

# **TOP KNIFE FIGHTER SURGEON COURSE**

173 Fighter Wing  
Kingsley Field Oregon

**RSV-1B2**

SPATIAL DISORIENTATION

# Criterion Referenced Objectives

- Identify the leading human factors causes of aircraft mishaps
- Recognize the cues/characteristics of spatial disorientation and how that recognition can lead to recovery
- Explain situational awareness as it applies to the fighter community, i.e. survivability and mission success

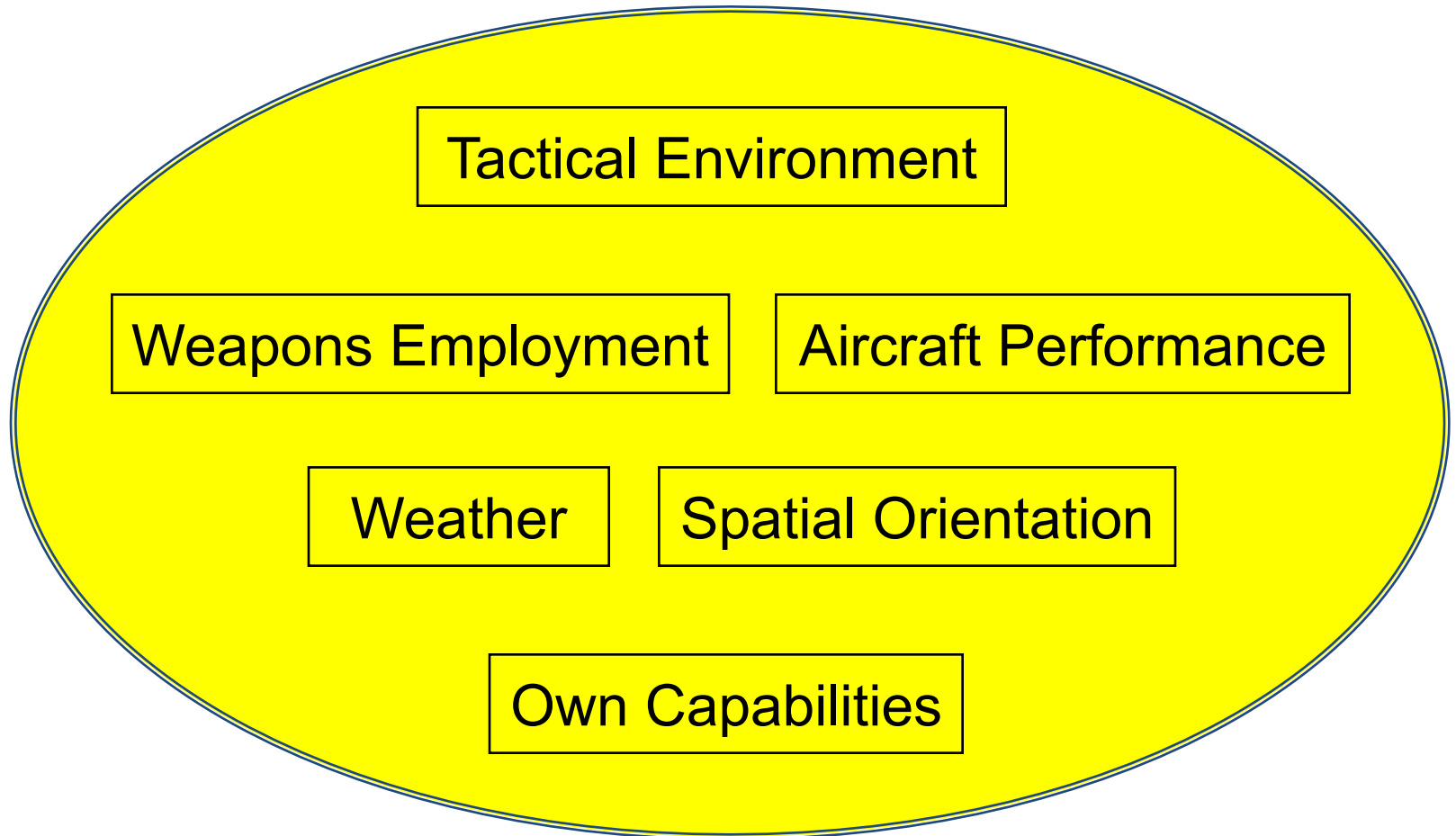
# Criterion Referenced Objectives

- Describe the causes of loss of Situational Awareness (SA) during a mission
- Recognize the differences between the three types of spatial disorientation
- Describe the methods and strategies used to enhance SA

# Overview

- The Problem – Loss of SA and Spatial Disorientation (SD)
- Types of SD
- Visual Illusions
- Vestibular Illusions
- Mishap Reviews
- Prevention?
- Summary

# Situational Awareness



# Loss of Situational Awareness

- Fixation – No longer scanning *all* instruments and looking outside cockpit
- Distraction – Event or occurrence takes pilot's attention away from flying the jet
- Complacency – “I've done this mission a hundred times”; *but this time it's different*
- Euphoria – Physiologic problem such as hypoxia

# SD Definition

An erroneous sense of any flight parameters normally displayed by control or performance instruments.

