

# Seeing is NOT Believing



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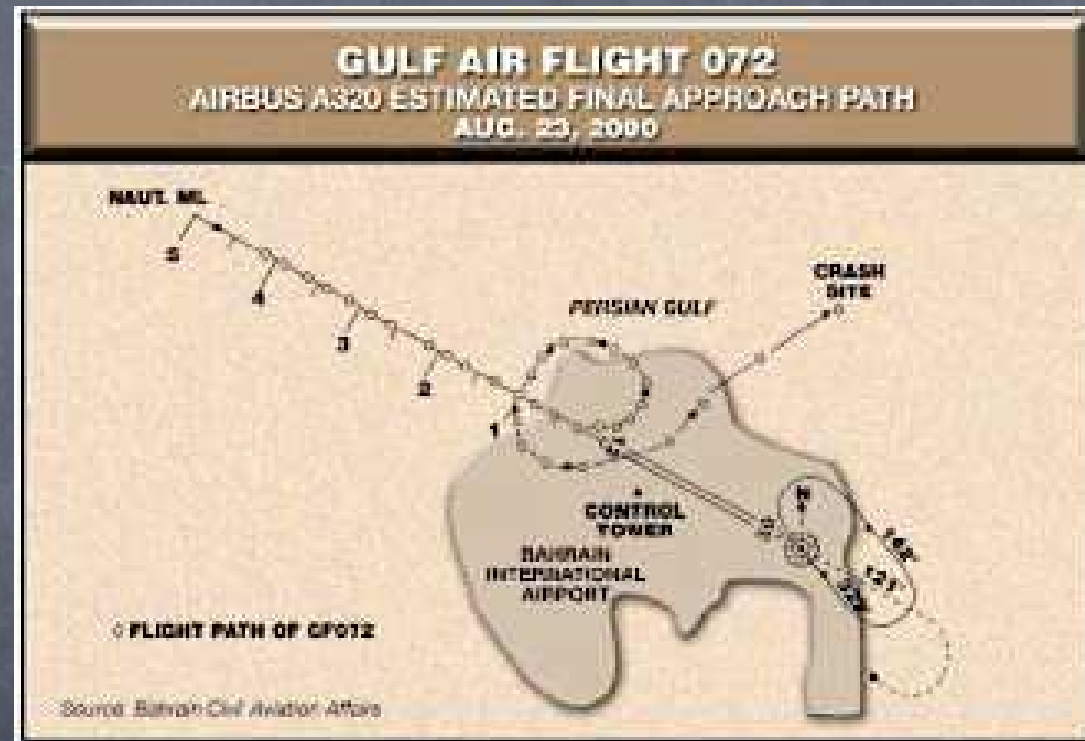
# Gulf Air Flight 072

- 23<sup>rd</sup> August, 2000
- Cairo – Bahrain A320
- Crashed, 143 killed
- 1930 hrs local time



# Gulf Air Flight 072

- Auto-pilot off
- VOR/DME approach
- Too high & too fast at 0.9 Nm from runway 12
- Approach aborted



# Gulf Air Flight 072

- 250 kts below 10000 ft as per flight manual
- 330 kts, at 2300 feet
- Did not execute missed approach
- 360° left, 500 – 600 ft attempt to land again



# Gulf Air Flight 072

- Non standard, involving considerable variations
- Re-intercept with approach
- Overshot runway



# Gulf Air Flight 072

- Ignored GPWS warnings
- Misperception of pitch, multiple cockpit distractions
- Spatial disorientation

# Spatial Disorientation

- Getting lost not covered by this definition
- Pilot confusion about position, attitude & motion of aircraft
- Rapidly changing, dynamic flight environment
- Degree of freedom, no direct link with Earth

# Spatial Orientation

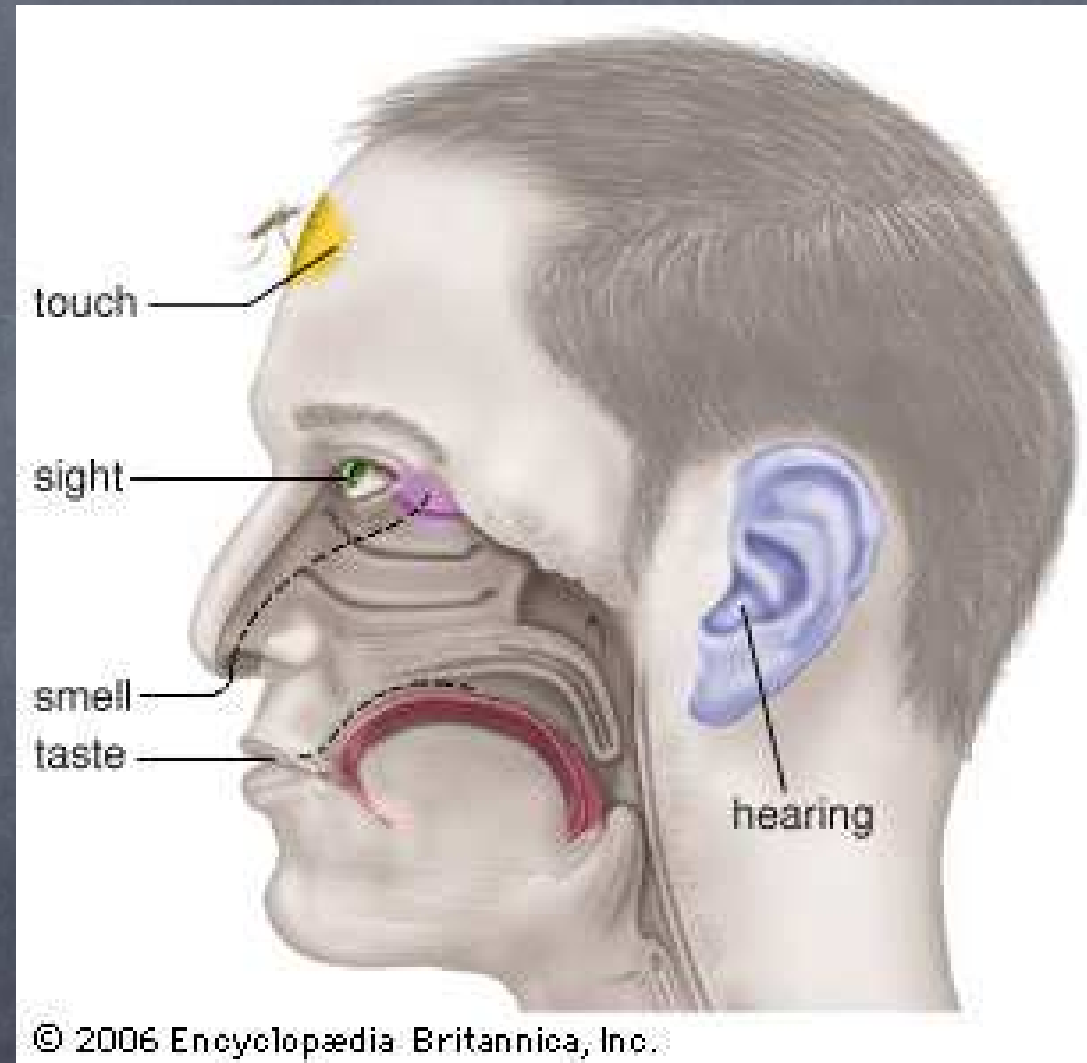
- *Natural ability to maintain our body orientation  $\pm$  posture in relation to the surrounding environment at rest & during motion*

# Spatial Orientation

- Designed to maintain spatial orientation on the ground
- Hostile flight environment creates conflict & illusions
- 5 – 10% GA accidents due to disorientation
- 90% **FATAL**

# Spatial Orientation

- Ground
- Visual, vestibular, proprioceptive inputs
- Acceleration & gravity changes
- Compared with visual information



# Spatial Orientation

- Flight
- Brain – key organ
- Attitude, position & motion

# Spatial Orientation #1

- Motion – directional
- Linear, rotational or combination
- No value w/o specific data on direction vector

# Spatial Orientation #2

- Information judged according to point of reference
- Intersection of Earth's surface & vertical vector of gravitational pull
- Earth is left behind in flight
- Gravitational vector may be modified
- Brain continues to interpret body position changes

# Spatial Orientation #3

- Reference point may change
- Aerial combat or formation flying
- Cloud top, moon, sun
- If you fly helicopter, beware of cables!

# Spatial Orientation #4

- Extrapolates what he feels to what he perceives the aircraft to be doing
- Strong
- Extreme freedom in flight, attitude potentially free to vary
- Confusion, nausea & stress

# Spatial Disorientation

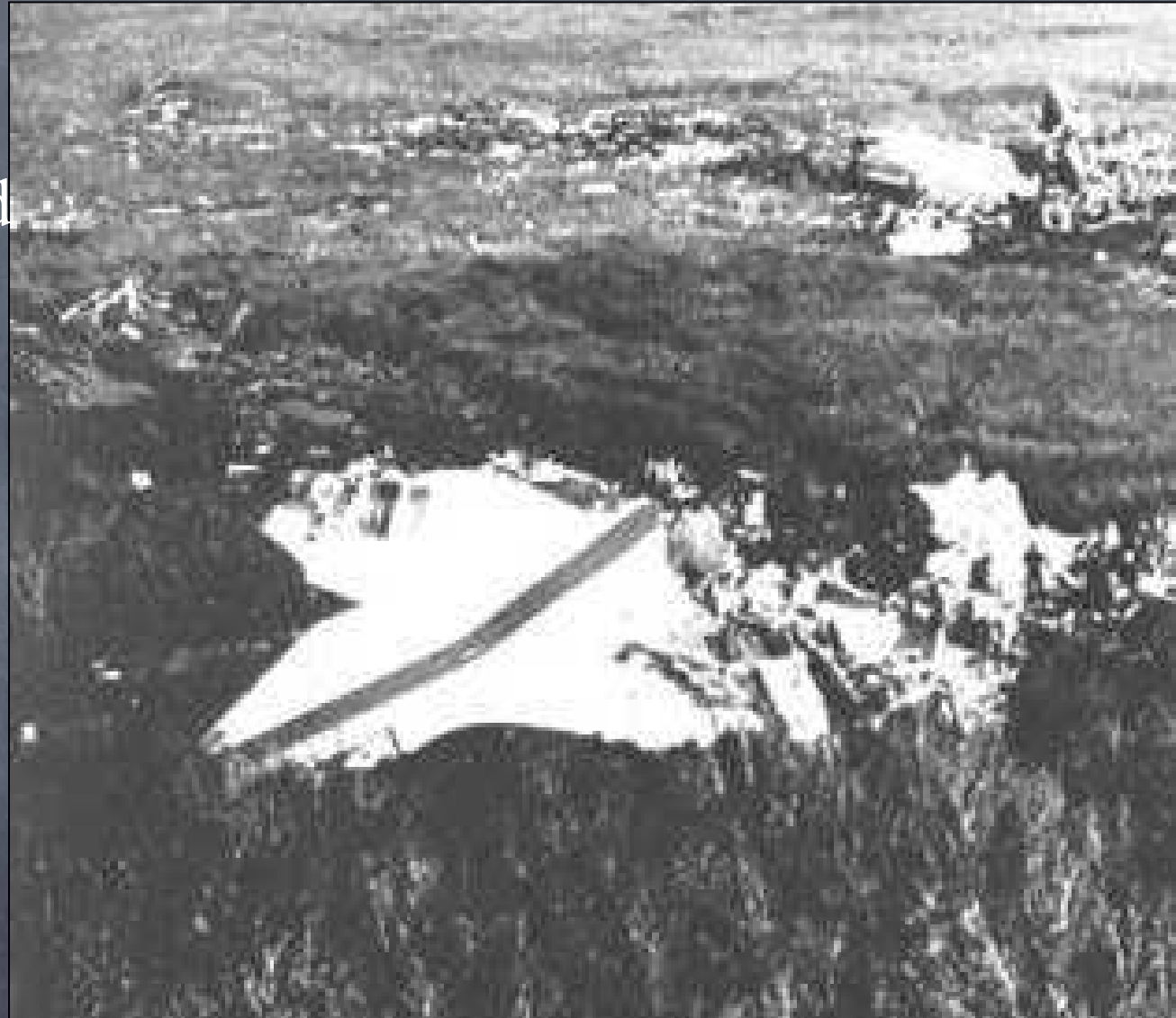
- Loss of situational awareness
- Type I : unrecognized – greater flight hazard
- Type II : recognized – discrepancy between pilot & aircraft

