Human Factors Issues

Loss of Control in General Aviation

Aerospace Human Factors Research Laboratory

Aerospace Human Factors Research Division (AAM-500)

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Federal Aviation Administration

Possible Approaches; GA Loss of Control

- Prevent aircraft from exiting “normal” envelope
  - Passive (displays; visual and/or auditory)
  - Active (intervention by automated system at boundaries)
  - Performance-control system (PCS)
- Provide recovery assistance when out of tolerance
  - Passive (displays)
  - Active (control-system intervention)

Human factors issues by intervention type: 1 – Visual Displays (passive)

- Visual display requires visual monitoring/attention
  - Auditory component recommended
- Conform with behavioral expectations/stereotypes?
  - Do they maintain expected directional relationships?
  - Do they use the principle of pictorial realism?
- How much resolution is needed in the display by task?
  - Can indications be categorical or need they be continuous?

Example: Angle-of-Attack Indicators (Add-on)

Observe Stereotypes

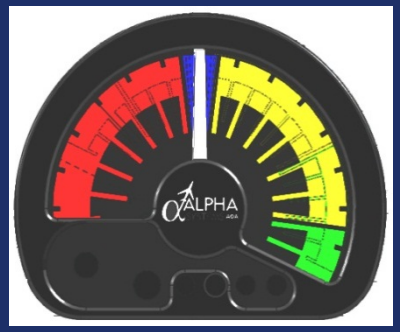
Clockwise=increase
Up = increase
Pictorial realism

Compare actual performance with desired performance

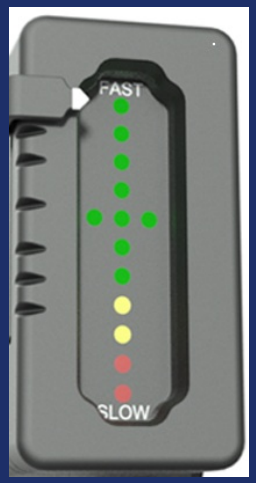
Up = increase
Chevrons = response direction

Note: Good display will show pilot how to respond

Do not observe stereotypes



Counter-clockwise = increase



Down = increase

Note: Display standards presently lacking

Provide Guidance for Attitude Recovery

With ADI background

Indicates magnitude of response needed

With SVS background

Results show pilots find these displays useful;
They reduce ambiguity and provide direct guidance.

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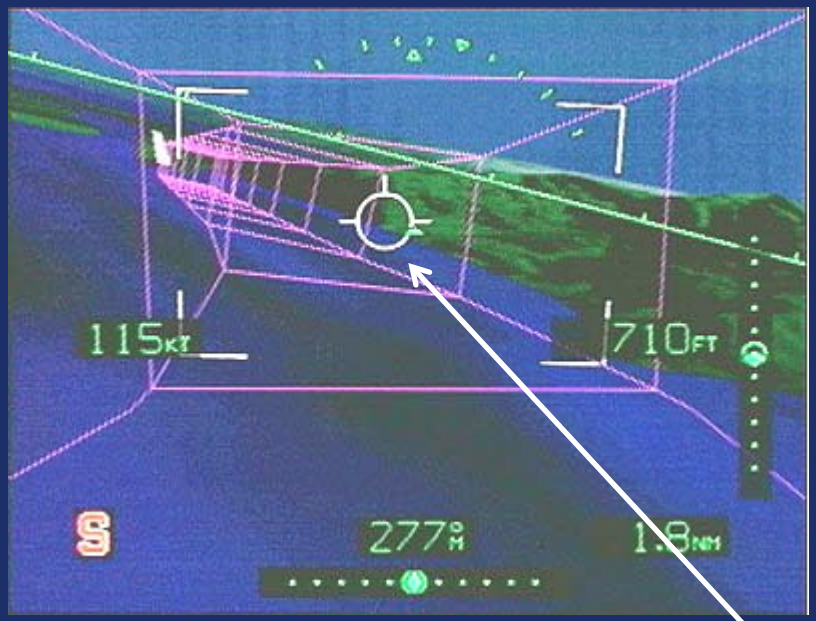
Continuous Information via Displays*

- Information depicting aircraft state
  - Information on aircraft performance relative to desired performance (flight director, highway-in-the-sky/pathway)
  - Information on aircraft state relative to operational envelope
  - Information on hazards external to aircraft (that may affect controlling behavior) (Beringer, 2013)
  - Information/alerts/warnings when aircraft approaches boundaries (Mulder, van Passen, et al., 2009-2011)

