GROUND SCHOOL SECTION 1

Pilot Resource Management;

Risk, Task, Automation, Crew Management,
Aeronautical Decision Making,
Controlled Flight Into Terrain, and
Situational Awareness.

Aviation Physiology

Aircraft Systems and Instrumentation

Aerodynamics

Congratulations

- Less than ½ of 1 percent (.33%) people do what you are about to do.
- The challenges as the rewards are formidable but well worth the effort.
- One half drop out because of the challenge but YOU CAN DO IT – I will help you accomplish your goal – just stick with it !

Getting your pilots license is ACHIEVABLE

1. Develop a plan of clear steps in getting what you wish to achieve.
2. Be SMART
   Specific Goal: Be specific as to what you want to accomplish.
   Measurable Goals: Milestones are good measurable goals in achieving your license.
      First Flight
      Getting your "Student Pilot License" needed to solo
      First Solo Flight
      First Cross Country
      First LONG Cross Country (Private Pilots)
      First Night Cross Country (Private Pilots)
      Passing the Aeronautical Written Exam
      Passing Your Checkride – Getting the license
      Flying your 1st Passenger
   Achievable: Don't beat yourself up – baby steps before big steps!
   Realistic: *Flying is expensive* – even in a "club."
      Pace yourself to find a working budget.
   Time Based: Set a time table and try to hold to it.
      If your schedule slips as might happen – then readjust it realistically.

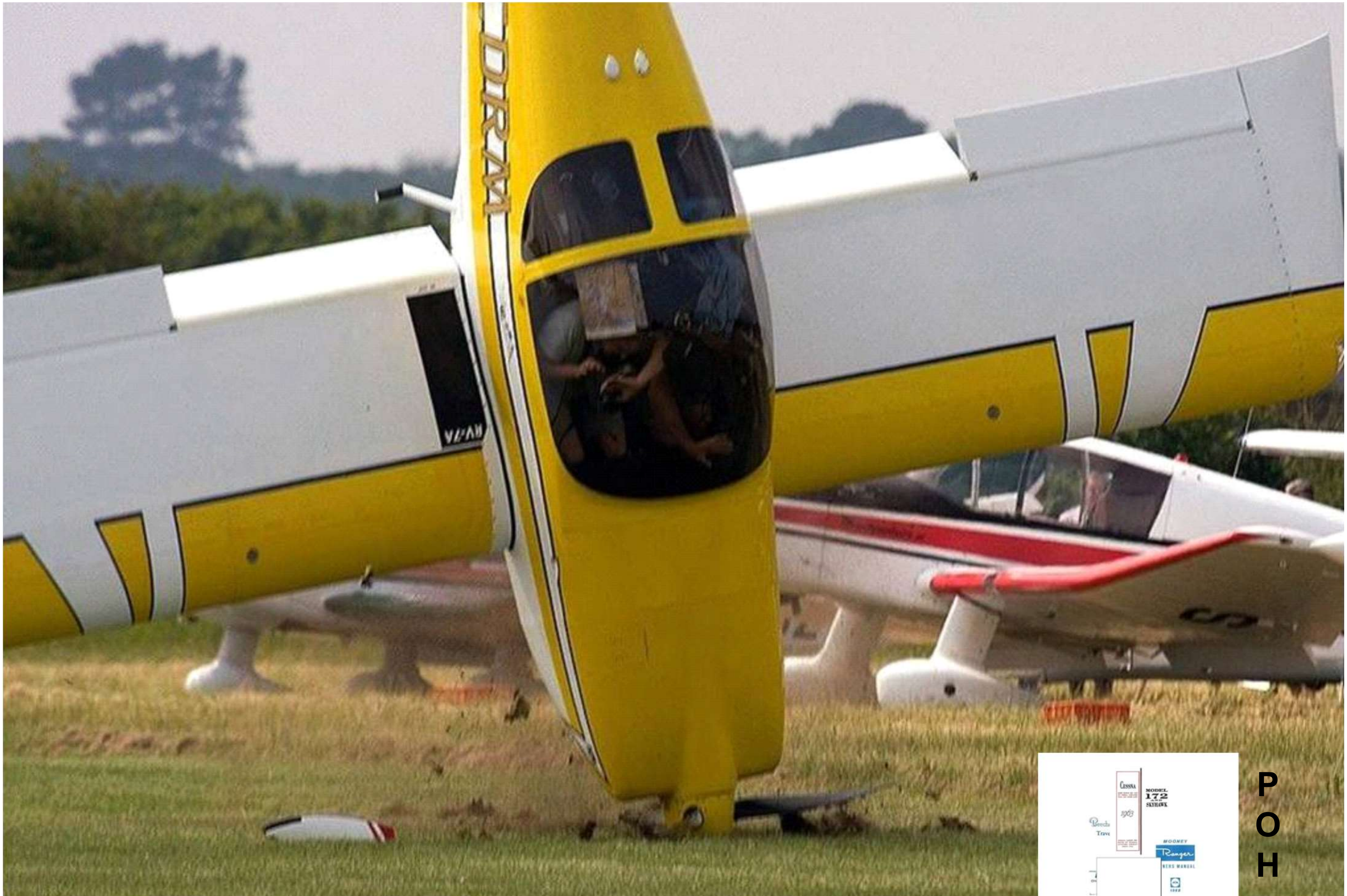
- Develop a ritual or pattern of study and flight training. Set specific times and hold to it to do your studies and flights

4. Expect occasional setbacks. It is human to have occasional problems along the way.
5. Don't let it discourage you or cause you to give up your dream. YOU CAN DO IT☺

IT IS MY PASSION

Latin: Non Nobis Solum ("not for us alone")

Why do you think accidents happen?



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FOLLOW THE RULES – OR ELSE

Single-pilot Resource Management (SRM)

What is SPRM?

- The art and science of *managing all resources* (both on-board the aircraft and from outside resources) available to a *single-pilot* (*prior and during flight*) *to ensure the successful outcome of the flight* is never in doubt. (FAA/Industry Training Standards, FAA-H-8083-9)

- SPRM's origin comes from Cockpit/Crew Resource Management: The effective *utilization of all available human, informational, and equipment resources* toward the goal of safe and efficient flight.

SPRM Skills?

- Aeronautical Decision Making
- Risk Management
- Task Management
- Automation Management
- Controlled Flight into Terrain
- Situational Awareness

WHAT IS...

Aeronautical Decision Making

According to the FAA…

Aeronautical Decision Making (*ADM*) is a "systematic approach to the mental process used by aircraft pilots to consistently determine the best course of action in response to a given set of circumstances."

FAA Advisory Circular AC 60-22 in jewel box

There is also more to consider …..

Part of ADM is risk management. You must manage risks associated with:

- Yourself as The **P**ilot in Command
- Your **A**ircraft
- The En**V**ironment (surface and airborne)
- The Operations of Flight (safety first)
- **E**xpectations (Risk pertaining to the Pressure to Fly)

ADM means managing risk elements for all situations.

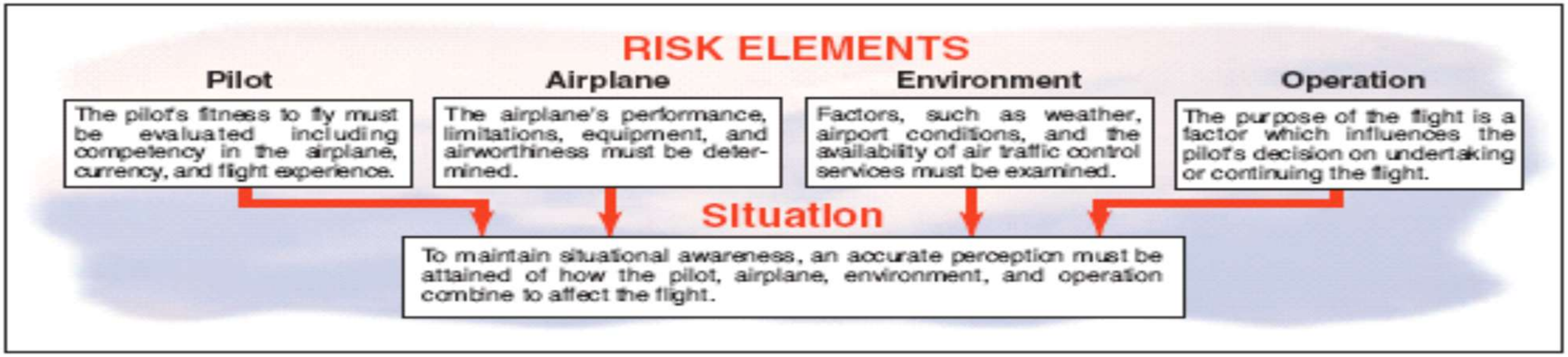


Figure 16-3. When situationally aware, the pilot has an overview of the total operation and is not fixated on one perceived significant factor.

<u>Pilot</u>: A pilot had only 4 hours of sleep the night before. The boss then asked the pilot to fly to a meeting in a city 750 miles away. The reported weather was marginal and not expected to improve. *After assessing fitness as a pilot, it was decided that it would not be wise to make the flight. The boss was initially unhappy, but later convinced by the pilot that the risks involved were unacceptable.*	*<u>Airplane</u>: During a preflight, a pilot noticed a small amount of oil dripping from the bottom of the cowling.* *Although the quantity of oil seemed insignificant at the time, the pilot decided to delay the takeoff and have a mechanic check the source of the oil. The pilot's good judgment was confirmed when the mechanic found that one of the oil cooler hose fittings was loose.*	*<u>Environment</u>: A pilot was landing a small airplane just after a heavy jet had departed a parallel runway. The pilot assumed that wake turbulence would not be a problem since landings had been performed under similar circumstances.* *Due to a combination of prevailing winds and wake turbulence from the heavy jet drifting across the landing runway, the airplane made a hard landing. The pilot made an error when assessing the flight environment.*	*<u>Operation</u>: On a ferry flight to deliver an airplane from the factory, in marginal weather conditions, the pilot calculated the groundspeed and determined that the airplane would arrive at the destination with only 10 minutes of fuel remaining. The pilot was determined to keep on schedule by trying to "stretch" the fuel supply instead of landing to refuel.* *After landing with low fuel state, the pilot realized that this could have easily resulted in an emergency landing in deteriorating weather conditions. This was a chance that was not worth taking to keep the planned schedule.*

Human Factors-AERONAUTICAL DECISION MAKING

PILOT IN COMMAND RESPONSIBILITY

RESPONSIBILITY = E V E R Y T H I N G

PRE-FLIGHT YOURSELF – IF YOUR NOT READY THEN DON’T FLY TODAY !

Human Factors-AERONAUTICAL DECISION MAKING

- Communications
  - Actively Listen and communicate as needed
- Resources: Utilize all available resources provided to and for you including other pilots, instructors, and www resources (Join AOPA for free as a student pilot)
- Workload Management also called Plan, Prioritize, Prepare to prevent overload. In a multiperson crew configuration, effectively use all personnel and material assets available.
- Situational Awareness: be aware of all factors (self, airplane, environment, and operations of aircraft. Also keep your eye on the sky - Scan, Observe and Fly the airplane first above all things

Please see “AC 60-22” ADM on CD for full details.

Human Factors-AERONAUTICAL DECISION MAKING

Poor Judgment (PJ) Chain is a series of mistakes that may lead to an accident or incident. Two basic principles generally associated with the creation of a PJ chain are:

(1) One bad decision often leads to another; and

(2) as a string of bad decision grows, it reduces the number of subsequent alternatives for continued safe flight. ADM is intended to break the PJ chain before it can cause an accident or incident.

RECOGNIZE AND DEAL with problems while they are small before they get BIG.

Task Management

Flying an airplane is a multitasking operation. We are constantly starting new tasks, monitoring ongoing tasks, prioritizing tasks, giving more attention to more critical tasks than other less critical tasks, interrupting tasks and ending tasks.

- If we become “task saturated” we miss important input that can lead to the poor judgment chain, after which “the airplane doesn’t cause an accident, the pilot does”.

- If overwhelmed STOP, THINK, SLOW DOWN, and PRIORITIZE. (delegate if someone is there to assist)

How can *tasks be completed in a timely manner without causing a distraction* from flying?

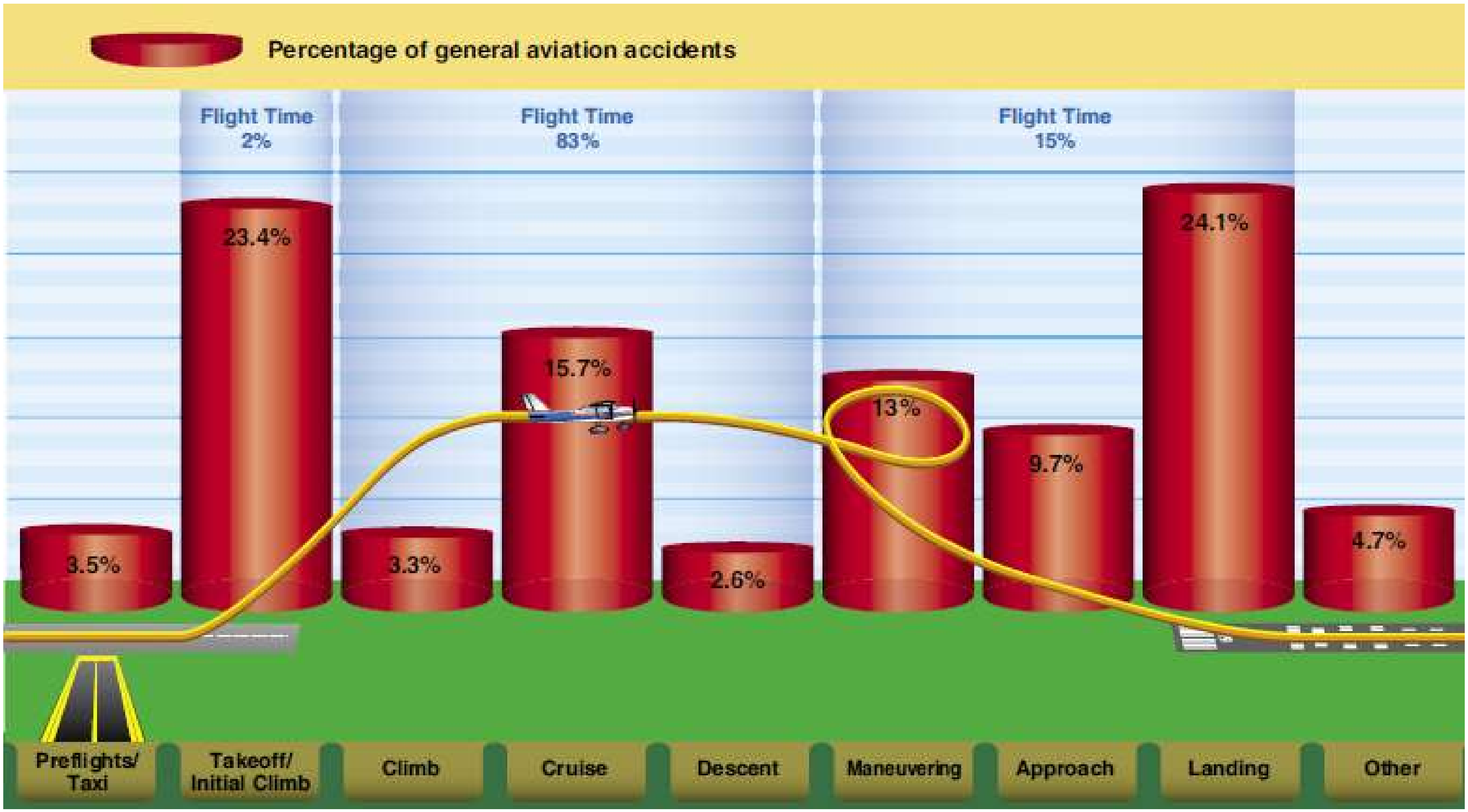
By planning, *prioritizing*, and *sequencing* tasks, a potential work overload situation can be avoided. As experience is gained, a pilot learns to *recognize future workload requirements* and can prepare for high workload periods during times of low workload.

Remember Aviate, Navigate, Communicate

What does that mean to you?

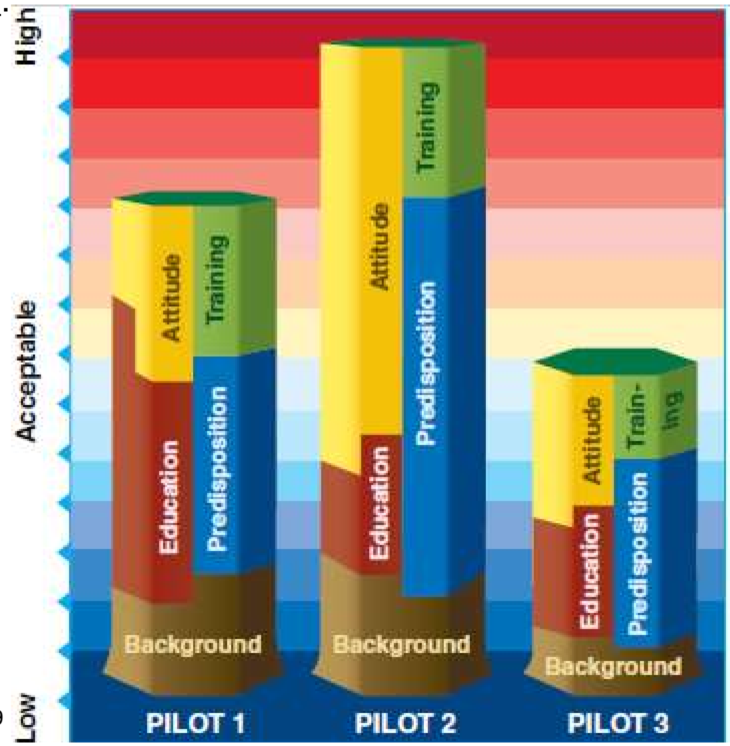
AT WHAT ASPECT OF FLIGHT DO YOU THINK WE SEE THE MOST ACCIDENTS?

To properly evaluate that we must look at phases of flight, risks, and workloads


Percentage of general aviation accidents
Flight Time
2%
Flight Time
83%
Flight Time
15%
3.5%
23.4%
3.3%
15.7%
2.6%
13%
9.7%
24.1%
4.7%
Preflights/
Taxi
Takeoff/
Initial Climb
Climb
Cruise
Descent
Maneuvering
Approach
Landing
Other

The hazards a pilot faces and those that are created through adverse attitude predispose his or her actions. **Predisposition** is formed from the pilot's foundation of beliefs and, therefore, affects all decisions he or she makes. A key point must be understood about risk. *Once the situation builds in complexity, it exceeds the pilot's capability and requires luck to succeed and prevail.*

Unfortunately, when a pilot survives a situation above his or her normal capability, perception of the risk involved and of the ability to cope with that level of risk become skewed. The pilot is encouraged to use the same response to the same perceived level of risk, viewing any success as due to skill, not luck. *The failure to accurately perceive the risk involved and the level of skill, knowledge, and abilities required to mitigate that risk may influence the pilot to accept that level of risk or higher levels*.

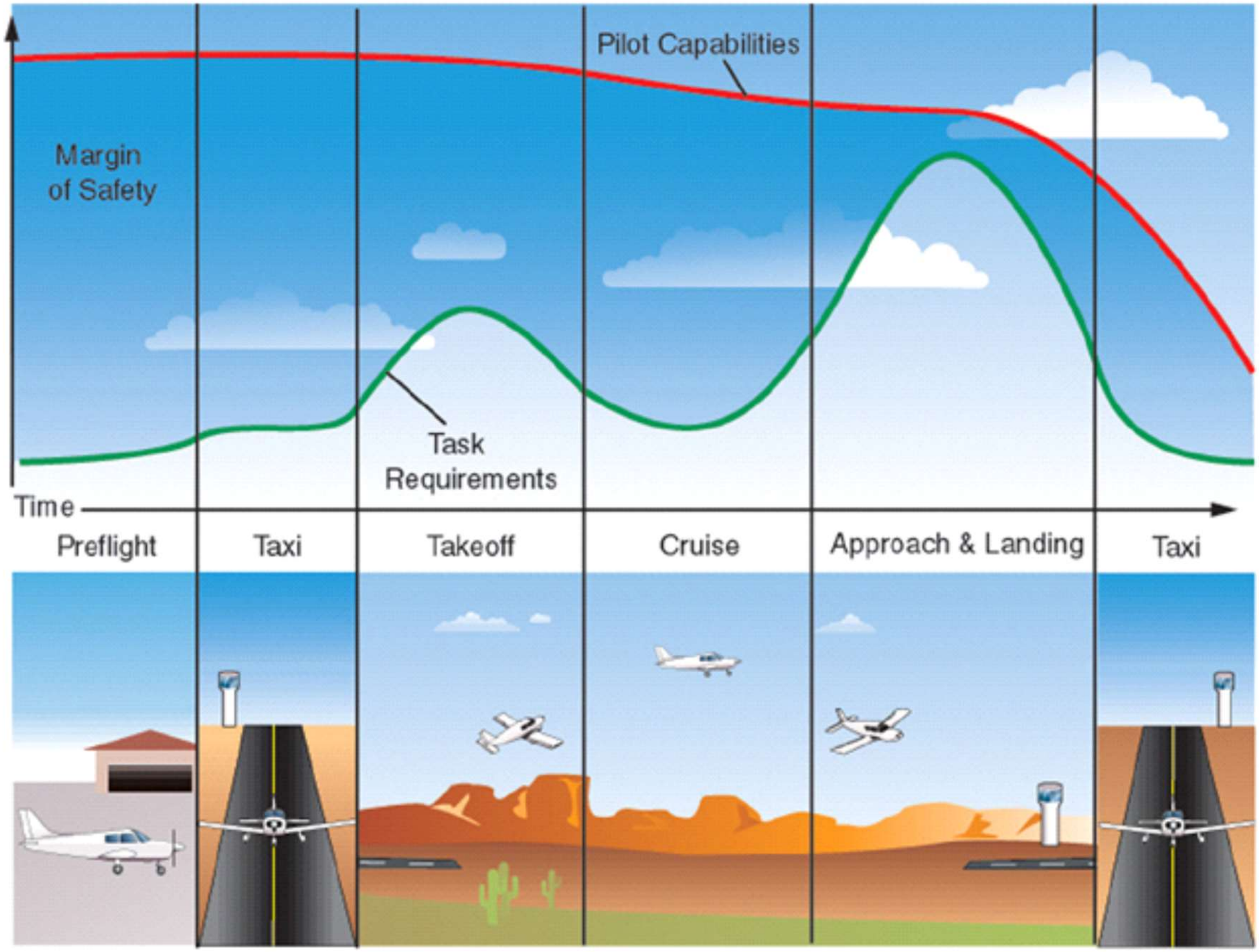


Total Risk	The sum of identified and unidentified risks.
Identified Risk	Risk that has been determined through various analysis techniques. The first task of system safety is to identify, within practical limitations, all possible risks.
Unidentified Risk	Risk not yet identified. Some unidentified risks are subsequently identified when a mishap occurs. Some risk is never known.
Unacceptable Risk	Risk that cannot be tolerated by the managing activity. It is a subset of identified risk that must be eliminated or controlled.
Acceptable Risk	Acceptable risk is the part of identified risk that is allowed to persist without further engineering or management action. Making this decision is a difficult yet necessary responsibility of the managing activity. This decision is made with full knowledge that it is the user who is exposed to this risk.
Residual Risk	Residual risk is the risk remaining after system safety efforts have been fully employed. It is not necessarily the same as acceptable risk. Residual risk is the sum of acceptable risk and unidentified risk. This is the total risk passed on to the user.

Workload Management

MANAGE THE LOAD NOT TO EXCEED YOUR CAPABILITY

Work



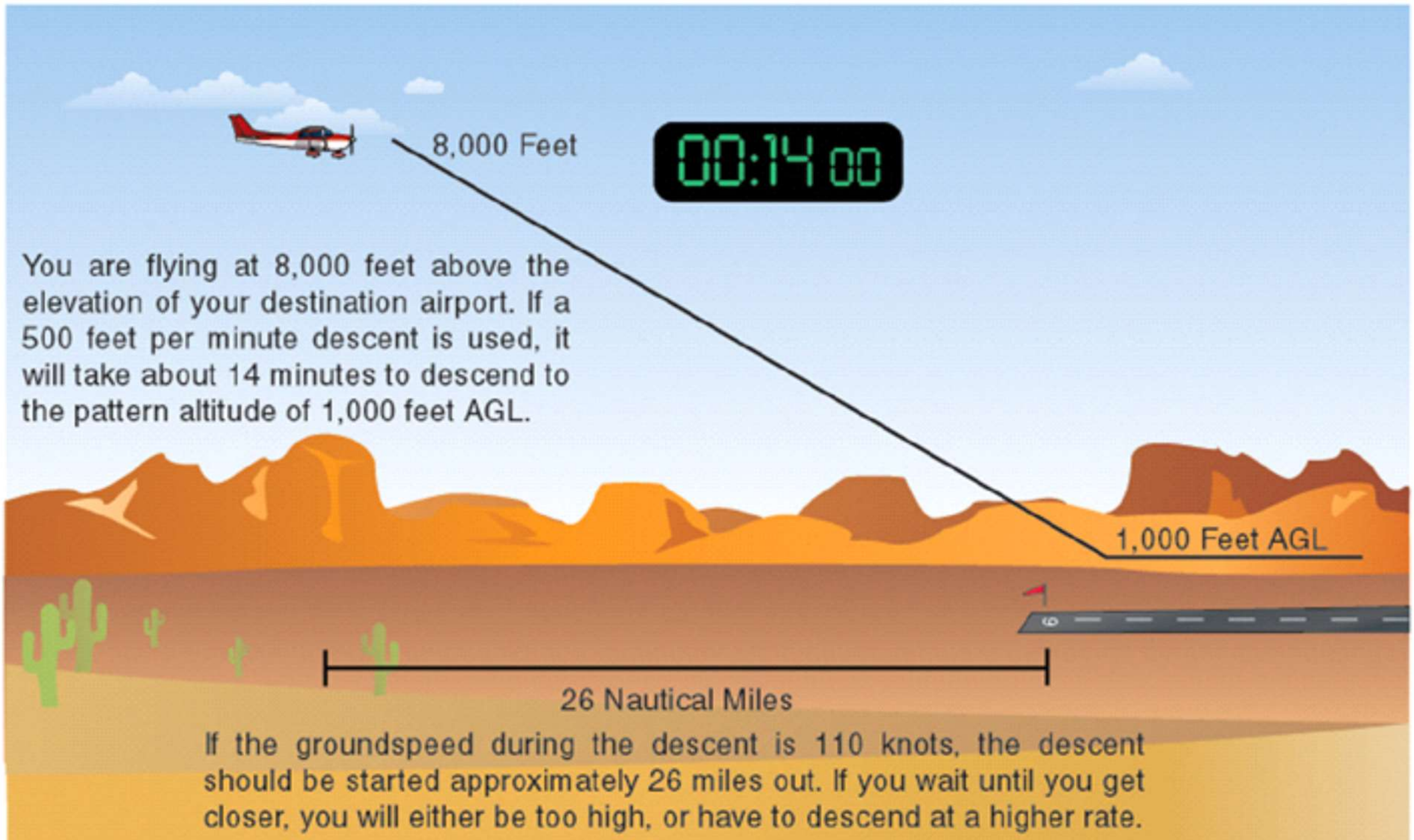
Phase Of Flight

Time →

Created by Steve Reisser

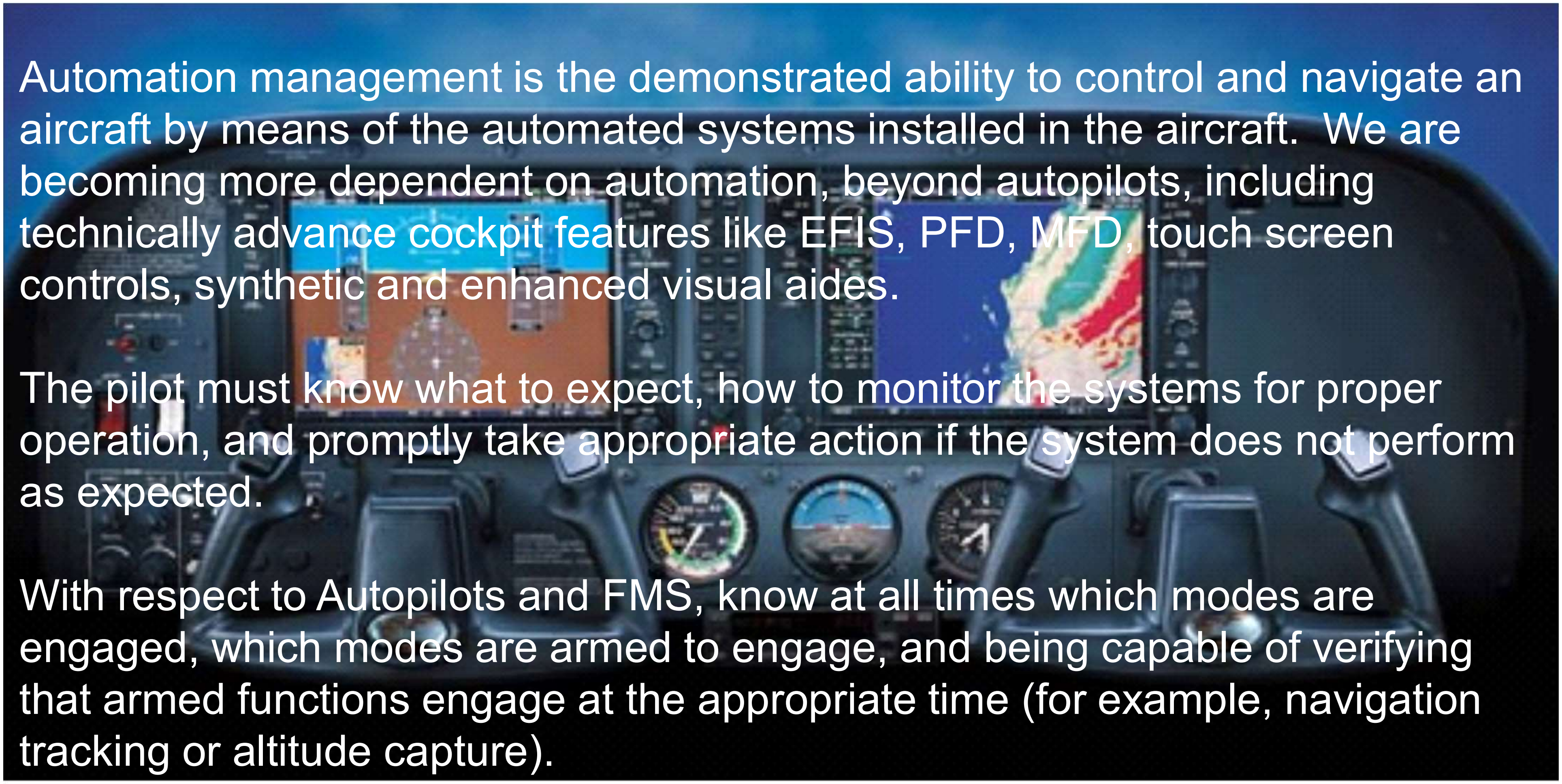
Workload Management

Planning and Preparation: Always be “ahead,” on the ground and in the air. Never get “behind the your personal mental power curve.”



Prioritize: Do what is necessary 1st. TRIAGE. *ALWAYS FLY THE AIRPLANE 1st*.

Automation Management



Automation management is the demonstrated ability to control and navigate an aircraft by means of the automated systems installed in the aircraft. We are becoming more dependent on automation, beyond autopilots, including technically advance cockpit features like EFIS, PFD, MFD, touch screen controls, synthetic and enhanced visual aides.

The pilot must know what to expect, how to monitor the systems for proper operation, and promptly take appropriate action if the system does not perform as expected.

With respect to Autopilots and FMS, know at all times which modes are engaged, which modes are armed to engage, and being capable of verifying that armed functions engage at the appropriate time (for example, navigation tracking or altitude capture).

At a minimum, the pilot flying with advanced avionics must know how to manage the course deviation indicator (CDI), the navigation source, and the autopilot.

Problem Solving

- When on the ground and flying, if you have the feeling that something isn't quite right with either you or the airplane – it is time to do something…..
- DON'T WAIT

STRATEGIES

The DECIDE model
New and improved 3-P model

IS PROBLEM SOLVING DIFFERENT IN AVIATION THAN ANY OTHER ASPECT OF OUR LIFE?

Not really: the process is the same but SYSTEMATIC


Identify Hazards
Assess Risks
Analyze Controls
Make Control Decisions
Use Controls
Monitor Results
RISK
MANAGEMENT
PROCESS

Use the 'DECIDE' Model for Making Systematic Decisions

<u>Detect</u> the change that is occurring or has occurred.

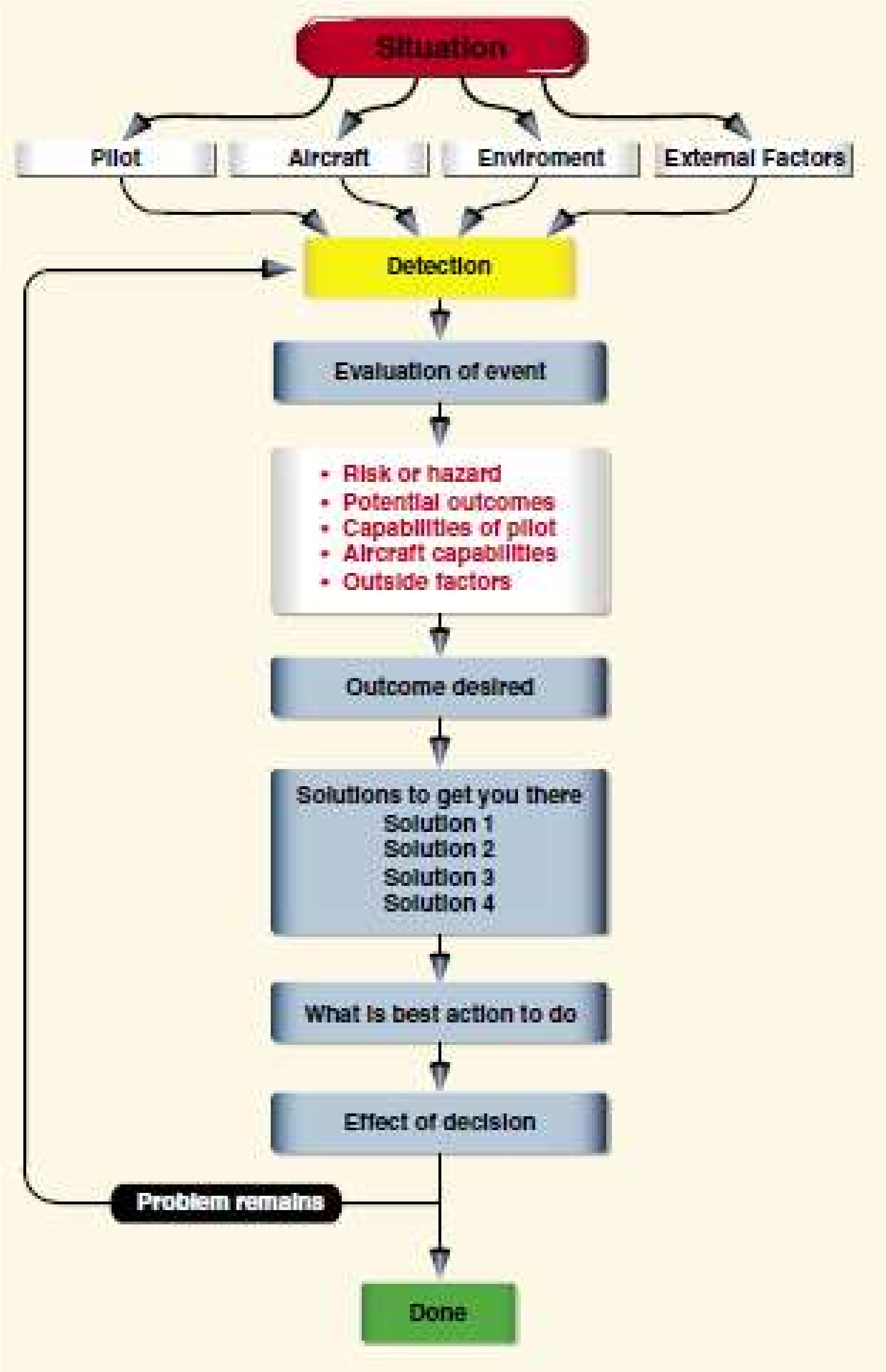
Estimate the effect of the change (what happens if I ignore it) – You "define the problem"

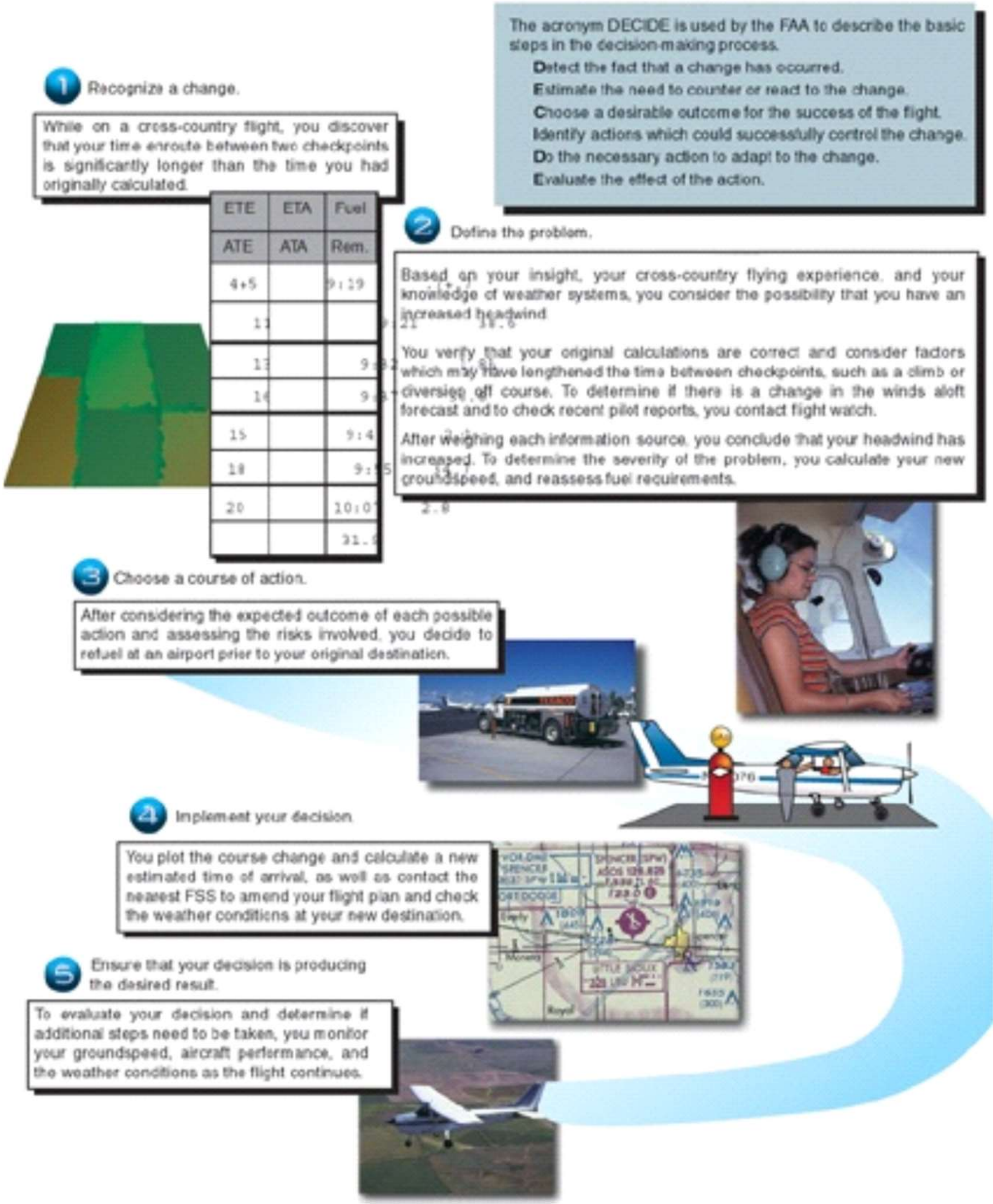
Choose a desirable outcome +Communicate + Climb

Identify suitable courses of action/s to achieve outcome

Do the action/s. Take action now – don't let situation deteriorate.

<u>Evaluate</u> the effect of your actions. If the outcome is not what you expect or does not accomplish the desired objective, then go back to "I"dentify a different course of action/s.


Situation
Pilot
Aircraft
Enviroment
External Factors
Detection
Evaluation of event
• Risk or hazard
• Potential outcomes
• Capabilities of pilot
• Aircraft capabilities
• Outside factors
Outcome desired
Solutions to get you there
Solution 1
Solution 2
Solution 3
Solution 4
What is best action to do
Effect of decision
Problem remains
Done


The acronym DECIDE is used by the FAA to describe the basic steps in the decision-making process.
Detect the fact that a change has occurred.
Estimate the need to counter or react to the change.
Choose a desirable outcome for the success of the flight.
Identify actions which could successfully control the change.
Do the necessary action to adapt to the change.
Evaluate the effect of the action.
1 Recognize a change.
While on a cross-country flight, you discover that your time enroute between two checkpoints is significantly longer than the time you had originally calculated.
ETE ETA Fuel
ATE ATA Rem.
2 Define the problem.
Based on your insight, your cross-country flying experience, and your knowledge of weather systems, you consider the possibility that you have an increased headwind.
You verify that your original calculations are correct and consider factors which may have lengthened the time between checkpoints, such as a climb or diversion off course. To determine if there is a change in the winds aloft forecast and to check recent pilot reports, you contact flight watch.
After weighing each information source, you conclude that your headwind has increased. To determine the severity of the problem, you calculate your new groundspeed, and reassess fuel requirements.
3 Choose a course of action.
After considering the expected outcome of each possible action and assessing the risks involved, you decide to refuel at an airport prior to your original destination.
4 Implement your decision.
You plot the course change and calculate a new estimated time of arrival, as well as contact the nearest FSS to amend your flight plan and check the weather conditions at your new destination.
5 Ensure that your decision is producing the desired result.
To evaluate your decision and determine if additional steps need to be taken, you monitor your groundspeed, aircraft performance, and the weather conditions as the flight continues.

Newest Info on ADM from FAA

The 3-P Model for ADM

Perceive, Process, Perform

To help pilots put the concept of ADM into practice, the FAA Aviation Safety Program developed a new framework for aeronautical decision-making and risk management:

Perceive – Process – Perform.
This model offers a simple, practical, and systematic approach to accomplishing each ADM task during all phases of flight. To use it, you:

Perceive the “given set of circumstances” for your flight.

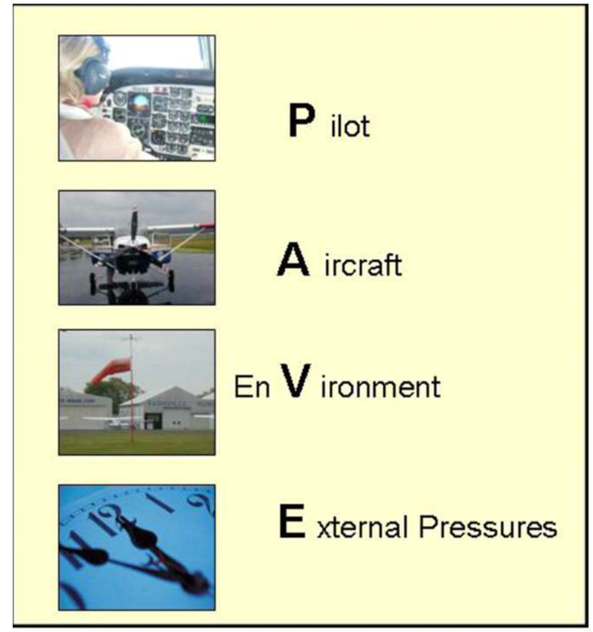
Process by evaluating their impact on flight safety.

Perform by implementing the best course of action.

PERCIEVE - Develop Situational Awareness

To navigate to a particular destination, the first step is to determine exactly where you are right now. The same principle applies in ADM: to navigate to a safe outcome, you first need to understand the "given set of circumstances" you face.

The first step in the 3-P model, PERCEIVE, is about developing a clear and comprehensive awareness of your particular situation. Consider:



For each element, ask "what could hurt me, my passengers, or my aircraft?"

All four elements combine and interact to create a unique situation for any flight. Pay special attention to the pilot-aircraft combination, and consider whether the combined "pilot-aircraft team" is capable of the mission you want to fly. For example, you may be a very experienced and proficient pilot, but your weather flying ability is still limited if you are flying a 1970s-model aircraft with no weather avoidance gear. On the other hand, you may have a new technically advanced aircraft with moving map GPS, weather datalink, and autopilot – but if you do not have much weather flying experience or practice in using this kind of equipment, you cannot rely on the airplane's capability to compensate for your own lack of experience.

The PAVE Checklist

Another way to mitigate risk is to perceive hazards. By incorporating the PAVE checklist into preflight planning, the pilot divides the risks of flight into four categories: Pilot-in-command (PIC), Aircraft, enVironment, and External pressures (PAVE) which form part of a pilot's decision-making process.

RISK ASSESSMENT

Pilot's Name ____________ Flight From ________ To ________

SLEEP

1. Did not sleep well or less than 8 hours		2
2. Slept well		0

HOW DO YOU FEEL?

1. Have a cold or ill		4
2. Feel great		0
3. Feel a bit off		2

WEATHER AT TERMINATION

1. Greater than 5 miles visibility and 3,000 feet ceilings		1
2. At least 3 miles visibility and 1,000 feet ceilings, but less than 3,000 feet ceilings and 5 miles visibility		3
3. IMC conditions		4

Column total ____

HOW IS THE DAY GOING?

1. Seems like one thing after another (late, making errors, out of step)		3
2. Great day		0

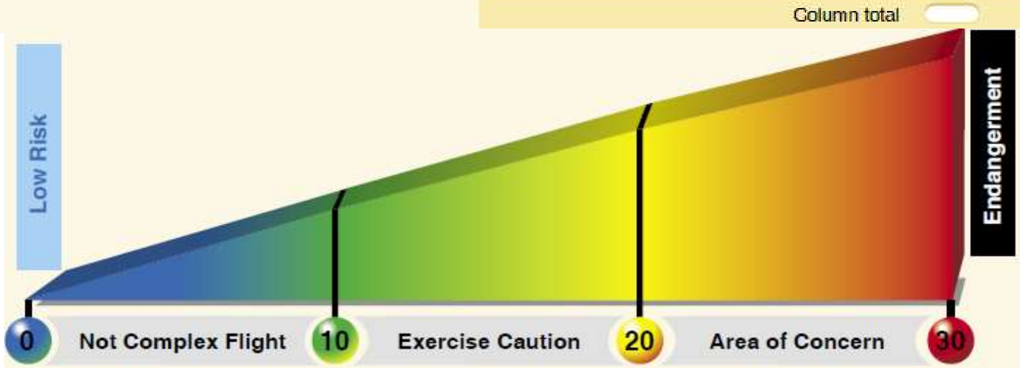
IS THE FLIGHT

1. Day?		1
2. Night?		3

PLANNING

1. Rush to get off ground		3
2. No hurry		1
3. Used charts and computer to assist		0
4. Used computer program for all planning	Yes	3
	No	0
5. Did you verify weight and balance?	Yes	0
	No	3
6. Did you evaluate performance?	Yes	0
	No	3
7. Do you brief your passangers on the ground and in flight?	Yes	0
	No	2

Column total ____



PAVE

P = Pilot in Command (PIC)

The pilot is one of the risk factors in a flight. The pilot must ask, “Am I ready for this trip?” in terms of experience, recency, currency, physical and emotional condition. The IMSAFE checklist provides the answers.

A = Aircraft

What limitations will the aircraft impose upon the trip? Ask the following questions:

- Is this the right aircraft for the flight?
- Am I familiar with and current in this aircraft? Aircraft performance figures and the AFM are based on a brand new aircraft flown by a professional test pilot. Keep that in mind while assessing personal and aircraft performance.
- Is this aircraft equipped for the flight? Instruments? Lights? Navigation and communication equipment adequate?
- Can this aircraft use the runways available for the trip with an adequate margin of safety under the conditions to be flown?
- Can this aircraft carry the planned load?
- Can this aircraft operate at the altitudes needed for the trip?

V = EnVironment

Weather

Weather is an major environmental consideration. Earlier it was suggested pilots set their own personal minimums, especially when it comes to weather. As pilots evaluate the weather for a particular flight, they should consider the following:

PAVE

(V = enVironment, WEATHER: continued.)

- What are the current ceiling and visibility? In mountainous terrain, consider having higher minimums for ceiling and visibility, particularly if the terrain is unfamiliar.
- Consider the possibility that the weather may be different than forecast. Have alternative plans and be ready and willing to divert, should an unexpected change occur.
- Consider the winds at the airports being used and the strength of the crosswind component.
- If flying in mountainous terrain, consider whether there are strong winds aloft. Strong winds in mountainous terrain can cause severe turbulence and downdrafts and be very hazardous for aircraft even when there is no other significant weather.
- Are there any thunderstorms present or forecast?
- If there are clouds, is there any icing, current or forecast? What is the temperature/dew point spread and the current temperature at altitude? Can descent be made safely all along the route?
- If icing conditions are encountered, is the pilot experienced at operating the aircraft's deicing or anti-icing equipment? Is this equipment in good condition and functional? For what icing conditions is the aircraft rated, if any?

TERRAIN

Evaluation of terrain is another important component of analyzing the flight environment.

- To avoid terrain and obstacles, especially at night or in low visibility, determine safe altitudes in advance by using the altitudes shown on VFR and IFR charts during preflight planning.
- Use maximum elevation figures (MEFs) and other easily obtainable data to minimize chances of an inflight collision with terrain or obstacles.

PAVE

(V = enVironment, continued.)

<u>*Airport*</u>

• What lights are available at the destination and alternate airports? VASI/PAPI or ILS glideslope guidance? Is the terminal airport equipped with them? Are they working? Will the pilot need to use the radio to activate the airport lights?

• Check the Notices to Airmen (NOTAMS) for closed runways or airports. Look for runway or beacon lights out, nearby towers, etc.

• Choose the flight route wisely. An engine failure gives the nearby airports supreme importance.

• Are there shorter or obstructed fields at the destination and/or alternate airports?

<u>*Airspace*</u>

• If the trip is over remote areas, are appropriate clothing, water, and survival gear onboard in the event of a forced landing?

• If the trip includes flying over water or unpopulated areas with the chance of losing visual reference to the horizon, the pilot must be prepared to fly IFR.

• Check the airspace and any temporary flight restriction (TFRs) along the route of flight.

<u>Night Flight</u>

Night flying requires special consideration.

• If the trip includes flying at night over water or unpopulated areas with the chance of losing visual reference to the horizon, the pilot must be prepared to fly IFR.

• Will the flight conditions allow a safe emergency landing at night?

• Preflight all aircraft lights, interior and exterior, for a night flight. Carry at least two flashlights—one for exterior preflight and a smaller one that can be dimmed and kept nearby.

E = External Pressures

External pressures are influences external to the flight that create a sense of pressure to complete a flight—often at the expense of safety. Factors that can be external pressures include the following:

- Someone waiting at the airport for the flight's arrival.
- A passenger the pilot does not want to disappoint.
- The desire to demonstrate pilot qualifications.
- The desire to impress someone. (Probably the two most dangerous words in aviation are "Watch this!")
- The desire to satisfy a specific personal goal ("get-home-itis," "get-there-itis," and "let's-go-itis").
- The pilot's general goal-completion orientation.
- Emotional pressure associated with acknowledging that skill and experience levels may be lower than a pilot would like them to be. Pride can be a powerful external factor!

Managing External Pressures

- Allow time on a trip for an extra fuel stop or to make an unexpected landing because of weather.
- Have alternate plans for a late arrival or make backup airline reservations for must-be-there trips.
- For really important trips, plan to leave early enough so that there would still be time to drive to the destination.
- Advise those who are waiting at the destination that the arrival may be delayed. Know how to notify them when delays are encountered.
- Manage passengers' expectations. Make sure passengers know that they might not arrive on a firm schedule, and if they must arrive by a certain time, they should make alternative plans.
- Eliminate pressure to return home, even on a casual day flight, by carrying a small overnight kit containing prescriptions, contact lens solutions, toiletries, or other necessities on every flight.

The pilot's goal is to manage risk, not create hazards !

Pilot

A pilot must continually make decisions about competency, condition of health, mental and emotional state, level of fatigue, and many other variables. For example, a pilot may be called early in the morning to make a long flight. If a pilot has had only a few hours of sleep and is concerned that the congestion being experienced could be the onset of a cold, it would be prudent to consider if the flight could be accomplished safely.

A pilot had only 4 hours of sleep the night before being asked by the boss to fly to a meeting in a city 750 miles away. The reported weather was marginal and not expected to improve. After assessing fitness as a pilot, it was decided that it would not be wise to make the flight. The boss was initially unhappy, but later convinced by the pilot that the risks involved were unacceptable.

Environment

This encompasses many elements not pilot or airplane related. It can include such factors as weather, air traffic control, navigational aids (NAVAIDS), terrain, takeoff and landing areas, and surrounding obstacles. Weather is one element that can change drastically over time and distance.

A pilot was landing a small airplane just after a heavy jet had departed a parallel runway. The pilot assumed that wake turbulence would not be a problem since landings had been performed under similar circumstances. Due to a combination of prevailing winds and wake turbulence from the heavy jet drifting across the landing runway, the airplane made a hard landing. The pilot made an error when assessing the flight environment.

Aircraft

A pilot will frequently base decisions on the evaluations of the airplane, such as performance, equipment, or airworthiness.

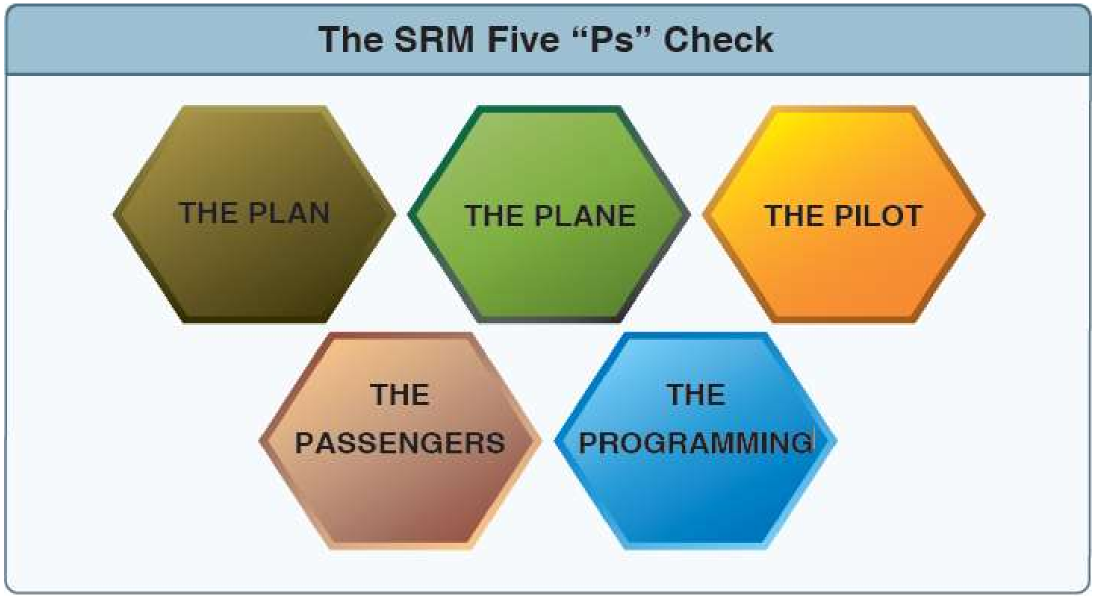
During a preflight, a pilot noticed a small amount of oil dripping from the bottom of the cowling. Although the quantity of oil seemed insignificant at the time, the pilot decided to delay the takeoff and have a mechanic check the source of the oil. The pilot's good judgment was confirmed when the mechanic found that one of the oil cooler hose fittings was loose.

External Pressures

The interaction between the pilot, airplane, and the environment is greatly influenced by the purpose of each flight operation. The pilot must evaluate the three previous areas to decide on the desirability of undertaking or continuing the flight as planned. It is worth asking why the flight is being made, how critical is it to maintain the schedule, and is the trip worth the risks?

On a ferry flight to deliver an airplane from the factory, in marginal weather conditions, the pilot calculated the groundspeed and determined that the airplane would arrive at the destination with only 10 minutes of fuel remaining. The pilot was determined to keep on schedule by trying to "stretch" the fuel supply instead of landing to refuel. After landing with low fuel state, the pilot realized that this could have easily resulted in an emergency landing in deteriorating weather conditions. This was a chance that was not worth taking to keep the planned schedule.

MITIGATING RISK



The 5 Ps are used to evaluate the pilot's current situation at key decision points during the flight, or when an emergency arises. These decision points include, preflight, pre-takeoff, hourly or at the midpoint of the flight, pre-descent, and just prior to the final approach fix or for visual flight rules (VFR) operations, just prior to entering the traffic pattern.

1. The easiest point to cancel a flight due to bad weather is <u>before the pilot and passengers walk out the door and load the aircraft</u>.
2. The second easiest point in the flight to make a critical safety decision is <u>just prior to takeoff</u>.
3 .The third place to review the 5 Ps is at the <u>mid point of the flight before entering the highest workload</u>.
4. Just prior to descent into the terminal area, and
5. Just prior to the final approach fix, or if VFR just prior to entering the traffic pattern, as preparations for landing commence.

MITIGATINGI RISK

The Plan

The “Plan” can also be called the mission or the task. It contains the basic elements of cross-country planning, weather, route, fuel, publications currency, etc. The “Plan” should be reviewed and updated several times during the course of the flight

The Plane

Both the “plan” and the “plane” are fairly familiar to most pilots. The “plane” consists of the usual array of mechanical and cosmetic issues that every aircraft pilot, owner, or operator can identify. With the advent of advanced avionics, the “plane” has expanded to include database currency, automation status, and emergency backup systems that were unknown a few years ago.

The Pilot

Flying, especially when used for business transportation, can expose the pilot to high altitude flying, long distance and endurance, and more challenging weather. An advanced avionics aircraft, simply due to their advanced capabilities can expose a pilot to even more of these stresses.

The Passengers

One of the key differences between CRM and SRM is the way passengers interact with the pilot. The pilot of a highly capable single-engine aircraft has entered into a very personal relationship with the passengers. In fact, the pilot and passengers sit within an arm’s reach all of the time. (Briefings, Sterile Cockpits and Active SA.)

The Programming

The advanced avionics aircraft adds an entirely new dimension to the way GA aircraft are flown. The electronic instrument displays, GPS, and autopilot reduce pilot workload and increase pilot situational awareness.

5P CHECKLIST	Use to identify and manage your risk during pre-flight				
PILOT					
SUMMARY OF TRAINING			YES	NO	N/A
Do I have a current flight review (BFR)?					
Am I “current” to carry passengers?					
Have I had recent refresher training in this airplane?					
Am I instrument current?					
Have I had recent mountain flying training or experience?					
EXPERIENCE		Personal Minimums	YES	NO	N/A
Hours					
Landings					
Instrument Approaches					
LAST 6 MONTHS		Personal Minimums	YES	NO	N/A
IFR Hours					
Instrument Approaches					
Night Hours					
Night Landings					
Strong/Gusty Crosswind Landings					
Mountain Flying Hours					
FITNESS-IM'SAFE			YES	NO	N/A
Illness-Am I healthy?					
Medications-Am I free of prescription or OTC drugs?					
Stress-Am I free of pressures(job, home, finance, health,etc)?					
Alcohol-Have I consumed within the previous 24 hours?					
Fatigue-Did I get at least 7 hours of sleep?					
Eatinig-Am I adequately nourished?					
Emotions-Am I free of emothional upset?					
PASSENGERS					
EXPERIENCE			YES	NO	N/A
Are my passengers comfortable flying? (spent time in small					
aircraft, certified pilots, etc)					
FITNESS			YES	NO	N/A
Are my passengers feeling well? (sickness, or likely to feel					
airsick during flight, etc.)					
FLEXIBILITY			YES	NO	N/A
Are my passengersf flexible and well informed about the					
possible changing conditions of flight?					

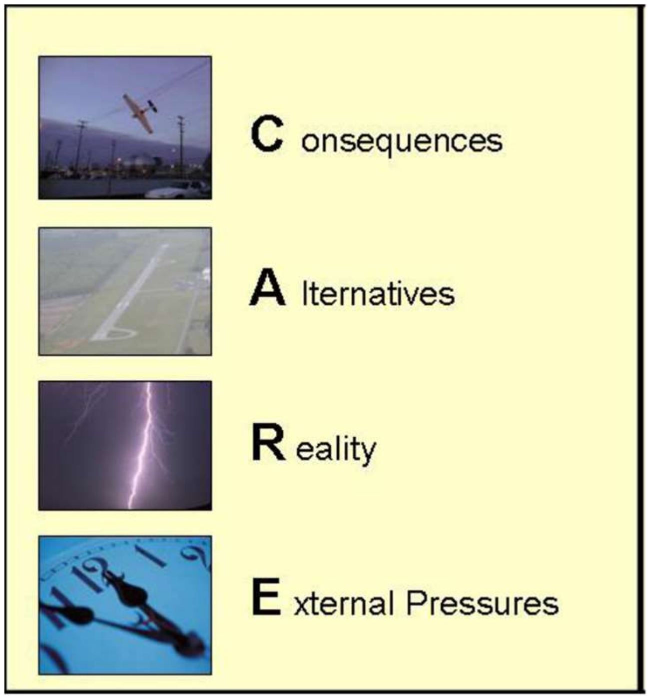
PLANE					
AIRWORTHINESS			YES	NO	N/A
Are the aircraft inspections current and appropriate to the					
type of flight? (annual, 100-hour, VOR)					
Is the required equipment onboard for the type of flight?					
(lights for night flight, onboard oxygen, survival gear, etc.)					
Have all prior maintenance issues been taken care of?					
(sqawks resolved, inoperative equipment placarded, etc,)					
PERFORMANCE			YES	NO	N/A
Perfomance adequate for runways, DA,		Both engines operating			
and terrain conditions? (TO, climb, etc)		One engine inoperative			
Can the aircraft be flown as planned load within proper CG limits?					
Is fuel capacity adequate for proposed flight legs, including					
alternate airport if required?					
PROGRAMMING					
AVIONICS AIRWORTHINESS			YES	NO	N/A
Is the avionics equipment working properly? (sqwalks resolved					
autopilot function)					
AVIONICS OPERATION			YES	NO	N/A
Are you proficient at working the avionics equipment?					
AVIONICS CONFIGURATION			YES	NO	N/A
Is the avionics configuration appropriate for the navigation					
required?					

PLAN					
AIRPORT CONDITIONS			YES	NO	N/A
Do NOTAMS indicate that I can proceed as planned?					
(no runway or NAVAIDs closed for proposed flight)					
TERRAIN and AIRSPACE			YES	NO	N/A
Does terrain/airspace allow me to fly planned route?					
(Check mountains terrain, TFRs, restricted-prohibited aispaces)					
MISSION			YES	NO	N/A
Do I have alternate plans for destination such as rescheduling					
or checking airline schedules should alternates be required?					
Did I tell people I'm meeting at destination that I could be late?					
Do I have an overnight kit containing any necessary toiletries					
and prescriptions?					
WEATHER		LOCATION	YES	NO	N/A
Are weather conditions acceptable?		Departure			
(no weather hazards such as icing,		Enroute			
thunderstorms, turbulance)		Destination			
Is there a suitable airport that meets the regulatory requirements					
for an alternate if the forecast at my destination requires one?					
WEATHER	PERSONAL	LOCATION	YES	NO	N/A
LIMITATIONS	LIMITATIONS				
Are the weather conditions for my flight within my limitations?					
- Minimim IFR approach ceiling and		Departure			
visibility?		Destination			
- Minimum ceiling and visibility for day		Departure			
VFR?		Destination			
- Minimum ceiling and visibility for night		Departure			
VFR?		Destination			
- Maximum surface winds and gusts?		Departure			
		Destination			
- Maximum direct crosswind?		Departure			
(cross-wind component determined)		Destination			

PROCESS - Evaluate with CARE

Next, you mentally PROCESS information about the circumstances that you have identified. The goal is to evaluate their impact on the safety of your flight, and consider "why must I CARE about these circumstances?"

For each hazard that you perceived in step one, process with CARE. Example: for a night flight to attend a business meeting:



C onsequences (e.g., departing after a full workday creates fatigue & pressure)

A lternatives (e.g., delay until morning; reschedule meeting; drive)

R eality (e.g., dangers and distractions of fatigue could lead to an accident)

E xternal pressures (e.g., business meeting at destination might influence me)

A good rule of thumb for the processing phase: if you find yourself saying that it will "probably" be okay, it is definitely time for a solid reality check.

If you are worried about missing a meeting, be realistic about how that pressure will affect not just your initial go/no-go decision, but also your inflight decisions to continue the flight or divert.

Perceive, Process, Perform with CARE and TEAM

Most flight training activities take place in the "time-critical" timeframe for risk management. *Figures 17-8* and *17-9* combine the six steps of risk management into an easy-to-remember 3P model for practical risk management: Perceive, Process, Perform with the CARE and TEAM models. Pilots can help perceive hazards by using the PAVE checklist of: Pilot, Aircraft, enVironment, and External pressures. They can process hazards by using the CARE checklist of: Consequences, Alternatives, Reality, External factors.

Pilots can perform risk management by using the TEAM choice list of: Transfer, Eliminate, Accept, or Mitigate. These concepts are relatively new in the GA training world, but have been shown to be extraordinarily useful in lowering accident rates in the world of air carriers.

The next two frames show the use of both CARE and TEAM. TEAM focuses on Tools of risk MITIGATION. What to do upon perception using CARE.

Pilots can perceive hazards by using the PAVE checklist:

Pilot

Gayle is a healthy and well-rested private pilot with approximately 300 hours total flight time. Hazards include her lack of overall and cross-country experience and the fact that she has not flown at all in two months.

Aircraft

Although it does not have a panel-mount GPS or weather avoidance gear, the aircraft—a C182 Skylane with long-range fuel tanks—is in good mechanical condition with no inoperative equipment. The instrument panel is a standard "six-pack."

EnVironment

Departure and destination airports have long runways. Weather is the main hazard. Although it is VFR, it is a typical summer day in the Mid-Atlantic region: hot (near 90 °F) hazy (visibility 7 miles), and humid with a density altitude of 2,500 feet. Weather at the destination airport (located in the mountains) is still IMC, but forecast to improve to visual meteorological conditions (VMC) prior to her arrival. En route weather is VMC, but there is an AIRMET Sierra for pockets of IMC over mountain ridges along the proposed route of flight.

External Pressures

Gayle is making the trip to spend a weekend with relatives she does not see very often. Her family is very excited and has made a number of plans for the visit.

Pilots can perform risk management by using the TEAM choice list:

Pilot

To manage the risk associated with her inexperience and lack of recent flight time, Gayle can:

- Transfer the risk entirely by having another pilot act as PIC.
- Eliminate the risk by canceling the trip.
- Accept the risk and fly anyway.
- Mitigate the risk by flying with another pilot.

Gayle chooses to mitigate the major risk by hiring a CFI to accompany her and provide dual cross-country instruction. An added benefit is the opportunity to broaden her flying experience.

Aircraft

To manage risk associated with any doubts about the aircraft's mechanical condition, Gayle can:

- Transfer the risk by using a different airplane.
- Eliminate the risk by canceling the trip.
- Accept the risk.
- Mitigate the remaining (residual) risk through review of aircraft performance and careful preflight inspection.

Since she finds no problems with the aircraft's mechanical condition, Gayle chooses to mitigate any remaining risk through careful preflight inspection of the aircraft.

Environment

To manage the risk associated with hazy conditions and mountainous terrain, Gayle can:

- **T**ransfer the risk of VFR in these conditions by asking an instrument-rated pilot to fly the trip under IFR.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk.
- **M**itigate the risk by careful preflight planning, filing a VFR flight plan, requesting VFR flight following, and using resources such as Flight Watch.

Detailed preflight planning must be a vital part of Gayle's weather risk mitigation strategy. The most direct route would put her over mountains for most of the trip. Because of the thick haze and pockets of IMC over mountains, Gayle might mitigate the risk by modifying the route to fly over valleys. This change will add 30 minutes to her estimated time of arrival (ETA), but the extra time is a small price to pay for avoiding possible IMC over mountains. Because her destination airport is IMC at the time of departure, Gayle needs to establish that VFR conditions exist at other airports within easy driving distance of her original destination. In addition, Gayle should review basic information (e.g., traffic pattern altitude, runway layout, frequencies) for these alternate airports. To further mitigate risk and practice good cockpit resource management, Gayle should file a VFR flight plan, use VFR flight following, and call Flight Watch to get weather updates en route. Finally, basic functions on her handheld GPS should also be practiced.