# Spatial Disorientation

- Pilot preoccupation or distraction
- Failure to respond to warning devices
- Over-reliance on automated systems
- Interpretation errors
- CRM failures

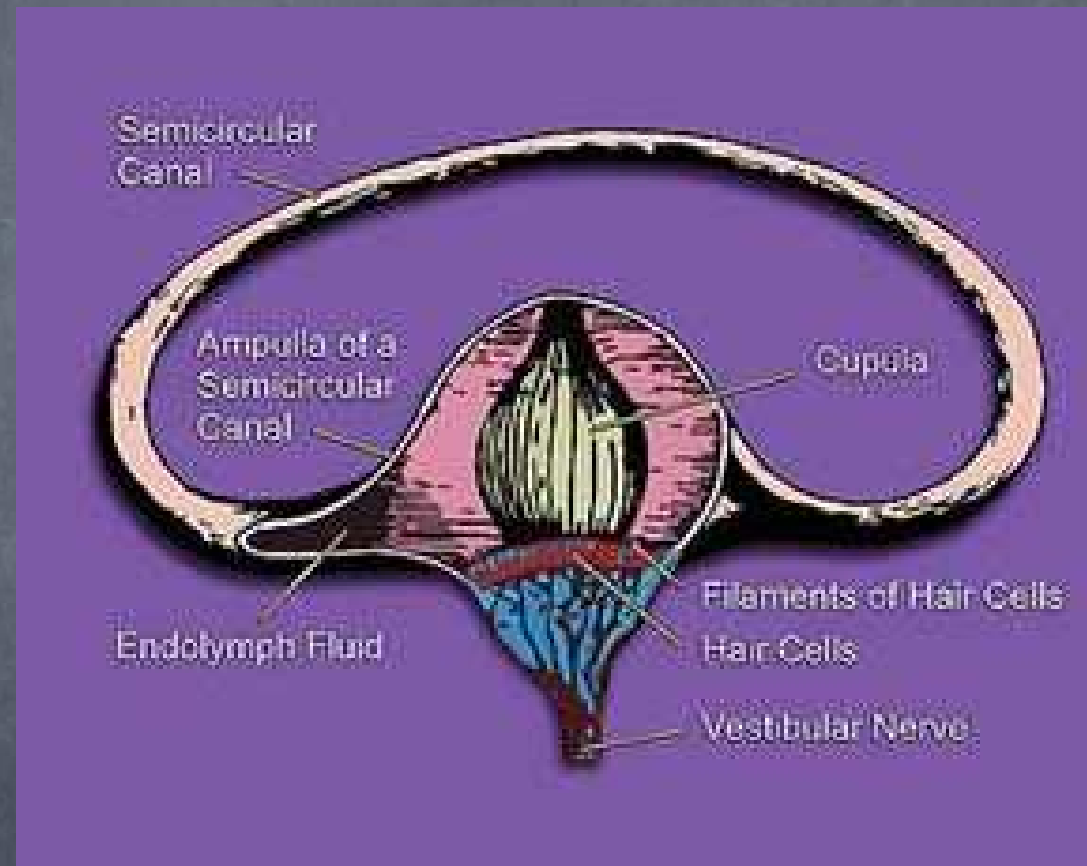
# “Coning of Attention”

Eastern Airlines 401 L-1011 (1972).  
Flight crew became pre-occupied  
by a faulty landing wheel light  
indicator and accidentally turned off  
autopilot set for 2000 feet. The  
crew realised their error too late and  
was too low to recover, impacting  
the Florida Everglades



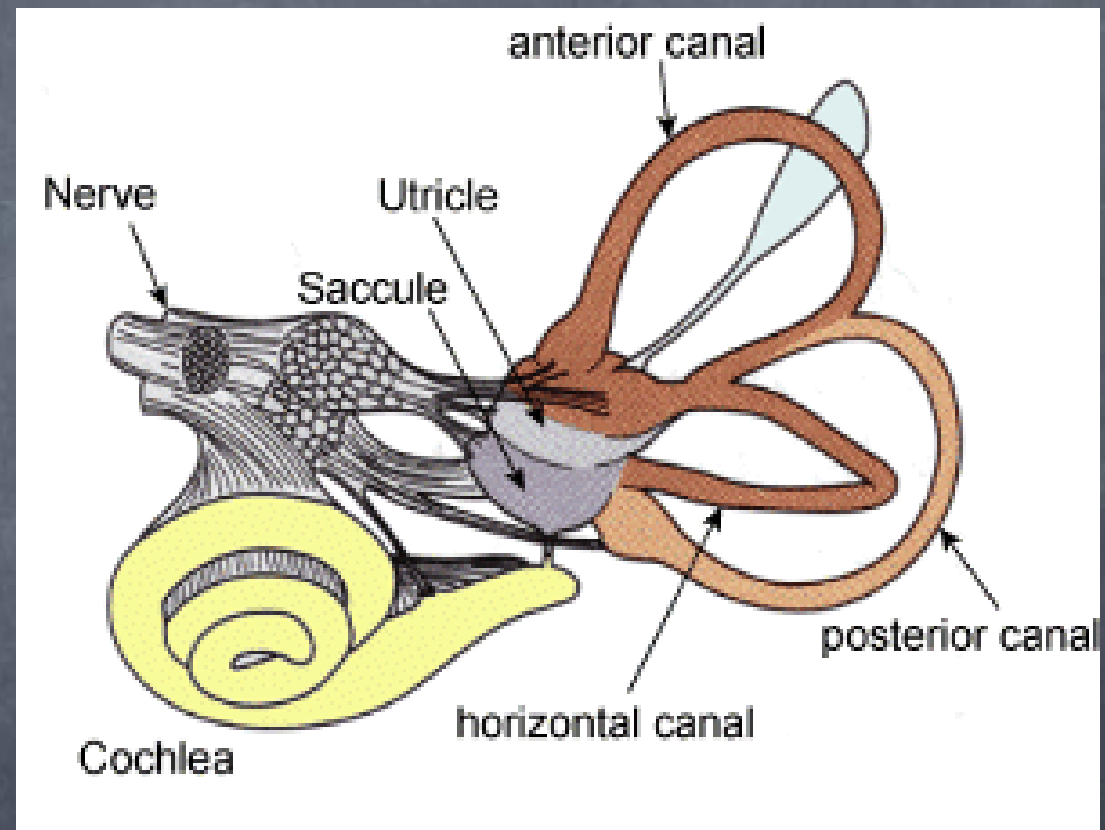
# Vestibular Physiology

- Inner ear
- Organ of equilibrium
- Semicircular canals : angular acceleration
- Otolith organs : linear acceleration & gravity



