The Attitude Component of the Primary Flight Reference
Where do we go from here?
Regardless of the type of aircraft, mission, or mission phase, attitude awareness .... [is] a full time Air Force mission requirement

-- AFI 11-206, 1 Dec 96 (“General Flight Rules”)
What is the Mil Std 1787 PFR?

- Critical Flight Data (minimum, all the time)
  - Pitch/VVI
  - Bank
  - Altitude
  - Airspeed
- Attitude Awareness (maintain to counter SD)
  - Recognition
  - Recovery
- Flight Instrumentation (task specific)
- Single Medium Display (HDD, HUD, HMD)
- Fault Indications (positive presentation)
Pitch and Bank Display (Attitude)

Split Display

Combined Display
EARLIEST RECOGNITION FOR THE NEED IN THE U.S.A.

- T-2 Fokker
- First nonstop trans-continental flight by Lts Macready and Kelly
- May 2-3, 1923
- New York to San Diego
THE FIRST ATTEMPT AT AN ATTITUDE INDICATOR IN THE INSTRUMENT PANEL?

Spirit of St. Louis Cockpit--1927
THE FIRST BLIND SORTIE
TAKEOFF TO LANDING

This instrument panel opened a new era of flight.

JIMMY DOOLITTLE

Doolittle & Sperry “Blind” Flight Cockpit 1929
THE WORLD BEGINS TO "SHRINK"

Major Bill Ocker
Brooks Field, 1929

Elmer Sperry, 1918
Turn and Bank Indicator

Capt (Dr.) David Myers
Crissy Field, 1926
THE ATTITUDE INDICATOR
with 1960 technology
THE ATTITUDE INDICATOR with 1990 technology

C-130J Glass Cockpit with HUD
AN EXPLANATION OF AN ATTITUDE INDICATOR

Time-Life, circa 1960
THE TWO FUNDAMENTAL CONCEPTS

Comparison of the two attitude concepts

Inside-out
(moving horizon)

Outside-in
(moving aircraft)

Human Factors Engineering and Design,
Sanders and McCormick, 1993
ANOTHER CONCEPT OF PITCH AND BANK (attitude)

Su-25k (Russian Aircraft)
Given the two depictions: (Agree--Neutral--Disagree)
The O-I AI is a better depiction of the aircraft's spatial orientation.

- Experiencenced Outside-In User: 63
- Inexperienced No prior instrument knowledge: 51
- Experiencenced Inside-Out User: 58

Outside-in (moving aircraft)

Inside-out (moving horizon)
Results of Attitude Concept Preference

Pongratz & Ercoline, AsMA 99
FINDINGS

- Flight-experienced subjects (pilots) strongly prefer their current attitude display
- Flight-inexperienced subjects prefer the outside-in attitude display
THE TWO FUNDAMENTAL CONCEPTS ON THE HUD

HUD: MiG-29

HUD: NATO-Standard

10° pitch-up  45° bank to left
USAF IFC asked to endorse
Rejected until issues were addressed
Issues addressed by 1993
HUD as a PFR endorsed in 1996
Integration of HUD with AI not an easy task
THE NEWEST TECHNOLOGY
THE HMD AS A PFR?

• Initial use of HMD seems to be much like that of the HUD—targeting and weapons aiming

• Considered by many a large solution to the SD problem

• Use of the HUD pitch ladder for attitude information (non-conformal symbology becomes an issue)

Integration of HMD with HUD and AI not an easy task
NON-CONFORMAL ISSUE for HMD and HUD-typed ATTITUDE DISPLAYS

- Straight-and-level (forward-view)
- 45-deg left-bank (forward-view)
- 30-deg left-bank (look of 90-deg-off-axis view)
CAN ONE OF THE ATTITUDE CONCEPTS WORK ON THE HMD?

• HUD ladder (Inside-Out)
• Aircraft symbol (Outside-In)
• ASAR (aka Grapefruit or Orange Peel)
HMD Candidate Symbology

• **Subjects** (9 pilots)
  - 3000 flight hours (avg)
  - 350 HUD hours (avg)

• **Attitude Awareness Lab**
  - HMD (collimated)
  - Reverse projection outside scene
  - SGI Computers, BARCO Projector
  - Right-handed side joystick

Ercoline, Self, Matthews, & Orzech, AsMA 00
HMD Candidate Symbology Results

- Reaction Time (sec)
- Error Rate (avg #/subj)
- Preference

Legend:
- I-O HUD
- I-O GF
- O-I AC

Symbols:
- HUD
- GF
- AC
FINDINGS

• GF (aka ASAR) significantly faster in reaction time and fewer reversal errors
• Subjects (experienced pilots) preferred the GF over the other two (8 of 9)
• No differences found between this traditional HUD ladder and this O-I airplane
• Training time much less for GF (observation)
• GF concept should be considered as a candidate for attitude information on HMD (variant of the NDF)

• USAFA Longitudinal Study with Dr. Self
• Non-conformal symbology
USAF Academy Resources

Cessna 172 (T-41)

ASK-21 Glider

Gyro IPT

GAT II
NON-CONFORMAL ATTITUDE DISPLAYS

- Peripheral arc-segmented attitude display
- Sextant roll-pitch display
- NAWC display
- Virtual aircraft display
WHAT HAVE WE LEARNED?
SD IS STILL A KILLER!

SD Class A Mishap Rate is Largely Unchanged from 1970s!

- **Operations -- includes Loss of Situational Awareness**
- **Spatial Disorientation**
SUMMARY--MORE CAN BE DONE

• Research
  – Mechanization
    • Information processing
    • Modeling (pilot and vehicle)
  – Sensory (displays and controls)
    • Visual
    • Alternative
    • Automation
  – Training
    • Ground based
    • Flight based

• Information Accessibility
WHERE DO WE GO FROM HERE?

• Standard PFR
• Other sensory support (3-D Audio, TSAS)
• SD training (Does it work? What type?)
• Automation (When? What kind?)
• Type III SD (Significance?)
• Look for opportunities to collaborate (USAFA, Tri-Service, International WGs …)