Bill Ercoline

SD Symposium (Veridian/TASC) 15 – 17 Nov 2000

PRIMARY FLIGHT INFORMATION

CONTROL AND PERFORMANCE DISPLAYS

- **Attitude**
- **Altitude/vertical velocity**
- **Airspeed**
- **Heading (turn rate)**
- **AOA**
- **Acceleration/Thrust**

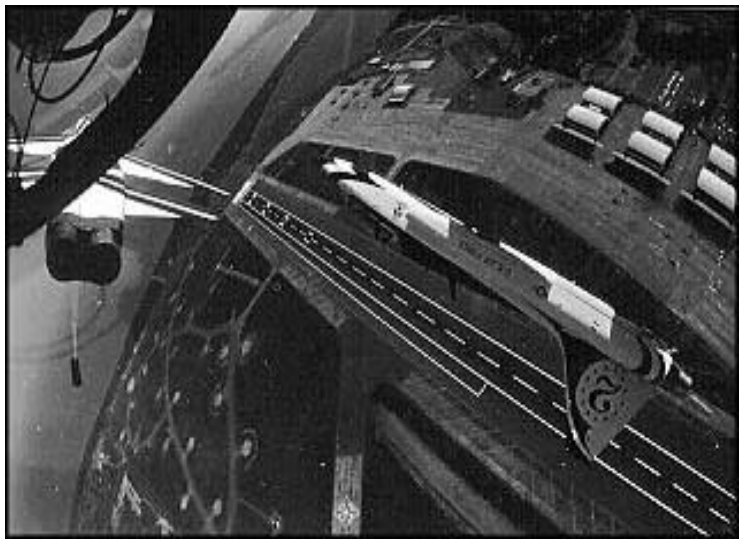
"Regardless of the type of aircraft, mission, or mission phase, attitude awareness .... [is] a full time Air Force mission requirement"

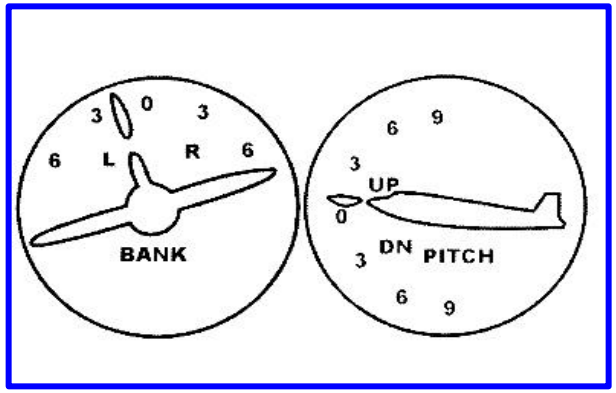
-- AFI 11-206, 1 Dec 96 ("General Flight Rules")

What is the Mil Std 1787 PFR?

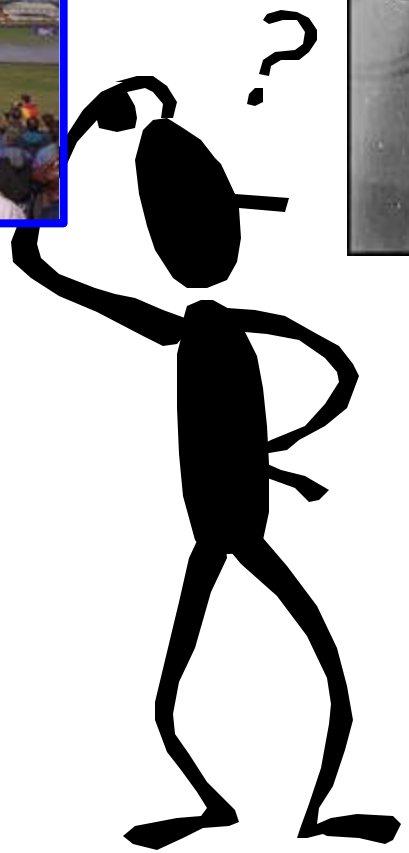
- Critical Flight Data (minimum, all the time)
  - Pitch/VVI
  - Bank
  - Altitude
  - Airspeed
- Attitude Awareness (maintain to counter SD)
  - Recognition
  - Recovery
- Flight Instrumentation (task specific)
- Single Medium Display (HDD, HUD, HMD)
- Fault Indications (positive presentation)

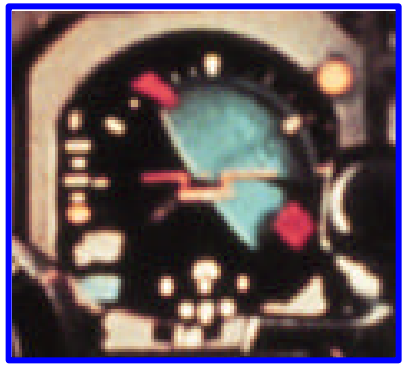
Pitch and Bank Display (Attitude)





