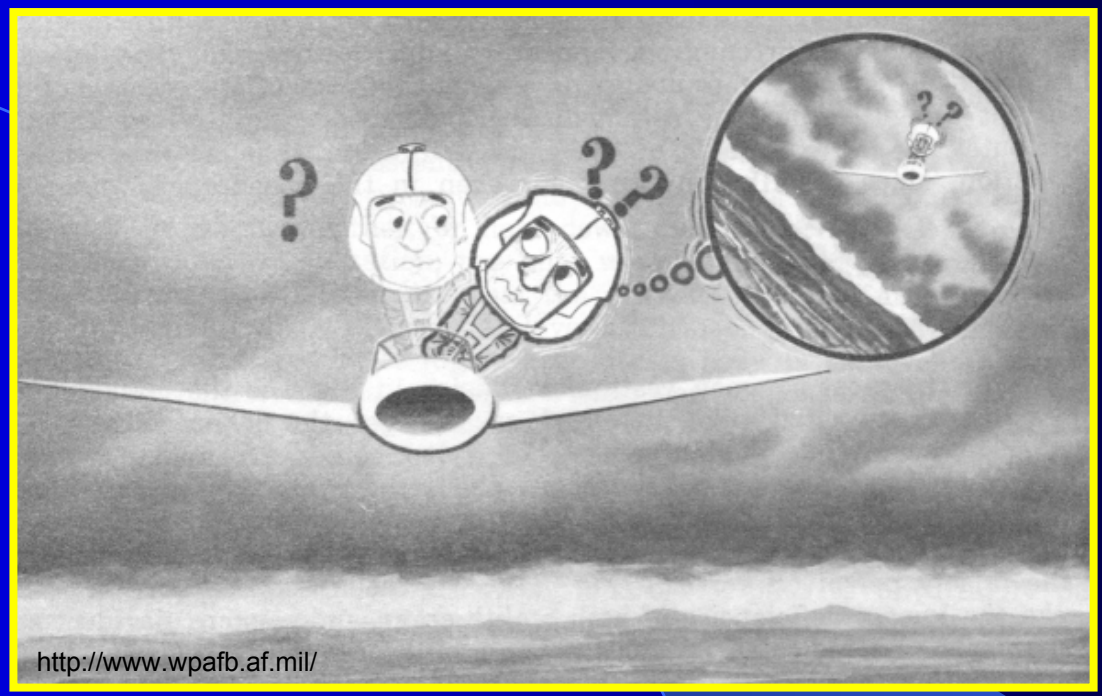
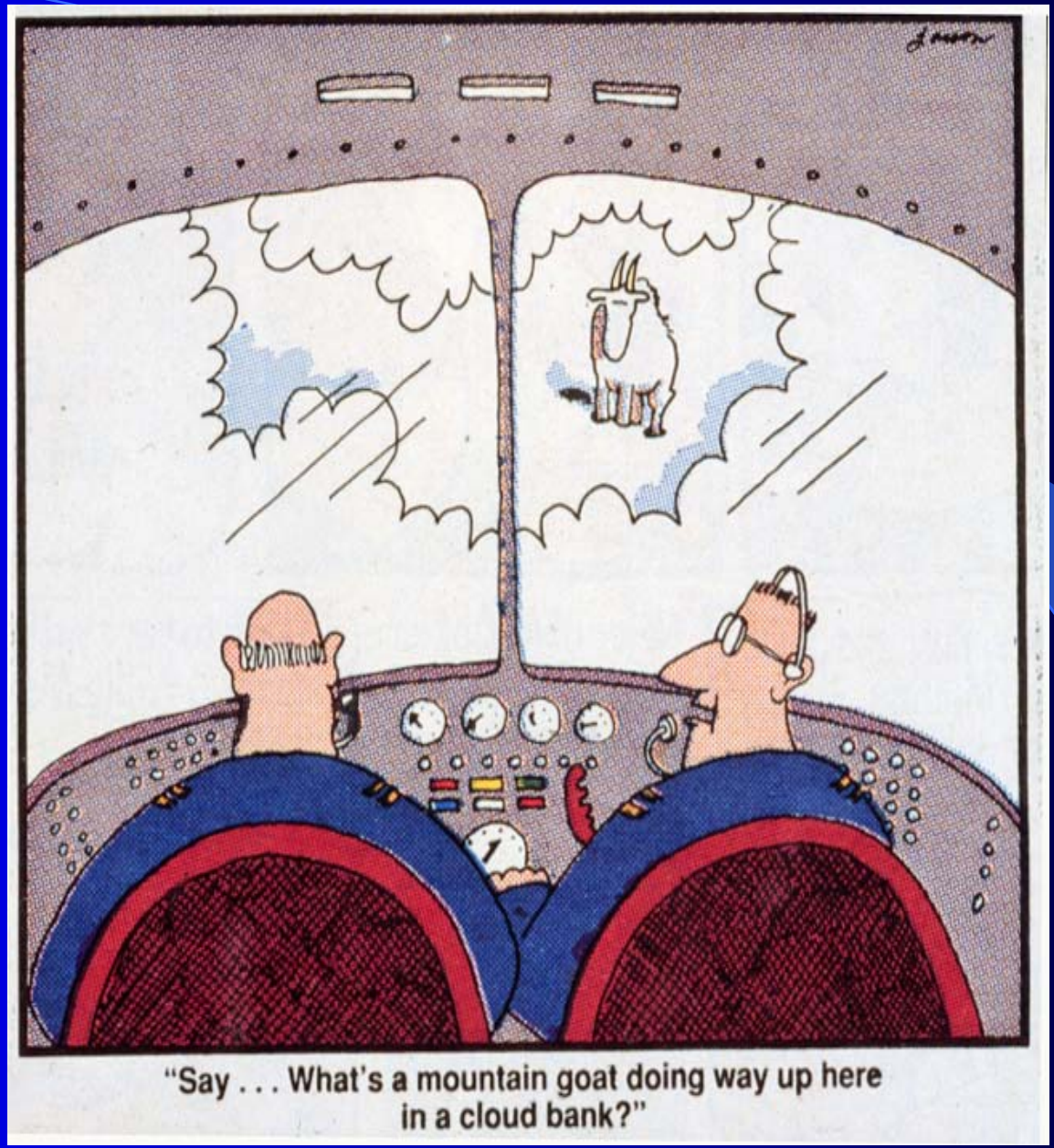
Spatial Disorientation



