



Low Visibility Loss of Control Experiment

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Outline



Aviation Safety Program: Synthetic Vision Systems – General Aviation

- Goals and Objectives of the Experiment
- Independent Variables
- Scenarios
- Test Equipment and Assumptions
- Pilots
- Dependent variables
- Data analyses
- Results and Discussions
- Concluding Remarks

Goals, Objectives and Benefits



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- Develop tools to characterize the onset of low visibility loss of control
 - Provide tools for future display research in this area
 - Augment literature base in this area
- Apply tool set to evaluate SVS displays to:
 - Mitigate occurrences of low visibility loss of control
 - Reduce controlled flight into terrain (CFIT) accidents

Definitions



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- Low Visibility induced Aircraft Upset (LVAU) condition was considered to be when either pitch angle was greater than +25/ -10 degrees or bank angle was greater than +/-45 degrees
- LVAU without recovery might lead to a LVLOC
- Massive loss of Situation Awareness (SA) was defined as altitude errors greater than 1,000 ft and heading errors greater than 45°

NASA General Aviation Work Station (GAWS)



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Displays as Independent Variables



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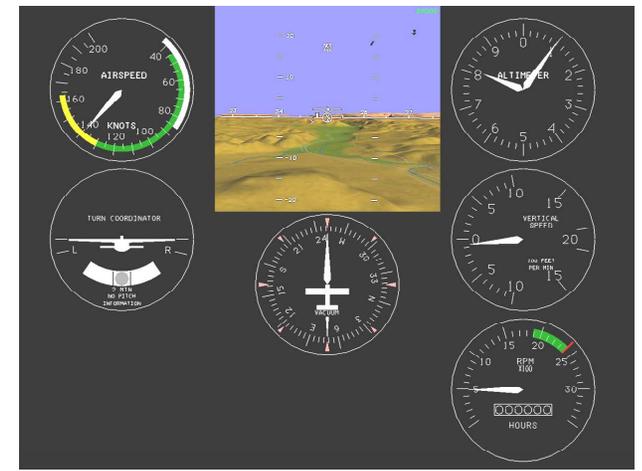
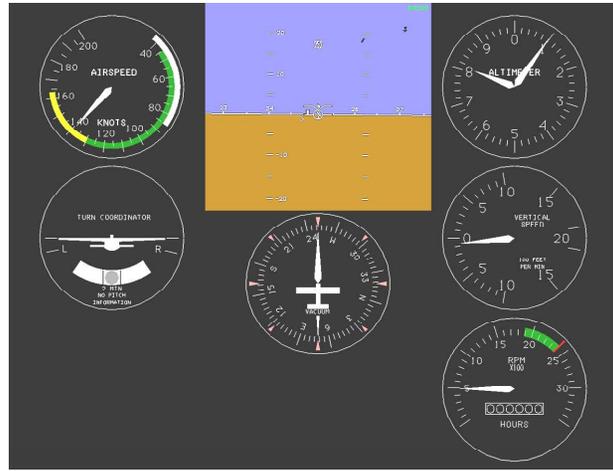
Size

Terrain

Baseline AI Display

EAI Display

SVS Display



NO PFD, NO ND

Baseline AI Display



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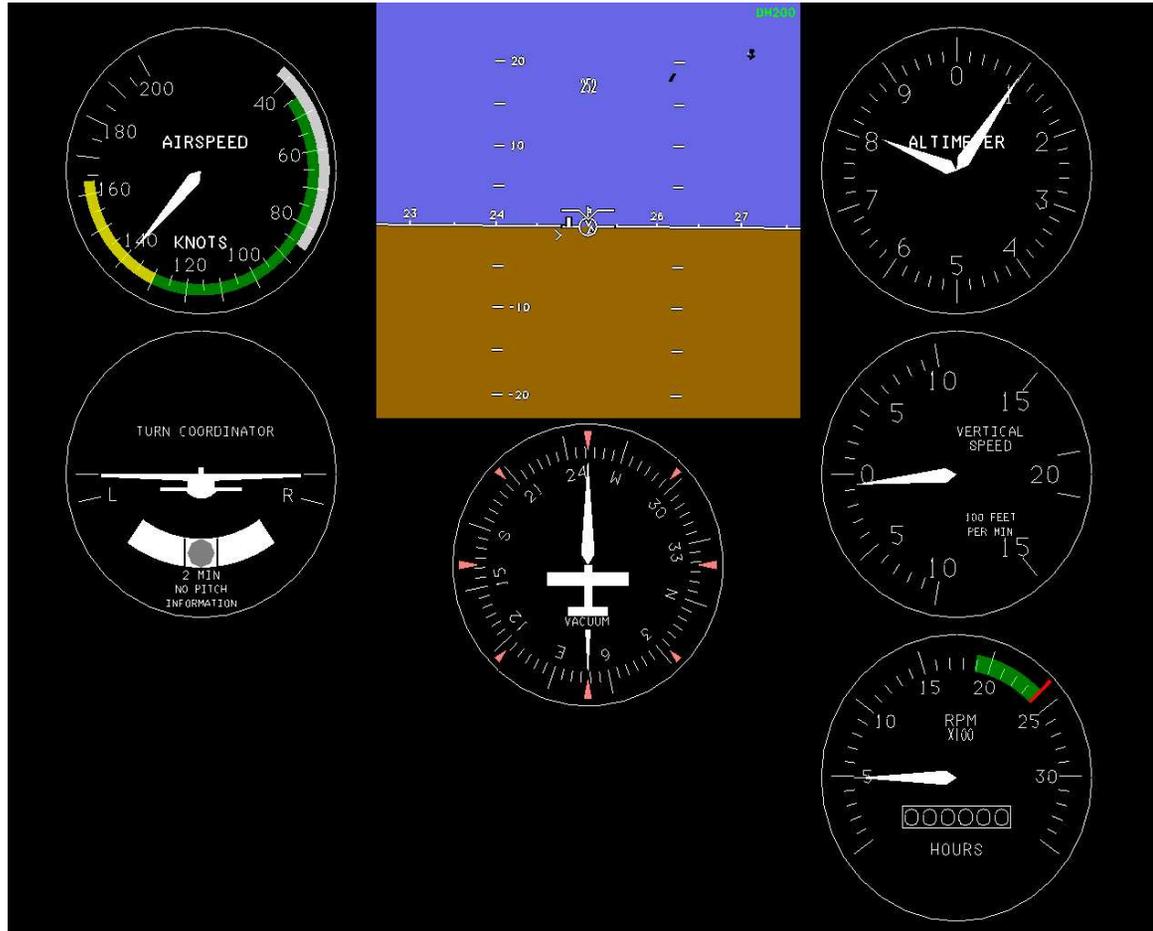