Split Display



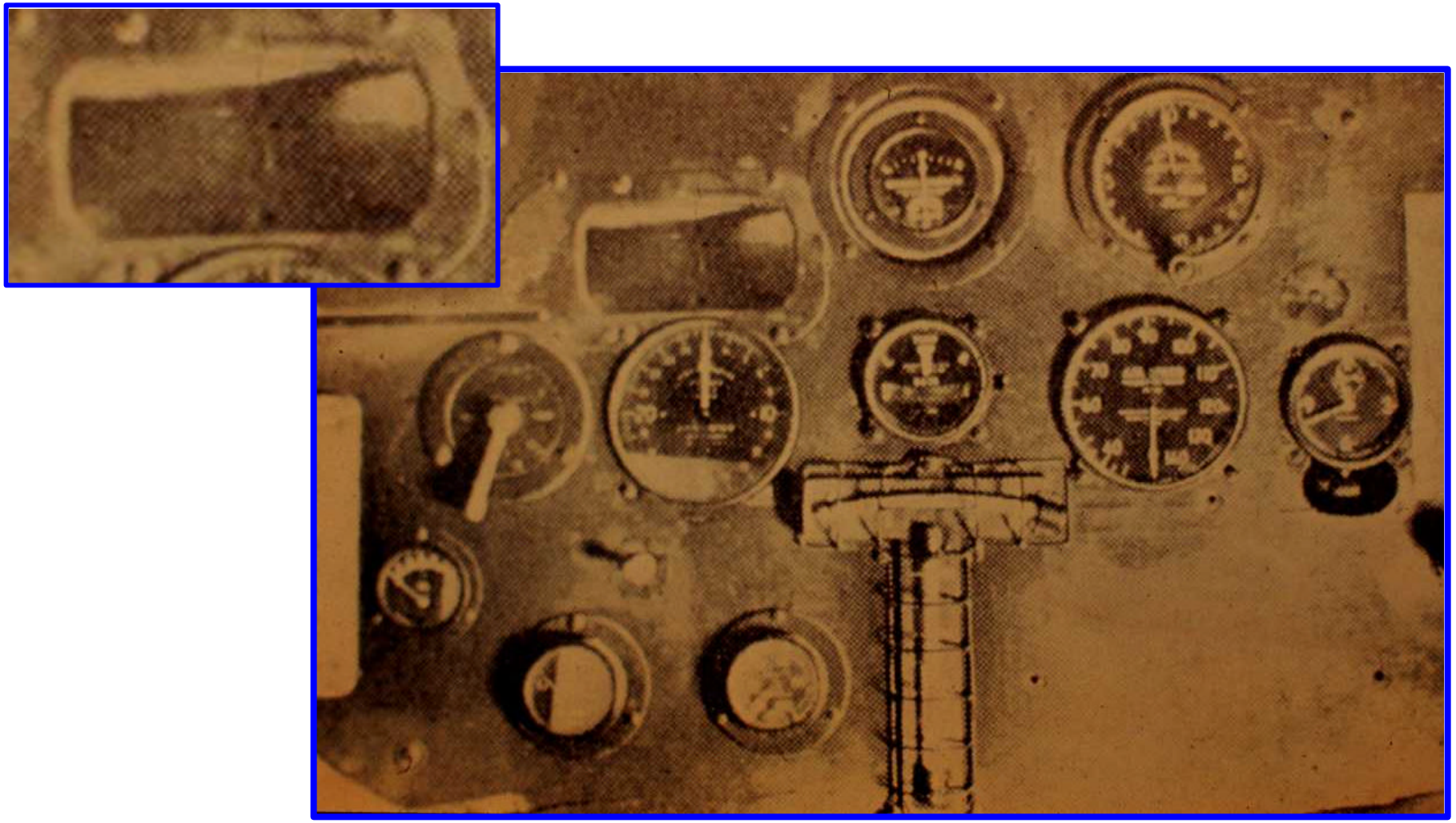


Combined Display

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

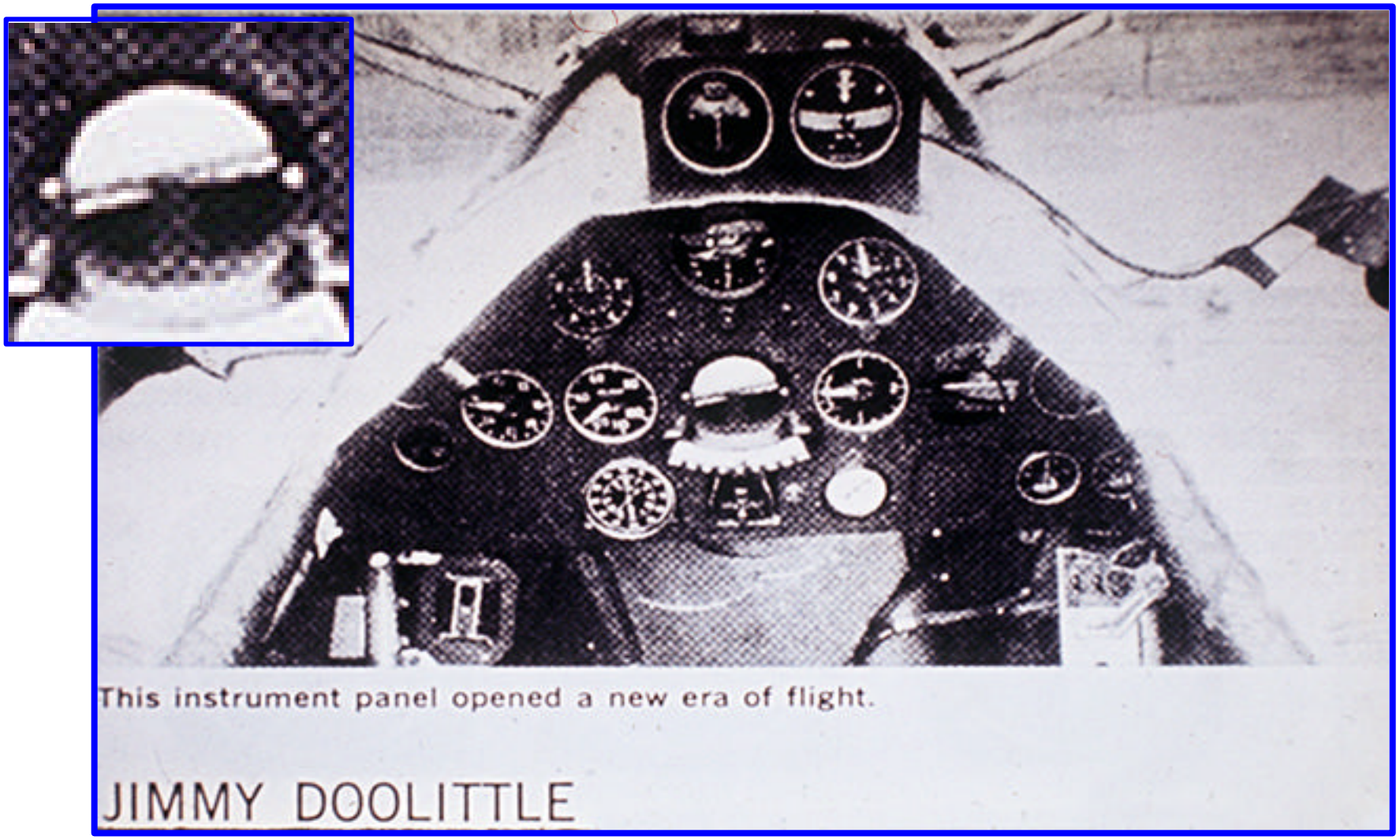
- T-2 Fokker
- First nonstop trans-continental flight by Lts Macready and Kelly
- May 2-3, 1923
- New York to San Diego

THE FIRST ATTEMPT AT AN ATTITUDE INDICATOR IN THE INSTRUMENT PANEL?



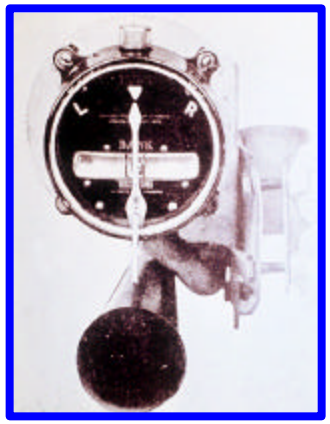
Spirit of St. Louis Cockpit--1927

THE FIRST BLIND SORTIE
TAKEOFF TO LANDING



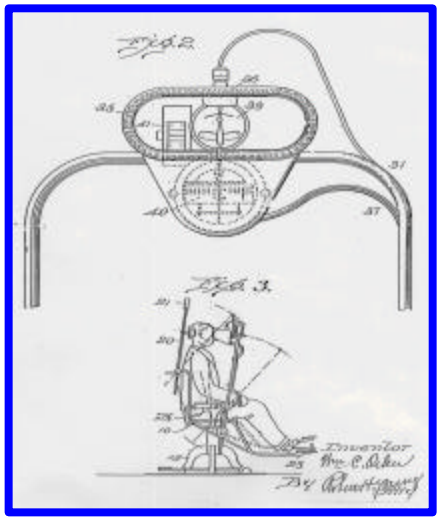
Doolittle & Sperry “Blind” Flight Cockpit 1929

THE WORLD BEGINS TO “SHRINK”