16.459 - Humans and Automation Journal Club

Kevin Duda

April 17, 2002



"Say . . . What's a mountain goat doing way up here in a cloud bank?"

NTSB Report: NYC99MA178

- VFR Conditions at night
- Descent of 400 – 800 fpm
- Entered a right turn, stopped at 2,200 feet
- Climbed to 2,600 feet, Entered a left turn
  - Descending 900 fpm
- Rate of descent increased to ~4,700 fpm
- Airplane struck the water in a nose-down attitude

Can you identify the cause?

Spatial Disorientation, A Definition

- "[A failure] to sense correctly the position, motion, or attitude of the aircraft or of him/herself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical." (Benson, 1998)

Lost Resources, An Issue

- Military
  - 1980 – 89, $500M in USAF resources lost
  - Currently, $100M per year
- General Aviation
  - 1976 – 92, ~10% of fatalities resulted from SD
  - Numbers have declined

(Fatal General Aviation Accidents Involving Spatial Disorientation: 1976-1992, Collins and Dollar (1996))

Types of Spatial Disorientation

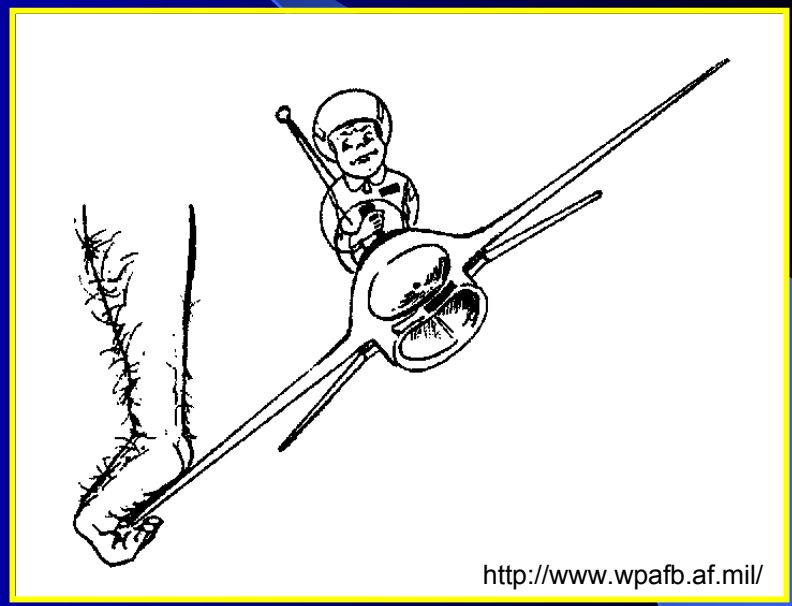
- Type I
  - Unrecognized (most common)
- Type II
  - Recognized (more traditional)
- Type III
  - Incapacitating (least known and understood)

Physiological Mechanisms

- Visual Orientation
  - Object Recognition, Spatial Orientation
- Vestibular Function
  - Stabilize Vision, Orientational Information, Percept of Motion and Position
- Auditory
  - Location of Sound Source

Dynamics

- Visual Dominance
- Vestibular Suppression
- Opportunism
- Giant Hand
- Disintegration of Flying Skill



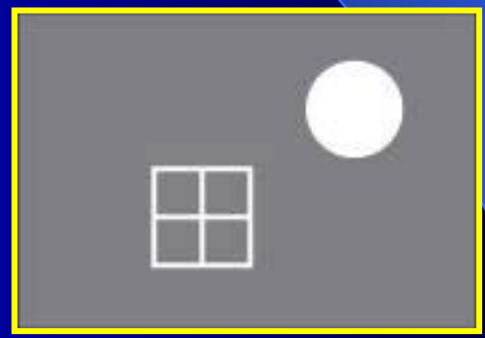
Research and Technology Development

- Human Systems IAC Gateway (Vol. XII, No.3 (2001)
  - Measuring the Head Tilt Illusion During Sustained Acceleration
  - Canadian Approach to Spatial Disorientation Training
  - SD, GD, LSA, and CFIT
  - Advanced Display Technologies
  - Desdemona: Advanced Disorientation Trainer