External Pressures

To mitigate the risk of emotional pressure from family expectations that can drive a "get-there" mentality, Gayle can:

- **T**ransfer the risk by having her co-pilot act as PIC and make the continue/divert decision.
- **E**liminate the risk by canceling the trip.
- **A**ccept the risk.
- **M**itigate the risk by managing family expectations and making alternative arrangements in the event of diversion to another airport.

Gayle and her co-pilot choose to address this risk by agreeing that each pilot has a veto on continuing the flight, and that they will divert if either becomes uncomfortable with flight conditions. Because the destination airport is still IMC at the time of departure, Gayle establishes a specific point in the trip—an en route VORTAC located between the destination airport and the two alternates—as the logical place for her "final" continue/divert decision. Rather than give her family a specific ETA that might make Gayle feel pressured to meet the schedule, she manages her family's expectations by advising them that she will call when she arrives.

Pilots can perceive hazards by using the CARE checklist:

Pilot

- **C**onsequences: Gayle's inexperience and lack of recent flight time create some risk of an accident, primarily because she plans to travel over mountains on a hazy day and land at an unfamiliar mountain airport that is still in IMC conditions.
- **A**lternatives: Gayle might mitigate the pilot-related risk by hiring a CFI to accompany her and provide dual cross-country instruction. An added benefit is the opportunity to broaden her flying experience in safe conditions.
- **R**eality: Accepting the reality that limited experience can create additional risk is a key part of sound risk management and mitigation.
- **E**xternal Factors: Like many pilots, Gayle must contend with the emotional pressure associated with acknowledging that her skill and experience levels may be lower than she would like them to be. Pride can be a powerful external factor!

Aircraft

- **C**onsequences: This area presents low risk because the aircraft is in excellent mechanical condition and Gayle is familiar with its avionics.
- **A**lternatives: Had there been a problem with her aircraft, Gayle might have considered renting another plane from her flight school. Bear in mind, however, that alternatives sometimes create new hazards. In this instance, there may be hazards associated with flying an unfamiliar aircraft with different avionics.
- **R**eality: It is important to recognize the reality of an aircraft's mechanical condition. If you find a maintenance discrepancy and then find yourself saying that it is "probably" okay to fly with it anyway, you need to revisit the consequences part of this checklist.
- **E**xternal Factors: Pilot decision-making can sometimes be influenced by the external pressure of needing to return the airplane to the FBO by a certain date and time. Because Gayle owns the airplane, there was no such pressure in this case.

Environment

- **C**onsequences: For a pilot whose experience consists mostly of local flights in good VMC, launching a long cross-country flight over mountainous terrain in hazy conditions could lead to pilot disorientation and increase the risk of an accident.
- **A**lternatives: Options include postponing the trip until the visibility improves, or modifying the route to avoid extended periods of time over the mountains.
- **R**eality: Hazy conditions and mountainous terrain clearly create risk for an inexperienced VFR-only pilot.
- **E**xternal Factors: Few pilots are immune to the pressure of "get-there-itis," which can sometimes induce a decision to launch or continue in less than ideal weather conditions.

External Pressures

- **C**onsequences: Any number of factors can create risk of emotional pressure from a "get-there" mentality. In Gayle's case, the consequences of her strong desire to visit family, her family's expectations, and personal pride could induce her to accept unnecessary risk.
- **A**lternatives: Gayle clearly needs to develop a mitigating strategy for each of the external factors associated with this trip.
- **R**eality: Pilots sometimes tend to discount or ignore the potential impact of these external factors. Gayle's open acknowledgement of these factors (e.g., "I might be pressured into pressing on so my mother won't have to worry about our late arrival.") is a critical element of effective risk management.
- **E**xternal Factors: (see above)

PERFORM - Mitigate, Eliminate, Evaluate

Once you have perceived a hazard (step one) and processed its impact on flight safety (step two), it is time to PERFORM by taking the best course of action, and then evaluating its impact. Your goal is to

M itigate or eliminate risk

E valuate outcome of action(s)

Your mental willingness to follow through on safe decisions, especially those that require delay or diversion is critical. You can bulk up your mental muscles by:

- Using personal minimums checklist to make some decisions in advance of the flight. If you are unsure of how to develop personal minimums, take a look at the methods presented in the three documents below. Choose one that works for you, and stick to it!

- Develop a list of good alternatives during your processing phase. In marginal weather, for instance, you might mitigate the risk by identifying a reasonable alternative airport for every 25-30 nm segment of your route.

- Preflight your passengers by preparing them for the possibility of delay and diversion, and involve them in your evaluation process.

Common Errors in ADM

Types of Pilot Error

Pilot mistakes are often called “pilot error,” formally defined as: An action or inaction that leads to a deviation from intentions and expectations .

Sometimes, pilot error involves deficiencies in aircraft control, or "physical airplane," skill. These errors can be prevented through maneuvers-based training and practice.

In other cases, accidents attributed to pilot error result from shortcomings in the pilot's "mental airplane" systems knowledge. Examples might include errors in programming the autopilot, or turning the wrong knob on the GPS navigator. Use of aircraft training devices, computer-based training, and regular practice in the aircraft can help prevent these errors.

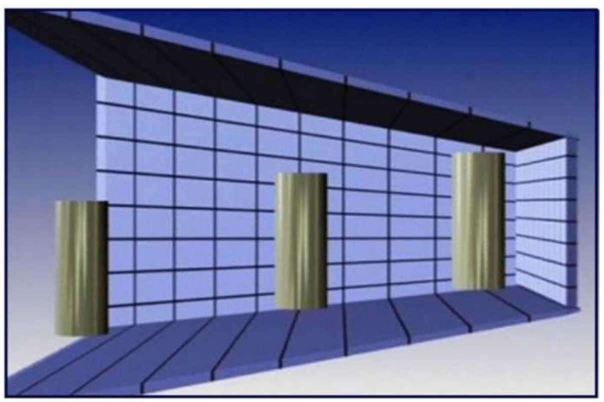
Effects of Human Limitations

Human limitations can play a significant role in how we perceive, process, and perform in complex activities, like flying. For example: Filtering, Filling in the gaps, Confirmation Bias, and Framing,

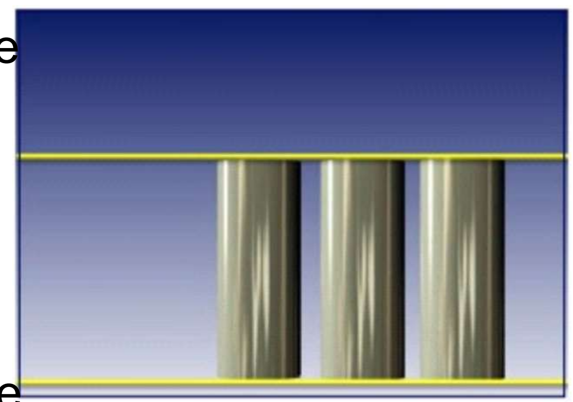
Human Limitations

Filtering: The brain's working *memory capacity is limited to about seven (7) pieces, or "chunks," of information* at one time, so one of the life skills we acquire is the ability to filter the flood of information arriving through our senses. In any flight, especially one with challenging weather, we may unconsciously screen out vital information. Use of the PAVE checklist as a guide to your ongoing mental hazard scan can help prevent inappropriate filtering, because it provides a comprehensive and methodological approach to the information gathering process.

Filling in the Gaps: When there is more information than the brain can accurately perceive and process, it compensates by *filling in the gaps and producing an interpretation that is not correct*. Take a look at the corridor illustration below on the left.



The brain quickly processes the information in this illustration and concludes that the cylinders in the picture are different heights, and that they appear to be growing larger from left to right. In fact they are the same size!



Runway illusions, which can result in unsafe decisions when flying an approach, are a good example of this type of human error.

Human Limitations

Patterns and Expectations: The brain uses existing knowledge and experience as a shortcut to processing new information. This tendency can be useful, but it can also be dangerous. Examples:

- When you are processing information from an unfamiliar GPS navigator, you might unconsciously make incorrect assumptions on the basis of how information is accessed or displayed on the one you normally use.
- If previous experience at a familiar airport leads you to expect a clearance to land on runway 10, you may "hear" a clearance to land

Confirmation Bias: Human beings also have a tendency to look for information that confirms a decision we have already made. For example, imagine that you have decided to continue a flight you have already started. You call Flight Watch for updated weather information on several nearby airports, but you might unconsciously give more weight to the information that supports your decision to press ahead.

The "reality" part of the systematic ADM process is especially useful in countering errors associated with patterns, expectations, and confirmation bias. Make a conscious effort to identify your expectations, and then be alert to how reality differs.

Human Limitations

Framing: When you evaluate options for a decision, be sensitive to how you state, or "frame," your alternatives. Assume you are deciding whether to continue a flight in deteriorating weather. If you frame the “continue” decision in positive terms (e.g., “I can save a lot of time and inconvenience if I go on”), you are probably more likely to decide on continuing. If, on the other hand, you frame the decision in negative terms (e.g., “I could get myself in real trouble if I push on”), you are more likely to divert to a safer destination.

Error Prevention, Detection, and Management Summary

No matter how hard we try, it is simply not possible for human beings to avoid errors entirely, especially when complex systems are involved. **By using a systematic approach to continuous ADM, however, and developing awareness of common types of human ADM error, we can seek to minimize mistakes.**

Consistent use of these tools can also help with quick recognition of errors we do make, and safe management of the resulting situation.

USE PERSONAL MINIMUMS

PILOT

Experience/Recency

Takeoffs/landings................ _____ in the last _____ days

Hours in make/model .... _____ in the last _____ days

Instrument approaches .... _____ in the last (simulated or actual) _____ days

Instrument flight hours .... _____ in the last (simulated or actual) _____ days

Terrain and airspace ....familiar

Physical Condition

Sleep .... _____ in the last 24 hours

Food and water .... in the last _____ hours

Alcohol ....None in the last _____ hours

Drugs or medication.............None in the last _____ hours

Stressful events ....None in the last _____ days

Illnesses ....None in the last _____ days

▶ ____________________

AIRCRAFT

Fuel Reserves (Cross-Country)

VFR Day .... _____ hours

Night..................................... _____ hours

IFR Day .... _____ hours

Night..................................... _____ hours

Experience in Type

Takeoffs/landings................ _____ in the last

in aircraft type _____ days

Aircraft Performance

Establish that you have additional performance available over that required. Consider the following:

- Gross weight
- Load distribution
- Density altitude
- Performance charts

Aircraft Equipment

Avionics.................... familiar with equipment (including autopilot and GPS systems)

COM/NAV.................. equipment appropriate to flight

Charts .... current

Clothing.................... suitable for preflight and flight

Survival gear .... appropriate for flight/terrain

▶ ____________________

ENVIRONMENT

Airport Conditions

Crosswind .... _____ % of max POH

Runway length........ _____ % more than POH

Weather

Reports and forecasts ....not more than _____ hours old

Icing conditions ....within aircraft/pilot capabilities

Weather for VFR

Ceiling Day........................ _____ feet

Night .... _____ feet

Visibility Day........................ _____ miles

Night .... _____ miles

Weather for IFR

Precision Approaches

Ceiling .... _____ feet above min.

Visibility .... _____ mile(s) above min.

Non-Precision Approaches

Ceiling .... _____ feet above min.

Visibility .... _____ mile(s) above min.

Missed Approaches

No more than ...... _____ before diverting

Takeoff Minimums

Ceiling .... _____ feet

Visibility .... _____ mile(s)

▶ ____________________

EXTERNAL PRESSURES

Trip Planning

Allowance for delays .... _____ minutes

Alternate Plans for Diversion or Cancellation

Notification of person(s) you are meeting

Passengers briefed on diversion or cancellation plans and alternatives

Modification or cancellation of car rental, restaurant, or hotel reservations

Arrangement of alternative transportation (airline, car, etc.)

Personal Equipment

Credit card and telephone numbers available for alternate plans

Appropriate clothing or personal needs (eye wear, medication...) in the event of unexpected stay

▶ ____________________

Debriefing: Self Assessment

• Pilots operating as single pilots need to be able to *critique their own performance.*
• Hard to do.
• Several ways it can be done.
- Take notes – keep a journal, what did you learn, what when wrong?.
- Assess the different situations that occurred.
- What could have been done differently.
- Use different scenarios.
• Analyze contributing factors:
- Weather
    - Air Traffic Control
    - Aircraft
    - Workload
    -Flight conditions (VMC/IMC)
• Use all available resources to provide feedback
    - Passengers
    - Other pilots
    - Scenario based training
• Determine improvement areas
• Take measurements to improve these areas for future flights. **NEVER STOP LEARNING**

Situational Awareness

It is the *accurate perception and understanding* of *all* the factors and conditions (inside and outside) within the four fundamental risk elements (Pilot, Aircraft, enVironment, External pressures) *that affect safety* before, during, and after the flight.

Things that reduce your situational awareness are things like:

- Fatigue
- Distractions and Unsterile Cockpits
- Unusual or unexpected events
- Complacency
- High workloads
- Unfamiliar situations
- Inoperative Equipment
- Unmanaged Automation in technically advanced aircraft

Recommendations for better SA

- Perform verification checks on all programming while on the GROUND.
- Check flight routing that all routing matches planned route.
- Verify waypoints
- Make sure to make use of ALL onboard navigation equipment (i.e. use VOR to back up GPS)
- Match use of automated systems with pilot proficiency (don’t learn as you go, know before you go!)
- Be ready to verify computer data entries for incorrect keystroke that could lead to loss of SA.

CFIT

Failure to Control Flight Into Terrain is a situation in which an airworthy aircraft is flown, under the control of a qualified pilot, into terrain with inadequate awareness on the part of the pilot of the impending collision.

Major causes include…

- ✓ Lack of pilot currency
- ✓ Loss of SA
- ✓ Pilot distraction or breakdown of risk management
- ✓ Failure to comply with minimum safe altitudes
- ✓ Breakdown in effective ADM
- ✓ Insufficient planning especially in the descent and arrival segments.

CFIT

Techniques that will assist in avoidance of CFIT accidents

- ❖ Maintain situational awareness at all times.
- ❖ Adhere to safe takeoff and departure procedures.
- ❖ Familiarize yourself with surrounding *terrain features* and obstacles.
- ❖ Adhere to published routes and minimum altitudes.
- ❖ Fly a stabilized approach.
- ❖ Understand ATC clearances and instructions.
- ❖ Don't become complacent.
- ❖ "SLOWER" AIRCRAFT ALLOW A SHORTER TURNING RADIUS IF 180 TURN IS REQUIRED!

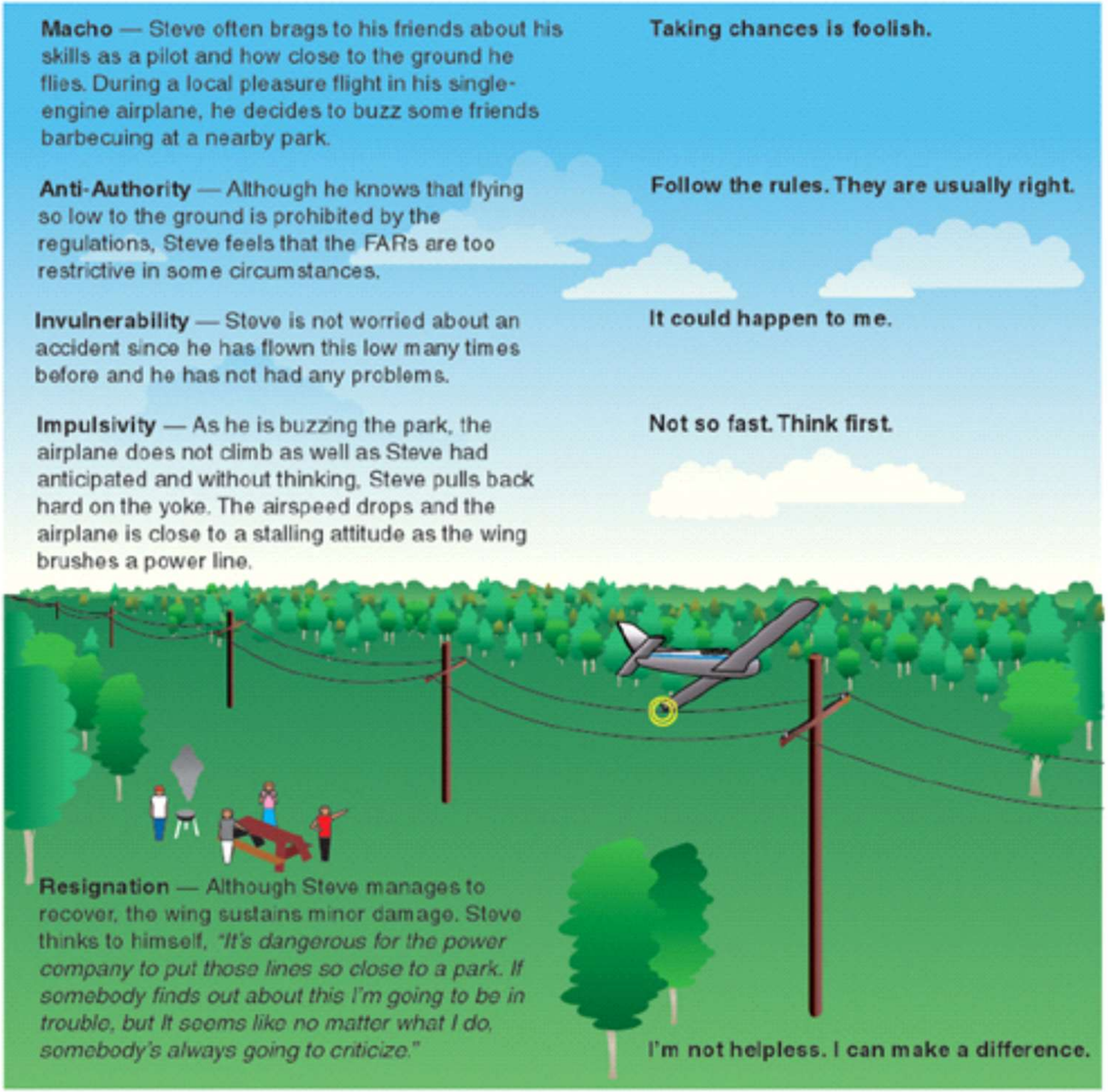
ATTITUDE AND ETHICAL BEHAVIOR

In aviation, dense regulations, technical skill and knowledge are insufficient to ensure safe flying. Ethical behavior, constructive attitudes, and a *positive culture* add to safety for individual pilots and foster a healthy aviation community.

Flying is not about ME, it is about WE. Your actions as a pilot have significant effects and implications on OTHERS on the ground, in the sky, and at your side in the cockpit. You mess up and EVERYBODY in the community pays. You should not consider being a pilot if you are only thinking of yourself.

WE MUST NOT TO ENGAGE INDANGEROUS ATTITUDES ABOUT FLYING. **Like what?**

DANGEROUS ATTITUDE – "There are old pilots and bold pilots There are NO old bold pilots because of bad attitudes and risks."



DANGEROUS ATTITUDES

Peer Pressure. Poor decision making based upon emotional response to peers rather than evaluating a situation objectively.

Mind Set. The inability to recognize and cope with changes in the situation different from those anticipated or planned.

Get-There-Itis. This tendency, common among pilots, clouds the vision and impairs judgment by causing a fixation on the original goal or destination combined with a total disregard for any alternative course of action.

Duck-Under Syndrome. The tendency to sneak a peek by descending below minimums during an approach. Based on a belief that there is always a built-in “fudge” factor that can be used or on an unwillingness to admit defeat and shoot a missed approach.

Scud Running. Pushing the capabilities of the pilot and the aircraft to the limits by trying to maintain visual contact with the terrain while trying to avoid physical contact with it. This attitude is characterized by the old pilot’s joke: “If it’s too bad to go IFR, we’ll go VFR.” Continuing visual flight rules (VFR) into instrument conditions often leads to spatial disorientation or collision with ground/obstacles. It is even more dangerous if the pilot is not instrument qualified or current.

Getting Behind the Aircraft. Allowing events or the situation to control your actions rather than the other way around. Characterized by a constant state of surprise at what happens next. (STAY AHEAD: You not the airplane is in control)

Loss of Positional or Situation Awareness. Another case of getting behind the aircraft which results in not knowing where you are, an inability to recognize deteriorating circumstances, and/or the misjudgment of the rate of deterioration.

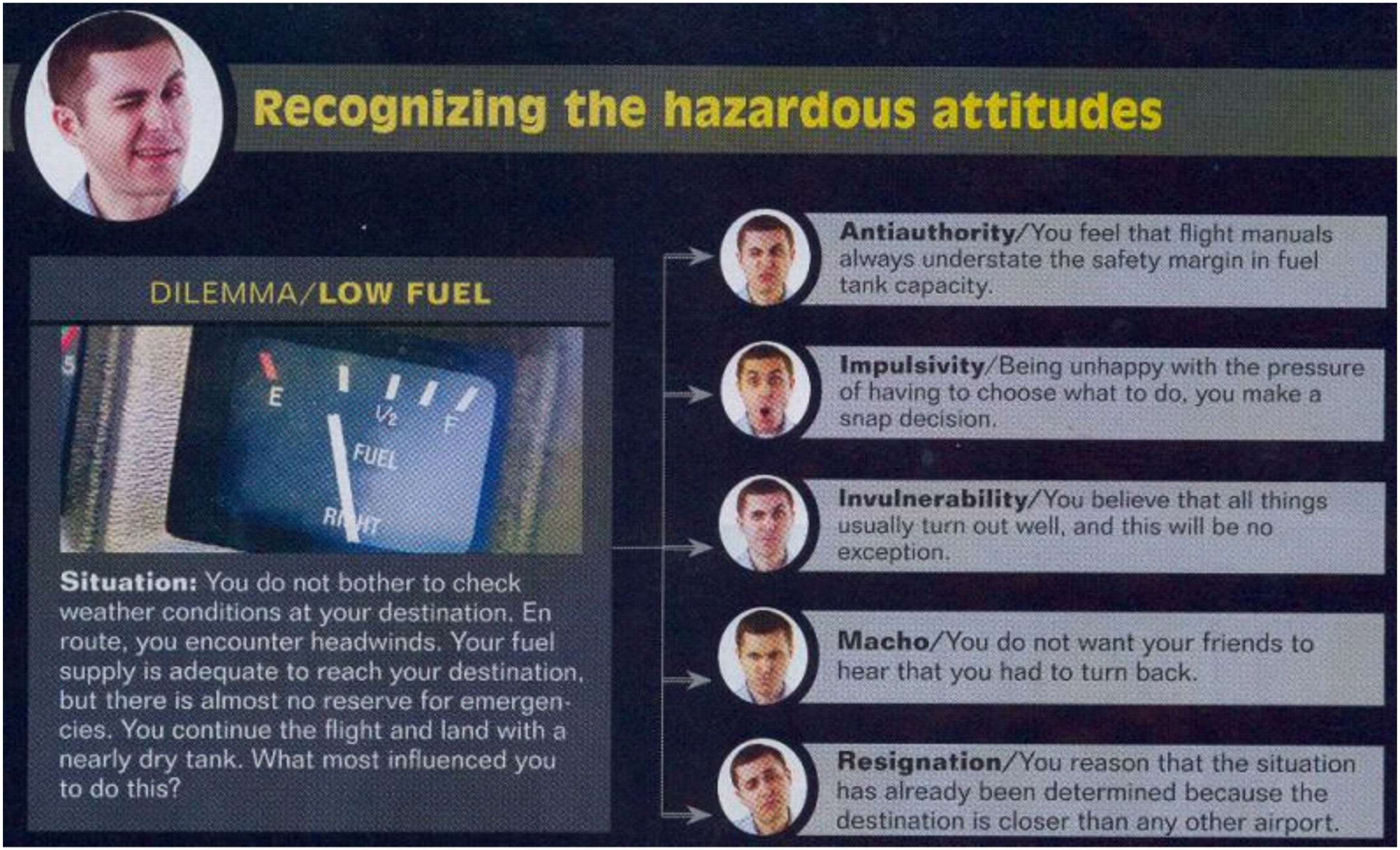
Operating Without Adequate Fuel Reserves. Ignoring minimum fuel reserve requirements, either VFR or Instrument Flight Rules (IFR), is generally the result of overconfidence, lack of flight planning, or ignoring the regulations.

Descent Below the Minimum Enroute Altitude. The duck-under syndrome (mentioned above) manifesting itself during the en route portion of an IFR flight.

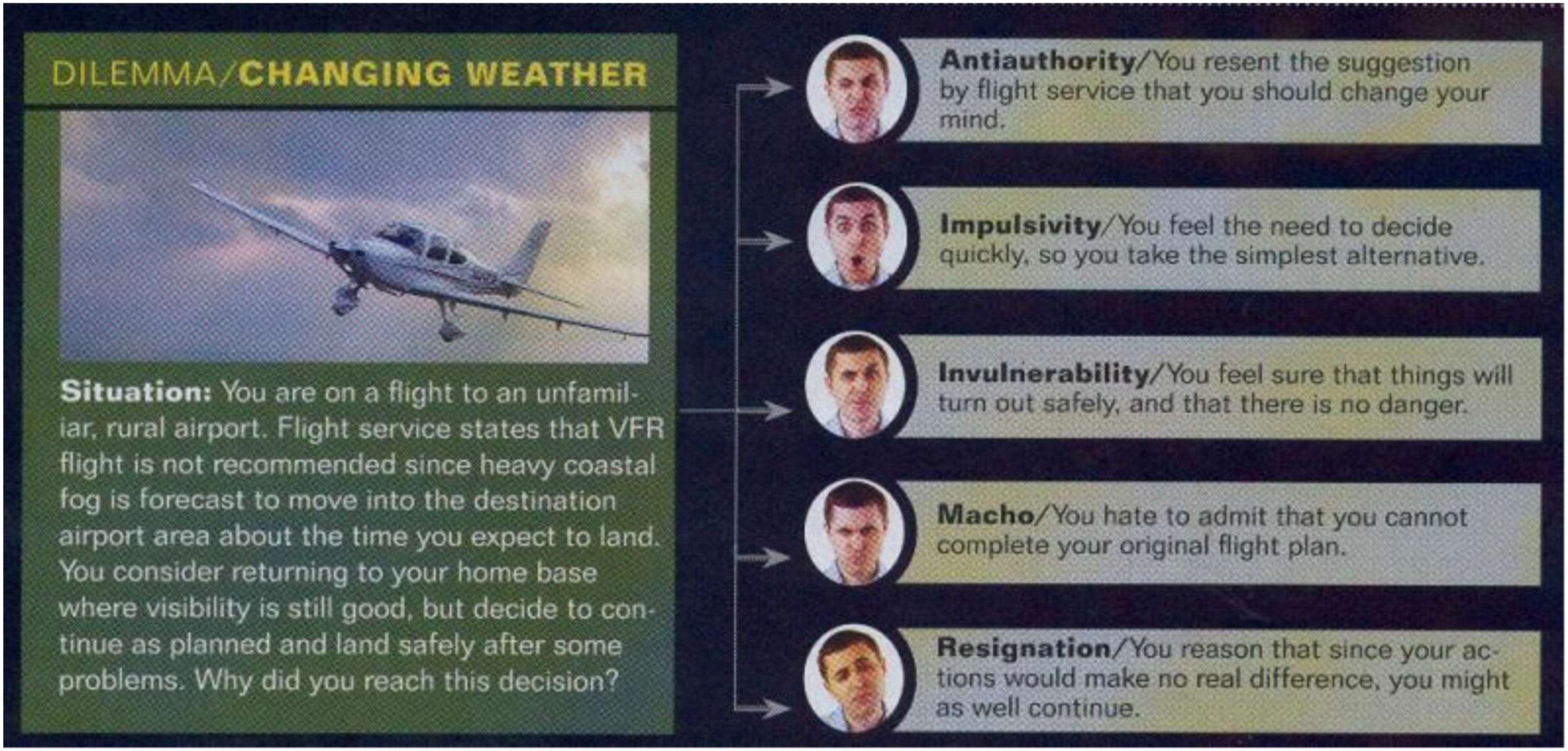
Flying Outside the Envelope. Unjustified reliance on the (usually mistaken) belief that the aircraft’s high performance capability meets the demands imposed by the pilot’s (usually overestimated) flying skills.

Neglect of Flight Planning, Preflight Inspections, Checklists, Etc. Unjustified reliance on the pilot’s short and long term memory, regular flying skills, repetitive and familiar routes, etc.

HAZARDOUS ANTIDOTE ATTITUDE



HAZARDOUS ANTIDOTE ATTITUDE



DILEMMA/**CHANGING WEATHER**

Situation: You are on a flight to an unfamiliar, rural airport. Flight service states that VFR flight is not recommended since heavy coastal fog is forecast to move into the destination airport area about the time you expect to land. You consider returning to your home base where visibility is still good, but decide to continue as planned and land safely after some problems. Why did you reach this decision?

Antiauthority/You resent the suggestion by flight service that you should change your mind.

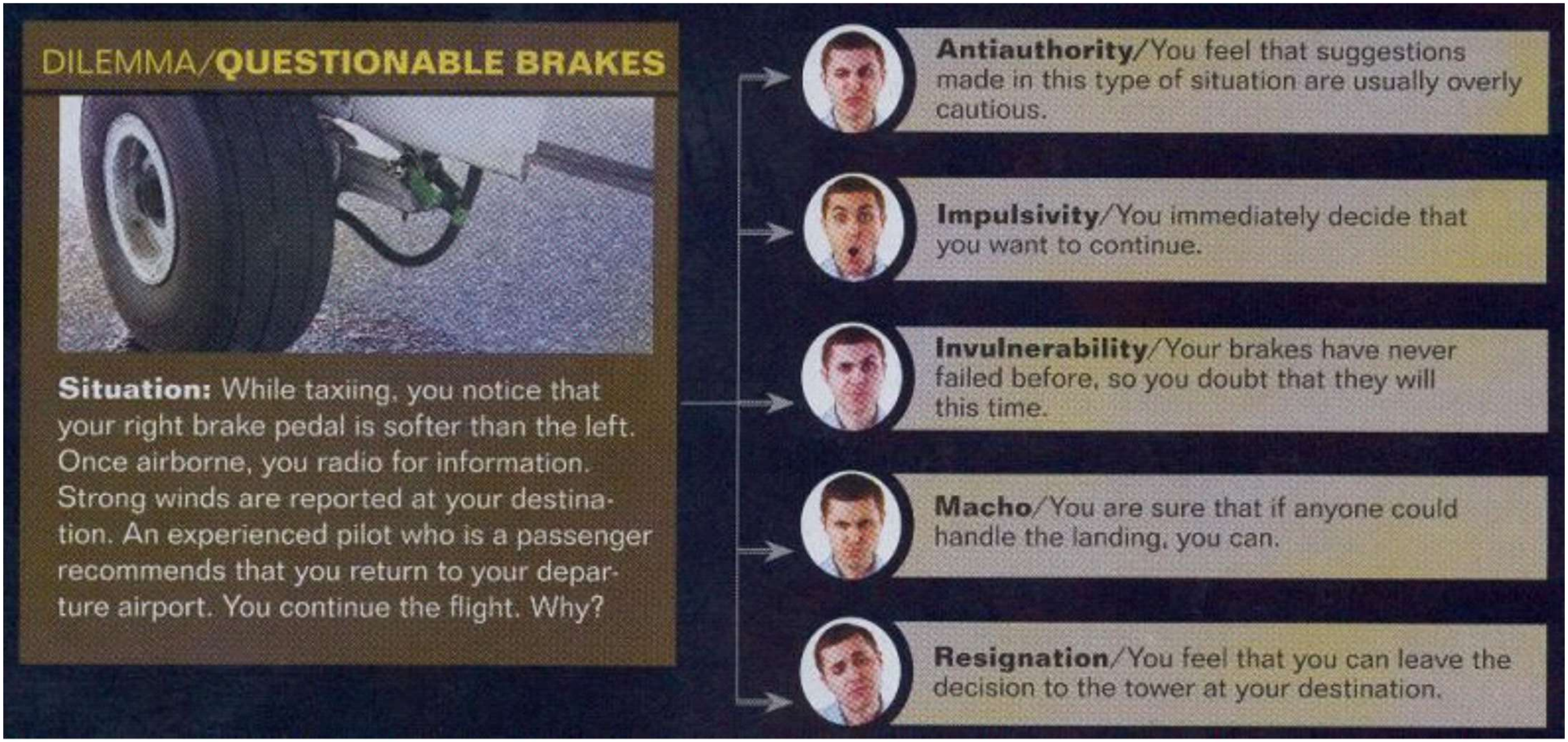
Impulsivity/You feel the need to decide quickly, so you take the simplest alternative.

Invulnerability/You feel sure that things will turn out safely, and that there is no danger.

Macho/You hate to admit that you cannot complete your original flight plan.

Resignation/You reason that since your actions would make no real difference, you might as well continue.

HAZARDOUS ANTIDOTE ATTITUDE



DILEMMA/**QUESTIONABLE BRAKES**

Situation: While taxiing, you notice that your right brake pedal is softer than the left. Once airborne, you radio for information. Strong winds are reported at your destination. An experienced pilot who is a passenger recommends that you return to your departure airport. You continue the flight. Why?

Antiauthority/You feel that suggestions made in this type of situation are usually overly cautious.

Impulsivity/You immediately decide that you want to continue.

Invulnerability/Your brakes have never failed before, so you doubt that they will this time.

Macho/You are sure that if anyone could handle the landing, you can.

Resignation/You feel that you can leave the decision to the tower at your destination.

HAZARDOUS ANTIDOTE ATTITUDES and ANTIDOTES

- Antiauthority: Don’t tell me. *Follow the rules*. *They are usually right.*
- Impulsivity: Do something quick. *Not so fast*. Think first
- Invulnerability: It won’t happen to me. *It could happen to me.*
- Macho: I can do it. *Taking chances is foolish.*
- Resignation: What’s the use? *I’m not helpless. I can make a difference*.

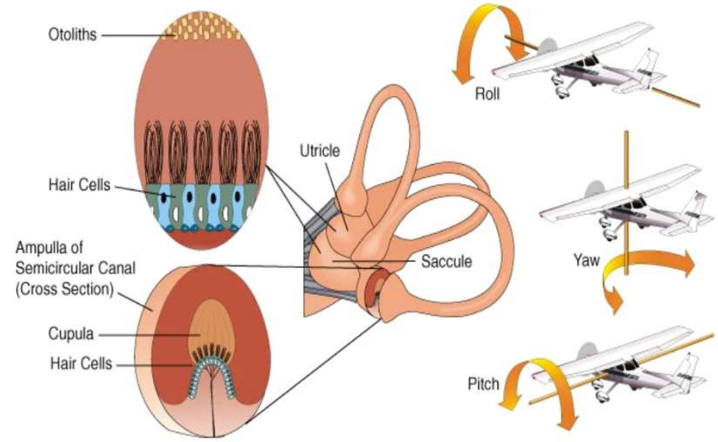
Aviation Physiology

How might your body work differently in the air from how it works on the ground?

Aviation Physiology

- Disorientation
  - Brain receives conflicting messages from our senses
  - Spatial disorientation
    - Central vision differs from peripheral vision
    - Example: Car in spot adjacent to you begins to move
    - To overcome spatial disorientation, you must rely on, and properly interpret, your flight instruments
    - Using your body to interpret flight attitude makes you more susceptible to disorientation

Aviation Physiology



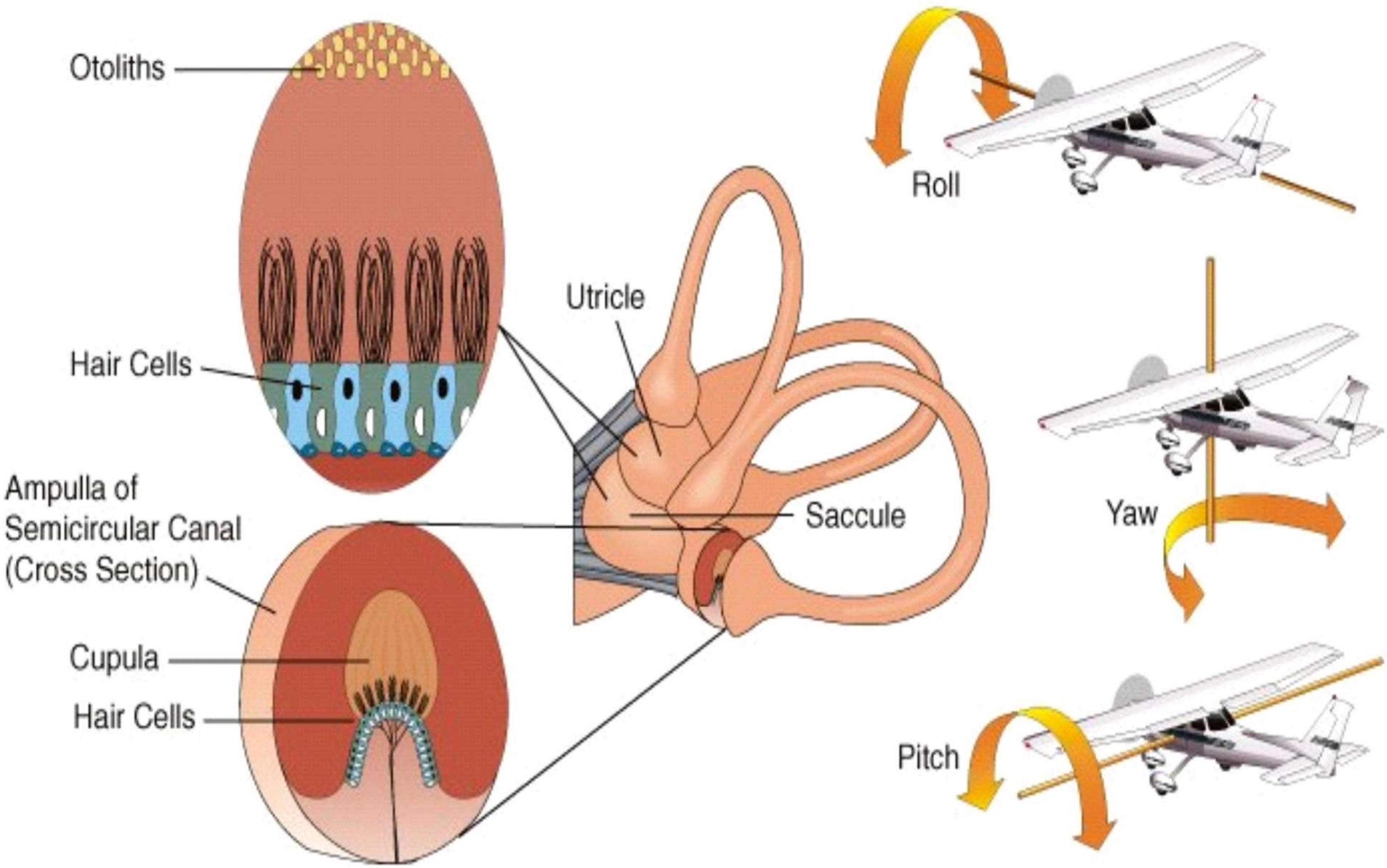
- Disorientation (cont'd)
  - Vestibular disorientation
    - Fluid in bony canals of inner ear is set in motion (acceleration)
    - Interpreted as movement by the brain
    - Since bony canals are oriented in three axes, fluid movement in any canal is interpreted as movement in that direction
    - Constant movement (no *acceleration*) is interpreted as no movement, i.e., no acceleration -> no movement

Vertigo

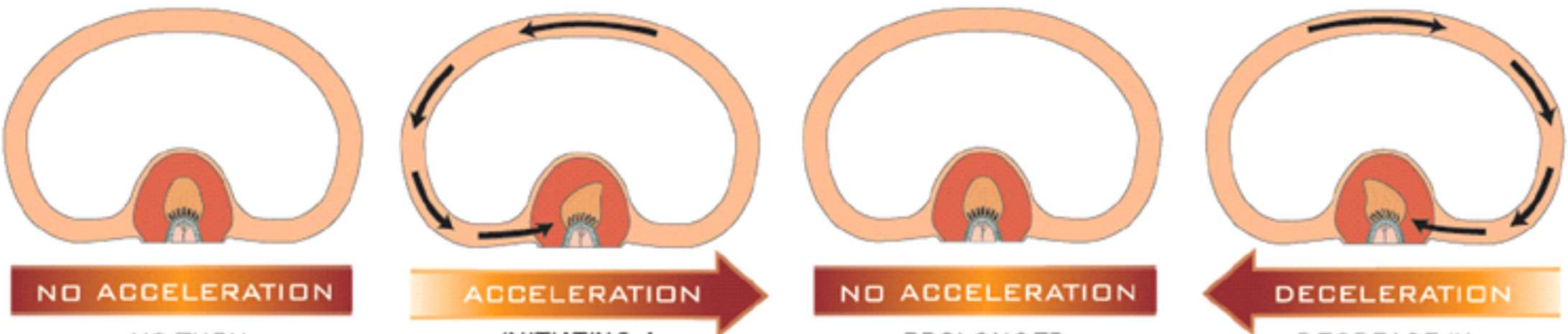
What do you think you should do if you get vertigo ….

- On the ground before a flight?
- In the air as pilot-in-command?

Aviation Physiology - Equilibrium



Aviation Physiology - Equilibrium



NO TURN

If no acceleration is taking place, the cupula is stationary and the hair cells are not deflected. No sensation of a turn is felt.

INITIATING A CLOCKWISE TURN

A clockwise turn deflects the hair cells in the direction opposite of the acceleration. You experience an accurate sensation of the turn direction.

PROLONGED CONSTANT-RATE TURN

During a prolonged constant rate turn, you may not sense any motion since the fluid in the canals eventually reaches equilibrium and the hair cells are no longer deflected.

DECREASE IN RATE OF TURN

If you decrease the rate of turn, the deflection of the hair cells may produce a false sensation of a turn in the opposite direction. In this example, you experience the sensation of a counterclockwise turn.

Aviation Physiology

*Rapid acceleration during takeoff will be interpreted as ?

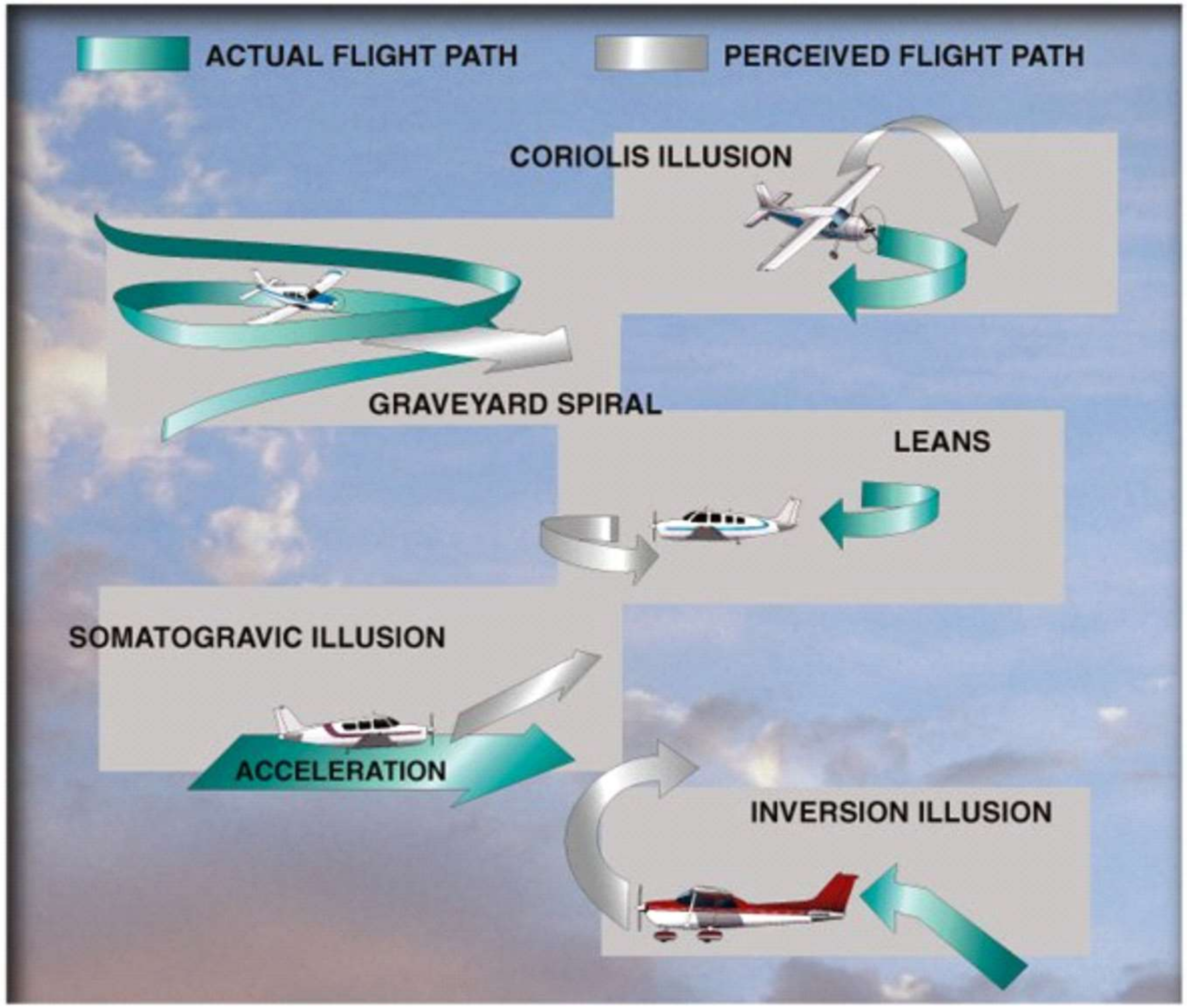
Being in a nose-up attitude

*Abrupt change from a climb to straight and level will be interpreted as ?

Tumbling backwards

*Abrupt movement of your head during a constant rate turn will produce ?

Coriolis illusion



Vertigo frequently leads to “Air Sickness”

- Physical symptoms include loss of appetite, saliva collecting in the mouth, nausea, nausea, vomiting.
- Actions a pilot might take if the passenger is suffering air sickness might include open air vents, loosen clothing, use supplemental oxygen and keep the eyes on a point outside the airplane. Avoid unnecessary head movement. Get the passenger down on the ground as soon as possible.

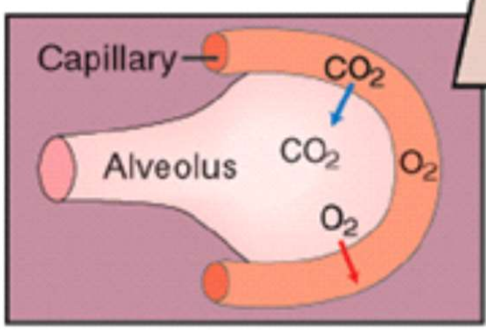
Ear Blockage

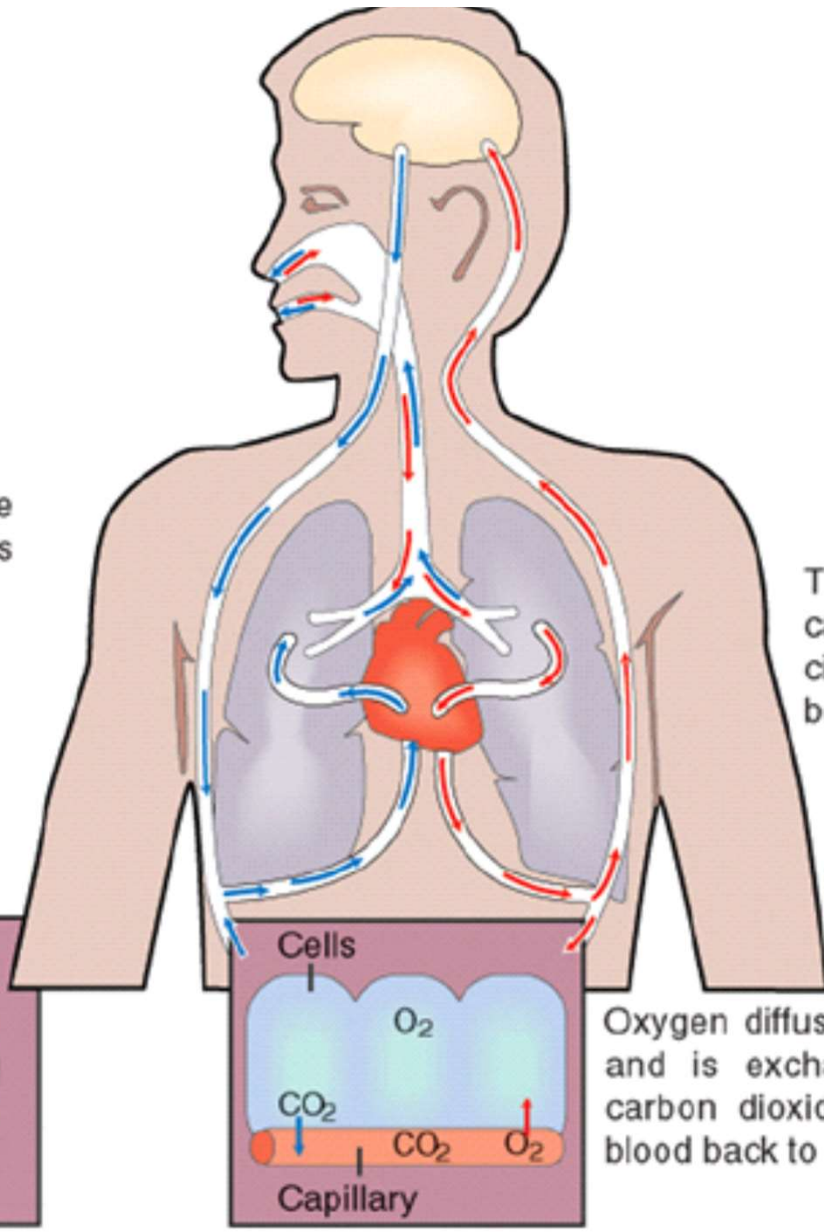
- Infections, colds, allergic reactions prevent equalization of external pressure to internal pressure in the Eustachian tube between throat and inner ear causing sever pain and loss of hearing. Duration hours to days.
- Possible relief by yawning, swallowing, tensing muscles in throat, pinching nostrils and exerting pressure (“Valsalva Maneuver”)

Aviation Physiology

Oxygen is inhaled into the lungs and carbon dioxide is exhaled from the lungs.

Oxygen is transferred from the lungs to the bloodstream by diffusion through the thin membranes of small air sacs called alveoli.





The heart pumps blood carrying oxygen through the circulatory system to the body cells.

Oxygen (O_2)

Carbon Dioxide (CO_2)

Oxygen diffuses through cell membranes and is exchanged for the waste gas carbon dioxide which is carried by the blood back to the lungs.

Aviation Physiology

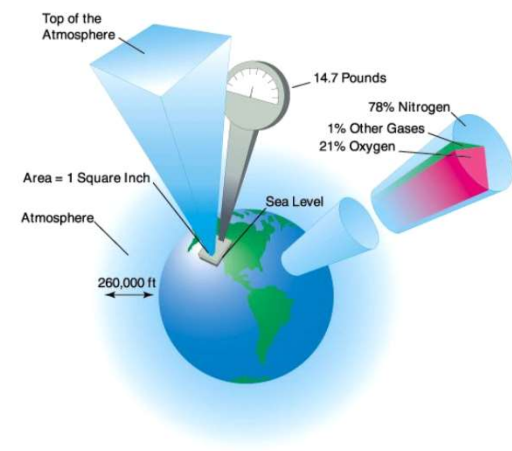
Altitude	Time of Useful Consciousness
45,000 feet MSL	9 to 15 seconds
40,000 feet MSL	15 to 20 seconds
35,000 feet MSL	30 to 60 seconds
30,000 feet MSL	1 to 2 minutes
28,000 feet MSL	2 1/2 to 3 minutes
25,000 feet MSL	3 to 5 minutes
22,000 feet MSL	5 to 10 minutes
20,000 feet MSL	30 minutes or more

Aviation Physiology

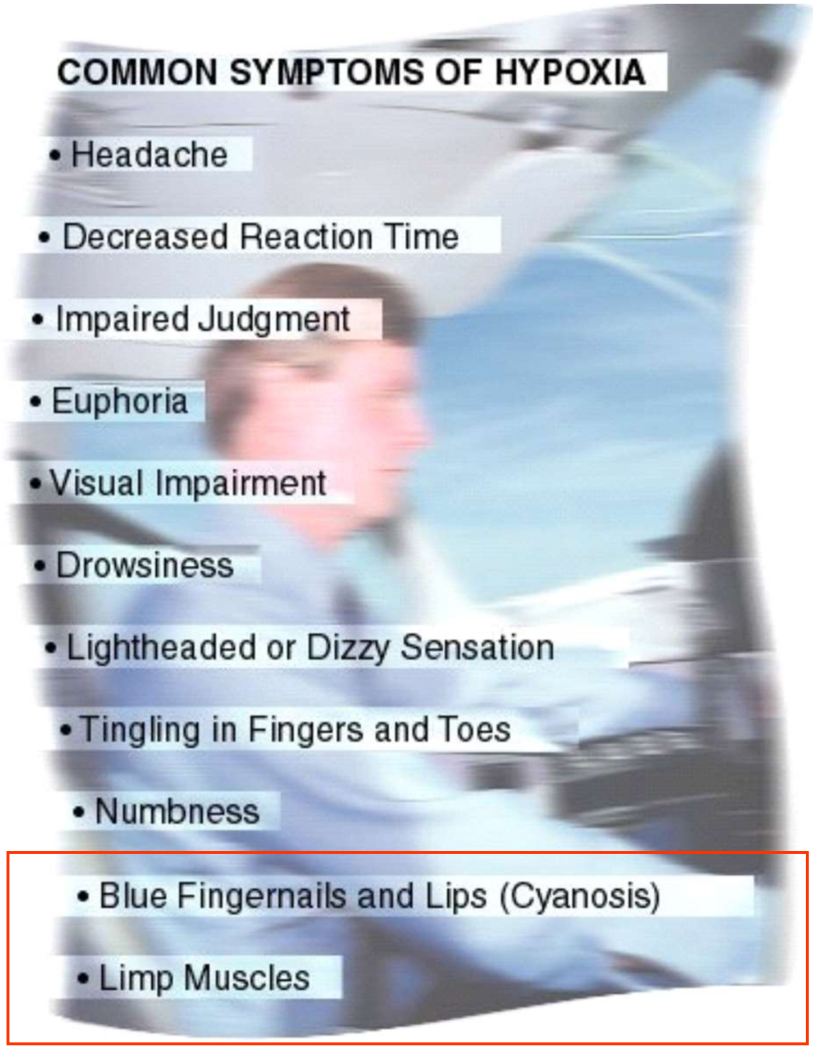
- Hypoxia
  - Tissues, e.g, the brain, the eyes, in the body do not receive enough oxygen (hypo -> below, ox -> oxygen, -ia -> condition of)
  - * Insidious because the symptoms are difficult to recognize before your reactions are affected!
  - Hypoxic hypoxia is due

  to insufficient partial pressure

  of oxygen in the atmosphere
  - What are the symptoms?



Aviation Physiology - Hypoxia



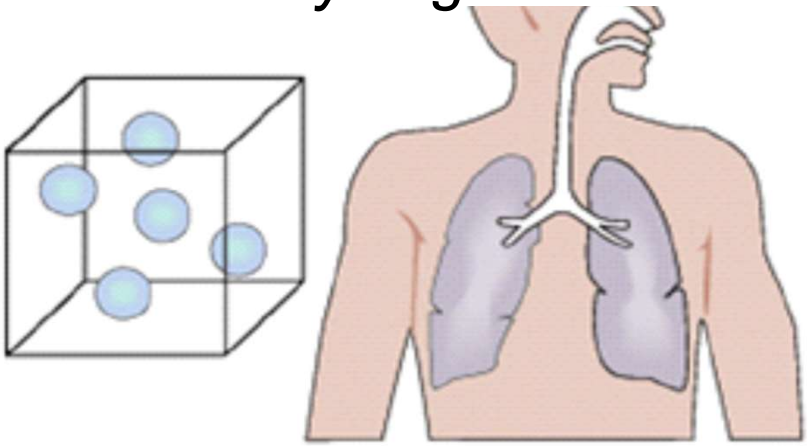
What's the remedy for hypoxia?

Oxygen (O_2)

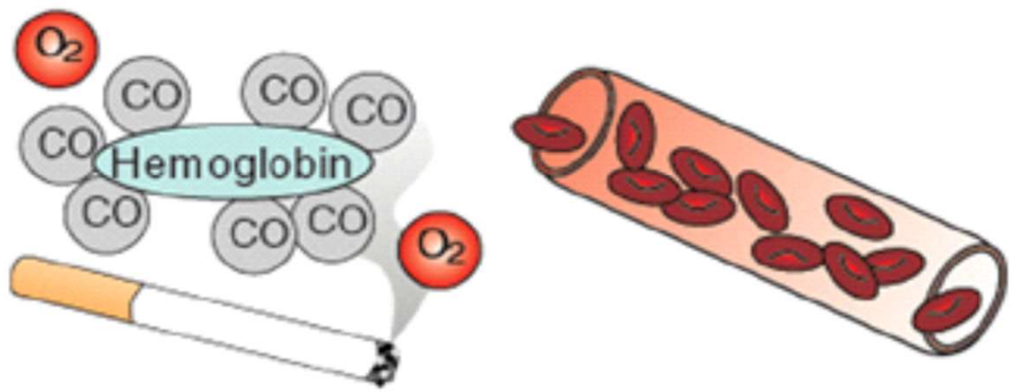
Either use O_2 or descend to lower altitude.

Aviation Physiology

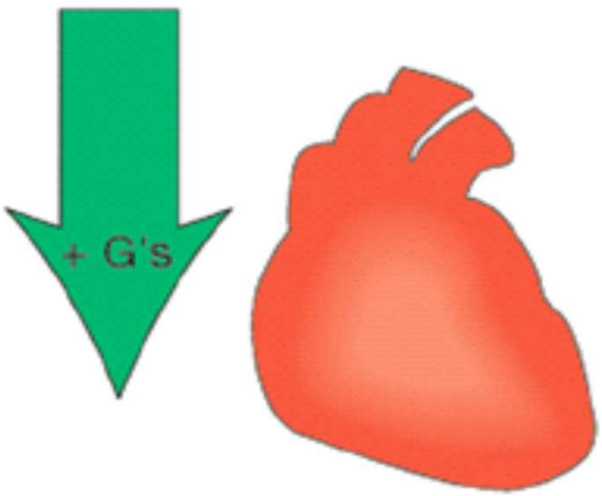
Why might sufficient oxygen not get into your body?



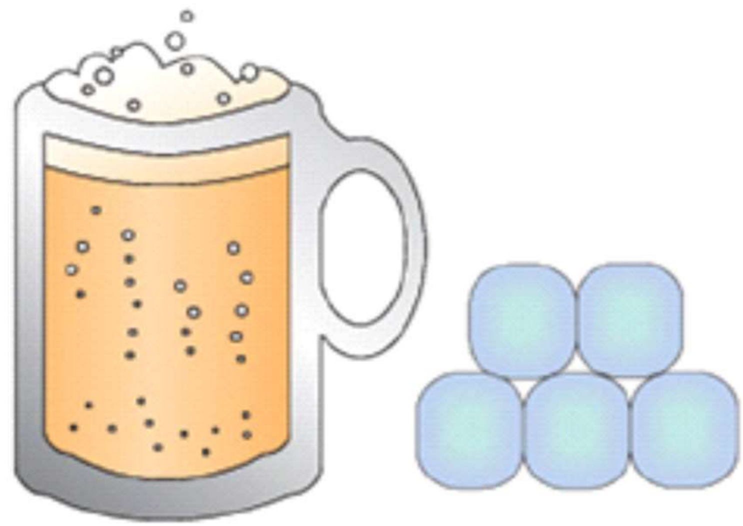
Hypoxic Hypoxia – Inadequate
Supply of Oxygen



Hypemic Hypoxia – Inability of
the Blood to Carry Oxygen

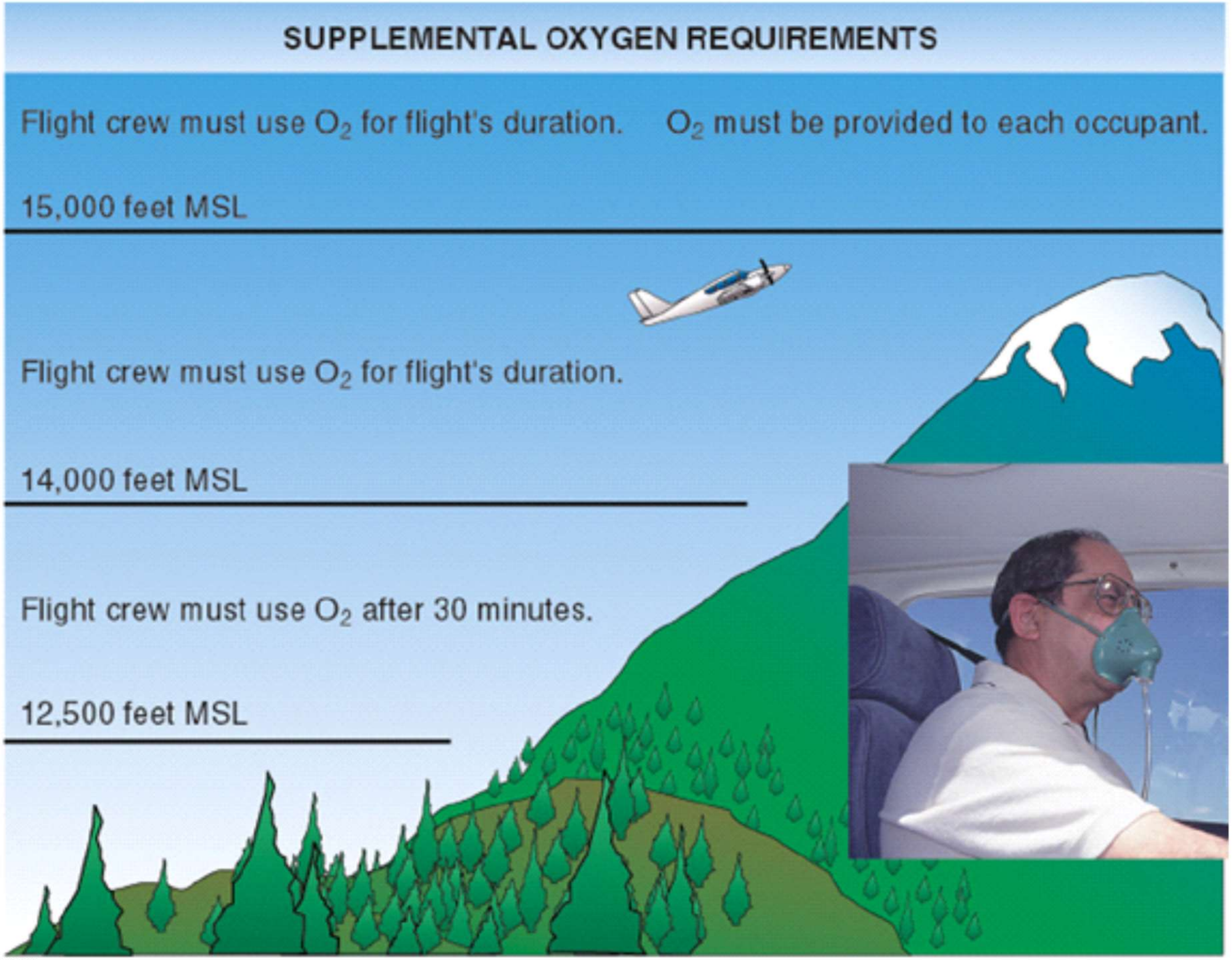


Stagnant Hypoxia – Inadequate
Circulation of Oxygen



Histotoxic Hypoxia – Inability of the
Cells to Effectively Use Oxygen

Aviation Physiology



Aviation Physiology

- Carbon monoxide, CO, can cause hypemic hypoxia
  - CO is found in cigarette smoke
    - 3 cigarettes ⟶ equivalent of 8,000 feet!
    - *If you are around smokers, you are being exposed to CO*!
  - CO is found in internal combustion engine exhaust
    - Cabin heat is provided by a shroud around exhaust pipe
    - Hole in exhaust pipe will cause CO to enter cabin
    - *If you smell exhaust, you are being exposed to CO*!

How can hypoxia be avoided?

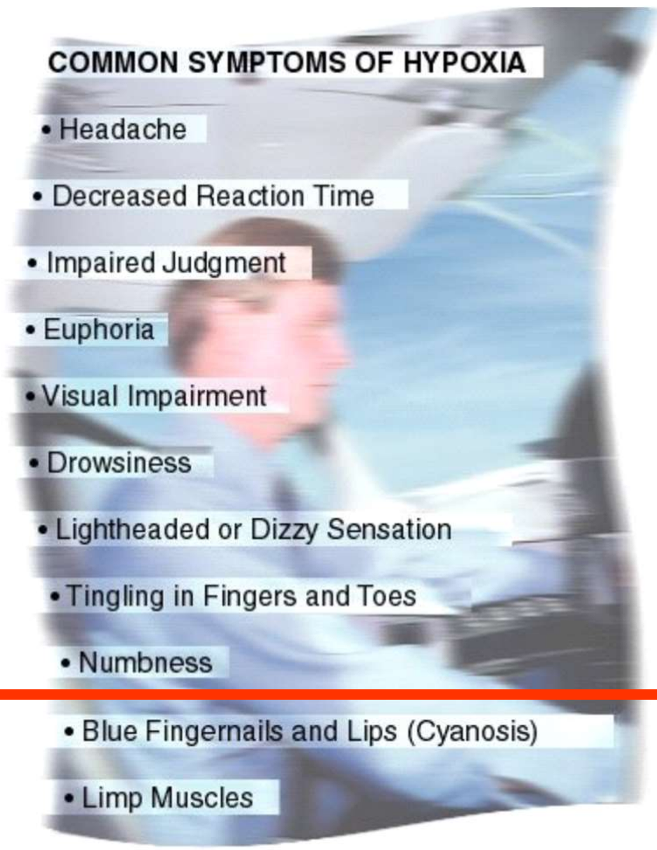
- Maintain a safe, comfortable, oxygen rich pressure cabin level
- Although not required by FAA regulation, it is wise to use supplemental oxygen above 10,000 MSL during the day.
- Although not required by FAA regulation, it is wise to use supplemental oxygen above 5,000 MSL during the night.

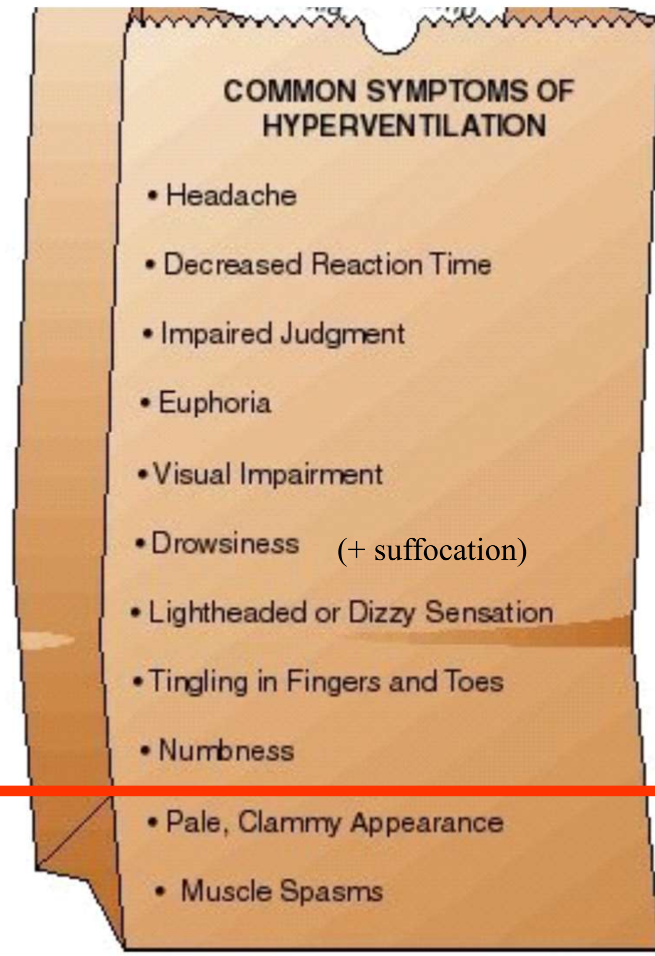
Aviation Physiology

- Hyperventilation
  - Breathing too rapidly (hyper -> above, ventilation -> breathing) - Why?
  - Causes too much carbon dioxide, CO_2, to be lost
  - The remedy is simple - *slow your breathing down*!
    - Conscious effort to slow breathing
    - Breathing into a paper bag
  - What are the symptoms?
  - How can these symptoms be distinguished from hypoxia?