*Requires pilot monitoring & response

Provide Continuous Guidance: HITS & FPM



- **Highway-in-the-Sky shows desired flight path**
- **Flight-path marker shows actual performance**
- **Will also show when performance is inadequate to maintain flight (high sink rates)**

Flight-path Marker

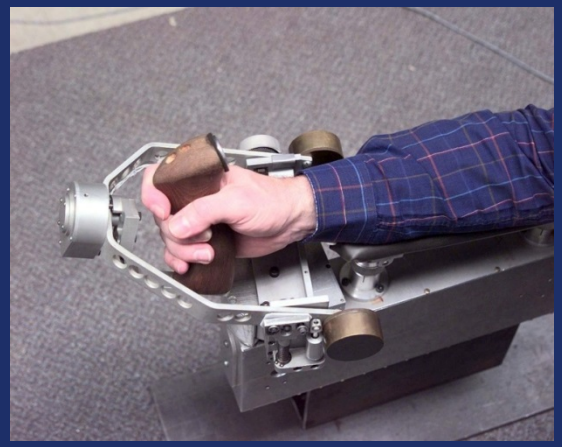
Results of numerous studies have shown this guidance is beneficial in maintaining desired aircraft flight path and recovering from stalls

Active "Envelope Protection"*

- Active System Intervention
  - Intervention by system to resist actions that will take system outside operational envelope (Saab/Sensis, 2012; Beringer & Rogers, in preparation)
    - Physically resists pilot attempts to exceed boundaries of limits, but can be physically overridden
  - Performance-control system
    - Commands aircraft performance, not control-surface position (Beringer, 1999; Kraus, 1973; Bergman, 1976; Roscoe & Williges, 1975)
    - De facto limitation to operations within envelope (no aerobatics)

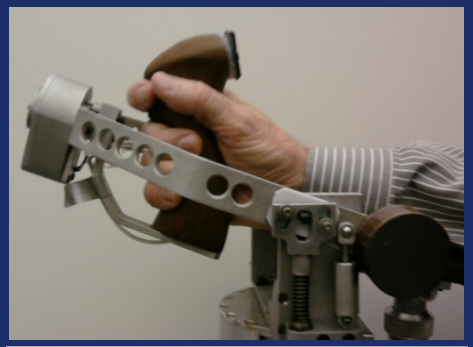
*Monitors performance for pilot and alerts or intervenes

Active “Envelope Protection” Example: PCS

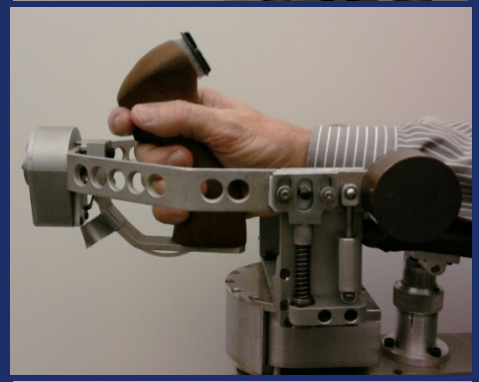


PCS using 4-axis side-arm controller

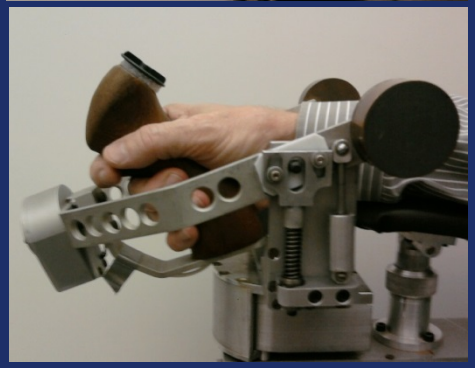
Constant climb



Hold altitude



Constant descent



(Kraus, 1973; Bergman, 1976; Duerksen, 1996; Beringer, 1999)