Elmer Sperry, 1918

Turn and Bank Indicator

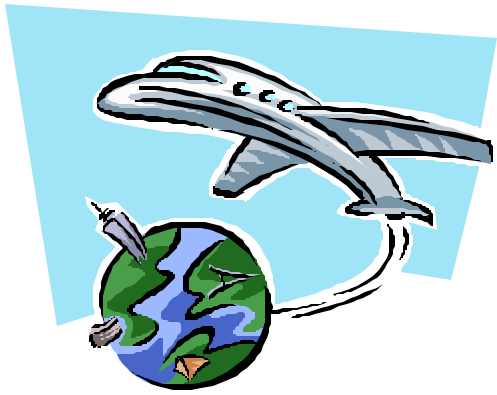


Major Bill Ocker

Brooks Field, 1929

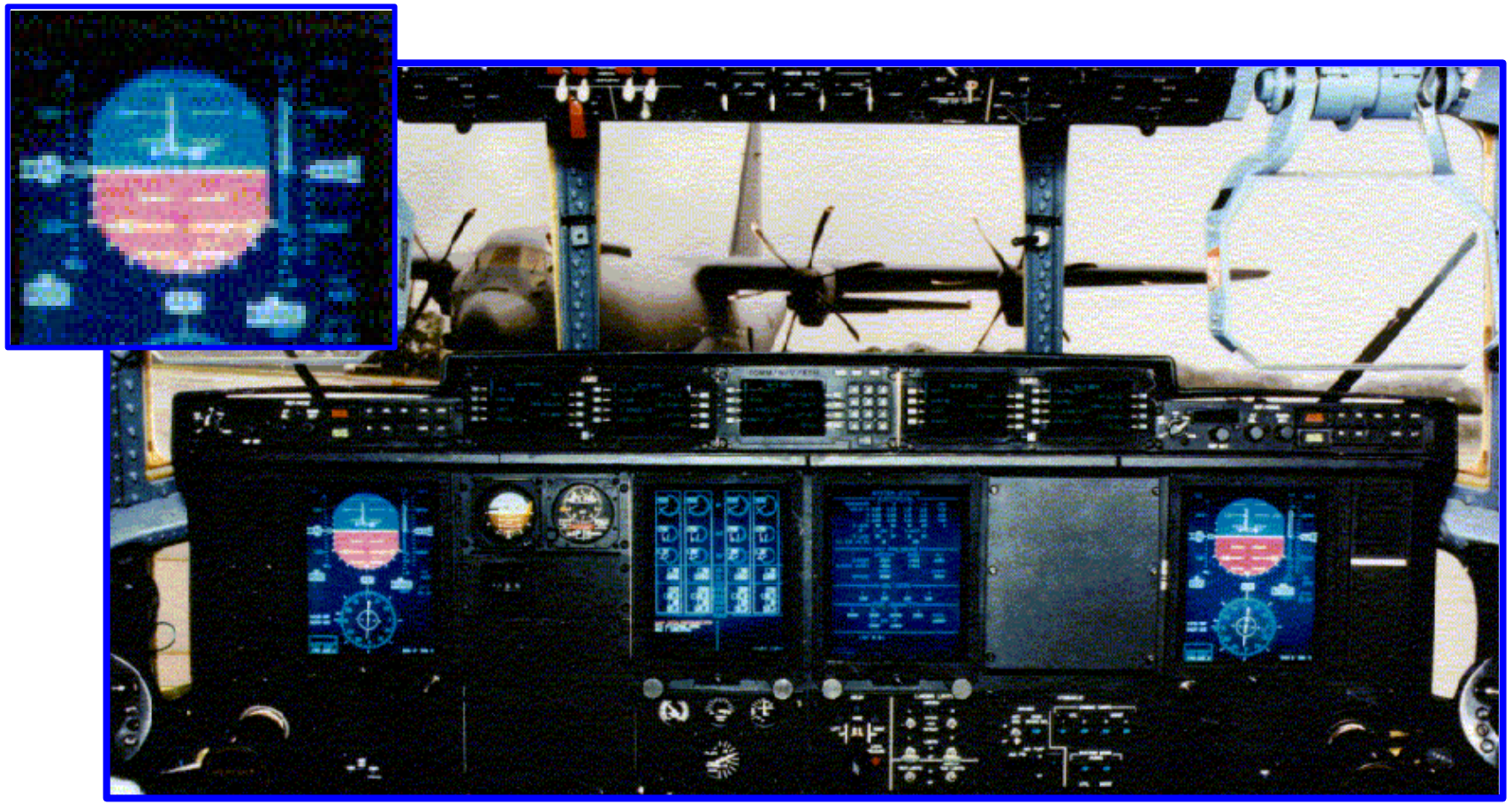
Capt (Dr.) David Myers

Crissy Field, 1926



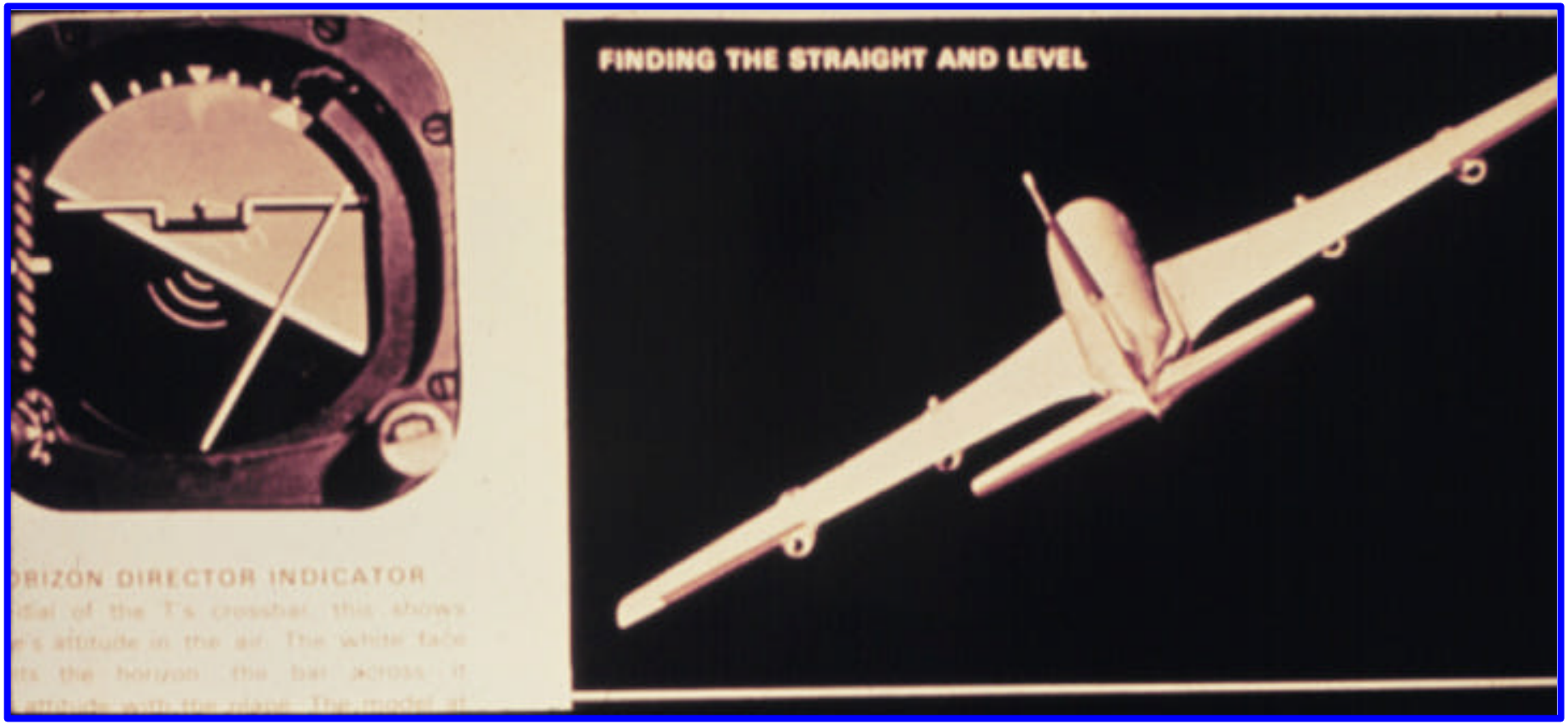
THE ATTITUDE INDICATOR
with 1960 technology