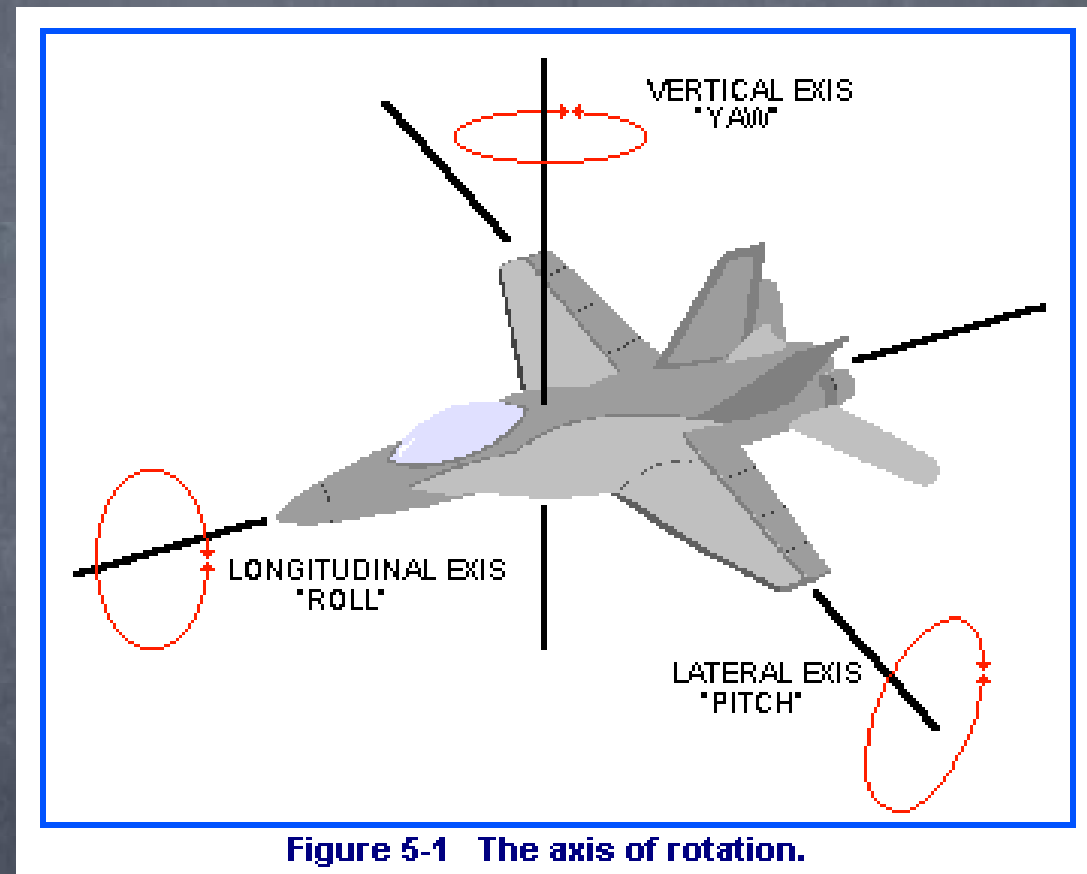
# Vestibular Physiology

- 3 circular canals
- Connected at right angles to one another

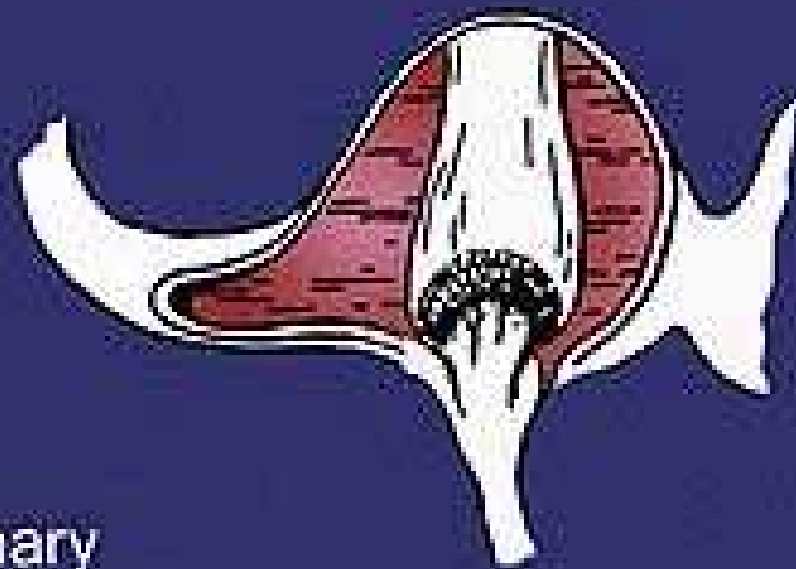


# Vestibular Physiology

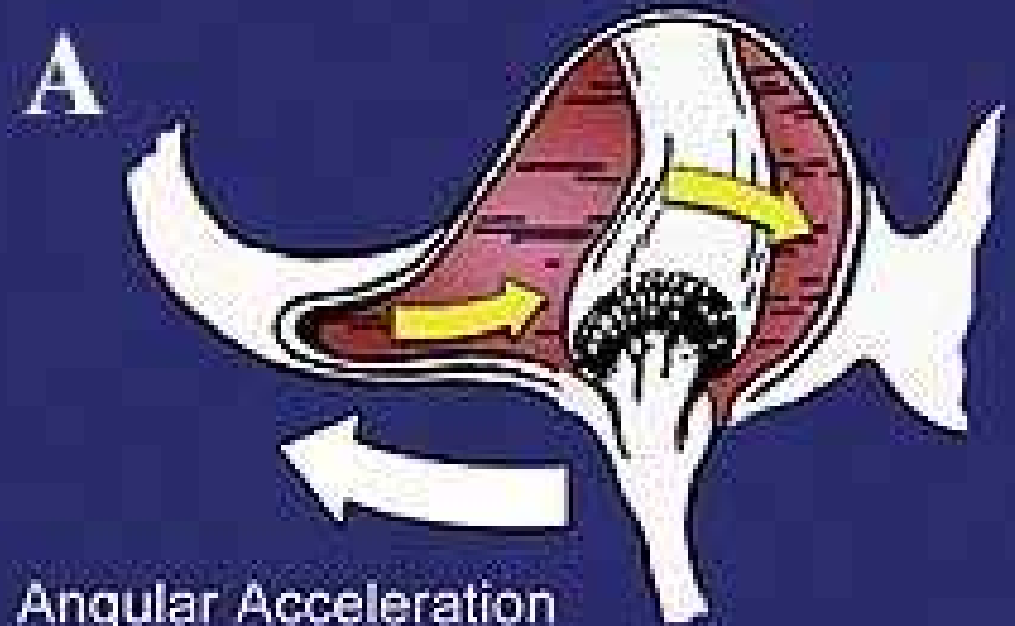
- Corresponds to pitching, rolling & yawing



# Vestibular Physiology



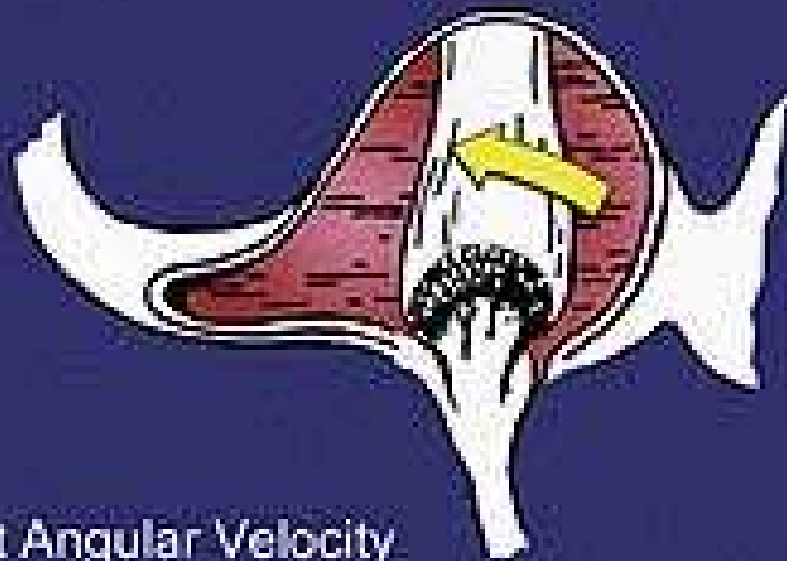
Stationary



Angular Acceleration

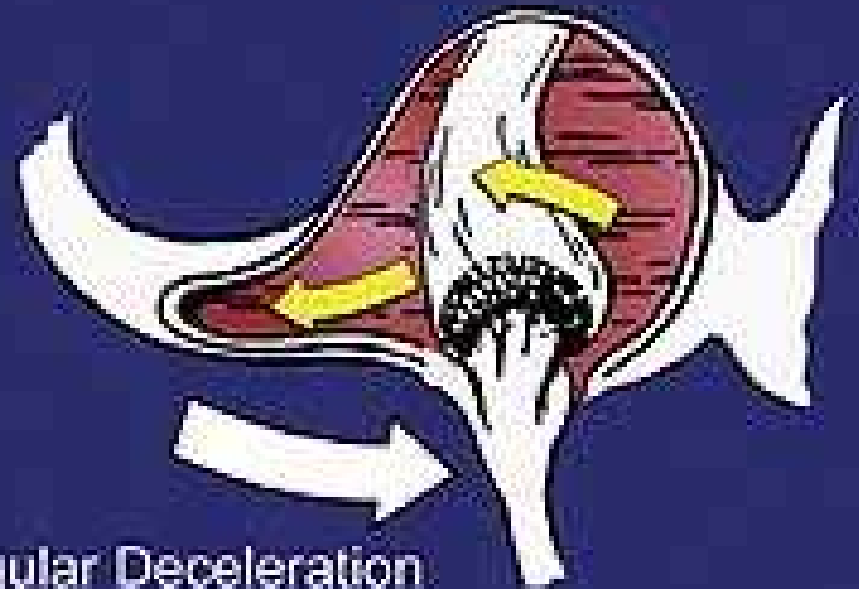
# Vestibular Physiology

B



Constant Angular Velocity

C



Angular Deceleration

# Vestibular Illusions

- Somatogyral illusions
- Leans
- Graveyard spin
- Graveyard spiral
- Coriolis illusion

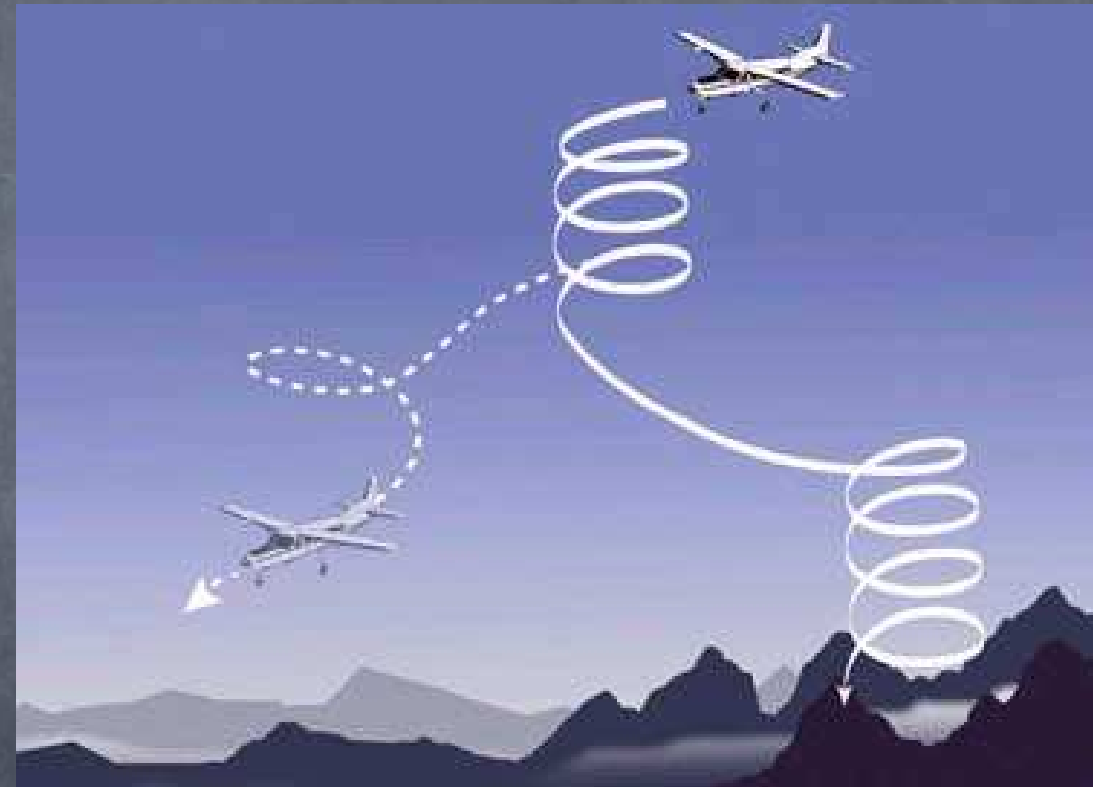
# The “Leans”

- Most common, clearly identifiable, single
- Type II
- Nuisance
- Sudden return to level flight, following gradual prolonged turn