Measuring the Head Tilt Illusion

- Coriolis and G-excess Illusions
- Objective
  - Determine the effect of head tilt in > 1G environment on perception of attitude

Measuring the Head Tilt Illusion



Measuring the Head Tilt Illusion

- Conclusions
  - Pitching and yawing in > 1G acceleration can lead to a misperception of attitude
  - Magnitudes of illusions were greater for larger head movements and accelerations

Canadian Approach to SD Training

- Demonstration of other illusions after basic jet training
- Complement ground training with in-flight training
- Provide trainee with procedures to cope with illusions

SD, GD, LSA, and CFIT

- Spatial Orientation
  - Control and Performance Instruments
- Geographic Orientation
  - Navigational Instruments
- Loss of Situational Awareness
- Controlled Flight into Terrain

SD, GD, LSA, and CFIT

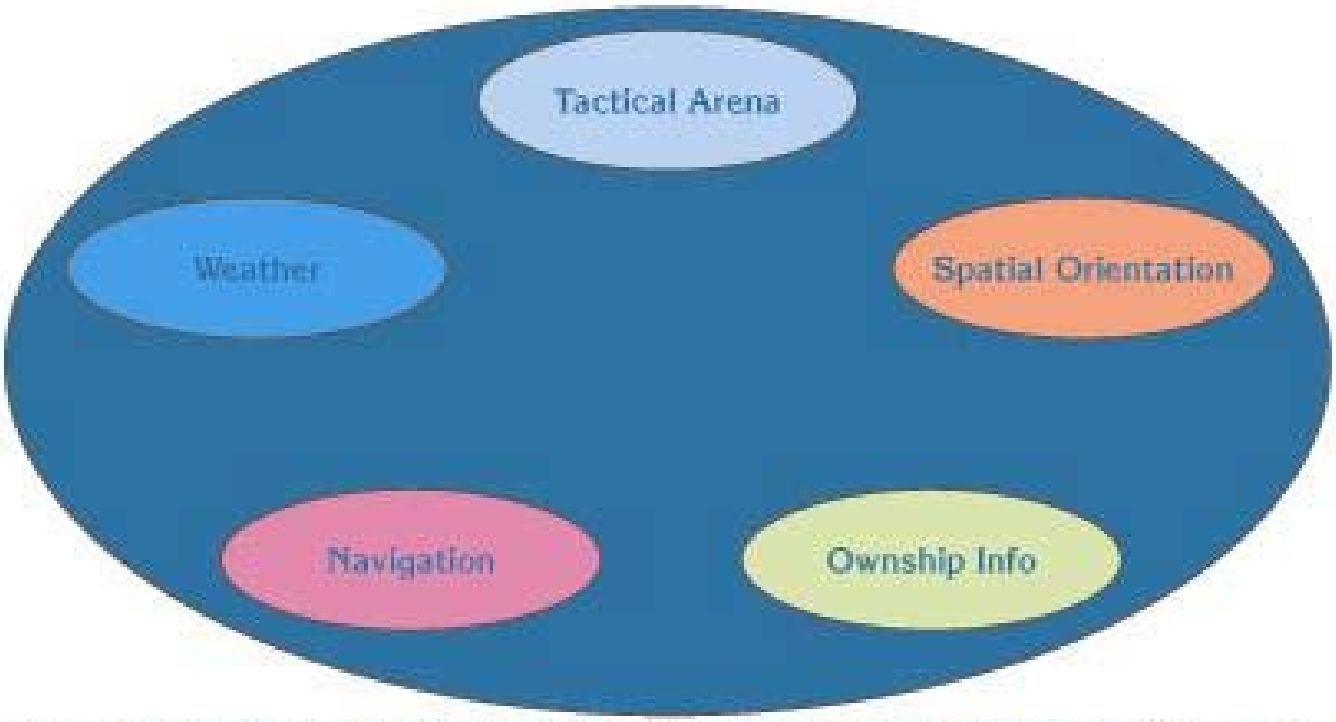


Figure 1. An illustration of the relationship between spatial orientation and situation awareness. In this scheme, spatial orientation is a subset of situation awareness. (Adapted from Previc et al., 1995).