- Basic Six Pack
 - Airspeed, attitude, altitude, heading, and vertical speed indicators, turn/bank coordinator
- Engine RPM

EAI Display



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- Velocity vector with sideslip flag and acceleration caret
- Replace AI with horizon line, pitch grid, roll scale with sideslip wedge and a digital heading

SVS Display



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- Fixed FOV=50 , DEM= 3 arc-sec , Elevation Based Texturing

Scenarios



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- **Evaluation pilots were asked to continue flight from Visual Meteorological Conditions (VMC) into Instrument Meteorological Conditions (IMC) while performing a series of 4 basic precision maneuvers at 6500 MSL**
 1. Continue Straight/Level flight at 100 kt, heading 020 and maintain 6500
 2. Execute a level 180° turn, Maintain airspeed and altitude
 3. Descent (straight) 1000 ft and level-off, Maintain airspeed
 4. Climb (straight) 1000 ft at 80 kt and level-off

- **Out-of-window visibility was linearly reduced from 20 (VMC) to 3 miles (IMC) in 3 minutes**

- **Each scenarios was about 5 minutes long**

- **No approaches or landings were conducted in this experiment**

Asheville, North Carolina



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Pilots and Equipment



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- **All 17 evaluation pilots were GA pilots with following qualification:**
 - Private pilot, single engine land rating, with no additional instrument training beyond private pilot license
 - Each pilot's aeronautical experience was less than 400 hours, average value was 112 hours

- **Scenario training and familiarization with GAWS was provided.**

- **FAA Practical Test Standards (PTS) for Private Pilot License (PPL):**
 - Airspeed within 10 kt
 - Altitude within 100 ft
 - Heading within 10°
 - Roll/bank within 10°

- **After the training session pilots had to perform at or better than PTS level for PPL during VFR standardization maneuvers**

Measurements and Data Recording



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- **Quantitative Data**
 - Relevant pilot/vehicle performance variables and pilot control inputs
 - Physiological data

- **Qualitative Data**
 - Human factors questionnaires after each scenario
 - Exit interviews after each session

Definition of Non-Dimensional Errors



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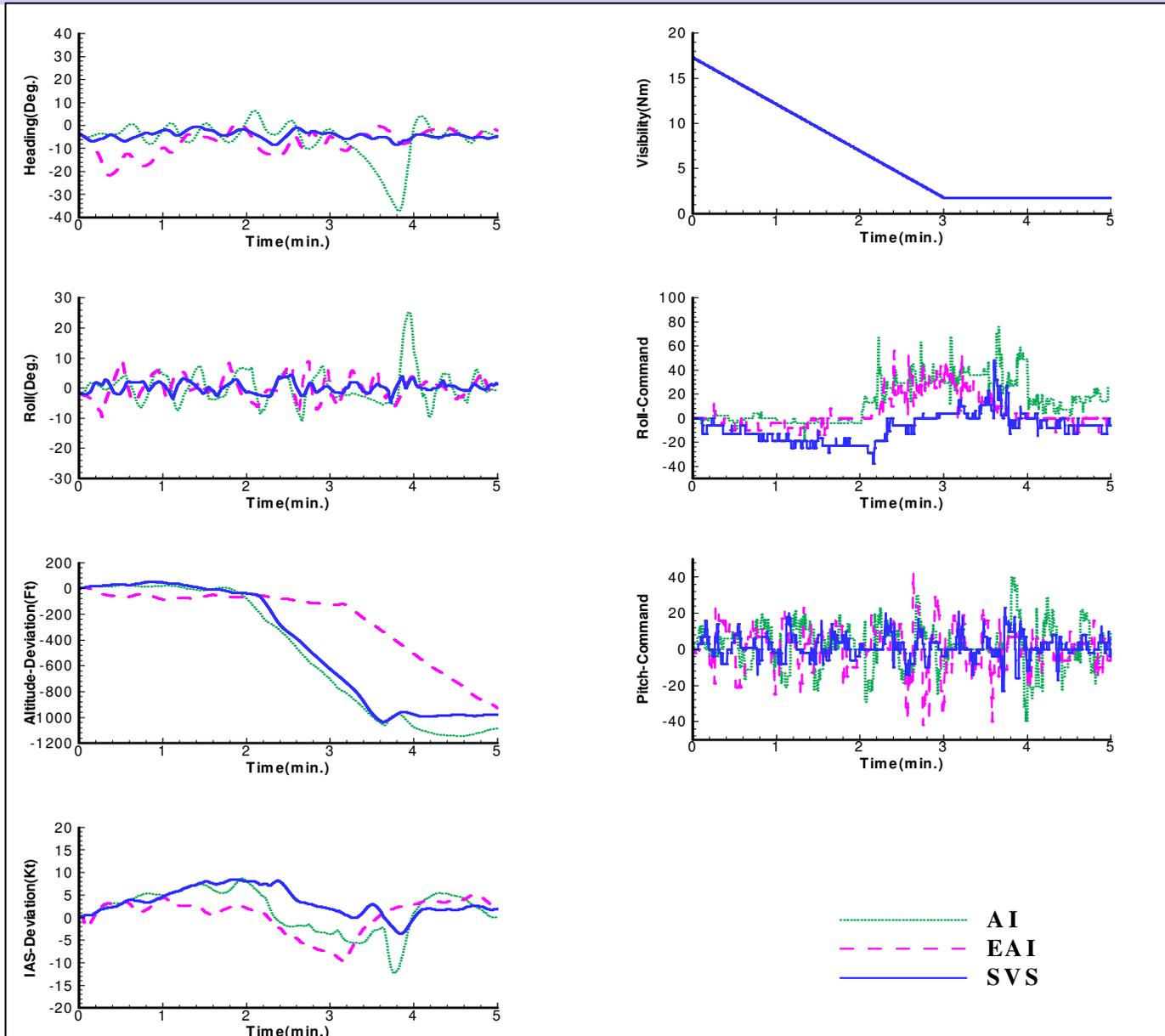
- Errors of measured variables were defined as:

