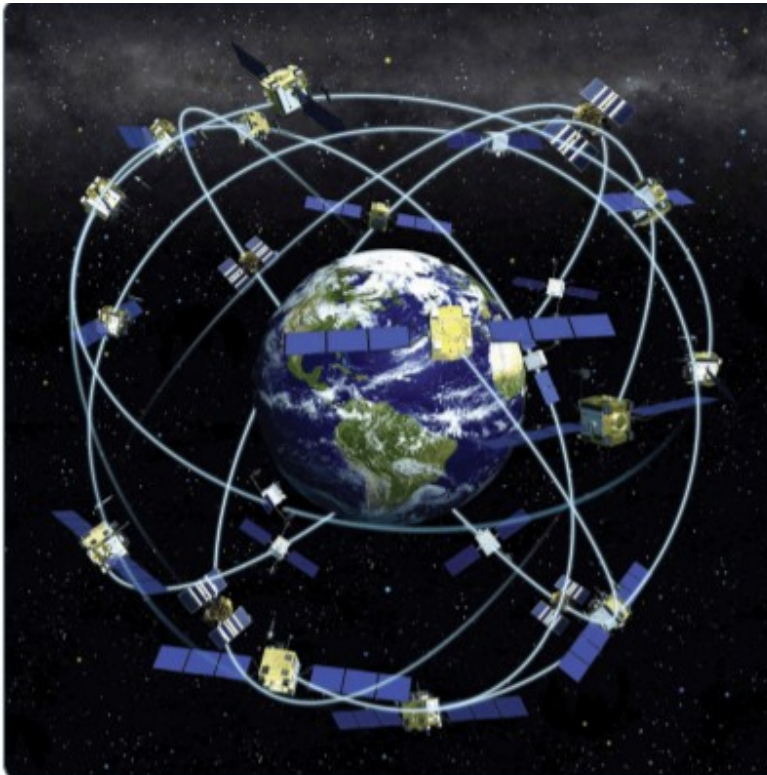
- Pilot's roadmap
- Sectional Chart (most commonly used)
 - Airport data, navigation aids, airspace, topography
 - 1:500,000 scale (1" = 6.86 NM); Revised every 56 days
- Terminal Chart
 - Helpful around Class B – More detailed version of the Sectional Chart
 - 1:250,000 scale (1" = 3.43 NM); Revised every 56 days
- VFR Wall Planning Chart
 - Aeronautical & topographic info covering the conterminous US
 - 1:3,100,000 scale (1" = 43 NM); Revised annually
- Current Charts
 - Information changes rapidly, always verify current charts
 - Check NOTAMs for updates between publication cycles



Chart Supplement

- Essential to planning
- Most comprehensive information on a given airport
 - Detailed runway info, procedures, frequencies, services, hours of op, & more
- Reference all airports during planning
 - Departure, Destination, all potential alternates





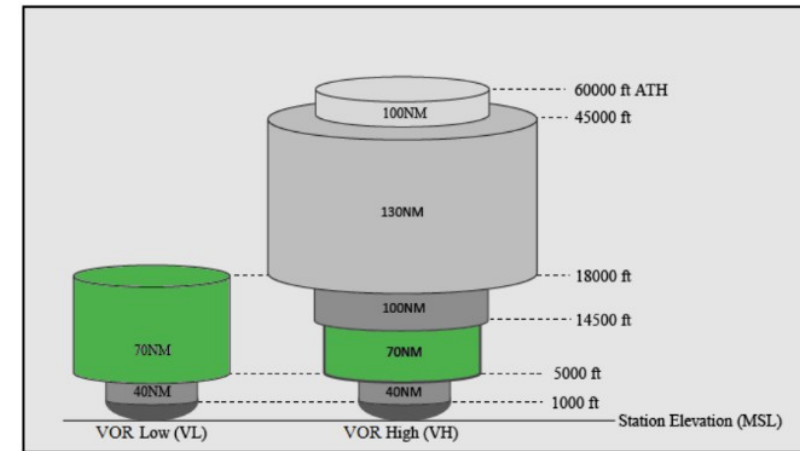
- Pilotage
 - Navigation by landmarks on the ground
 - Rivers, mountains, roads, cities, airports, etc.
- Dead Reckoning
 - Navigation on time, speed, distance, & direction
- Radio Navigation
 - Navigation by which a preset course is followed
 - GPS, VOR, NDB, etc.
- Ideally, pilotage, dead reckoning, & radio navigation should be used together