Kent Gillingham

*Aircraft Design + Pilot + External Sources = SA*

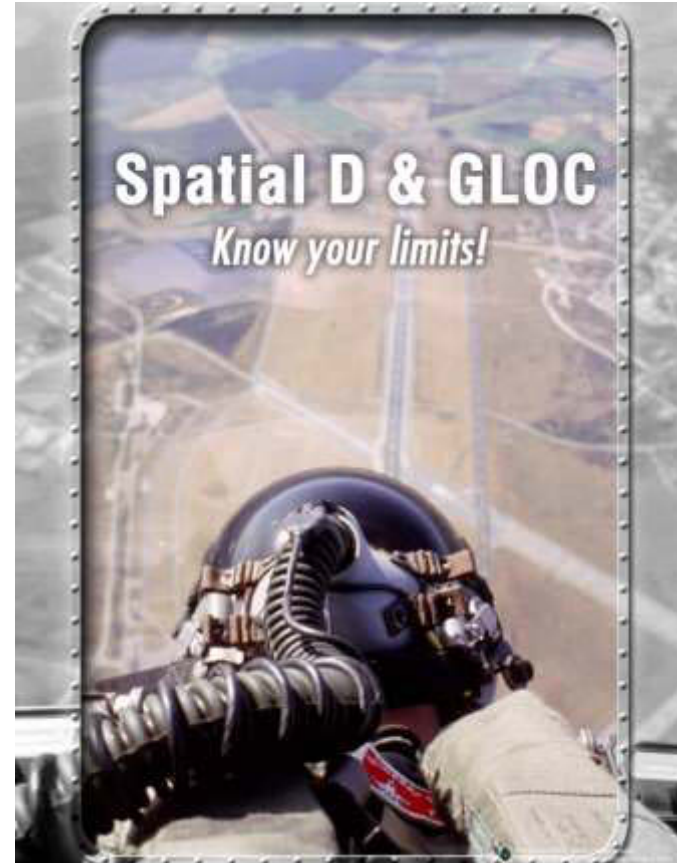
# SD – Problem and Progress

- Previous reports (Top Knife before 2006):
  - Caused 14% OF USAF Class A mishaps
  - Leading cause USAF human factor Class A mishaps
- 1 Jan 2000 – Oct 2012 AFSAS Reports
  - 2 Class A mishaps out of 478 total
- 1 Jan 2009 – Oct 2012 AFSAS Reports
  - 5 Class E mishaps out of 821 physiologics



# SD Typical Mishap Pilot

- 31 years old
- 1000+ flying hours
- One or more predisposing human factors



# Type I SD (Unrecognized)

- Pilot does not consciously perceive any of the manifestations of SD
  - Controls the aircraft in response to what he/she *incorrectly* perceives as his/her orientation
  - No suspicion of flight instrument malfunction
  - No appearance of control malfunction
- >50% of SD mishaps, *more dangerous*
- Sometimes referred to as “misorientation”

# Type II SD (Recognized)

- Pilot consciously perceives a manifestation of disorientation
  - Perceives a conflict between what he/she *feels* the aircraft doing and what the instruments say
  - Leads to suspicion of flight instrument malfunction
  - Appearance of control malfunction
- Pilot perceives a problem, but may not diagnose SD
- <50% of SD mishaps

# Type III SD

## (Vestibulo-Ocular Disruption)

- Pilot experiences overwhelming physiologic response to physical or emotional stimuli from SD
  - Nystagmus may be prominent
  - Panic
  - Pilot knows he/she is disoriented and can't do anything about it
  - Rare (thankfully!)