Aviation Physiology - Hyperventilation

Hypoxia or Hyperventilation?





Aviation Physiology – IMPAIRMENT

- FATIGUE – You must be SHARP, ALERT, and IN CONTROL. Fatigue jeopardizes.
- NOISE – Causes fatigue and problems with communications – use headphones.
- MEDICATION, DRUGS, ALCOHOL – Impair response and judgment.
- ATTITUDES (Anti-authority, "Beat the Clock", Ego Trips, etc.)

Alcohol Impairs Judgment

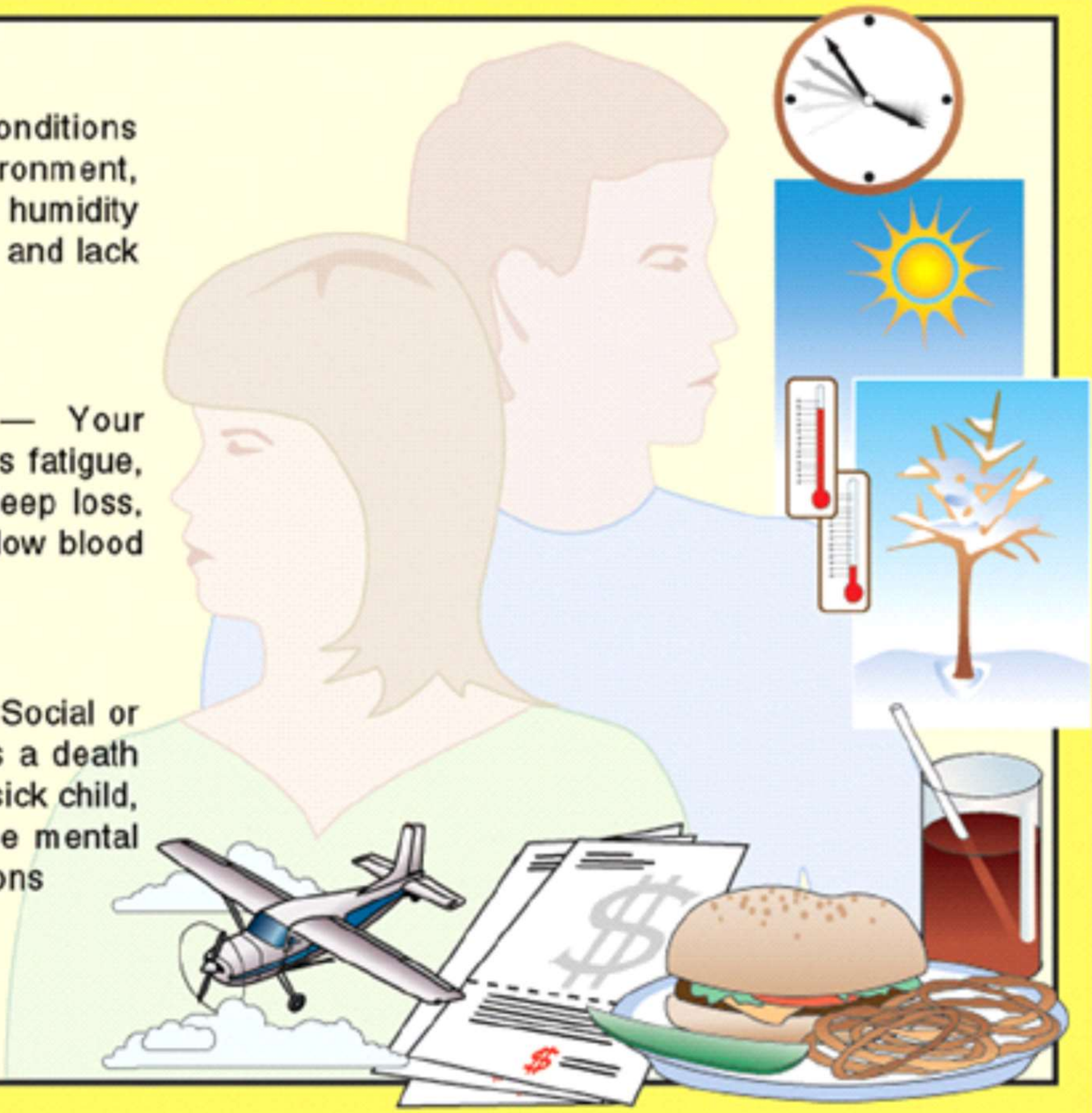
- NEVER DRINK AND FLY - P E R I O D
- FAA says 12 hours bottle to throttle and less than .04% percent blood alcohol level as PIC
- Wiser judgment says 24 hours bottle to throttle!!

Aviation Physiology – IMPAIRMENT

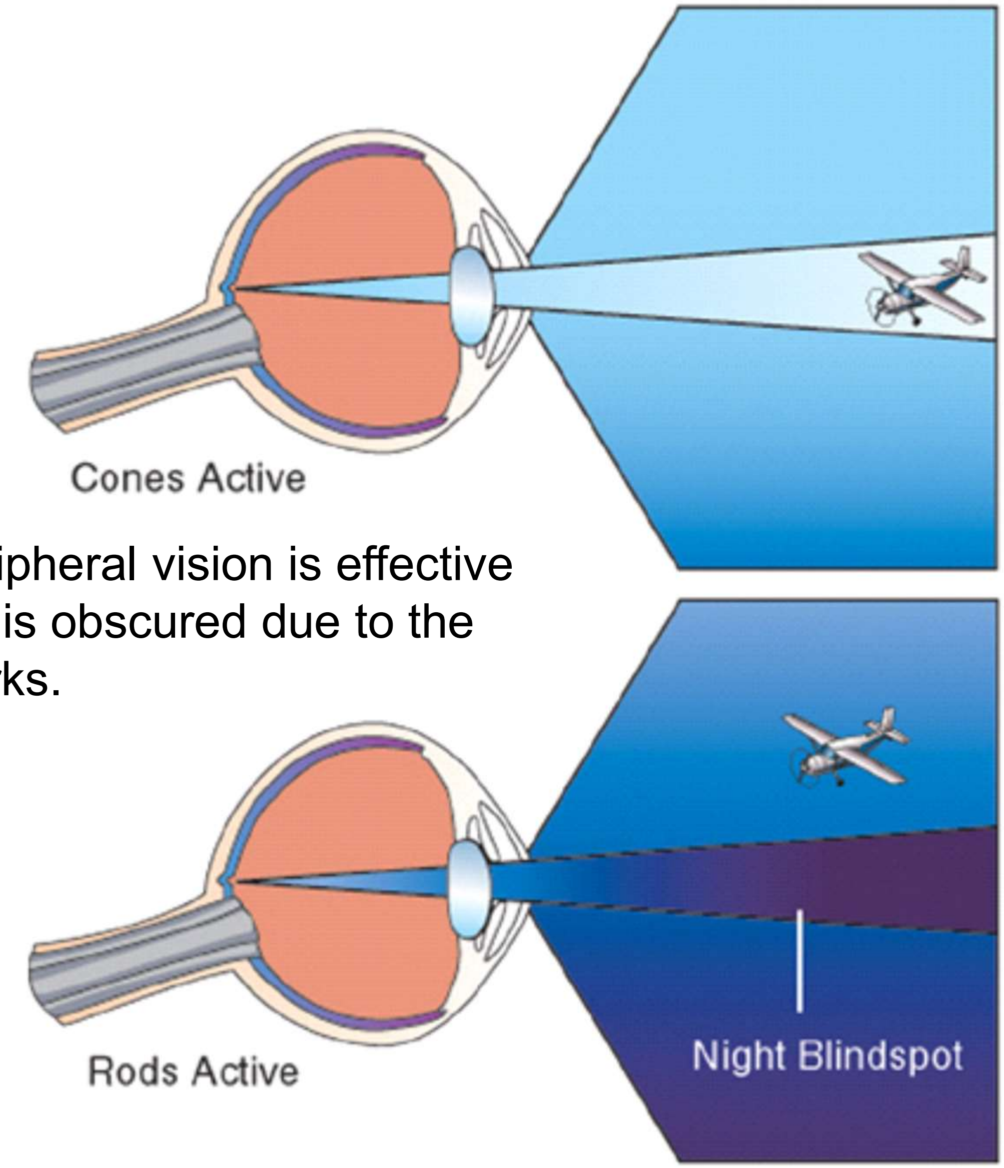
Physical Stress — Conditions associated with the environment, such as temperature and humidity extremes, noise, vibration, and lack of oxygen

Physiological Stress — Your physical condition, such as fatigue, lack of physical fitness, sleep loss, missed meals (leading to low blood sugar levels), and illness

Psychological Stress — Social or emotional factors, such as a death in the family, a divorce, a sick child, a demotion at work, or the mental workload of in-flight situations



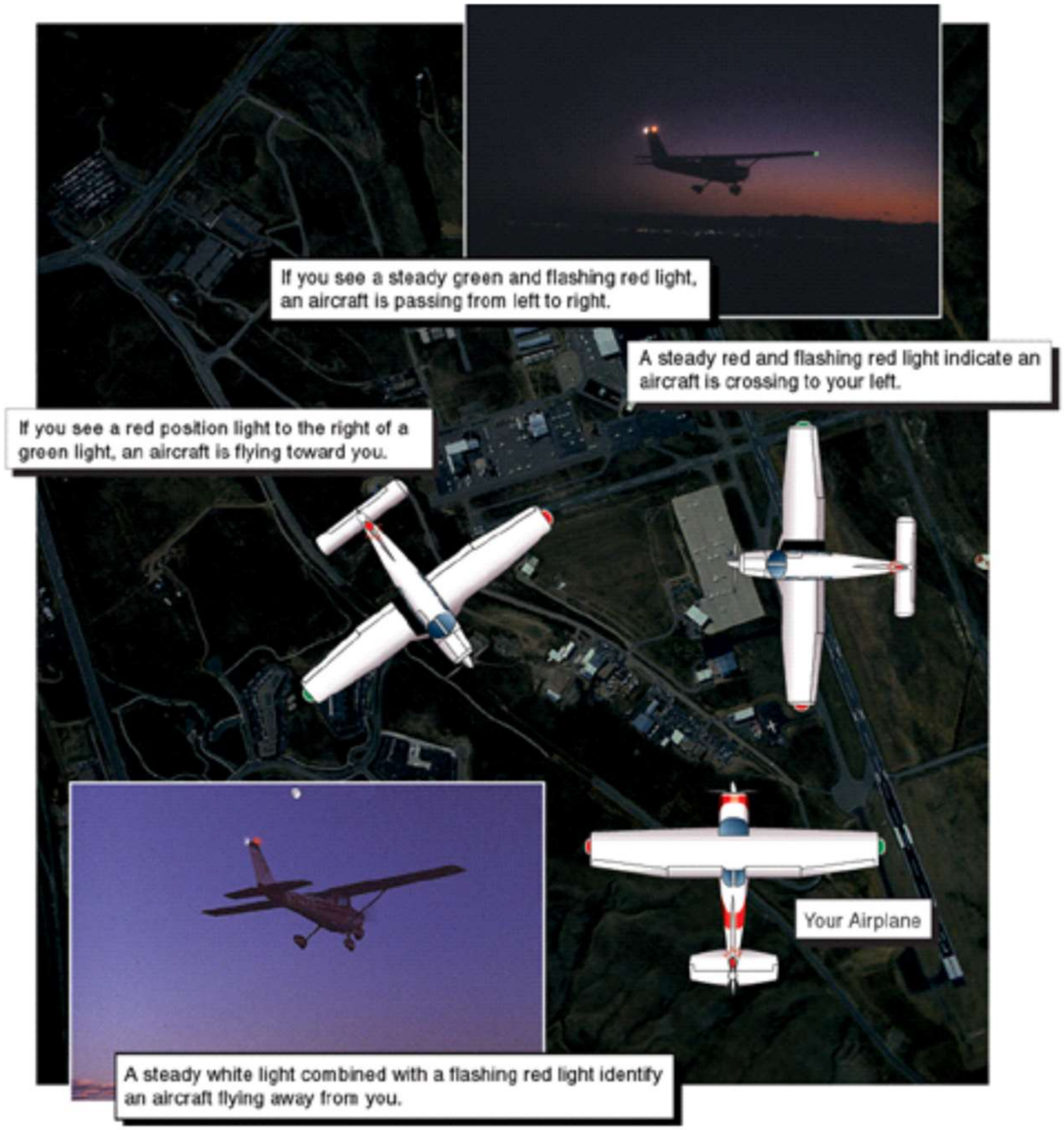
Aviation Physiology – Vision



At night, your peripheral vision is effective but central vision is obscured due to the way your eye works.

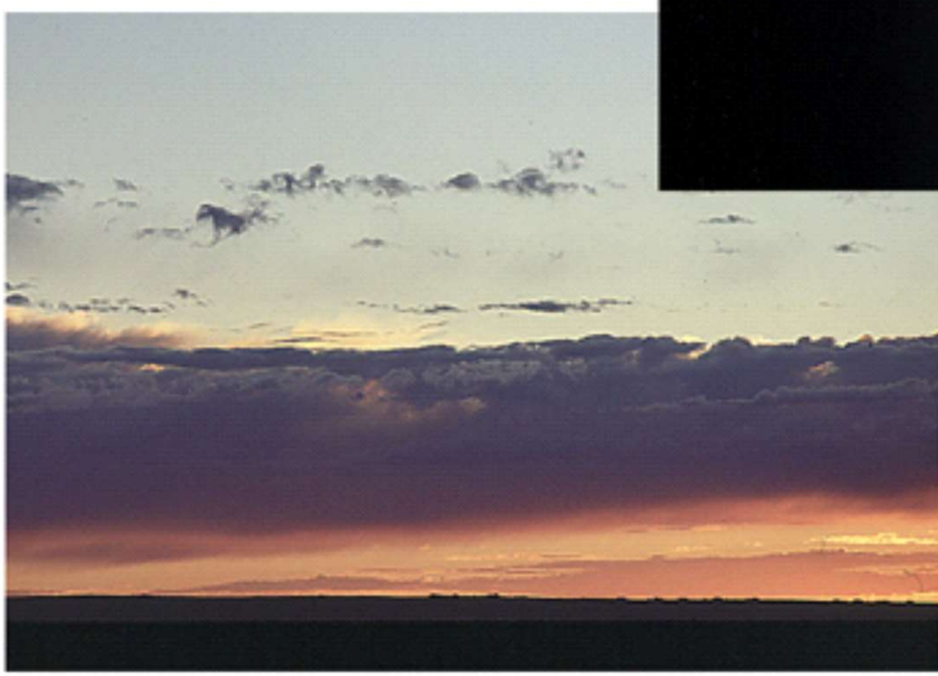
Aviation Physiology – Vision

At night you must see lighting to determine movement of other aircraft.



Aviation Physiology – Vision

<u>CAUTION</u>
Twilight can cause you
to misinterpret the horizon.
Cloud banks are sometimes
mistaken for the horizon

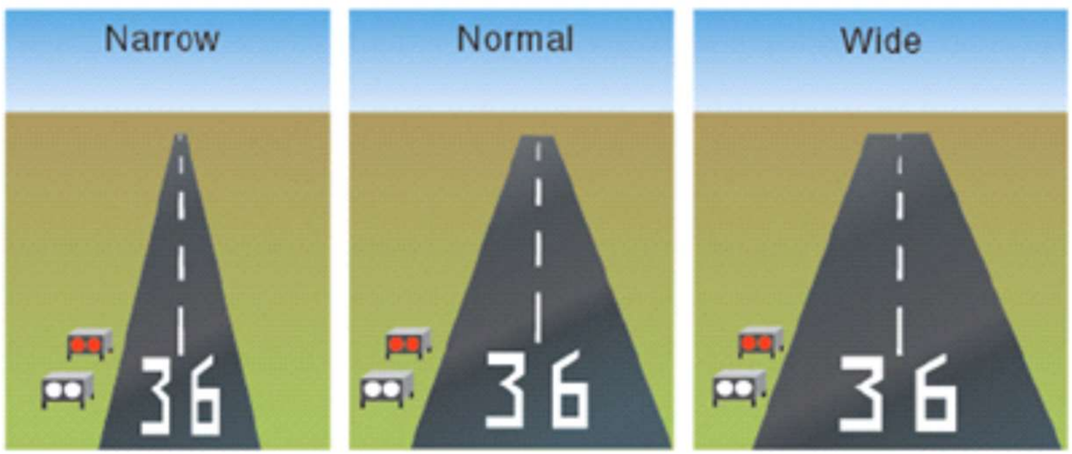


Aviation Physiology – Vision

Elements that create any type of visual obstruction, such as rain or haze, can cause you to fly a low approach.

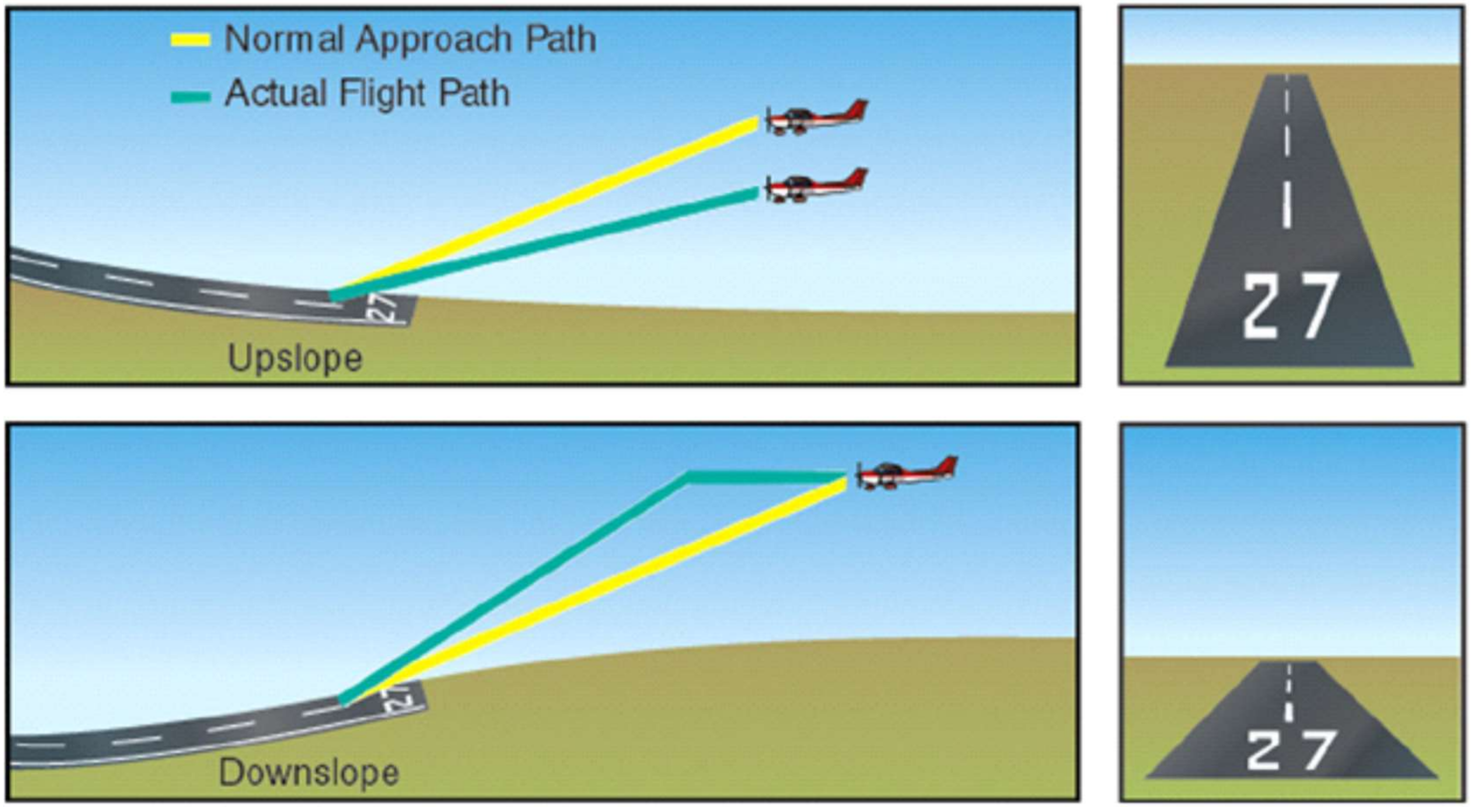
Over water, at night, or over featureless terrain, such as snow-covered ground, there is a natural tendency to fly a lower-than-normal approach.

Penetration of fog can create the illusion of pitching up which can cause you to steepen your approach.



Due to the illusion of greater height, you may fly a lower approach than normal to a narrow runway. A wide runway can have the opposite effect and produce higher-than-normal approaches.

Aviation Physiology – Vision



These runway views illustrate how normal 3° approaches might look for upslope and downslope runways.

SLOPE can cause you to misjudge your approach. CHECK the AIRPORT FACILITIES DIRECTORY to know that slope could occur BEFORE you take-off.

DO YOU SCUBA DIVE?

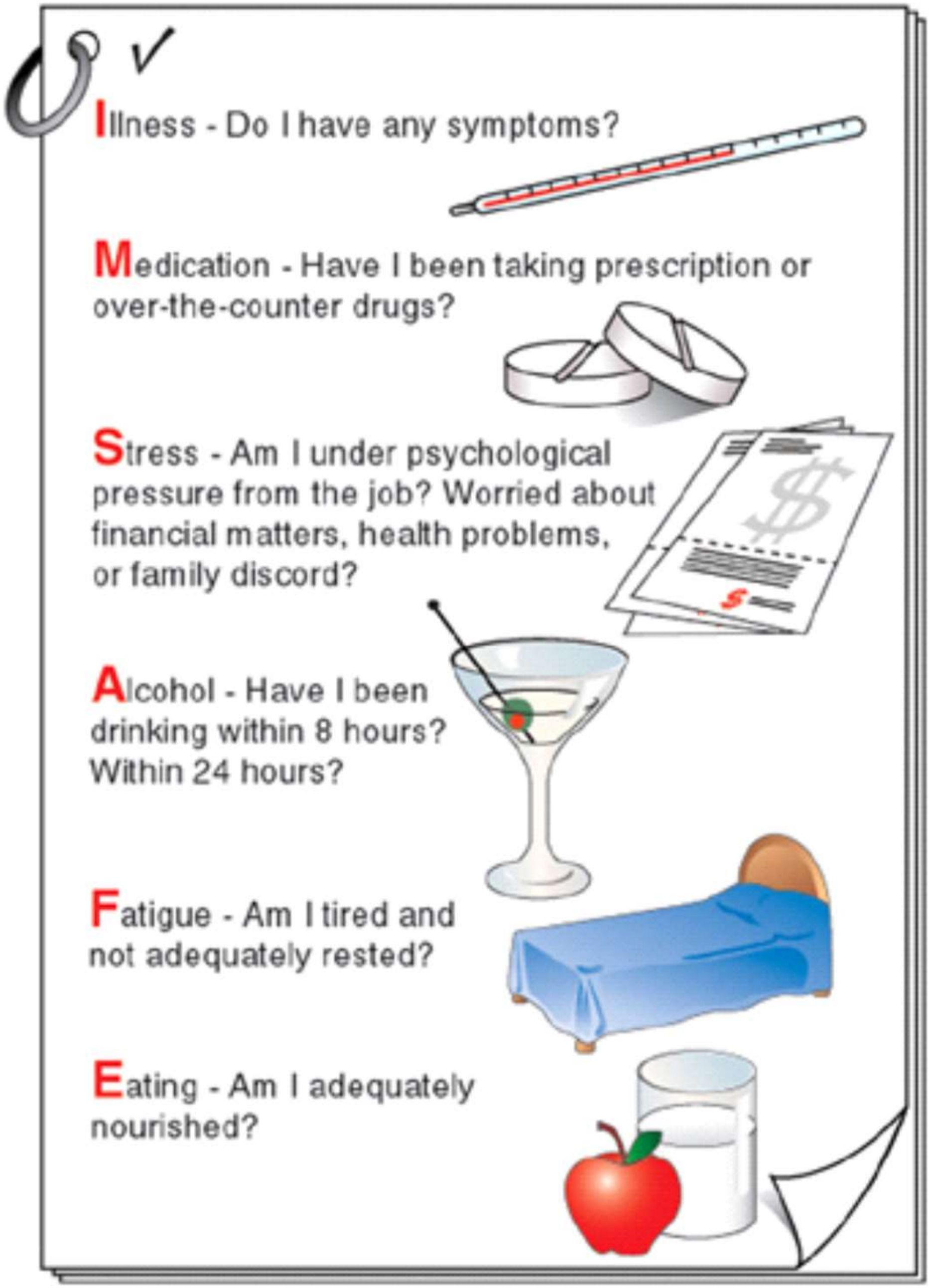
- If you or a passenger scuba dives be careful. The divers body must have sufficient time to expel and nitrogen build up from the dive before flying.

WAIT TIMES

Flight altitudes below 8,000 feet: Wait at least 12 hrs after dives not requiring controlled ascent. Wait at least 24 hrs after dives requiring controlled ascents.

Flight altitudes above 8,000 feet. Wait at least 24 hours after any scuba dive.

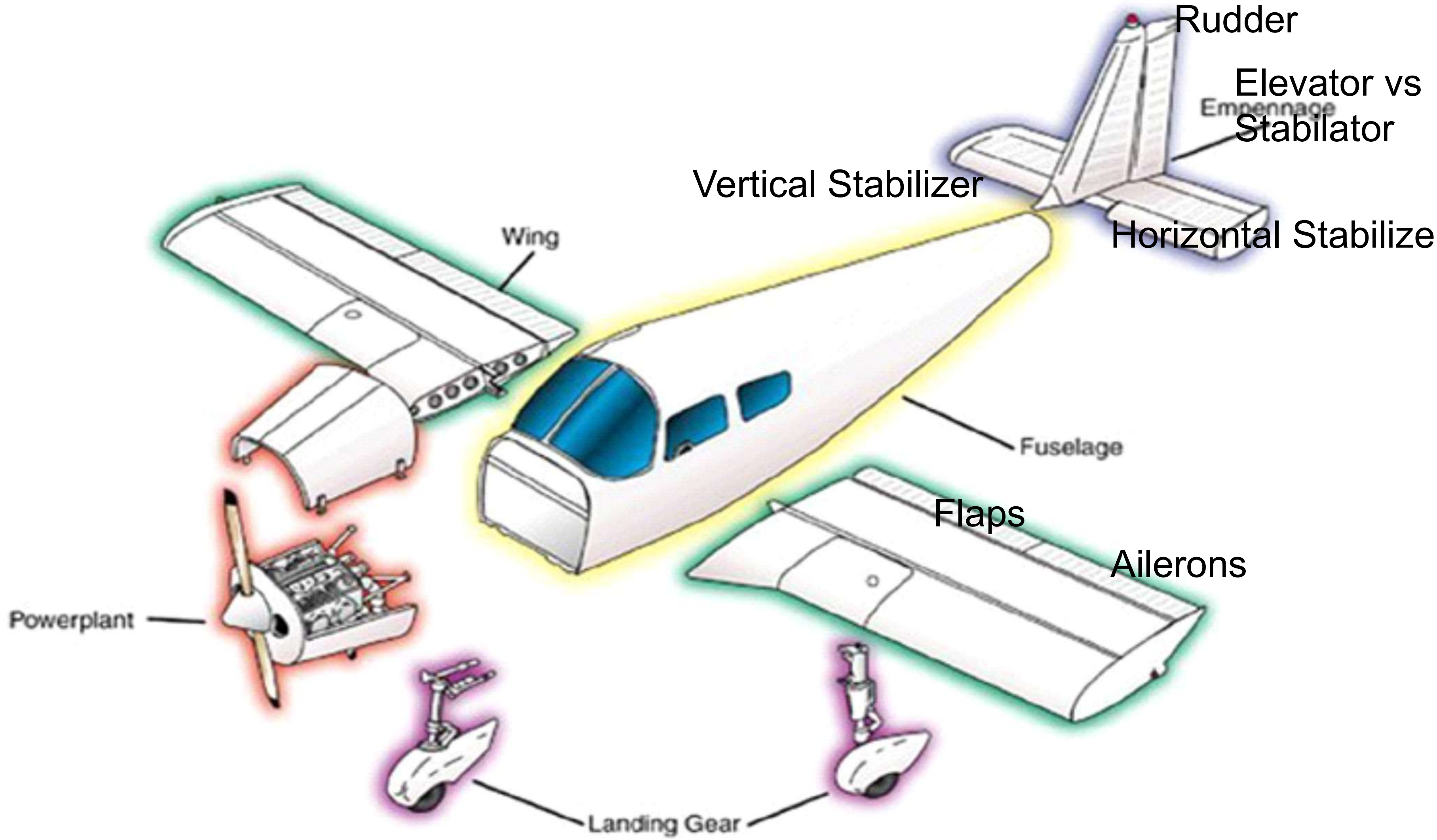
Aviation Physiology



AIRCRAFT SYSTEMS

Created by Steve Reisser

Aircraft Systems – Parts of the Airplane



What do we mean when we perform a "Preflight"?

PREFLIGHT YOURSELF AND THE AIRCRAFT

Preflight is a set of operations to insure the safety of your airplane and passengers. It MUST be done prior to each and every flight. It may seem tedious but is critical to insure everyone's safety both in the air and on the ground.

A preflight begins *BEFORE* ever getting to the airport.

• You must preflight yourself to insure that you are up to "Pilot In Command" responsibilities.

• Check if it safe to conduct your flight before going to the airport and again before completing a physical inspection of the aircraft – weather, weight and balance (W&B) calculations.

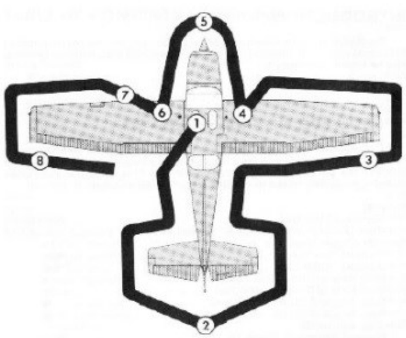
• Flight bag for flight containing logbook, current maps (sectional) and Airport, Facilities Directory (AF/D), navigation log and flight plan (if X/C), E6B, plotter, backup GPS or handheld radio, mobile device/s and water for hydration, and for night operations a flashlight (or portable headlight) and extra fuses.

PREFLIGHT AIRCRAFT INSPECTION

The manufacturer of your aircraft provides a Pilot Operating Handbook (POH) containing everything you need to know about the aircraft when it left the factory including recommended “Checklists”.   Checklists are REALLY important to insure you don’t miss any critical steps for both normal and emergency operations. Below is a sample of checklist items for an older Cessna 172.

SECTION 4
NORMAL PROCEDURES

CESSNA
MODEL 172P



NOTE

Visually check airplane for general condition during walk-around inspection. Use of the refueling steps and assist handles (if installed) will simplify access to the upper wing surfaces for visual checks and refueling operations. In cold weather, remove even small accumulations of frost, ice or snow from wing, tail and control surfaces. Also, make sure that control surfaces contain no internal accumulations of ice or debris. Prior to flight, check that pitot heater (if installed) is warm to touch within 30 seconds with battery and pitot heat switches on. If a night flight is planned, check operation of all lights, and make sure a flashlight is available.

Figure 4-1. Preflight Inspection

Original Issue

CESSNA
MODEL 172P

NORMAL PROCEDURES

CHECKLIST PROCEDURES

PREFLIGHT INSPECTION

(1) CABIN

1. Pilot's Operating Handbook -- AVAILABLE IN THE AIRPLANE.
2. Parking Brake -- SET.
3. Control Wheel Lock -- REMOVE.
4. Ignition Switch -- OFF.
5. Avionics Power Switch -- OFF.
6. Master Switch -- ON.

WARNING

When turning on the master switch, using an external power source, or pulling the propeller through by hand, treat the propeller as if the ignition switch were on. Do not stand, nor allow anyone else to stand, within the arc of the propeller, since a loose or broken wire or a component malfunction could cause the propeller to rotate.

7. Fuel Quantity Indicators -- CHECK QUANTITY.
8. Low-Vacuum Warning Light -- CHECK ON.
9. Avionics Cooling Fan -- CHECK AUDIBLY FOR OPERATION.
10. Master Switch -- OFF.
11. Static Pressure Alternate Source Valve (if installed) -- OFF.
12. Fuel Selector Valve -- BOTH.
13. Baggage Door -- CHECK, lock with key if child's seat is to be occupied.

(2) EMPENNAGE

1. Rudder Gust Lock -- REMOVE.
2. Tail Tie-Down -- DISCONNECT.
3. Control Surfaces -- CHECK freedom of movement and security.

(3) RIGHT WING Trailing Edge

1. Aileron -- CHECK freedom of movement and security.

SECTION 4
NORMAL PROCEDURES

MODEL 172P

(4) RIGHT WING

1. Wing Tie-Down -- DISCONNECT.
2. Main Wheel Tire -- CHECK for proper inflation.
3. Fuel Tank Sump Quick-Drain Valve -- DRAIN at least a cupful of fuel (using sampler cup) to check for water, sediment, and proper fuel grade before first flight of day and after each refueling. If water is observed, take further samples until clear and then gently rock wings and lower tail to the ground to move any additional contaminants to the sampling points. Take repeated samples from all fuel drain points until all contamination has been removed.
4. Fuel Selector Quick-Drain Valve (located on bottom of fuselage) -- DRAIN at least a cupful of fuel (using sampler cup) to check for water, sediment, and proper fuel grade before first flight of day and after each refueling. If water is observed, take further samples until clear and then gently rock wings and lower tail to the ground to move any additional contaminants to the sampling points. Take repeated samples from all fuel drain points until all contamination has been removed.
5. Fuel Quantity -- CHECK VISUALLY for desired level.
6. Fuel Filler Cap -- SECURE.

(5) NOSE

1. Engine Oil Dipstick/Filler Cap -- CHECK oil level, then check dipstick/filler cap SECURE. Do not operate with less than five quarts. Fill to seven quarts for extended flight.
2. Fuel Strainer Drain Knob -- PULL OUT for at least four seconds to clear strainer of possible water and sediment before first flight of day and after each refueling. Return drain knob full in and check strainer drain CLOSED. If water is observed, perform further draining at all fuel drain points until clear and then gently rock wings and lower tail to the ground to move any additional contaminants to the sampling points. Take repeated samples from all fuel drain points until all contamination has been removed.
3. Propeller and Spinner -- CHECK for nicks and security.
4. Engine Cooling Air Inlets -- CLEAR of obstructions.
5. Carburetor Air Filter -- CHECK for restrictions by dust or other foreign matter.
6. Nose Wheel Strut and Tire -- CHECK for proper inflation.
7. Nose Tie-Down -- DISCONNECT.
8. Static Source Opening (left side of fuselage) -- CHECK for stoppage.

(6) LEFT WING

1. Fuel Quantity -- CHECK VISUALLY for desired level.

CESSNA
MODEL 172P

SECTION 4
NORMAL PROCEDURES

2. Fuel Filler Cap -- SECURE.
3. Fuel Tank Sump Quick-Drain Valve -- DRAIN at least a cupful of fuel (using sampler cup) to check for water, sediment, and proper fuel grade before first flight of day and after each refueling. If water is observed, take further samples until clear and then gently rock wings and lower tail to the ground to move any additional contaminants to the sampling points. Take repeated samples from all fuel drain points until all contamination has been removed.
4. Main Wheel Tire -- CHECK for proper inflation.

(7) LEFT WING Leading Edge

1. Pitot Tube Cover -- REMOVE and check opening for stoppage.
2. Fuel Tank Vent Opening -- CHECK for stoppage.
3. Stall Warning Opening -- CHECK for stoppage. To check the system, place a clean handkerchief over the vent opening and apply suction; a sound from the warning horn will confirm system operation.
4. Wing Tie-Down -- DISCONNECT.
5. Landing Light(s) -- CHECK for condition and cleanliness of cover.

(8) LEFT WING Trailing Edge

1. Aileron -- CHECK for freedom of movement and security.

ADVANCED PREFLIGHT

MY start *is in the cockpit*

• required documents present? (AROW)
Airworthiness Certificate,
Registration,
Owners Manual (POH), and
Weight and Balance documents.

- parking brake set
- remove and control wheel lock and stow in side panel
- ignition switch OFF
- avionic switch OFF
- all fuses in proper position (not popped)
- master switch ON -Extend full flaps
- check fuel gauges
- check lights, exterior and interior if night])
- master switch OFF
- fuel selector valve – BOTH
- baggage door - Check
- remove drain sump fuel tester for fuel contamination inspection from flight bag.

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

FUEL CHECK

- Don't trust the fuel gauges, visually check by viewing mid-tank tabs, or if possible, measure exact quantity using a fuel dip tube (specific to each type aircraft) in each tank. If necessary, have ground crew refuel to desired quantity BUT verify. Don't presume the refueling truck is contaminant free. SUMP check after refueling! It is important to weight and balance, duration of flight, and overall safety that you verify the quantify and quality of fuel.

- You may have anywhere from 3 to 12 drains to check. SUMPS under the wing and on the bottom of the fuselage are drained before each flight. Drain the fuel sumps to insure no water has condense or other contaminants that may have settled in the bottom of the tanks. Contaminants can damage or cause engine failure.

- NEVER THROW DRAINED FUEL ON THE GROUND. Most pilots put drained GOOD fuel back in the tank. Make sure that the fuel is 100LL not Jet-A (kerosene, white, distinctive smell). Your 100LL is very, very pale blue and smells like gas.

- Make sure fuel caps are *tight* and in the <u>*correct orientation*</u>.

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

Cowling and Oil

- Open the cowling on the engine. Remove the oil cap (use a cloth if the engine is hot). Make sure you have sufficient oil for the flight. DIFFERENT procedure for Rotex engines (belching the engine is required). Never depart without the oil level above the minimum mark on the oil stick! (Check POH).

- Visually check the interior of the engine compartment for things like small animals, loose connections, leaking oil, etc). Fasten the cowl cover after checking the interior.

- Preflight inspection inside the engine compartment. Especially *if maintenance has been performed* on the engine or components, you must check that nothing was inadvertently been done incomplete, (i.e. loose cables). If you rent and maintenance logs are not in the airplane, ask if and what type of maintenance was recently performed on the airplane so you can visually inspect for problems.

- Check underneath the cowling for any signs of leaking oil. Note, overfilling oil will cause oil to be blown off and smoke appearing as though your aircraft engine is leaking oil. Don't overfill.)

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

Propeller and cowl opening.

- See that the front cowl opening is free of contaminants for proper engine cooling. Pilots sometimes find bird nests cats, rodents, wasp nests, etc. It happens especially if tied down on the flight line and not hangered.

- Look carefully and feel the leading edge go the propeller. You are looking for fractures or deep nicks cause by rocks or gravel. If it's deep, it must be fixed or the blade can separate in flight.

Front wheel strut and tire for tricycle gear configurations.

- Check proper tire inflation, check for excessive ware or worn or flat spots. Gives better, safer landings and prevents damage to firewall.

- If shock absorber is used, make sure it is not deflated

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

Left Wing

Under left wing are some important structures

- Pitot tube (critical to static flight instruments) – clear of contaminants (bugs), ice, or dirt.
- Fuel Tank Sump Drain which you used earlier.
- Fuel tank vent – make sure it is open – no contaminants

Leading Edge (front part of wing)

- Stall warning opening (suction type) clear, or tab (electric switch) moves up and down freely
- remove contaminants along leading edge to insure smooth airflow.
- observe the top and bottom of the wing for any rivets that might be working loose.
- if landing and or taxi light are present, check for damage. If you are preparing for night operations, test that all lights are operational on your preflight check.

Wing Tip

- Check that navigation and strobe lights (if present) are undamaged. Verify operations for night flight.

Trailing Left Wing

- Verify free operation of aileron. Visually check cotter pins in place on hinges of aileron. View that upward and downward movement of aileron correspond to proper position of the yoke in the cockpit (up-yoke turns to left, down-to right)
- Visually inspect Flaps. Jiggle and make sure they are solid with fixed.

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

<u>Main Landing Gear</u>
As with the Nose Gear, you want check for proper inflation and excessive ware.

<u>Cargo Door</u>
Make sure cargo door is securely closed and locked.

<u>Empennage</u> (horizontal and vertical stabilizer)… a.k.a. The Tail
• As you move back from the wing towards the tail, look for the “static port”. A small circular object which is flush on the fuselage with a small hole at its center can be found along the fuselage. This is critical to correct flight displays. Make sure the hole in the center is free of dirt or wax that could obstruct airflow.
• Also check that all antennas and antenna cables appear secure as you work your way back to the tail.

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

Empennage (horizontal and vertical stabilizer)… a.k.a. The Tail

Horizontal Stabilizer and Elevator

The fixed (non-movable portion) is referred to as the horizontal stabilizer. Attached to the rear of that structure is a movable surface called an Elevator because it is critical to pitch (nose up and now) that like an elevator helps you orient the attitude of the aircraft either up or down. It is controlled by pushing forward or pulling back on the control yoke, full stick, or joystick.

The cables that control the elevator movement are in the tail and visible as you manually move the elevator up and down. Check that the pins and cables are affixed, and view forward to make sure that the yoke moves in the correct corresponding manner.

Piper aircraft use a Stabilator. They do not have elevators separate from horizontal stabilizers. The entire horizontal stabilizer moves without elevators.

Vertical Stabilizer and Rudder

- The fixed non-movable portion is referred to as the vertical stabilizer. Attached at the rear of that structure is the Rudder which is critical in both flight and ground operations. This is controlled by the rudder pedals in the cockpit and must be verified for correct movement from within the cockpit. You may be able to view the cabling in some aircraft.
- Atop the vertical stabilizer is a “rotating beacon” - not many rotate, just blink red
- On the very top rear of the horizontal stabilizer is a white position light.

TRIM TABS: Trim tabs are small devices that help the aerodynamic pressures in controlling the aircraft. They may located on the rudder and ailerons, but ALWAYS present on the elevator. Do not manipulate these small structures.

INSURE ALL LIGHTS, INTERIOR AND EXTERIOR FUNCTION PROPERLY FOR NIGHT OPERATIONS!

ADVANCED PREFLIGHT

Generic Single Engine, Land, Cessna

Basically do the reverse along the right side doing similar checks of the right wing (one one static port, stall warning, pitot tube which you may have found on the left side)

<u>Trailing Right Wing</u>
check Flaps, and Ailerons

<u>Right Wing Tip</u>
Check for damage of navigation light and strobe

<u>Leading Edge Right Wing</u>
Check for contaminants or damage.

<u>Secure equipment</u> in the cockpit and cargo area

<u>*Load Passenger and BRIEF*</u>: What is a briefing?
Operation of seat belts and “sterile cockpit” procedures. YOU verify seatbelts are fastened, and if shelterbelt is present, it must be fastened.

REMEMBER: POH IS PRIMARY FOR PERFORMING AIRCRAFT PREFLIGHT

PASSENGER BRIEFING

Safety Belts
- How to fasten and unfasten the safety belts and shoulder harnesses.
- When safety belts must be fastened—prior to movement on the surface, takeoff, and landing

Air Vents
- Location and operation
- Operation of heating or air conditioning controls

Fire Extinguisher
Location and operation

Egress and Emergency
- Operation of doors and windows
- Location of the survival kit
- Use of onboard emergency equipment

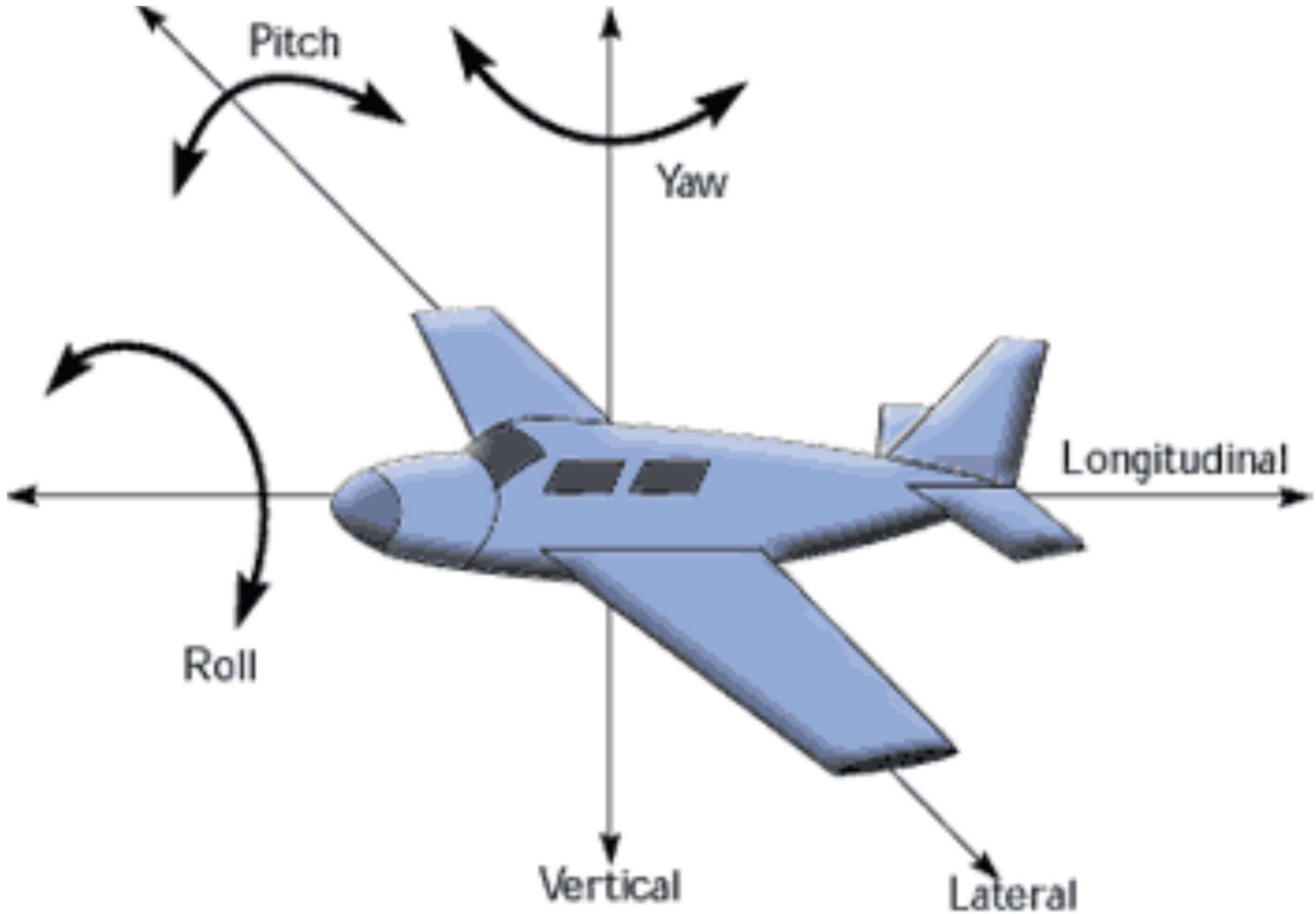
Traffic and Talking
- Pointing out traffic
- Use of headsets
- Avoiding unnecessary conversation during critical phases of flight

Your Questions
Solicit questions from your passengers.

THE 4 CONTROL SURFACES OF AN FIXED WING AIRCRAFT

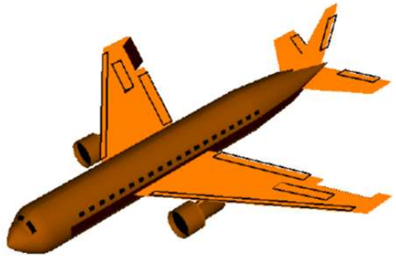
- Elevator: Control the movement about the lateral axis called pitch.
- Ailerons: Control the airplanes movement about it's longitudinal axis called roll.
- Rudder: Controls movement about the vertical axis called yaw.
- TRIM TABS: Small, adjustable hinged-surfaces on ailerons, rudder, or elevator control surfaces easing manual pressure by pilot to control other surfaces.

Aircraft Systems – 3 Axes of Flight



Aircraft Systems – 3 Axes of Flight

ROLL - AILERONS →



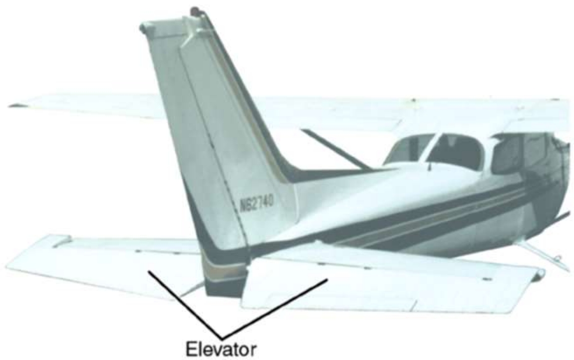


FIG 02-08

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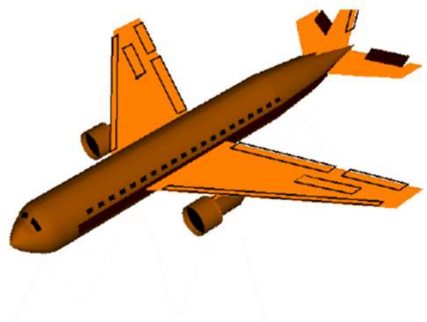
← ELEVATORS - PITCH



YAW – RUDDER →

FIG 02-07

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Aircraft Systems – Landing Gear

- Tricycle vs. Conventional
- Retractable vs. Fixed Gear
- Others
  - Skids
  - Floats

FIG 02-11/12

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FIG 02-13

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Aircraft Systems – Powerplants

FIG 02-20

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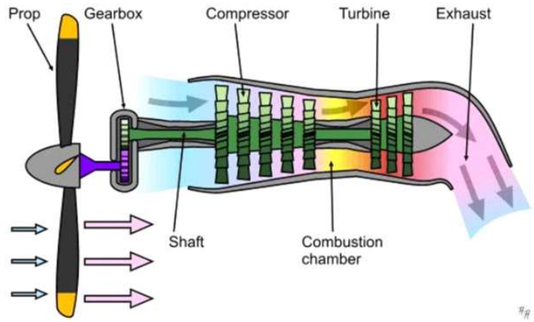
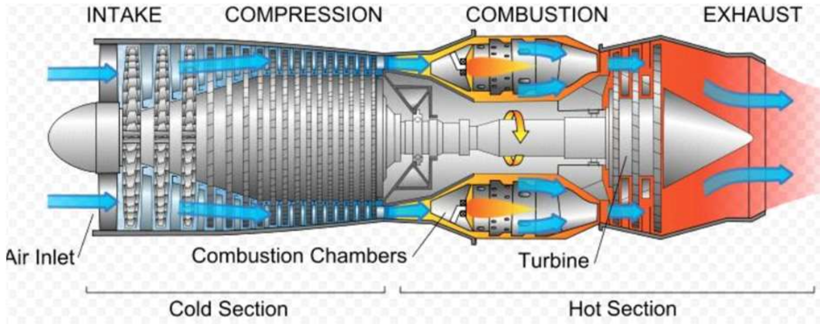
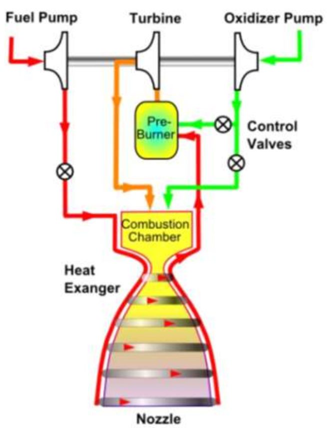
Aircraft Systems – High Performance Powerplants



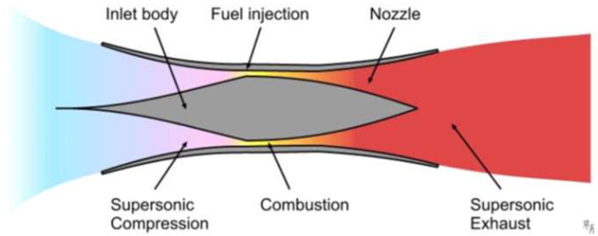
Turboprop- 350 Kts



Turbojet- 550 Kts



Rocket- 2600 Kts (above X-15)



Scramjet-13,000 Kts (15,000 mph): X43A (10,000+ Hypersonic)
X43D coast to coast US in 12 minutes.
2023: S- & H-MAGJETS ARE COMING

First “Green” Commercially Available Electric Airplane

Yuneec has test flown an electric airplane, which they expect to bring to market for the price of an (expensive) car. The airplane, dubbed the E430, seats two and is made with lightweight composites. The 230-volt powerplant charges in three hours, and can fly for about 2.5 hours on a single charge. Yuneec says it'll cost just $89,000. That's fairly cheap for an aircraft of this sort--for example, the much ballyhooed Icon A5 begins at $139,000, and over 400 have already been pre-ordered.

Aircraft Systems – Reciprocating Engine

- 4-Cycles of the reciprocating engine

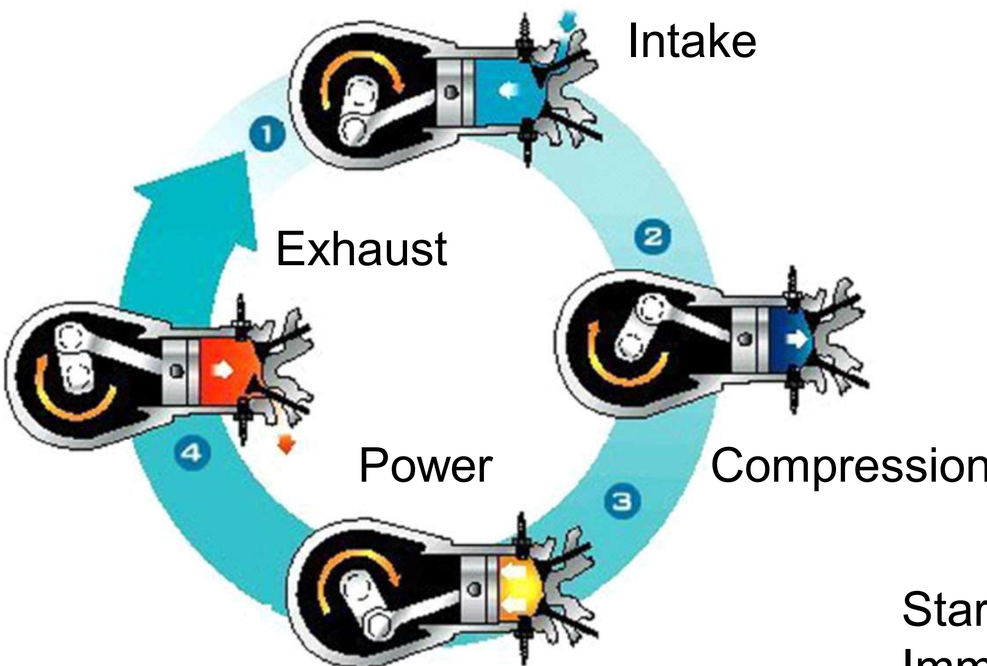


FIG 02-22

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FIG 02-17

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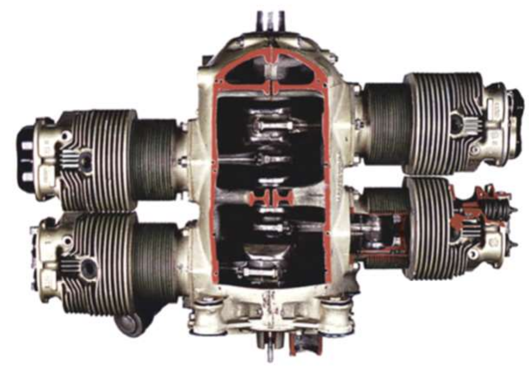

FIG 02-21

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Starting – tendency to over-rev,
Immediately adjust to proper RPM,
And insure oil pressure/temp OK

THE IGNITION SYSTEM

- In a spark ignition engine the ignition system provides a spark that ignites the fuel/air mixture in the cylinders and is made up of **magnetos, spark plugs, high-tension leads, and the ignition switch**.

- A magneto uses a permanent magnet to generate an electrical current completely independent of the aircraft's electrical system. The magneto generates sufficiently high voltage to jump a spark across the spark plug gap in each cylinder. The system begins to fire when the starter is engaged and the crankshaft begins to turn. It continues to operate whenever the crankshaft is rotating.
- All standard certificated aircraft incorporate a dual ignition system with two individual magnetos, separate sets of wires, and spark plugs to increase reliability of the ignition system. Each magneto operates independently to fire one of the two spark plugs in each cylinder. The firing of two spark plugs improves combustion of the fuel/air mixture and results in a slightly higher power output. If one of the magnetos fails, the other is unaffected.

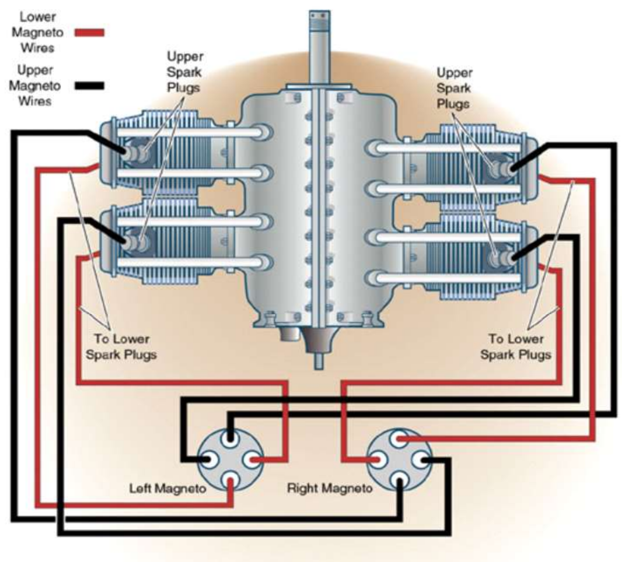

FIG 02-31

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Aircraft Systems – Induction System

The induction system brings in air from the outside, mixes it with fuel, and delivers the fuel/air mixture to the cylinder where combustion occurs.

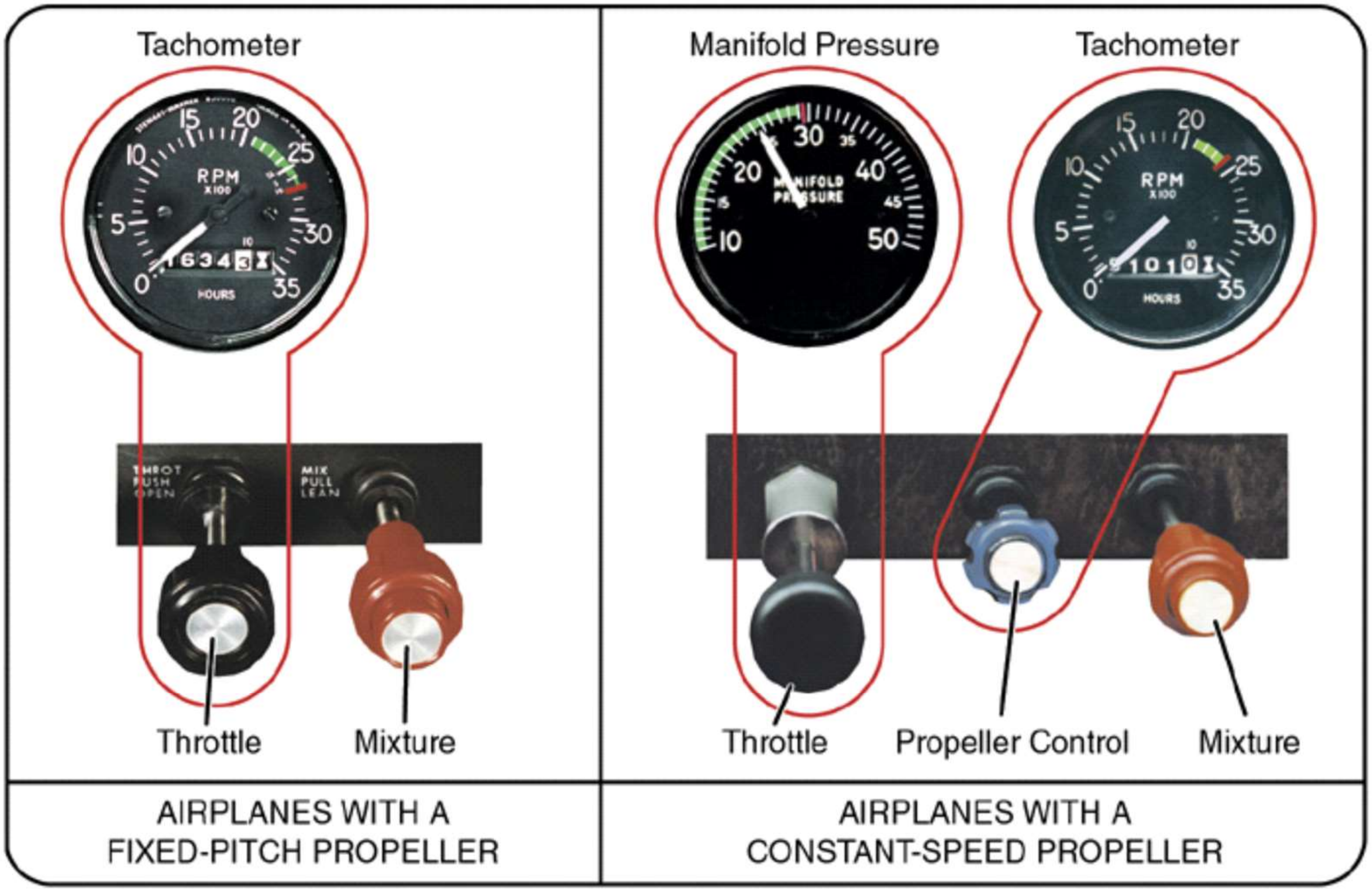

FIG 02-23

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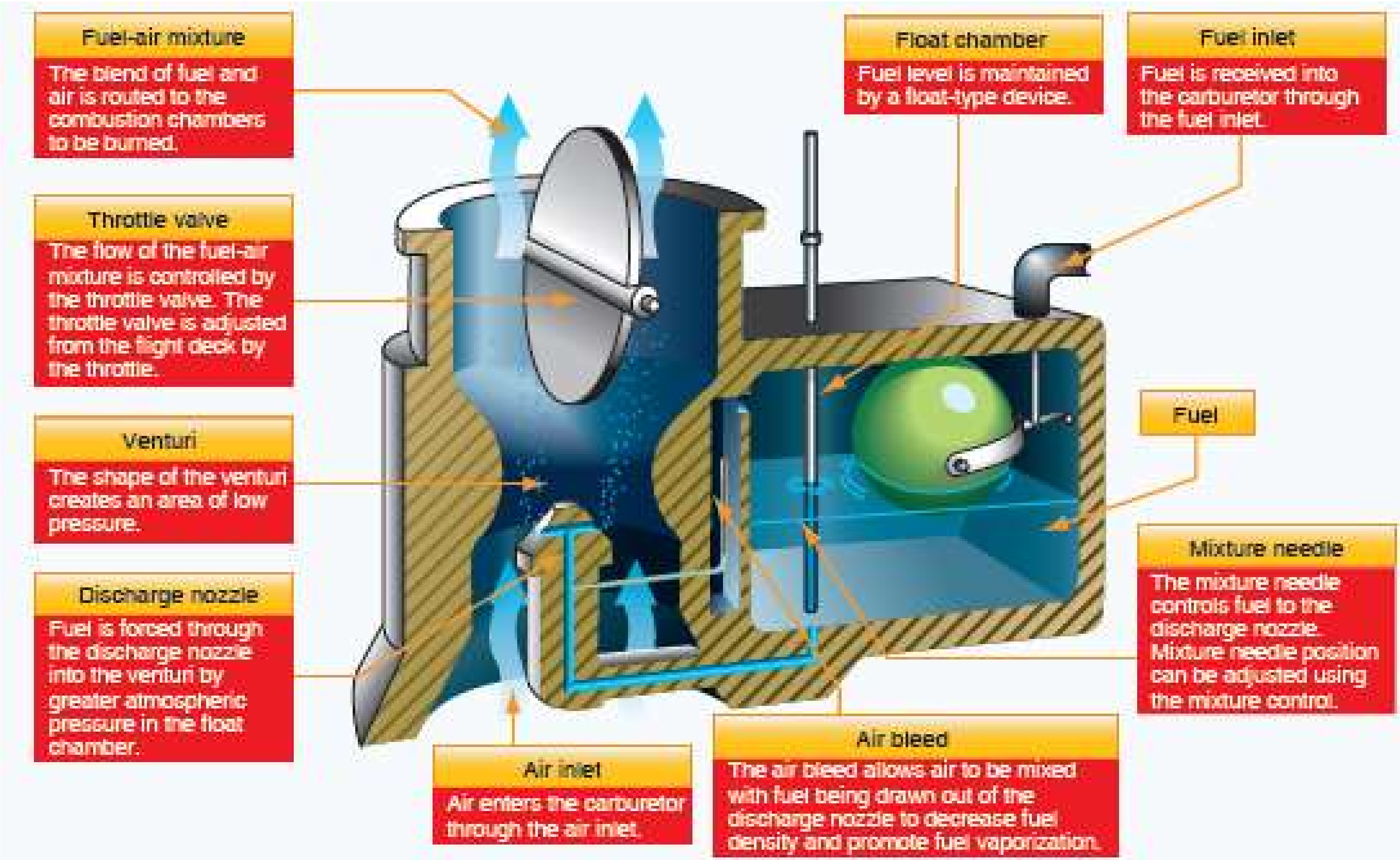
Types of Induction Systems

- The *carburetor system*, which mixes the fuel and air in the carburetor before this mixture enters the intake manifold

- The *fuel injection system*, which mixes the fuel and air immediately before entry into each cylinder or injects fuel directly into each cylinder



Disadvantages: First, the effect of abrupt maneuvers have on the float action. Second, the fact that its fuel must be discharged at low pressure leads to incomplete vaporization and difficulty in discharging fuel into some types of supercharged systems. The chief disadvantage of the float carburetor, however, is its <u>icing tendency</u>.

Aircraft Systems – Carburetor Heat

CARBURETOR ICING

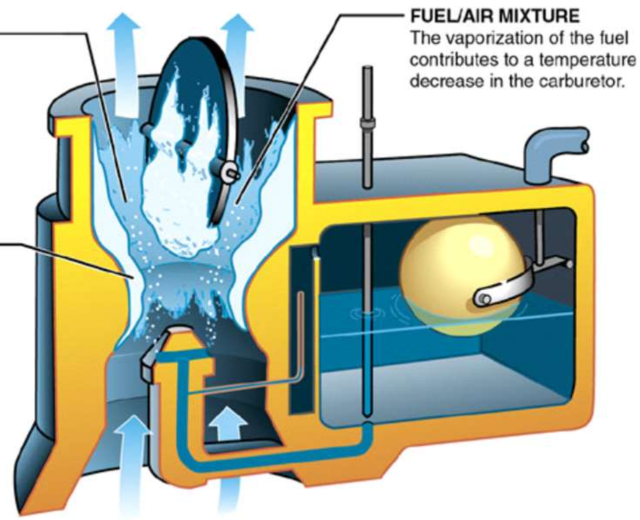
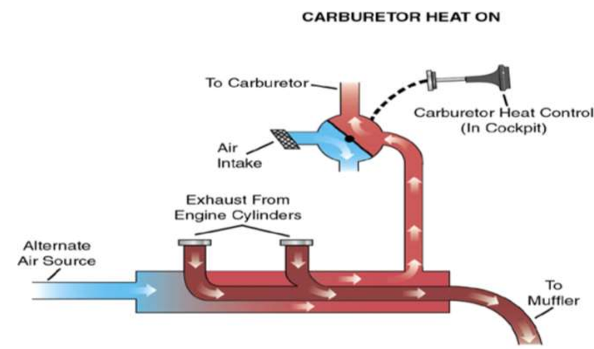


FIG 02-26

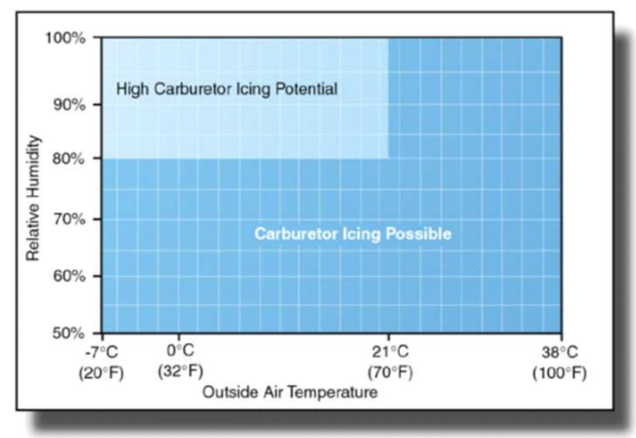
DROP IN RPM

ROUGHNESS

FAILURE



Application of Carb Heat > decrease in RPM followed by increase to normal.