$$E = (\text{actual value} - \text{assigned value})$$

A Typical Time History of Primary Variables for a Pilot during Descent



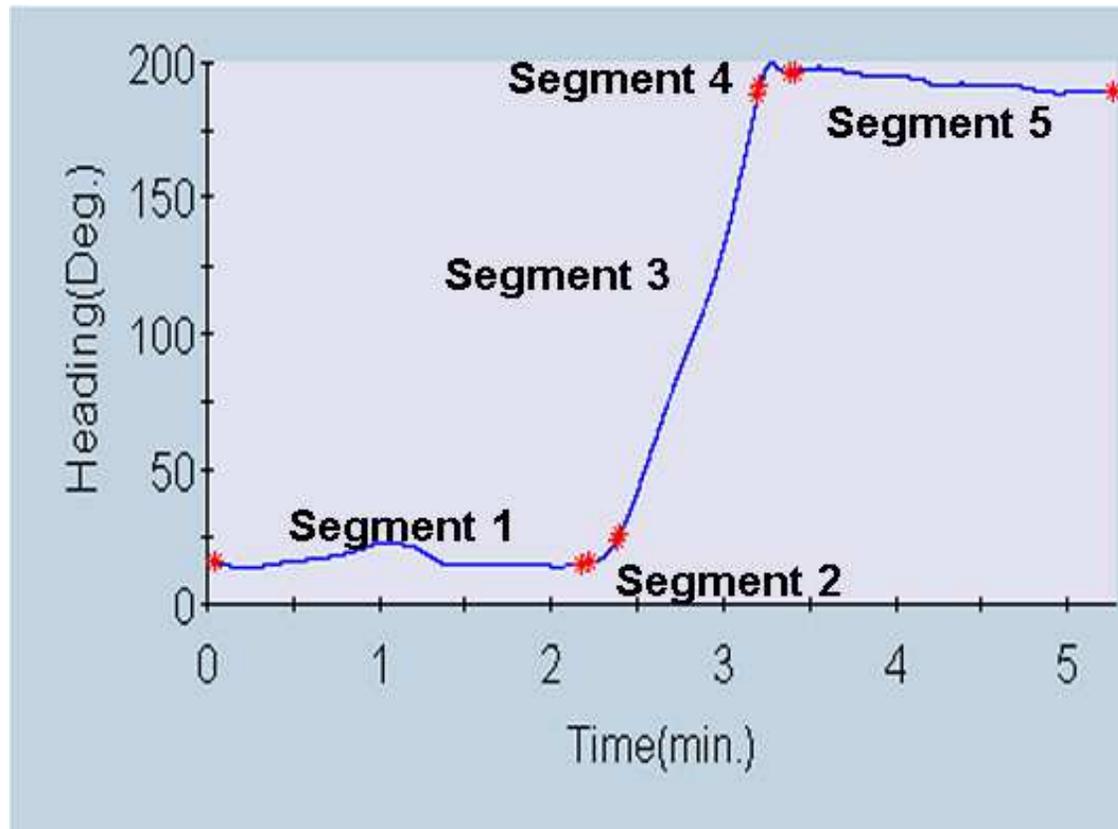
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Segmentation of a Scenario



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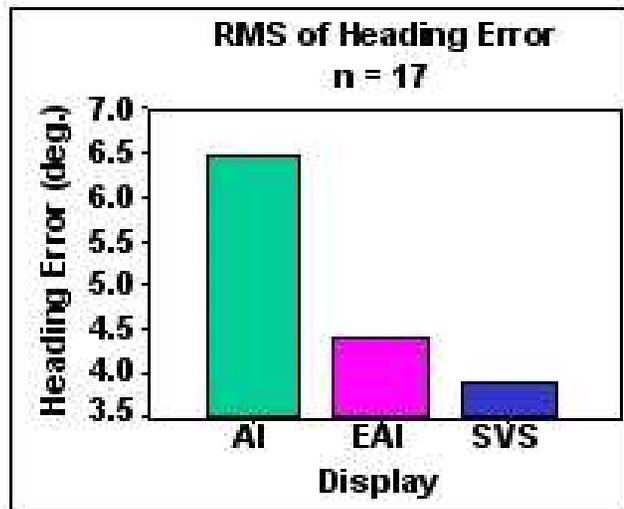