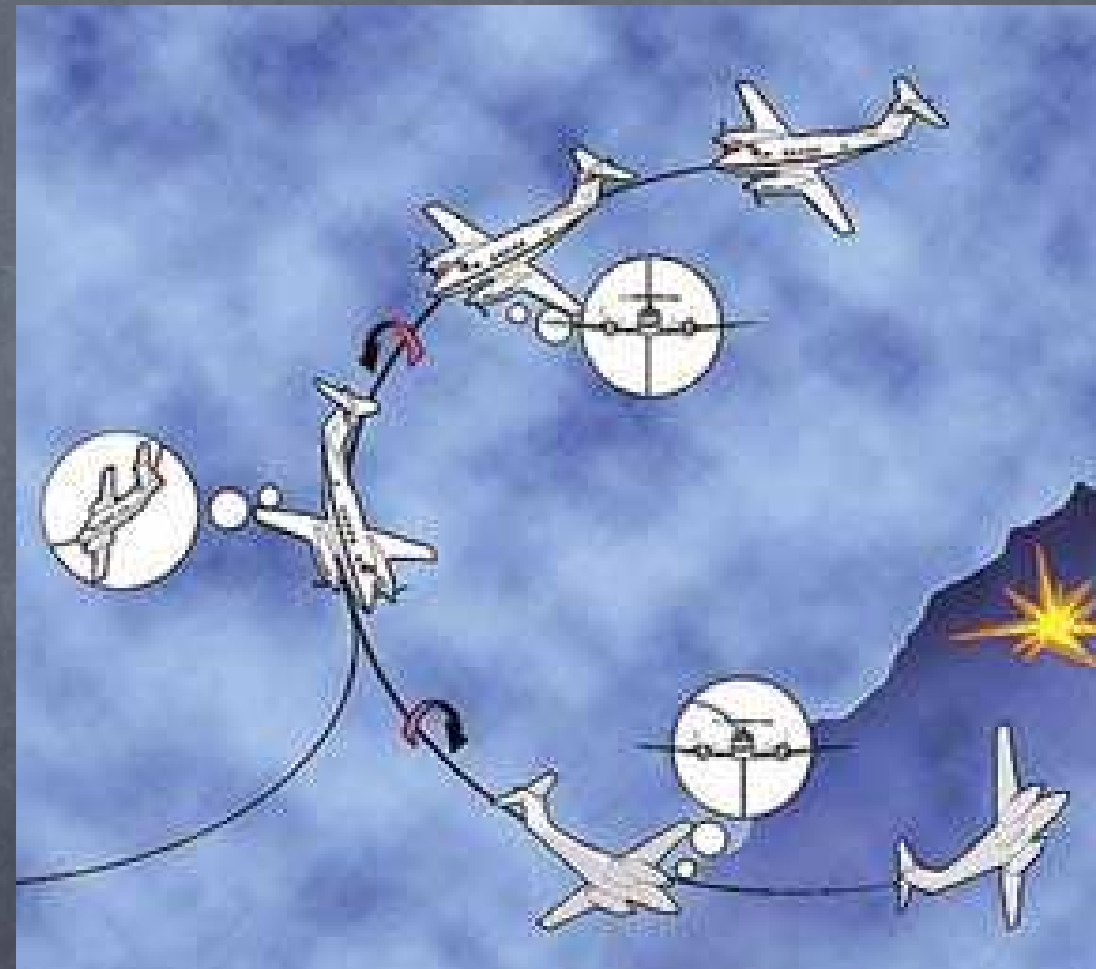
# The “Graveyard Spin”

- Intentional or unintentional spin
- Idle throttle, ailerons neutral
- Apply & hold rudder in opposite direction
- Break stall
- Hold & wait until rotation stops



# The “Graveyard Spiral”

- More common
- Return to level flight following intentional or prolonged bank turn



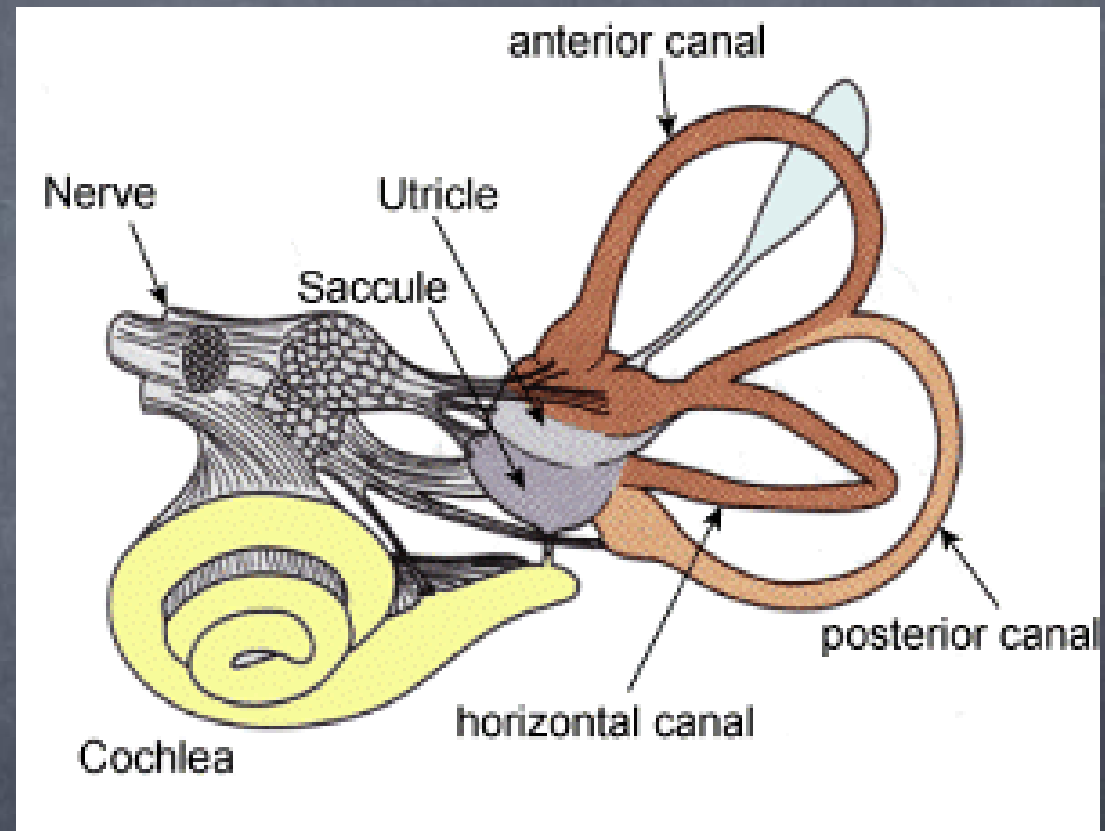
# The “Coriolis Illusion”

- Stimulation of 2 semi-circular canals
- Sudden tilting of pilot’s head when aircraft is turning
- Pitching, rolling & yawing at the same time



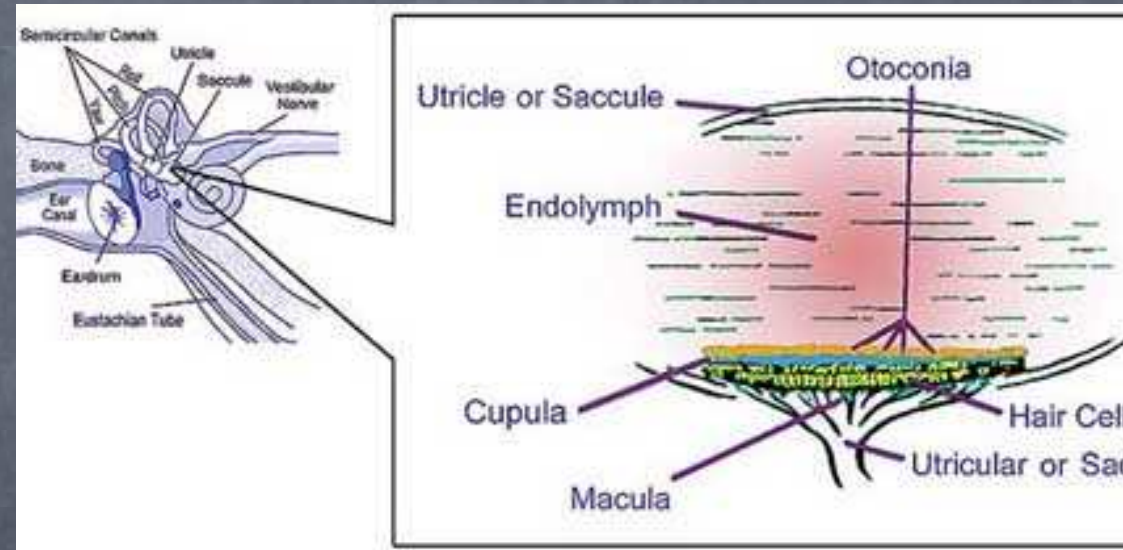
# The Otoliths

- Sacculle & utricle
- Right angle to each other
- Utricle : linear acceleration in horizontal
- Sacculle : gravity changes in vertical plane



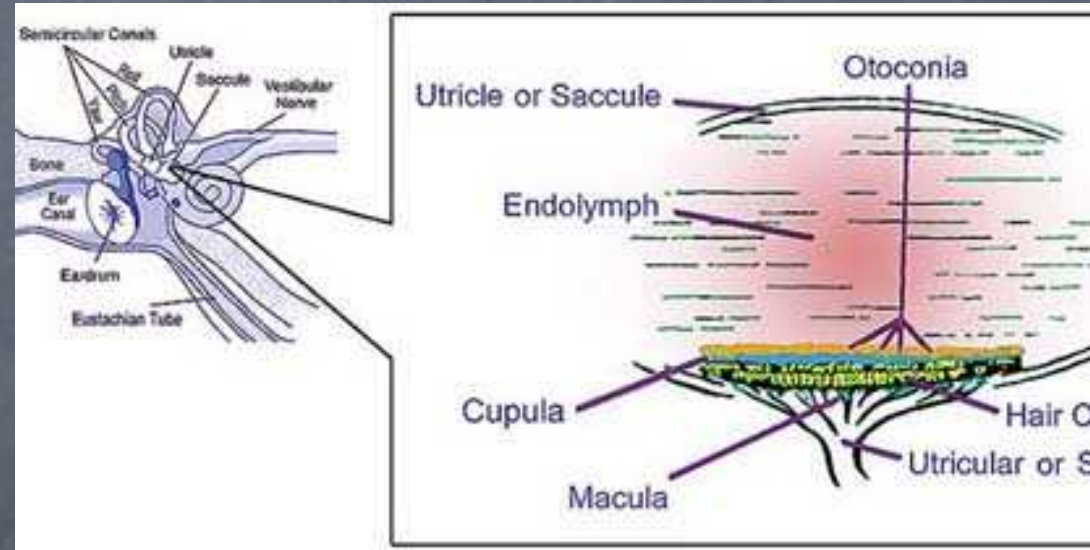
# The Otoliths

- Located at base of semicircular canals
- Contain small sacs covered by hair filaments
- Project into gelatinous membrane