Highest icing risk 20-70F and high humidity, but is still possible to 100F

Carburetor Heat is an anti-icing system that preheats the air before it reaches the carburetor, and is intended to keep the fuel/air mixture above the freezing temperature to prevent the formation of carburetor ice. It can be used to melt ice that has already formed in the carburetor if the accumulation is not too great, but using carburetor heat as a preventative measure is the better options.

Mixture Control

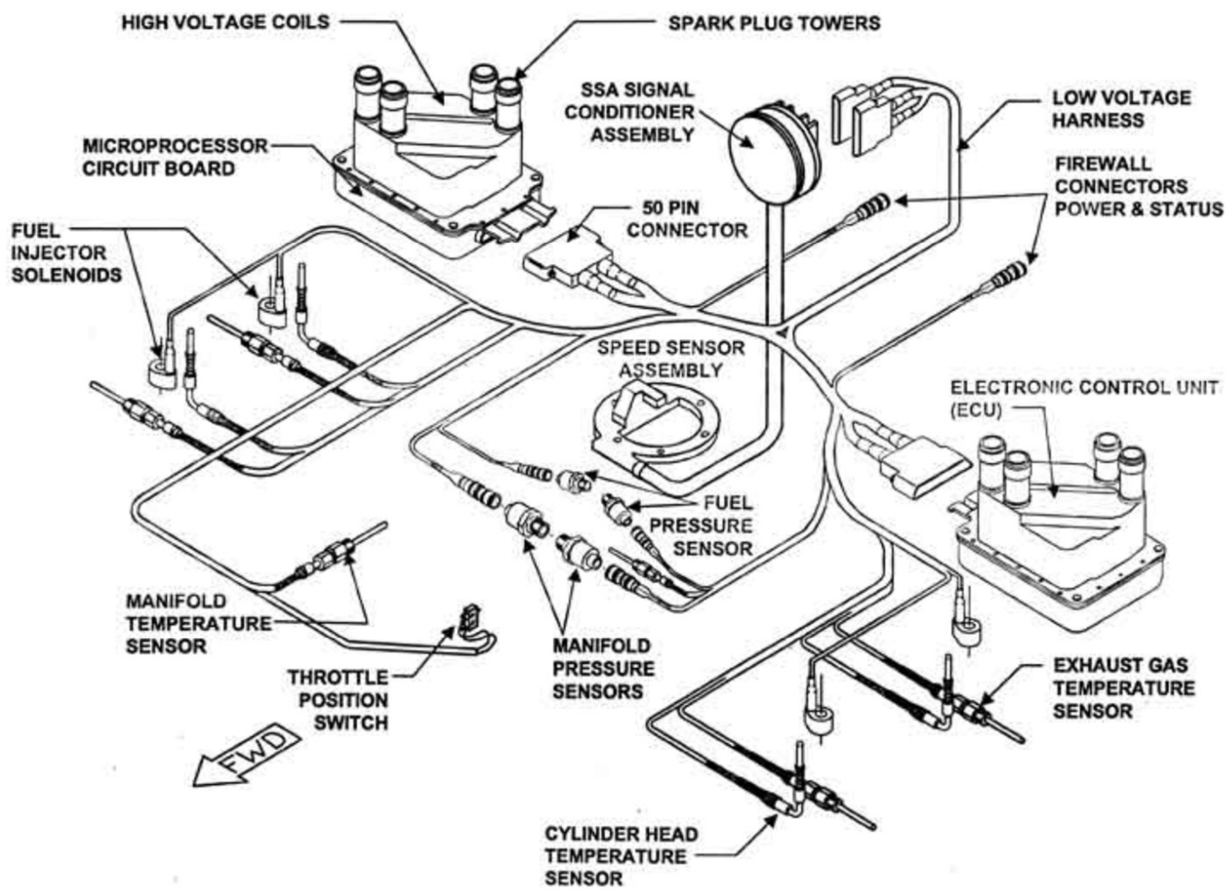
Carburetors are normally calibrated at sea-level pressure, where the correct fuel-to-air mixture ratio is established with the mixture control set in the FULL RICH position. However, as altitude increases, the density of air entering the carburetor decreases, while the density of the fuel remains the same. This creates a progressively richer mixture, which can result in engine roughness and an appreciable loss of power. The roughness normally is due to spark plug fouling from excessive carbon buildup on the plugs. Carbon buildup occurs because the rich mixture lowers the temperature inside the cylinder, inhibiting complete combustion of the fuel. This condition may occur during takeoff run-up at high-elevation airports and during climbs or cruise flight at high altitudes. <u>To maintain the correct fuel/air mixture, the mixture must be leaned using the mixture control. Leaning the mixture decreases fuel flow, which compensates for the decreased air density at high altitude.</u>

During a descent from high altitude, the mixture <u>must be enriched</u>, or it may become too lean. An overly lean mixture causes detonation, which may result in rough engine operation, overheating, and a loss of power. The best way to maintain the proper mixture is to monitor the engine temperature and enrich the mixture as needed. Proper mixture control and better fuel economy for fuel-injected engines can be achieved by use of an exhaust gas temperature (EGT) gauge. Since the process of adjusting the mixture can vary from one aircraft to another, it is important to refer to the airplane flight manual (AFM) or the pilot's operating handbook (POH) to determine the specific procedures for a given aircraft.

Aircraft Systems – Induction

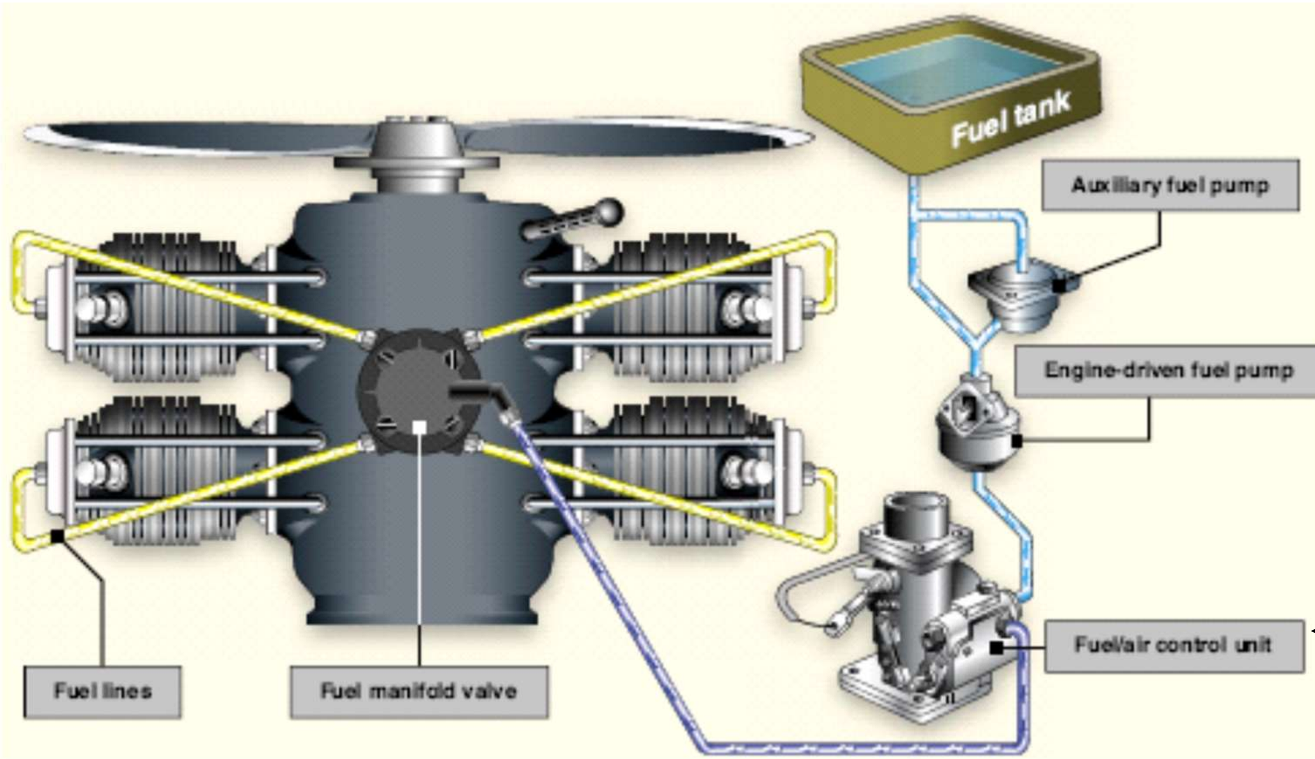
FADEC

FADEC is the acronym for Full Authority Digital Engine Control is a system consisting of a digital computer (called EEC /Electronic Engine Control/ or ECU /Electronic Control Unit/) and its related accessories which control all aspects of aircraft engine performance.



NO MIXTURE REQUIRED – SAMPLES EACH CYLINDER & ADJUSTED FUEL-AIR RATION ON EACH FIRING !!!

Fuel Injection Systems



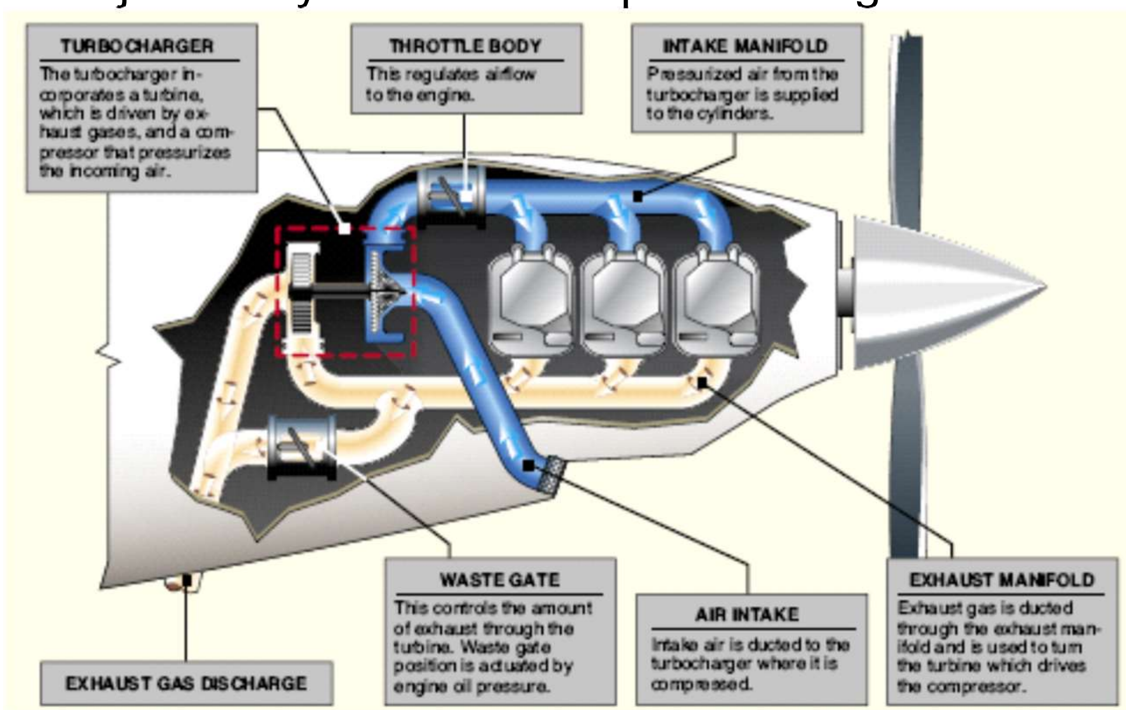
← Replaces Carburetor

In a fuel injection system, the fuel is injected directly into the cylinders, or just ahead of the intake valve. Six basic components: an engine-driven fuel pump, a fuel/air control unit, fuel manifold (fuel distributor), discharge nozzles, an auxiliary fuel pump, and fuel pressure/flow indicators. It is less susceptible to icing than the carburetor system, but impact icing on the air intake is a possibility in either system. Impact icing occurs when ice forms on the exterior of the aircraft, and blocks openings such as the air intake for the injection system.

Supercharged Engines

A supercharger is an engine-driven air pump or compressor that provides compressed air to the engine to provide additional pressure to the induction air so the engine can produce additional power. It increases manifold pressure and forces the fuel/air mixture into the cylinders. The higher the manifold pressure, the more dense the fuel/air mixture. Superchargers are especially valuable at high altitudes (such as 18,000 feet) where the air density is 50 percent that of sea level.

Turbosupercharged Engines: booster uses the engine's exhaust gases to drive an air compressor to increase the pressure of the air going into the engine through the carburetor or fuel injection system to boost power at higher altitude.



Aircraft Systems – Fuel System

Detonation : “Uncontrolled, explosive ignition of the fuel/air mixture within the cylinder’s combustion chamber causing excessive heat and pressure. Characterized by high cylinder head temperature at higher RPMs.
** What to do? Reduce power, reduce rate of climb, enrich mixture, open cowl.

Pre-ignition: Explosion of fuel prior to normal ignition (premature explosion) and can be accompanied by Detonation. Overheated exhaust valves, carbon, cracked spark insulators-plugs/electrodes heated to incandescent state cause premature firing.
** What to do? Same as above. If you are on the ground, shut down and fix problem!!! ESPECIALLY IF FUEL RELATED.

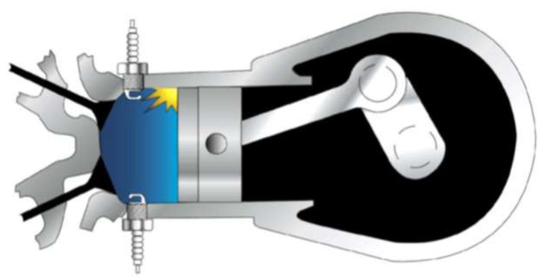


FIG 02-33

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Aircraft Systems – Fuel System

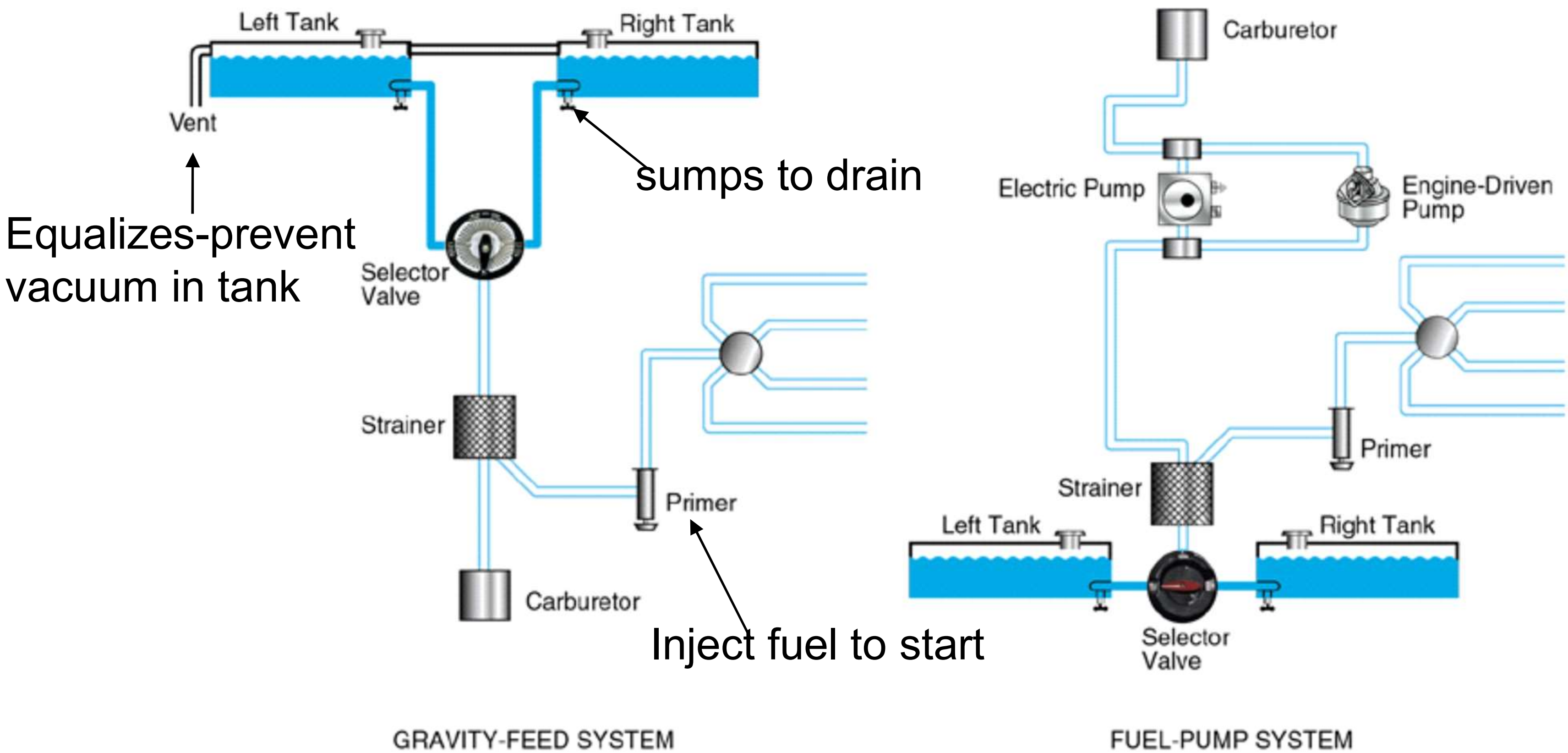

FIG 02-34

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Aircraft Systems – Fuel System

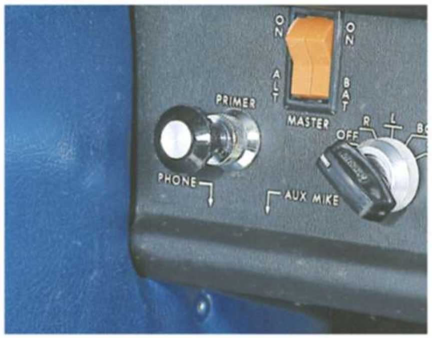

FIG 02-35

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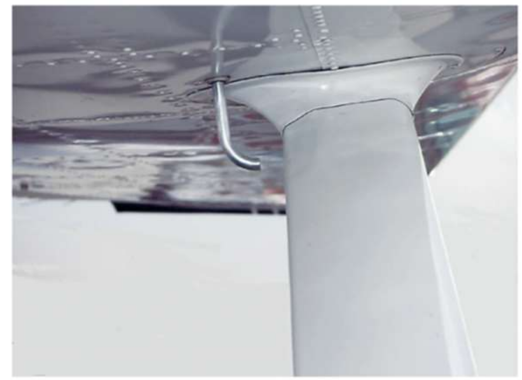

FIG 02-36

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FIG 02-38/39

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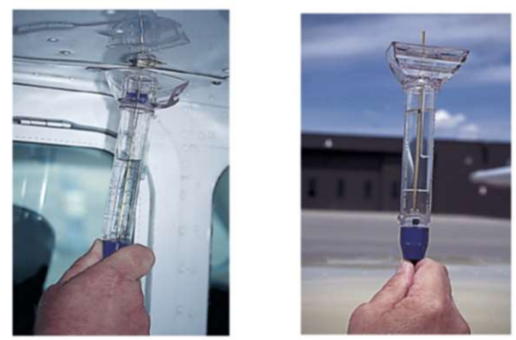

FIG 02-40

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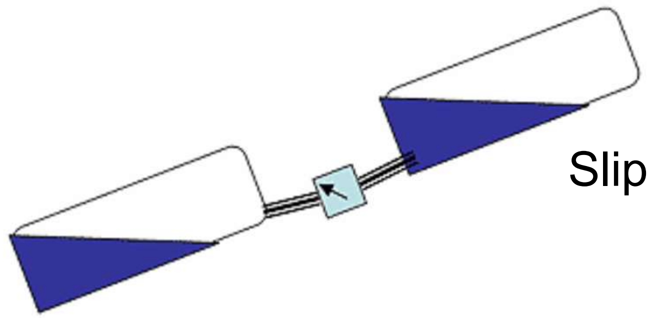
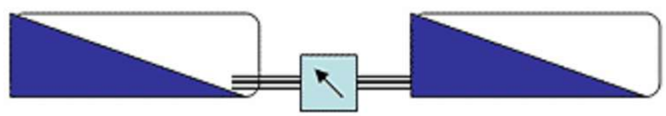
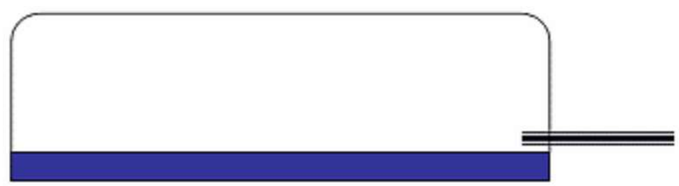
__Uncoordinated turns on landings and takeoffs without full fuel can cause engine failures.__



Slipping on the downhill tank



"Turning-type" takeoff;



Unusable fuel.

VAPOR LOCK – If air allowed to get into fuel line – fuel cannot flow.
Should the fuel VENT get block (bug) a vacuum is created and fuel cannot flow.
Should you not tighten the fuel CAP, the lift of the wing can suck the tank dry!

Aircraft Systems – REFUELING

CAUTION: STATIC

When self-fueling (about $1 cheaper) make sure that you attach a static line to the aircraft before attempting to refuel.

FUEL GRADES (100LL)

Grade 80=light pink, 100LL=light blue
Turbines=colorless (kerosene)
(80 & 100/130 no longer available in the USA.]

NEVER use grade LESS than recommended -=> Detonation. If your grade not available use a HIGHER grade of fuel. **NEVER allow ETHANOL into your fuel systems** !!!
Check Fuel strainer for water contamination, top of tanks at end to prevent condensation

Aircraft Systems – Oil System

Insufficient oil pressure or sudden drop spells TROUBLE

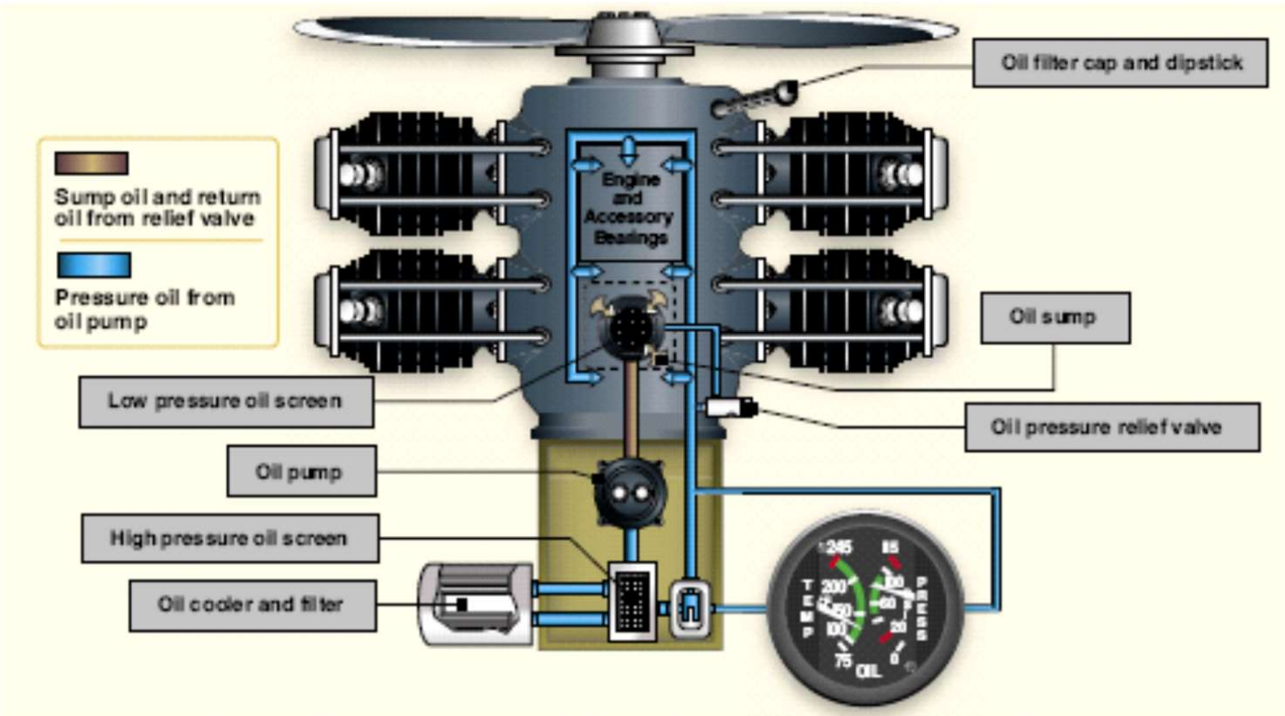


FIG 02-45

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Excessive Temperature
damages engine

FIG 02-46

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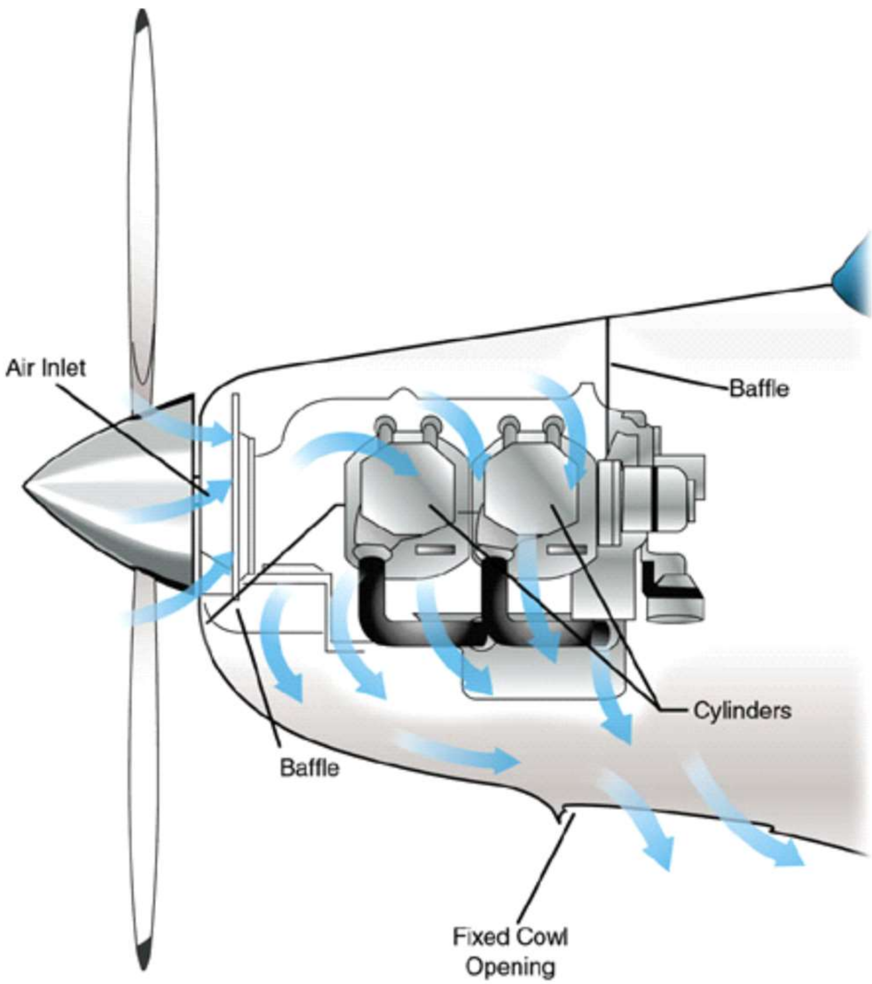
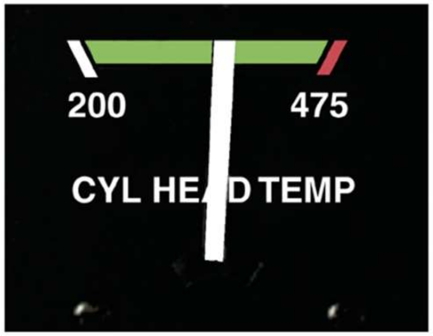
Oil/Engine temperature causes include operating with too much power, climbing too steeply in hot weather, using fuel at lower-than normal octane, too lean mixture (descending or set incorrectly, and/or low oil levels.

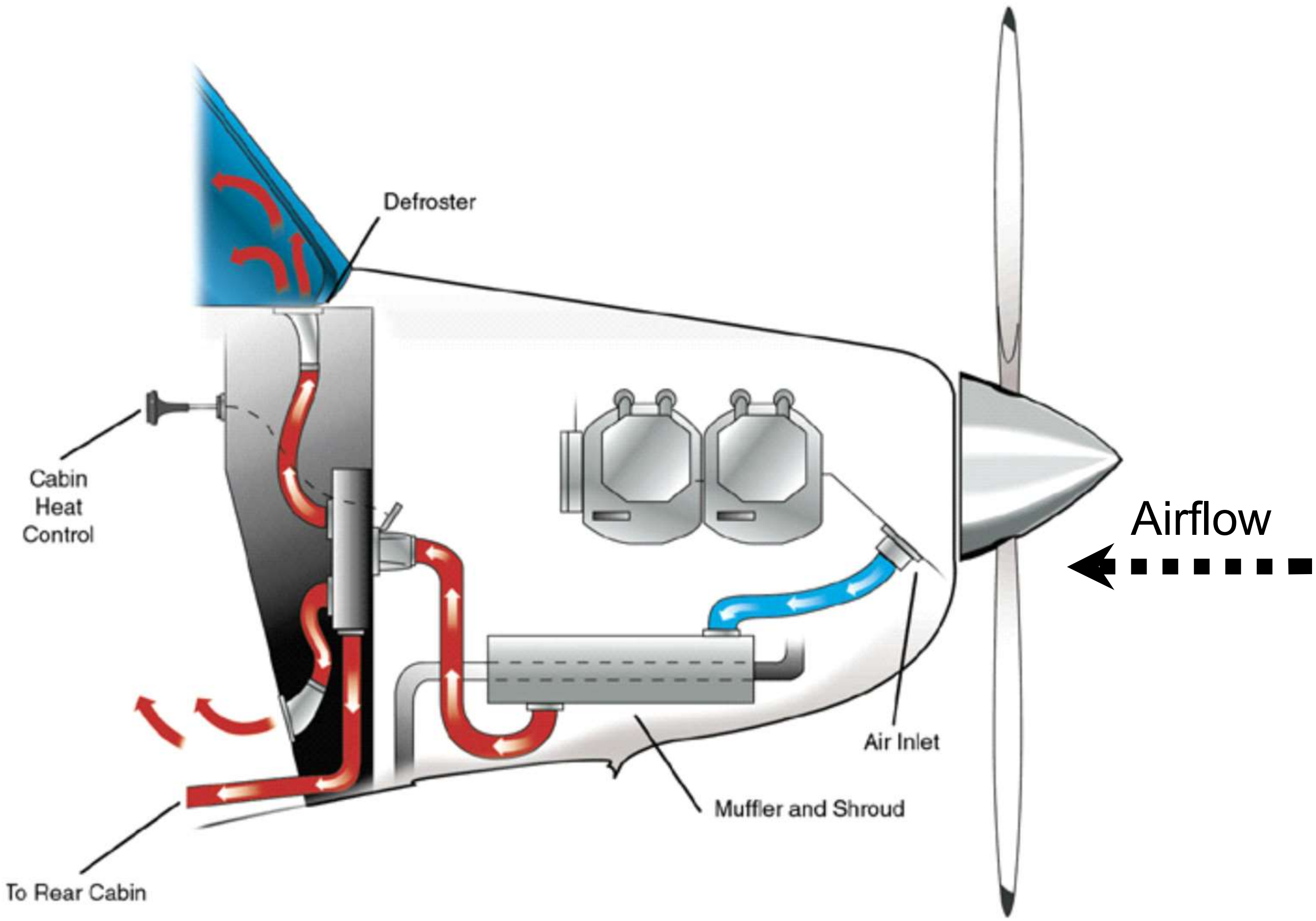
Aircraft Systems – Cooling System



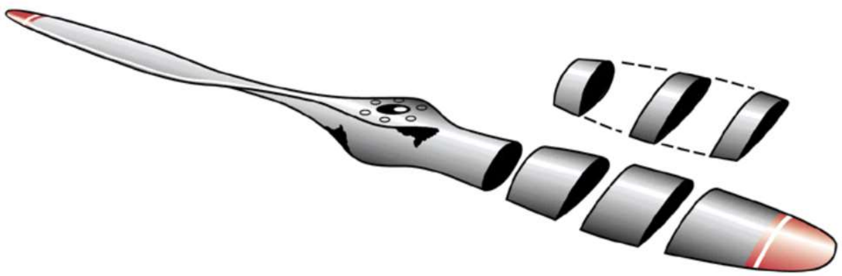


Aircraft Systems – Exhaust System

CABIN
HEAT
FROM
HEATED
AIR OF
EXHAUST
SYSTEM



Aircraft Systems – Propellers



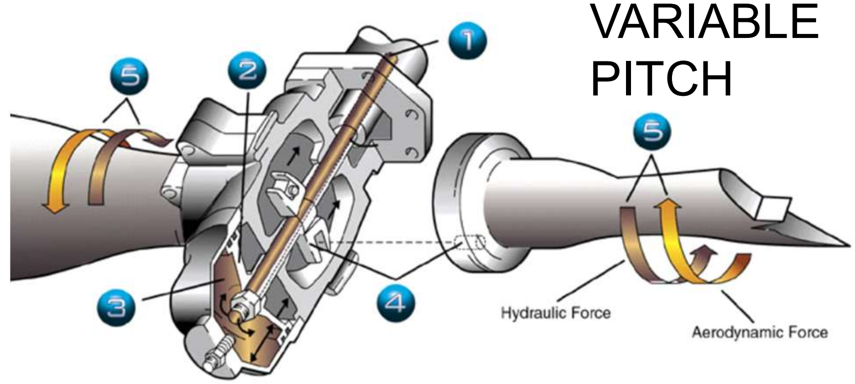
FIXED PITCH

WHEN HAND STARTING AN AIRPLANE – A COMPETENT PILOT MUST BE AT THE CONTROLS

THIS CAN BE EXTREMELY DANGEROUS

CONSTANT SPEED – VARIABLE PITCH

MP RPM



Propeller Blade angle changes from root to tip producing differences in Angle of Attack (AOA). Byproducts are Torque and Corkscrew Effect.

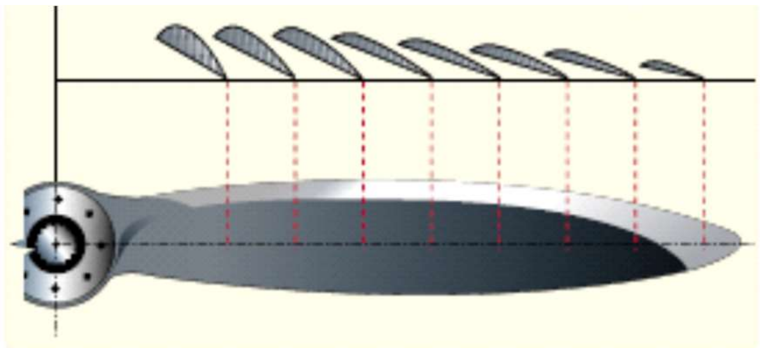


Figure 4-35. *Airfoil sections of propeller blade.*

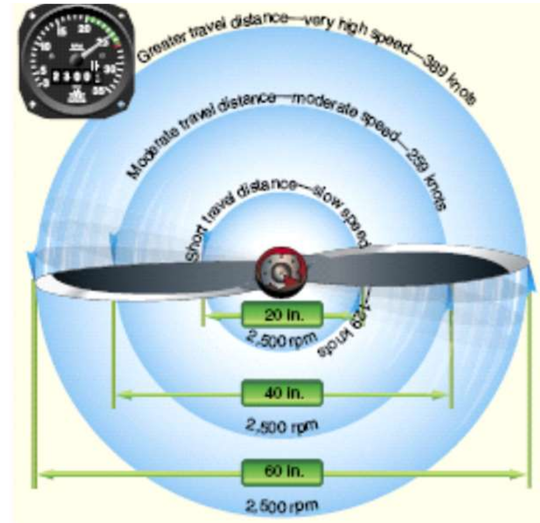


Figure 4-38. *Propeller tips travel faster than the hub.*

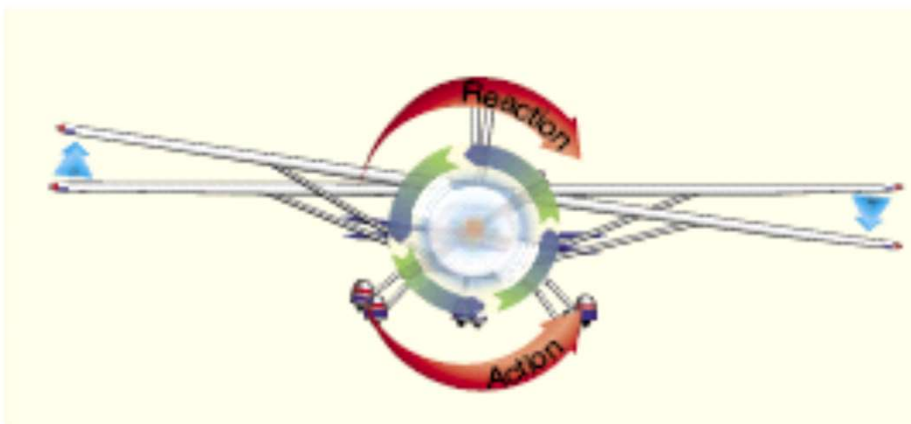
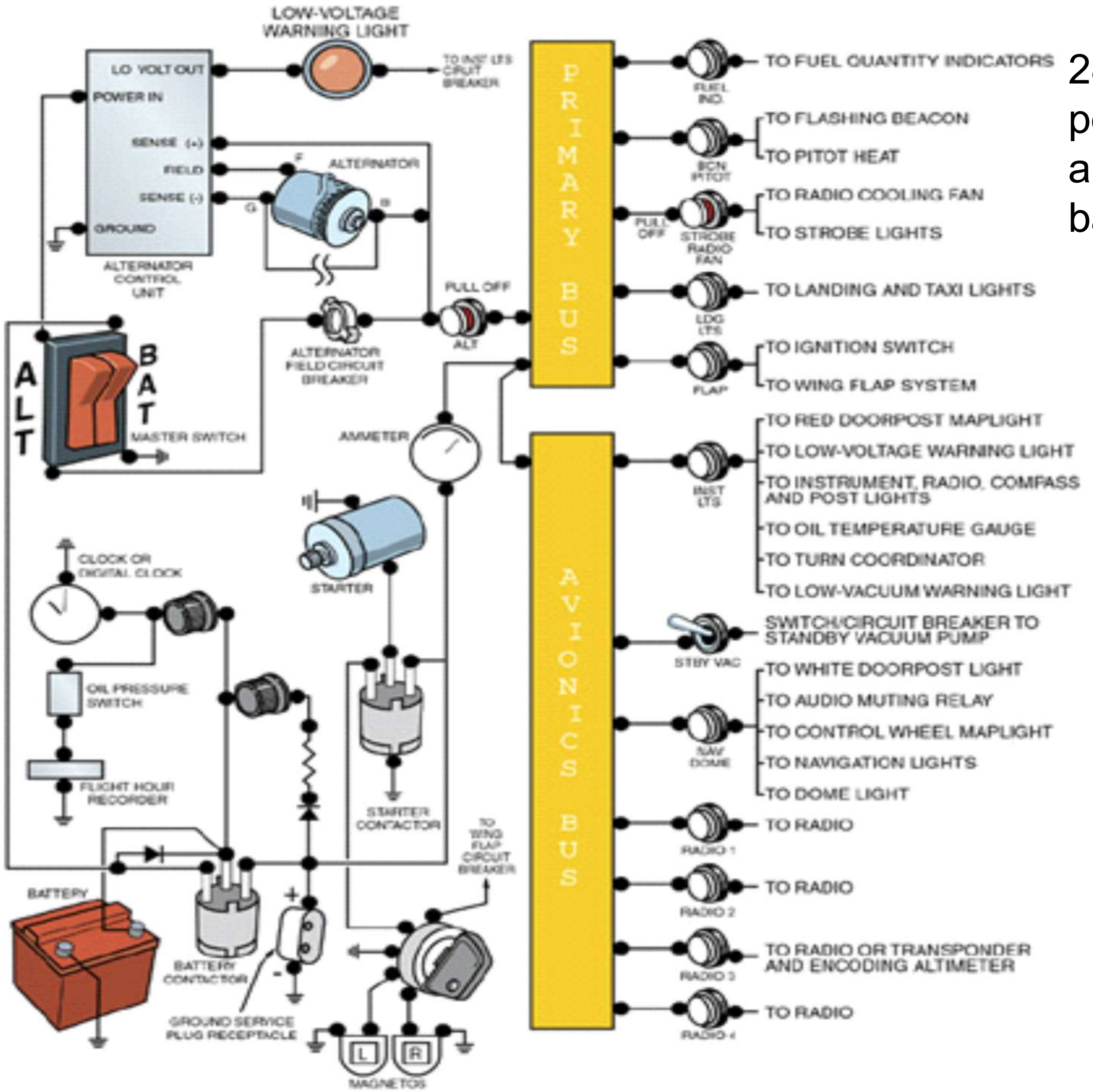


Figure 4-39. *Torque reaction.*

Figure 4-40. *Corkscrewing slipstream.*

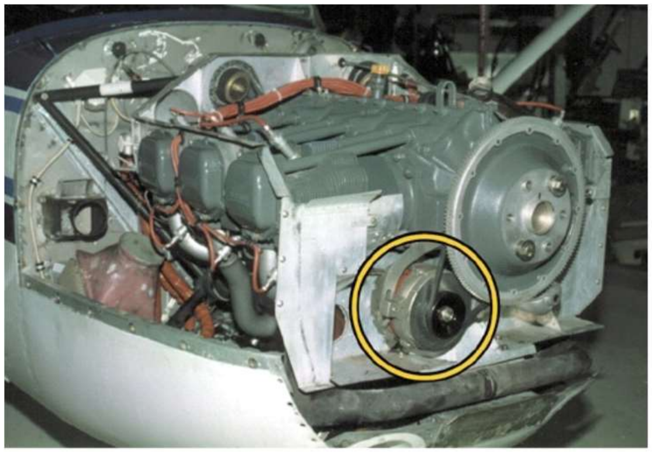
Aircraft Systems – Electrical System



28 volt, direct current (DC) powered by a 60-amp alternator and a 24-volt battery.

Gr

Aircraft Systems – Electrical System



Alternator (AC->14/28 VDC)

Alternator Control

Battery Control

WARNING: ENGINES CAN BE STARTED WITHOUT THE BATTERY (HAND PROP WITH ALTERNATOR ON-EXTREMELY DANGEROUS

VFR REQUIRED EQUIPMENT

ACRONYM:**TOMATO FLAMES 🔥 + FLAPS**

Visualize this →

DAY

T achometer
O il pressure gauge
M anifold pressure gauge for each atmospheric engine
A irspeed
T emperature gauge for each liquid cooled engine
O il temperature gauge

F uel gauge
L anding gear position indicator
A ltimeter
M agnetic heading indicator
E mergency locator transmitter
S eat belts

NIGHT (includes all DAY items)

F uses
L anding lights
A nticollision lamps
P osition indicator lamps
S ource of power (battery)

ANTI-ICE AND DEICE SYSTEMS

Anti-Icing Equipment is designed to prevent the formation of ice, while **Deicing Equipment** is designed to remove ice once it has formed. These systems *protect the leading edge of wing and tail surfaces, pitot and static port openings, fuel tank vents, stall warning devices, windshields, and propeller blades*. Ice detection lighting may also be installed on some aircraft to determine the extent of structural icing during night flights.

Airfoil Anti-Ice and Deice

Inflatable deicing boots consist of a rubber sheet bonded to the leading edge of the airfoil. When ice builds up on the leading edge, an engine-driven pneumatic pump inflates the rubber boots.

Another type of leading edge protection is the thermal anti-ice system. Heat provides one of the most effective methods for preventing ice accumulation on an airfoil.

An alternate type of leading edge protection that is not as common as thermal anti-ice and deicing boots is known as a weeping wing. The weeping-wing design uses small holes located in the leading edge of the wing to prevent the formation and build-up of ice.

Windscreen Anti-Ice

There are two main types of windscreen anti-ice systems. The first system directs a flow of alcohol to the windscreen. Another effective method of anti-icing equipment is the electric heating method. Small wires or other conductive material is imbedded in the windscreen. The heater can be turned on by a switch in the flight deck, causing an electrical current to be passed across the shield through the wires to provide sufficient heat to prevent the formation of ice on the windscreen.

Propeller Anti-Ice

Propellers are protected from icing by the use of alcohol or electrically heated elements. Some propellers are equipped with a discharge nozzle that is pointed toward the root of the blade. Alcohol is discharged from the nozzles, and centrifugal force drives the alcohol down the leading edge of the blade.

Other Anti-Ice and Deice Systems

Pitot and static ports, fuel vents, stall-warning sensors, and other optional equipment may be heated by electrical elements.

OXYGEN SYSTEMS

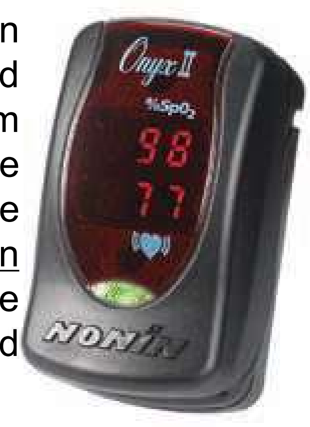
Cannula: An ergonomic piece of plastic tubing that runs under the nose to administer oxygen to the user.

Continuous-Flow Oxygen System: Continuous-flow oxygen systems are usually provided for passengers. The passenger mask typically has a reservoir bag that collects oxygen from the continuous-flow oxygen system during the time when the mask user is exhaling.

Diluter-Demand Oxygen Systems: Supplies oxygen only when the user inhales through the mask. An automix lever allows the regulators to automatically mix cabin air and oxygen or supply 100 percent oxygen, depending on the altitude. The demand mask provides a tight seal over the face to prevent dilution with outside air and can be used safely up to 40,000 feet

Pressure-Demand Oxygen Systems: Similar to diluter demand oxygen equipment, except that oxygen is supplied to the mask under pressure at cabin altitudes above 34,000 feet.

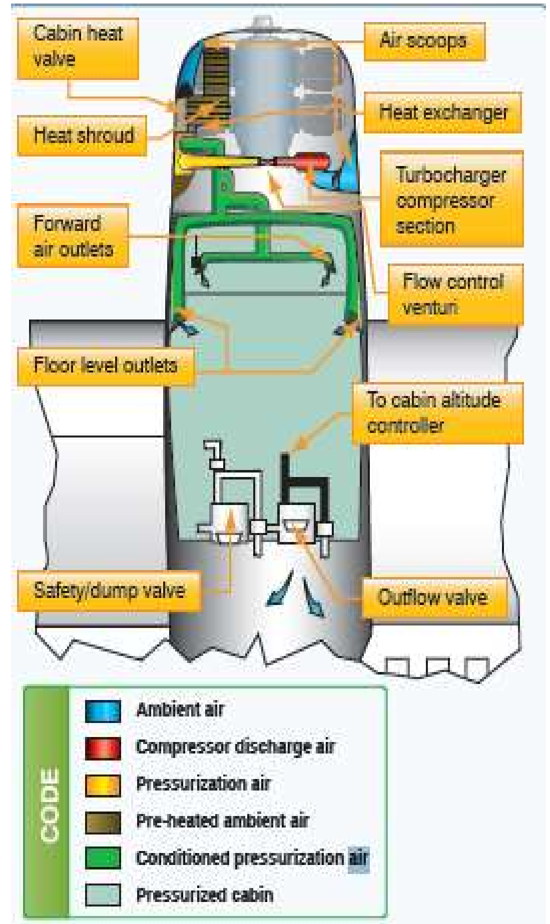
Electrical Pulse-Demand Oxygen System: This is a portable deliver oxygen by detecting an individual's inhalation effort and provide oxygen flow during the initial portion of inhalation. Pulse demand systems do not waste oxygen during the breathing cycle because oxygen is only delivered during inhalation



Pulse Oximeters: *A device that measures the amount of oxygen in an individual's blood*, in addition to heart rate. This non-invasive device measures the color changes that red blood cells undergo when they become saturated with oxygen. By transmitting a special light beam through a fingertip to evaluate the color of the red cells, a pulse oximeter can calculate the degree of oxygen saturation within one percent of directly measured blood oxygen. Because of their portability and speed, pulse oximeters are very useful for pilots operating in nonpressurized aircraft above 12,500 feet where supplemental oxygen is required. A pulse oximeter permits crewmembers and passengers of an aircraft to evaluate their actual need for supplemental oxygen.

AIRCRAFT PRESSURIZATION

Aircraft are flown at high altitudes for two reasons. First, an aircraft flown at high altitude consumes less fuel for a given airspeed than it does for the same speed at a lower altitude because the aircraft is more efficient at a high altitude. Second, bad weather and turbulence may be avoided by flying in relatively smooth air above the storms. Many modern aircraft are being designed to operate at high altitudes, taking advantage of that environment. In order to fly at higher altitudes, the aircraft must be pressurized or suitable supplemental oxygen must be provided for each occupant. It is important for pilots who fly these aircraft to be familiar with the basic operating principles
In a typical pressurization system, the cabin, flight compartment, and baggage compartments are incorporated into a sealed unit capable of containing air under a pressure higher than outside atmospheric pressure.



On aircraft powered by turbine engines, bleed air from the engine compressor section is used to pressurize the cabin. Superchargers may be used on older model turbine-powered aircraft to pump air into the sealed fuselage.

Piston-powered aircraft may use air supplied from each engine turbocharger through a sonic venturi (flow limiter). Air is released from the fuselage by a device called an outflow valve. By regulating the air exit, the outflow valve allows for a constant inflow of air to the pressurized area.

Pressurization is used to keep cabin pressure altitude **at or below 8,000 feet.**

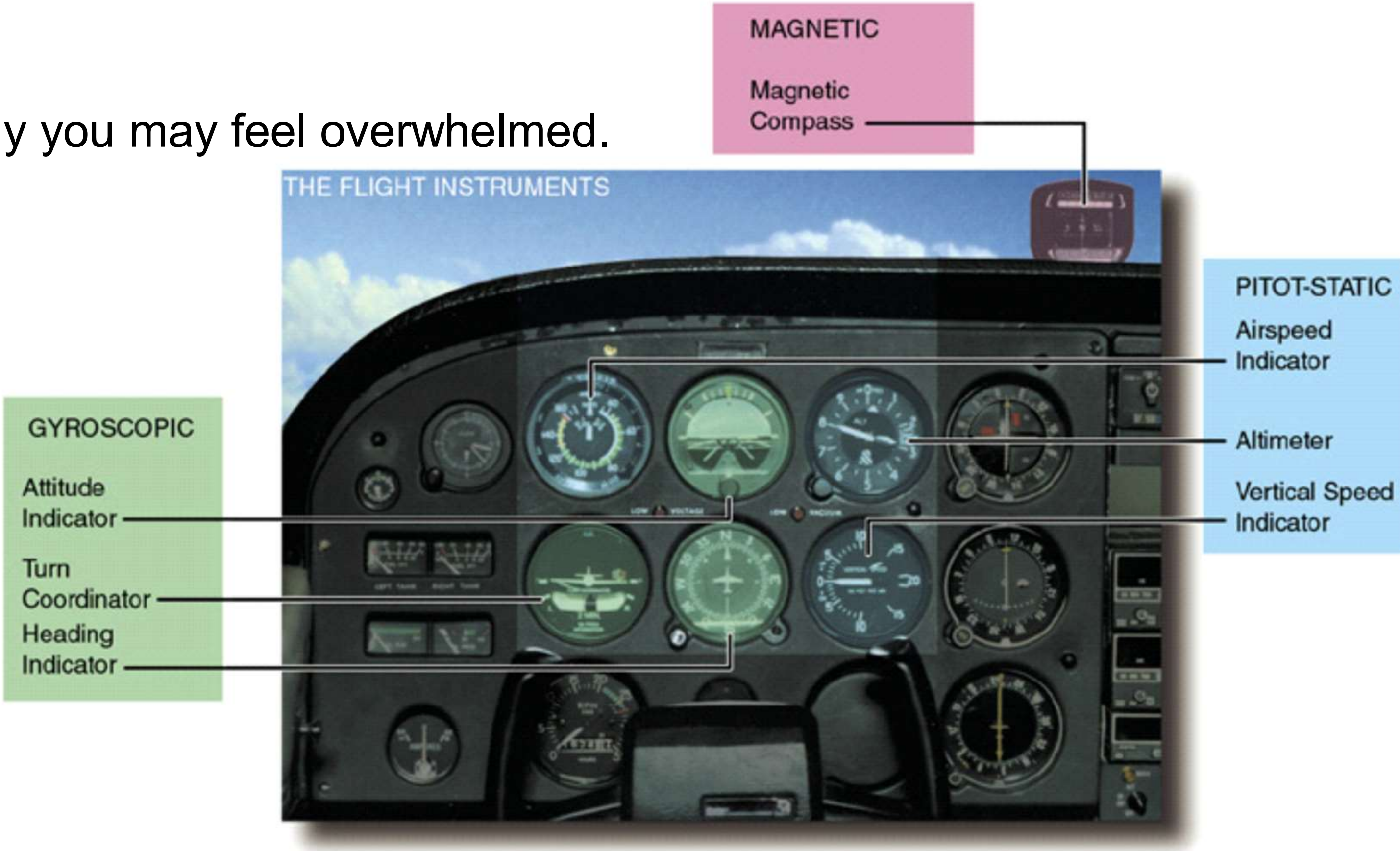
Aircraft Instruments

Ground School 2019

Created by Steve Reisser

FLIGHT INSTRUMENTS

Initially you may feel overwhelmed.

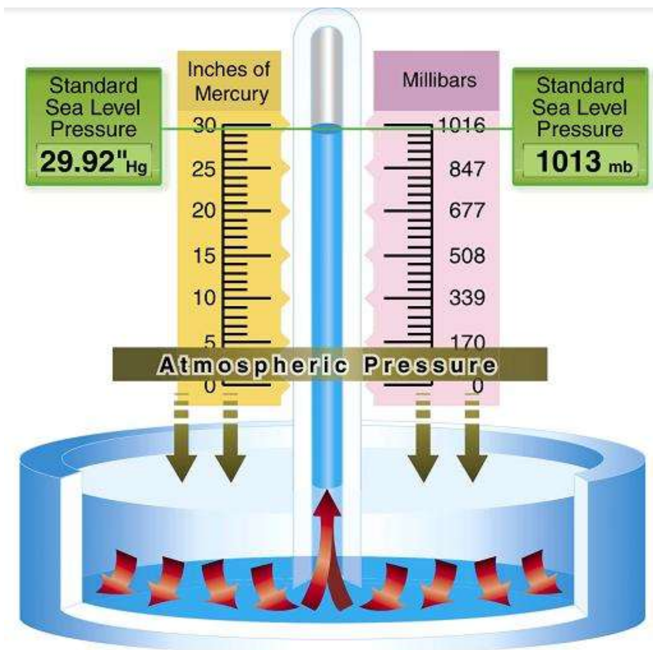


DON'T FEEL OVERWHELMED, IT IS SIMPLER THAN IT APPEARS
Think of them as functional groups of information (i.e., Engine, Flight Control, Communication, Electrical, Power, etc.) and it makes sense and easier to manage.

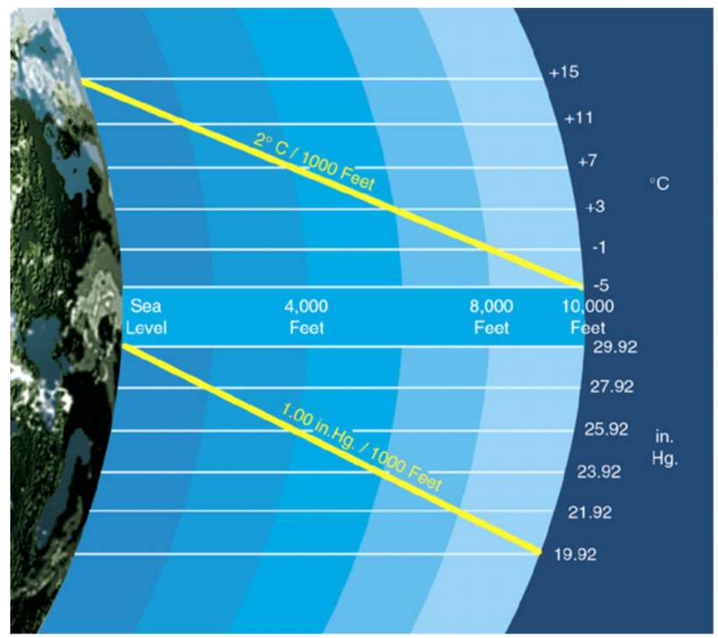
Flight Instruments: Pitot-Static System

Relies on atmospheric pressure to measure altitude, rate of climb and impact pressure to measure speed.

Barometric Pressure



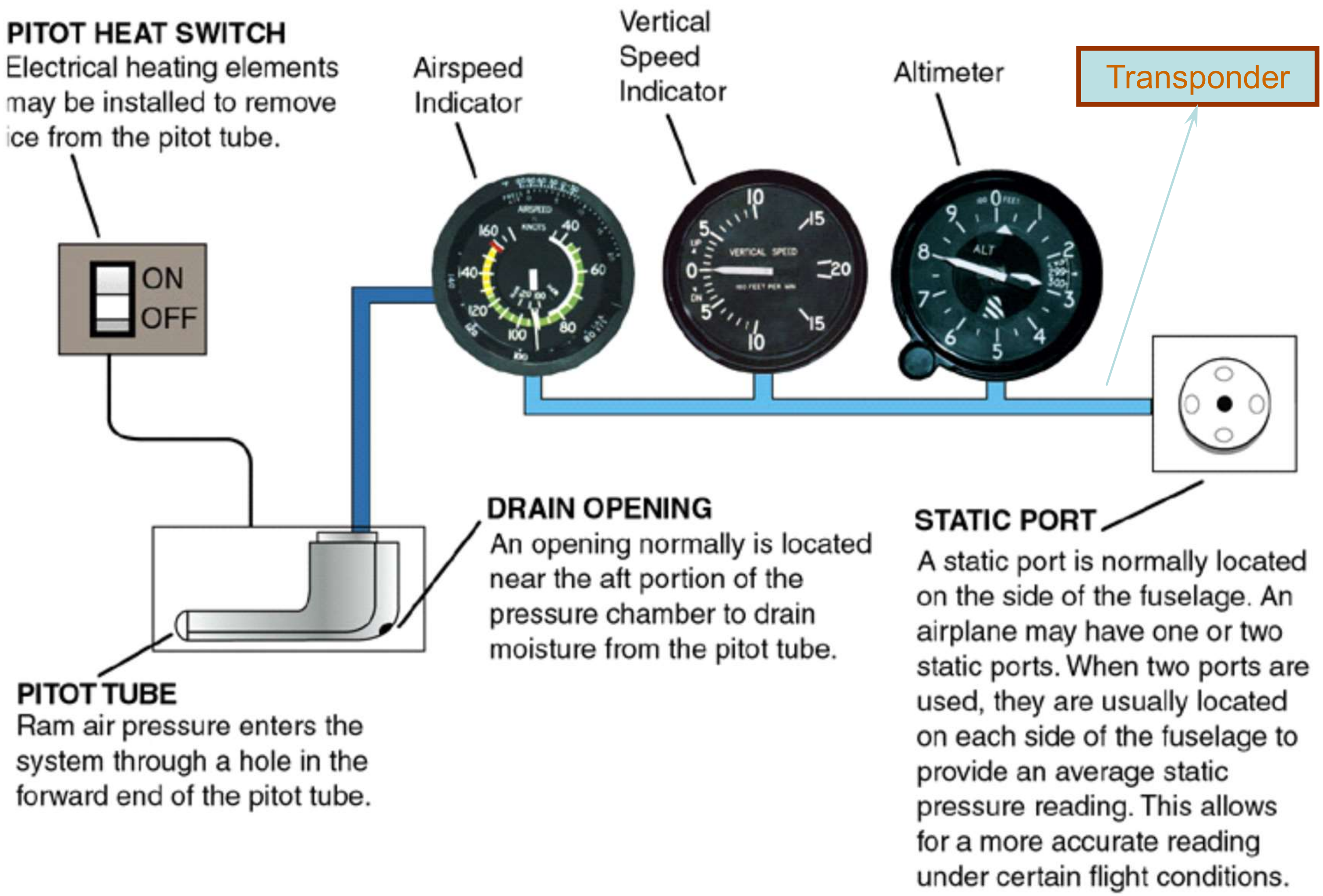
Lapse Rate



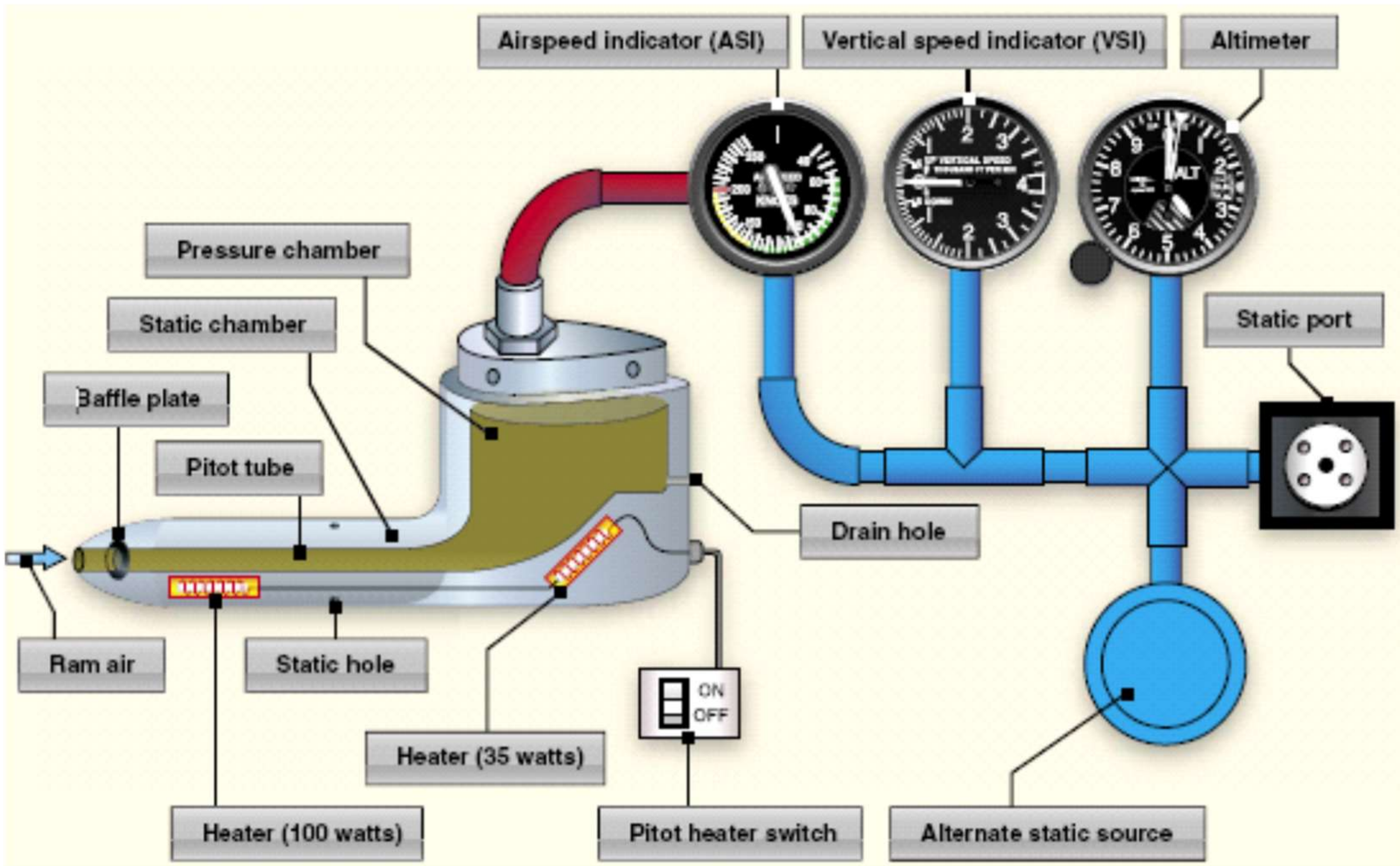
These constants are important to both flight instruments and meteorology

Altitude (ft)	Pressure ("Hg)	Temperature (°C)	Temperature (°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	–0.9	30.5
9,000	21.38	–2.8	26.9
10,000	20.57	–4.8	23.3
11,000	19.79	–6.8	19.8
12,000	19.02	–8.8	16.2
13,000	18.29	–10.8	12.6
14,000	17.57	–12.7	9.1
15,000	16.88	–14.7	5.5
16,000	16.21	–16.7	1.9
17,000	15.56	–18.7	–1.6
18,000	14.94	–20.7	–5.2
19,000	14.33	–22.6	–8.8
20,000	13.74	–24.6	–12.3

Flight Instruments: Pitot-Static



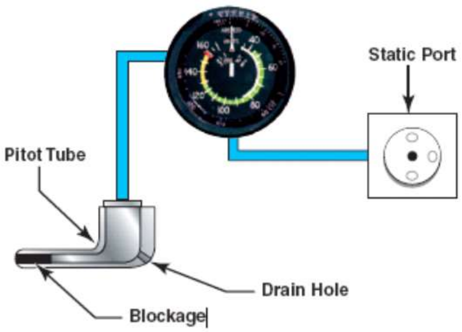
The one instrument that utilizes the pitot tube is the ASI. The total pressure is transmitted to the ASI from the pitot tube's pressure chamber via a small tube. The static pressure is also delivered to the opposite side of the ASI which serves to cancel out the two static pressures, thereby leaving the dynamic pressure to be indicated on the instrument. The two remaining instruments (altimeter and VSI) utilize only the static pressure which is derived from the static port.



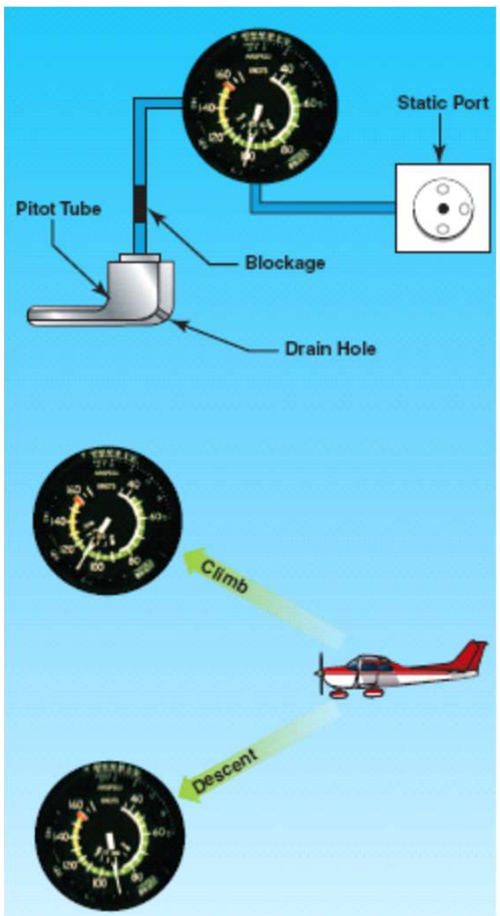
When the alternate static source pressure is used, the following instrument indications are observed:

1. The altimeter indicates a slightly higher altitude than actual.
2. The ASI indicates an airspeed greater than the actual airspeed.
3. The VSI shows a momentary climb and then stabilizes if the altitude is held constant.

Blocked Static System

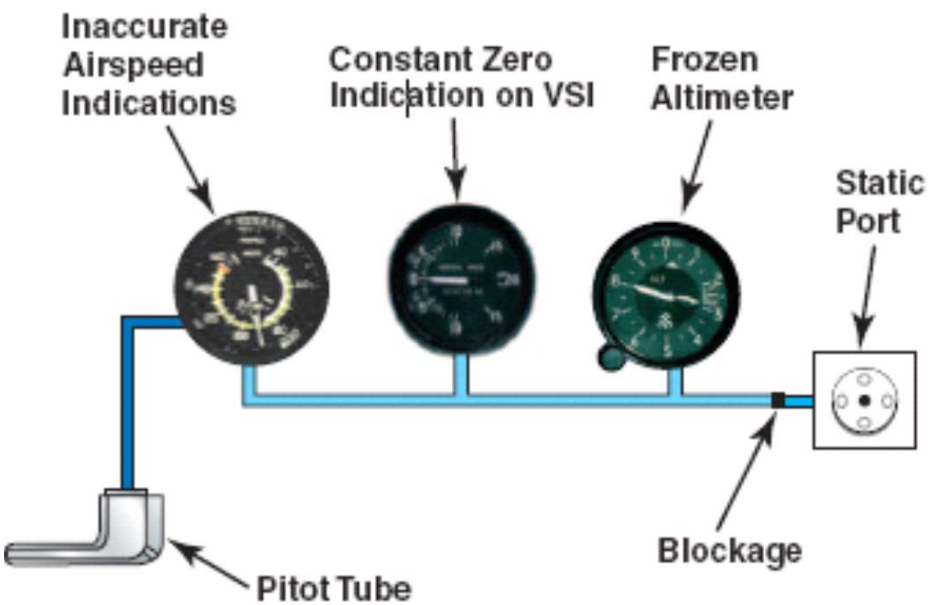


The pitot system can become blocked completely or only partially if the pitot tube drain hole remains open. If the pitot tube becomes blocked and its associated drain hole remains clear, ram air no longer is able to enter the pitot system. Air already in the system will vent through the drain hole, and the remaining pressure will drop to ambient (outside) air pressure. Under these circumstances, the airspeed indicator reading decreases to zero, because the airspeed indicator senses no difference between ram and static air pressure.