Quantitative Results, Pilot Performance

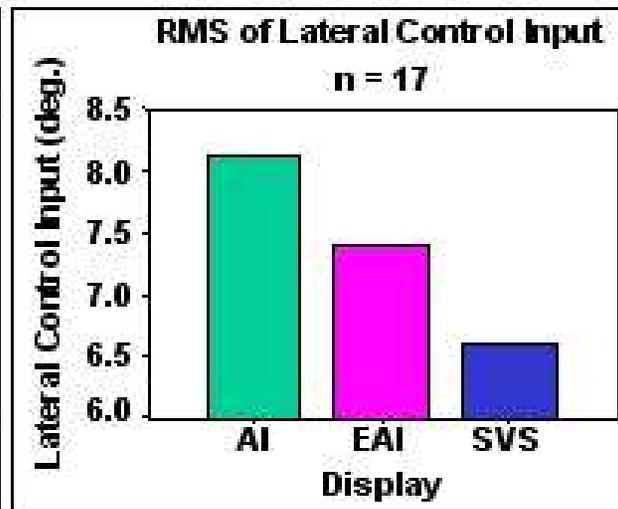


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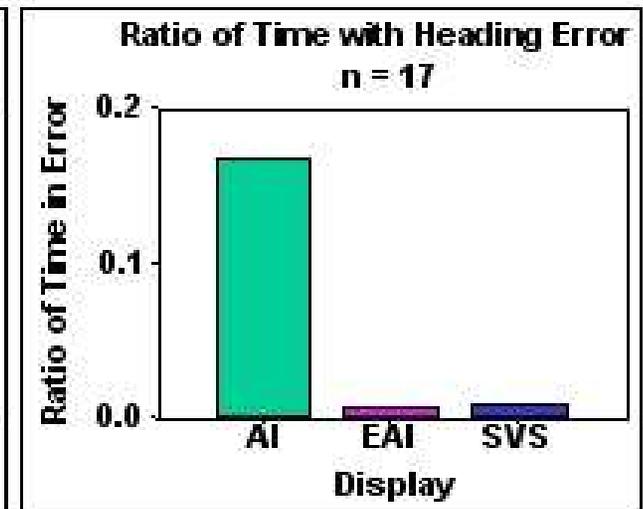
Scenario 3, Straight Descent and Level-off



Statistically Significant



Statistically Significant



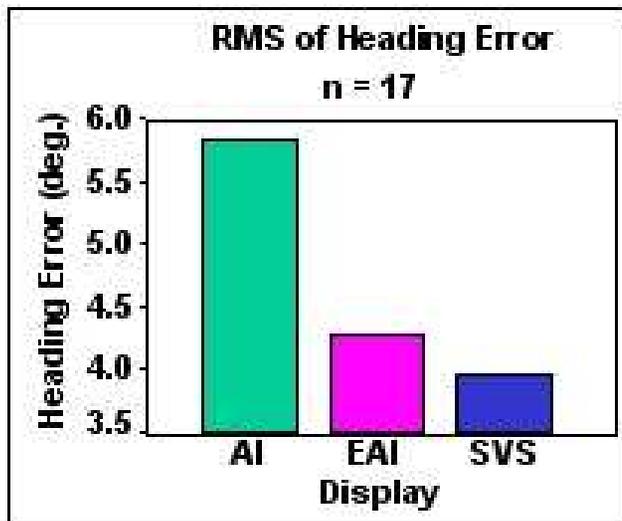
Statistically Significant

Quantitative Results, Pilot Performance

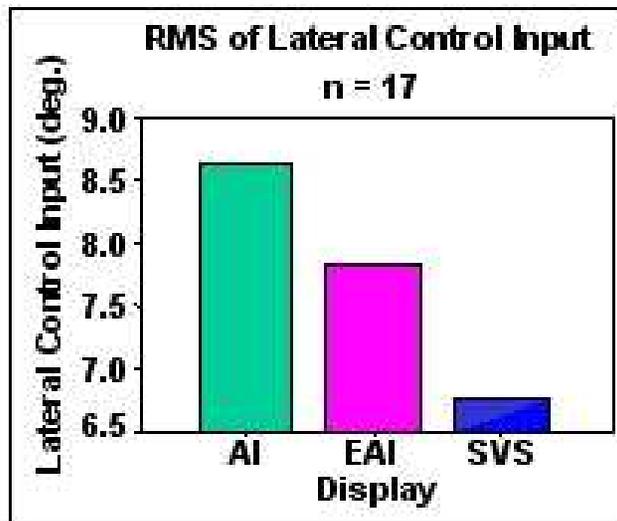


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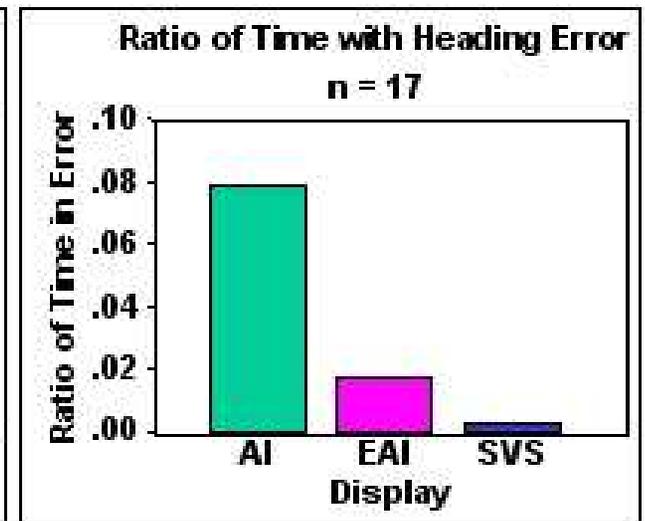
Scenario 4, Straight Climb and Level-off