Navigation

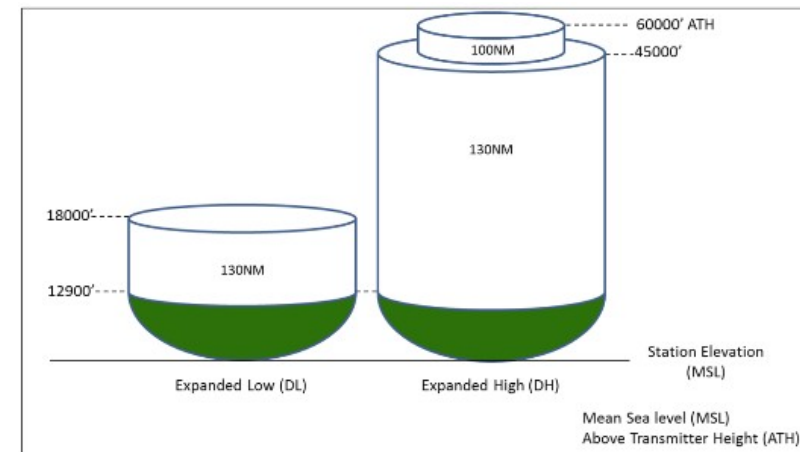
VOR Mon (Min Op Network)

- Minimum Operating Network
 - NAS is transitioning to PBN
 - Reducing VORs (from 896 to 590)
 - New service volumes – VOR service at/above 5,000' AGL
- Enables aircraft having lost GPS to use conventional navigation to reach a MON airport
- MON Airport
 - Conventional approach
 - Assured within 100 nm

MON VOR SERVICE VOLUMES



MON DME SERVICE VOLUMES



Source (both): FAA



Navigation

Magnetic Compass Errors

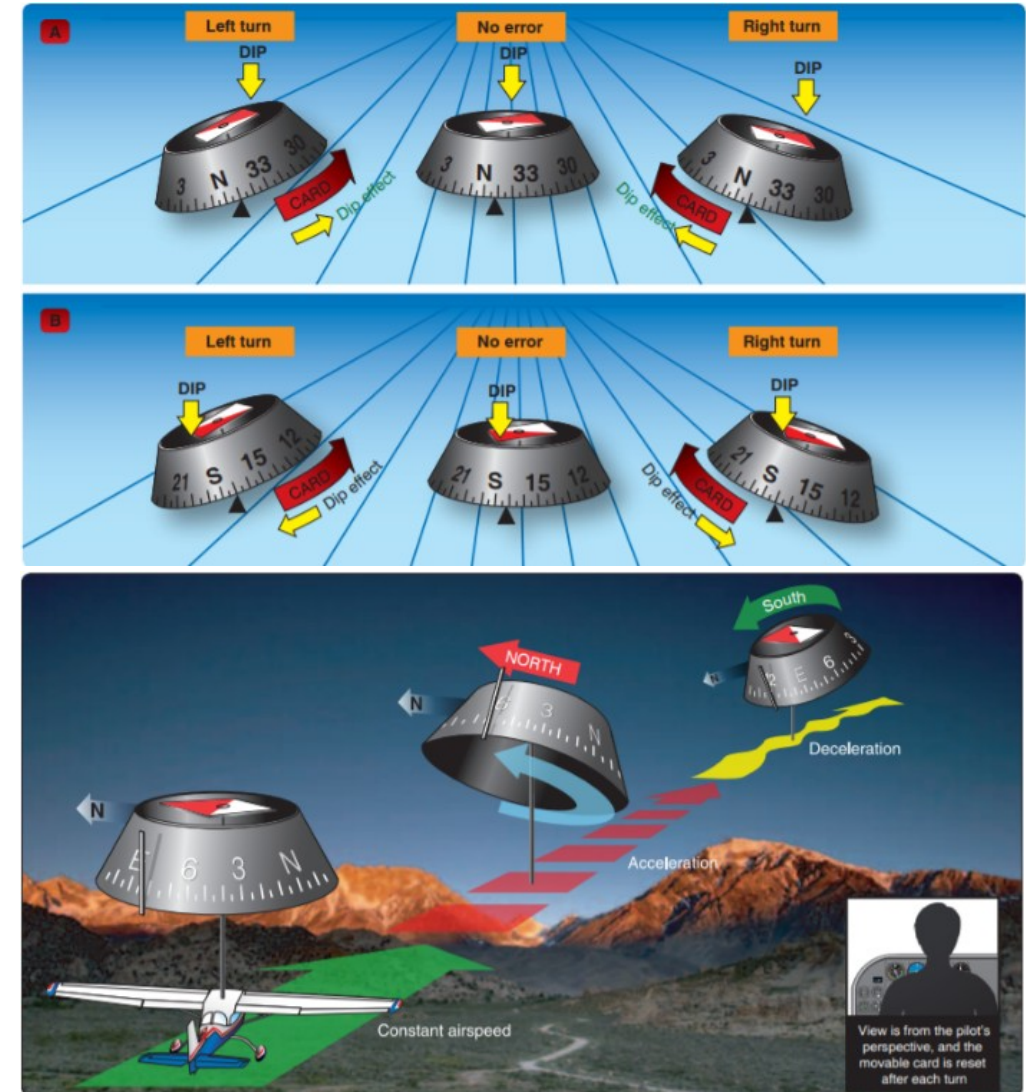
- Variation
 - Difference between magnetic & true North
 - Isogonic line: Connect points with the same magnetic variation
 - Agonic line: Line along which the two poles are aligned – No variation
- Deviation
 - Magnetic fields within the aircraft (on compass correction card)
- Compass Course
 - True course corrected for Variation & Deviation
 - True Course $\pm$ Variation = Magnetic Course
 - Magnetic Course $\pm$ Deviation = Compass Course
 - East is least, West is best