THE ATTITUDE INDICATOR
with 1990 technology



C-130J Glass Cockpit with HUD

AN EXPLANATION OF AN ATTITUDE INDICATOR



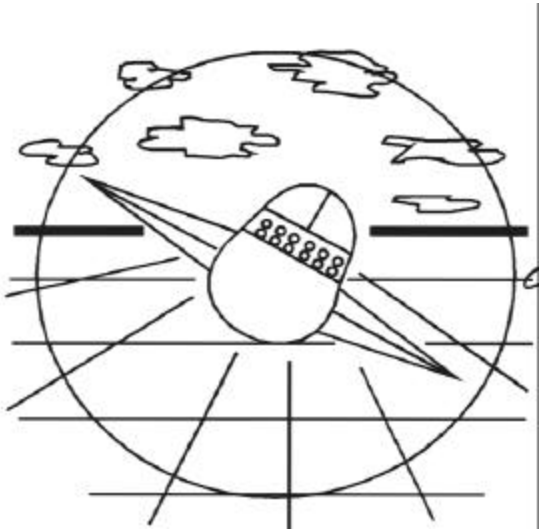
Time-Life, circa 1960

THE TWO FUNDMENTAL 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)

Attitude Concept Preference Survey

Survey Structure--Pongratz & Ercoline, AsMA 99

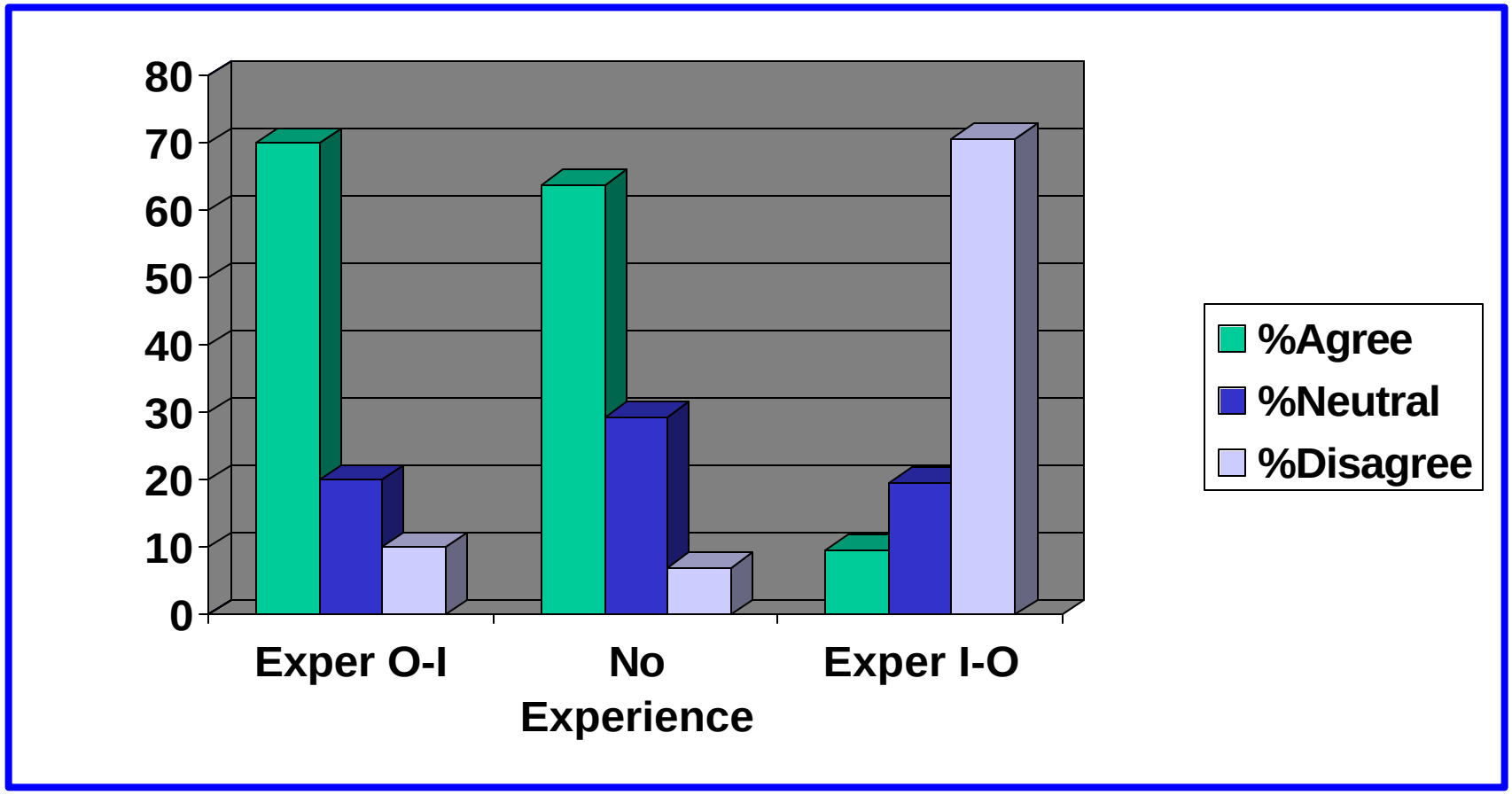
Given the two depictions:
(Agree--Neutral--Disagree)
The O-I AI is a better depiction of the aircraft's spatial orientation.