Statistically Significant



Statistically Not Significant

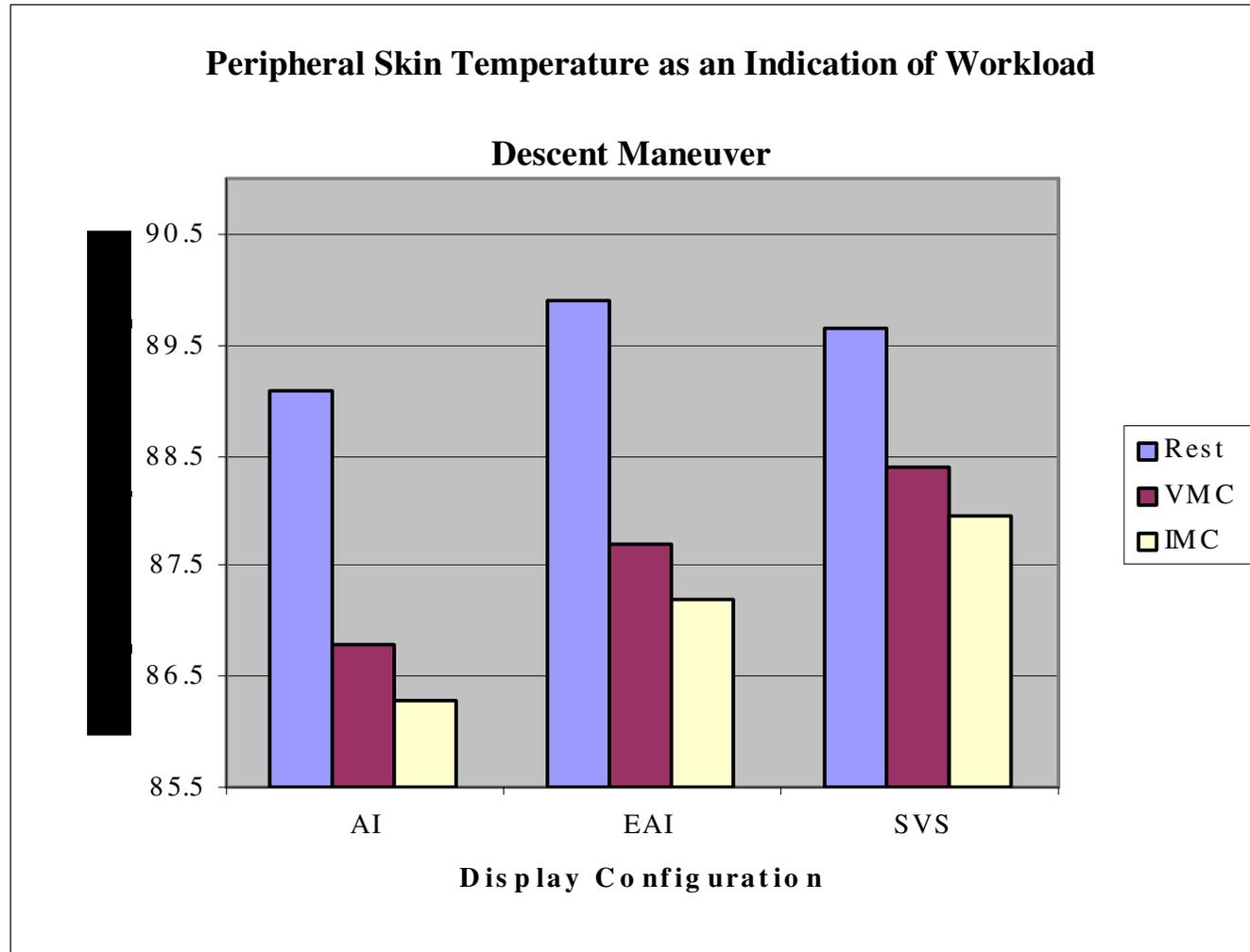


Statistically Significant



Quantitative Results, Physiological Measures

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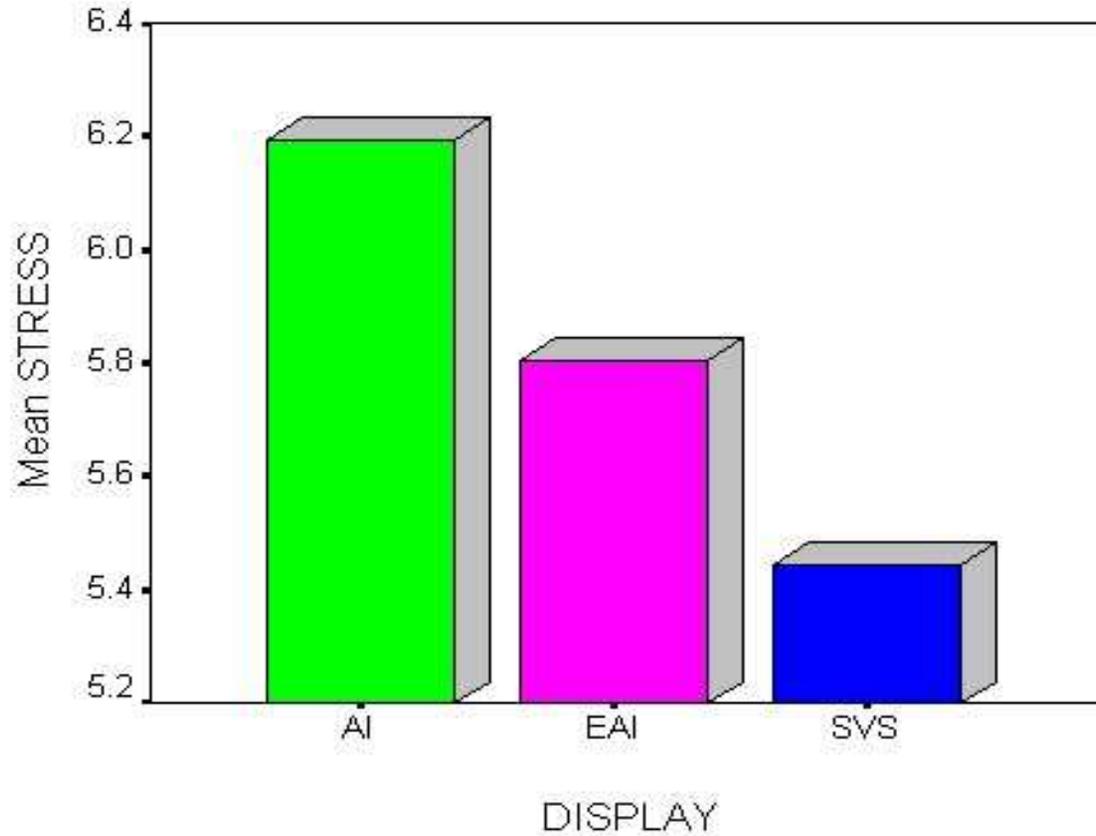
Statistically Not Significant