If the pitot tube, drain hole, and static system all become blocked in flight, changes in airspeed will not be indicated, due to the trapped pressures. However, if the static system remains clear, the airspeed indicator acts as an altimeter.

Blocked Static System

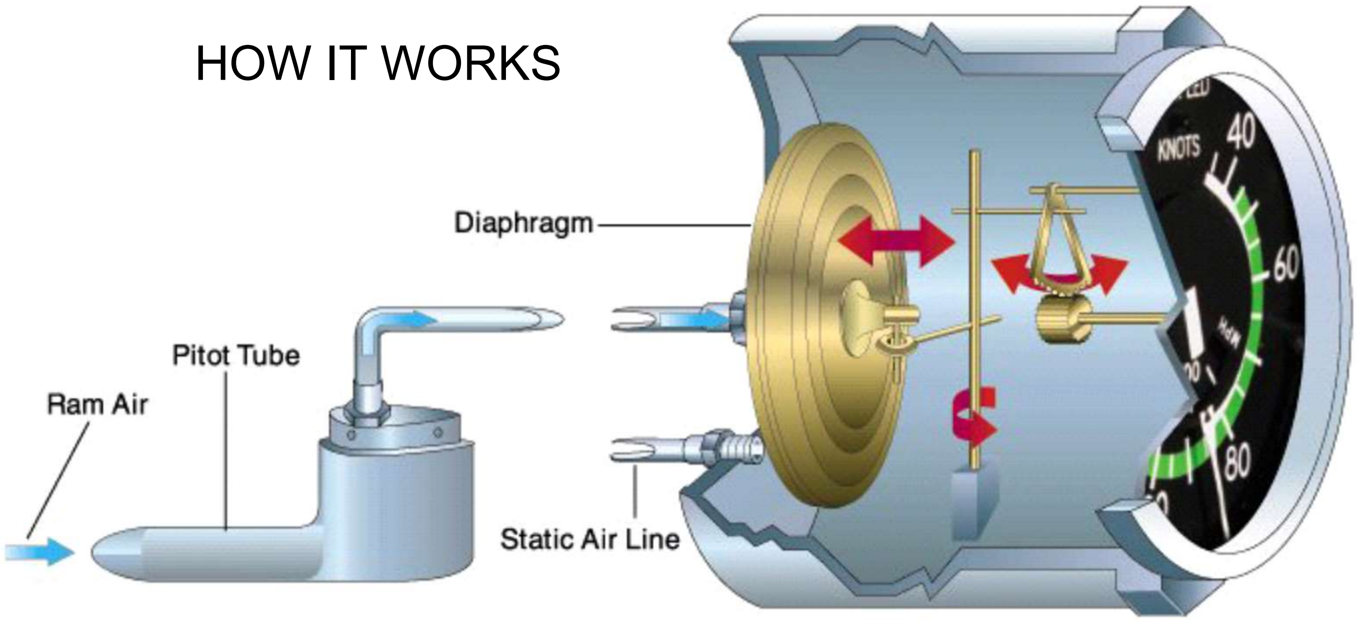


If the static system becomes blocked but the pitot tube remains clear, the airspeed indicator continues to operate; however, it is inaccurate. Airspeed indications are slower than the actual speed when the airplane is operated above the altitude where the static ports became blocked, because the trapped static pressure is higher than normal for that altitude. When operating at a lower altitude, a faster than actual airspeed is displayed due to the relatively low static pressure trapped in the system.

A blockage of the static system also affects the *altimeter and VSI*. Trapped static pressure causes the altimeter to freeze at the altitude where the blockage occurred. In the case of the VSI, a blocked static system produces a continuous zero indication.

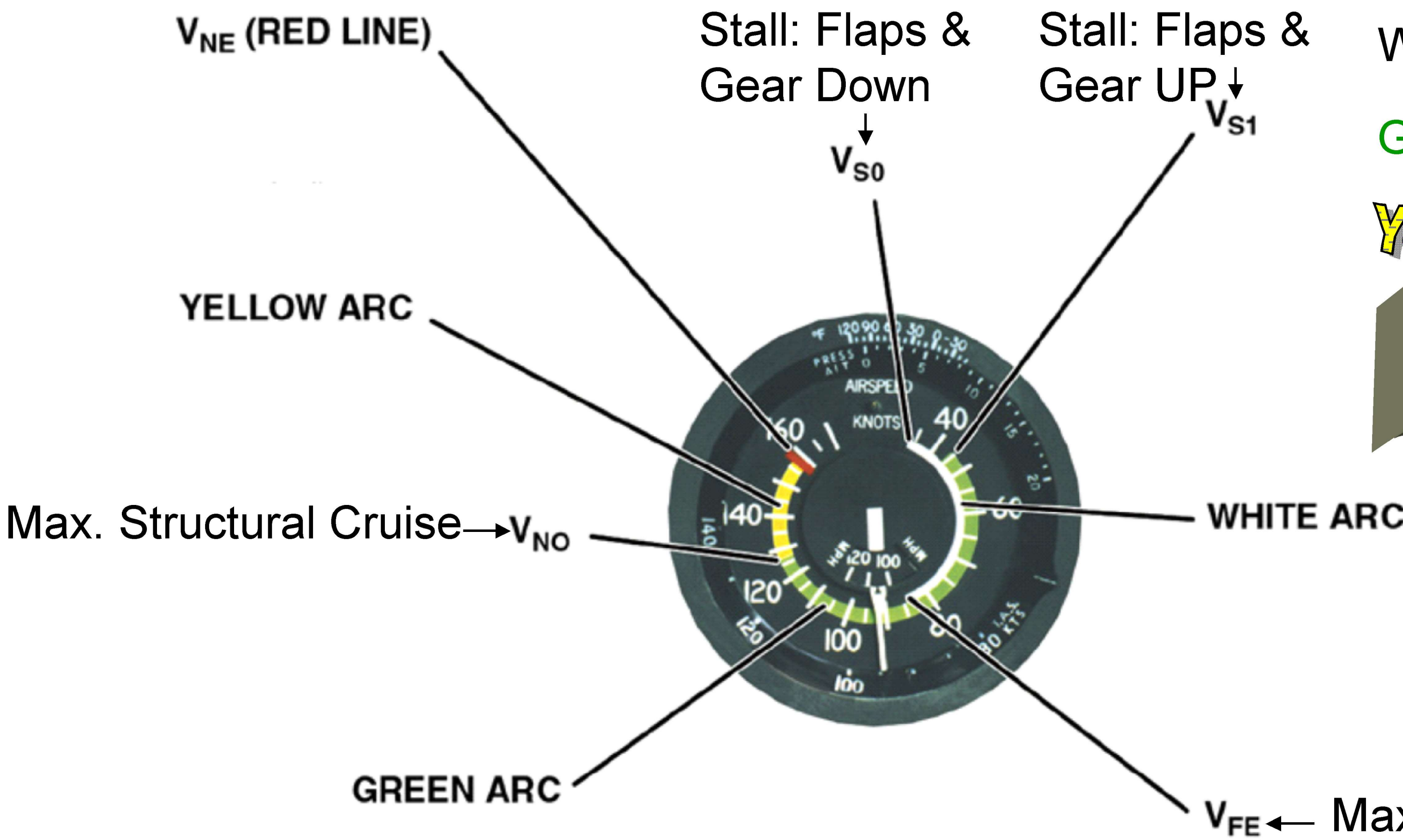
Flight Instruments: Pitot-Static System – Airspeed Indicator

HOW IT WORKS



AIRSPEED INDICATOR IS ONLY INSTRUMENT TO USE “RAM AIR” FROM THE PITOT TUBE.

Flight Instruments: Pitot-Static System – Airspeed Indicator



White-Flaps

Green-Cruise

Yellow-Caution

RED EXTREME DANGER

NOT marked on airspeed indicator: V_A Maneuvering Speed

Important Single-Engine V-Speeds

V_A- Maneuvering speed, the maximum speed at which application of full available aerodynamic control will not overstress the airplane; usually decreases as gross weight decreases. More on next slide.

V_{FE} - Maximum flap-extended speed, the highest speed permissible with wing flaps in a prescribed extended position; top of white arc.

V_{NE}-Never-exceed speed, the speed that may not be exceeded at any time; redline.

V_{NO} - Maximum structural cruising speed, the speed that should not be exceeded except in smooth air and then only with caution; top of green arc.

V_{REF} — Reference speed for final approach, usually 1.3 times VSO.

V_{S1} — Stall speed or minimum steady flight speed obtained in a specific configuration; bottom of the green arc.

V_{SO} — Stall speed or minimum steady flight speed at which the airplane is controllable in the landing configuration; bottom of white arc.

V_X — Best angle-of-climb speed, the airspeed that delivers the greatest gain of altitude in the *shortest possible horizontal distance*. [short field TO]

V_Y — Best rate-of-climb speed, the airspeed that delivers the *greatest gain in altitude* in the shortest possible time.

Maneuvering Speed (Va)

Maneuvering speed is the highest speed at which full deflection of the controls aboutany one axis are guaranteed not to overstress the airframe.

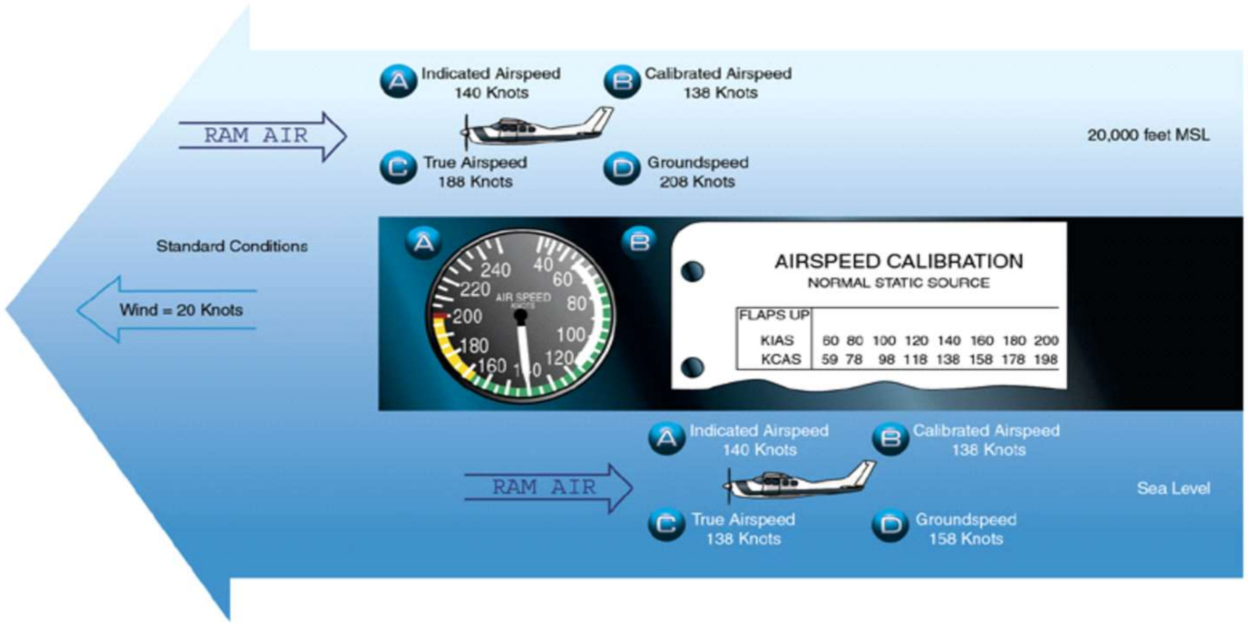
Maneuvering speed is stall speed multiplied by the square root of the limit load factor. *Normal category limit is 3.8 Gs, the square root of which is 1.95*. If, for example, the flaps-up stalling speed is 70, the maneuvering speed would be 70 * 1.95 = 136.5.

The maneuvering speed decreases as the aircraft's weight decreases from maximum takeoff weight because the effects of the aerodynamic forces become more pronounced as its weight decreases. That is because *flying at a lower weight decreases the angle of attack and if the higher speed were maintained, excessive lift forces could cause structural damage at full deflection of the elevator*.

The flight manuals for some aircraft (such as the Piper Cherokee) specify the design maneuvering speeds for weights below the maximum takeoff weight but sometimes it is left to the pilot to calculate. Using a "Rule of Thumb", the reduction in Va will be *half the percentage reduction in aircraft weight*.

- A 10% reduction of weight would result in a 5% decrease in Va
- A 30% reduction of weight would result in a 15% decrease in Va

Flight Instruments: Pitot-Static System – Types of Airspeed



<u>INDICATED</u> (IAS) = What you read on the AS Indicator

<u>CALIBRATED</u> (CAS) = INDICATED AS **adjusted for installation errors**.

<u>TRUE</u> (TAS) = **CALIBRATED AS corrected for altitude and non-std temperature**

<u>GROUND SPEED</u> – TRUE AS **corrected for wind (actual speed moving across ground)**

TELL MEHOW DO YOU FIND EACH OF THESE AIRSPEEDS?

Flight Instruments: Pitot-Static System – What Affects Airspeed?

POWER

Add Power (more trust) increases airspeed (pitch up tendency)

Reduce Power (less trust) decreases airspeed (pitch down tendency)

PITCH

Pitch DOWN (descend) will increase airspeed

Pitch UP (climb) will decrease airspeed

Transition to climb or descent from level flight
Requires coordination of BOTH power and pitch.

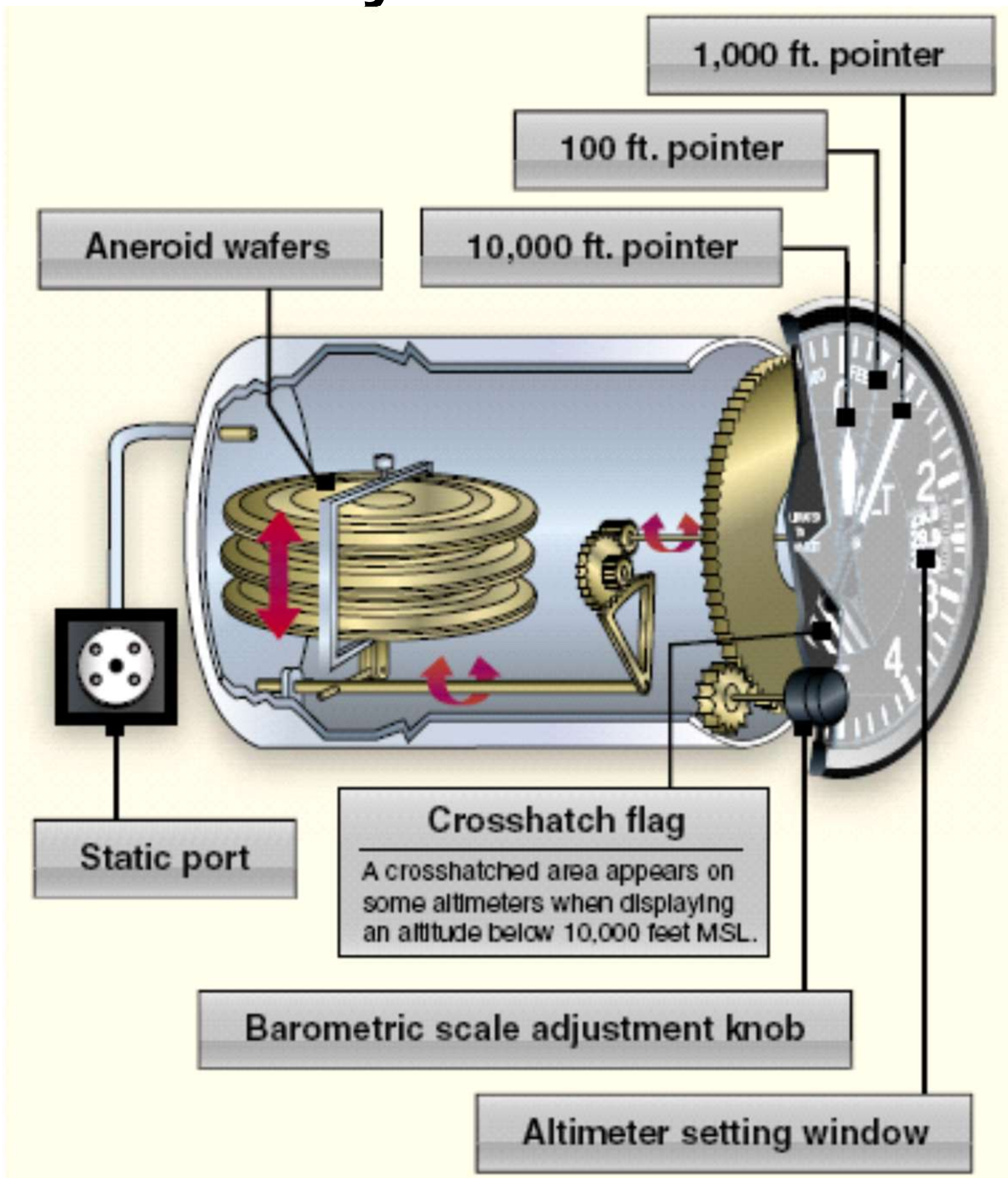
Airspeed Errors

Position Error:
Caused by the static ports sensing erroneous static pressure; slipstream flow causes disturbance at the static port preventing actual atmospheric pressure measurement. (varies with airspeed, altitude and configuration)

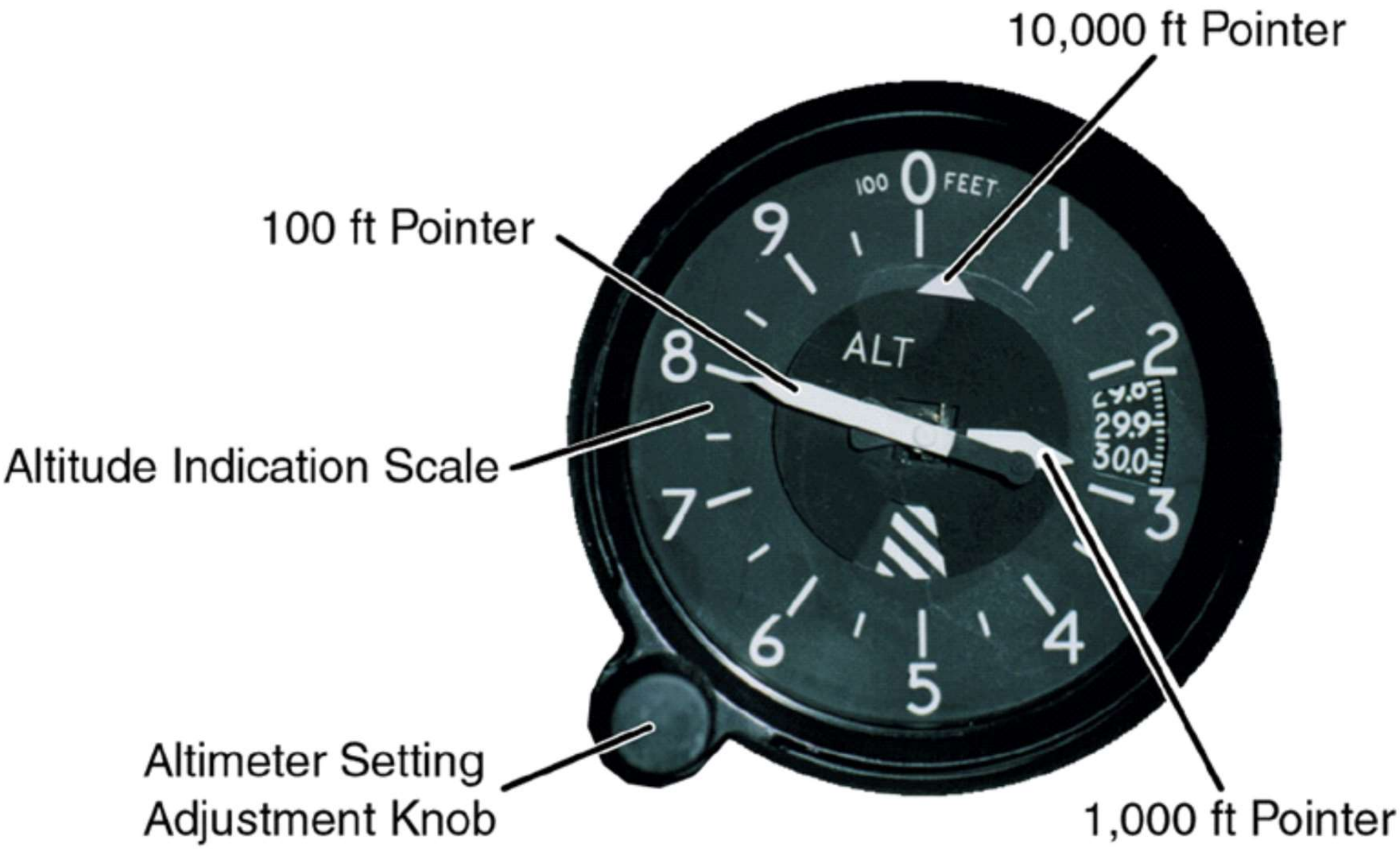
Density Error:
Changes in altitude and temperature are not compensated for by this instrument.

Compressibility Error:
Caused by “packing” of air into the pitot tube at HIGH airspeeds, resulting in higher than normal indications. “Usually” not a factor at low airspeed.

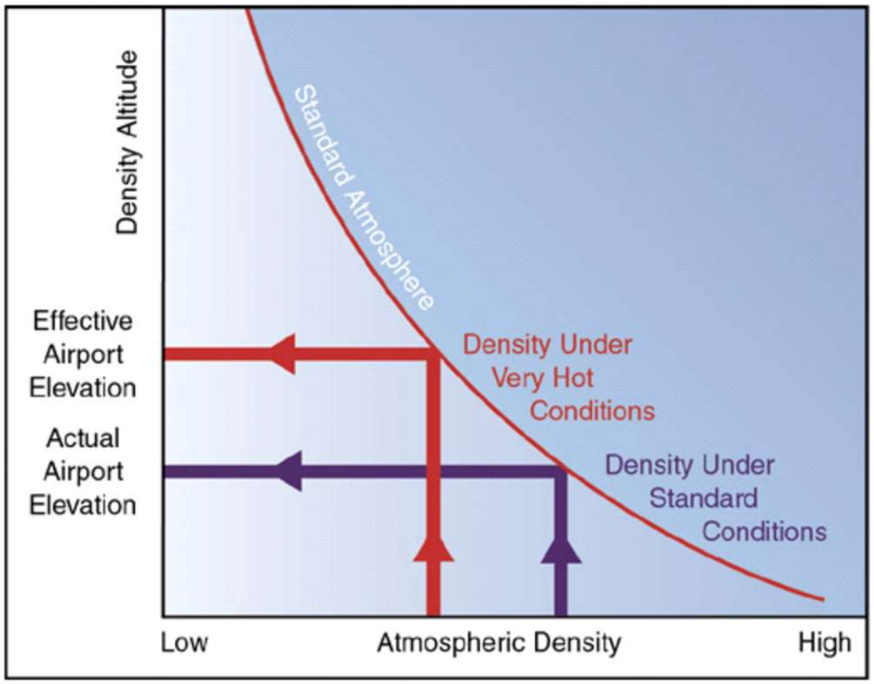
Pitot-Static System – ALTIMETER



Flight Instruments: Pitot-Static System – ALTIMETER



Flight Instruments: Pitot-Static System – 6 types of altitude



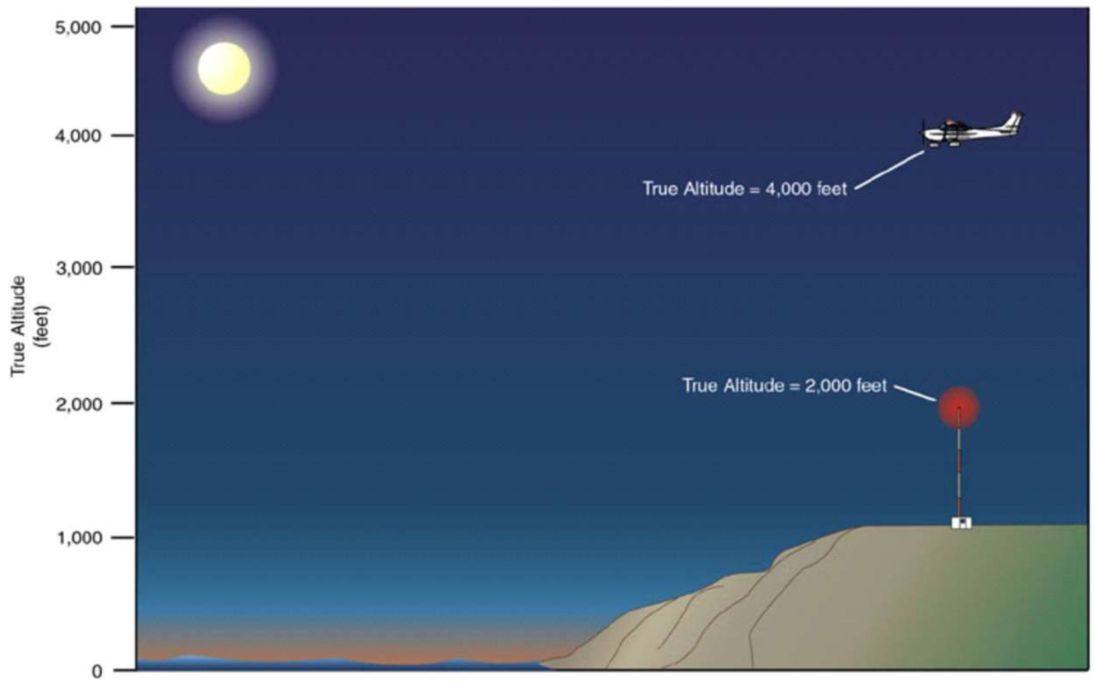
1. Indicated Altitude: Showing on altimeter

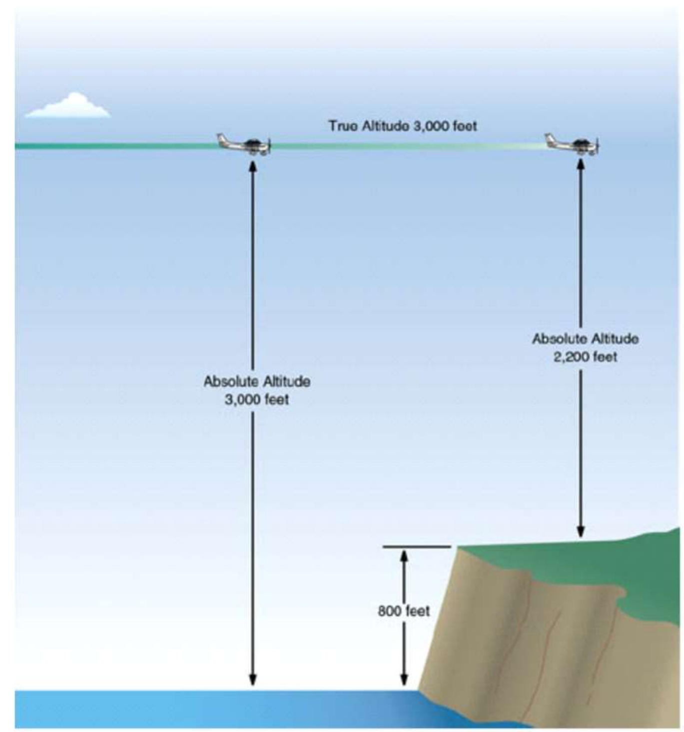
2. Pressure Altitude: Showing when set to standard pressure of 29.92" Formal definition is "the height above a standard datum plane (SDP),

3. Density Altitude is altitude adjusted for non-standard temperature. Less efficient in warmer whereas more efficient in cooler conditions.

Flight Instruments: Pitot-Static System – TYPES of altitude

4. Calibrated Altitude – correction to compensate for instrument error for your specific aircraft (see POH).
5. True Altitude – "MSL" (Measure Sea Level) "Height above seal level."
6. Absolute Altitude – above ground level (AGL)





Limitations of Pressure Altitude

PRESSURE

Higher than standard pressure: Altimeter indicates *lower than actual*.

Lower than standard pressure: Altimeter indicates *higher than actual*.

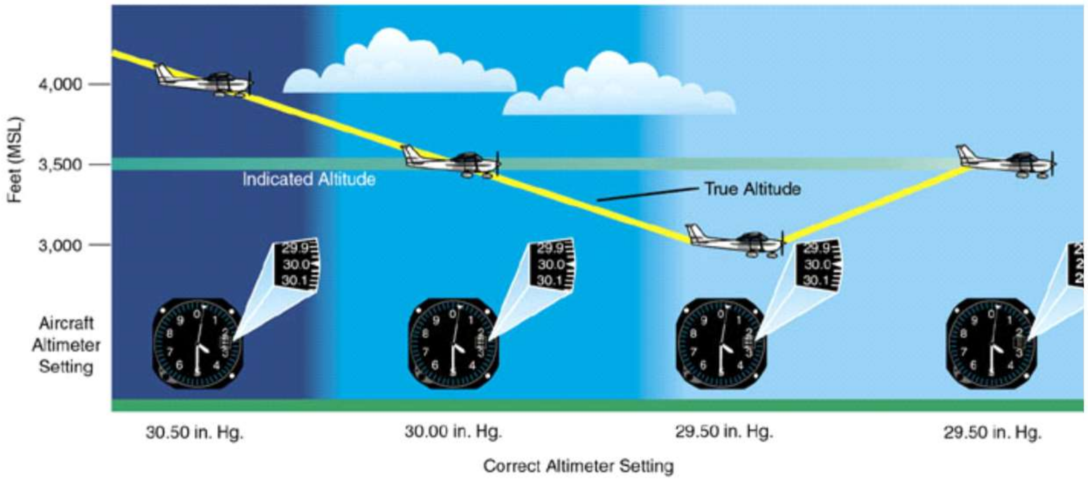
TEMPERATURE

On a Cold day: Temperature is lower than on standard day – altimeter indicates higher *than actual*. You are LOWER than you think! Critical to instrument approaches!

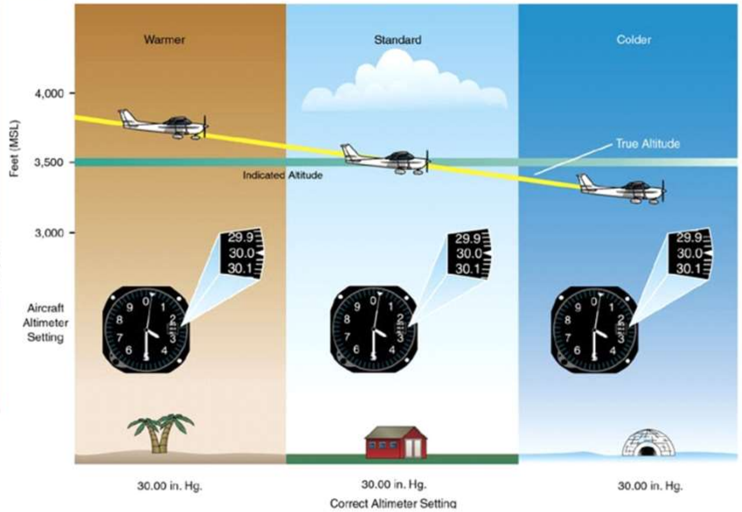
On a Warm day: Temperature is higher than on a standard day – altimeter indicates *lower than actual*. You are HIGHER than you think!

Pitot-Static System

PRESSURE



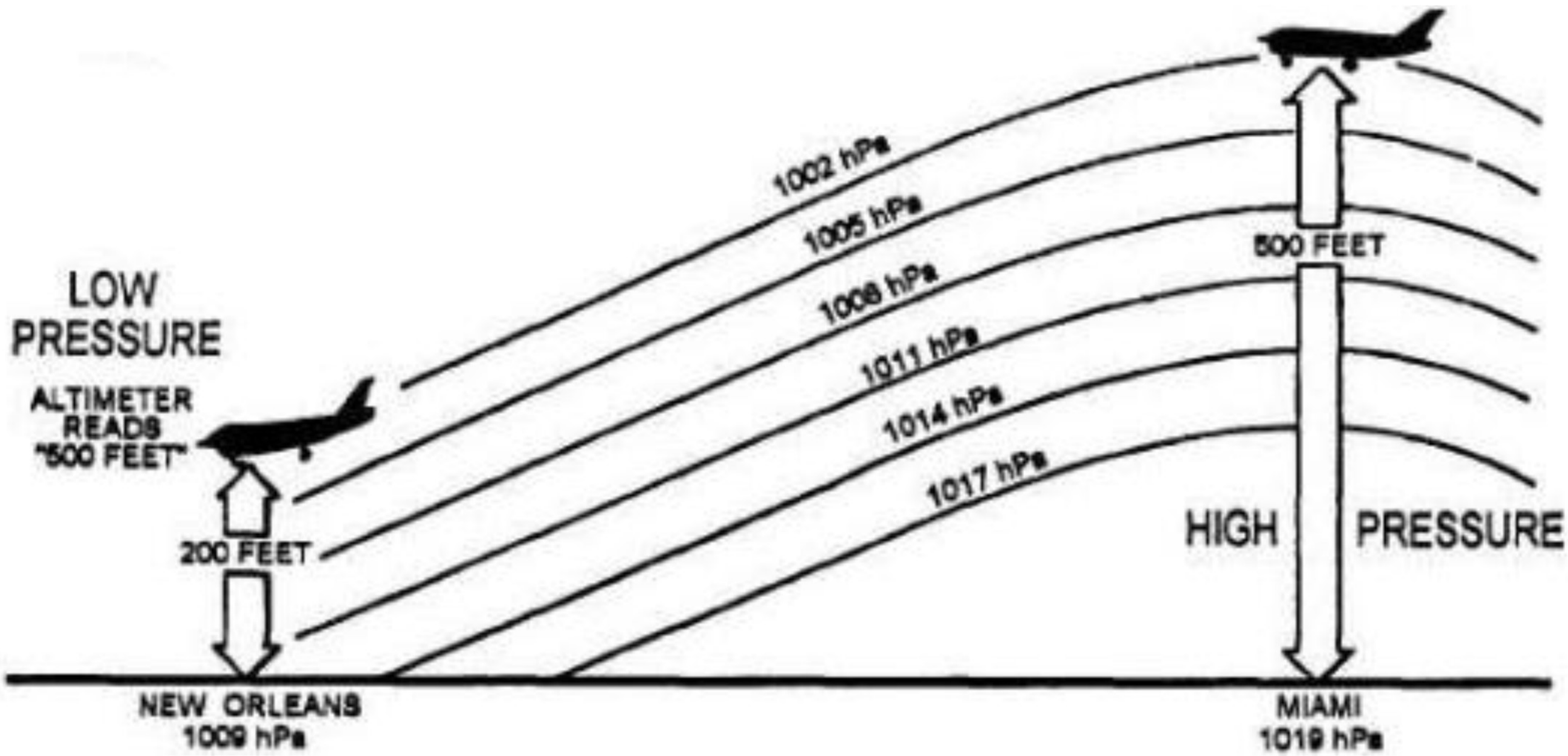
TEMPERATURE



If correct pressure not adjusted on altimeter, the indicated altitude will be I N C O R R E C T.

"High to low – Look out below"
"Low to high – Look to the sky"

Flying from warm to cooler the altimeter will indicate lower indicated altitude than true altitude.
"FROM HOT TO COLD, LOOK OUT BELOW."
"FROM COLD TO HOT LOOK TO THE TOP."


LOW
PRESSURE
ALTIMETER
READS
"500 FEET"
200 FEET
1002 hPa
1005 hPa
1008 hPa
1011 hPa
1014 hPa
1017 hPa
500 FEET
HIGH
PRESSURE
NEW ORLEANS
1009 hPa
MIAMI
1019 hPa

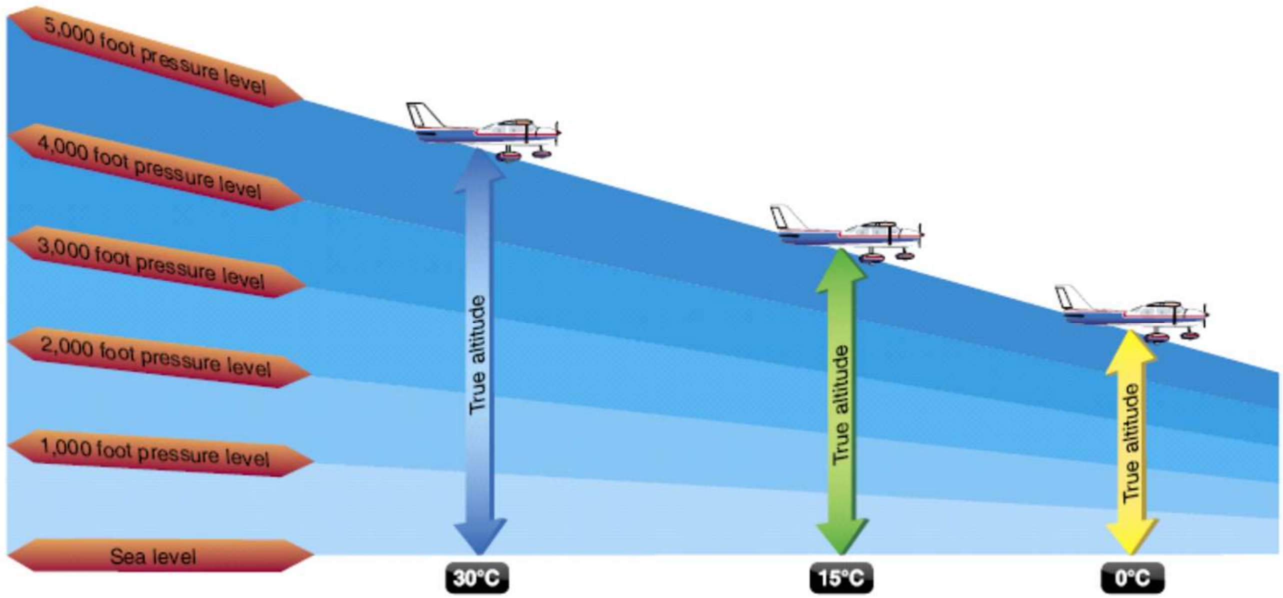


Figure 7-3. *Effects of nonstandard temperature on an altimeter.*

Altimeter Check

Prior to each flight, a pilot should examine the altimeter for proper indications in order to verify its accuracy. To determine the condition of an altimeter, set the barometric scale to the current reported altimeter setting transmitted by the local automated flight service station (AFSS) or any other reliable source, such as ATIS, AWOS, or ASOS. The altimeter pointers should indicate the surveyed field elevation of the airport.

If the indication is off more than 75 feet from the surveyed field elevation, the instrument should be referred to a certificated instrument repair station for recalibration.

Since weather stations are located around the globe, all local barometric pressure readings are converted to a sea level pressure to provide a standard for records and reports. To achieve this, each station converts its barometric pressure by adding approximately 1 "Hg for every 1,000 feet of elevation. For example, a station at 5,000 feet above sea level, with a reading of 24.92 "Hg, reports a sea level pressure reading of 29.92 "Hg. *[Figure 11-8]* **Using common sea level pressure readings helps ensure aircraft altimeters are set correctly, based on the current pressure readings**.

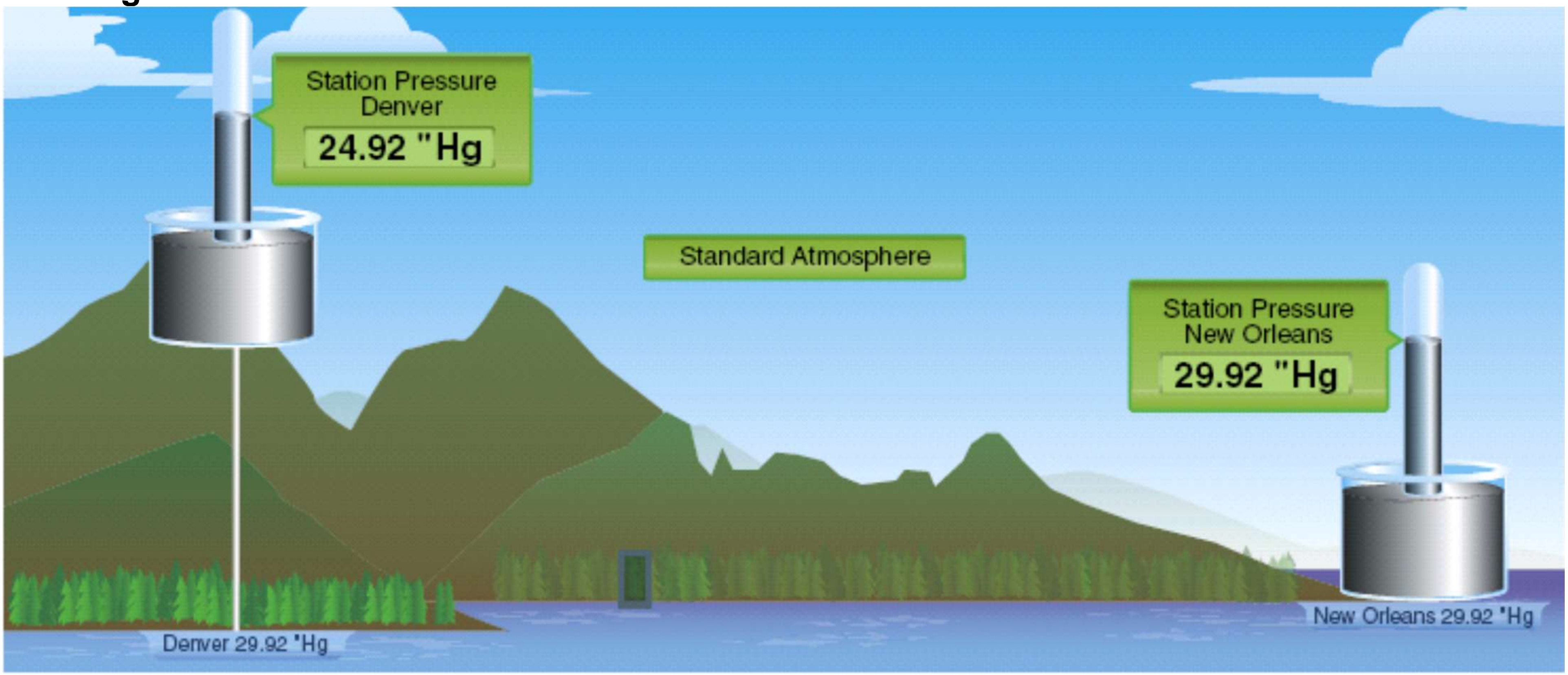
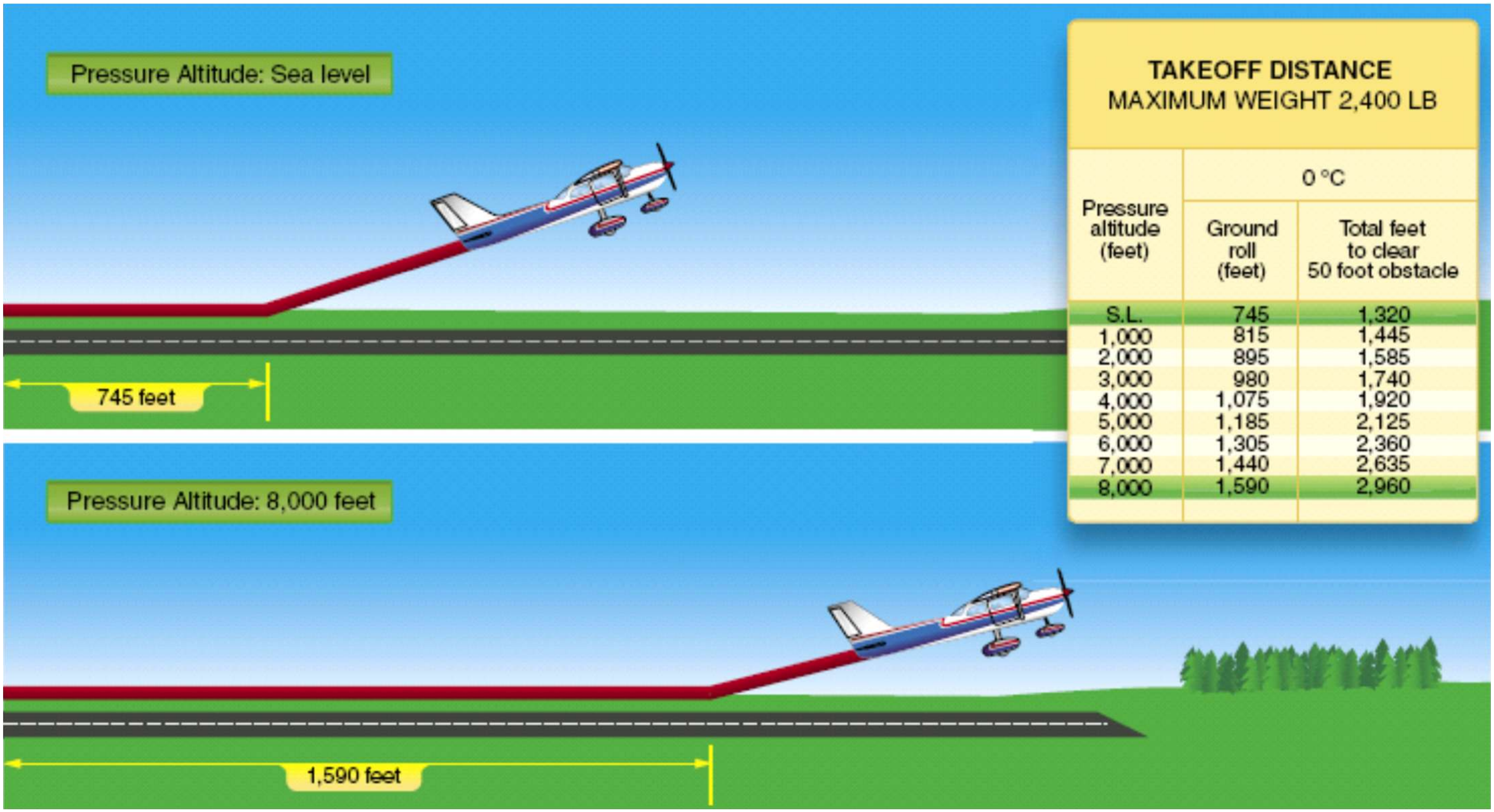


Figure 11-8. *Station pressure is converted to and reported in sea level pressure.*

Altitude and Flight

Altitude affects every aspect of flight from aircraft performance to human performance. **At higher altitudes, with a decreased atmospheric pressure, takeoff and landing distances are increased, as are climb rates**.

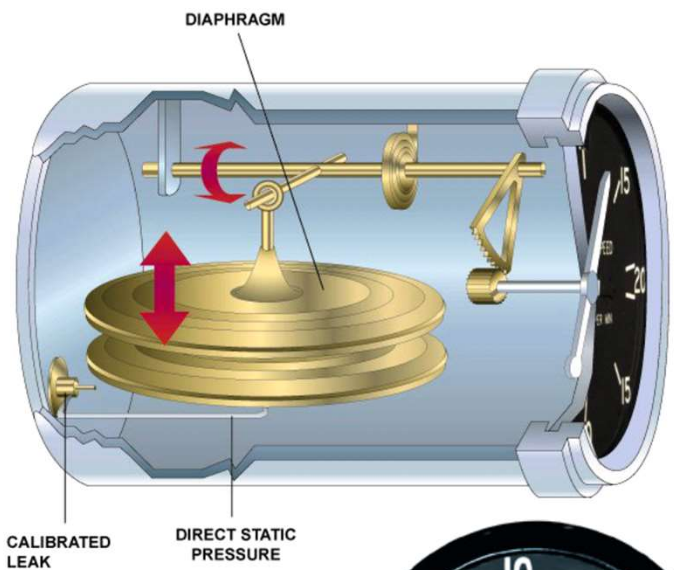
When an aircraft takes off, lift must be developed by the flow of air around the wings. If the air is thin, more speed is required to obtain enough lift for takeoff; therefore, the ground run is longer. An aircraft that requires 745 feet of ground run at sea level requires more than double that at a pressure altitude of 8,000 feet. [Figure 11-9]. It is also true that at higher altitudes, due to the decreased density of the air, aircraft engines and propellers are less efficient. This leads to reduced rates of climb and a greater ground run for obstacle clearance.



TAKEOFF DISTANCE
MAXIMUM WEIGHT 2,400 LB

Pressure altitude (feet)	0 °C	
	Ground roll (feet)	Total feet to clear 50 foot obstacle
S.L.	745	1,320
1,000	815	1,445
2,000	895	1,585
3,000	980	1,740
4,000	1,075	1,920
5,000	1,185	2,125
6,000	1,305	2,360
7,000	1,440	2,635
8,000	1,590	2,960

Flight Instruments: Pitot-Static System – Vertical Speed Indicator (VSI)



TREND INFORMATION ON CHANGE IN VERTICAL SPEED (rate of descent or climb in hundreds of feet per minute). Indicator not accurate until aircraft stabilized. There is a 6-9 second lag for stable pressure to give accurate reading. DON'T CHASE IT…

Flight Instruments: Gyroscopic

ATTITUDE INDICATOR

HEADING INDICATOR (DG)

TURN COORDINATOR

Attitude indicator shows a right turn

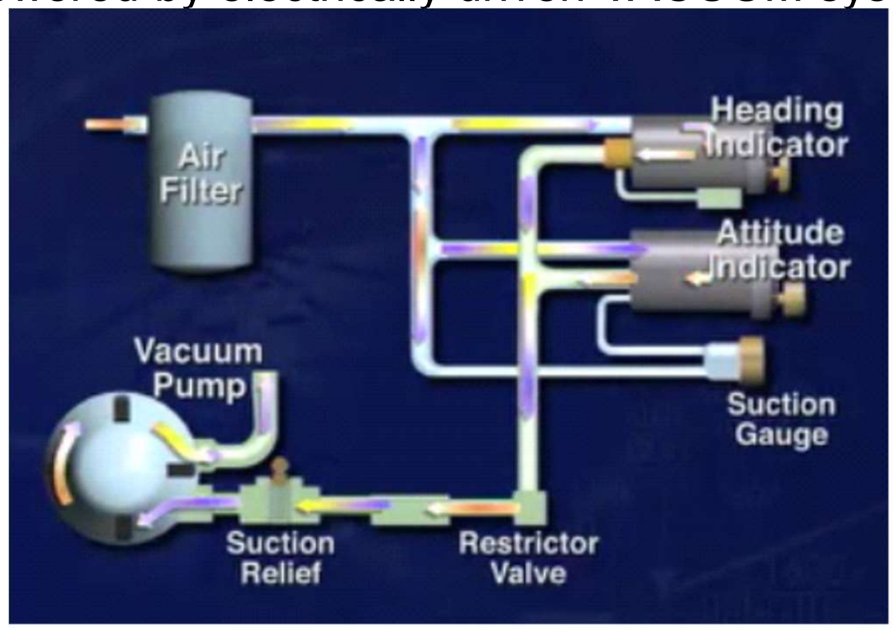
Turn coordinator indicates a right turn

Heading moves from northerly to easterly direction indicating a right turn

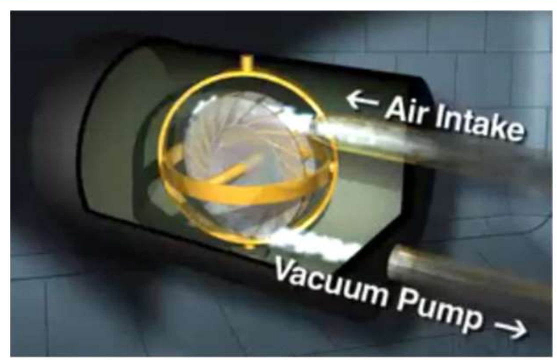
Flight Instruments: Gyroscopic Principles – Rigidity in Space and Precession

Rigidity: Tendency to remain in a constant position no mater what the orientation.

Powered by electrically driven VACUUM system



Precession: Small forces applied to a gyro will cause a resultant 90 degree force that is inversely proportional to the speed of the rotor and proportional to the deflective force.



Vacuum System Failure?

DISCUSSION

1. What are the chances of a vacuum system failure in your lifetime of flight?

   VERY LIKELY

2. IFR pilots are flying in conditions that require use of vacuum system instruments. You should **avoid being in IMC unless you are instrument rated**. What do you is the survival rate of pilots getting into IMC with a loss of the vacuum system?

   Only ***13%***

3. The key to surviving such an event is TRAINING. We react in emergencies in the manner of which we are trained. YOU MUST GET TRAINING TO HANDLE PARTIAL PANEL even if not IFR rated.

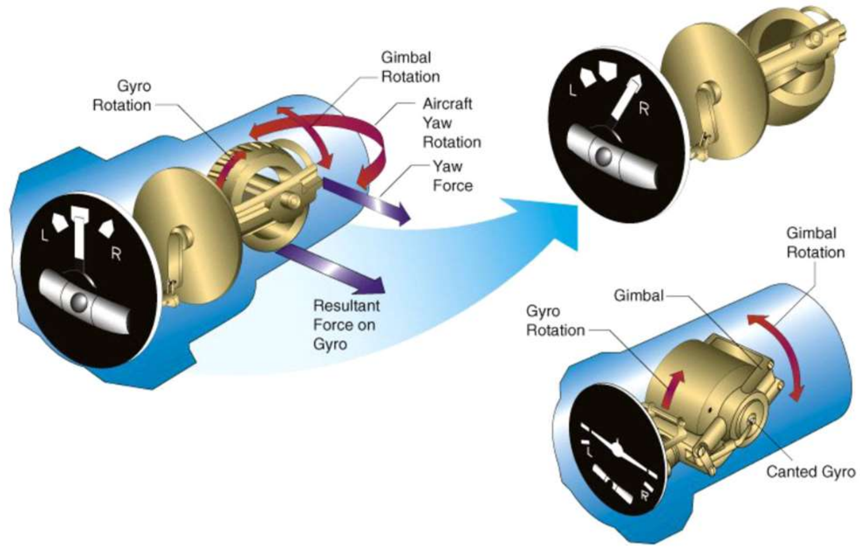
   INSIST you be taught use of Power Setting for controlled descents and airspeeds, and use of compass as only directional control.

4. Add ICING to that and without 2 instrument your toast! What might they be?

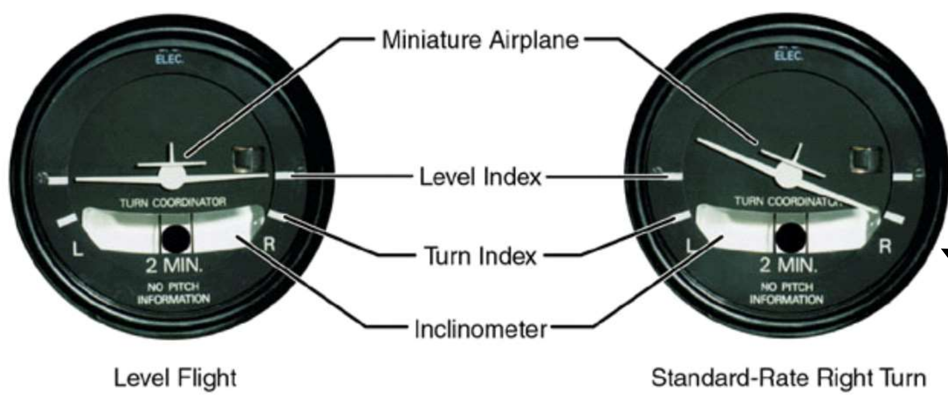
   Instrument covers to prevent DISORIENTATION, and consider a single-axis autopilot to keep wings level!

5. If using Foreflight consider Stratus with AHRS (Attitude Heading Reference System) as it can act as an artificial horizon should yours fail.

Flight Instruments: Gyroscopic
TURN COORDINATOR



Gyro driven by electrical or vacuum (pressure)

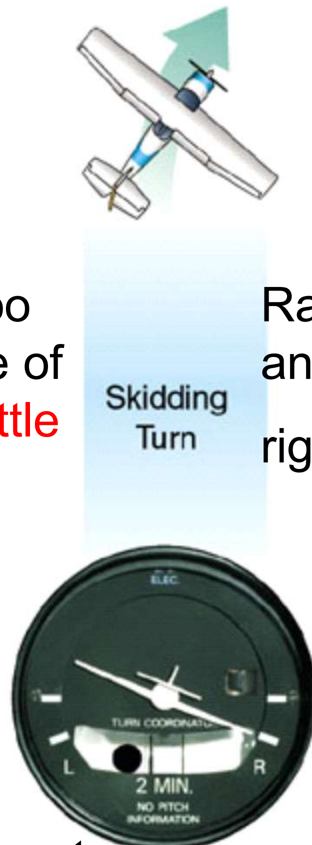


Standard rate turn-2 minutes

Flight Instruments: Gyroscopic
TURN COORDINATOR

Rate of turn too slow for angle of bank. ☹ Too much bank (roll)

Rate of turn too great for angle of bank. ☹ Too little bank (roll)

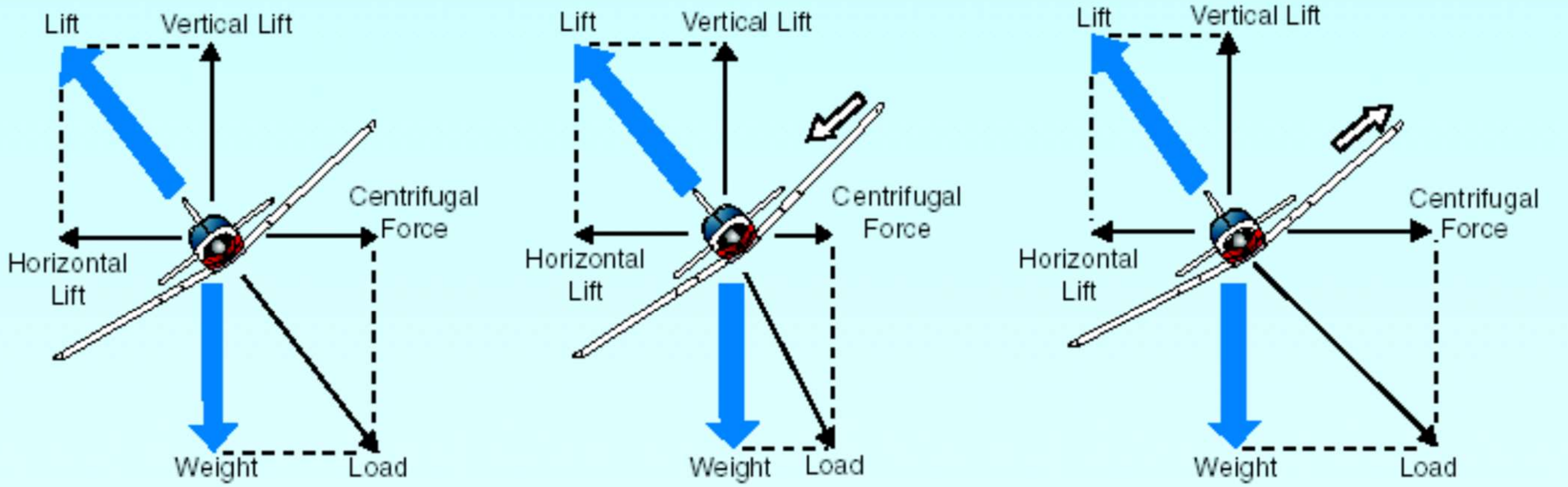


Rate of turn and angle of bank just right ☺

Vary rate of turn or "Step On the Ball"

Created by Steve Reisser

AERODYNAMICS OF SLIPS AND SKID



1. Normal Turn:
   Centrifugal Force Equals Horizontal Lift.
2. Slipping Turn:
   Centrifugal Force Less Than Horizontal Lift.
3. Skidding Turn:
   Centrifugal Force Greater Than Horizontal Lift.

Don't let this confuse you...
The turn and bank indicators
Show what the pilot observes →
Slip (slipping down to right)
Skid (skipping out to left)

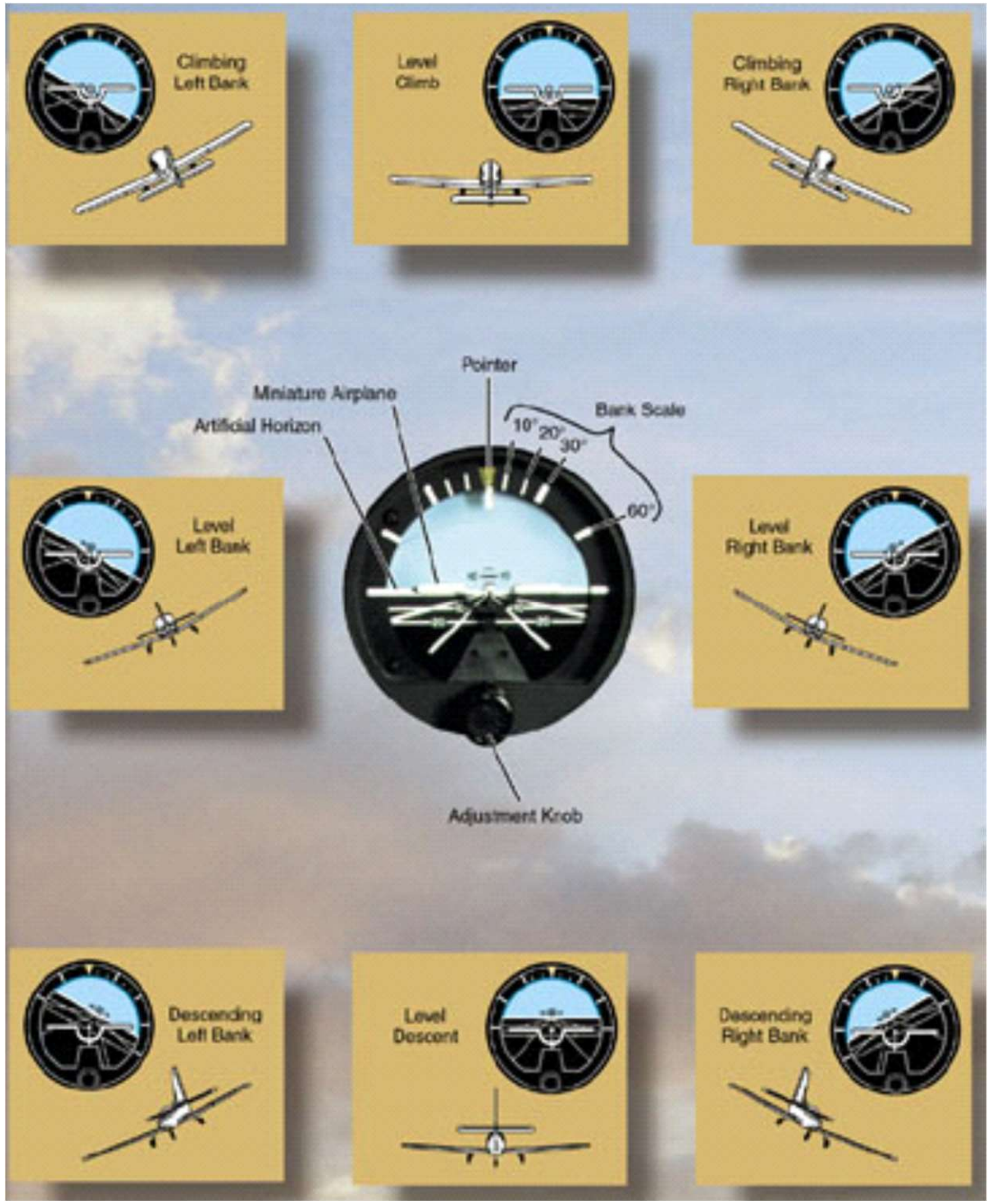
Standard Rate Turns

- Two Minute Turn (3 degrees per second)
- Always use Turn and Bank Indicator as your "primary" reference for standard rate turns !!
- You can determine the angle on the "Attitude Indicator" by a mental calculation of

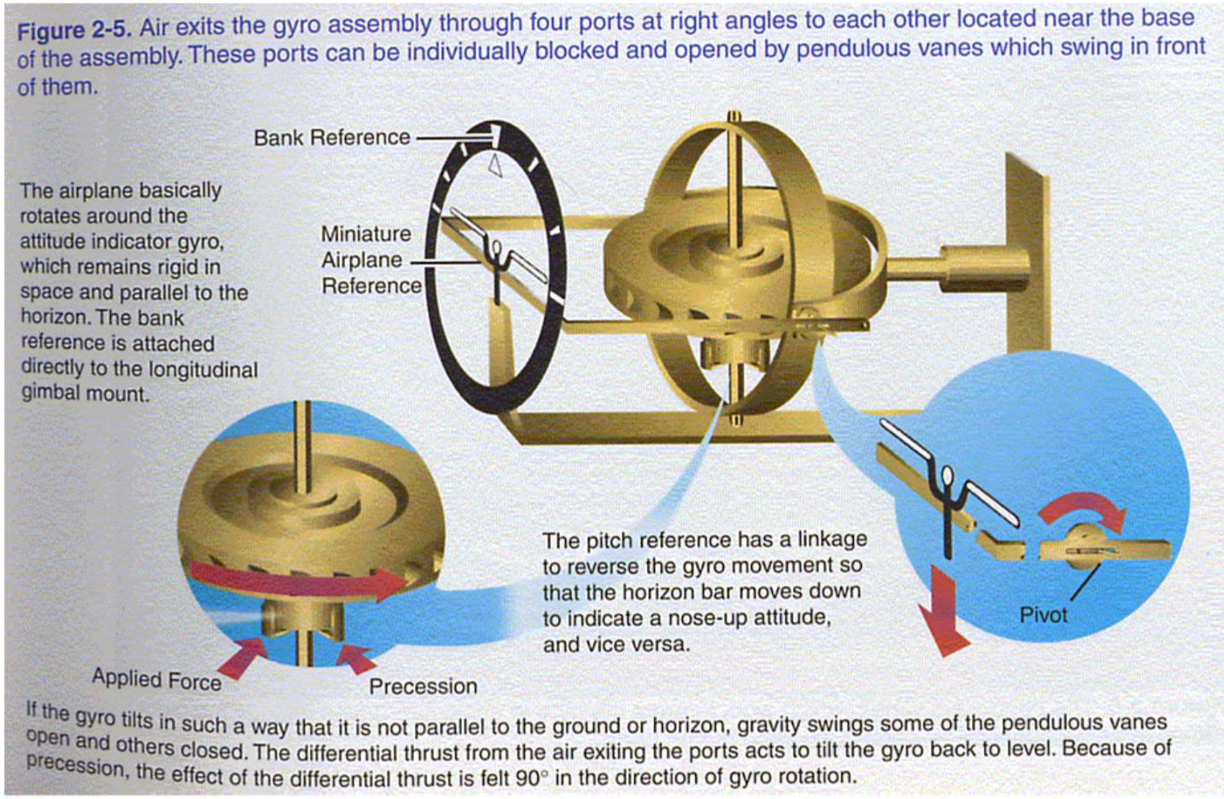
Airspeed / 10 * 1.5

TAS 80/10 = 8*1.5= 12 degrees
TAS 100 /10 = 10*1.5= 15 degrees
TAS 120 /10 = 12*1.5= 18 degrees
TAS 160 /10 = 16*1.5= 24 degrees

ATTITUDE INDICATOR also referred to as the Artificial Horizon



Flight Instruments: *<u>Mechanical</u>* Gyroscopic Attitude Indicator



LIMITS:

- Roll = 60-70 degrees and Pitch = 100-110 degrees after which the gyro will become *caged* and require service to unseat the gyros.
- Might be a “slight” nose-up indication in rapid acceleration or nose-down indication on rapid deceleration.
- There is a slight chance of a small bank or pitch error following a 180 degree turn that will correct itself after about a minute of straight and level flight.