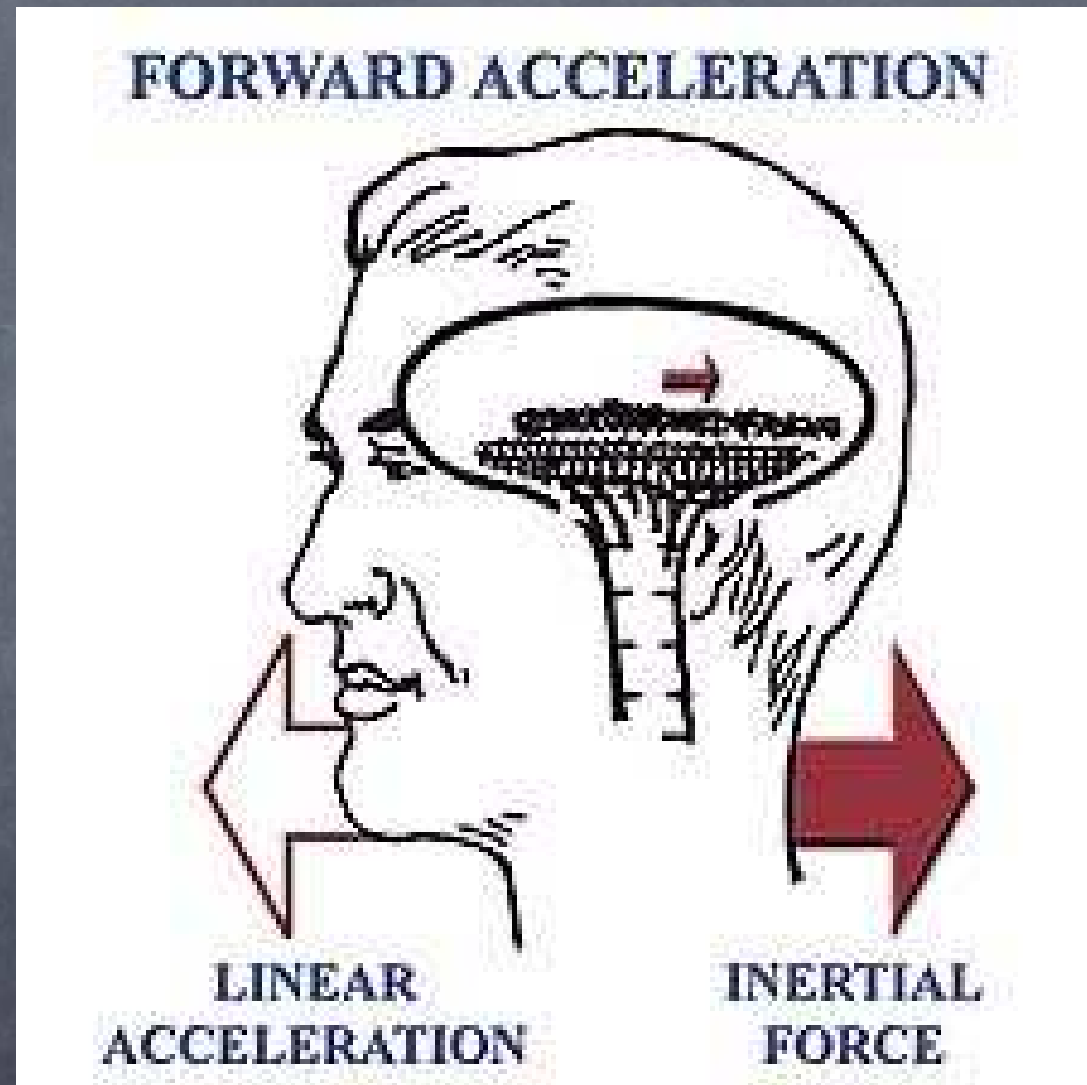
# The Otoliths

- Weight of organs pulls cupula (gelatinous membrane)
- Hair cells bent
- Signals sent to brain e.g. vertical take-off in helicopter



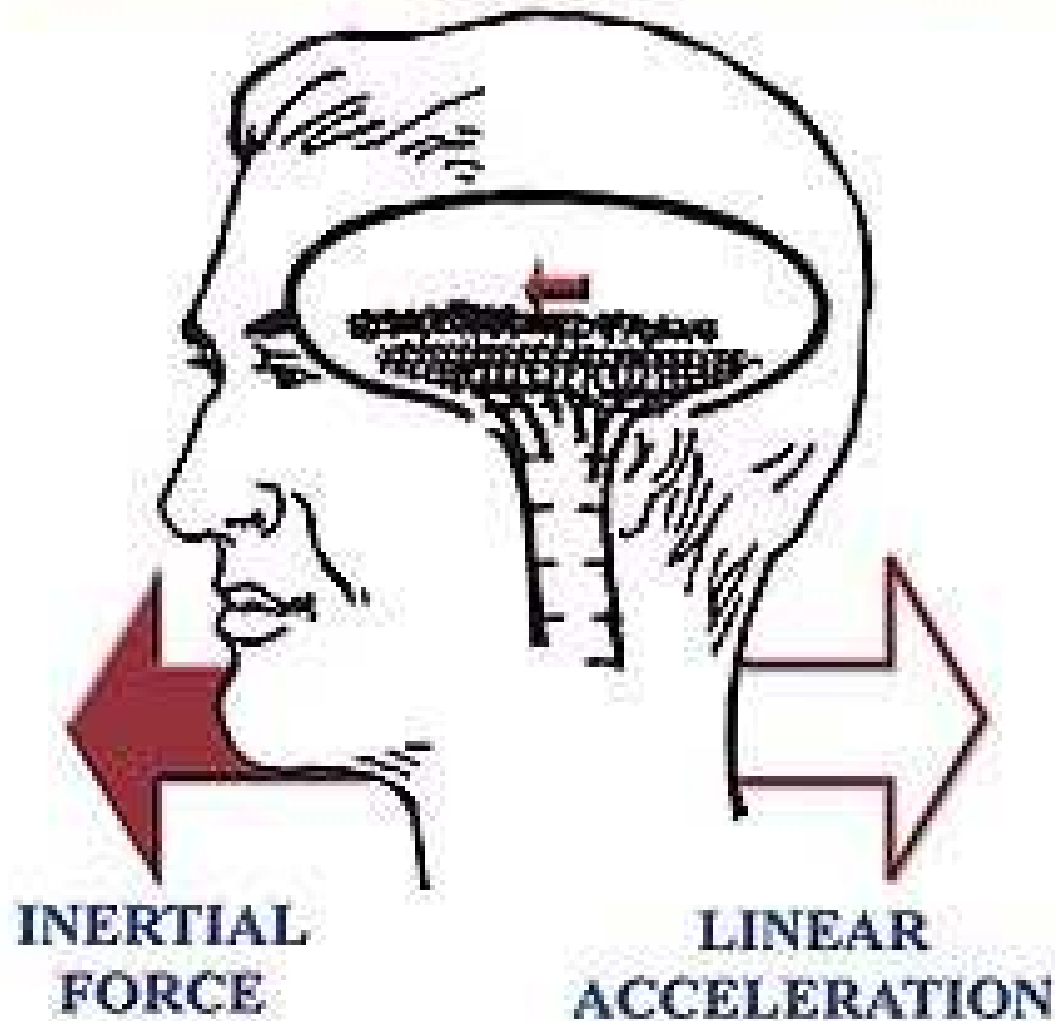
# The Otoliths

- Forward linear acceleration produces backward movement
- Hair cells bent
- Signals sent to brain
- Forward movement



# The Otoliths

**BACKWARD ACCELERATION**

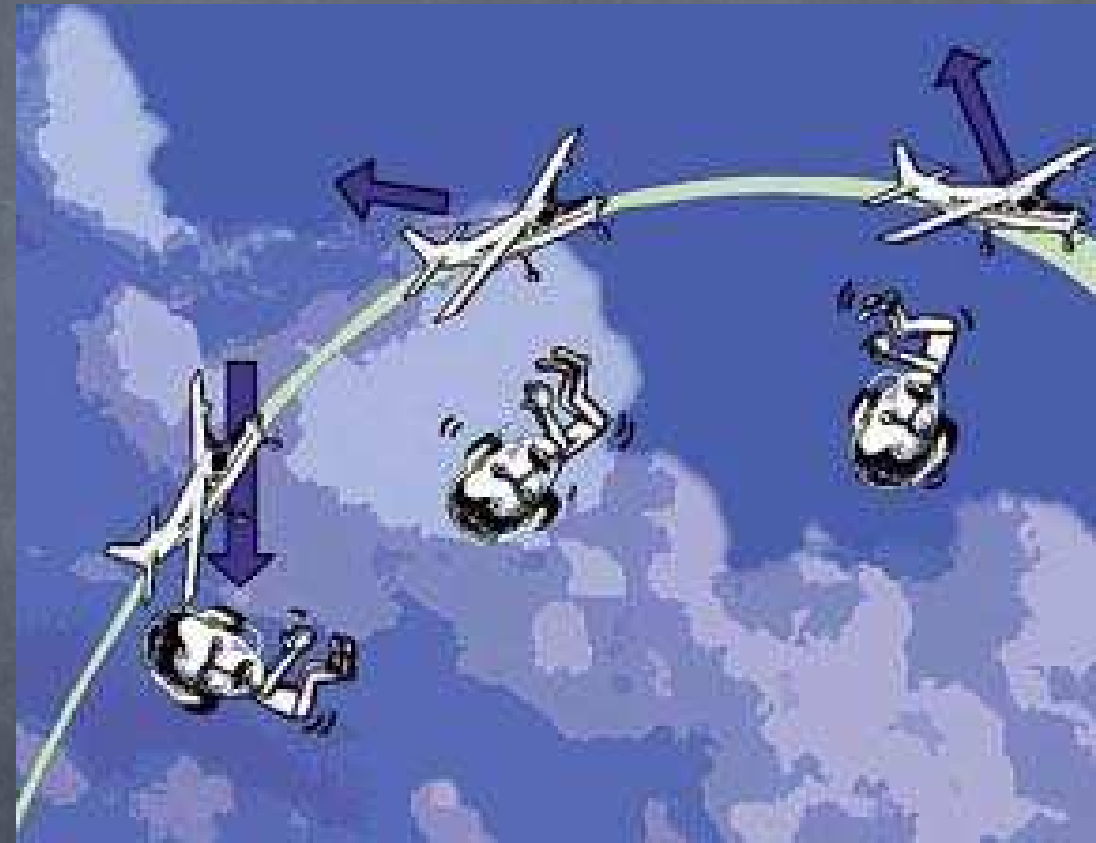


# Vestibular Illusions

- Somatogravic illusions
- Unreliable or unavailable external visual cues
- “Inversion” illusion
- “Head-up” illusion
- “Head-down” illusion

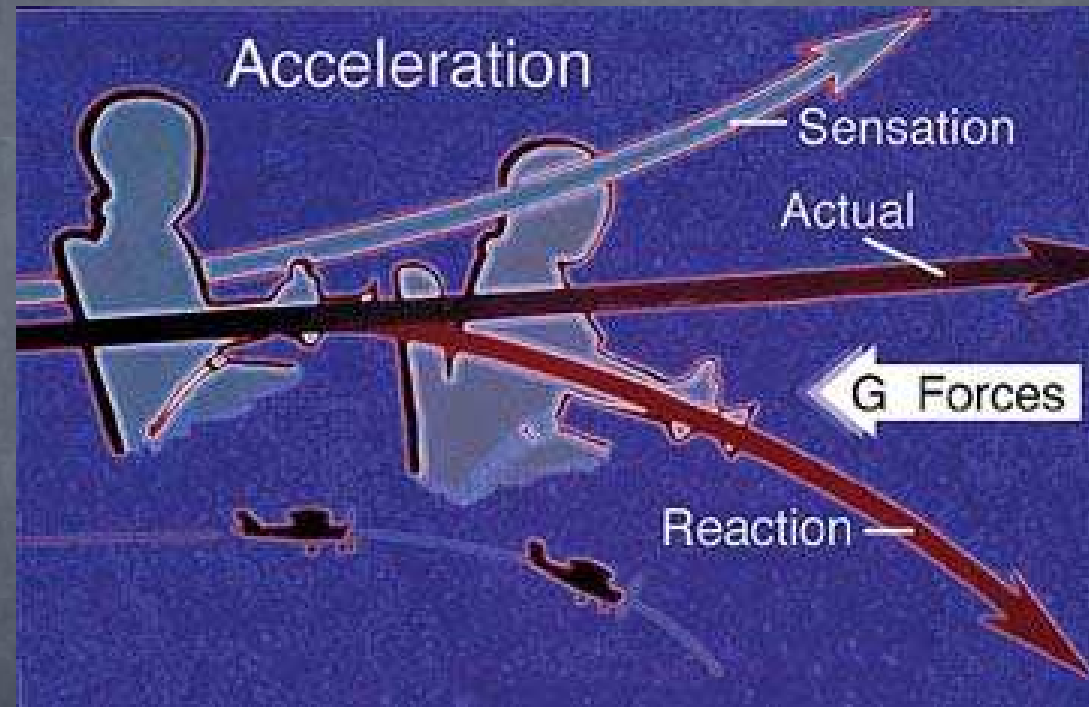
# The “Inversion Illusion”