Qualitative Results, Response to Questioners

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Stress and Arousal Checklist (SACL)



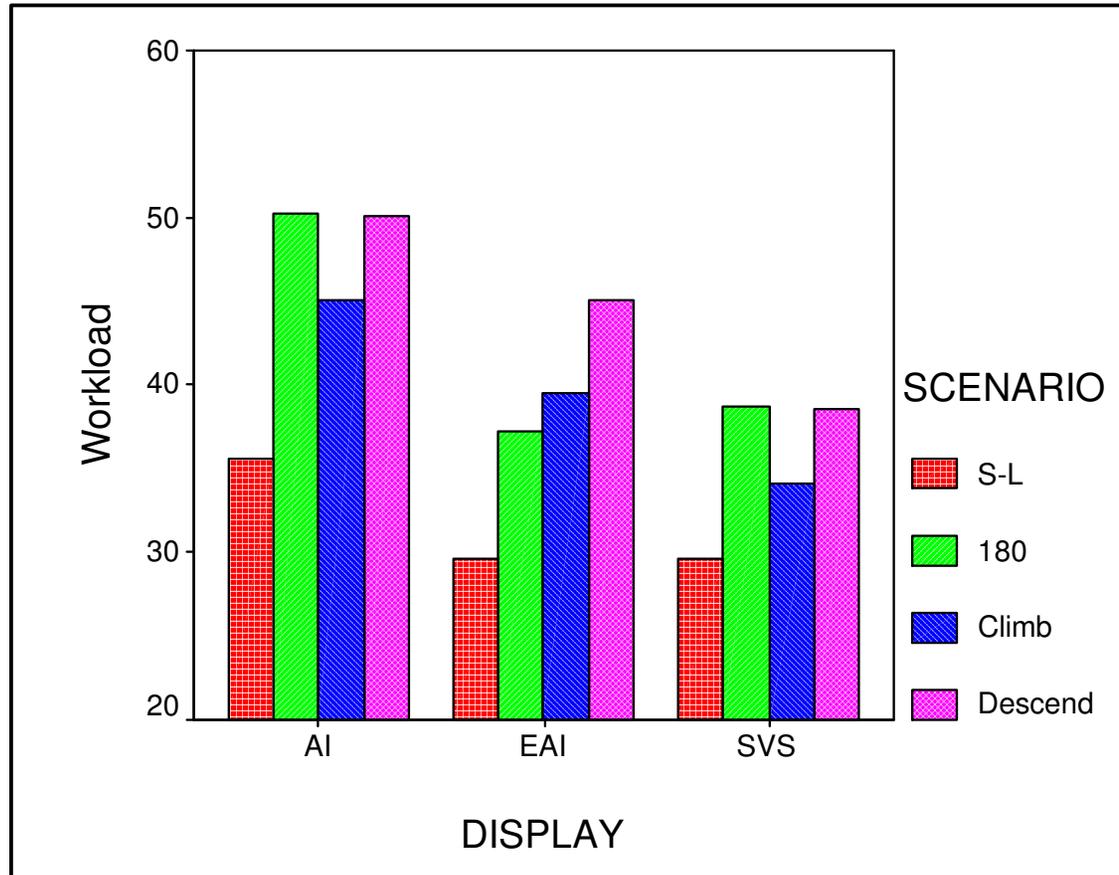
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Qualitative Results, Response to Questioners

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TLX Work Load

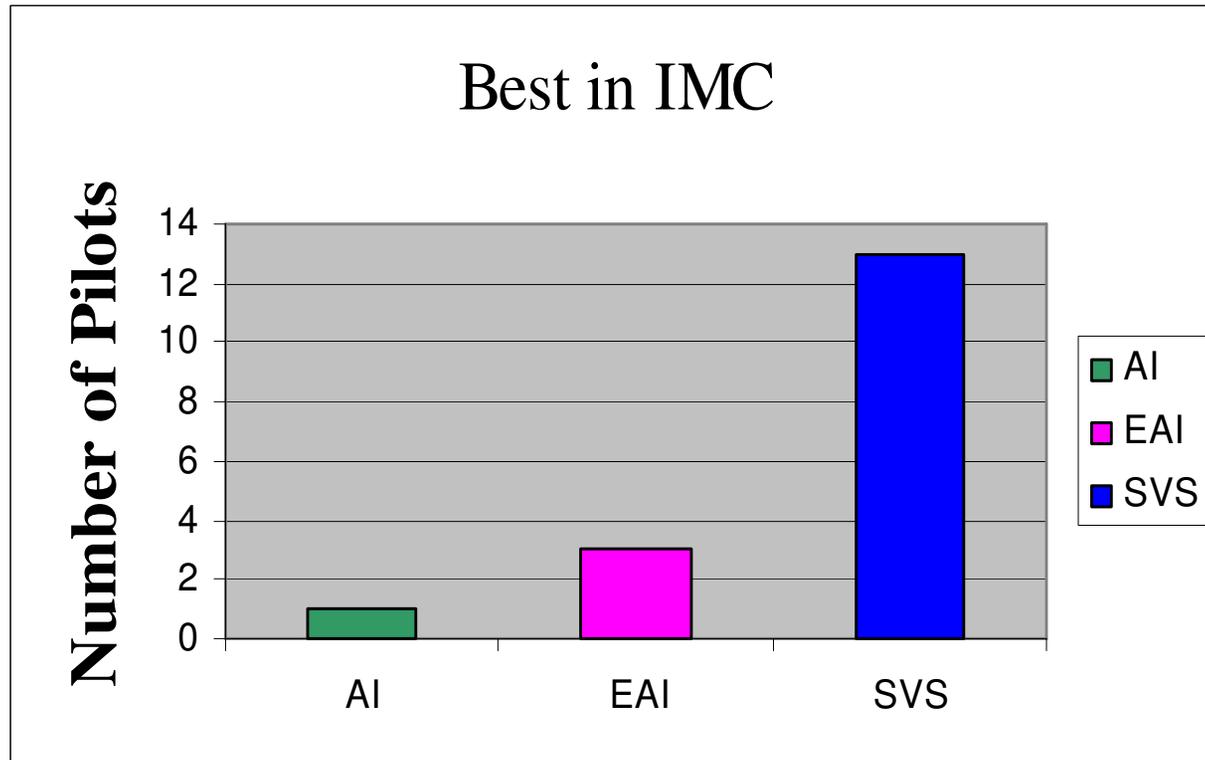


Statistically Significant for Scenarios 3 and 4



Qualitative Results, Response to Questioners

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Question:

Which of the three display concepts that you have used today was the most helpful flying in IMC?