Navigation

Magnetic Compass Errors

- Lines of magnetic flux
 - Perpendicular at the poles, parallel at the equator
- Northerly & Southerly Turning Errors
 - Turns from a Southerly Direction: Compass Leads
 - Turns from a Northerly Direction: Compass Lags
 - UNOS: Undershoot North, Overshoot South
- Acceleration Error
 - ANDS: Accelerate North, Decelerate South
- Oscillation Error
 - Combination of errors & plane movement
 - Use the average



Flight Planning

Nav Log

- Flight Log
 - Flight plan organized point by point
 - Fuel, time, altitudes, headings, & frequencies at each waypoint
- Plot the Course
 - Route & Altitude
 - Checkpoints
 - Top of Climb & Top of Descent
 - Additional checkpoints along the route
 - Record the checkpoints on the Nav Log
 - Fuel Stops
 - If required, create a separate log for each leg

PILOT'S PLANNING SHEET															
PLANE IDENTIFICATION												DATE			
N123DB															
COURSE	TC	WIND		ALTITUDE	WCA R+ L-	TH	MAG VAR W+ E-	MH	DEV	CH	TOTAL MILES	GS	TOTAL TIME	FUEL RATE	TOTAL FUEL
		Knots	From												
From Chickasha	031°	10	360°	8000	3° L	28	7° E	21°	+2°	23	53	106 kts	35 min	8 GPH	38 gal
To Guthrie															
From															
To															

VISUAL FLIGHT LOG								
TIME OF DEPARTURE	NAVIGATION AIDS	COURSE	ALTITUDE	DISTANCE	ELAPSED TIME	GS	CH	REMARKS
POINT OF DEPARTURE	NAVAID IDENT. FREQ.	TO FROM	TO FROM	POINT TO POINT CUMULATIVE	ESTIMATED ACTUAL	ESTIMATED ACTUAL	ESTIMATED ACTUAL	WEATHER AIRSPACE ETC.
Chickasha Airport								
CHECKPOINT #1			8000	11 NM	5 min	106 kts	023°	
			10000		+8			
CHECKPOINT #2			8000	10 NM	5 min	106 kts	023°	
			10000	21 NM				
CHECKPOINT #3			8000	10.5 NM	5 min	106 kts	023°	
			10000	31.5 NM				
CHECKPOINT #4			8000	13 NM	7 min	106 kts	023°	
			10000	44.5 NM				
DESTINATION				5.5 NM	5 min			
Guthrie Airport				53 NM				



Flight Planning

Nav Log

- Power setting
- True Airspeed
- Distance between each checkpoint
- Magnetic Heading
 - True Course for each leg;
 - Adjust for wind to get True Heading;
 - Adjust for Variation to get Magnetic Heading
 - Adjust for Deviation to get Compass Heading
- Groundspeed for each leg
 - Using wind & true airspeed