Attitude Determination

Mechanical attitude reference (shown on the previous page)

Heavy & big

Expensive to maintain

Dependent on vacuum system

Susceptible to mechanical failure (caging)

Non-mechanical attitude reference

GPS derived and 3-axis inferrometer gyroscopes, accelerometers, and magnetometers. Senses of position, speed, G-Forces

Inexpensive

Generally accurate

Much lighter than mechanical

Mobile: iPhone, iPad and integrated Apps

AHRS: Attitude Heading Reference System (3-axis laser inferrometer)

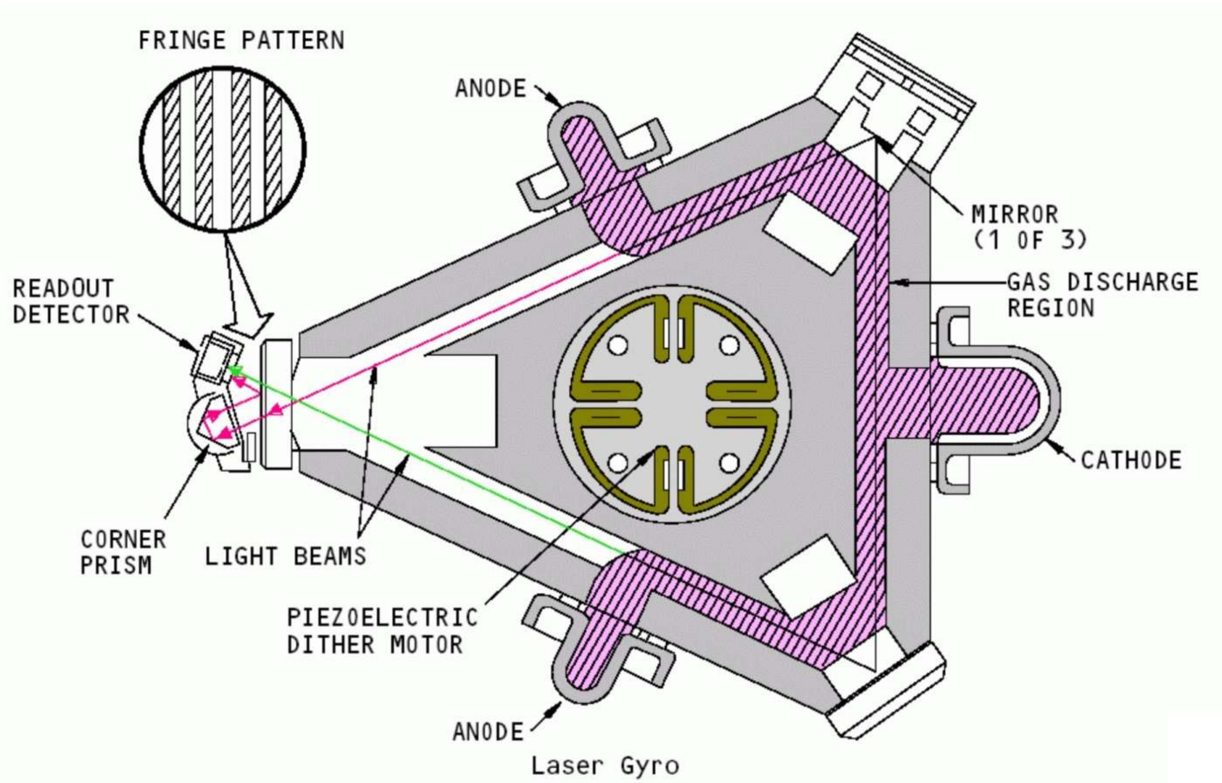
Inexpensive

Lightweight & Small

VERY accurate

Attitude Heading Reference System: AHRS

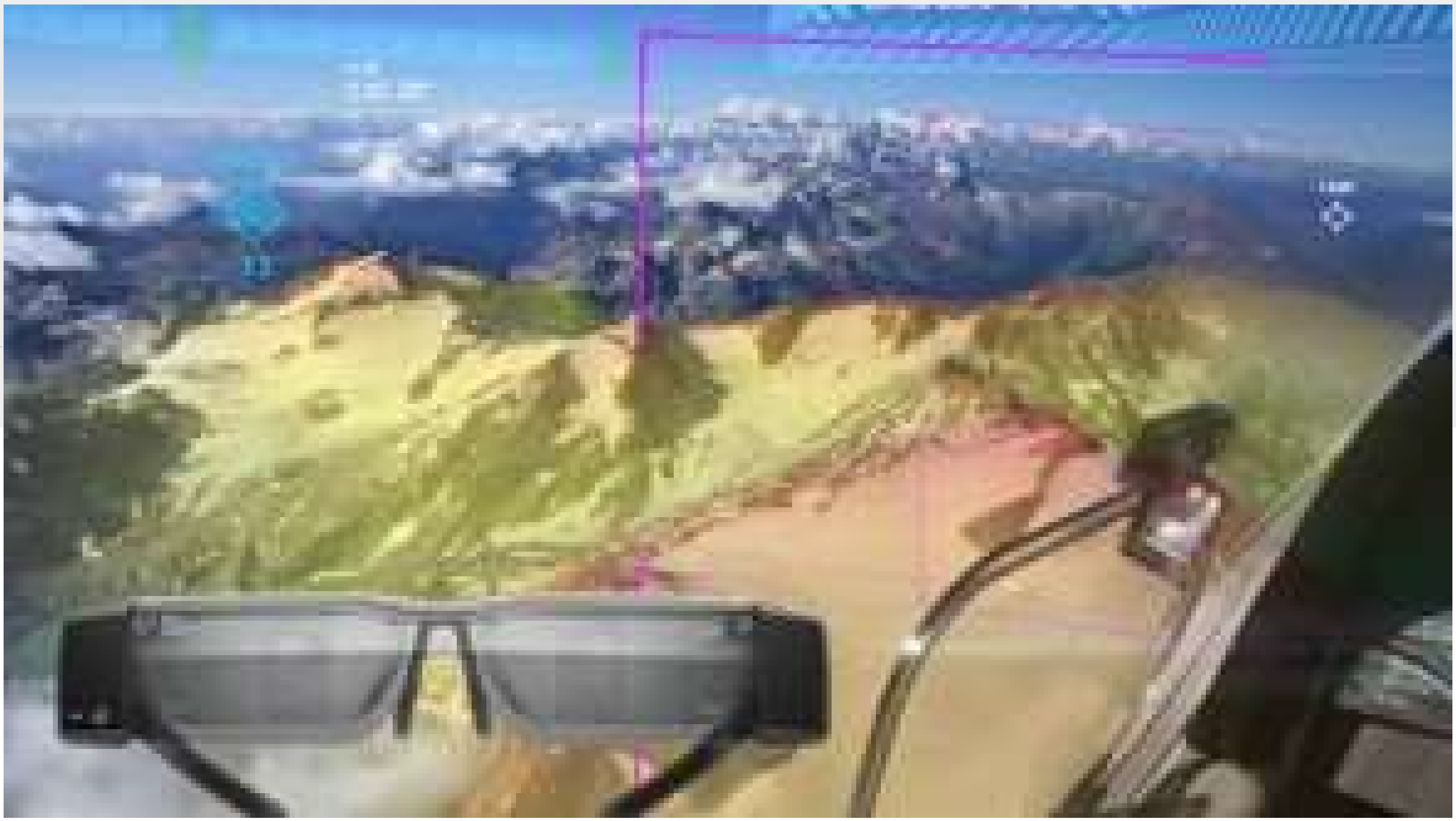
Video. iLevel http://youtu.be/1BVY7k3yeJc



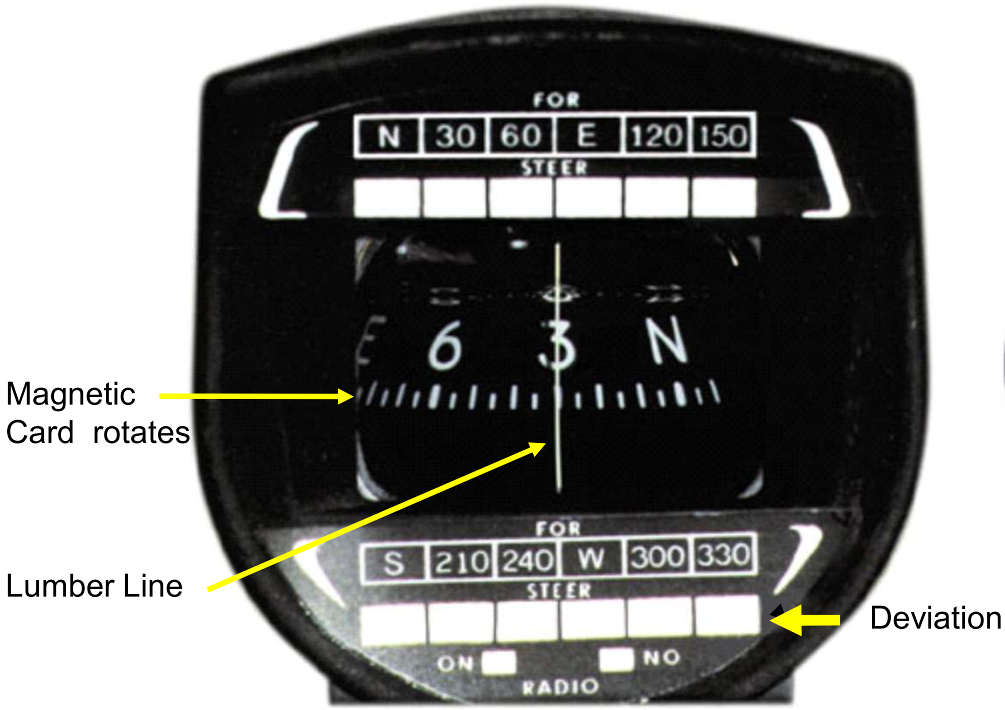
Stratus 2: http://youtu.be/Ijf8rOMq_nE

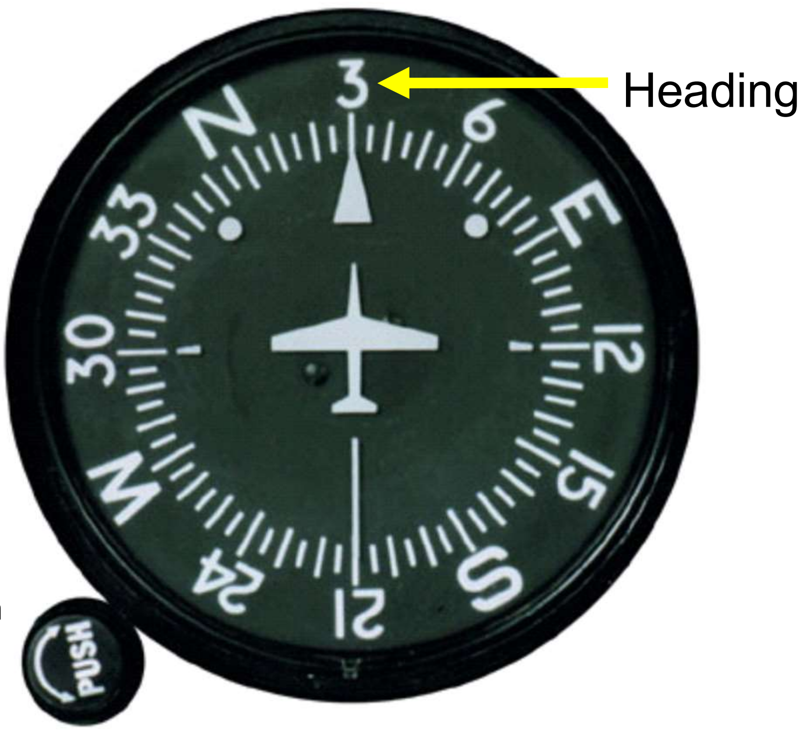
Augmented reality glasses for pilots!

Aero Glass showcased Augmented reality glasses for pilots using Epson's Moverio technology and Google Glass. The glasses display a virtual reality, in 360 degrees of view, showing victor airways, flight instrumentation, approaches and 3D airspace. When connected to an iLevil receiver, the glasses portray ADS-B information (traffic and weather) and uses the remote AHRS to display the attitude of your aircraft as a HUD! https://glass.aero/



Flight Instruments:
HEADING INDICATORS





NON-GYROSCOPIC: <u>Magnetic Compass</u>. Accurate in straight and level, non-accelerated flight.

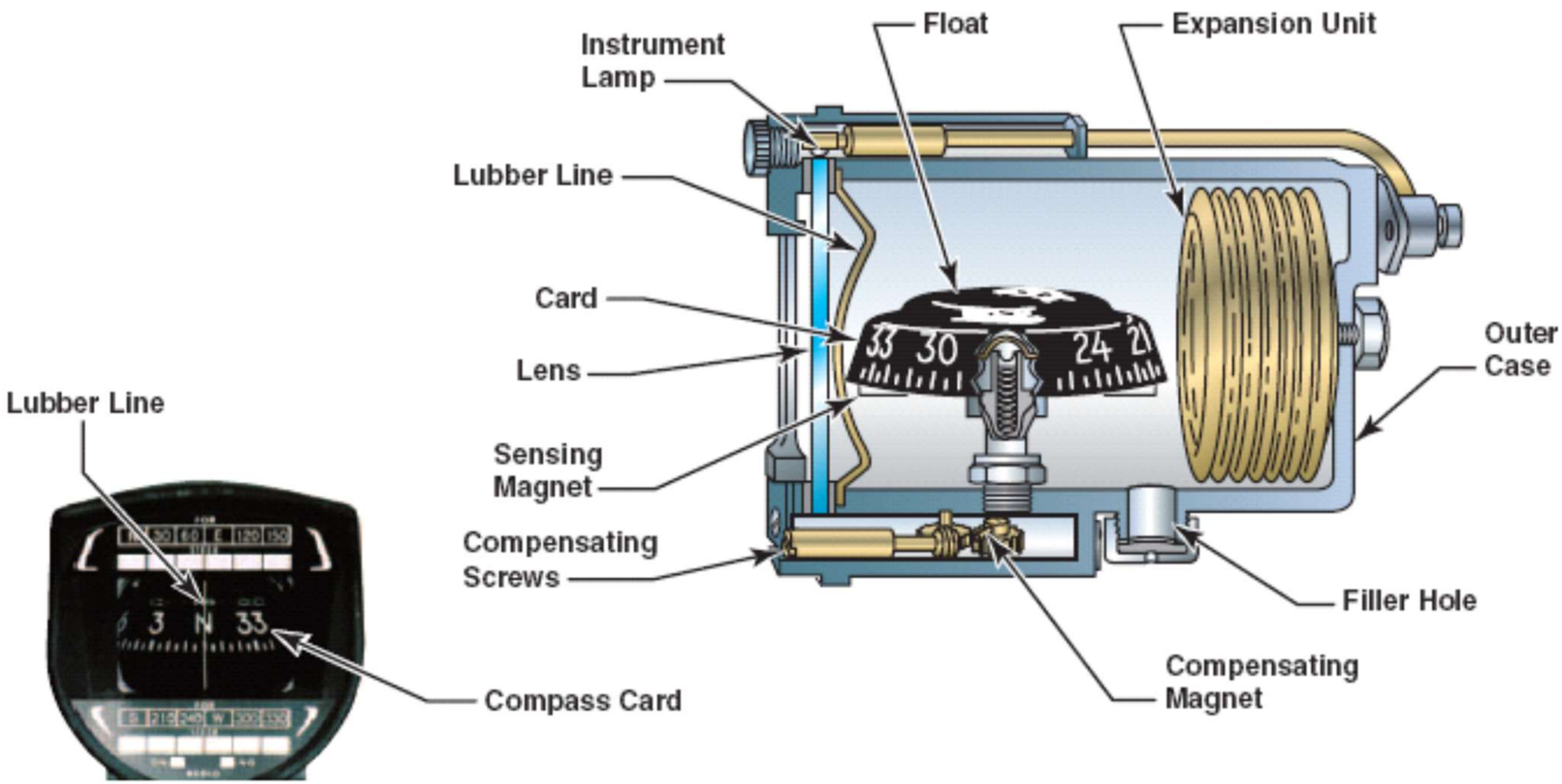
GYROSCOPIC: <u>Heading Indicator</u> also referred to as the Directional Gyro. Adjust with Magnetic Compass every 15 minutes during flight.

Created by Steve Reisser

Limitations of Gyroscopic Heading Indicator (Directional Gyro)

- On SOME older heading indicators, the limits are approximately 55 degrees of pitch and 55 degrees of bank.
- When exceeded the instrument “tumbles” or “spills” and no longer gives correct indication until reset.
- Many modern DGs will not tumble
- MUST re-align to COMPASS during straight and level flight because precession caused by friction may cause as much as 15 degree error every hour.

Magnetic Compass



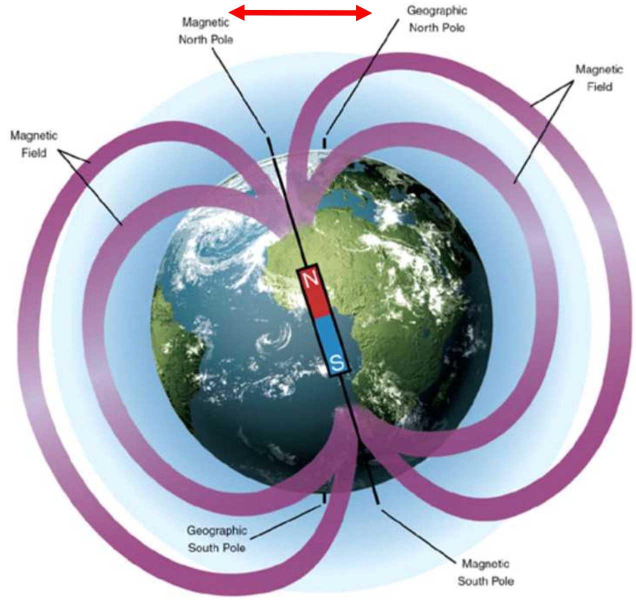
Floats in a solution of white kerosene

Note: Sensing Magnet positioned differently for Northern and Southern Hemisphere
360 Northern 180 Southern

Flight Instruments:

Magnetic Variation & Deviation

Variation: difference in True North and Magnetic North

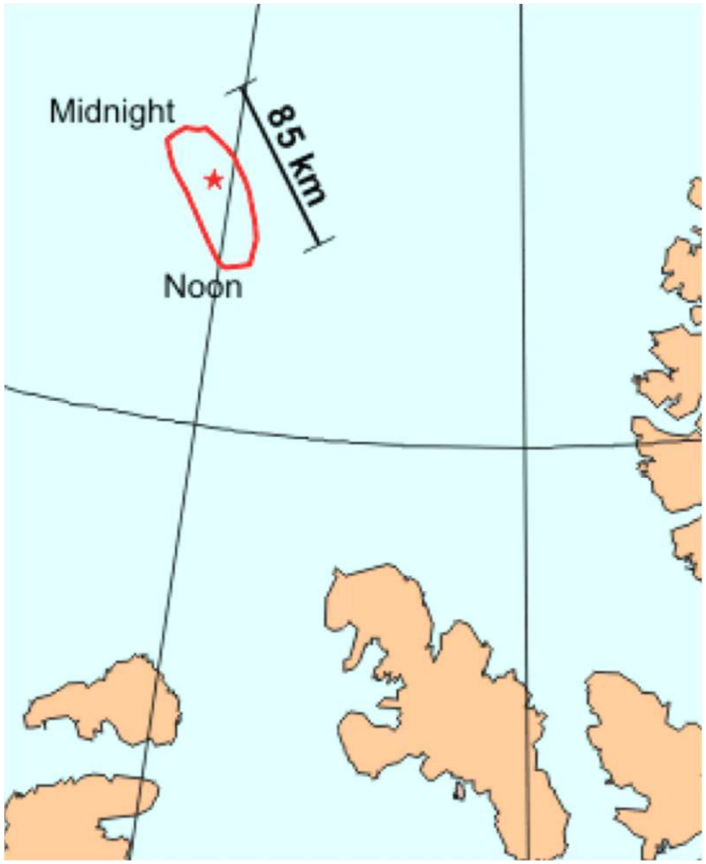


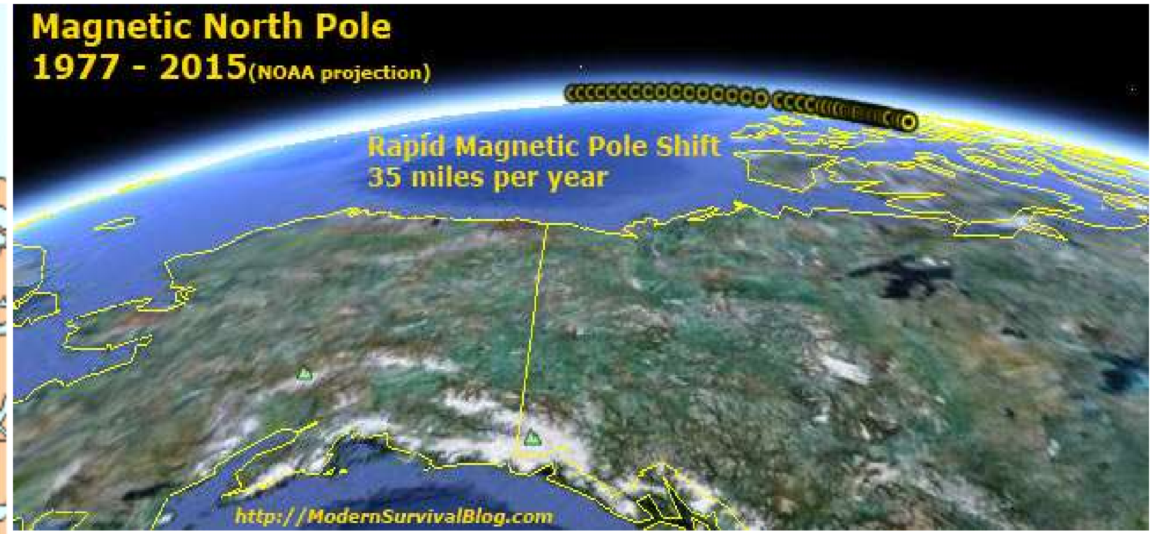
Deviation: Instrument error displayed on Magnetic Compass and aircraft documents (POH)

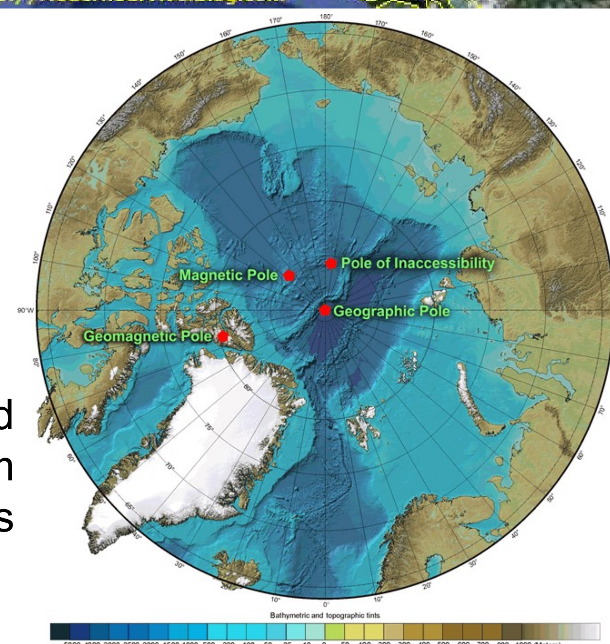
FOR (MH)	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
STEER (CH)	359°	30°	60°	88°	120°	152°	183°	212°	240°	268°	300°	329°
RADIO ON ☑						RADIO OFF ☐						

Where is Magnetic North?

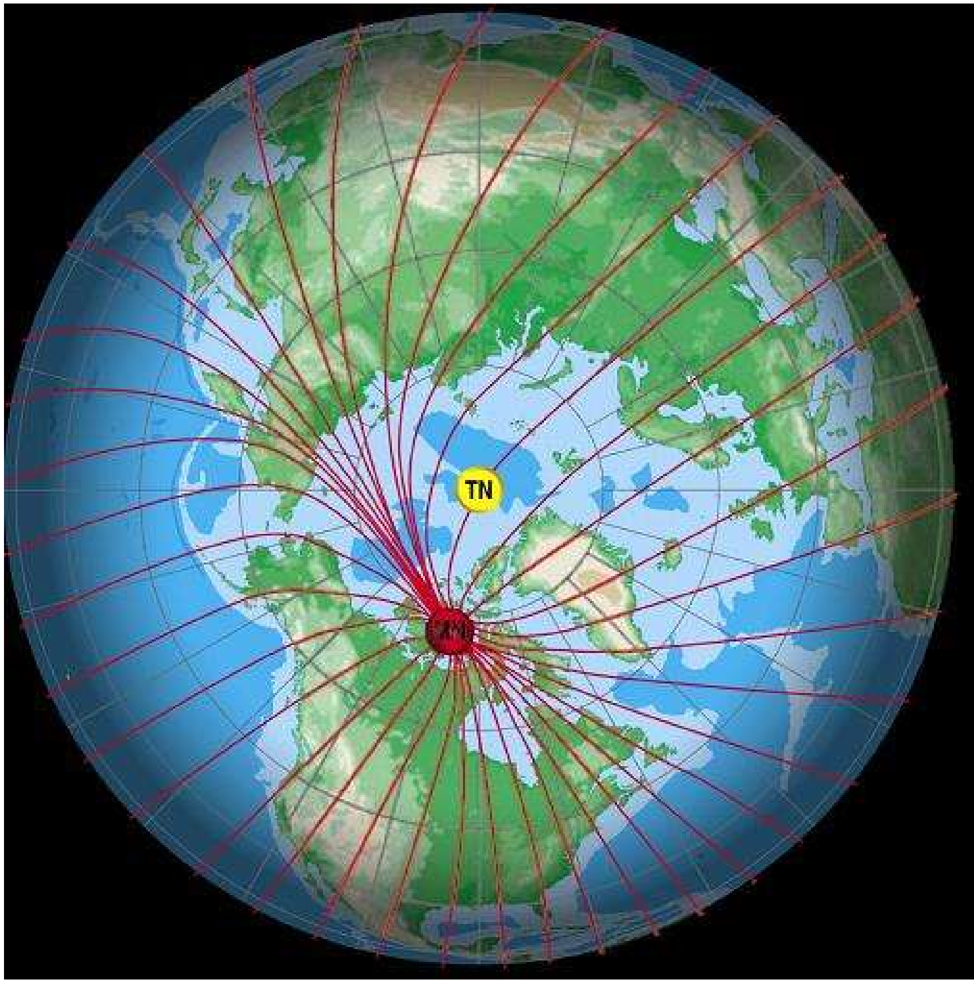
- Variation is the difference is position between True North (The North Pole) and Magnetic North Pole. NOT THE SAME – Moves daily and annually!





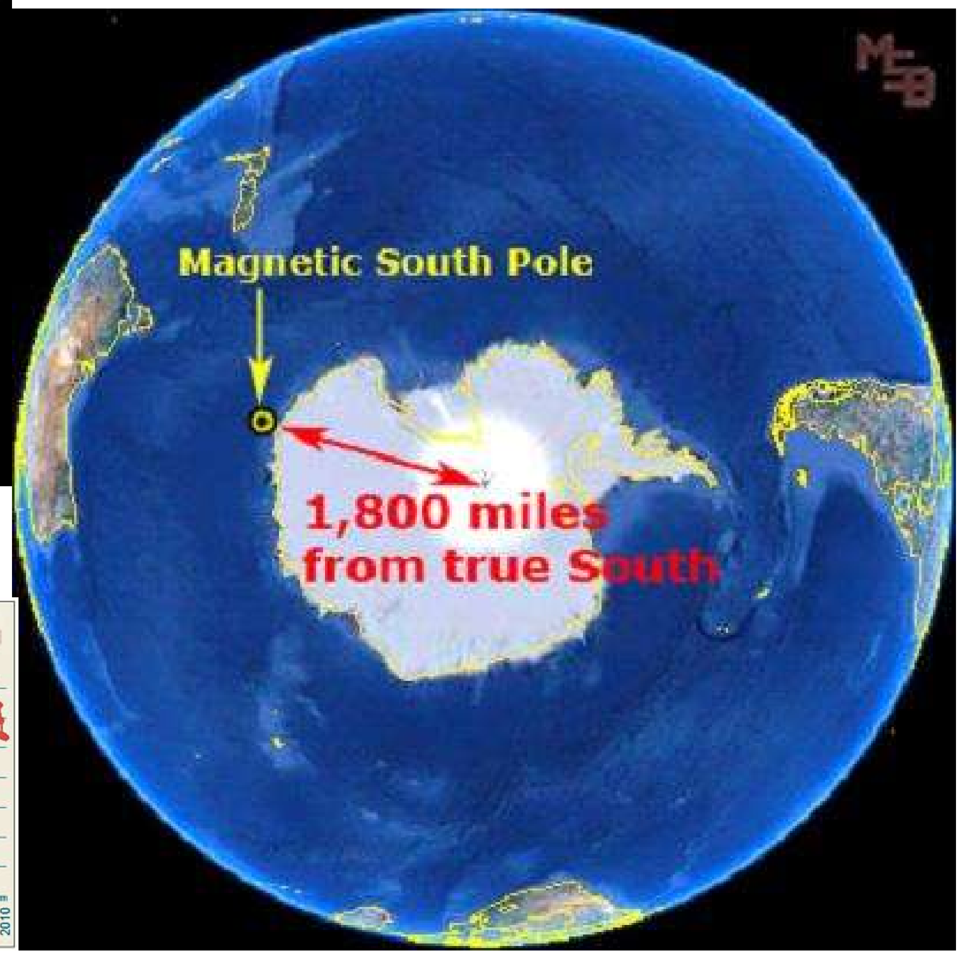


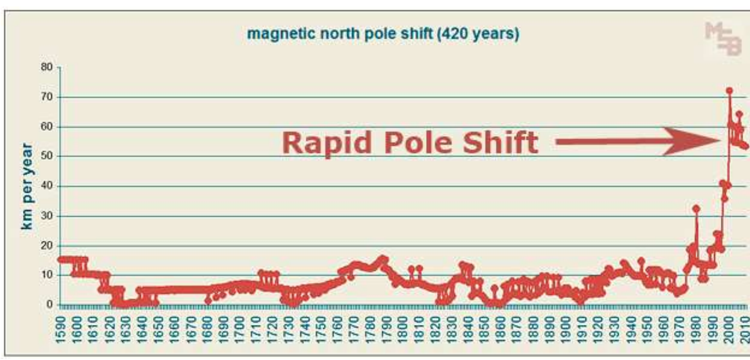
Just to add to the complexity there is a "Magnetic" and a "Geomagnetic" Pole which are both different from the "Geographic"-True North Pole. Offset 11 degrees



NORTHERN HEMISPERE

SOUTHERN HEMISPERE





Flight Instruments: Magnetic Compass Errors

Variation, Deviation, Oscillation

Variation: Difference in Magnetic / True North
Deviation: Electrical interference from aircraft
Oscillation: Rough handling or turbulence

Magnetic Dip

Magnetic dip is the result of the vertical component of the Earth's magnetic field. This dip is virtually non-existent at the magnetic equator. The vertical component increases at higher latitudes. DIP ERRORS are responsible for compass errors in acceleration, deceleration and turns. Magnetic bar is weighted to reduce dipping that is strongest at the poles and least at equator.

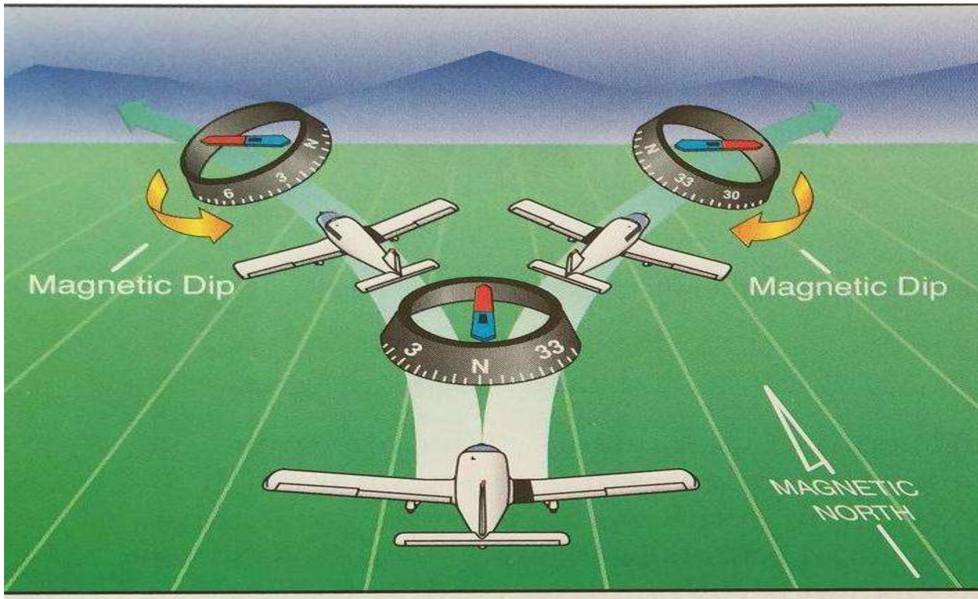
Acceleration - Deceleration

Deviates NORTH when accelerating, and Deviates SOUTH when decelerating. **On EASTERLY or WESTERLY HEADINGS.** "**ANDS**" (**Accelerate North Decelerate South**)

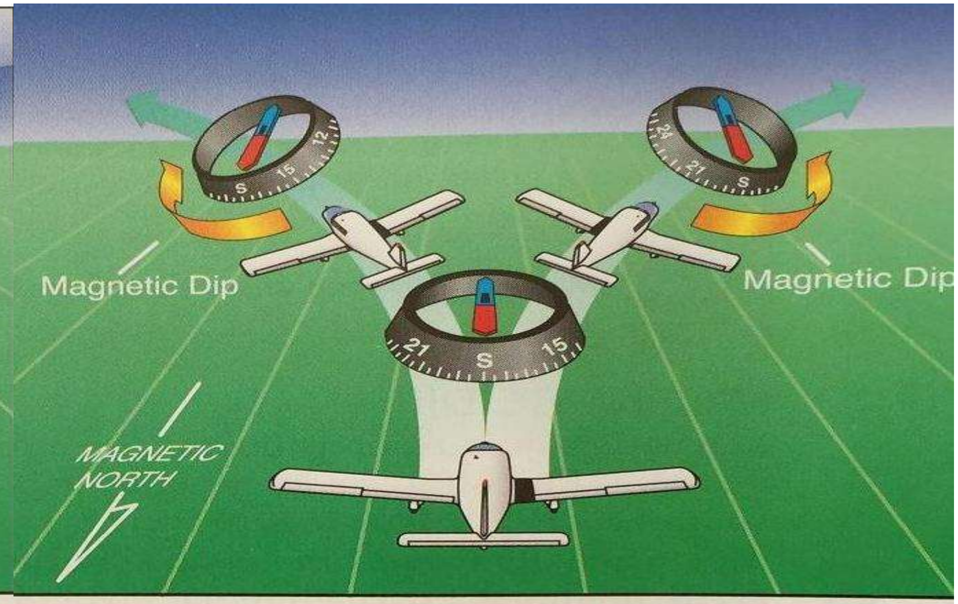
Deviation turning FROM North or South Heading (Undershoot North, Overshoots South … UNOS-OSUN

Turning Errors

Created by Steve Reisser



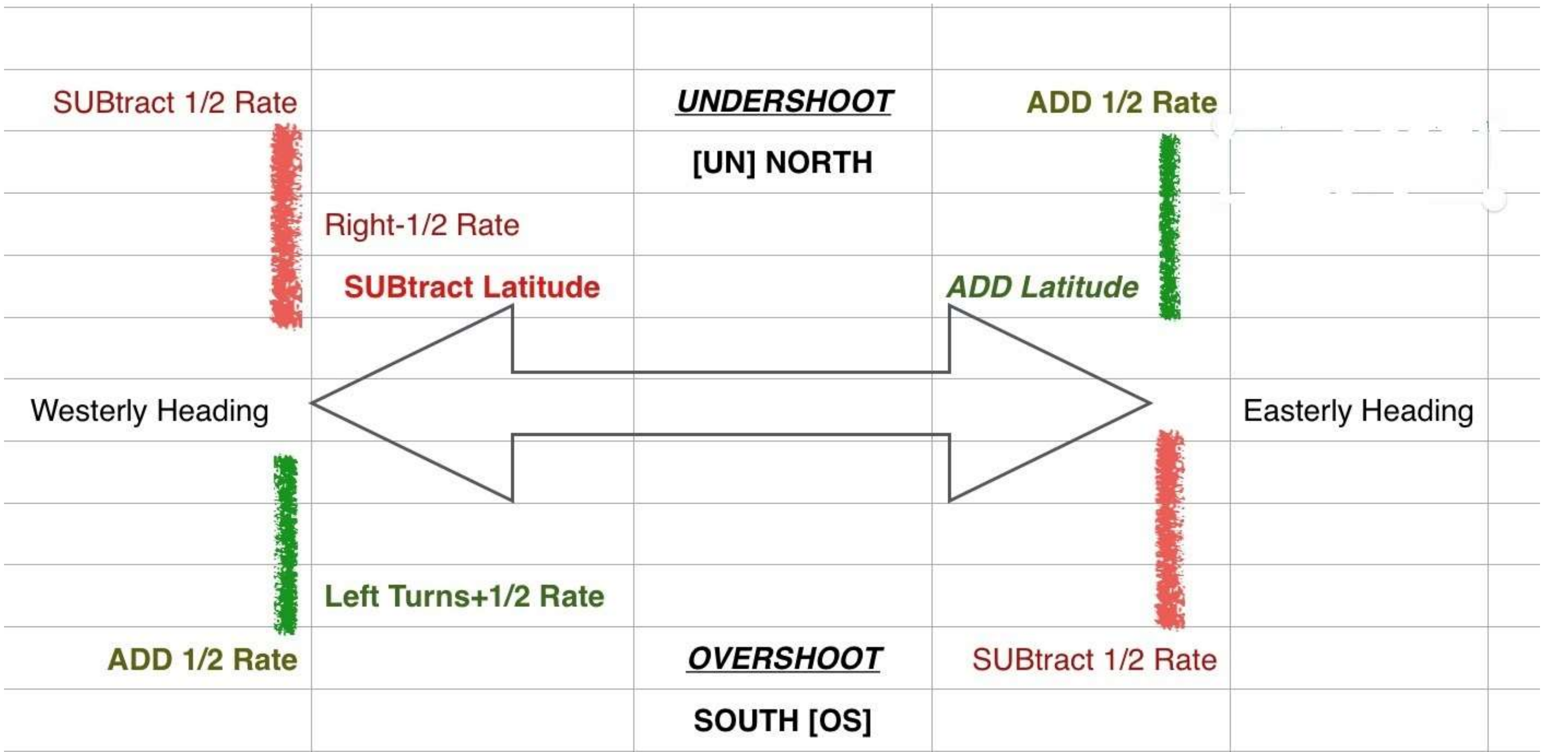
In the northern hemisphere, when entering a turn from a north heading, the compass will initially indicate a turn in the opposite direction.



When entering a turn from a south heading, the compass will turn in the proper direction, but will lead the turn until on a heading of east or west.

It is essential you use standard-rate turns if relying on the magnetic compass. When performing a compass turn to a northerly heading, you must roll out of the turn before the compass reaches the desired heading. When turning to a southerly heading, you must delay the roll-out until the compass card swings past the desired heading. When determining whether to lag or lead the desired heading on roll-out, remember the acronym, OSUN (Overshoot South, Undershoot North). The amount of correction depends on your latitude and angle of bank. With 15° to 18° bank (a standard-rate turn in a typical piston-powered airplane), the amount of lag or lead approximately matches your latitude, plus the one-half angle of bank you lead the roll-out on any turn. For example, at 35° N latitude and a 16° bank, a right turn to north requires a roll-out point of 317° (360 – 35 – 8). A right turn to south requires a roll-out point of 207° (180 + 35 – 8). When turning left to a north heading the roll-out point is 43° (360 + 35 + 8). When turning left to a south heading it is 153° (180 – 35 + 8).

Instrument Students: This helps visualize precision instrument turns using only the magnetic compass.



Heading	Turning	Latitude +/-	1/2 Rate +/-
East	Left to North	+	+
East	Right to South	+	-
West	Right to North	-	-
West	Left to South	-	+

PITCH, BANK, AND POWER INSTRUMENTS


Altimeter primary for pitch control


Heading indicator primary for
bank control


Airspeed indicator primary for
power control


Proper pitch and power
produces predictable performance

Climbing – On Take off useV_X and V_Y.

Start to Level off when at 10% of rate of climb depending on your airspeed.

Digital Based Instrument Systems

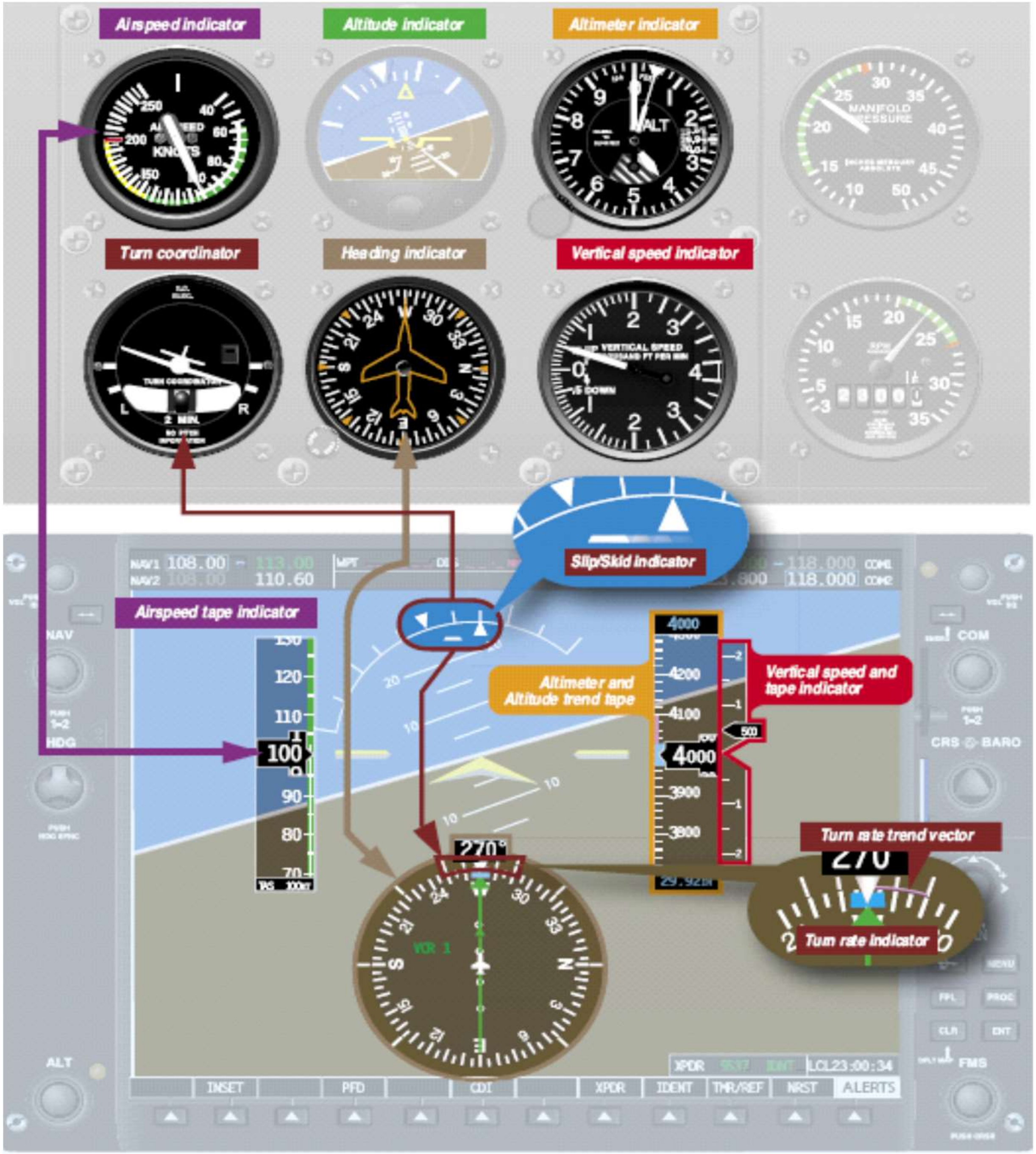
Instrumentation changes are in process to digital based information and displays.

- Electronic Flight Information Systems / Primary Flight Displays (EFIS-MFD)
- Engine Monitoring Systems (EMS)
- Synthetic Vision Systems (SV)
- Automatic Dependent Surveillance Broadcast (ADS-B)
- Global Positioning Systems (GPS)

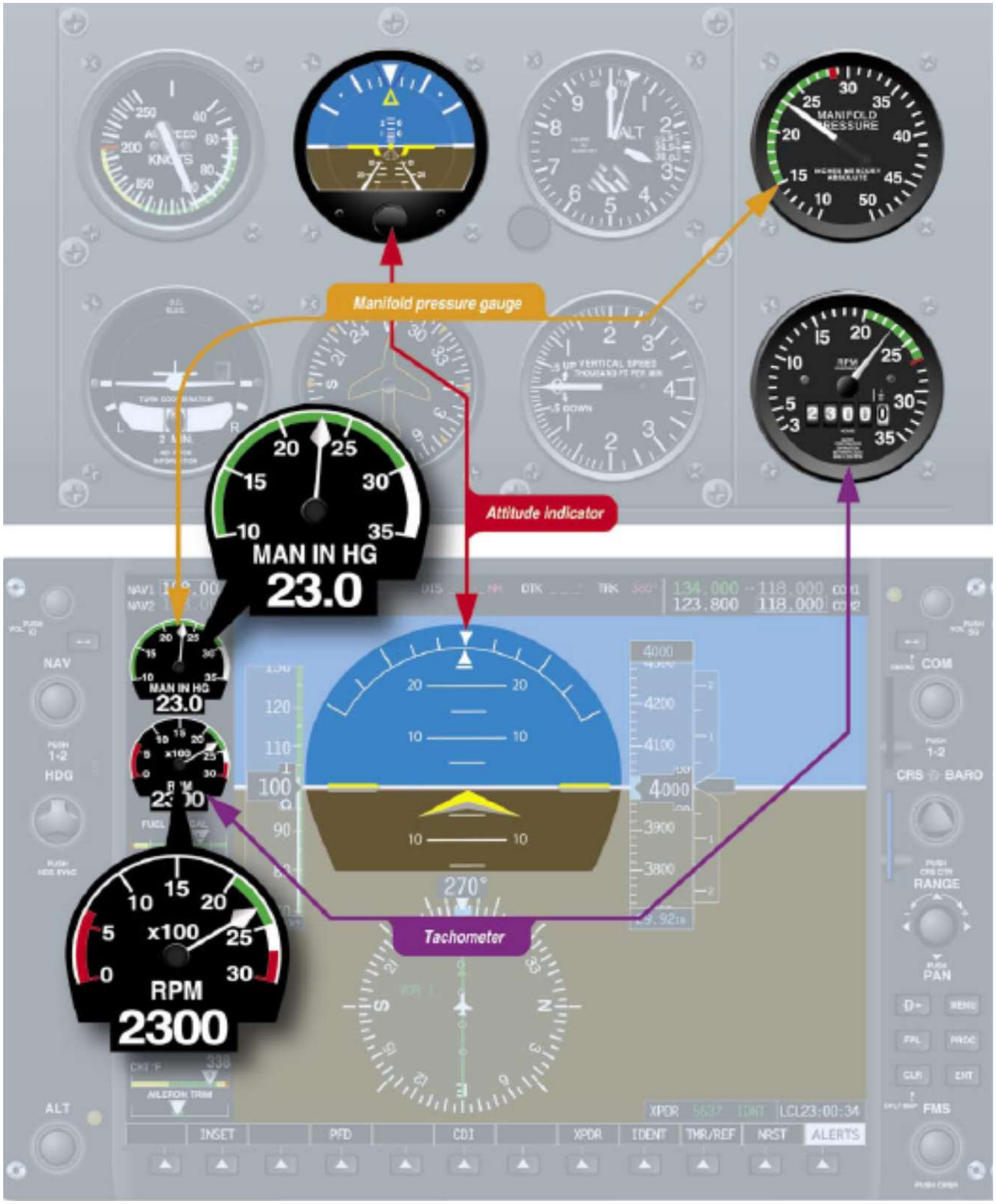
Example 1

"Six-pack"

Equivalent Digital



Example 2



Manifold pressure gauge
Attitude indicator
Tachometer
MAN IN HG
23.0
RPM
2300

EFIS/PFD/MFD/GDU

Electronic Flight Information Systems / Primary Flight Displays / Multi-Function Displays/Graphic Display Units

Global Positioning Satellites (GPS)

<u>GPS Positioning</u>

GPS is “line of site” a satellite-based system requiring approximately 60 seconds to acquire satellite acquisition. (e-GPS as initially used by mobile devices can triangulate from cell towers which is why you can see 2-dimensional triangulation before 60 seconds).
VFR flights may use portable, mobile, GPS (not e-GPS) as primary navigation. A portable GPS may not be used for primary navigation in IFR flights.

There are 5 satellites required for what activity?

The following 3 slides apply to <u>Commercial and future Instrument students</u>.

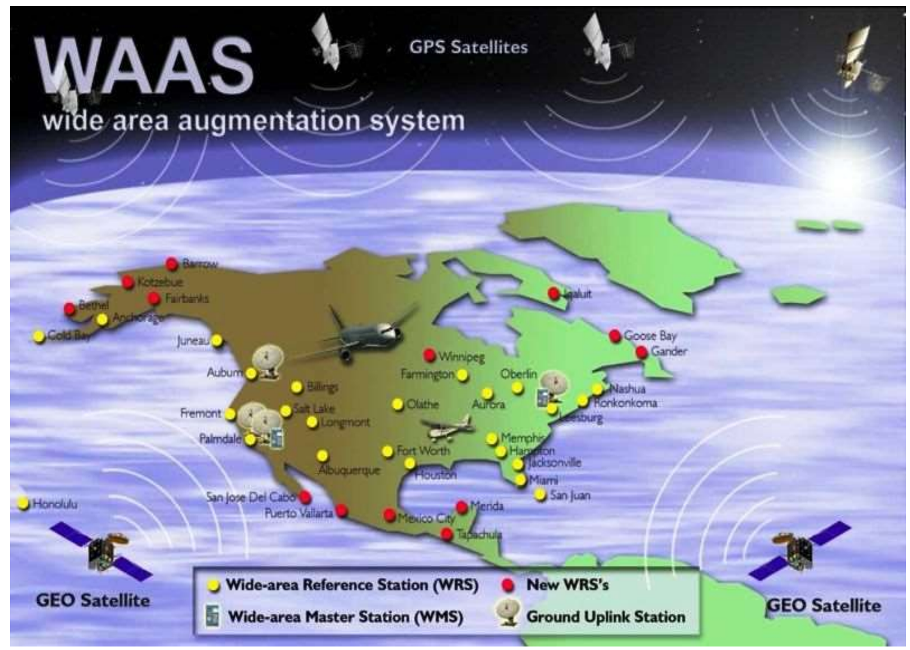
Flights into known *Instrument Meteorological Conditions* have additional requirements to utilize GPS as primary navigation.

The GPS devise is **panel mounted** (portables not allowed)

1. **External GPS antenna** is required do to changes roll and pitch maneuvers during maneuvering and landing. You cannot lose line of site connection with satellites.
2. You have acquired <u>at least **5** satellites</u>,
3. Your equipment utilizing both *<u>Wide Area Augmentation System (**WAAS**)</u>* and *<u>Receiver autonomous integrity monitoring (**RAIM**)</u>*.

<u>Wide Area Augmentation System (WAAS)</u>

WAAS uses a network of ground-based reference stations, in North America and Hawaii, to measure small variations in the GPS satellite signals in the western hemisphere. Measurements from the reference stations are routed to master stations, which queue the received Deviation Correction (DC) and send the correction messages to geostationary WAAS satellites in a timely manner (every 5 seconds or better). Those satellites broadcast the correction messages back to Earth, where WAAS-enabled GPS receivers use the corrections while computing their positions to improve accuracy.



Navigation System Accuracies

System	95% Accuracy (Lateral / Vertical)	Details
LORAN-C Measured	50 m / 50 m	The U.S. Coast Guard reports "return to position" accuracies of 50 meters in time difference
GPS Measured	2.5 m / 4.7 m	The actual measured accuracy of the system (excluding receiver errors), with SA turned off, based on the findings of the FAA's National Satellite Test Bed, or NSTB.
WAAS Measured	0.9 m / 1.3 m	The actual measured accuracy of the system (excluding receiver errors), based on the NSTB's findings.
Local Area Augmentation System (LAAS)	< 1 m	The goal of the LAAS program is to provide Category IIIC ILS capability. This will allow aircraft to land with zero visibility utilizing 'autoland' systems and will indicate a very high accuracy of < 1 m

Receiver Autonomous Integrity Monitoring (RAIM)

Provides integrity monitoring of GPS for aviation applications. In order for a GPS receiver to perform RAIM **or fault detection (FD) function**, a minimum of five visible satellites with satisfactory geometry must be visible to it. RAIM has various kind of implementations; one of them performs consistency checks between all position solutions obtained with various subsets of the visible satellites. The receiver provides an alert to the pilot if the consistency checks fail.

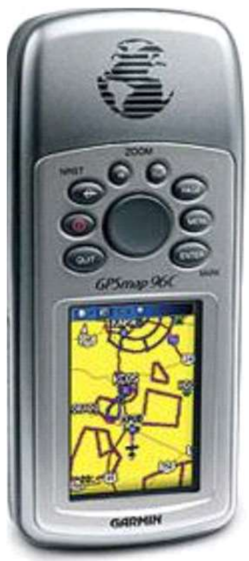
RAIM detects faults with redundant GPS "pseudorange" measurements. That is, when more satellites are available than needed to produce a position fix, the extra pseudoranges should all be consistent with the computed position. A pseudorange that differs significantly from the expected value (i.e., an outlier) may indicate a fault of the associated satellite or another signal integrity problem (e.g., ionospheric dispersion). Traditional RAIM uses fault detection (FD) only, however newer GPS receivers incorporate fault detection and exclusion (FDE) which enables them to continue to operate in the presence of a GPS failure.

The pseudorange (from pseudo- and range) is the *pseudo* distance between a satellite and a navigation satellite receiver (see GNSS positioning calculation) —for instance Global Positioning System (GPS) receivers, by multiplying the speed of light by the time the signal has taken from the satellite to the receiver. As there are accuracy errors in the time measured, the term *pseudo*-ranges is used rather than ranges for such distances.

ERROR detection alerts pilots of integrity problems

PFD/MFD

Prices range from $495 on bottom row to $30,000 above (2009 pricing)



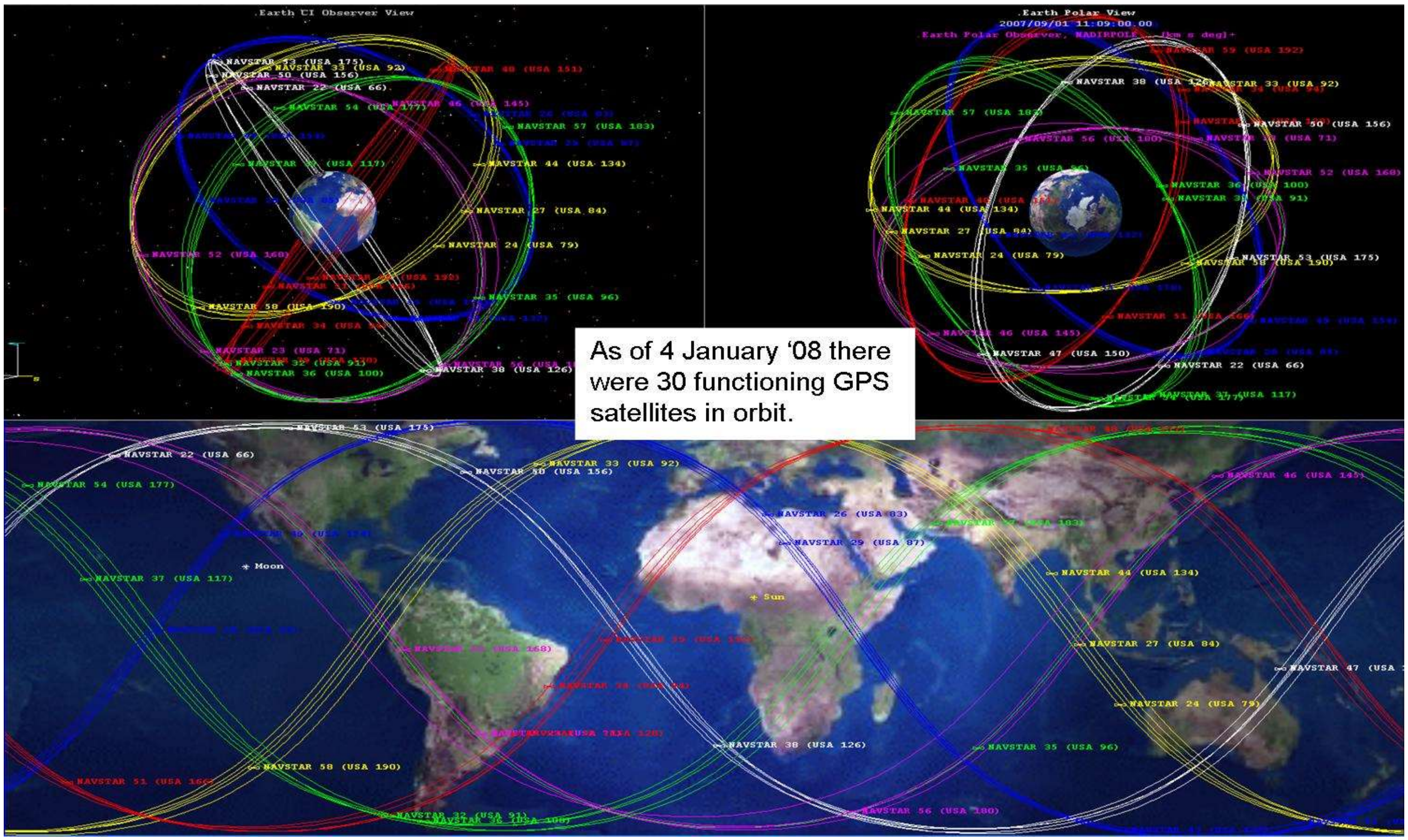
GPS Positioning

GPS is "*line of site*" a satellite-based system requiring approximately 60 seconds to acquire satellite acquisition. (e-GPS as initially used by mobile devices can triangulate from cell towers which is why you can see 2-dimensional triangulation before 60 seconds).

VFR flights may use portable, mobile, GPS (not e-GPS) as primary navigation. A portable GPS may not be used for primary navigation in IFR flights.

Otherwise:

1. For 2-dimensional positioning your GPS devises must have acquired at least 3 satellites.
2. For 3-dimensional positioning your GPS devises must have acquired at least 4 satellites.



EMS
Engine Monitoring System

Synthetic Vision Systems

Primary Flight Display OVERLAYED with real time graphic of outside conditions regardless of visibility. Can be panel mounted or used with Tablet Personal Computer OR projected onto the back of the spinning propeller so directly viewed by pilot looking out the windshield.

Primary Flight Display OVERLAYED with real time graphic of outside conditions regardless of visibility. Can be panel mounted or used with Tablet Personal Computer OR projected onto the back of the spinning propeller so directly viewed by pilot looking out the windshield.

[Infrared Display for enhanced Night Flights]

[EFIS Runway Seeker]

Flight Director System (FDS)

A Flight Director System (FDS) combines many instruments into one display that provides an easily interpreted understanding of the aircraft's flightpath. *The computed solution furnishes the steering commands necessary to obtain and hold a desired path. They become exceptionally powerful when coupled to the autopilot and attenuator panel*.

FDI(ADI) "yellow bar"

Figure 5-39. *A typical cue that a pilot would follow.*

Figure 5-40. *Components of a typical FDS.*

Major components of an FDS include an ADI, also called a Flight Director Indicator (FDI), an HSI, a mode selector, and a flight director computer. It should be noted that a flight director in use does not infer the aircraft is being manipulated by the autopilot(coupled) but is providing steering commands that the pilot (or the autopilot, if coupled) follows. Typical flight directors use one of two display systems for steerage. The first is a set of command bars, one horizontal and one vertical. The command bars in this configuration are maintained in a centered position (much like a centered glideslope). The second uses a miniature aircraft aligned to a command cue.

A flight director displays steerage commands to the pilot on the ADI. As previously mentioned, the flight director receives its signals from one of various sources and provides that to the ADI for steerage commands. The mode controller provides signals through the ADI to drive the steering bars, e.g., the pilot flies the aircraft to place the delta symbol in the V of the steering bars. "Command" indicators tell the pilot in which direction and how much to change aircraft attitude to achieve the desired result.

Autopilot Systems

An autopilot is a mechanical means to control an aircraft using electrical, hydraulic, or digital systems. Autopilots can control three axes of the aircraft: roll, pitch, and yaw. Most autopilots in general aviation control roll and pitch.

Autopilots also function using different methods. The first is “position based”. That is, the attitude gyro senses the degree of difference from a position such as wings level, a change in pitch, or a heading change.

The second method is “rate based”. Rate-based systems use the turn-and-bank sensor for the autopilot system. The autopilot uses rate information on two of the aircraft’s three axes: movement about the vertical axis (heading change or yaw) and about the longitudinal axis (roll). This combined information from a single sensor is made possible by the 30° offset in the gyro’s axis to the longitudinal axis.

Other systems use a combination of both position and rate based information to benefit from the attributes of both systems while newer autopilots are digital.

Flight Management Systems (FMS)

An FMS, used by commercial airliners, uses an *electronic database of worldwide navigational data including navigation aids, airways and intersections, Standard Instrument Departures (SIDs), STARs, and Instrument Approach Procedures (IAPs) together with pilot input through a CDU to create a flight plan*. The FMS provides outputs to several aircraft systems including desired track, bearing and distance to the active waypoint, lateral course deviation and related data to the flight guidance system for the HSI displays, and roll steering command for the autopilot/flight director system. This allows outputs from the FMS to command the airplane where to go and when and how to turn. To support adaptation to numerous aircraft types, an FMS is usually capable of receiving and outputting both analog and digital data and discrete information. Currently, electronic navigation databases are updated every 28 days. The use of the Global Positioning System (GPS) has provided extremely precise position at low cost, making GPS the dominant FMS navigation sensor today. Currently, typical FMS installations require that air data and heading information be available electronically from the aircraft. The FMS provides not only real-time navigation capability but typically interfaces with other aircraft systems providing fuel management, control of cabin briefing and display systems, display of uplinked text and graphic weather data and air/ground data link communications.

Safety Systems

Radio Altimeters commonly referred to as a radar altimeter, is a system used for accurately measuring and displaying the height above the terrain directly beneath the aircraft. It sends a signal to the ground and processes the timed information. Its primary application is to provide accurate absolute altitude information to the pilot during approach and landing. The radar altimeter also provides its information to other onboard systems such as the autopilot and flight directors while they are in the glideslope capture mode below 200-300 feet above ground level (AGL).

The Traffic Information Service (TIS) is both a ground-based and satellite-based (ADS-B) service providing information to the flight deck via data link using the S-mode transponder and altitude encoder or ADS-B Out transmitters. TIS improves the safety and efficiency of "see and avoid" flight through an automatic display that informs the pilot of nearby traffic.

Traffic Alert and Collision Avoidance Systems *(TCAS)* is an airborne system developed by the FAA that operates independently from the ground-based ATC system. TCAS was designed to increase flight deck awareness of proximate aircraft and to serve as a "last line of defense" for the prevention of mid-air collisions. There are *two levels of TCAS* systems.

- TCAS I was developed to accommodate the general aviation (GA) community and the regional airlines. This system issues traffic advisories(TAs) to assist pilots in visual acquisition of intruder aircraft. TCAS I provides approximate bearing and relative altitude of aircraft with a selectable range. It provides the pilot with TA alerting him or her to potentially conflicting traffic. The pilot then visually acquires the traffic and takes appropriate action for collision avoidance.
- *TCAS II is a more sophisticated system which provides the same information of TCAS I. It also analyzes the projected flightpath of approaching aircraft and issues resolution advisories to the pilot to resolve potential mid-air collisions. Additionally, if communicating with another TCAS II equipped aircraft, the two systems coordinate the resolution alerts provided to their respective flight crews.*

Terrain Alerting Systems

Ground Proximity Warning System (GPWS): An early application of technology to reduce controlled flight into terrain (CFIT) was the GPWS. In airline use since the early 1970s, GPWS uses the *radio altimeter, speed, and barometric altitude to determine the aircraft's position relative to the ground*.

Terrain Awareness and Warning System (TAWS) uses GPS positioning and a database of terrain and obstructions to p*rovide true predictability of the upcoming terrain and obstacles*. The warnings it provides pilots are both aural and visual, instructing the pilot to take specific action. Because TAWS relies on GPS and a database of terrain/obstacle information, predictability is based upon aircraft location and projected location. The system is time based and therefore compensates for the performance of the aircraft and its speed.

iCub - iPad

Four years ago Apple mobile devices provided over 500 Aviation applications (many more now). With Foreflight now available as an EFB, many aviation apps are gone since apps like Foreflight have it all including tons of documents, EFB, EFIS, PFD-MFD, HUD, all radial Instruments, & bunches of flight planning, cross-country tracking, weather radar, all charts. You can get latest flight briefings and even file flight plan directly using the iPad. Recommended as backup-not primary instrumentation, and also use of external GPS. Foreflight now includes D-ATIS(email and text) as well as Pre-Departure Clearance (PDC) for IFR flights.

ADS-B (NextGen-2020: In-Out)

Automatic - Periodically transmits information with no pilot or operator input required.
Dependent - Position and velocity vector are derived from the GPS or a Flight Management System (FMS)
Surveillance - A method of determining position of aircraft, vehicles, or other asset
Broadcast - Transmitted information available to anyone with the appropriate receiving equipment

INITIAL SERVICE

- Surveillance Broadcast Services (En Route, Terminal, Surface)
- Traffic/Flight Information Broadcast Services
- Enhanced Visual Acquisition
- Enhanced Visual Approaches
- Final Approach and Runway Occupancy Awareness
- Airport Surface Situational Awareness
- Conflict Detection

What is …

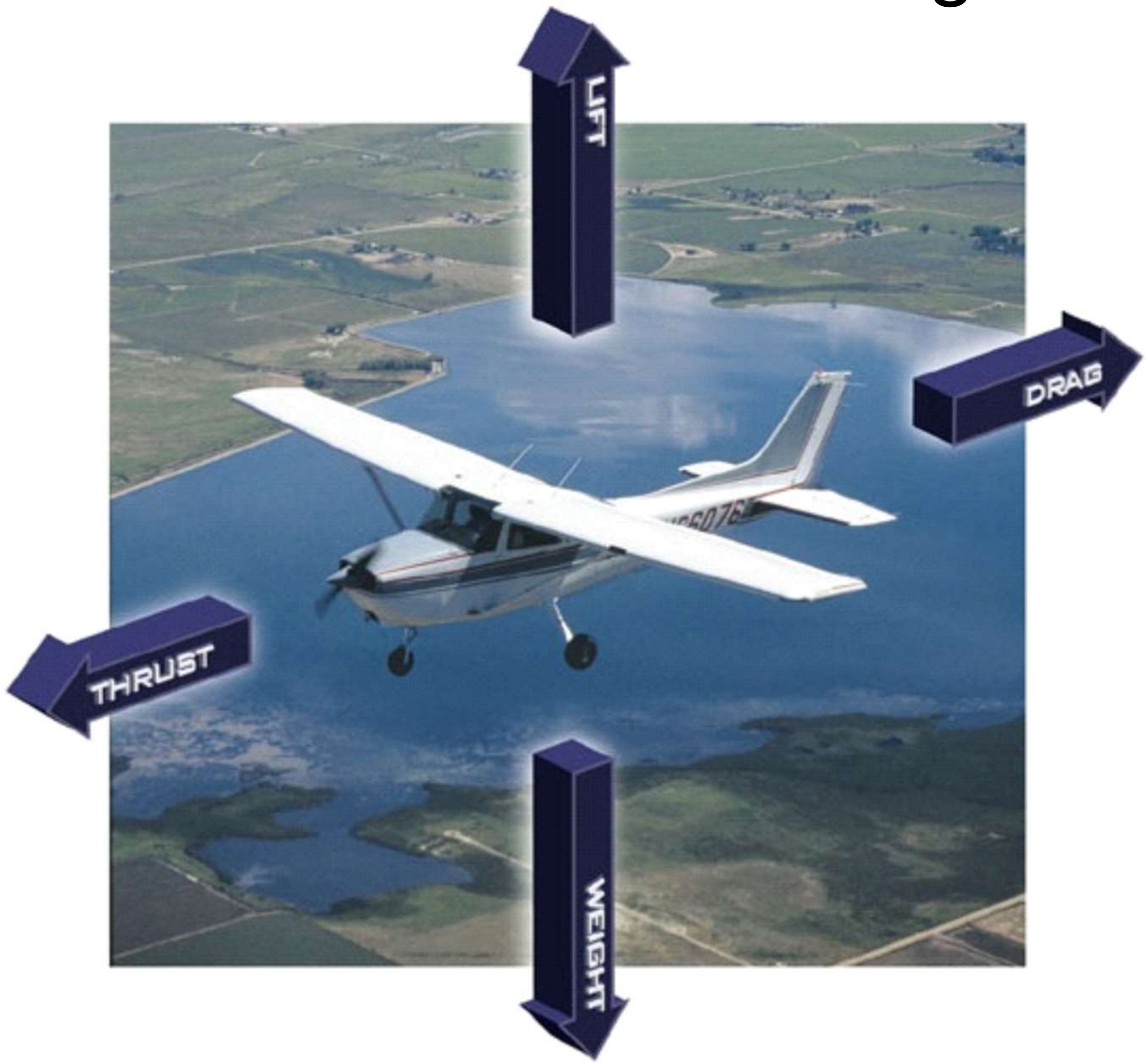
AERODYNAMICS

The study of the properties of moving air, and its interaction between the air and solid bodies (aircraft) moving through it.