Expericenced Outside-In User	Inexperienced No prior instrument knowledge	Experienced Inside-Out User
63	51	58

Outside-in
(moving aircraft)

Inside-out
(moving horizon)

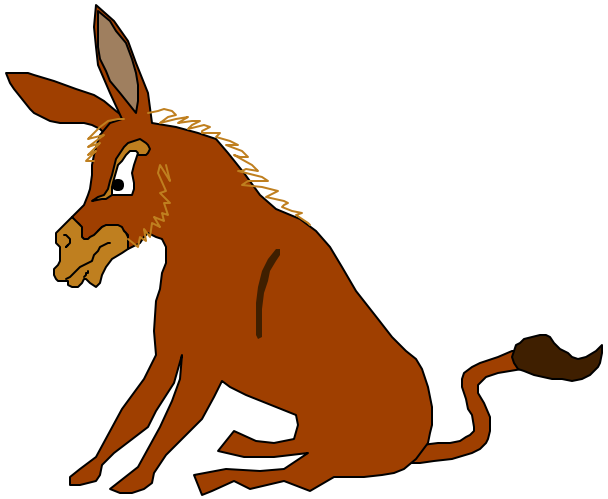
Results of Attitude Concept Preference



Pongratz & Ercoline, AsMA 99

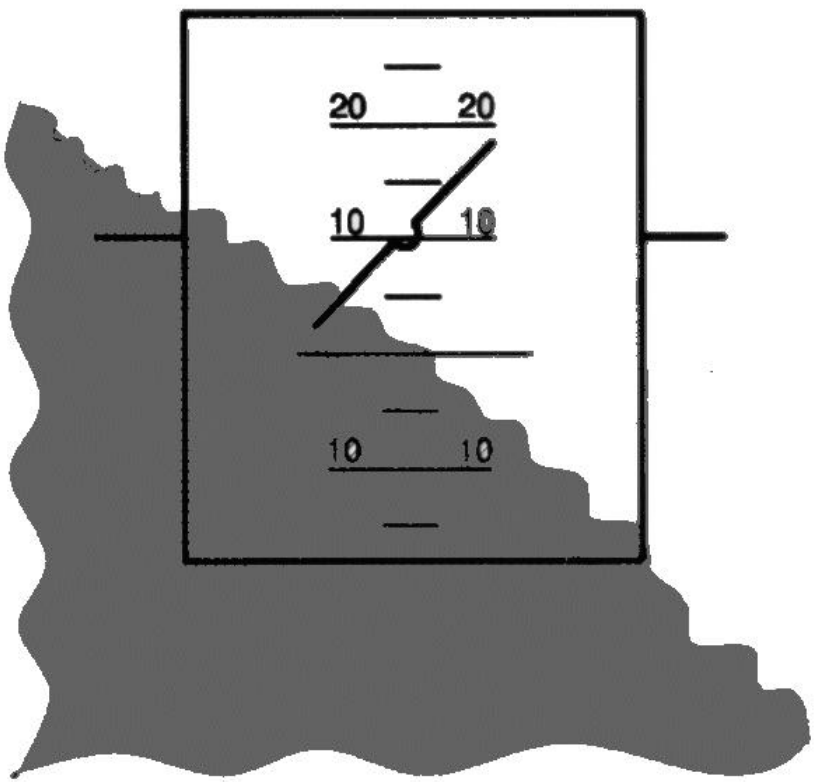
FINDINGS

- Flight-experienced subjects (pilots) strongly prefer their current attitude display
- Flight-inexperienced subjects prefer the outside-in attitude display