PILOT'S PLANNING SHEET															
PLANE IDENTIFICATION												DATE			
N123DB															
COURSE	TC	WIND		ALTITUDE	WCA R+ L-	TH	MAG VAR W+ E-	MH	DEV	CH	TOTAL MILES	GS	TOTAL TIME	FUEL RATE	TOTAL FUEL
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To Guthrie															
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Chickasha Airport								
CHECKPOINT #1			8000	11 NM	5 min	106 kts	023°	
			10000		5 min			
CHECKPOINT #2			8000	10 NM	5 min	106 kts	023°	
			10000	21 NM				
CHECKPOINT #3			8000	10.5 NM	5 min	106 kts	023°	
			10000	31.5 NM				
CHECKPOINT #4			8000	13 NM	7 min	106 kts	023°	
			10000	44.5 NM				
DESTINATION				8.5 NM	5 min			
Guthrie Airport				53 NM				



Flight Planning

Nav Log

- Time for each leg
 - Based on departure time, calculate expected arrival times using groundspeed & distance
 - Convert to UTC (below)
- Fuel burn for each leg
 - POH
 - Time multiplied by fuel burn
- Planned versus Actual
 - Planning is never perfect - Recognize & adjust

PILOT'S PLANNING SHEET															
PLANE IDENTIFICATION										DATE					
N123DB															
COURSE	TC	WIND		ALTITUDE	WCA R+ L-	TH	MAG VAR W+ E-	MH	DEV	CH	TOTAL MILES	GS	TOTAL TIME	FUEL RATE	TOTAL FUEL
		Knots	From												
From Chickasha	031°	10	360°	8000	3° L	28	7° E	21°	+2°	23	53	106 kts	35 min	8 GPH	38 gal
To Guthrie															
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To															

VISUAL FLIGHT LOG								
TIME OF DEPARTURE	NAVIGATION AIDS	COURSE	ALTITUDE	DISTANCE	ELAPSED TIME	GS	CH	REMARKS
POINT OF DEPARTURE	NAVAID IDENT. FREQ.	TO FROM	TO FROM	POINT TO POINT CUMULATIVE	ESTIMATED ACTUAL	ESTIMATED ACTUAL	ESTIMATED ACTUAL	WEATHER AIRSPACE ETC.
Chickasha Airport								
CHECKPOINT #1			8000 10000	11 NM	5 min +5	106 kts	023°	
CHECKPOINT #2			8000 10000	19 NM 21 NM	8 min	106 kts	023°	
CHECKPOINT #3			8000 10000	18.8 NM 31.5 NM	8 min	106 kts	023°	
CHECKPOINT #4			8000 10000	13 NM 44.5 NM	7 min	106 kts	023°	
DESTINATION				8.5 NM 53 NM	8 min			
Guthrie Airport								

UTC CONVERSION	Pacific Standard: 8 hrs	Mountain Standard: 7 hrs	Central Standard: 6 hrs	Eastern Standard: 5 hrs
Add to local time:	Pacific Daylight: 7 hrs	Mountain Daylight: 6 hrs	Central Daylight: 5 hrs	Eastern Daylight: 4 hrs