Advanced Display Technologies

- Advanced displays may overload operator
- Loss of confidence in “fused data”
- Attentional Capture

Advanced Disorientation Trainer

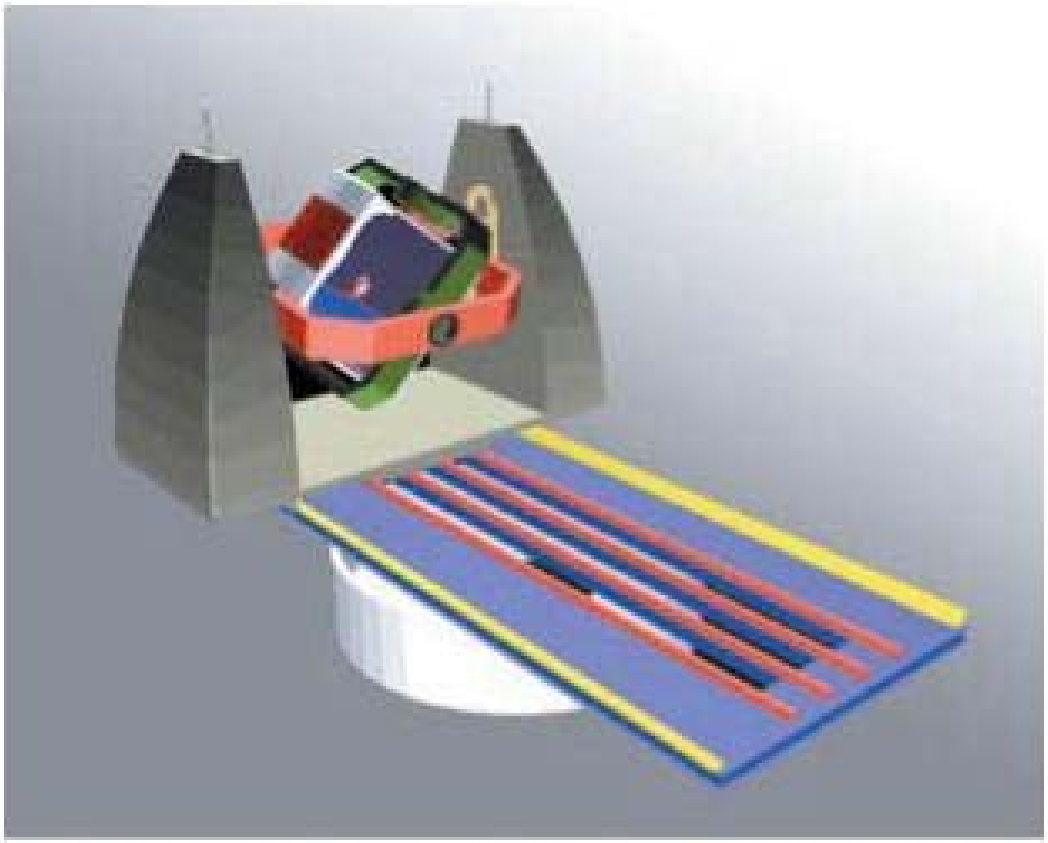


Figure 1. The Desdemona concept: Basic vestibular and visual disorienting illusions to be demonstrated with the pilot in control.

GYROLAB

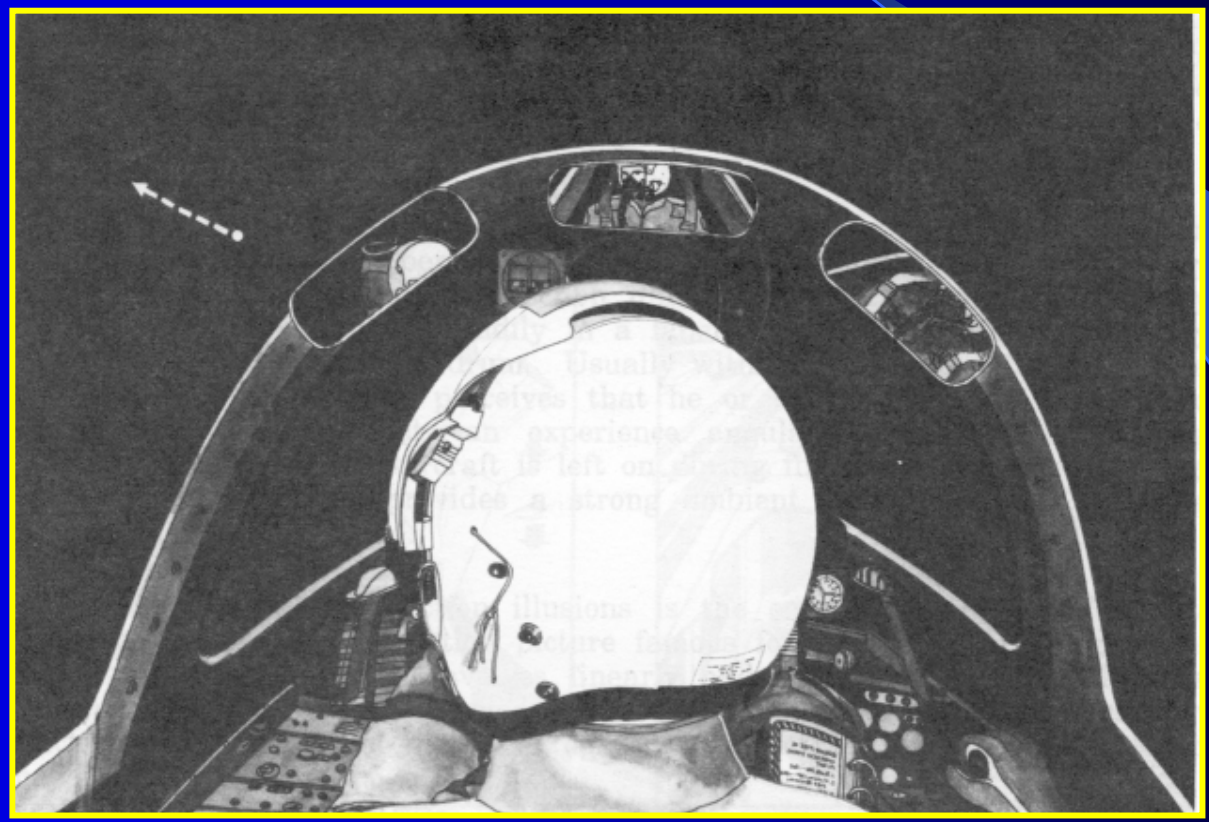
http://www.amtiusa.com/frst_ed/digpg6.htm