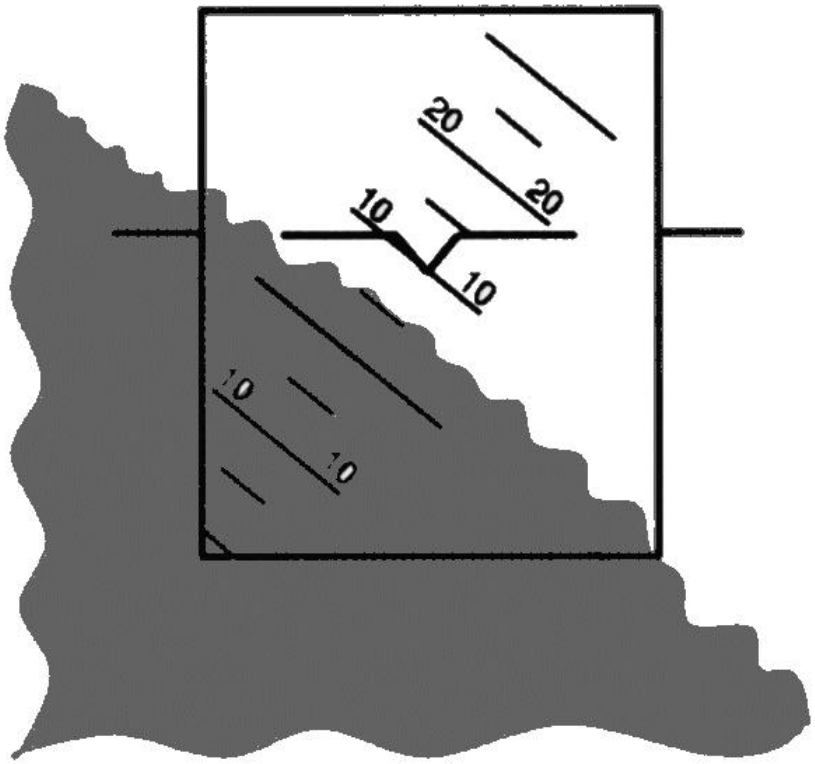


THE TWO FUNDAMENTAL CONCEPTS ON THE HUD

HUD: MiG-29



HUD: NATO-Standard



10° pitch-up 45° bank to left

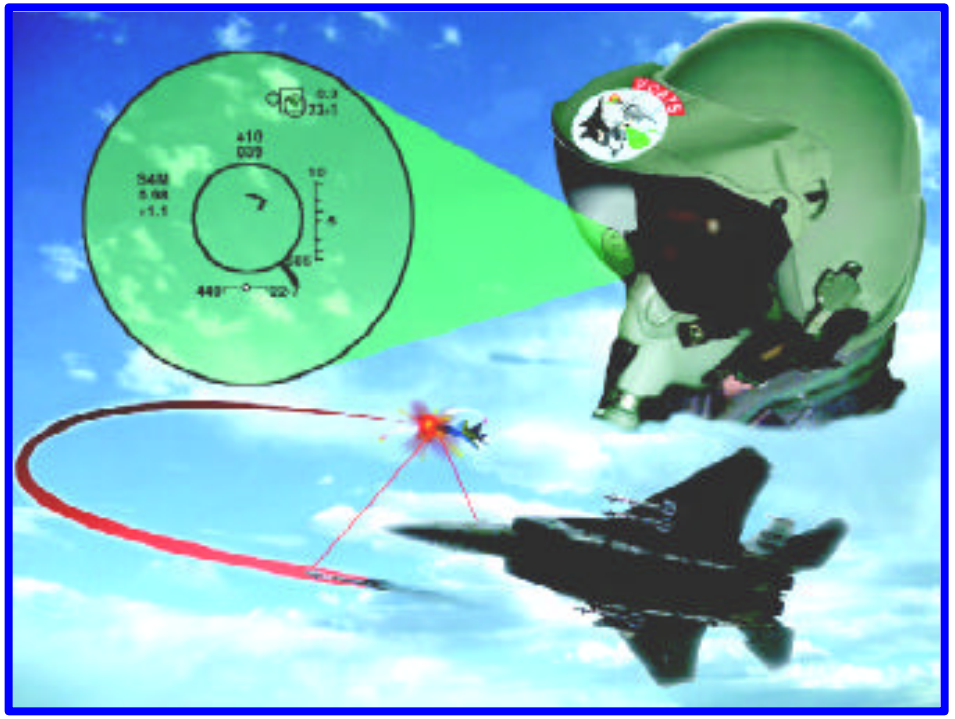
F-16 A/B HUD USHERS IN THE PFR, 1977

- 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

F-16 C/D

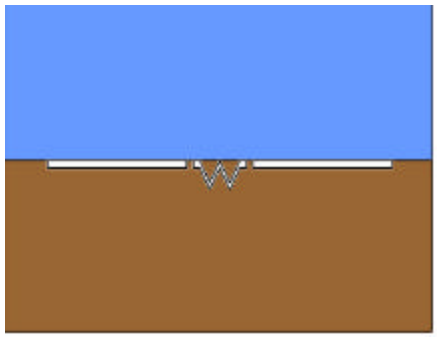
THE NEWEST TECHNOLOGY
THE HMD AS A PFR?

- 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)

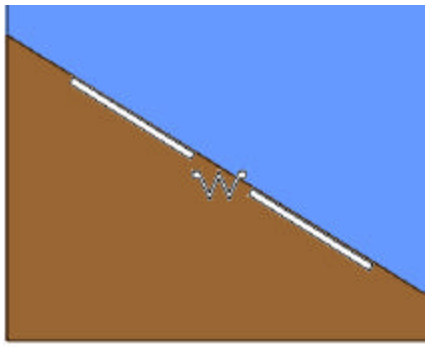


Integration of HMD with HUD and AI not an easy task

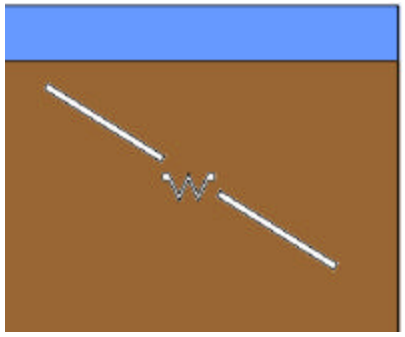
NON-CONFORMAL ISSUE for HMD and HUD-typed ATTITUDE DISPLAYS



Straight-and-level ***(forward-view)***



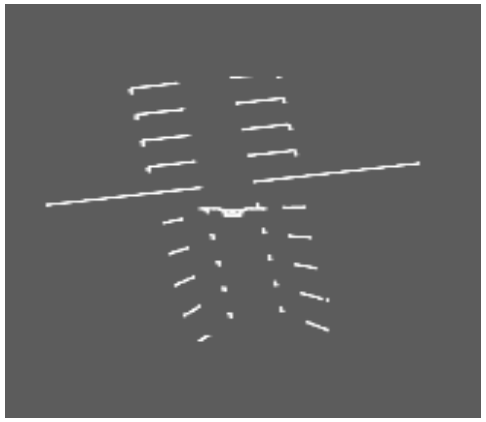
45-deg left-bank ***(forward-view)***



30-deg left-bank ***(look of 90-deg-off-axis view)***

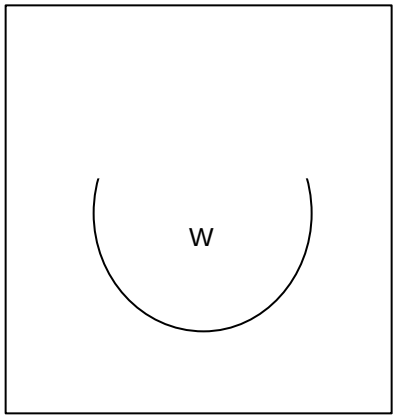
CAN ONE OF THE ATTITUDE CONCEPTS WORK ON THE HMD?

- **HUD ladder (Inside-Out)**
- **Aircraft symbol (Outside-In)**
- **ASAR (aka Grapefruit or Orange Peel)**