VFR Flight Plan

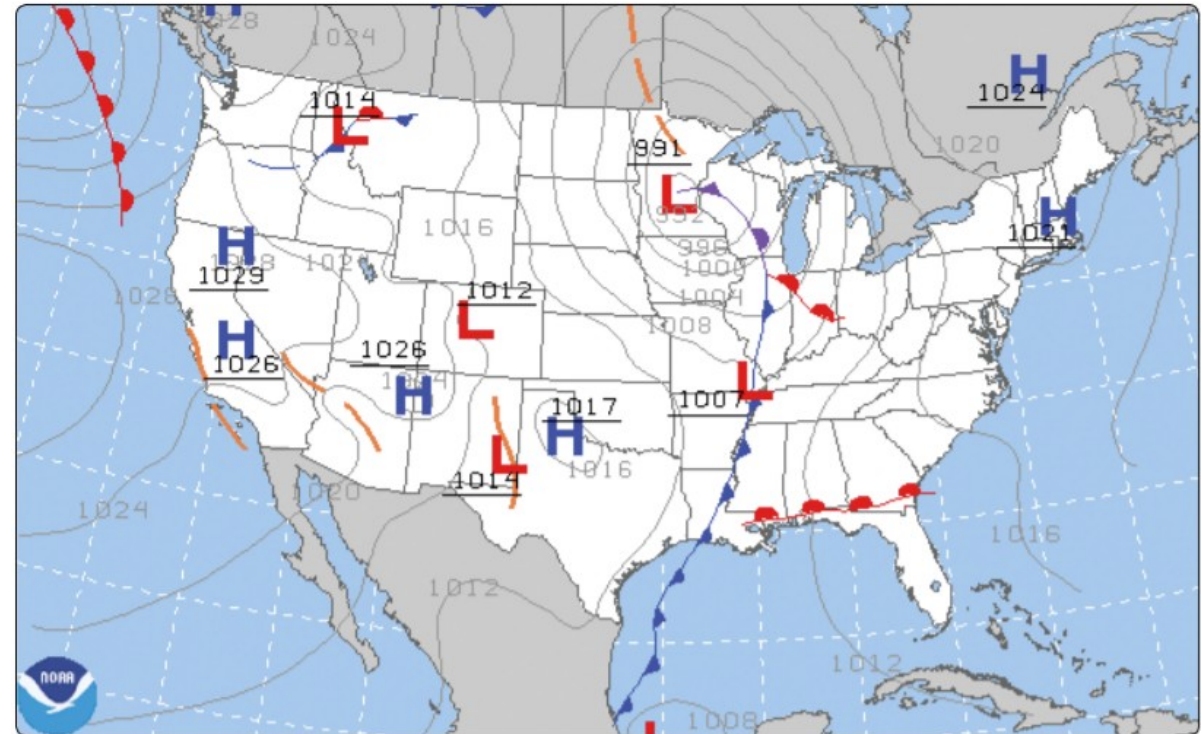
Filing a Flight Plan

- Not required, but good practice
- Can be filed on the ground or airborne
 - Ground: 1-800-WX BRIEF, ForeFlight, etc.
 - Airborne: FSS
 - Held for 1 hour after departure time
- ICAO Flight Plan
- Once airborne, open the flight plan
 - FSS, ForeFlight
- Don't forget to close the flight plan!
 - 1-800-WX Brief, or ForeFlight
 - Radio (discouraged to avoid congestion)



Preflight Weather Check

- First step to determining if the flight can be completed safely
 - FAR 91.103 requires a weather briefing
- Go/No Go Decision
 - Set limits and don't bend them
 - Weather is a major factor, but incorporate the entire PAVE checklist
 - Continual decision-making process



GPS Navigation

- Prior to flight, enter the flight plan waypoints into the GPS
- Avoid complacency with the GPS
 - Maintain situational awareness



Planned vs Actual Calculations

- Planning is never perfect
- Recognize deviations & adjust
- If time is off
 - Adjust power & airspeed
 - If fuel burn/power is a concern, accept the speed & adjust timing
- Use tools at your disposal
 - GPS, ForeFlight, rules of thumb, etc.
- Ignoring deviations only makes the problem worse



Diverting to an Alternate

Overview

- Preflight Planning: Be aware of potential diversion airports along the route
- When necessary to divert, use Shortcuts & Rule of Thumb Computations
 - Use your thumb to measure 10 NM increments
 - Use a compass rose or airway on the chart to estimate the heading
- GPS
 - If available, Use the 'Nearest' page or Direct To option in the GPS