# Visual Illusions – Foveal (Central)

- Runway slope (shape constancy)
  - Upslope – Approach too low, perceive aircraft too high
  - Downslope – Approach too high, perceive aircraft too low
- Runway width (size constancy)
  - Narrow – Approach too low, perceive the runway as distant
  - Wide – Approach too high, perceive the runway as near

# Visual Illusions – Ambient (Peripheral)

- Lean on the sun
  - Tend to associate brightness with sky, darkness with ground
  - Cloud layers cannot be depended upon to cooperate with this arrangement
- Vection
  - Perception that you are in motion when you aren't because of objects in your peripheral vision that move
  - Classic: Stopped at light, car next to you moves

# Visual Illusions – Ambient (Peripheral)

- Autokinesis
  - Star or other fixed light appears to move, confused with aircraft light
  - Same effect when looking at digital alarm clock or other small light in very dark room
  - The eyes need more than one fixed point to “anchor”
  - Do not stare at a single light

# Visual Illusions – Ambient (Peripheral)

- Black hole approach – Night landing with no other *nearby* visual reference, no discernible horizon
  - True orientation of runway misperceived
- Sloping cloud deck – No discernible horizon
  - Cloud deck perceived as true horizon
  - Incorrect bank angle results
- False horizon – Night, ground lights in a row mistaken for horizon
  - Might not be parallel with true horizon!