HUD

AC



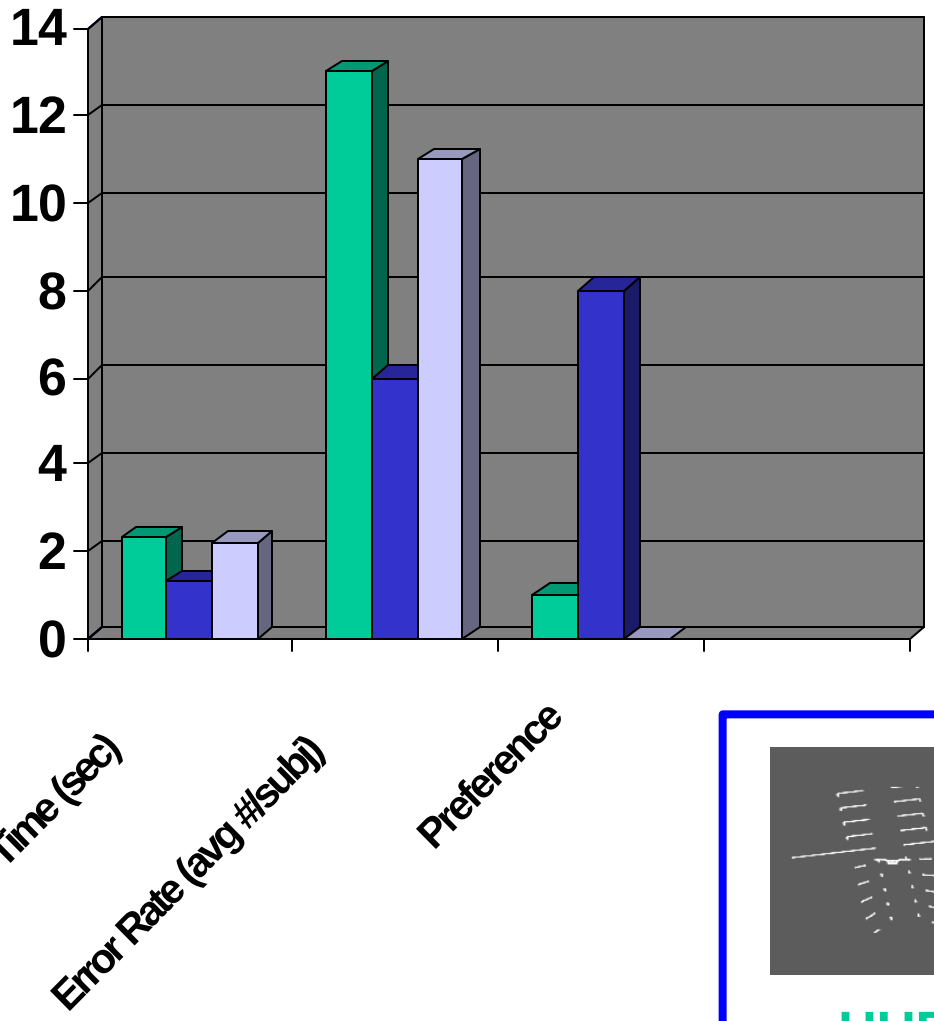
GF

HMD Candidate Symbology

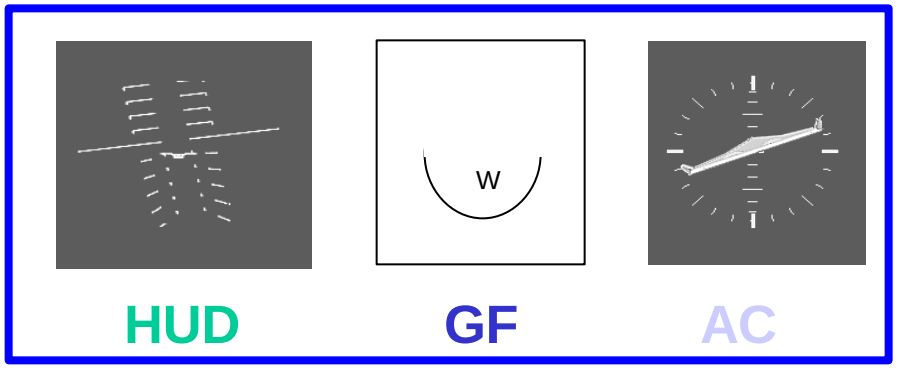
- **Subjects** (9 pilots)
  - 3000 flight hours (avg)
  - 350 HUD hours (avg)
- **Attitude Awareness Lab**
  - HMD (collimated)
  - Reverse projection outside scene
  - SGI Computers, BARCO Projector
  - Right-handed side joystick

Ercoline, Self, Matthews, & Orzech, AsMA 00

HMD Candidate Symbology Results



I-O HUD
I-O GF
O-I AC

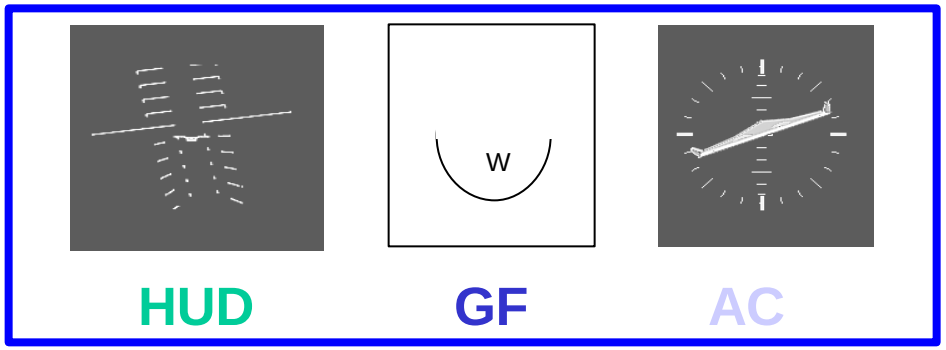


FINDINGS

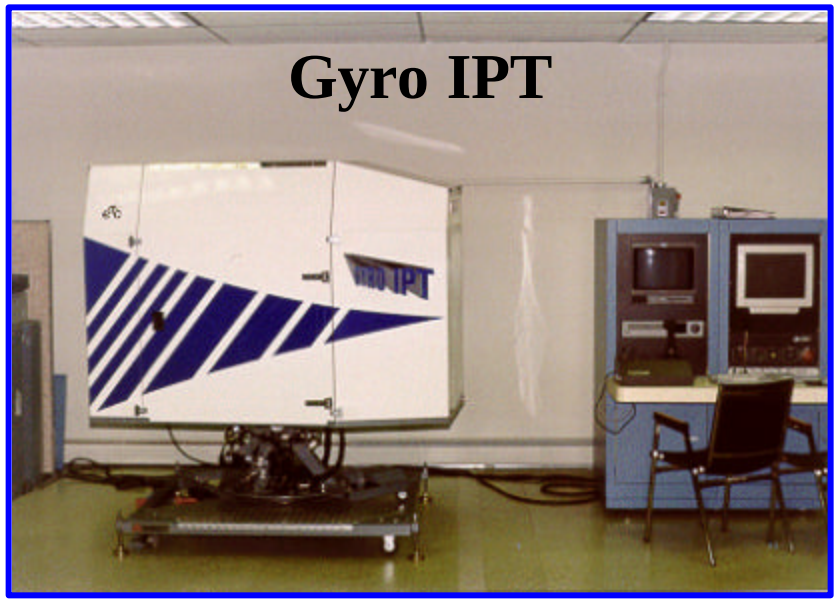
- GF (aka ASAR) significantly faster in reaction time and fewer reversal errors
- Subjects (experienced pilots) preferred the GF over the other two (8 of 9)
- No differences found between this traditional HUD ladder and this O-I airplane
- Training time much less for GF (observation)
- GF concept should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