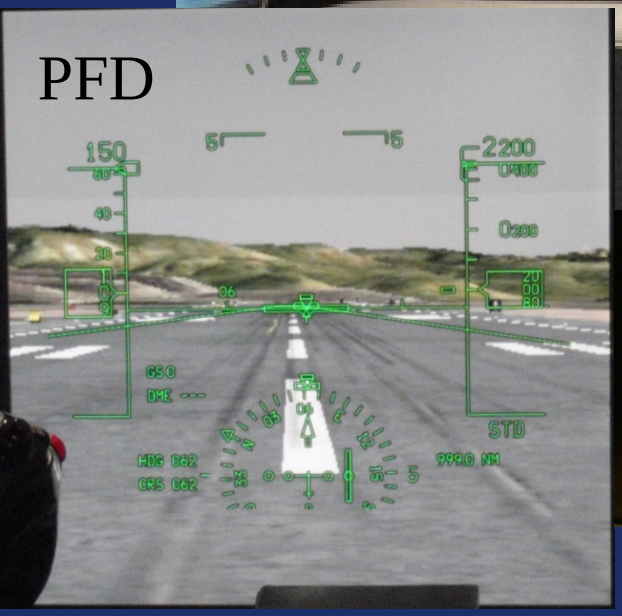
Summary (1)

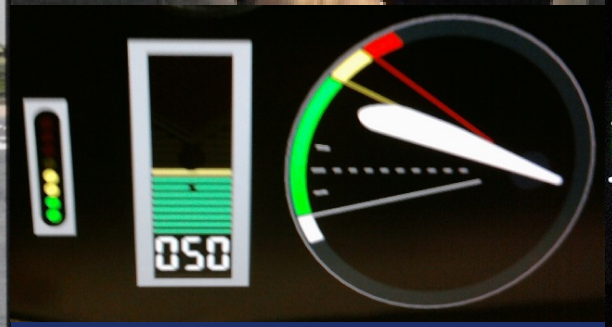
- **Approach dependent on philosophy and application: (1) Visual Displays**
  - Visual displays require pilot visual attention
    - May detract from external visual monitoring tasks
    - Need to be paired with auditory information/alerting
    - This approach maintains pilot control authority, but requires pilot intervention
  - Some displays (AoA) are available as retrofit
    - Need display standards for consistency and to conform with human performance stereotypes

Summary (2)

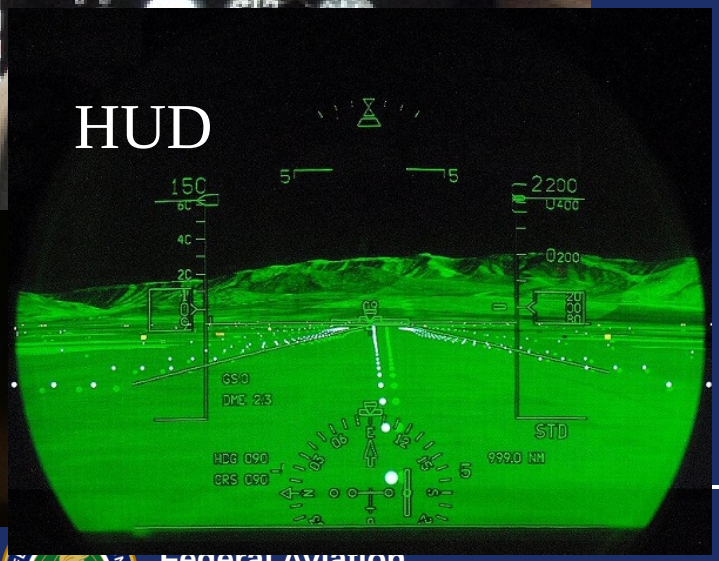
- **(2) Envelope-protection approaches (active)**
  - Monitoring is shifted from pilot to system
  - May or may not require pilot intervention
    - Active EP system can:
      - Resist but not inhibit attempts to exceed (pilot has authority)
      - Recover on authorization (pilot actively delegates authority)
    - Performance-control system
      - Prevents departing envelope (pilot gives up some authority)
      - Prioritization used in algorithms is critical (what performance is prioritized to be maintained)

Current Phase 1 Research: Synthetic Vision and AoA



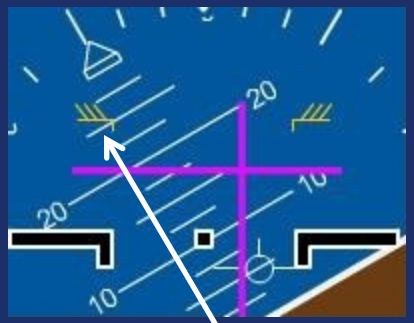


AoA



Phase 2 Research: AoA on PFD

Inset but not integrated



Integrated*

*Karwal, A.: ICAO LOC-I Symposium, Montréal 20-22 May 2014 (National Aerospace Laboratory NLR)