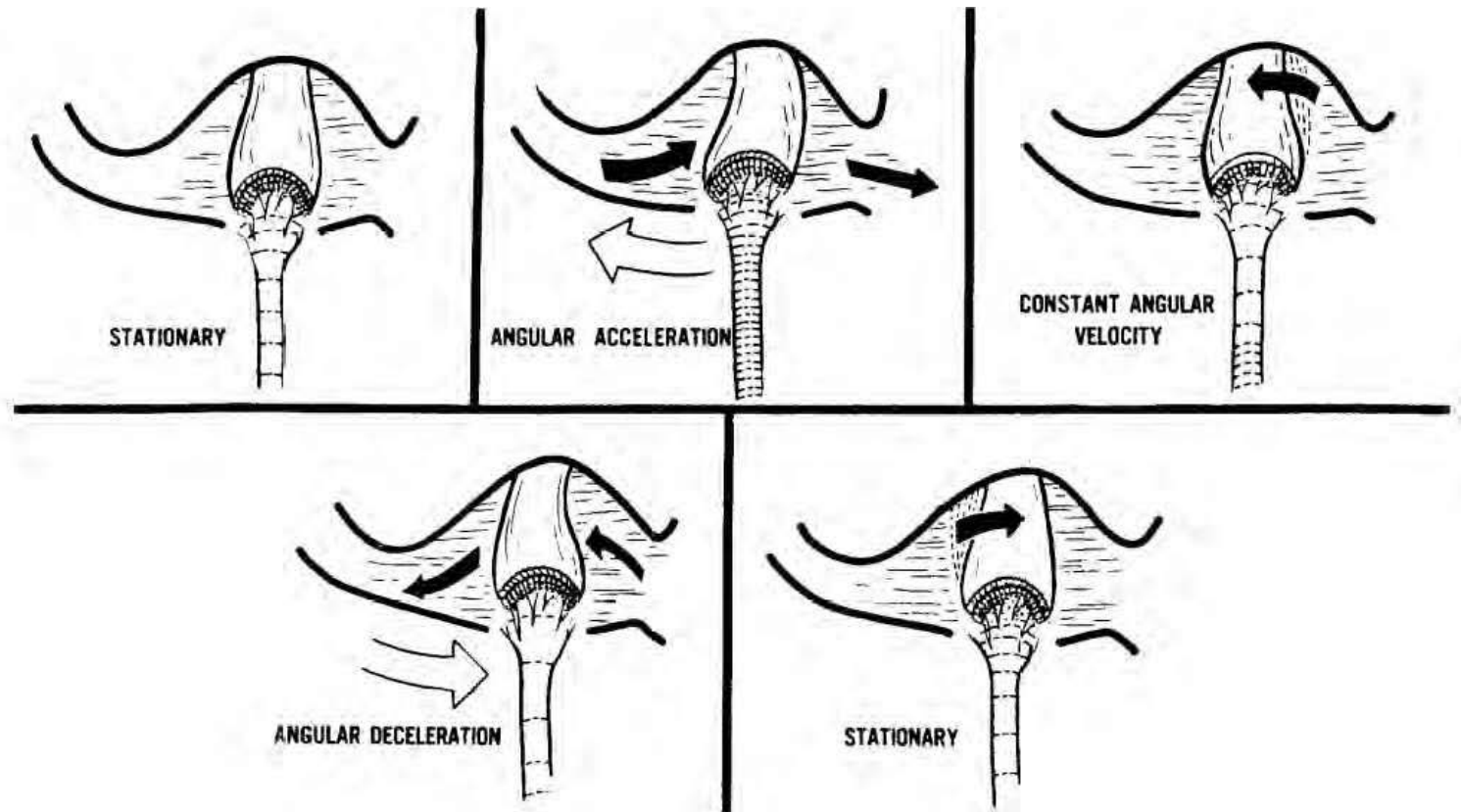
# Time Out for Some Definitions

- Semicircular Canals (SCCs) oriented in three planes, able to sense motion in any plane
  - Pitch (aircraft nose pitches up or down)
  - Roll (aircraft wings bank, or roll, left or right)
  - Yaw (aircraft nose yaws left or right)
- SCCs contain endolymph that causes hair cells in cupula to deviate, stimulating ampullary nerve and telling the brain you are moving in one or more plane

# Vestibular Illusions

## *Somatogyral*

- Inability of SCC to register sustained angular velocity
  - During prolonged turn, SCCs “recalibrate” and fail to perceive the turn as the endolymph stops moving and no longer stimulate the nerve
  - Rollout from prolonged turn moves endolymph in opposite direction, so return to straight and level is perceived as turn in opposite direction
- Results in classic graveyard spiral and graveyard spin



The Mechanism of the Somatogyral Illusion. Reproduced from The Flight Surgeon's Guide, 1995, and Kent Gillingham's chapter Spatial Orientation in Flight, DeHart, 1996