- **the properties of an airplane regarding the manner in which air flows around it**
- **the properties of aerodynamics insofar as they result in maximum efficiency of motion.**

Video

The Four Forces of Flight



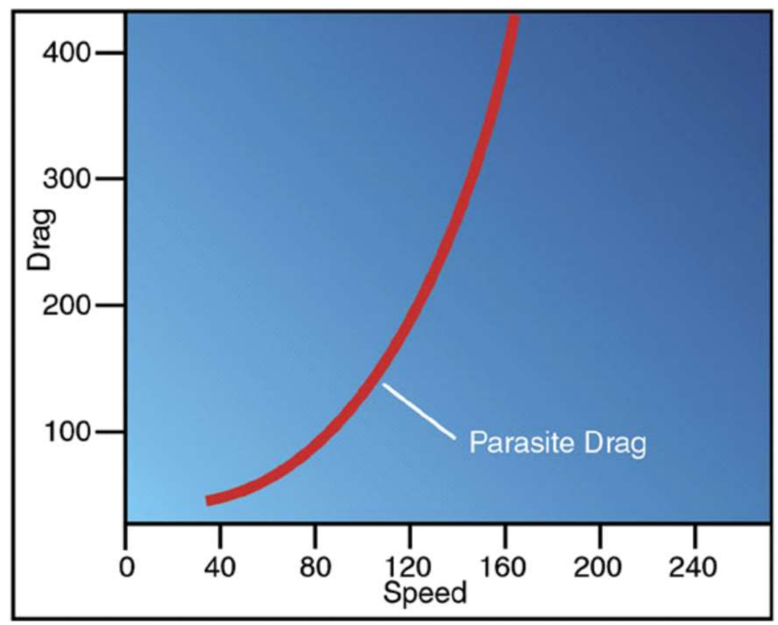
In steady-state straight and level unaccelerated flight, the sum of the opposing forces is equal to zero. Opposing forces cancel one another.

Aerodynamics: WEIGHT & THRUST & DRAG

WEIGHT – DOWNWARD FORCE OPPOSED BY LIFT

THRUST – FOREWARD FORCE OPPOSED BY DRAG

DRAG - BACKWARD (SLOWING) FORCE OPPOSED BY THRUST – FORM, INTERFERENCE, AND SKIN FRICTION

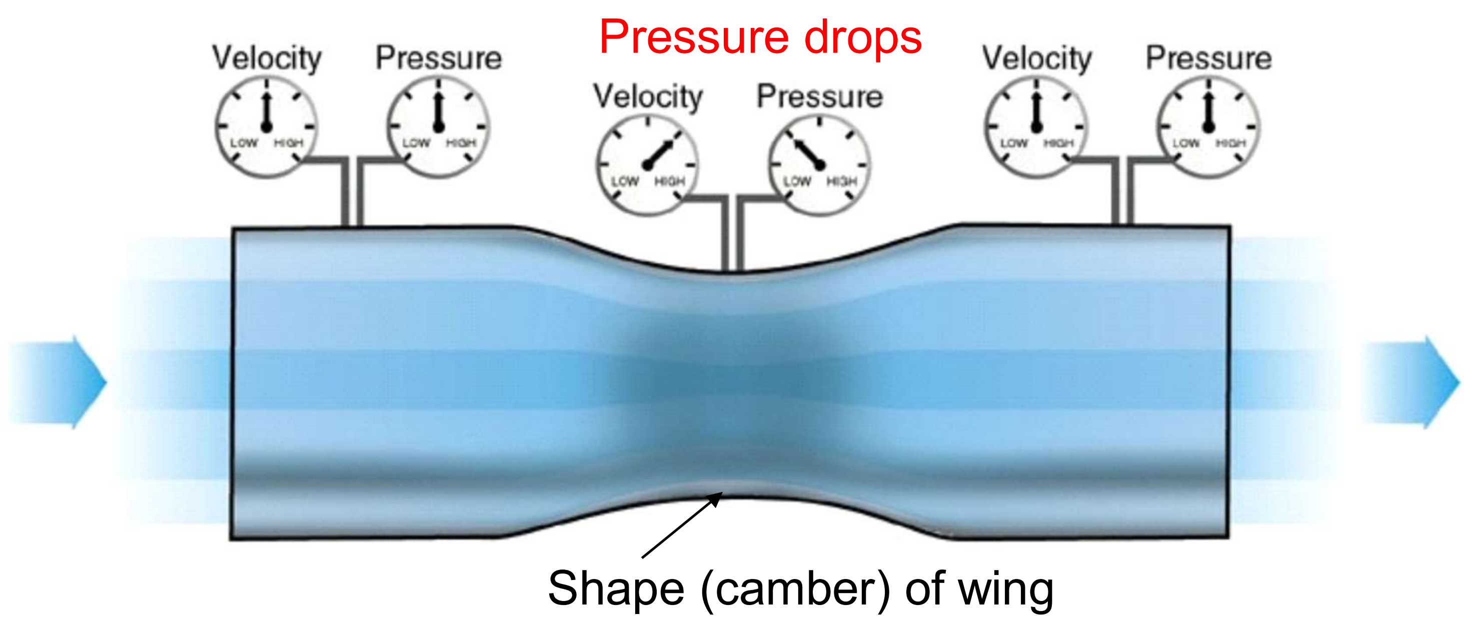


Aerodynamics: LIFT
Principles

Works because of Newton's Laws of Motion and Bernoulli's Principle … Plus

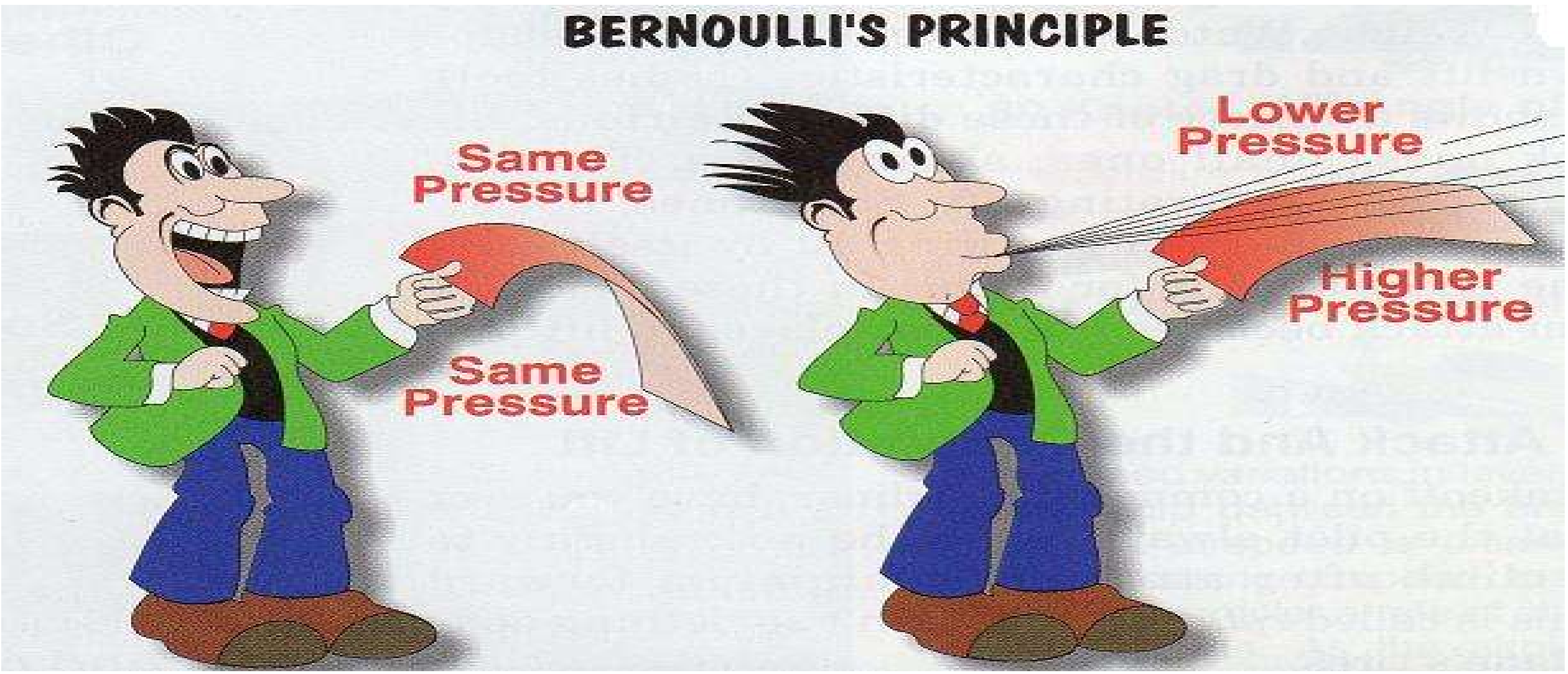
Three Laws of physics help explain: 1. If at rest-stays at rest, if in motion-stays in motion 2. F=ma, and 3. For every action there is an equal and opposite reaction.

Bernoulli's Law that attempts to account for negative pressure above the wing producing Lift as a result in the curve along the upper part of the wing (camber).

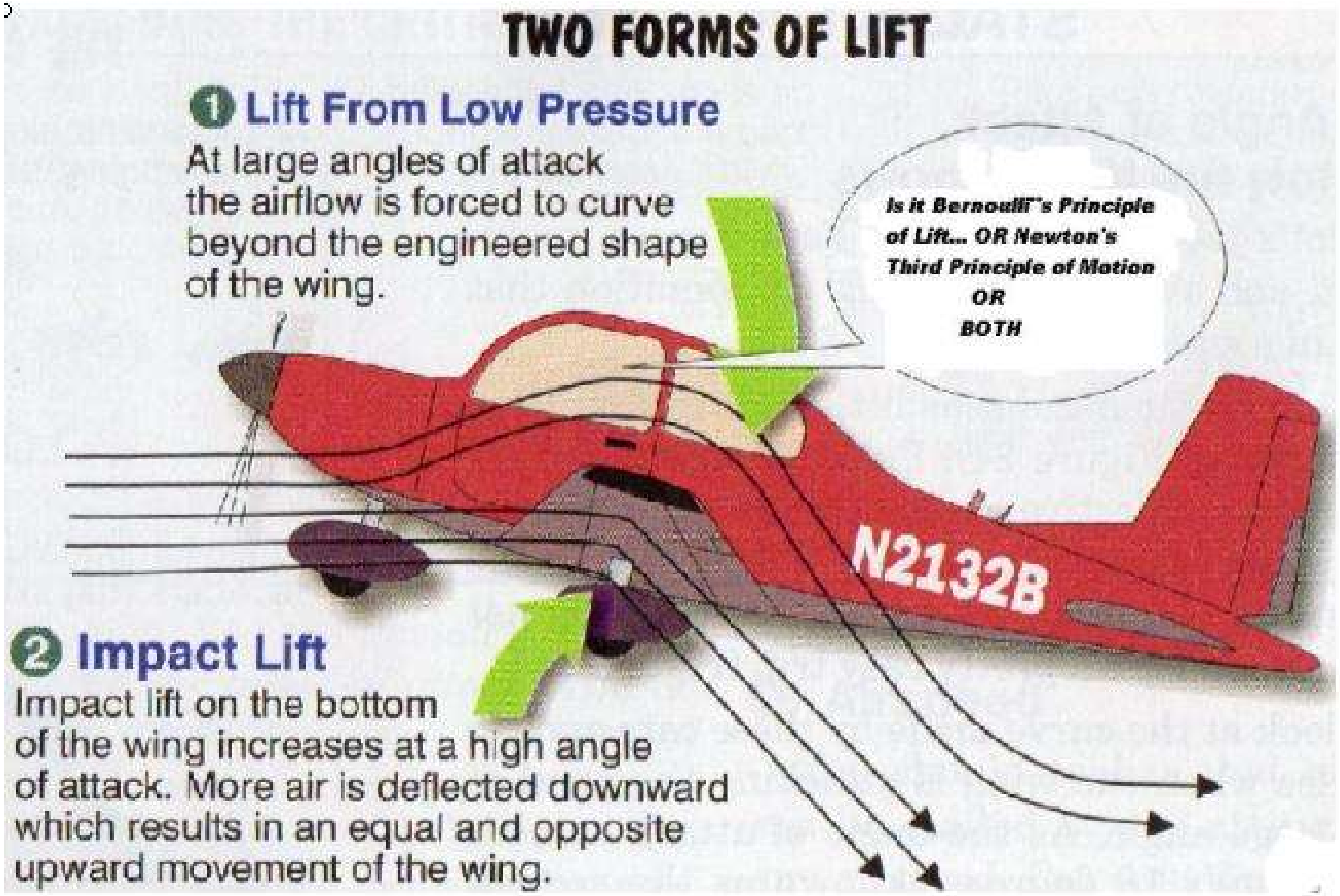


The camber, upper curved portion of a wing has only ½ of what Bernoulli demonstrate!
Could only ½ produce lift?

SOME, Yes -- There is more to the story !



It's NOT all about Bernoulli

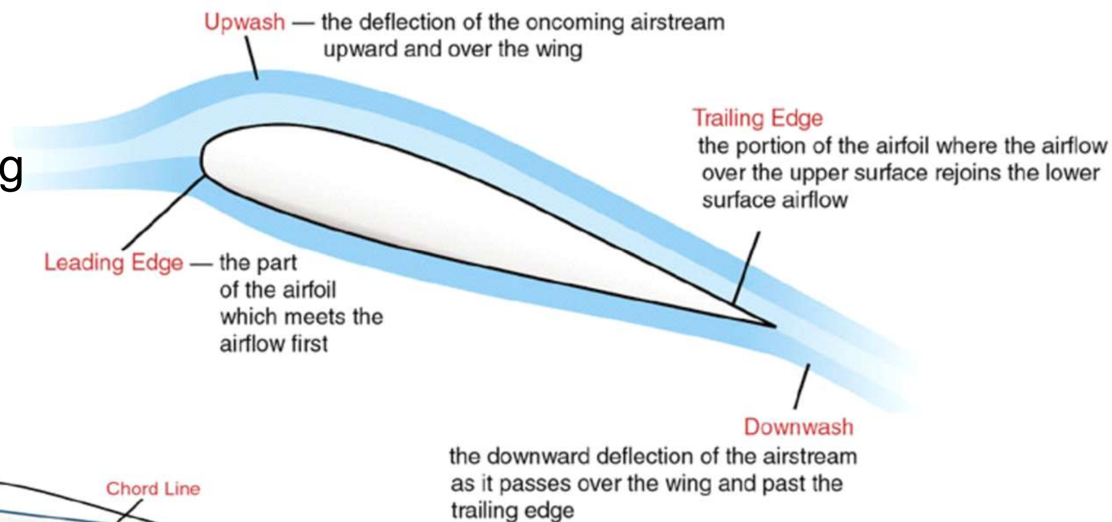


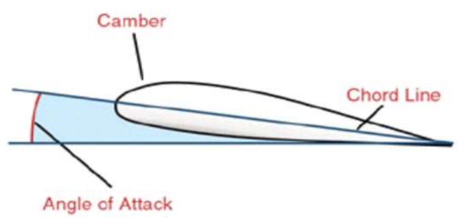
See discussion: www.grc.nasa.gov/WWW/K-12/airplane/bernnew.html
and Aerodynamic index: http://www.grc.nasa.gov/WWW/K-12/airplane/short.html

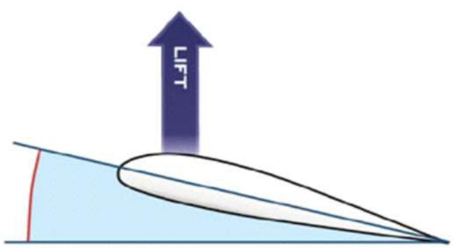
Thank you William Cutler for these links ☺

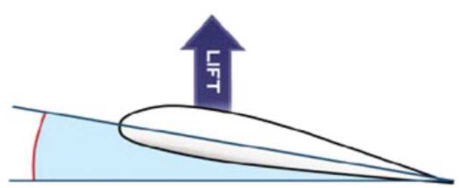
Aerodynamics: LIFT
AIRFOILS

Airflow across wing







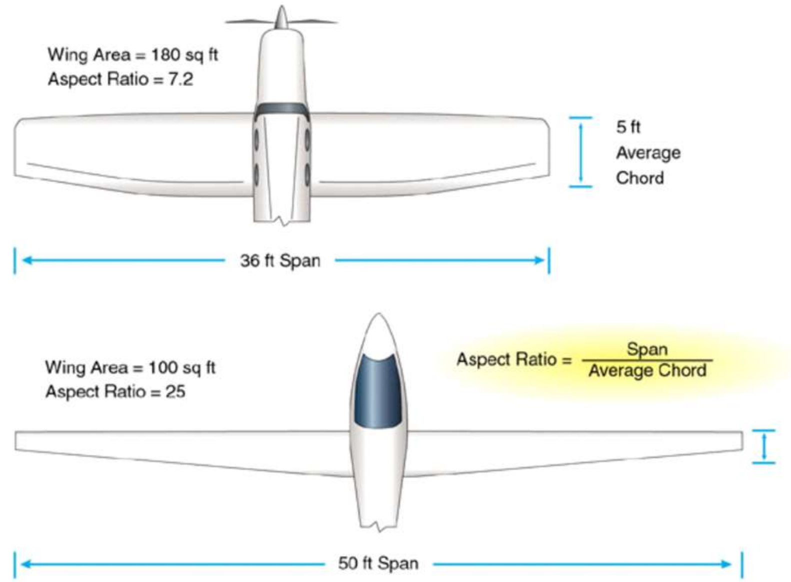


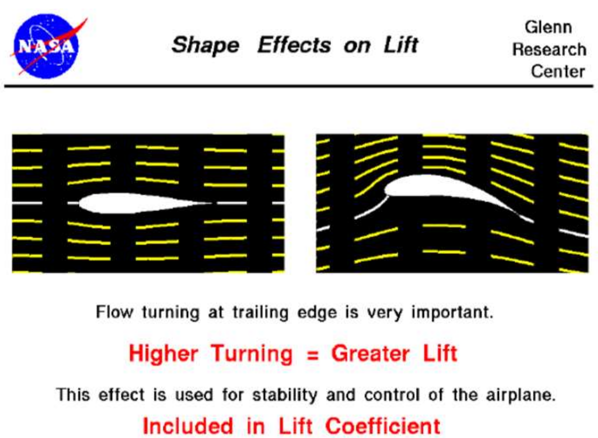
Anything that interferes with the flow of air over the surface of the wing negatively effects lift, such as frost (always clear). Cleaning, waxing helps !

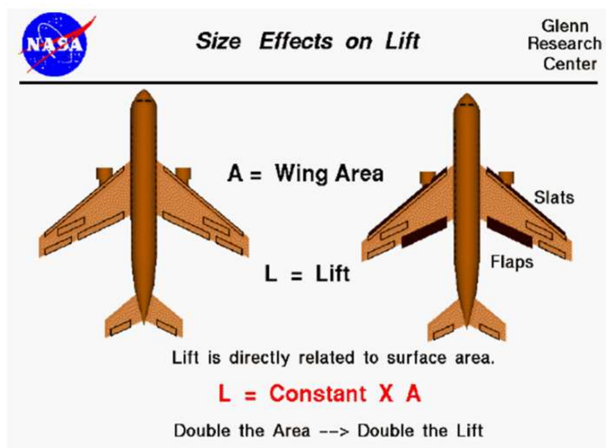
Angle of attack (angle between relative wind and chord line = greater lift …. To a point above which too much angle of attack is very bad (stalls). Stalls/Spins occur when "CRITICAL ANGLE OF ATTACK EXCEEDED."

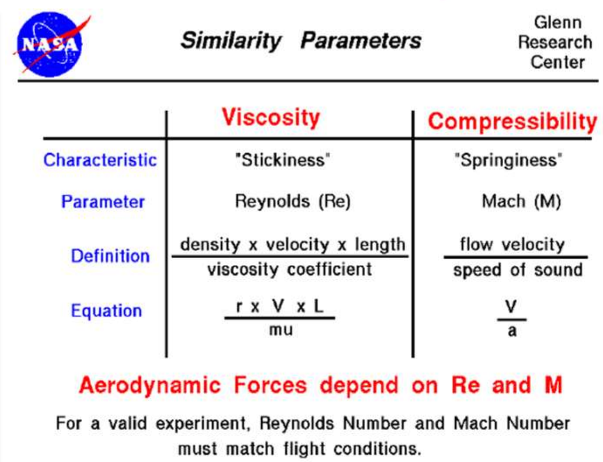
Aerodynamics: LIFT
OTHER FACTORS

WING Shape, Area, Aspect Ratio,
Angle of Attack, Velocity of air, & Density





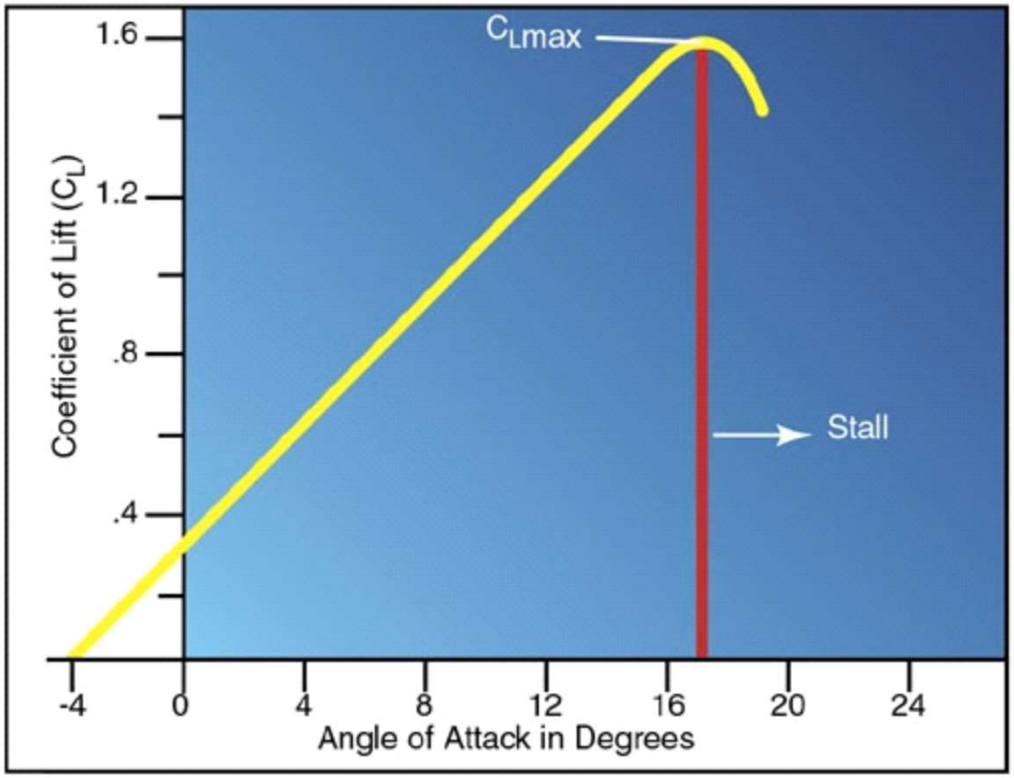


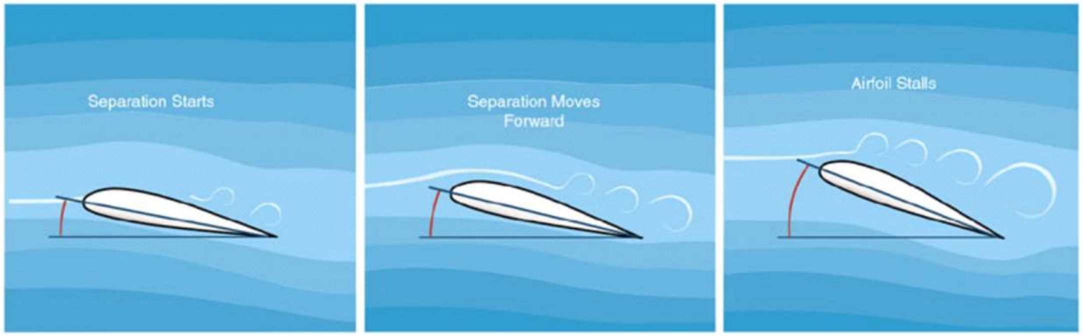


Pilot control of lift: – Increase thrust or airspeed and angle of attach increase lift. POWER, ELEVATOR, FLAPS

Aerodynamics: LIFT

ANGLE OF ATTACK (AOA)

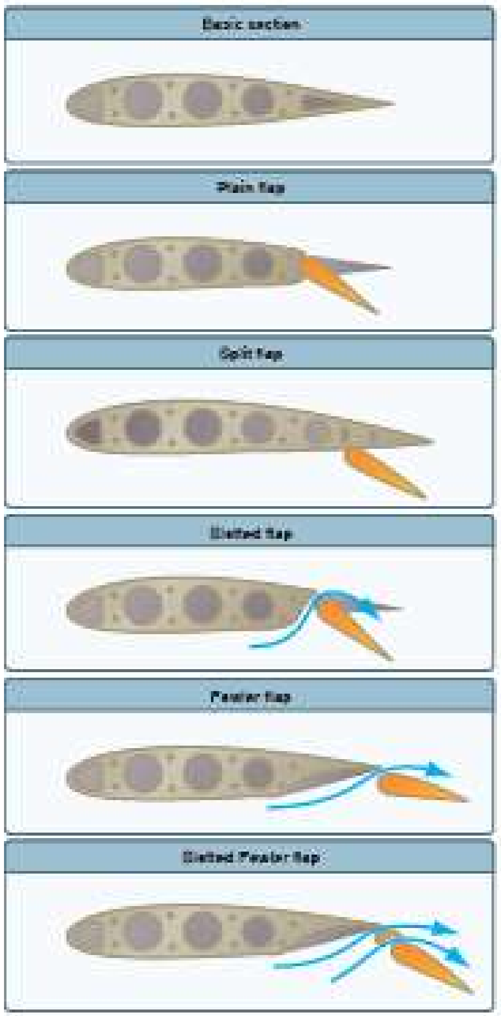




Aerodynamics

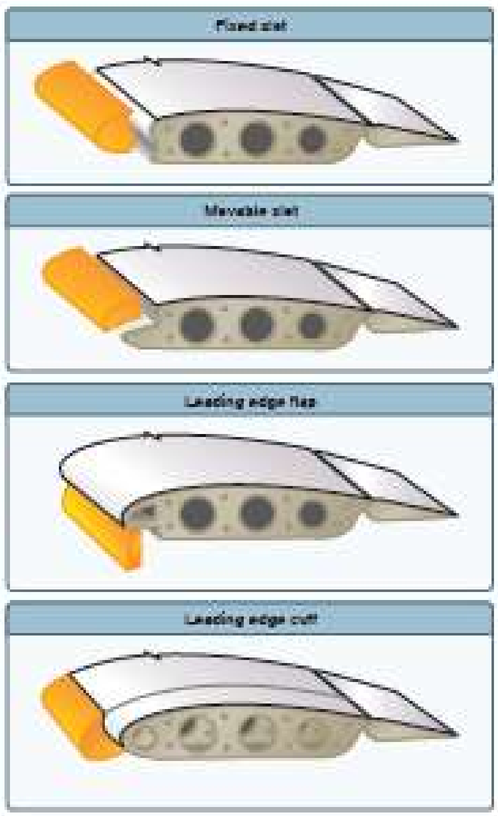
FLAPS / LEADING EDGE/ SPOILER DEVICES

Flaps allow for more lift (by increasing effective camber), to enable a *steeper descent angle without an increase in airspeed*.



Leading Edge Devices

Leading edge flaps, like trailing edge flaps, are used to increase both CL-MAX and the camber of the wings.



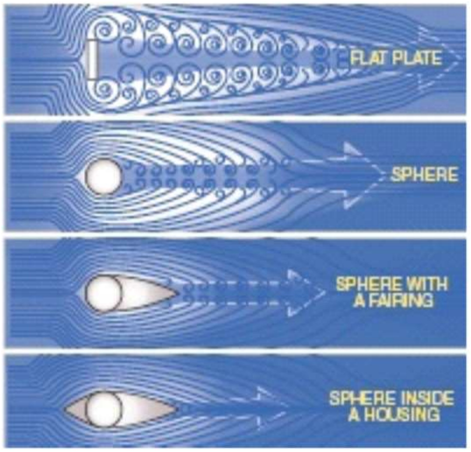
Spoilers

Found on some fixed-wing aircraft, high drag devices called spoilers are deployed from the wings to spoil the smooth airflow, reducing lift and increasing drag. On gliders, spoilers are most often used to control rate of descent for accurate landings.

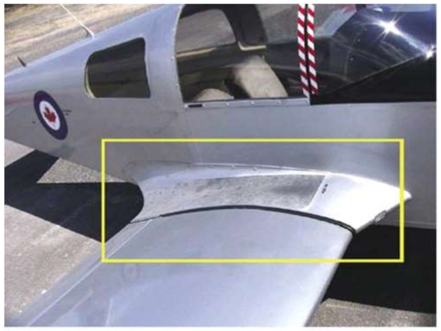
Types of Drag

Parasite Drag – all forces working to slow the aircrafts movement and increases as the square of the airspeed.

Form Drag-due to shape and airflow around aircraft



Interference Drag-the intersections of airstreams create eddy currents, turbulence, or restrictions to smooth airflow.



Skin Friction Drag-due to aerodynamic resistance du to contact of moving air with the surface of the aircraft.

Induced Drag – A *byproduct of lift*. The greater the lift, the greater the induced drag. It *increases inversely with the square of the airspeed*.

Induce Drag byproduct = *Wingtip Vortices*
When on the runway, "Wake Turbulence"

Avoiding Wake Turbulence

Avoid Flying through another aircraft's flight path or following another aircraft within 1,000 feet

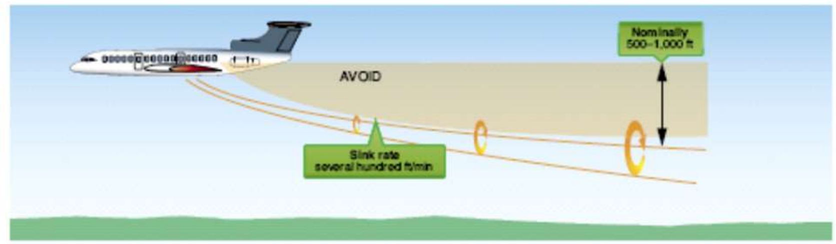


Figure 4-11. *Avoid following another aircraft at an altitude within 1,000 feet.*

Rotate prior to the point at which the preceding aircraft rotated when taking off behind an aircraft.

Approach the runway above a preceding aircraft's path when landing behind another aircraft, and touch down after the point at which the other aircraft wheels contacted the runway.

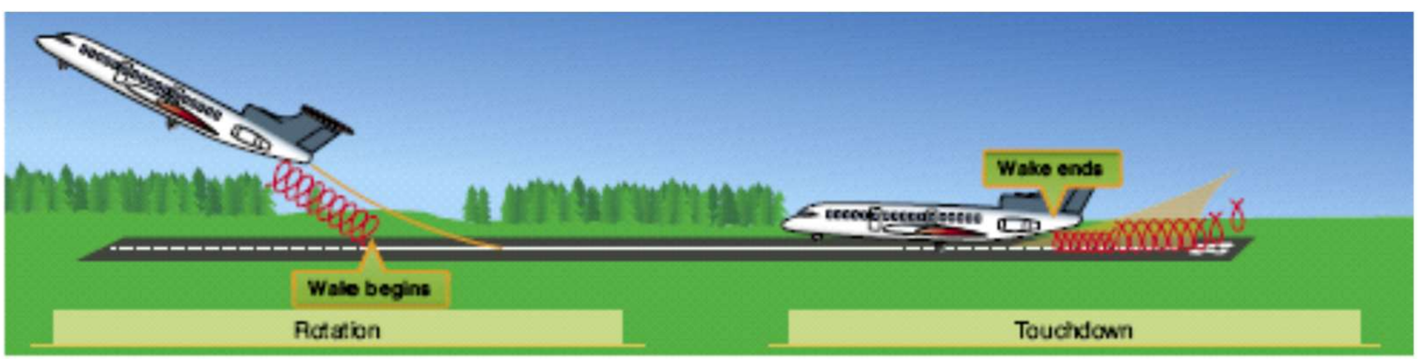
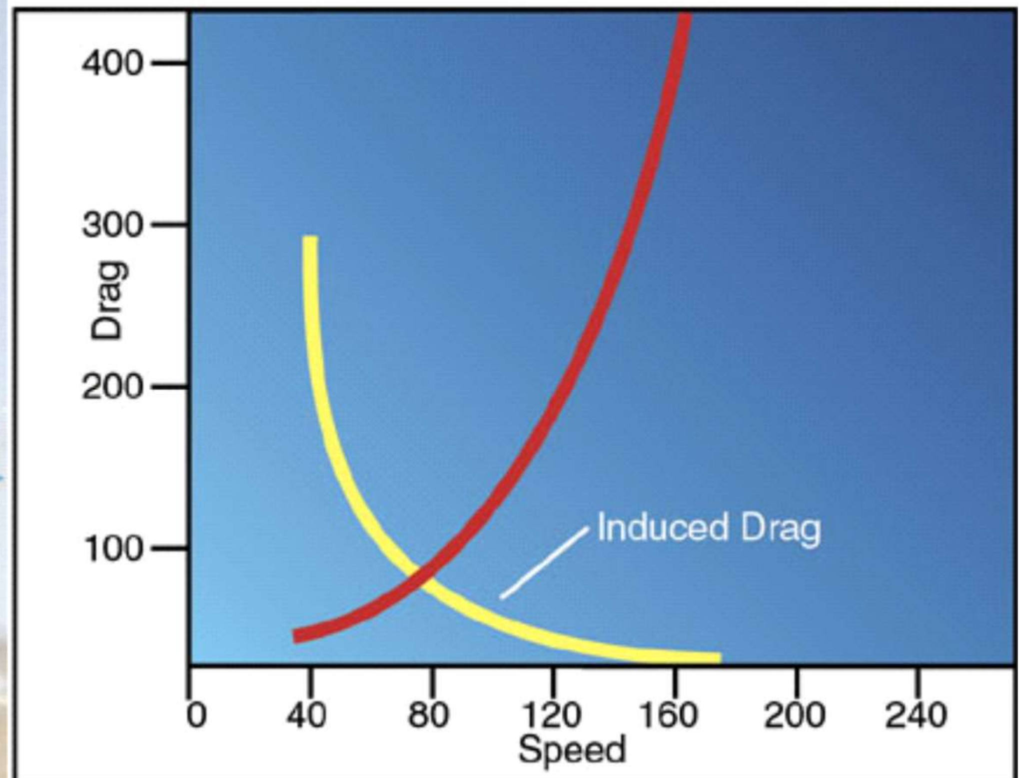


Figure 4-12. *Avoid turbulence from another aircraft.*

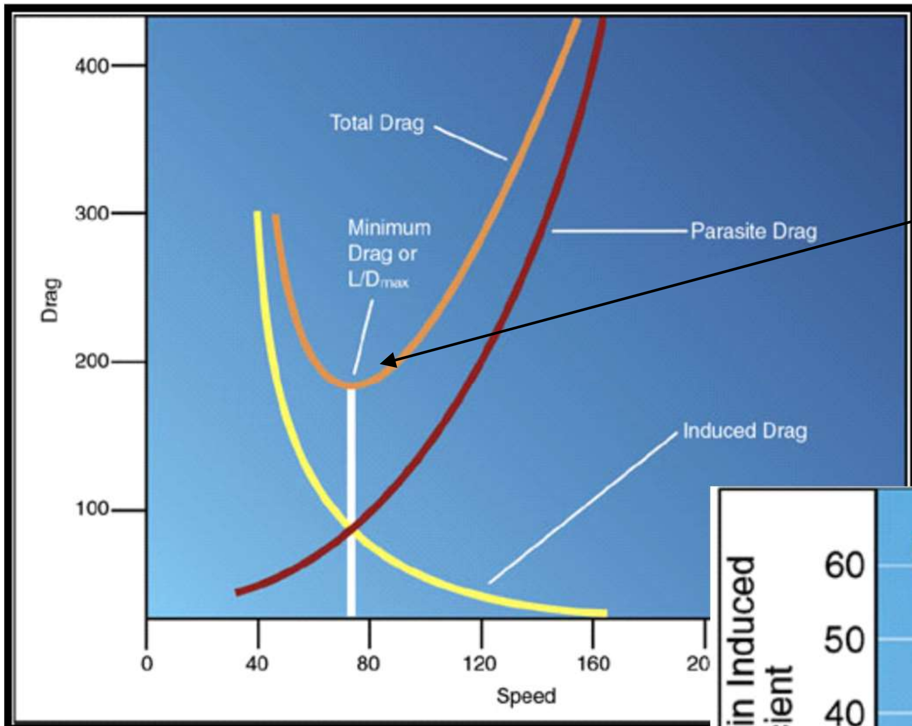
INDUCED DRAG

Increases inversely with the square of the airspeed. Greatest at low AS.



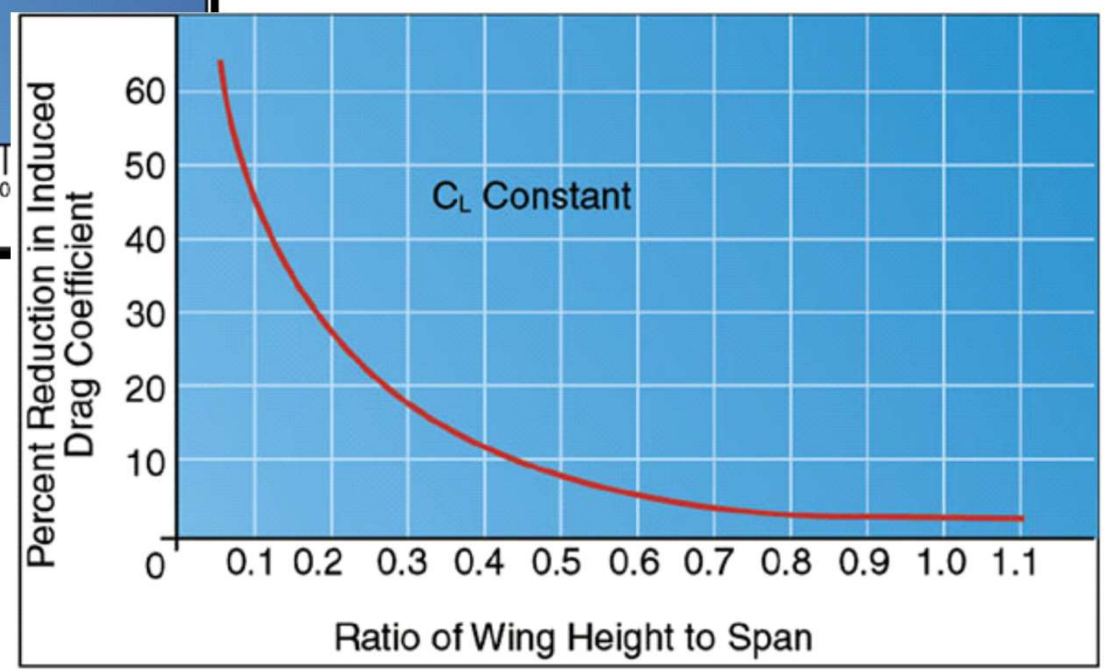
Rearward component of lift is induced drag.

Aerodynamics: TOTAL DRAG & GROUND EFFECT



POINT OF OPTIMAL LIFT/ DRAG. BEST GLIDE SPEED

GROUND EFFECT: interference of airflow with airflow patterns of airplane**. Reduces induced drag, reduces angel of attack to maintain lift. Land: FLOAT, Take-off lift off TOO SOON**



Ground Effect

Take Off-Decrease
In **induced drag causes liftoff too early**, out of GE loss of altitude-too little lift

Landing-Decrease in Induced drag **causes "float" – further landing distance.**

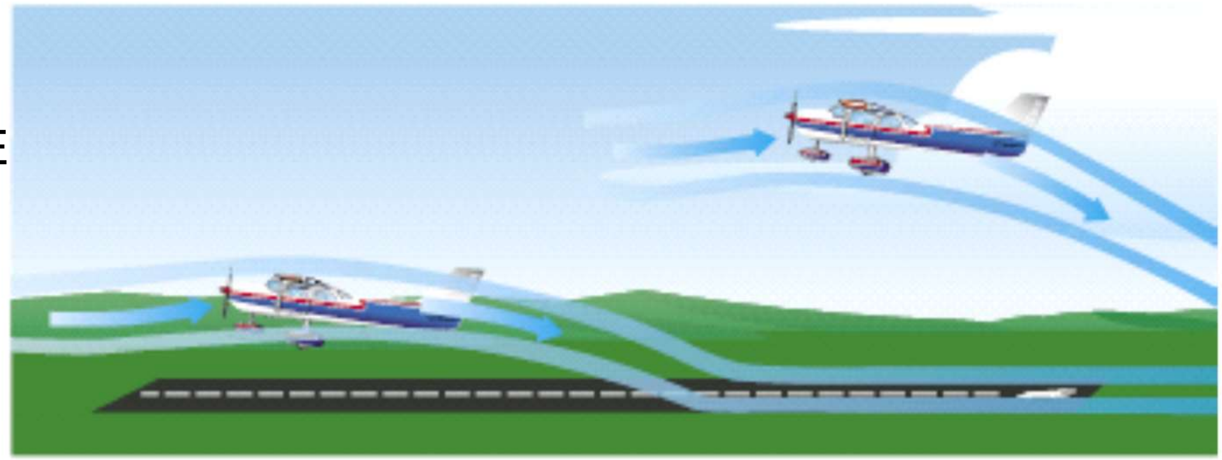


Figure 4-13. *Ground effect changes airflow.*

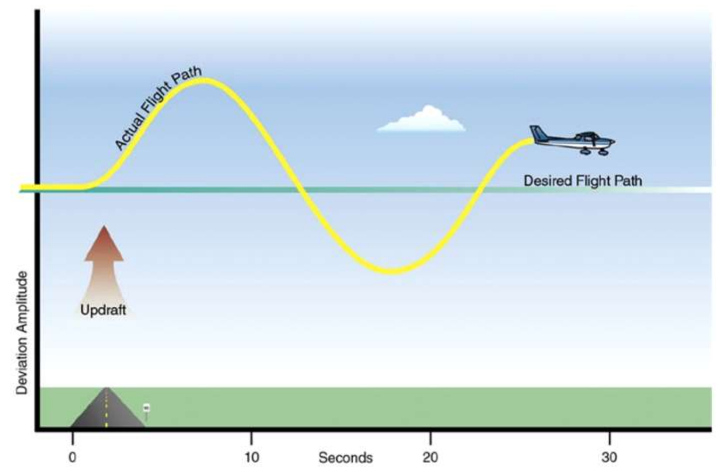
When an aircraft in flight comes within several feet of the surface, ground or water, a change occurs in the three-dimensional flow pattern around the aircraft because the vertical component of the airflow around the wing is restricted by the surface.
This alters the wing's upwash, downwash, and wingtip vortices. Ground effect, then, is due to the interference of the ground (or water) surface with the airflow patterns about the aircraft in flight. The principal effects due to proximity of the ground are the changes in the aerodynamic characteristics of the wing. As the wing encounters ground effect and is maintained at a constant lift coefficient, there is consequent reduction in the upwash, downwash, and wingtip vortices.

Distance: 1 wing span=1.4%, ¼ wingspan=23%, 1/10th wingspan=47.6% reduction of induced drag.

Aerodynamics: STABILITY

STABILITY is the characteristic of an airplane to return to a condition of equilibrium should its attitude be changed.

Static stability: quick equilibrium.
Dynamic stability: equilibrium of time.
Positive (static or dynamic) returns to the desired condition.
Negative (static or dynamic) gets worse instead of better over time.

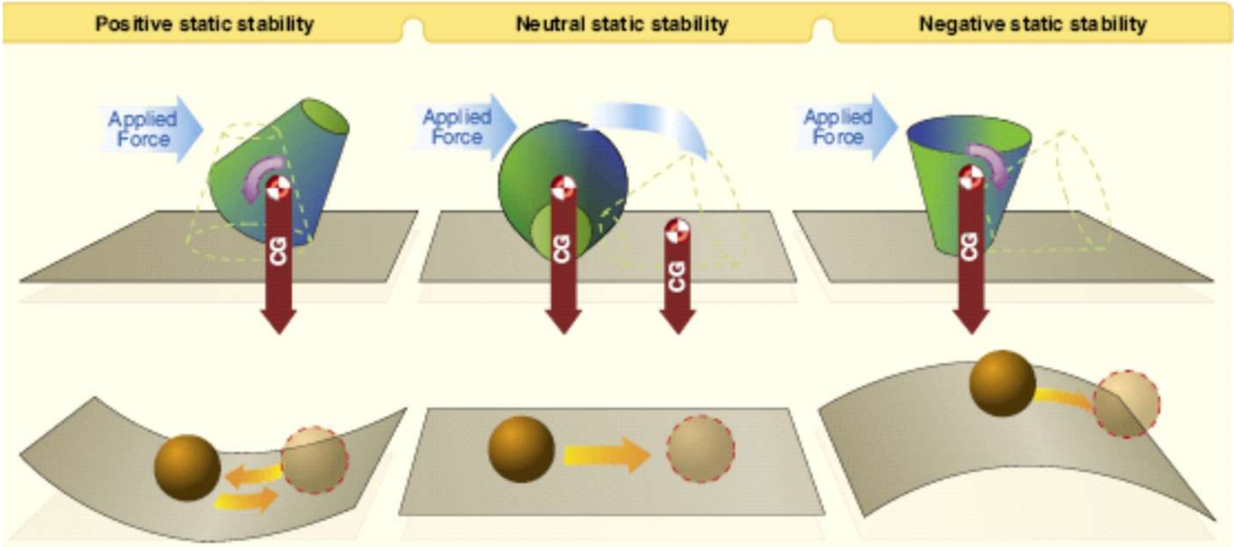


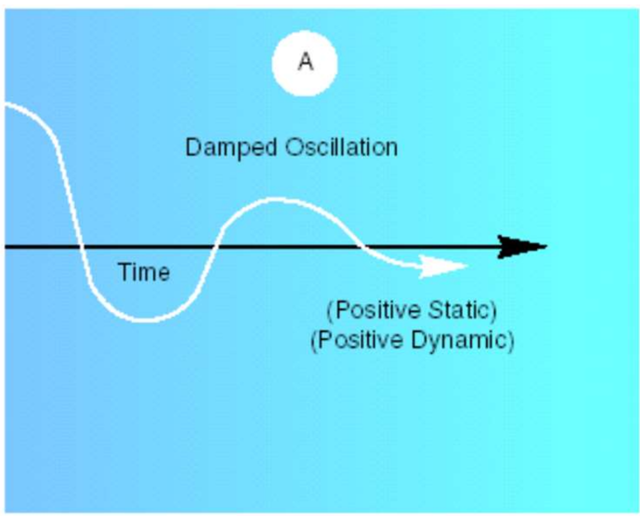
MANEUVERABILITY allows the pilot to change the attitude of the airplane in a manner to withstand the stresses without harm to the airplane.

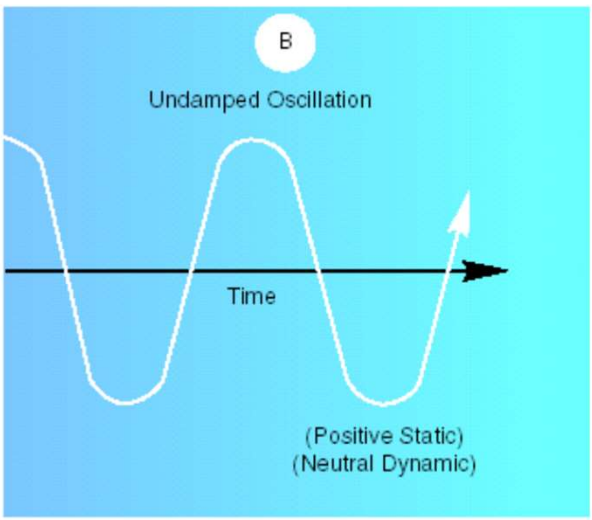
CONTROLABILITY is the capability of the airplane to respond to pilot input.

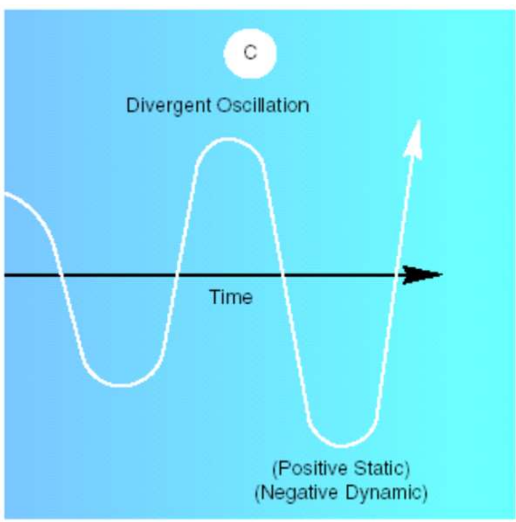
STABILITY, MANEUVERABILITY AND CONTROLABILITY ALL INVOLVE MOVEMENT ABOUT THE *THREE AXES OF FLIGHT*.

Aerodynamics: STABILITY

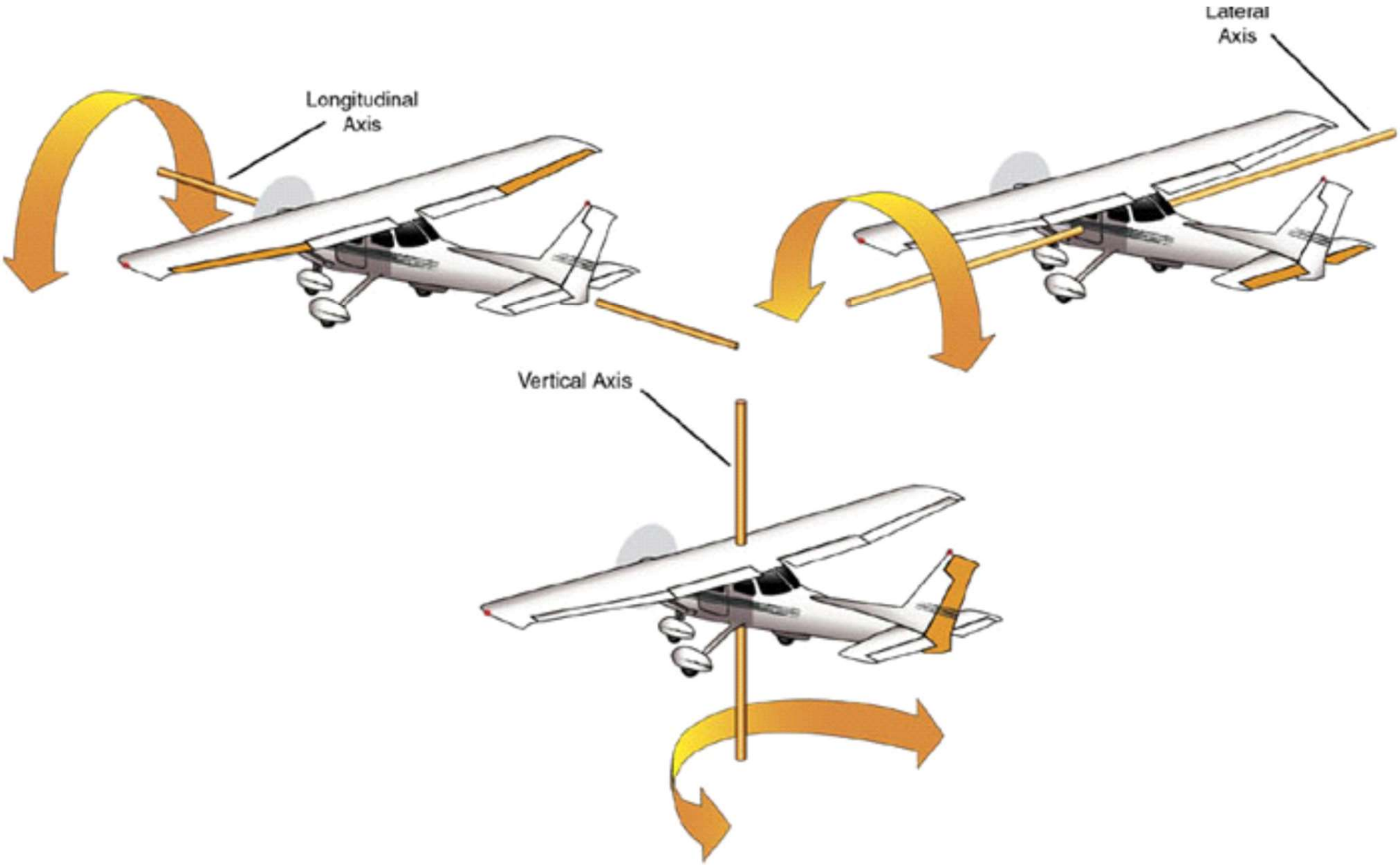








Aerodynamics: 3 Axes of Flight



Stability Control

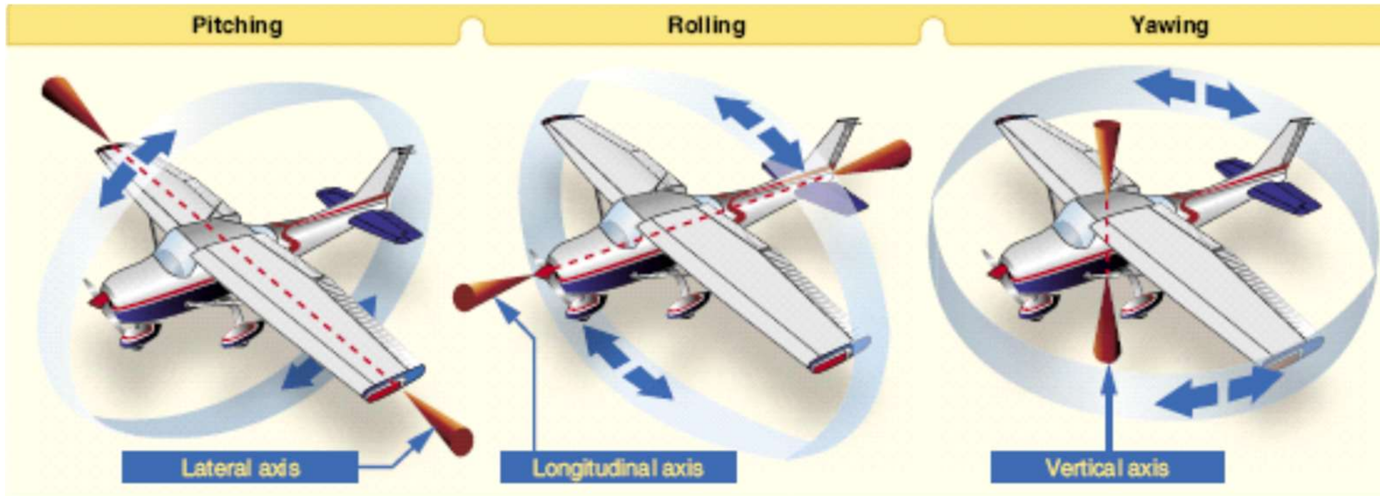
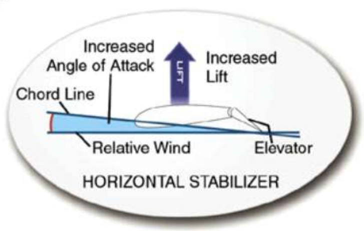
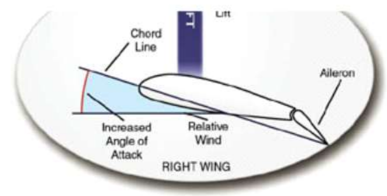
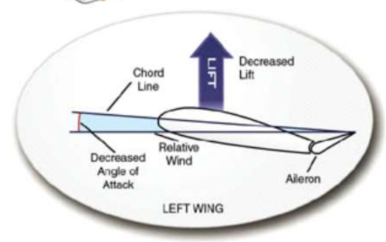


Figure 4-15. *Axes of an airplane.*

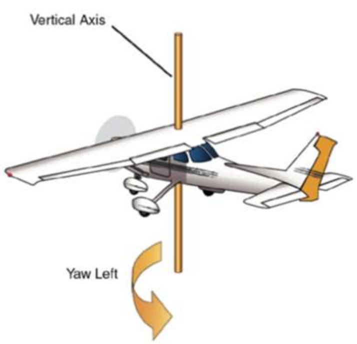
Lateral Axis (Pitch) = Elevators

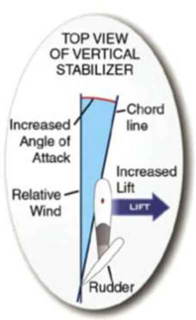






Longitudinal Axis (Roll) - Ailerons

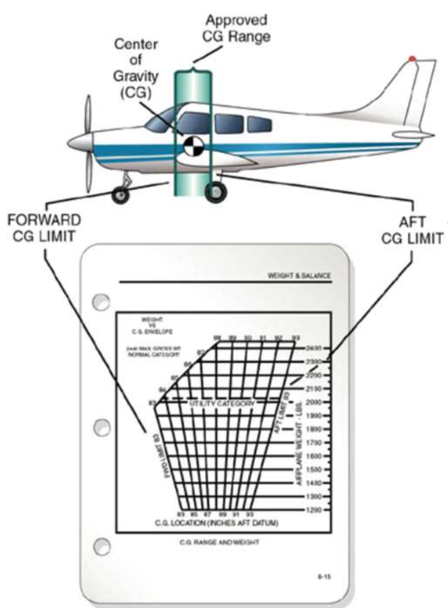




Vertical Axis (Yaw) = Rudder

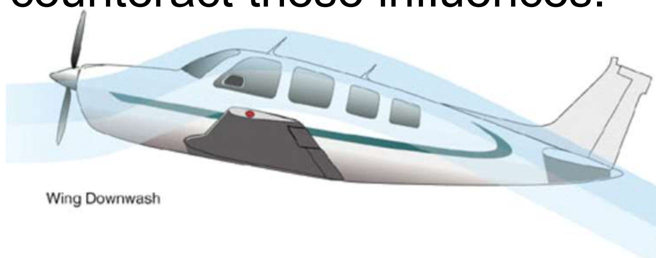
Longitudinal Stability

Longitudinal Stability is the tendency for an aircraft to *resist movement about it's Lateral axis*. Dependent upon: 1-Location of wing with respect to CG, 2-Location of horizontal tail surfaces with respect to CG, and 3-Area of tail surfaces. Downwash strikes the top of the stabilizer and produces a downwash pressure which at certain speed is enough to balance the "level."



MOST DANGER

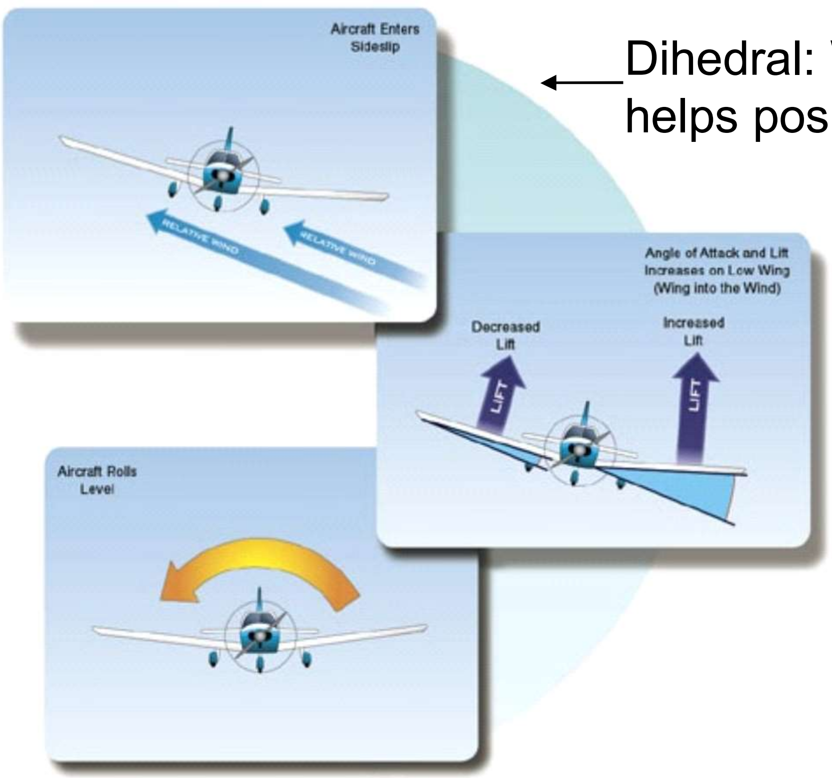
Horizontal Stabilizer subjected to downward forces – given negative angle of attack to counteract these influences.



Power effects can destabilize pitch (thrustline above CG and more downward force on Horizontal stabilizer

Lateral Stability

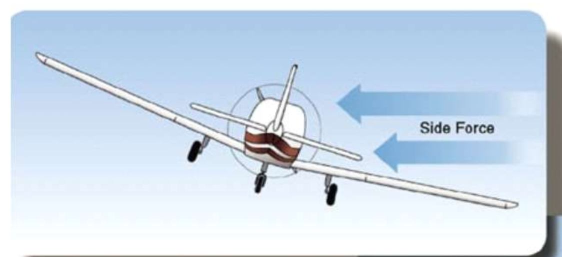
Lateral Stability is the tendency for an aircraft to *<u>resist movement about it's Longitudinal axis</u>* . Influenced by *dihedral, wing sweep, and keel effects*.

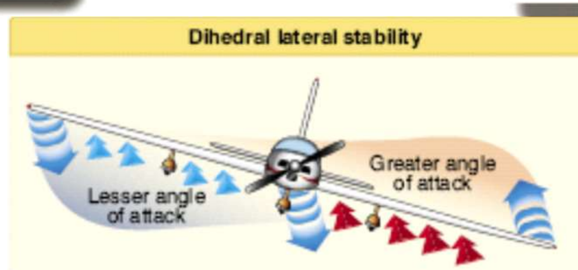


Dihedral: Wings angled up at fuselage helps positive lateral stability

HIGH SPEED aircraft need sweep back wings to help lateral stability.

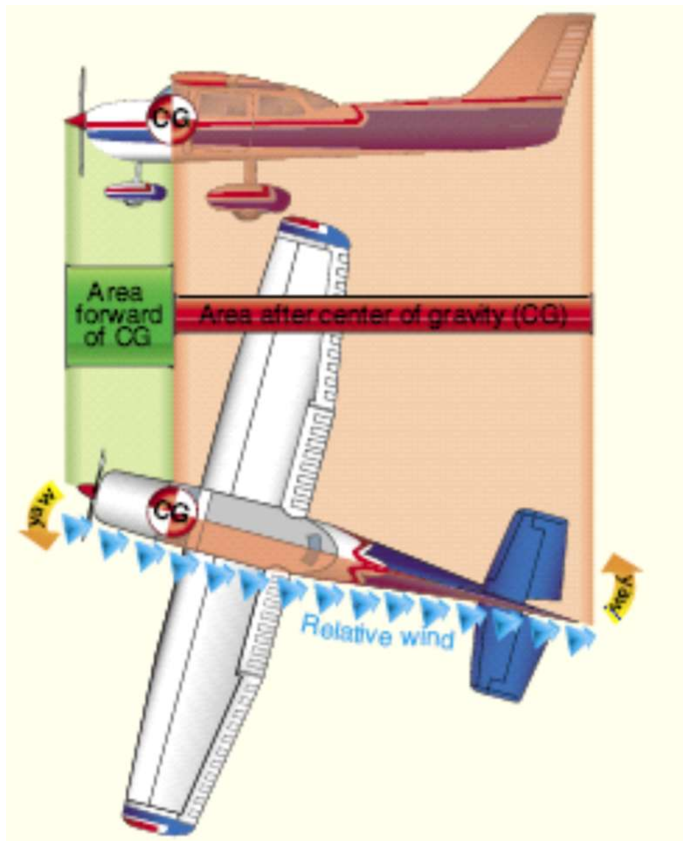
Side of the airplane act like keel on a ship to help stabilize.



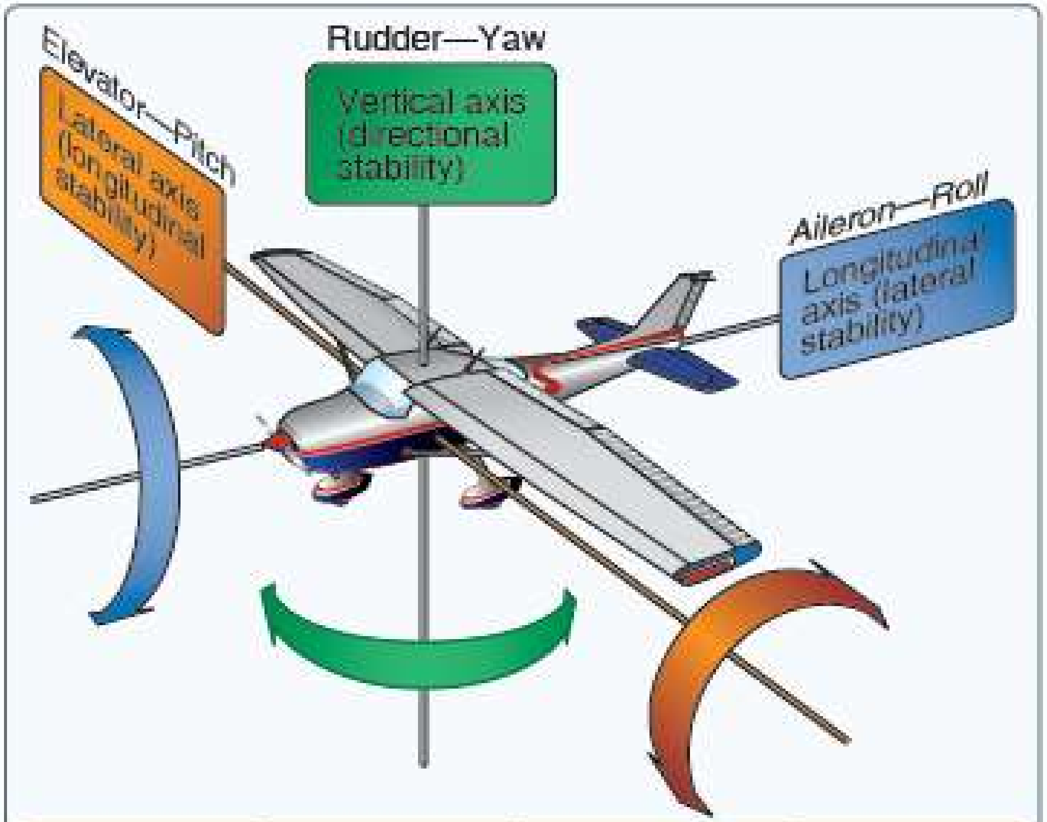


Aerodynamics: Directional (Vertical Axis) Stability

Stability about the vertical axis is call Directional Stability.   Main component to *resist directional instability is the vertical stabilizer*. Area behind CG must be greater than area forward of CG.