- Steep ascent then sudden level flight
- Relative high speed after leveling off
- False sensation of inverted



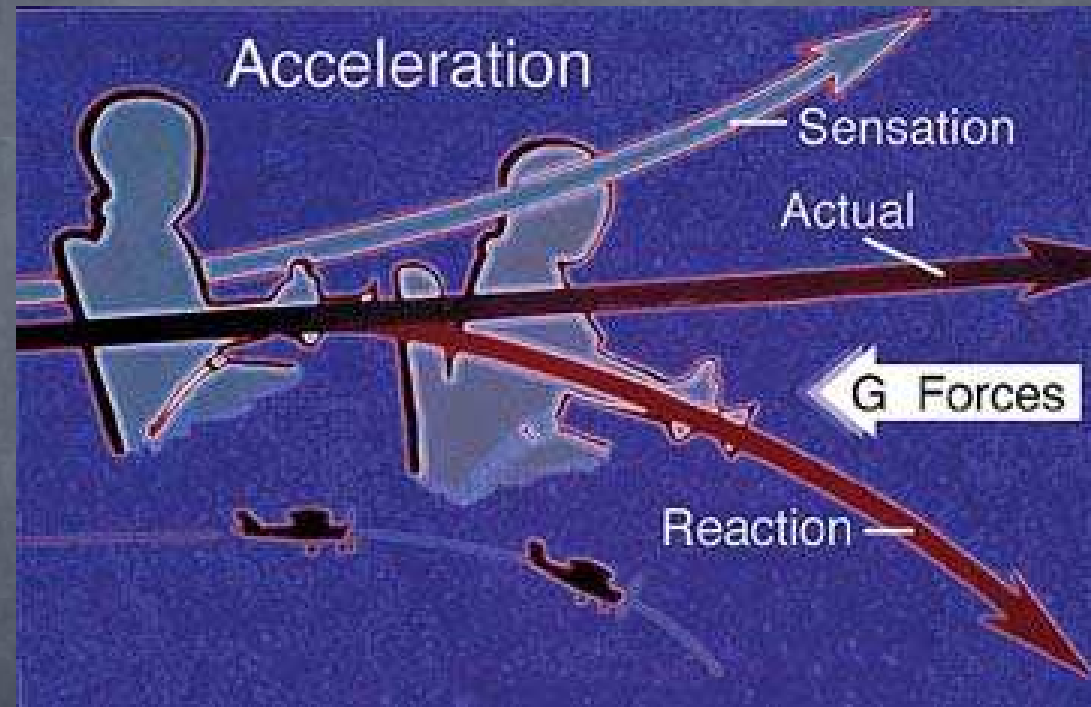
# The “Head-up Illusion”

- Sudden forward linear motion following level flight
- Pitch up
- Push yolk or stick forward
- Night or catapult T/O



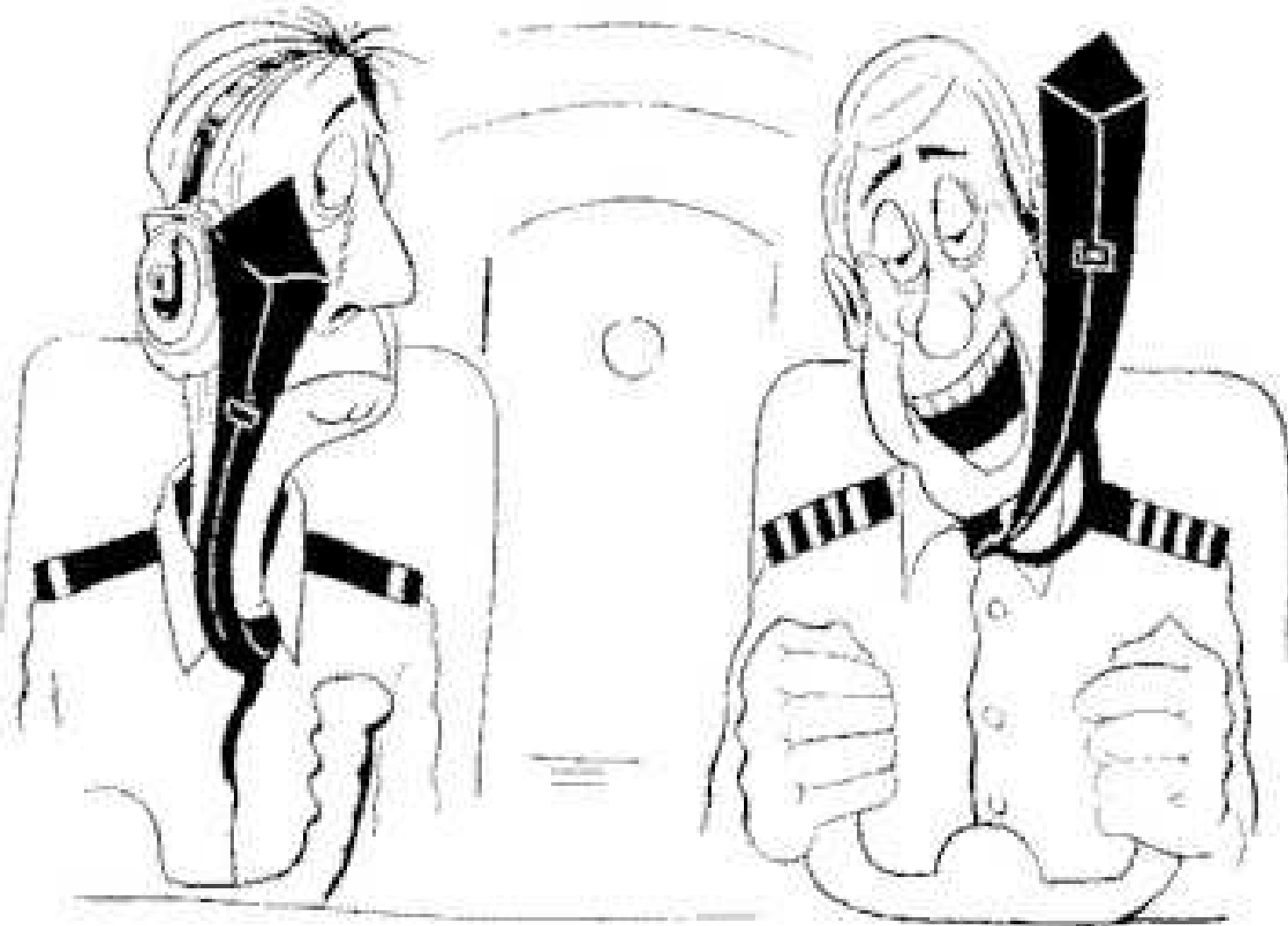
# The “Head-down Illusion”

- Sudden linear deceleration following level flight
- Pitch down
- Will stall aircraft if try to correct



# Prevention

- Spatial disorientation training
- Before flying < 3 miles visibility, training & proficiency in aircraft control w/ reference to instruments
- Maintain night flying currency
- If only VFR qualified, DO NOT t/o in deteriorating weather

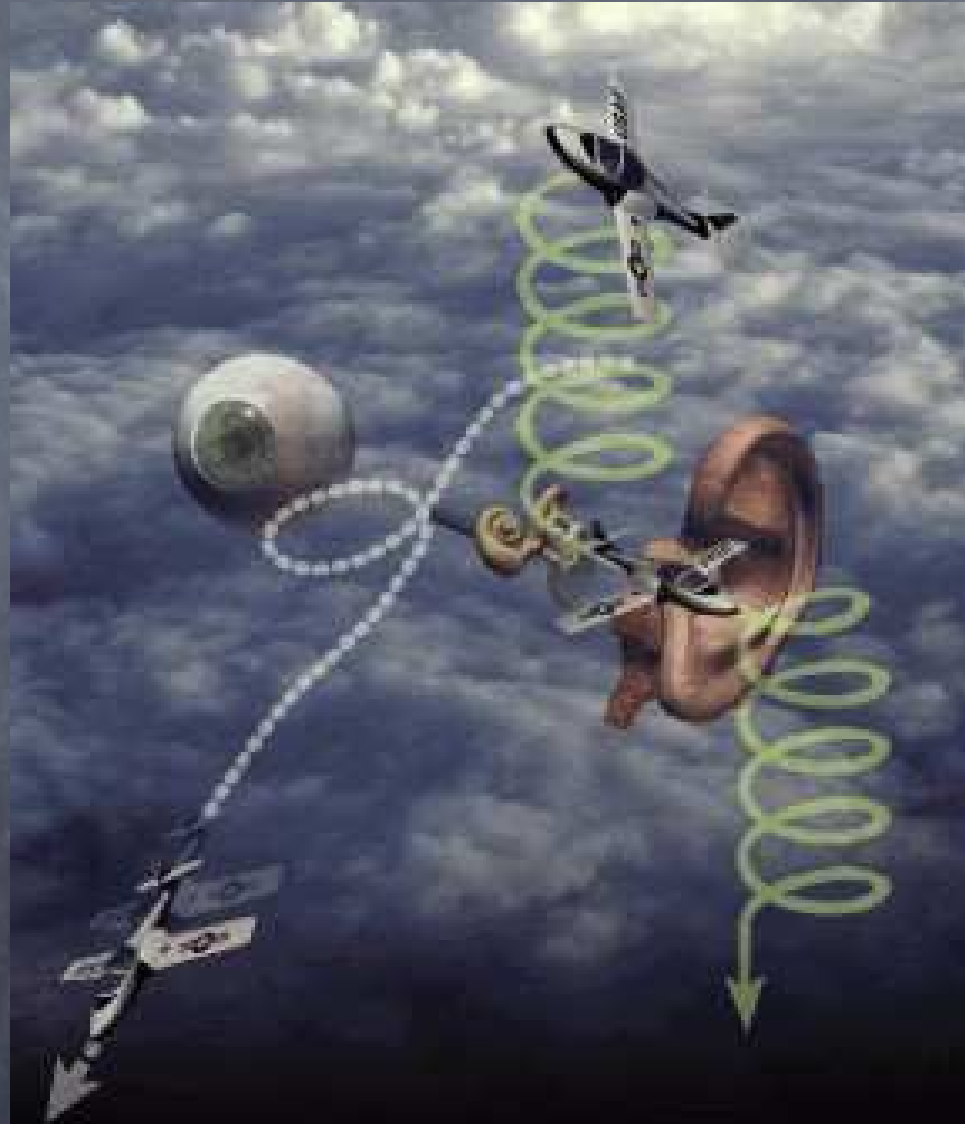


ALWAYS TRUST YOUR INSTRUMENTS, SON.