•USAFA Longitudinal Study with Dr. Self

•Non-conformal symbology



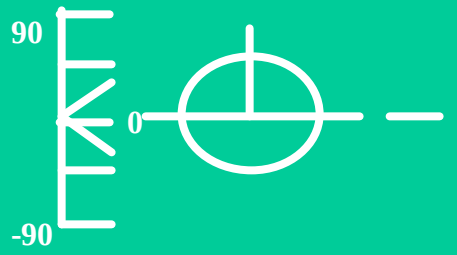
USAF Academy Resources



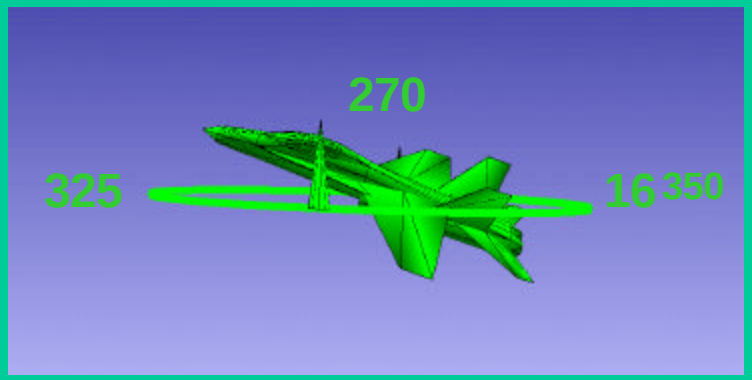
NON-CONFORMAL ATTITUDE DISPLAYS

Peripheral arc-segmented attitude display

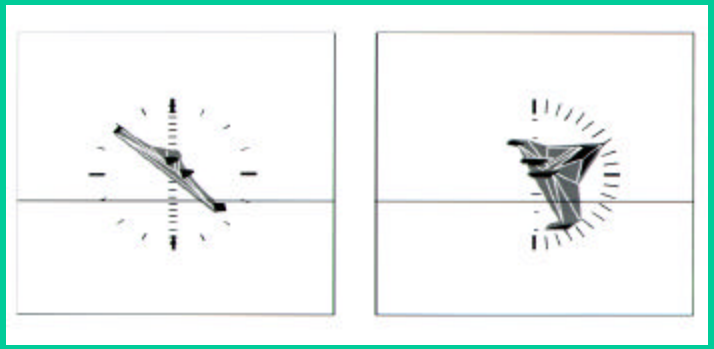
Sextant roll-pitch display



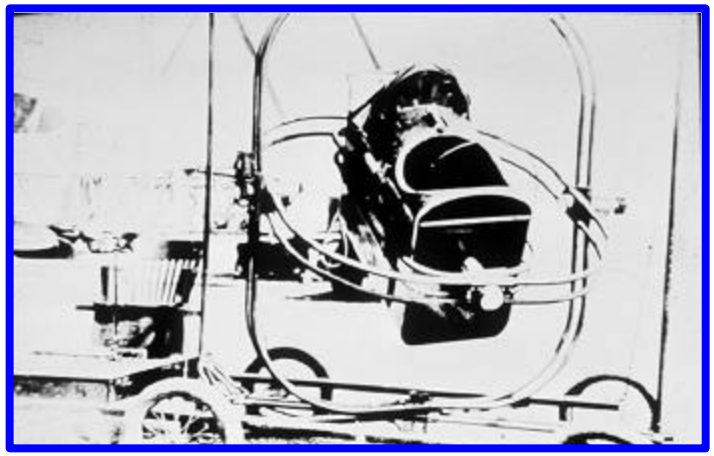
NAWC display



Virtual aircraft display

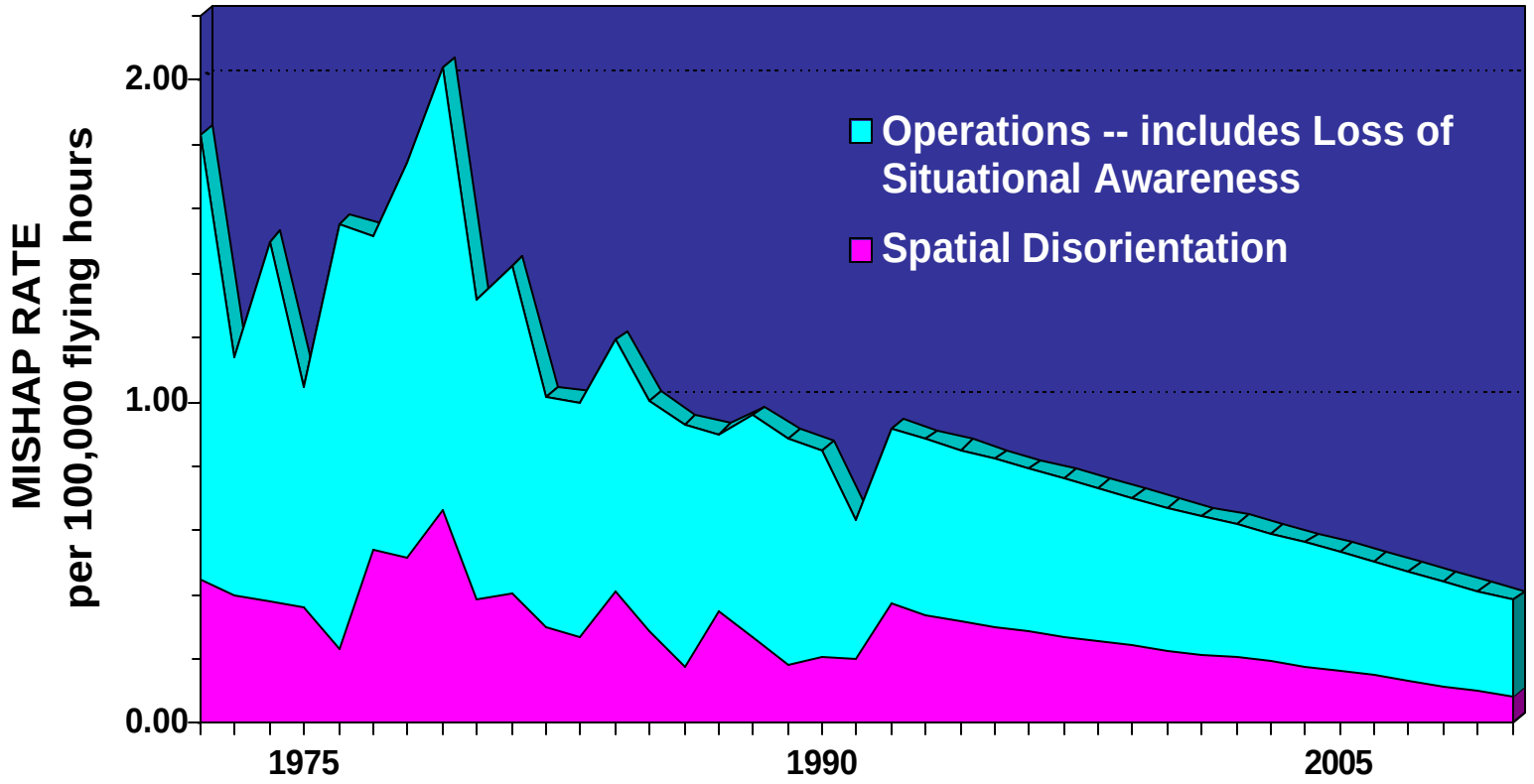


WHAT HAVE WE LEARNED?



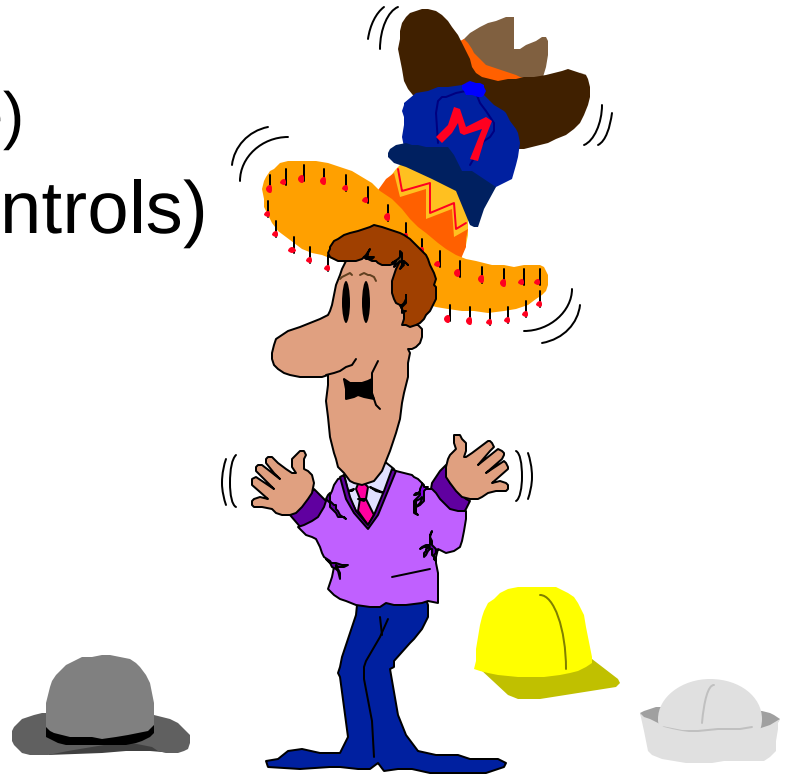
SD IS STILL A KILLER!

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



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 …)