SUMMARY: S T A B I L I T Y

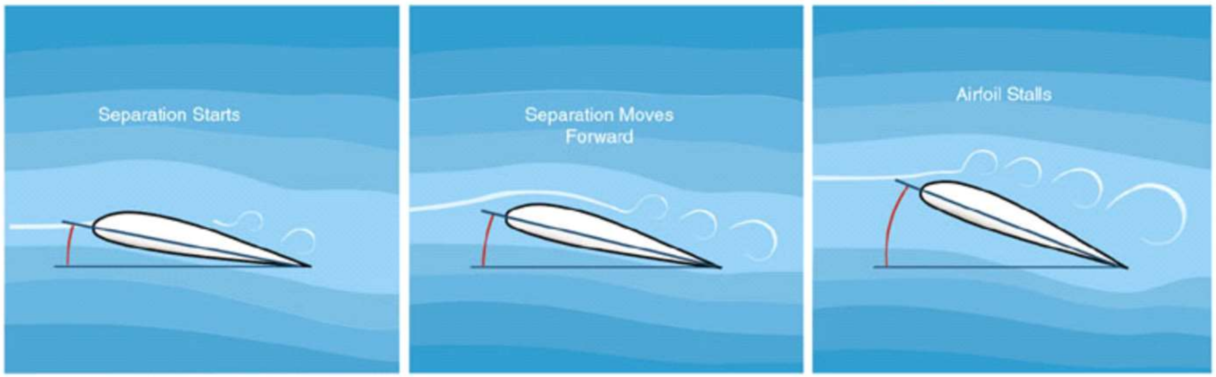


Primary Control Surface	Airplane Movement	Axes of Rotation	Type of Stability
Aileron	Roll	Longitudinal	Lateral
Elevator/ Stabilator	Pitch	Lateral	Longitudinal
Rudder	Yaw	Vertical	Directional

Aerodynamics: Stalls

Exceeding Critical Angle of Attack

GA aircraft 16-18 degrees



Power-On “Departure”

Accelerated (45 degree turning stall)

Power-Off “Approach”

Cross-Linked (Extremely bad on Landing)

- Bad approach – right turn
- Excessive right rudder
- Left turn to counter increasing angle of bank
- Right wing stalls and rolls to right. End of story.

Recognition and Recovery CRITICAL

DISCUSS IN DETAIL WITH YOUR FLIGHT INSTRUCTOR

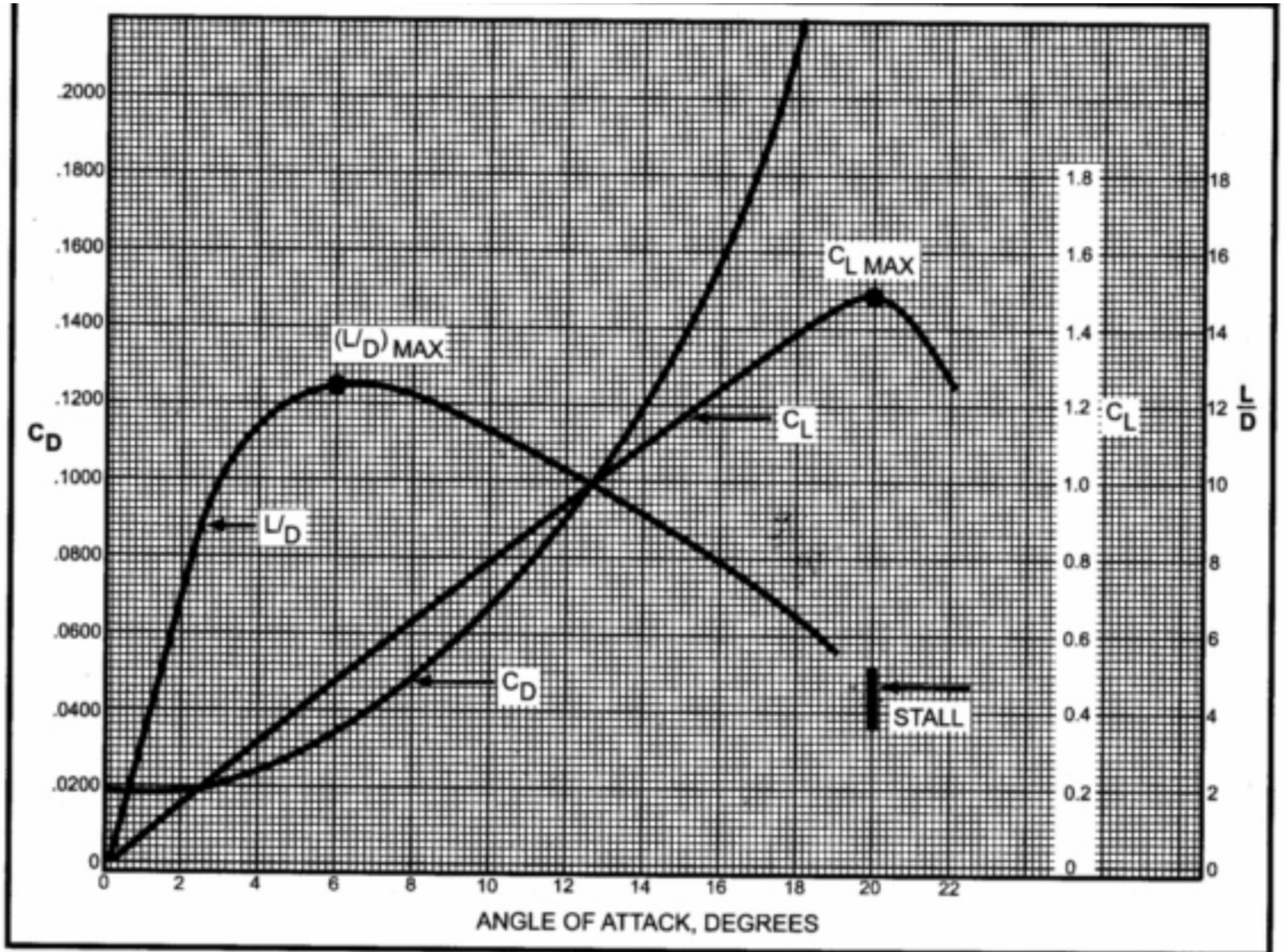


Figure 3. – Angle of Attack, Degrees.

31. (Refer to Figure 3 above.) The L/D ratio at a 2° angle of attack is approximately the same as the L/D ratio for a

A. 9.75° angle of attack.

B. 10.5° angle of attack.

C. 16.5° angle of attack.

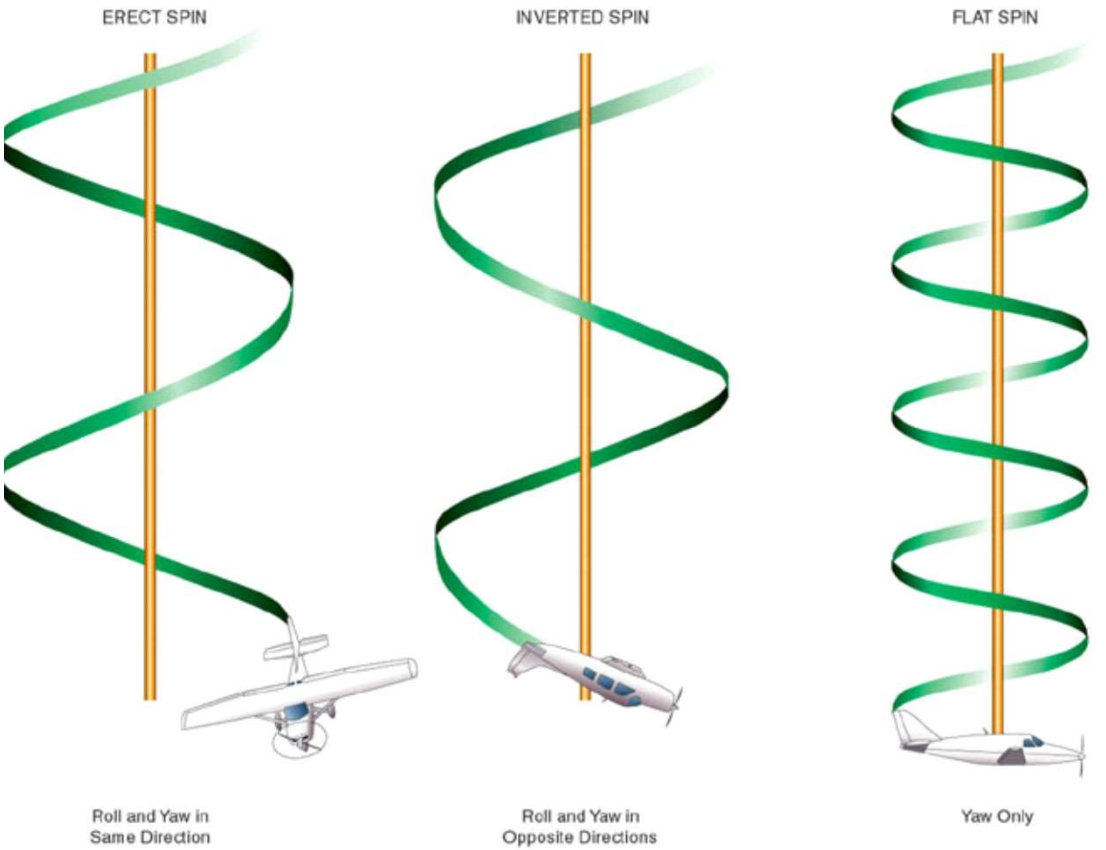
Answer (C) is correct. *(PHAK Chap 10)*

DISCUSSION: Enter the bottom of the chart in Fig. 3 at 2° angle of attack and move vertically up to the L/D curve. From this point, move right horizontally to the point where the L/D curve intersects. Then move vertically down to the bottom of the chart to determine a 16.5° angle of attack. Thus, the L/D ratio is approximately the same at both a 2° and 16.5° angle of attack.

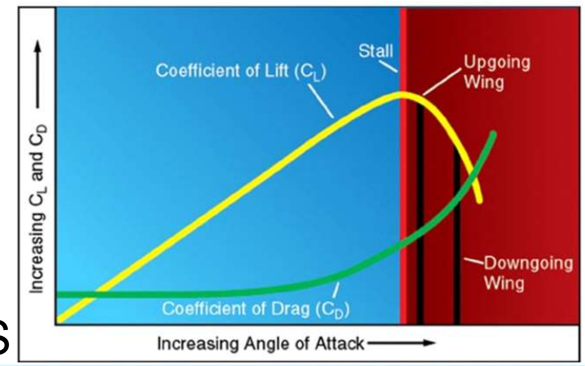
Answer (A) is incorrect because an angle of attack of 9.75° would have the same L/D ratio as a 3.75°, not 2.0°, angle of attack. Answer (B) is incorrect because an angle of attack of 10.5° would have the same L/D ratio as a 3.5°, not 2.0°, angle of attack.

Aerodynamics: Spins

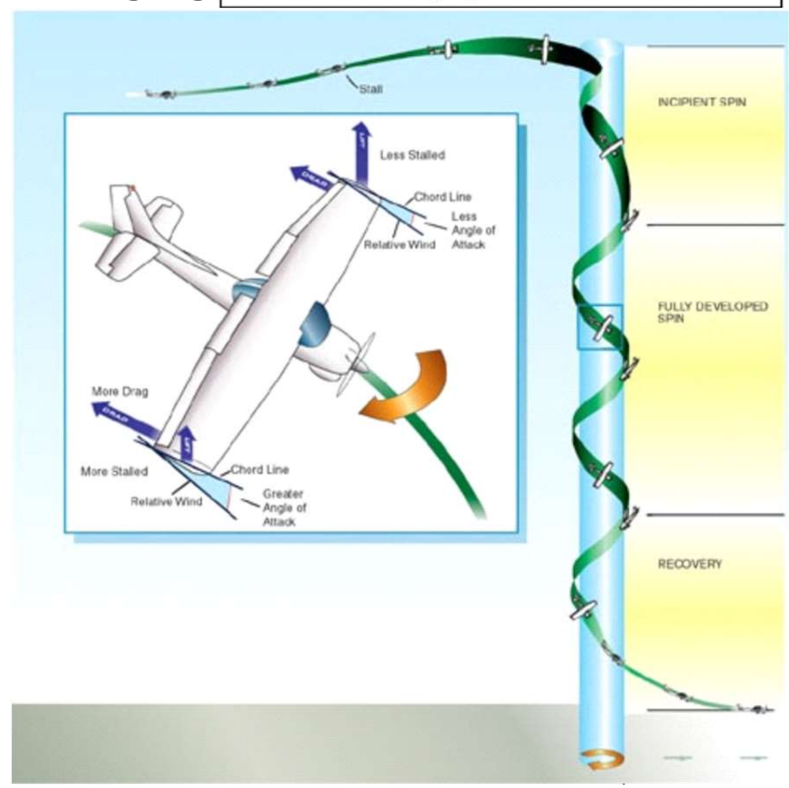
BOTH wings must be stalled to enter a spin.



PRIMARY CAUSE



PHASES



Recognition and Recovery CRITICAL

DISCUSS IN DETAIL WITH FLIGHT INSTRUCTOR

SPIN ENTRY AND RECOVERY

1. Stalls occur at any attitude.
2. Spins, like stalls, occur when BOTH wings are stalled with the cross control of aileron and rudder (full deflection of yoke in one direction and the rudder in the opposite direction.

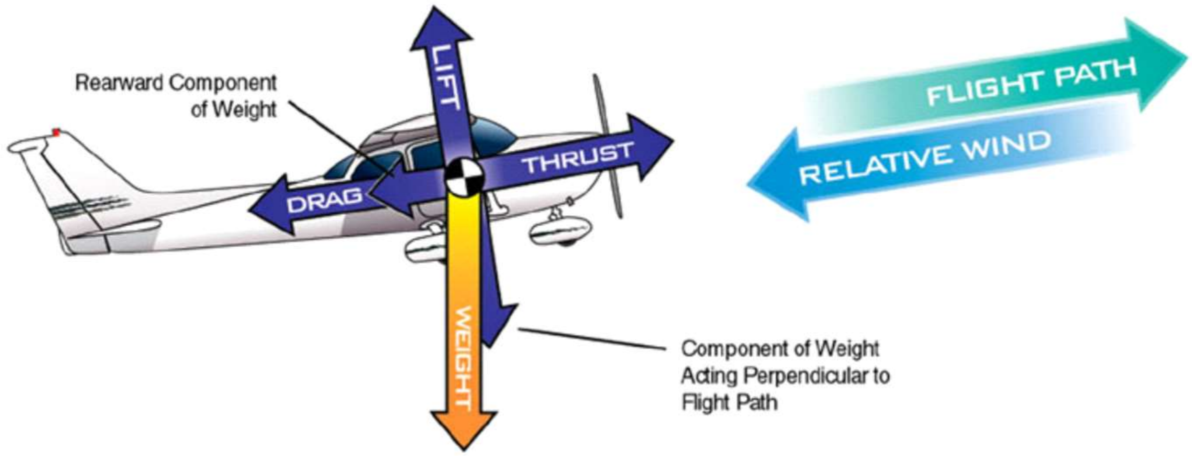
PHASES OF A SPIN

- Entry – The airplane is stalled by exceeding the wing's critical angle of attack, while allowing the aircraft to yaw, or by inducing yaw with rudder initiated skidding uncoordinated flight.
- Buffeting – The wing airfoil begins to lose its boundary layer, resulting in oscillations of the control surfaces from turbulent airflow.
- Departure – The aircraft can no longer maintain flight in a stalled condition and deviates from its projected flight-path.
- Post-stall gyration – The aircraft begins rotating about all three axes, the nose pitch attitude may fall, or in some cases rise, the aircraft begins yawing, and one wing drops.
- Incipient – With the inside wing stalled more deeply than the advancing wing, both the roll and yaw motions dominate.
- Developed – The aircraft's rotation rate, airspeed, and vertical speed are stabilized. One wing is stalled more deeply than the other as the aircraft spins downward along a corkscrew path.

Spin Recovery – Power is first reduced to idle and the ailerons are neutralized. Then, full opposite rudder is added and held to counteract the spin rotation, and the elevator control is moved briskly forward to reduce the angle of attack below the critical angle. Depending on the airplane and the type of spin, the elevator action could be a minimal input before rotation ceases, or in other cases the elevator control may have to be moved to its full forward position to effect recovery from the upright spin. Once the rotation has stopped, the rudder must be neutralized and the airplane returned to level flight. If you panic or forget the recovery procedure

1. reduce power to idle and take your feet off the rudder
2. take your hands off the control yoke. The rotation will stop. Take the yoke and very gradually level the aircraft and add power gradually.

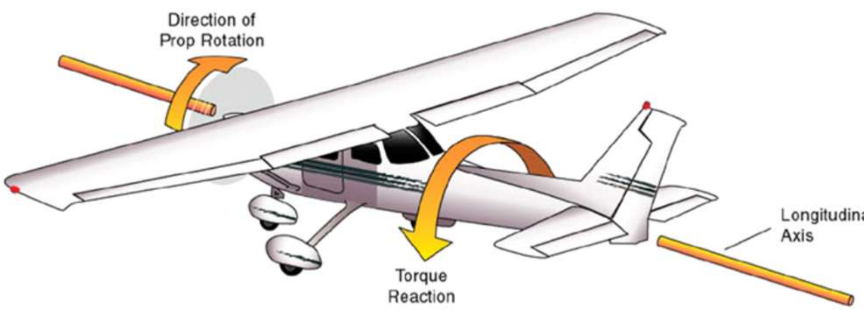
Aerodynamics: Climbing Flight



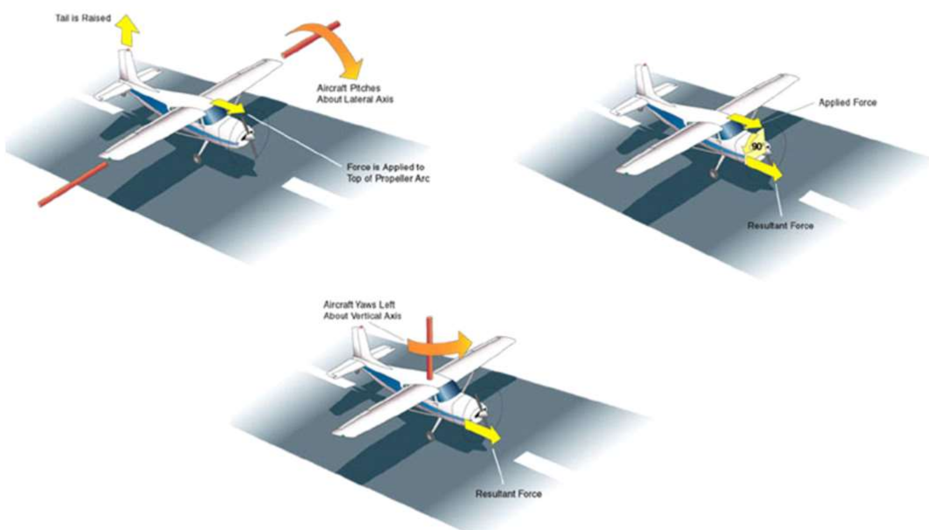
Climbing: Force of weight no longer perpendicular. Climbs also make you subject to Left-Turning Tendencies (Torque, Precession, Asymmetrical Trust and Side stream effects

Aerodynamics: Climbing Left-Turn Tendencies

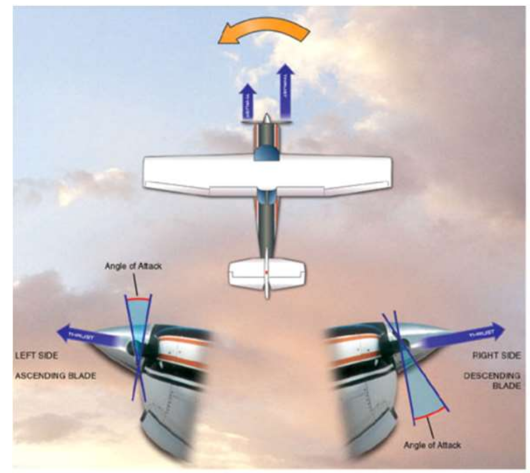
Torque (worst at low airspeed, high power, and high angle of attack)



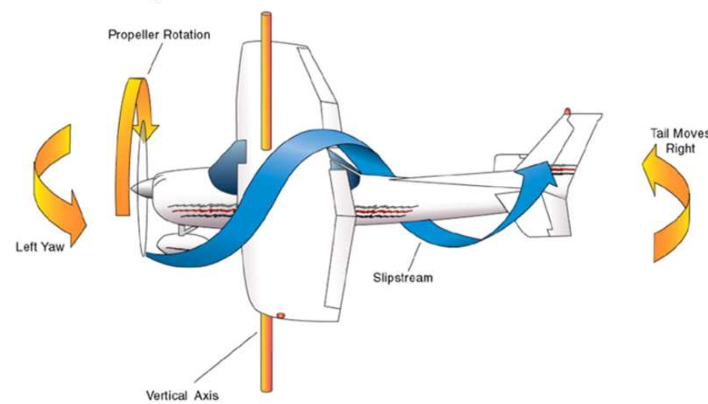
Gyroscopic Precession



Asymmetrical Thrust (P-Factor)



Slip Stream Effects

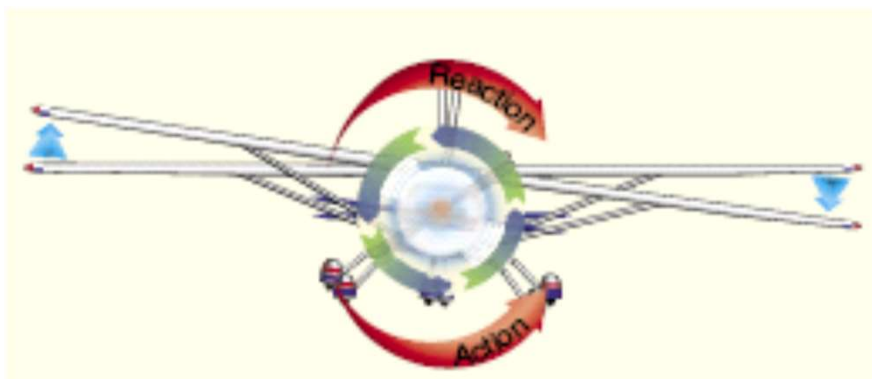


Torque Effects

Newton's 3rd Law of Physics (for ever reaction there is an equal an opposite reaction impacts flight in many ways. For instance: As internal engine parts and propeller are rotating in one direction, an equal force is trying to rotate the airplane in the opposite direction.

In Flight

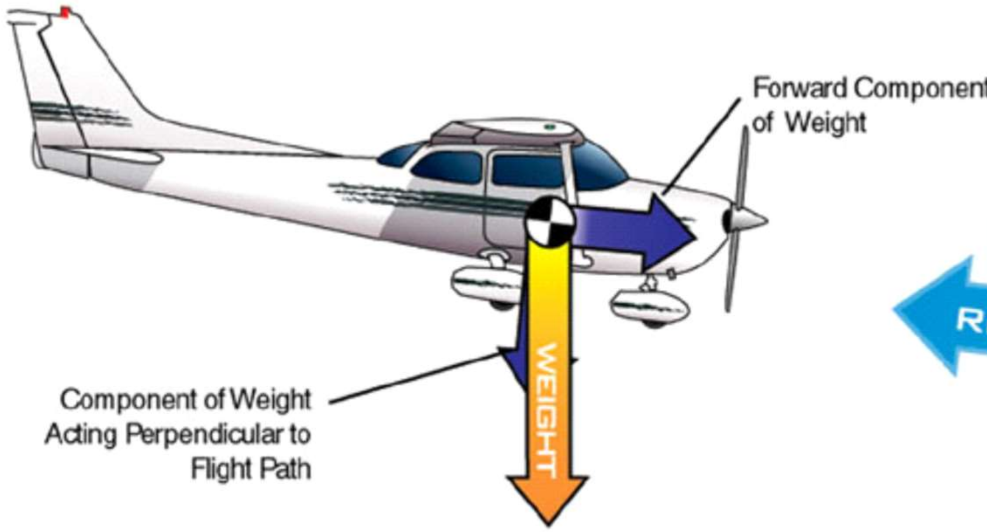
Tendency to roll due to torque on the longitudinal axes (straight along the fuselage).



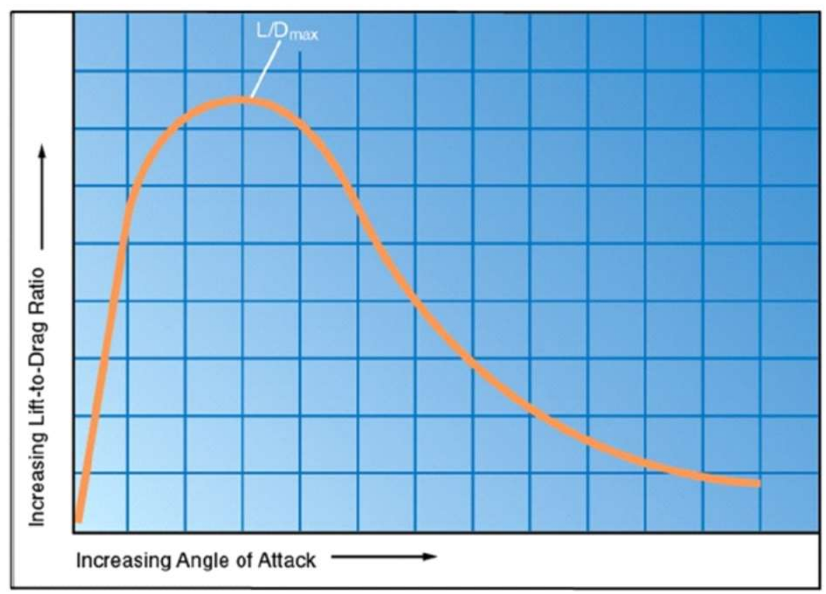
On the Ground

During takeoff roll, additional turning movement around the vertical axis is induced by torque. The left side of the airplane is being forced down by torque, more weight is place on the left landing gear. Results in more ground friction (drag) on left tire than On the right, causing a further turning movement to the left.

Aerodynamics: Descending Flight



Lift-to-Drag Ratio
L/D Max is best.
FIND IN P O H

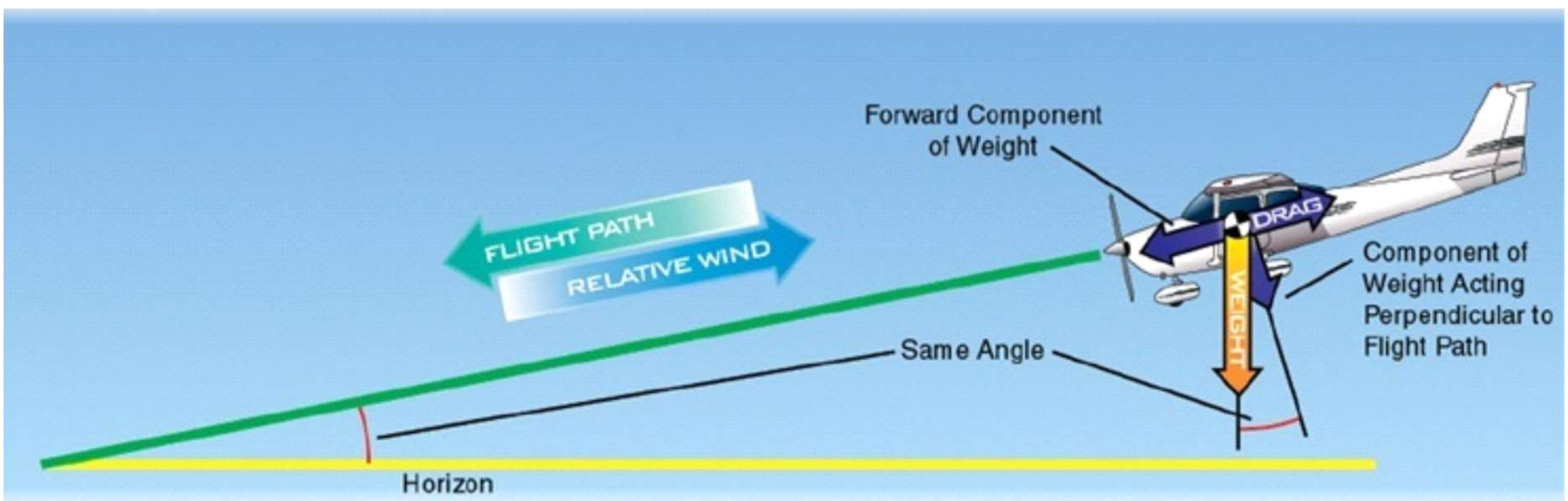


Aerodynamics: GLIDING

Glide Speed (See POH for L/D Max)

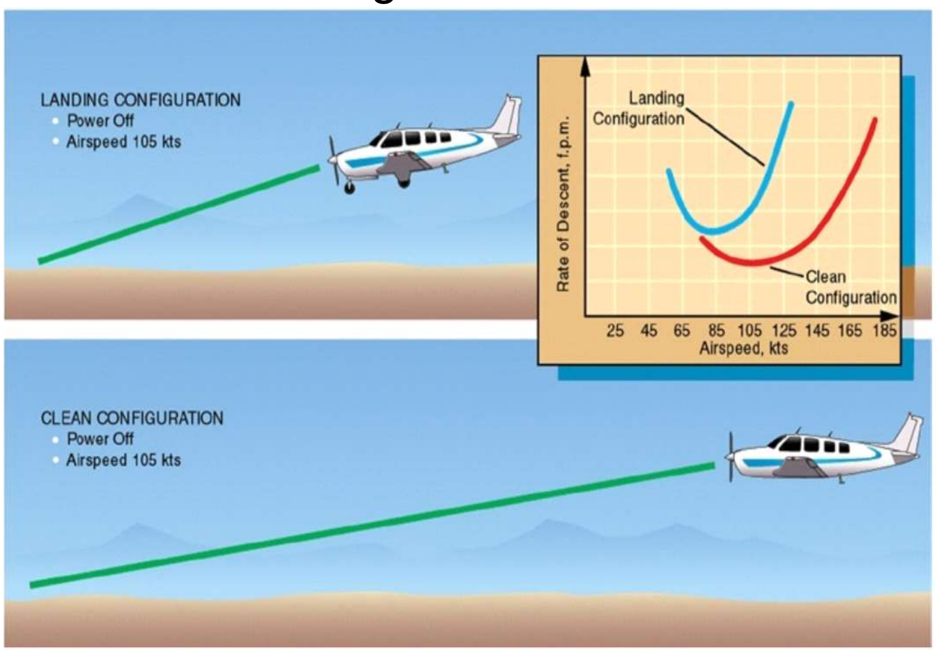
Glide Ratio. Specified in # of feet forward to # of feet down (10:1)

Glide Angle. Angle between glide path and horizon.



Aerodynamics: GLIDING INFLUENCES

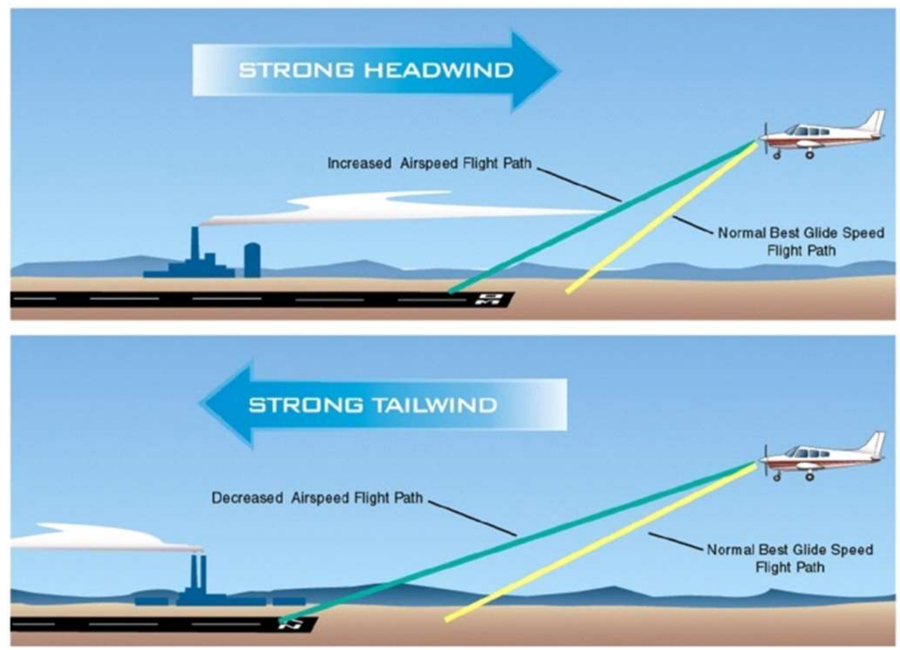
Landing CONFIGURATION = more drag = shorter glide distance



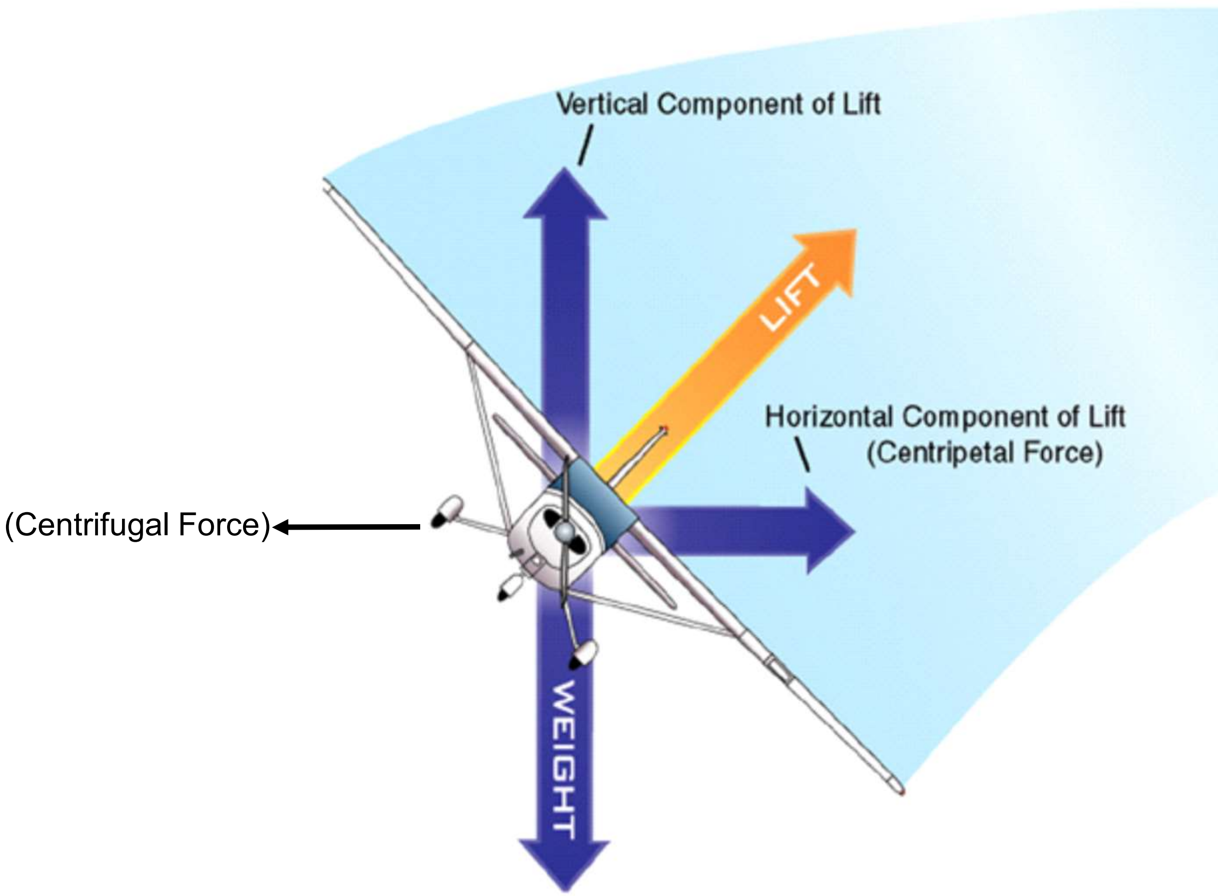
WEIGHT

Heavier airplanes glide the same distance as light airplanes but to do so the heavier aircraft must glide at a higher airspeed.

WIND

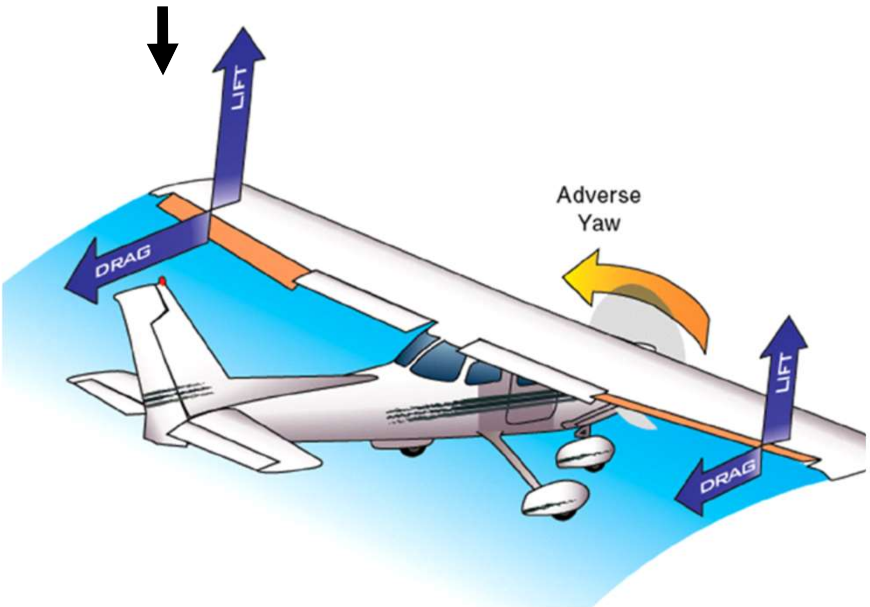


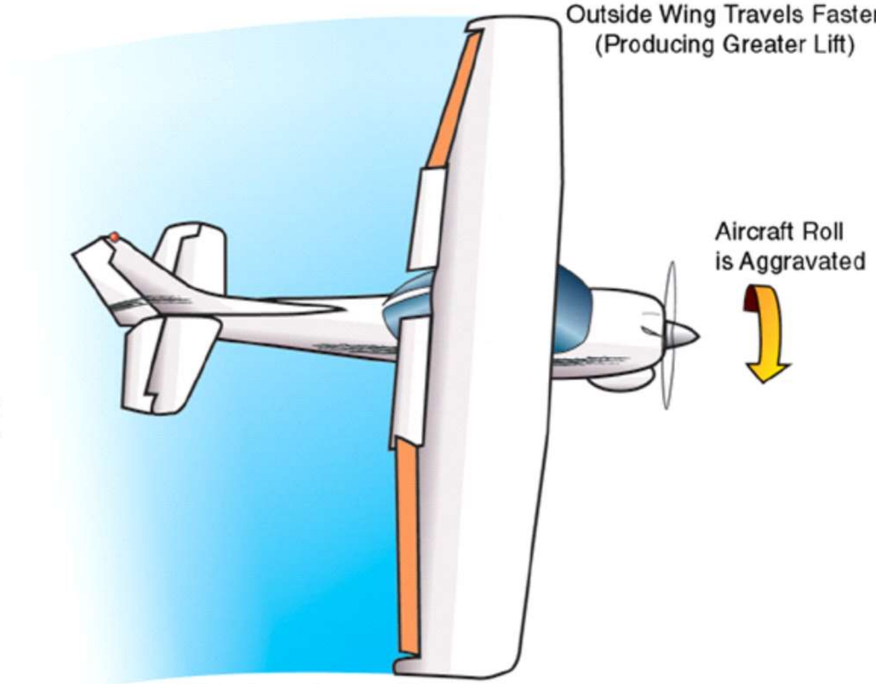
Aerodynamics: TURNS



Aerodynamics: TURNS

Adverse Yaw: Higher Lift and Drag on 1 wing results in opposite of turn yaw.

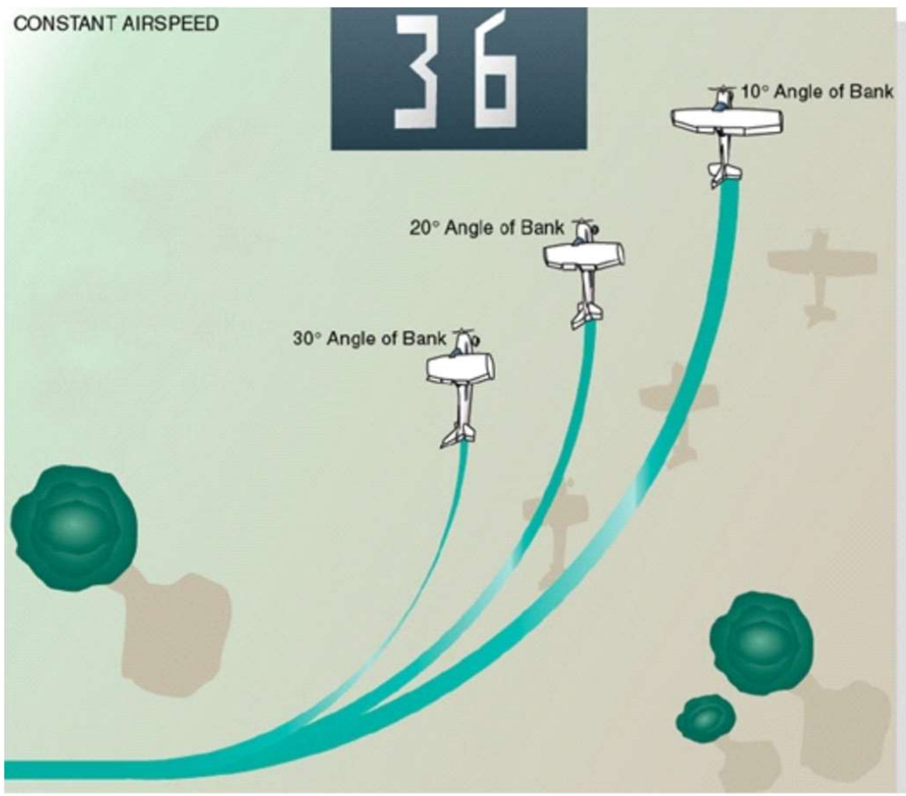




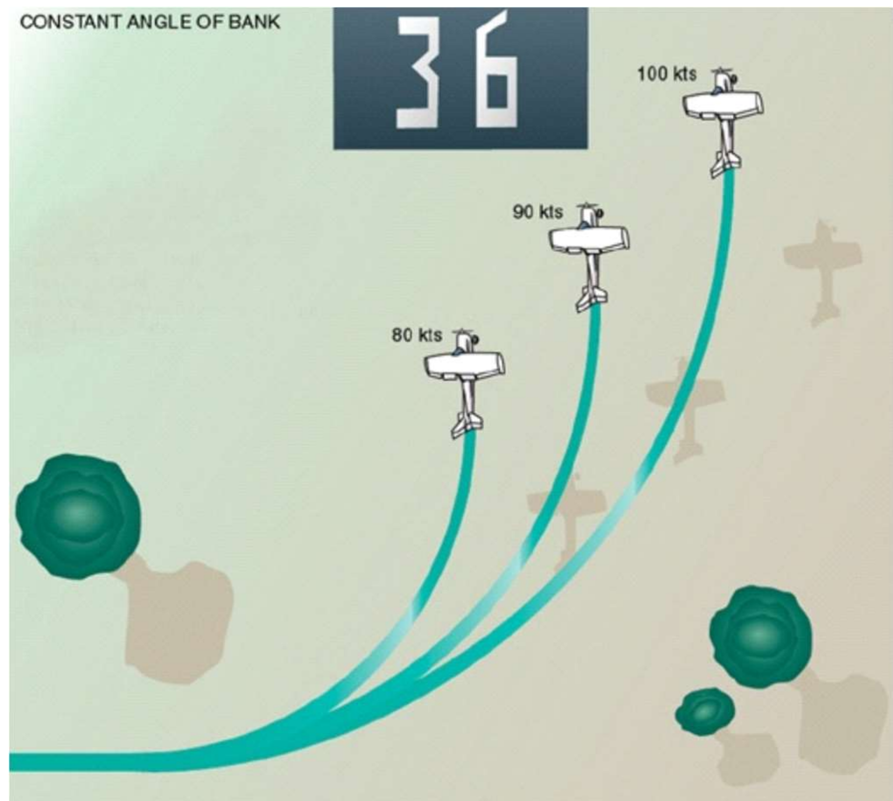
Over banking Tendency: Airplane wants to continue to roll (especially steep turns) even when controls neutralized.

Aerodynamics: TURNS

Angle of bank and Airspeed regulate the rate and radius of a turn.



Constant Airspeed



Constant Angle of Bank

Standard rate turn radius in NM?

- At 200 KTS, your turn radius is 1 NM so under 200KTS turn radius is TAS/200

Example: 100 KTs, Radius = 100/200=.5 NM

75 KTs, Radius = 75 / 200=.375 NM

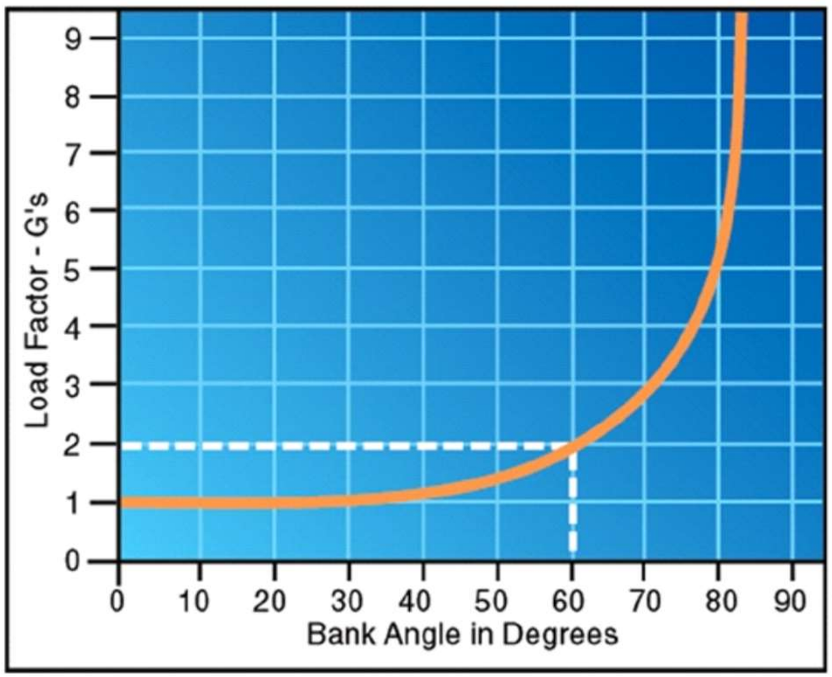
- For High Speed (Mach) turn radius is (Mach#*10)-2

Example: .8, radius = (.8*10)-2 = 8-2 = 6 NM

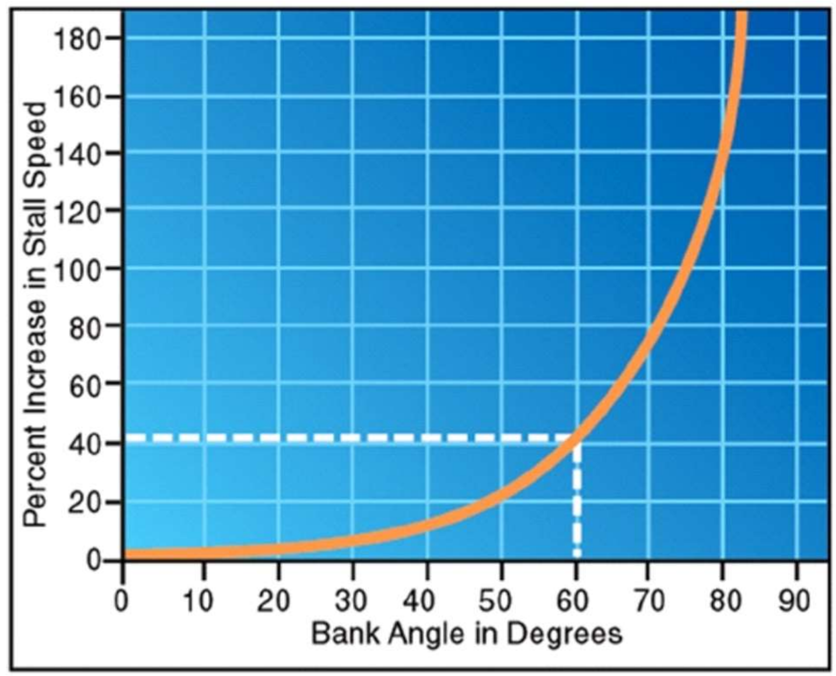
Aerodynamics: LOADS

Load is the ratio of the weight supported by the airplane's wings to the actual weight of the airplane and it's components. G-Forces produced by turns, wind shear, unusual attitudes or sudden changes in pitch.

G-Forces produce Weight Changes in Turns-aircraft must support more weight (weight x load)



Stall Speed Changes in Turns-cannot use Vs1, increases by % below.



LOADS CAN EXCEED INTEGRITY OF STRUCTURE!!!

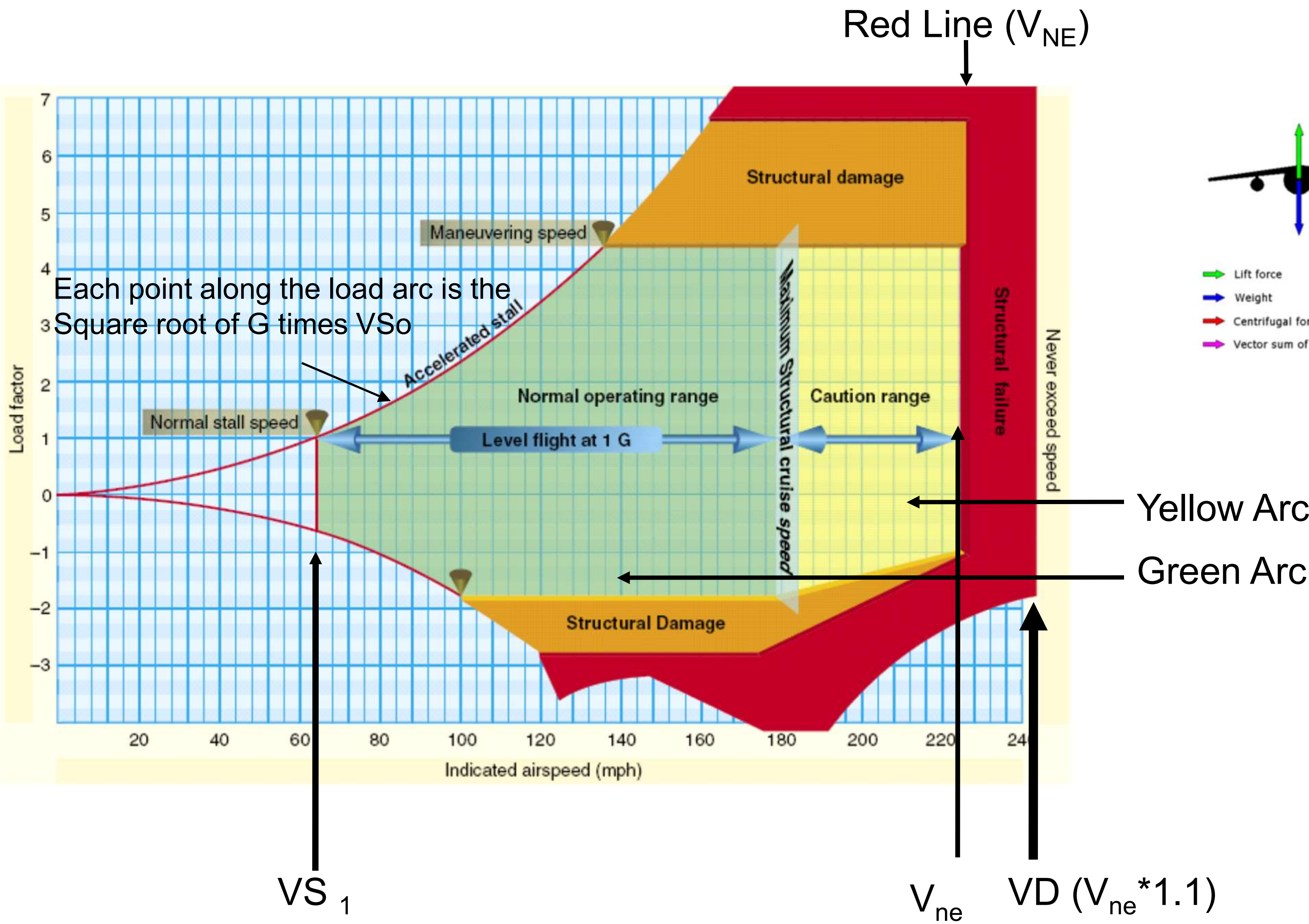
Level Turns: Loads increase terrifically after 45 degrees.
60 degrees =2 Gs, 80 degrees = 5.76 Gs

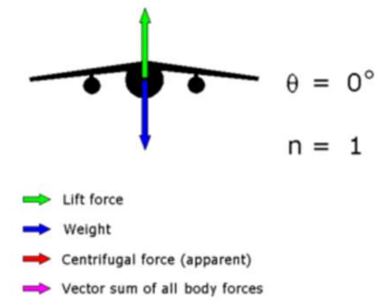
Turbulence: Severe vertical gusts can cause sudden increase in angle of attack, resulting in large loads which are resisted by the inertia of the airplane.

Speed: Excess load imposed on a wing depends on how FAST the airplane is flying. At speeds below maneuvering speed an airplane will stall before a load factor becomes destructive. Above maneuvering speed, the limit load factor for which an airplane is stressed can be exceeded by abrupt or excessive application of the controlsor by strong turbulence.

REMEMBER:	Normal limits:	+3.8 to -1.52 Gs
	Utility Limits:	+4.4 to -1.76 Gs
	Aerobatic:	+6.0 to -3.00 Gs

Aerodynamics: LOADS





How to create your aircrafts Load Chart: From POH, write down VS0, VS1, VNO, VA and VNE

Compute VD (dive speed) as VNE * 1.1

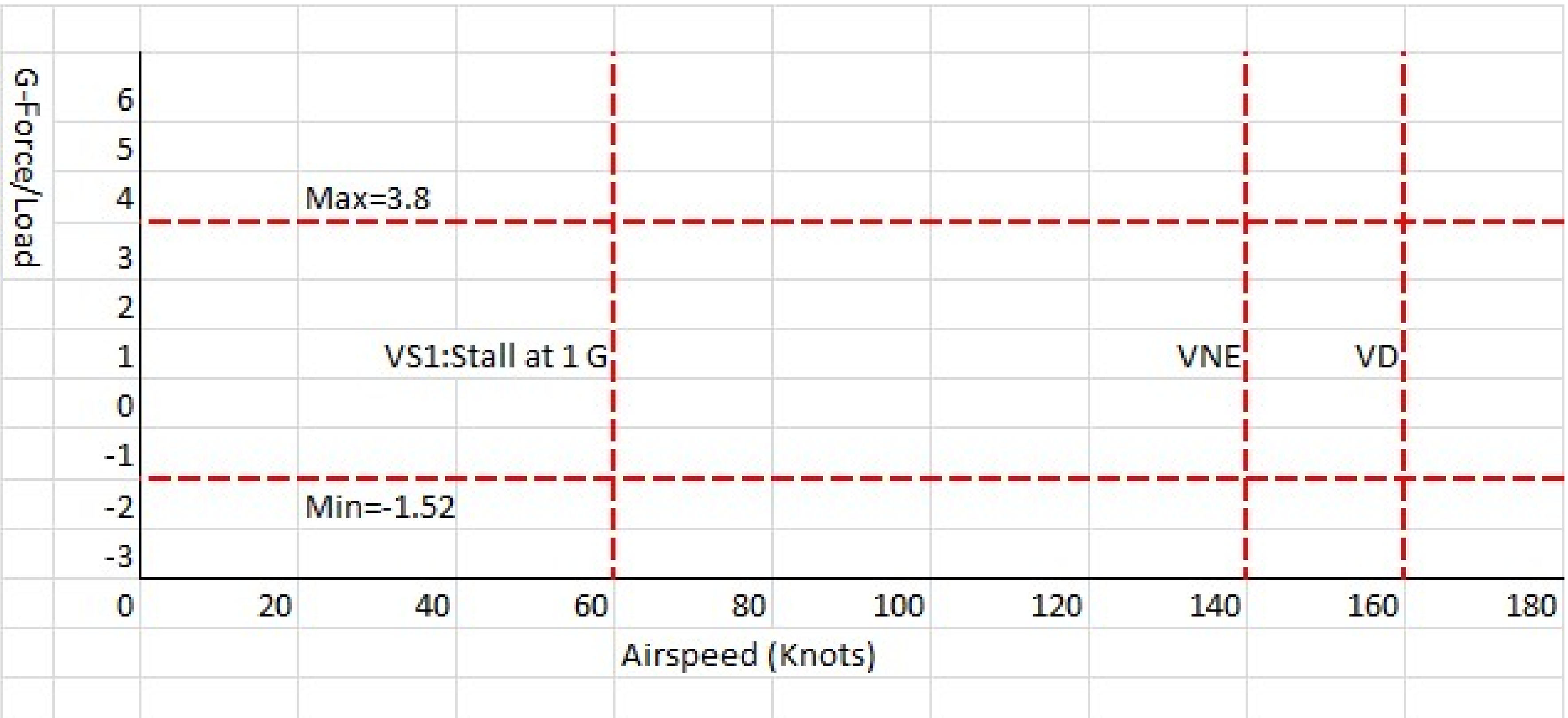
Draw the X-Axis at the bottom reprsenting airspeed from 0 to 20 Knots above VD

Draw Vertical Line on left (Y-Axis) representing G-Forces from +6 down to -4

Draw Vertical Line on the right representing VD

Draw a top horizontal line representing normal certified max positive G load of +3.8

Draw a low horizontal line representing normal certified max negative G load of -1.52



Creating the +G Stall Line: First, Place a data point for VS1 on the 1 G line

Create a datapoint up to 5 Gs and plot against airspeed as follows:

Take the square root of each +G value and multiply by VS_0 >>

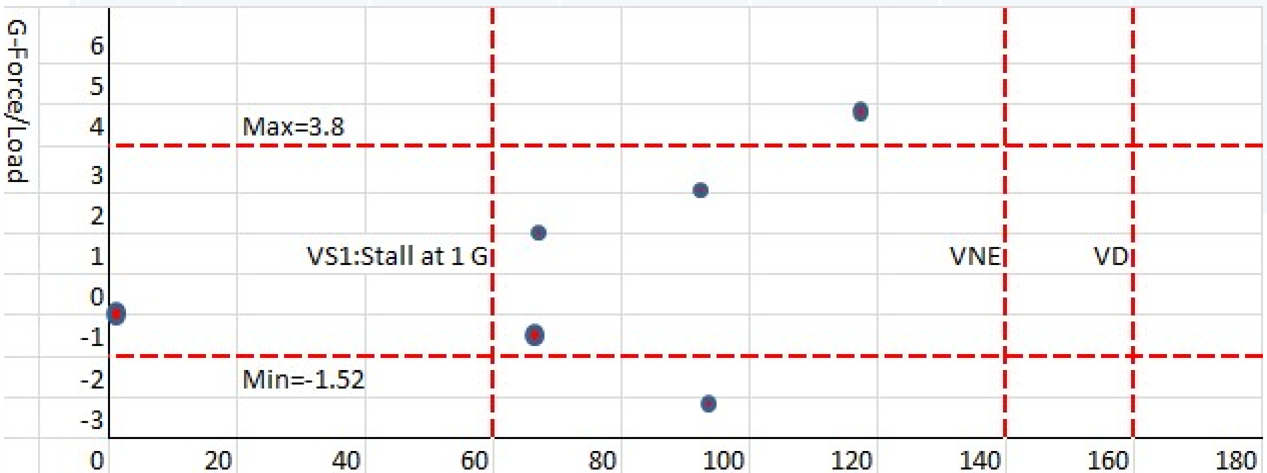
up to +3.8Gs

Do the same for -G values to -1.52

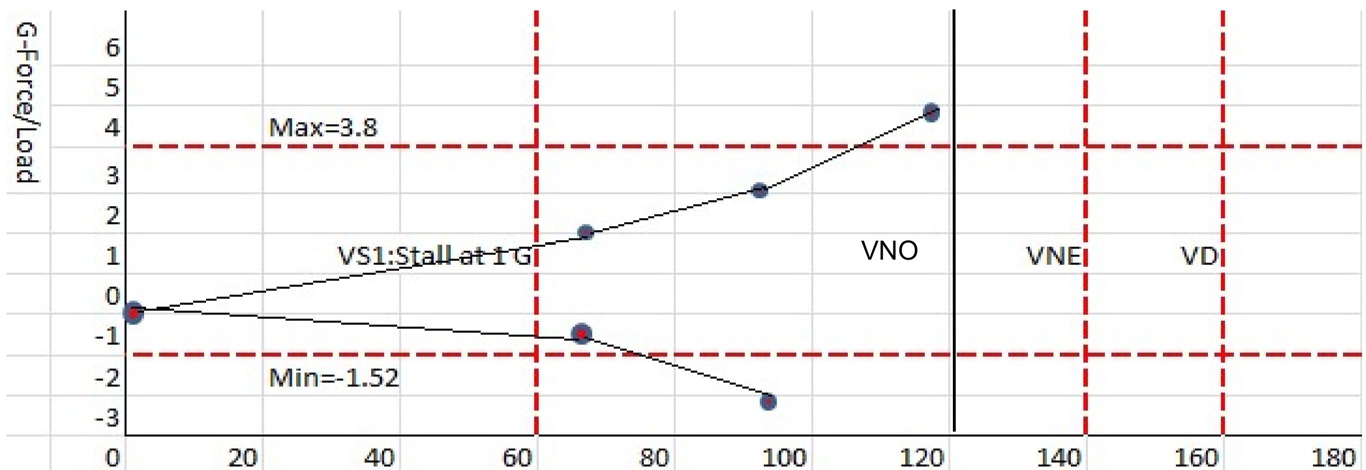
Draw vertical line for VNO

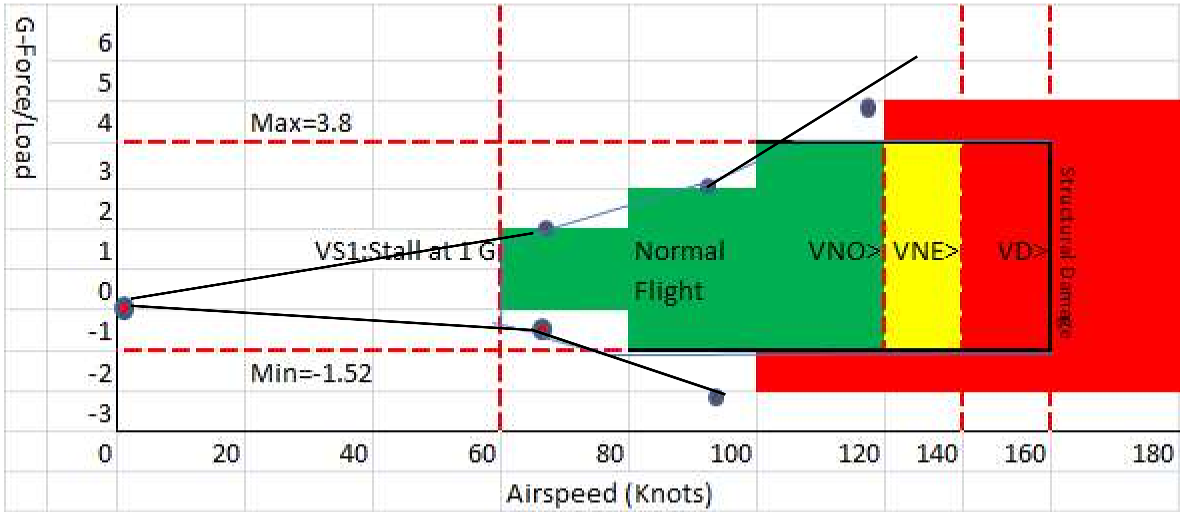
Example: $VS_0=52$

G	Sqr	x VS_0
1.5	1.22	64
2	1.41	74
2.5	1.58	82
3	1.73	90
3.5	1.87	97
4	2.00	104
5	2.24	116

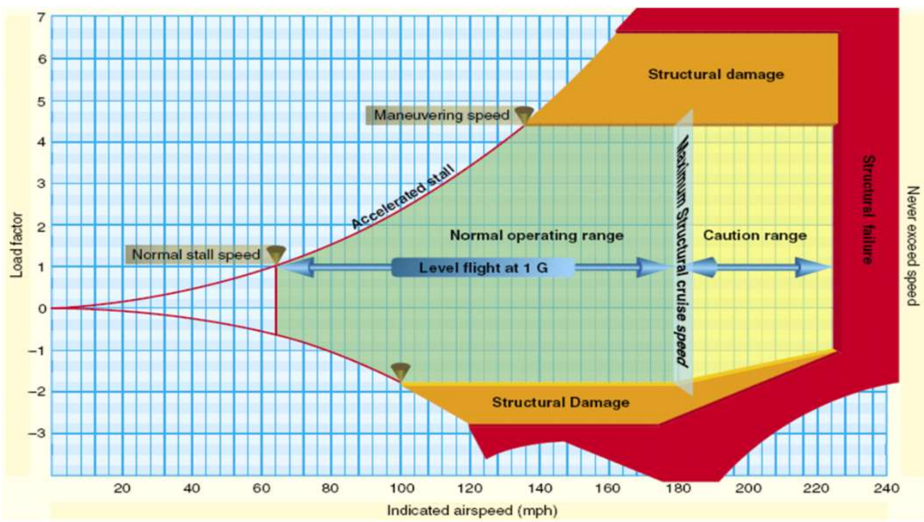


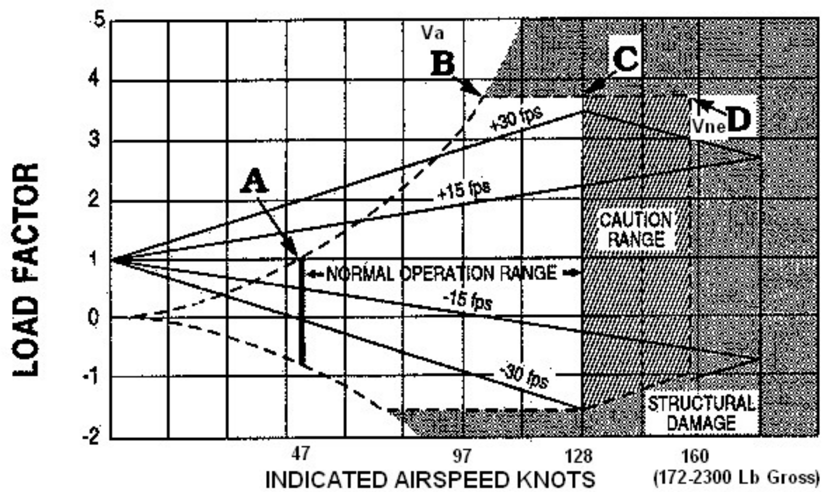
Connect data





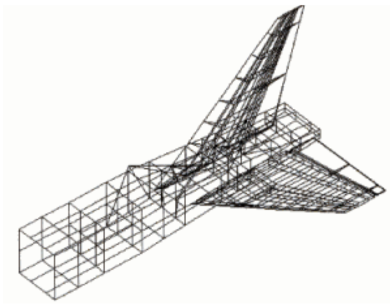
A bit crude but you see the process





Aerodynamics: FLUTTER

A self-feeding and potentially destructive vibration where aerodynamic forces on an object coupled with a structure's natural mode of vibration to produce rapid oscillating motion that can destroy any flexible surface of an airplane especially at *high speeds*.



https://www.youtube.com/watch?v=pEOmCkZyXzk

A series of six total in-flight structural failures of the Zodiac Model CH 601 XL (occurring in the US between February 2006 and November 2009) led the agency to stop issuing airworthiness approvals to those Zodiac 601 and 650 models in late 2009. Accidents were related to aircraft structure, flutter, proper airspeed calibration, and stick forces. NTSB concerns focused primarily on evidence that seemed to indicate flutter was a root cause for some, if not all, of the accidents.

https://www.youtube.com/watch?v=kQI3AWpTWhM&feature=related

Last item for Commercial Aeronautical Knowledge Information

Transonic and supersonic flight speeds are expressed in terms of true airspeed in knots to the speed of sound in knots. This ratio is called the **mach number**.

a. This ratio is not fixed because the speed of sound varies with altitude and temperature.

At low flight speeds, the study of aerodynamics is greatly simplified by the fact that air may experience relatively small changes in pressure with only negligible changes in density.

a. This airflow is termed incompressible since the air may undergo changes in pressure without apparent changes in density.

b. The study of airflow at high speeds must account for these changes in air density and must consider that the air is compressible and there will be compressibility effects.

c. Local airflow velocities around an aerodynamic shape can be greater than flight speed

1) Thus, an aircraft can experience compressibility effects at flight speeds well below the speed of sound.

Since an aircraft can have both subsonic and supersonic airflows simultaneously, certain regimes have been defined.

a. Subsonic: Mach numbers below 0.75.
b. Transonic: Mach numbers from 0.75 to 1.20.
c. Supersonic: Mach numbers from 1.20 to 5.00.
d. Hypersonic: Mach numbers above 5.00.

The **critical mach number** is the highest flight speed possible without supersonic flow.

a. Accelerating past critical mach is associated with trim and stability changes and a decrease in control surface effectiveness.

WRAP UP

Questions???

NEXT SESSION

Study for exam on ADM, Systems, Instrumentation, and Aerodynamics.

"That's All Folks"