# Gulf Air Flight 072

- Somatogravic illusion in total darkness
- False sense of pitching up
- Pilot responded
- Aircraft flew into sea at 280 kts & 6.5° nose down

# Central & Visual Forms of Disorientation



# Ryanair Flight 9884

- 29<sup>th</sup> March 2006
- Liverpool to City of Derry
- Maiden City
- Balleykelly Camp
- Army airfield 5 miles away



# Ryanair Flight 9884

- Cleared to land by ATC on VFR to Derry
- Mistook airfield

# Ryanair Flight 9884

- Steps brought by road for passengers to disembark
- Greeted by soldiers with a laugh!

# Vision & Spatial Orientation

- Visual cues
- Important information
- Maintain spatial orientation in flight & on ground
- Especially when in motion
- Birds cannot fly safely w/o visual reference

# Vision & Spatial Orientation

- Central or foveal
- Peripheral

# Central Vision

- Identification of objects
- Colour perception
- Allows pilots to gather info from instruments during IFR
- Allows pilots to acquire external info to judge distance, speed & depth during VFR

# Peripheral Vision

- Ambient vision
- Perception of movement
- Walk & read at the same time!
- Surrounding environment motion can produce self motion

# Central Forms of Disorientation

- Coning of attention, task saturation, stress reactions
- Giant hand illusion
- Negative transfer
- Temporal disorientation
- Break-off

# Giant Hand Illusion

- Loss of aircraft control to an external force pulling on control column
- Mechanical failure assumed
- Anxiety or over-arousal
- Period of distraction
- Hands occupied



# Giant Hand Illusion

- Prior misconception of aircraft attitude
- Change of gravity vector
- Involuntary & unconscious
- Pilot thinks he is pulling back, but really is pushing forward

# Negative Transfer Illusion

- When “feel” of aircraft’s controls or instrument display
- Differs from what pilot is used to

# Negative Transfer Illusion

- Aircraft type conversion e.g. trainer to strike
- Changing type & role e.g. fixed wing to rotary wing
- Expect trouble if instrument displays are different

# Temporal Disorientation

- Occurs in periods of intense stress
- Temporary slowing of perceived passage of time
- Leads to loss of situational awareness
- To eject or not to eject, that is the question

# Temporal Disorientation

- Brain unable to accept rapid development of events
- Forced to interpret huge amount in a short period as lengthening of time
- Distortion greatest when perceived dangers are more serious or recognized late

# Break-Off

- Unusual perception of depersonalization
- Sensory input reduced by high altitude
- Reduced sensory input or deprivation
- Student pilot 1<sup>st</sup> solo.

# Visual Illusions in Flight

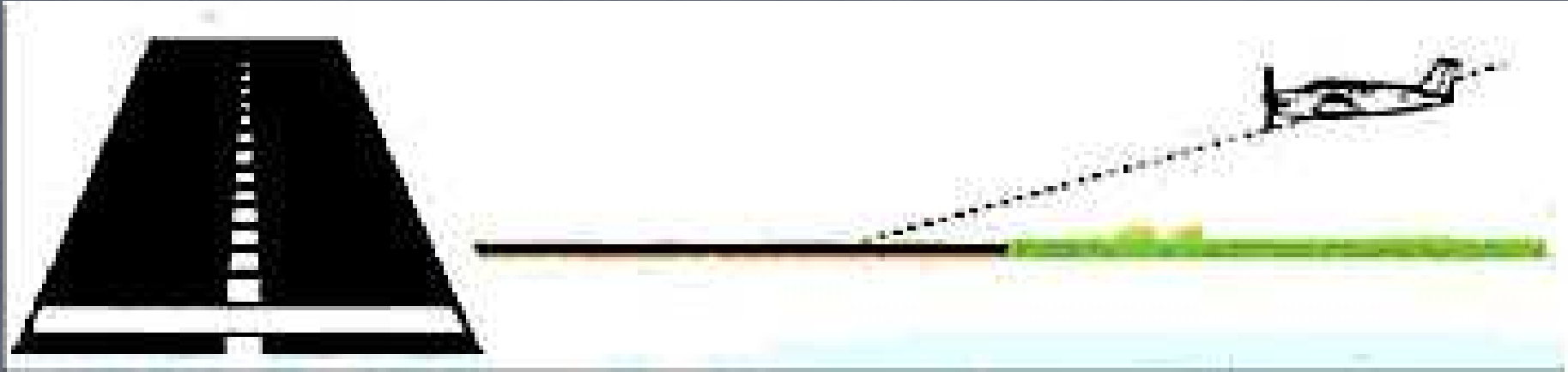
- *10 11 12 13 14*

- *E D C 13 A*

# Visual Illusions in Flight

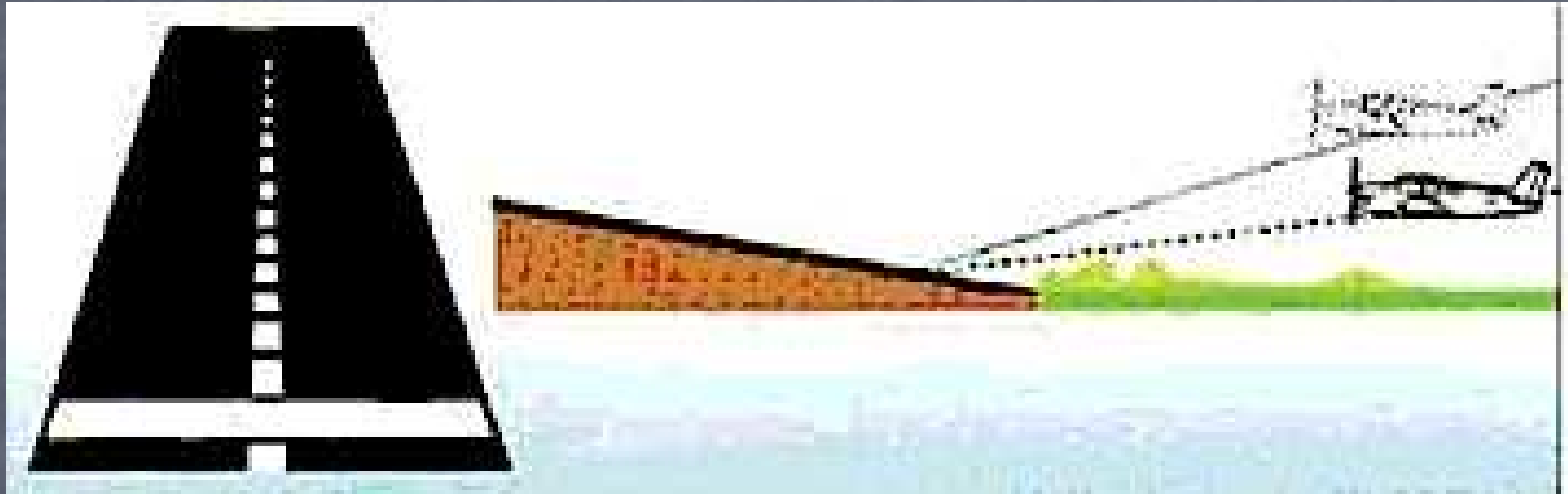
- Pilot's visual reference to natural horizon
- When obscured, can be maintained by surface below
- When both obscured, maintained by artificial means viz. instruments
- Smoke, fog, smog, haze, etc

# Visual Illusions in Flight



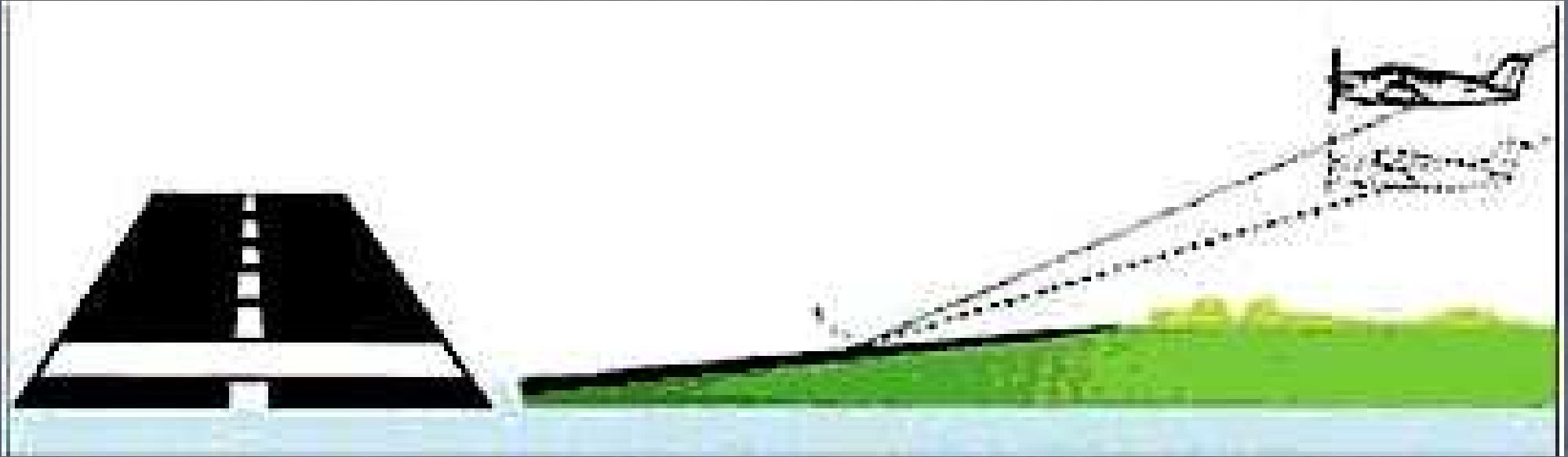
- Normal approach

# Visual Illusions in Flight



- Up-sloping runway on FLAT terrain
- High approach

# Visual Illusions in Flight



- Down-sloping runway on FLAT terrain
- Low approach

# Visual Illusions in Flight



- Flat runway on UPSLOPING terrain
- Low approach

# Visual Illusions in Flight



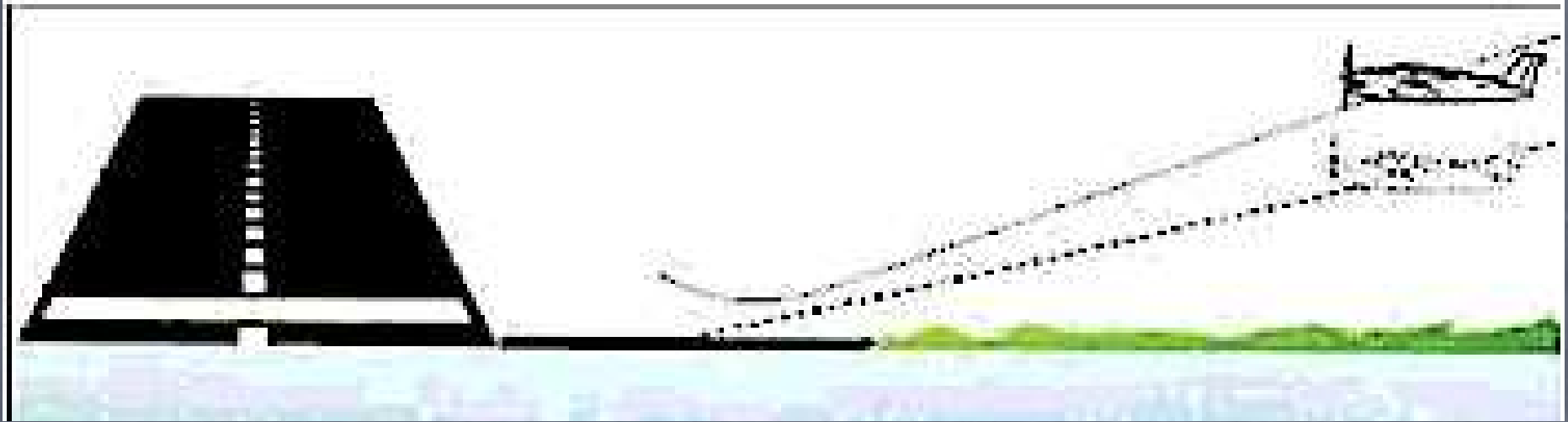
- Flat runway on DOWNSLOPING terrain
- High approach