SURE IS A EASY CLIMB.
CRASH
WHEN YOU GET YOUR DESCEND MIXED UP WITH YOUR ASCEND, YOU SOON RUN OUTTA SPACE TO DO EITHER.
SAY WHAT?

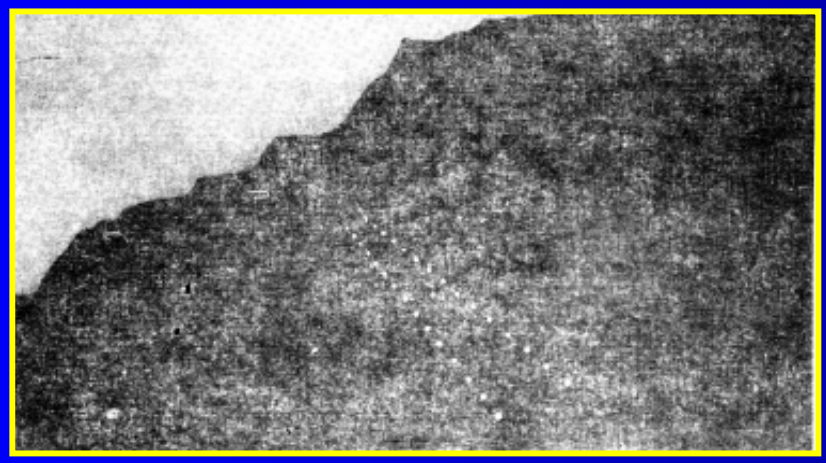
Illusions in Flight

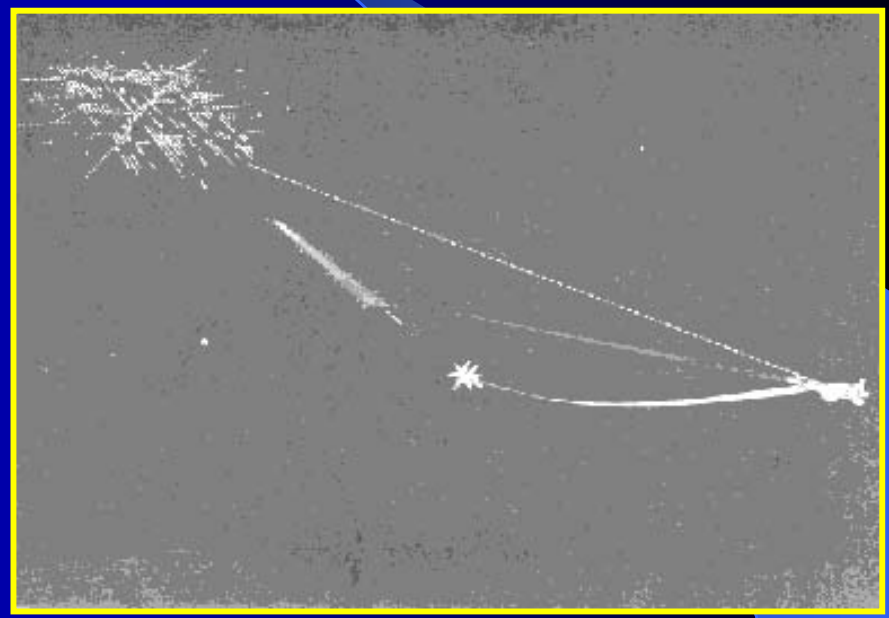
- Autokinesis
- Blackhole Approach
- False Horizon
- Leans
- Coriolis
- Somatogyral