Diverting to an Alternate

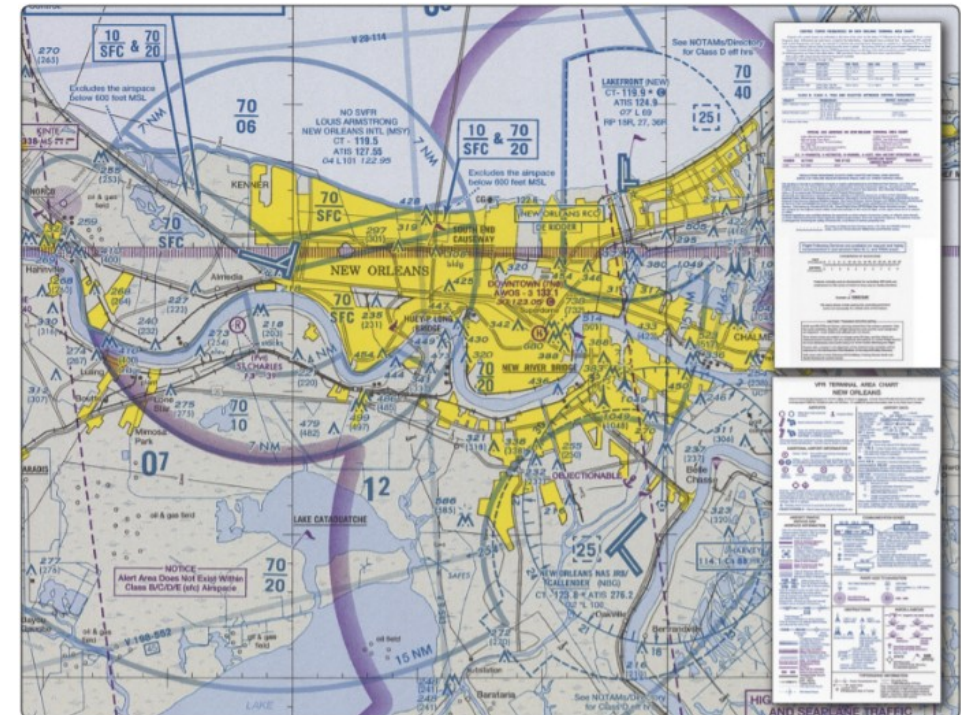
Procedure

- Find your position on the chart
- Divert immediately to the alternate using shortcuts/rules of thumb (or GPS info)
- Note the time
- Choose an altitude
 - Consider terrain, radio reception, clouds, winds, etc.
- Use winds aloft near the diversion point to determine a more exact heading & groundspeed
- Determine arrival time & fuel required
- Aviate, Navigate, Communicate