Summary



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- **No LVLOC occurred with any of displays tested**
 - No spatial disorientation (SD)
- **Some cases of loss of SA occurred when pilots were using AI display**
- **In all 4 scenarios, the trend for best to worst performance was typically (not all trends were statistically significant):**
 1. SVS
 2. EAI
 3. AI
- **TLX Workload was significantly higher for the AI display, while the lower workload with the SVS display was not statistically different from the EAI**

Backup Slides

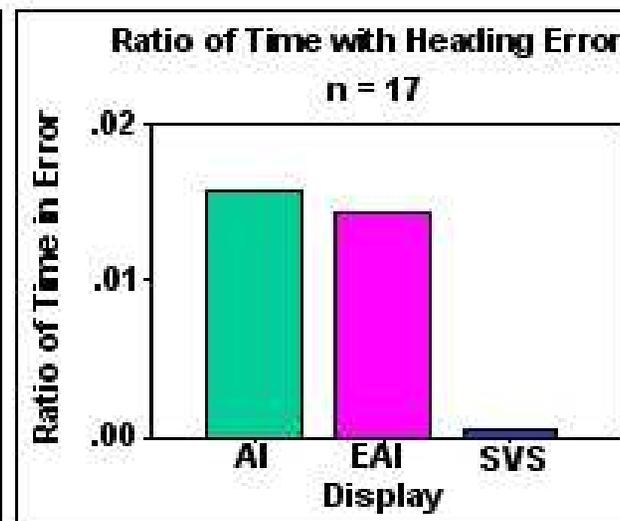
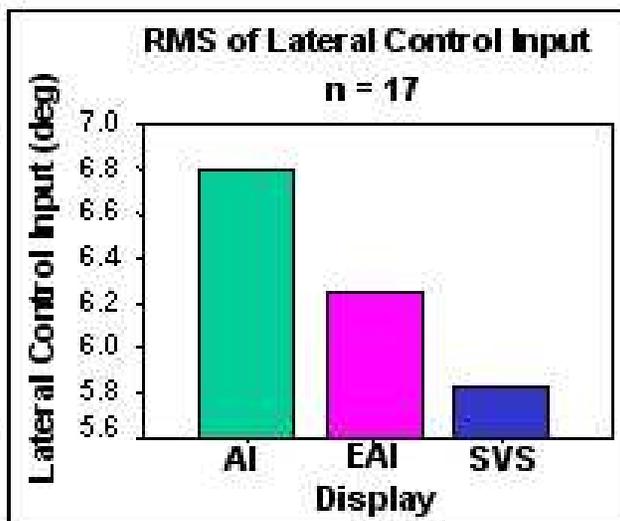
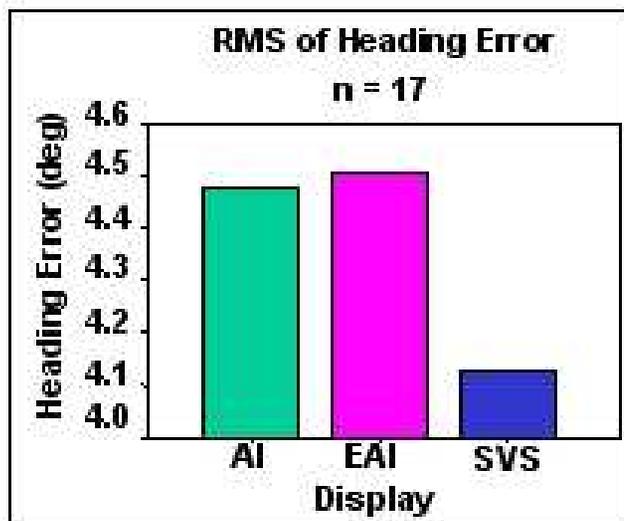


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Quantitative Results, Pilot Performance