# Vestibular Illusions

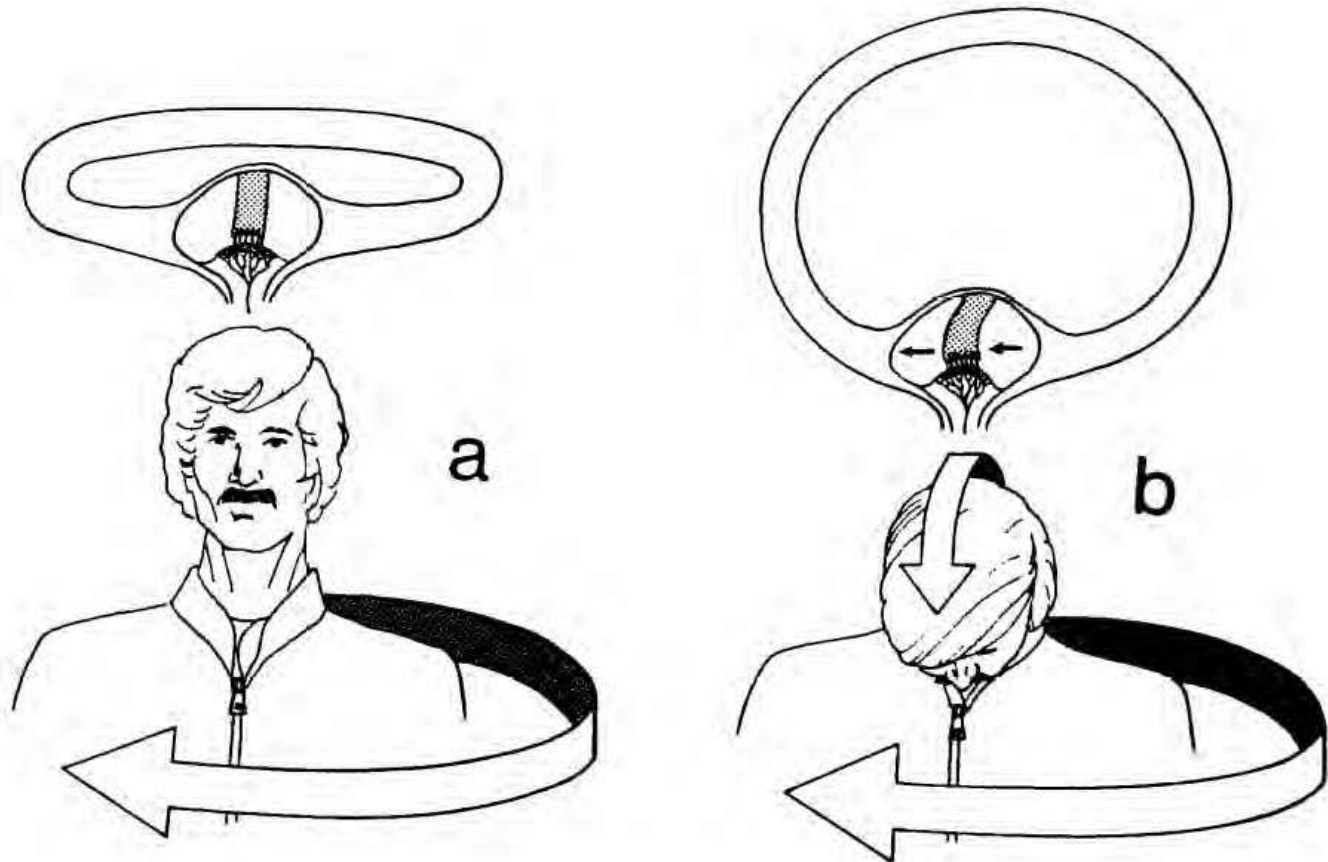
## *Oculogyral*

- False sensation of motion of a viewed object
  - Results from visual fixation during vestibulo-ocular reflex
- Illusory motion of moon moving through clouds

# Vestibular Illusions

## *Coriolis*

- Vestibular cross-coupling effect
- “Tip and turn”
  - Pilot rotating in yaw plane until endolymph stabilizes/stops flowing
  - Pilot then tilts cranium up or down, changing the plane of the SSC that was previously level and sensing yaw
  - Pilot now perceives a roll in the opposite direction



Mechanism of the Coriolis Illusion. Reproduced from The Flight Surgeon's Guide, 1995, and Kent Gillingham's chapter Spatial Orientation in Flight, DeHart, 1996

# Vestibular Illusions

## *Somatogravic*

- False sensation of body tilt caused by otolith membrane stimulation
- Somatogravic Illusion
  - Takeoff acceleration gives false perception that pilot is pitched up, “corrects” with pitch down
- Inversion Illusion
  - Rapid pitch down at level off gives false perception that pilot is inverted

# G-Excess Illusion

- Increased otolith hair cell deflection due to even minimal G
- *Turn and tilt* of cranium under G load causes pilot to perceive less bank angle than is actually present, so pilot “corrects” with overbank
- *Tilt only* creates illusion of climbing while in a turn, so pilot “corrects” with pitch down
- Causes mishaps in low altitude, low-G 180 degree turns



# Vestibular Illusions

## *Oculogravic*

- Visual correlate of somatogravic illusion
- Oculogravic
  - False downward movement of instrument panel upon deceleration (e.g. deploy speed brake)
- Elevator Illusion
  - False movements associated with change in  $G_z$

# The Leans

- Most common vestibular illusion in flight
- Illusion of bank associated with a vestibulospinal reflex
- Pilot actually leans in direction of perceived vertical

# Mishap Summary

- F-16 overseas deployment
- Brief at 0150, takeoff AT 0401
- Radar trail departure with 800 ft ceiling, breaking out at 3900 ft
- 2 min after takeoff, #4 reported a “problem”
- Approx 3 min after takeoff, #4 impacted ground 70 degrees nose-low and 160 degrees of bank at 400 KTS, pilot fatally injured after ejection out of the envelope

# Mishap Analysis

- Pilot failed to perceive left roll (the ‘leans’)
- Probably failed to perceive roll because of channelized attention on his radar or another cockpit distraction
- **Felt like he was wings level, surprised by his instrument indications**
- What type SD would this represent?

# Mishap Analysis

- Pulled the stick because altimeter indicated descent, leading to over-banked spiraling descent
- Rolled wings level at one point, but illusion was overpowering and he returned to over-banked attitude
  - Type II SD or Type III SD?
  - Hint: Was he flying the jet?
- Delayed decision to eject

# Factors Predisposing to SD

- Circadian desynchronization
- Poor nutrition
- Inadequate sleep
- No ambient view of the horizon
- Night inexperience
- Aircraft poorly designed for instrument flight
- Cockpit distraction

# Heads-Up Display

- Designed for weapons employment
- Poor for detection and recovery from unusual attitudes
- Many pilots are accustomed to using the HUD under instrument meteorological conditions (IMC)
- *The HUD is not a USAF primary flight instrument!*

# Proposed Remedies



# What Do We Do Now?

- Maintain instrument cross-check discipline
- Each mission has its risks for SD – Be aware of them
- Check your overall SA, be aware of imbalances
- Be aware of illusions under visual meteorological conditions (VMC)
- Check 12 during low altitude turns greater than 90°

# Summary

- Definitions
- Types of SD
- Visual Illusions
- Vestibular Illusions
- HUD is for war fighting, not SD recovery
- Prevention
- Next slide for quiz instructions

- [Go to quiz](#)
- Enter your answers on the [answer sheet](#)
- Print only one answer sheet for entire course
- Press ESC to go back to main menu