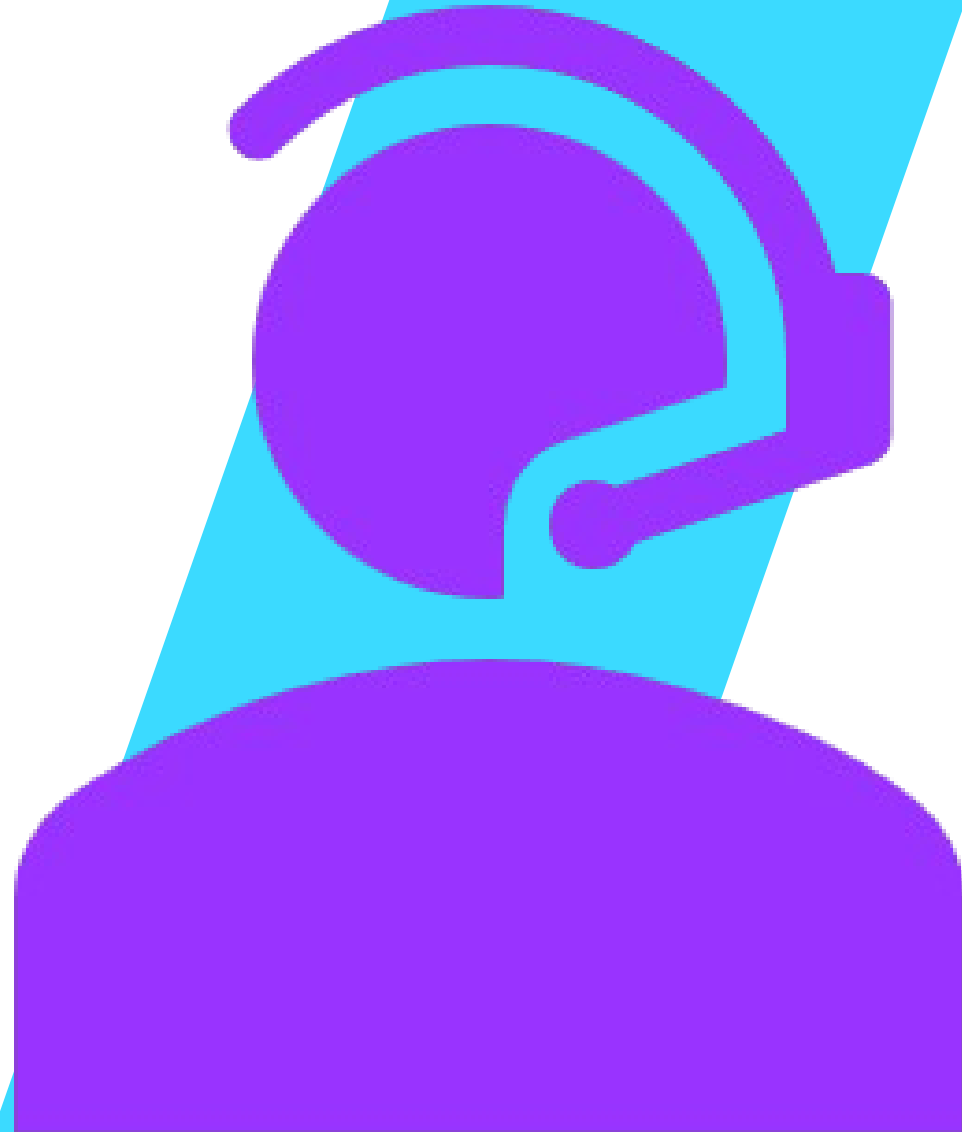
Lost Procedures

- Avoid getting lost
 - Plan ahead
 - Use multiple sources for location (Pilotage, Dead reckoning, Radio navigation, Flight following)
- If Lost
 - Don't panic
 - Five C's
 - Climb – See more, and improves radio reception
 - Communicate – ATC, Frequencies on charts, 121.5
 - Confess – Explain the situation
 - Comply – Follow ATC instructions
 - Conserve – Reduce power / airspeed to save fuel



Flight Following

- Radar equipped ATC facilities can provide radar assistance & navigation services
 - By request
 - Can be requested prior to departure, or airborne
- Limitations
 - Based on controller discretion
 - Advisory only
 - Cannot determine if their instructions will result in flight into IMC
 - Can only communicate with participating aircraft



Intercept Procedures

Aircraft may be intercepted in the interest of national security/defense

IN-FLIGHT INTERCEPT PROCEDURES				
If you are intercepted by a U.S. Military or law enforcement aircraft, immediately: - Follow the instructions given by the intercepting aircraft. (See chart at right.) - Notify ATC, if possible. - Attempt to contact the intercepting aircraft and/or ATC on the emergency frequency 121.5 MHz, giving the identity and position of your aircraft and the nature of the flight. - If equipped with a transponder, squawk 7700, unless otherwise instructed by ATC. If any instructions received by radio from any sources conflict with those given by the intercepting aircraft by visual or radio signals, request clarification while continuing to comply with the instructions given by the intercepting aircraft.	INTERCEPTING Aircraft Signal	Meaning	INTERCEPTED Aircraft Response	Meaning
	Rocks wings. After acknowledgement initiates a slow level turn, normally to the left, into the desired heading. (Also, at night flashes navigational lights.)	You have been intercepted.	Rocks wings and follow. (Also, at night flash navigational lights)	I understand and will comply.
	Performs an abrupt breakaway maneuver consisting of a climbing 90 degree turn, or more, without crossing the intercepted aircraft's flight path.	You may proceed.	Rocks wings.	I understand and will comply.
	Circles airport, lowers landing gear, and overflies runway in the direction of landing. (Also, at night turns landing lights on.)	Land at this airport.	Lower landing gear, follow the intercepting aircraft and land if the runway is considered safe. (Also, at night turn the landing lights on.)	I understand and will comply.



Intercept Procedures

Aircraft may be intercepted in the interest of national security/defense

Compliments of the Air Safety Institute • 800-638-3101 • www.airsafetyinstitute.org



INTERCEPTING Aircraft Signal	Meaning	INTERCEPTED Aircraft Response	Meaning
Raises landing gear while flying over runway between 1,000' and 2,000', and continues to circle the airport	This airport is inadequate.	If the intercepted aircraft is requested to go to an alternative airport, the intercepting aircraft raises its landing gear and uses the intercept procedures.	Understood, follow me.
(At night, the pilot of the intercepted aircraft will also flash landing lights while passing over the runway.)		To release the intercepted aircraft, the intercepting aircraft will perform the breakaway maneuver.	Understood, you may proceed.
The pilot switches on and off all available lights at regular intervals.	Cannot comply.	Performs the breakaway maneuver.	Understood.
The pilot switches on and off all available lights at irregular intervals.	In distress.	Performs the breakaway maneuver.	Understood.

For information on AOPA or AOPA Pilot Protection Services, call 800-USA-AOPA (872-2672) or visit pilot-protection-services.aopa.org





Questions?