Autokinesis



Blackhole Approach

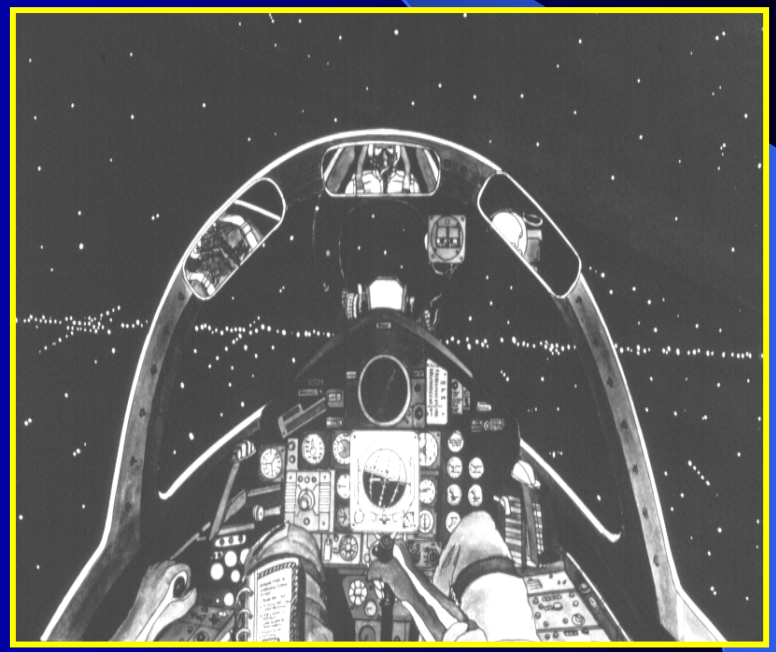




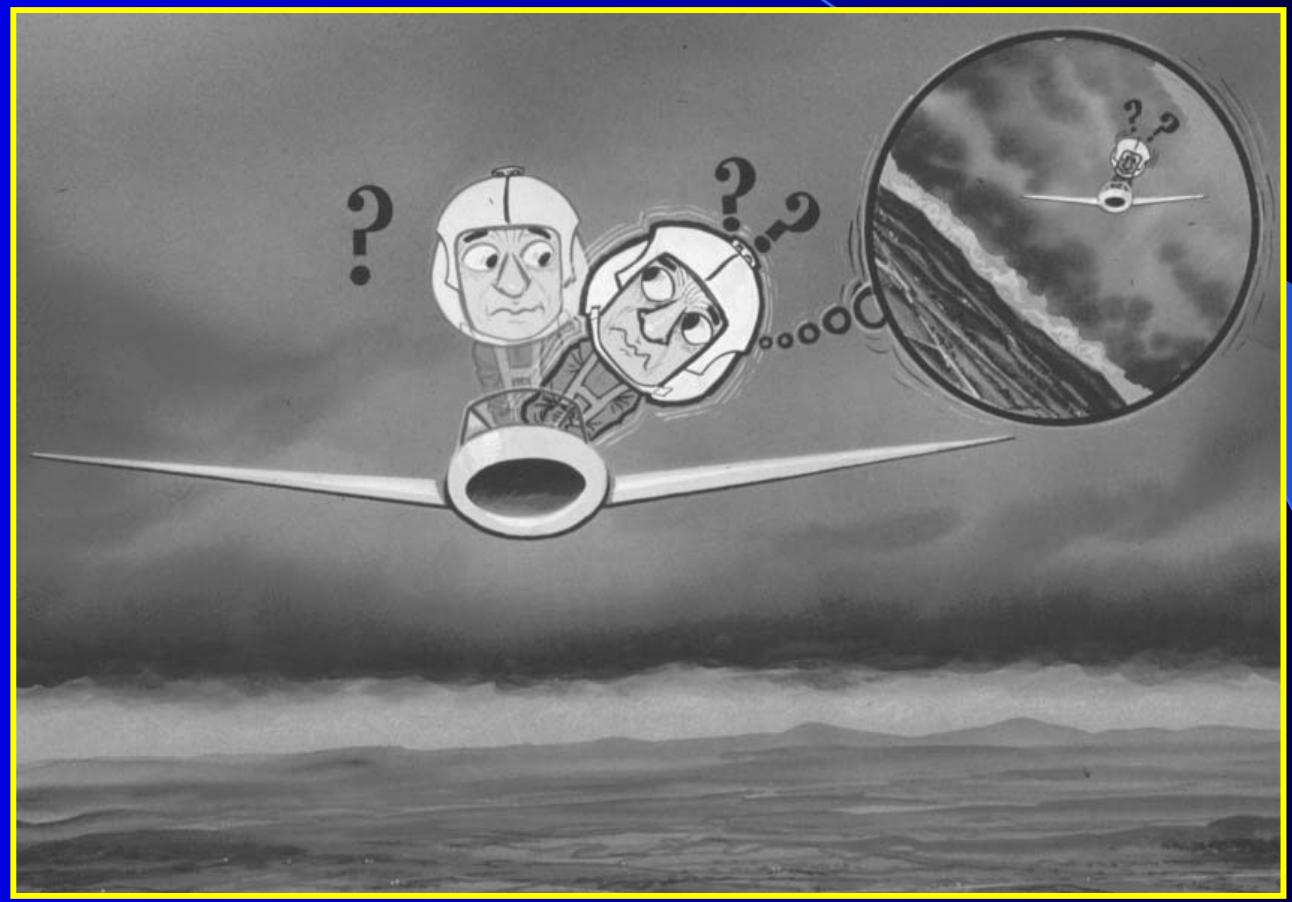
False Horizon Illusion

Northern Lights

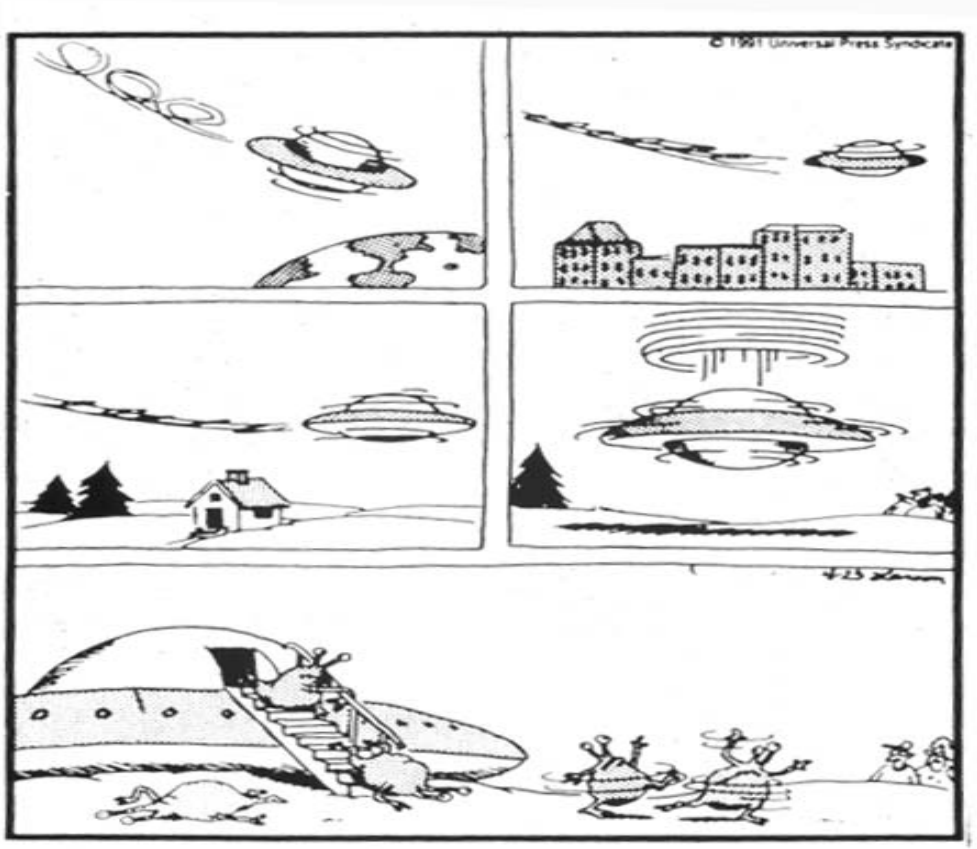
Sky-Ground Blending



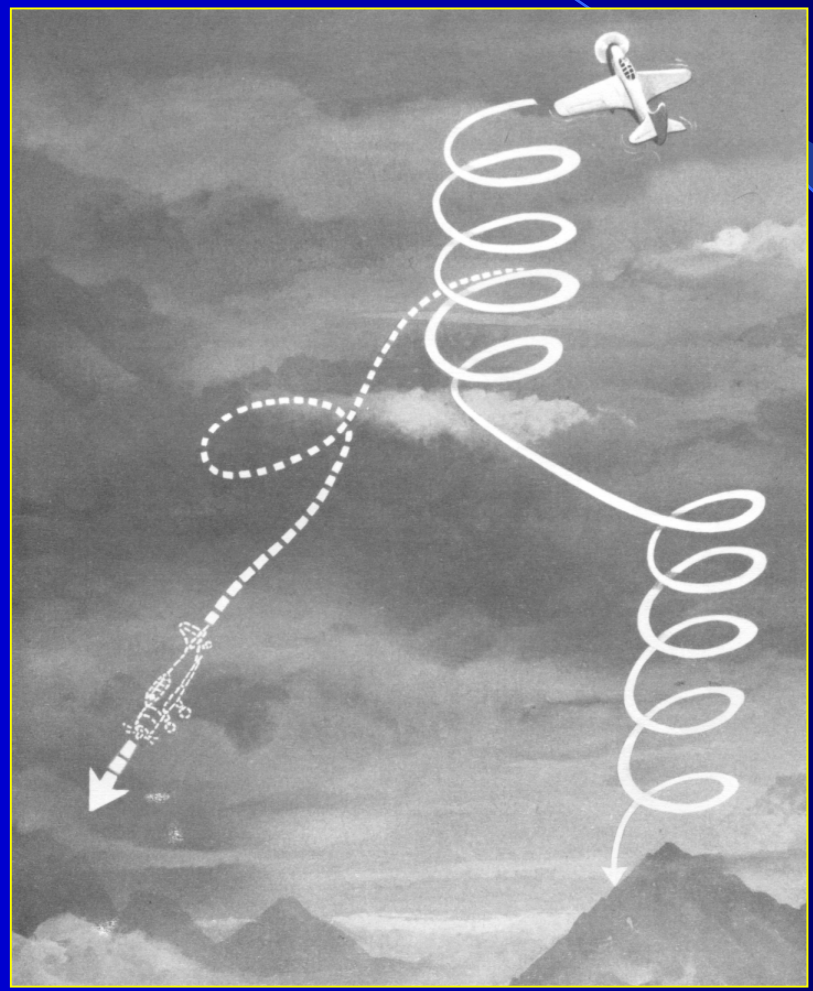
The Leans

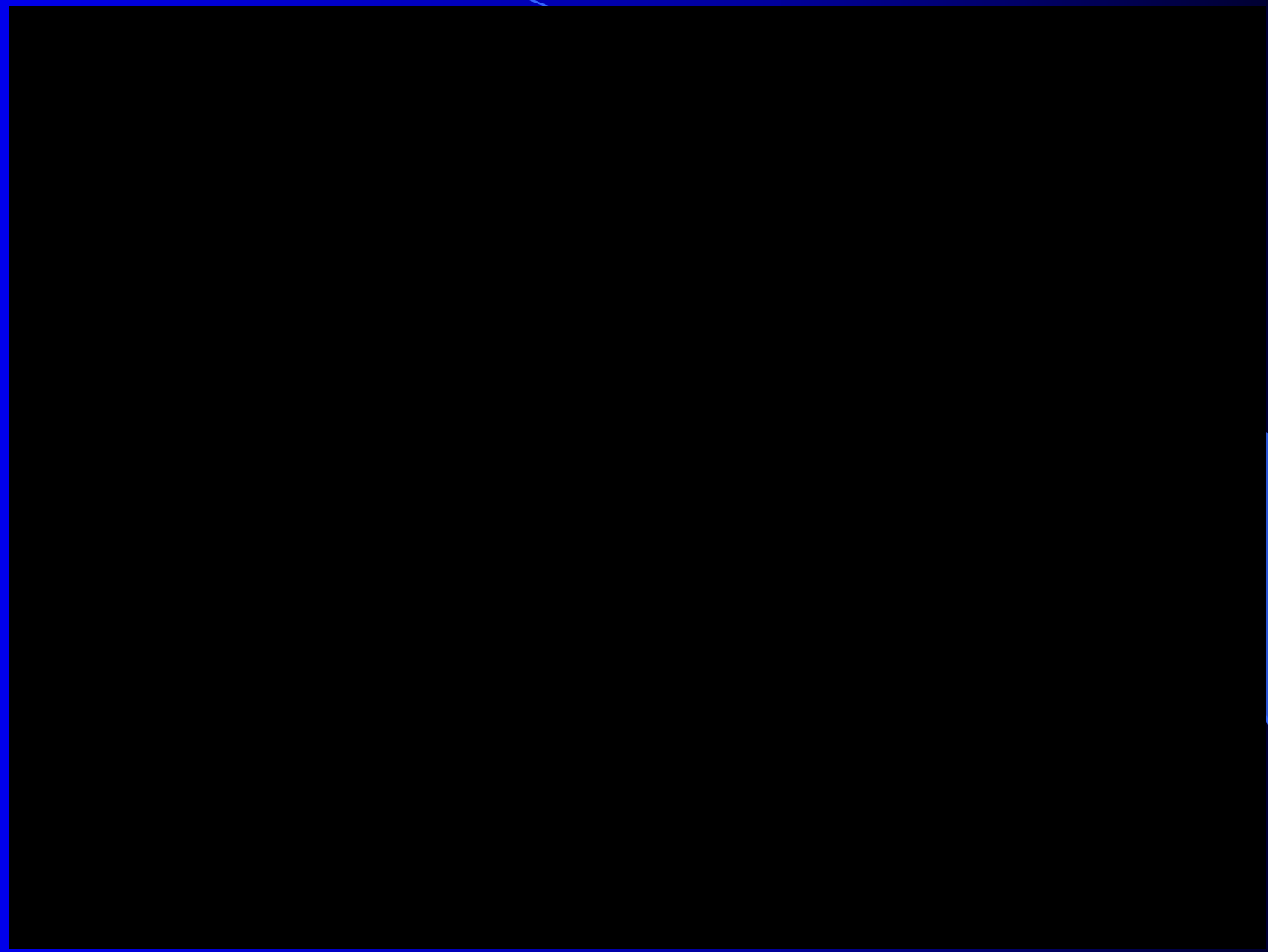


Coriolis Illusion



Somatogyral Illusion





Back to the NTSB Report

- FAA AC: VFR Minimums
- No pre-impact mechanical malfunction
- Probable cause:
  - "The pilot's failure to maintain control of the airplane during a descent over water at night, which was a result of spatial disorientation."
  - Graveyard spin?

Contributing Factors

- Fatigue
- Weather*
- Personal Time Pressures*
- Unexpected Flight Plan Changes
- Personal Attitude (self-confidence)

Reduction in SD Mishaps

- Improving training materials and techniques
- Development of technologies to
  - Minimize occurrence of SD
  - Assist in the recovery from SD
- Research in psychological mechanisms leading to SD
- Cockpit Layout and Flight Instruments

A Few Last Words

"Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is *Unforgiving* of any carelessness, incapacity, or neglect."

-- *Anonymous*

Questions / Discussion

- Personal Experiences with SD?
  - (Doesn't have to be related to flight)
- Should the FAA impose stricter minimums for VFR flight?