# Visual Illusions in Flight



- Unusually long or narrow runway
- High approach

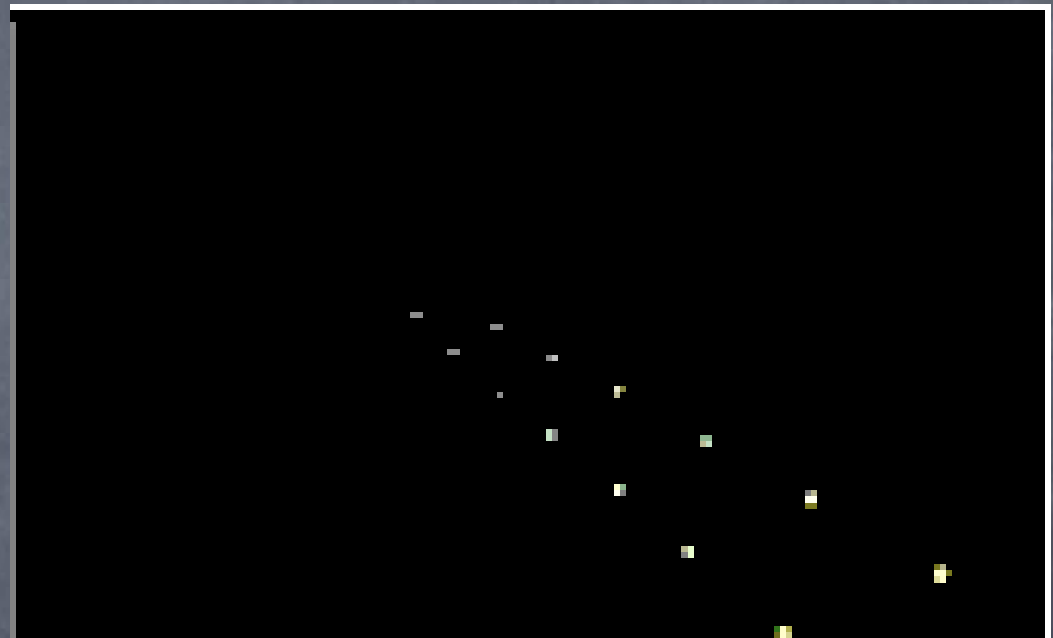
# Visual Illusions in Flight



- Unusually wide
- Low approach

# Visual Illusions in Flight

- “Black hole” approach
- No stars or moonlight over water
- Unlit terrain to lit runway
- No peripheral vision
- Runway tilted left & up-sloping

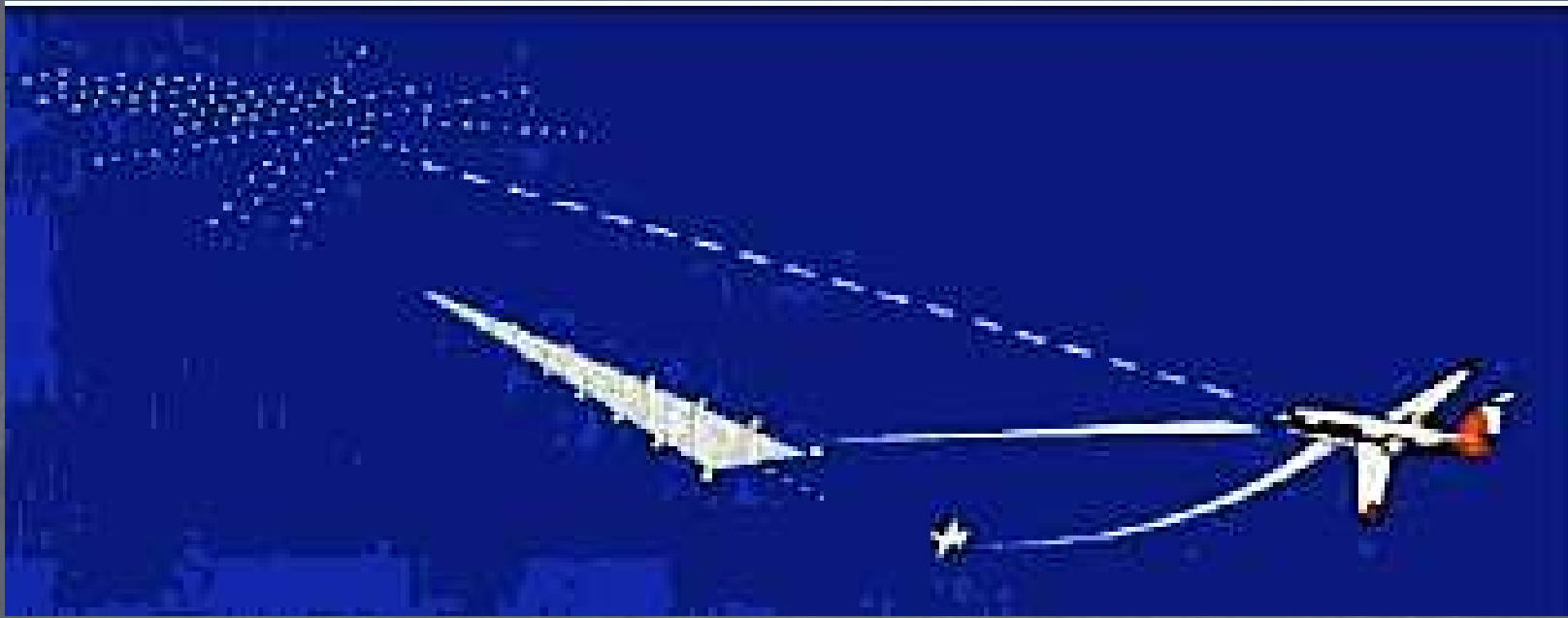


# Visual Illusions in Flight

- Visible horizon
- Easily orient w/ central vision



# Visual Illusions in Flight

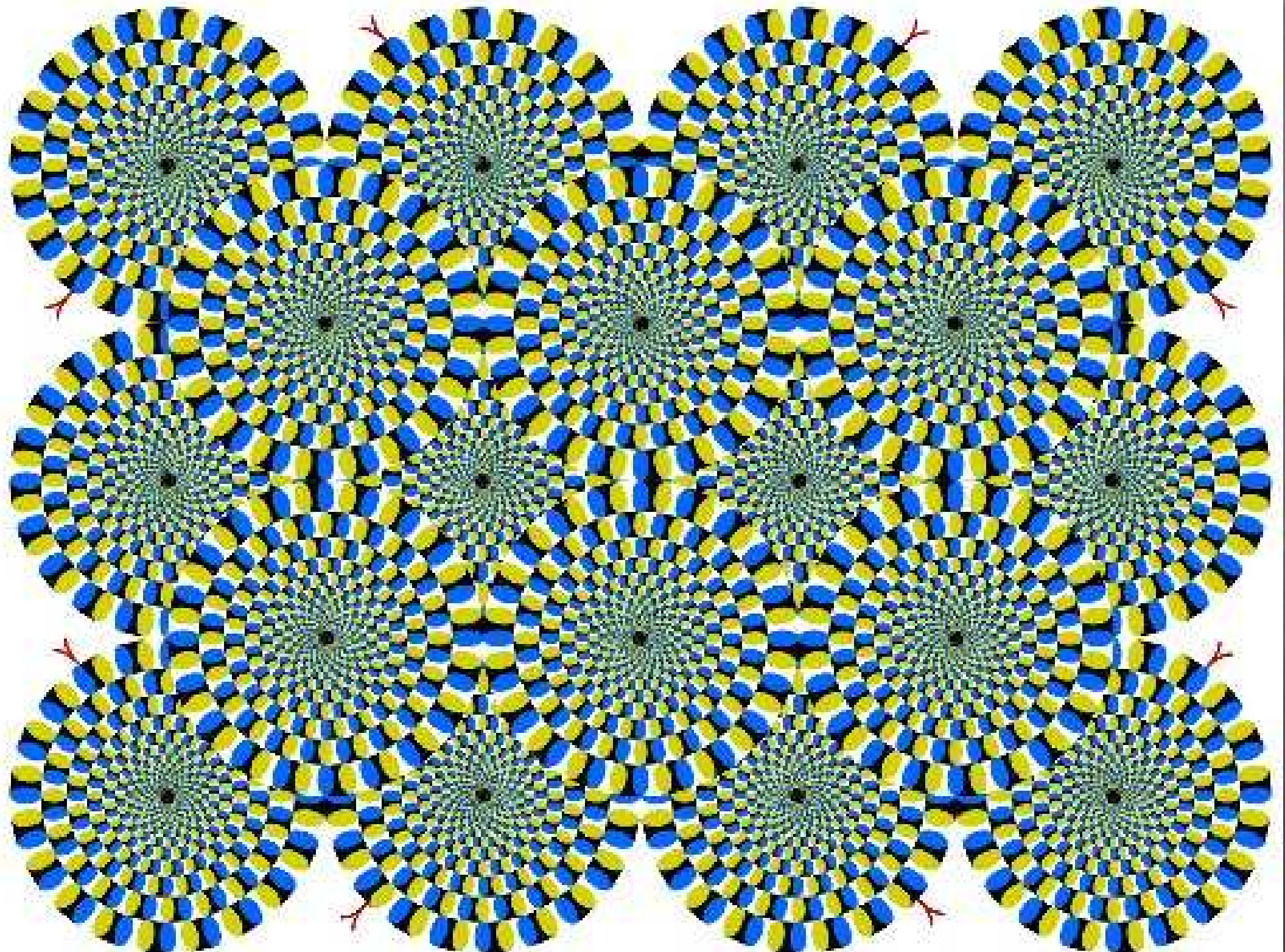


- Hazardous “black hole”
- No lights before runway
- City lights or rising terrain beyond runway
- High approach

# Visual Illusions in Flight

- Autokinetic illusion
- Stationary object moving in plane's path
- Staring a fixed point of light in totally dark & featureless background
- Light on collision course









# Summary

- No pilot can fly in IFR conditions without instruments
- The inner ear can give false positional information unless there is also a visual reference.
- You can literally fly upside down and not know it
- You can lose orientation in less than 20 seconds if you are in clouds and are not on instruments!

*Take off is VOLUNTARY.....*

*BUT*

*Landing is MANDATORY*