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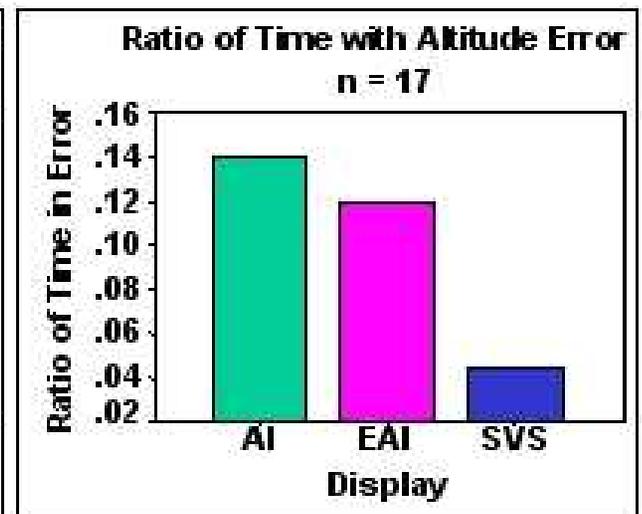
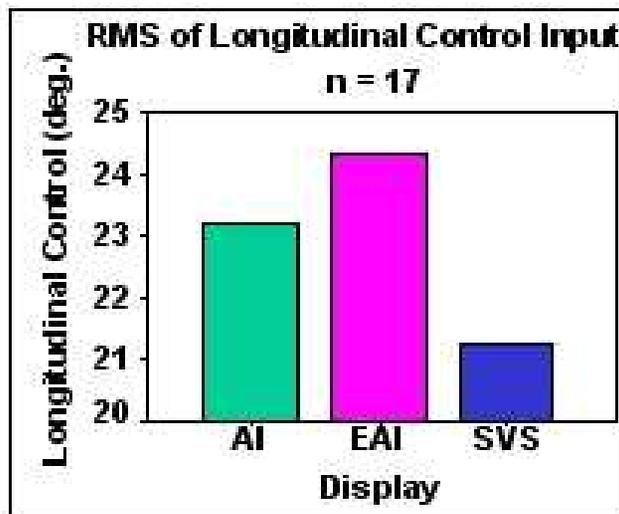
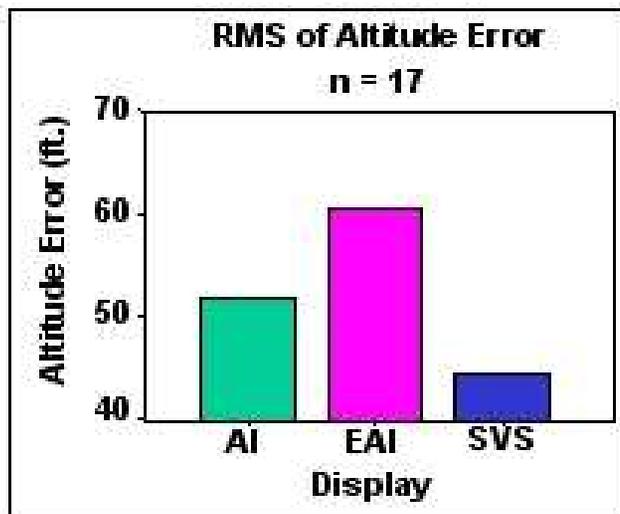


Scenario 1, Straight/Level

Quantitative Results, Pilot Performance

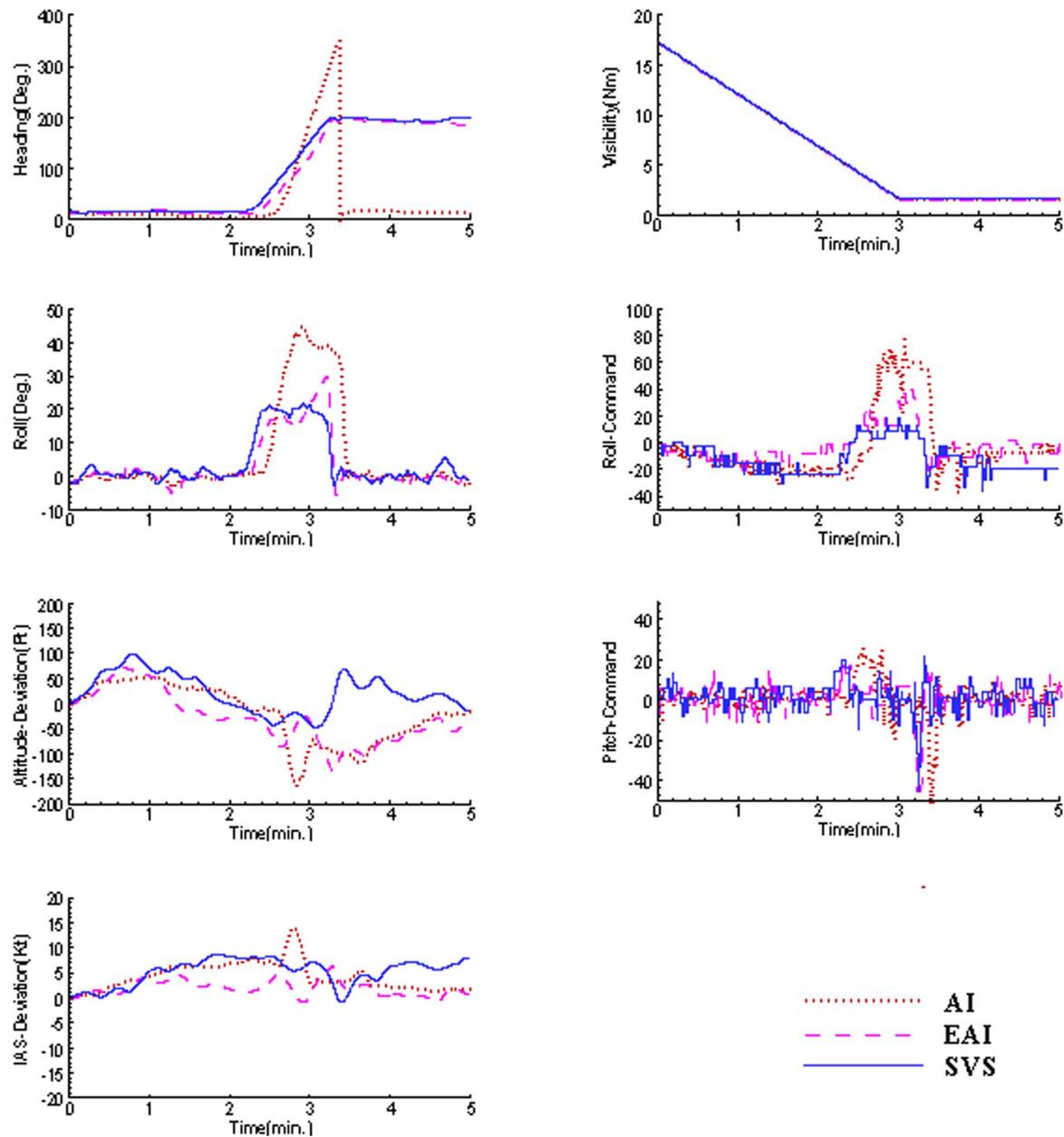


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Scenario 2, Level 180 degree Turn

A Typical Time History of Primary Variables for a Pilot during 180 Degree Turn





Qualitative Results, Response to Questioners

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