Decision-making in flight with different convective weather information sources:

Preliminary Results from the Langley CoWS Experiment (COnvective Weather Sources)

Jim Chamberlain
Crew Systems & Operations Branch

Kara Latorella
Crew/Vehicle Integration Branch

NASA Langley Research Center

Presented at the NASA Weather Accident Prevention Workshop~ 2001 ~ Chamberlain & Latorella

Outline

- CoWS Experimental Apparatus Development
  - Ground Station
  - B200 Aircraft
  - Airborne System
- CoWS Experiment
  - Experimental Conditions & Objectives
  - Procedures
  - Preliminary Results
  - Conclusions
  - The Future of CoWS

Experimental Apparatus

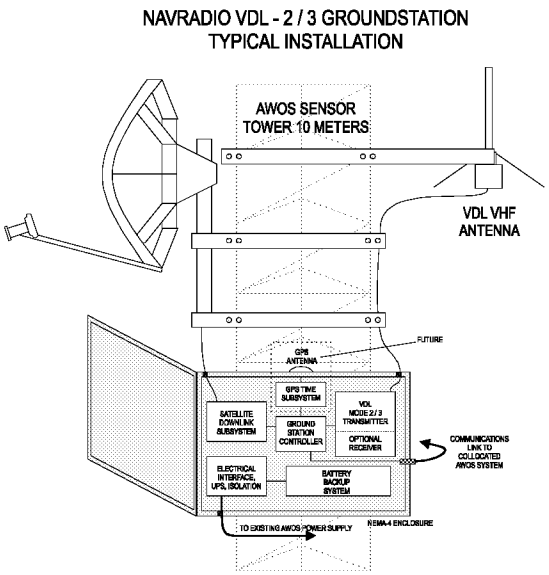
Approach

Use CRA-developed, removable tethered-display AWIN system in B200

Apparatus

- Honeywell CRA AWIN ground stations
- Langley B200 Super King Air
- Honeywell CRA tethered AWIN system

Ground Infrastructure



Typical Honeywell CRA

AWIN Ground Station

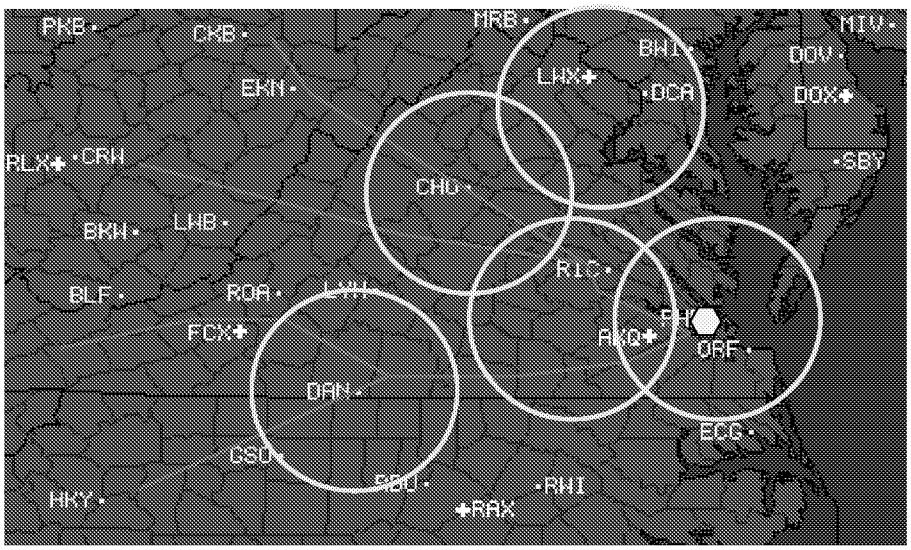
- Satcom antenna & receiver
- Processor & power supply
- VDL transmitter & antenna

Ruggedized, Compact, Self-Contained

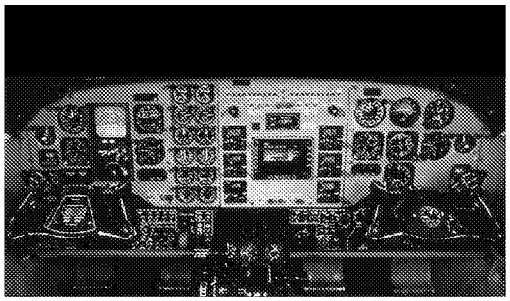
AWIN Receiver/Processor at RTI/Hampton can record Wx

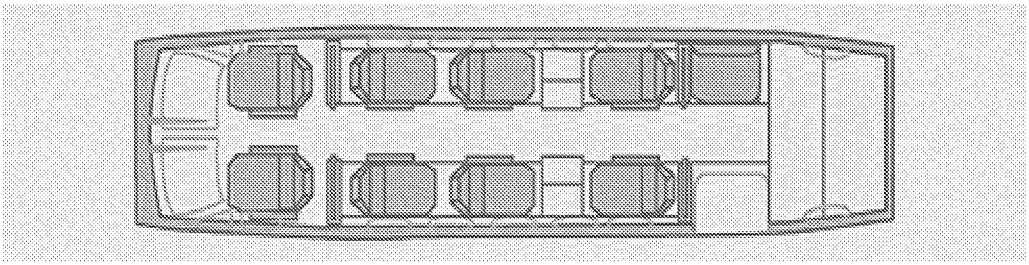
Test Range

- Five ground stations, 40nm radius
- Four destinations & flight paths

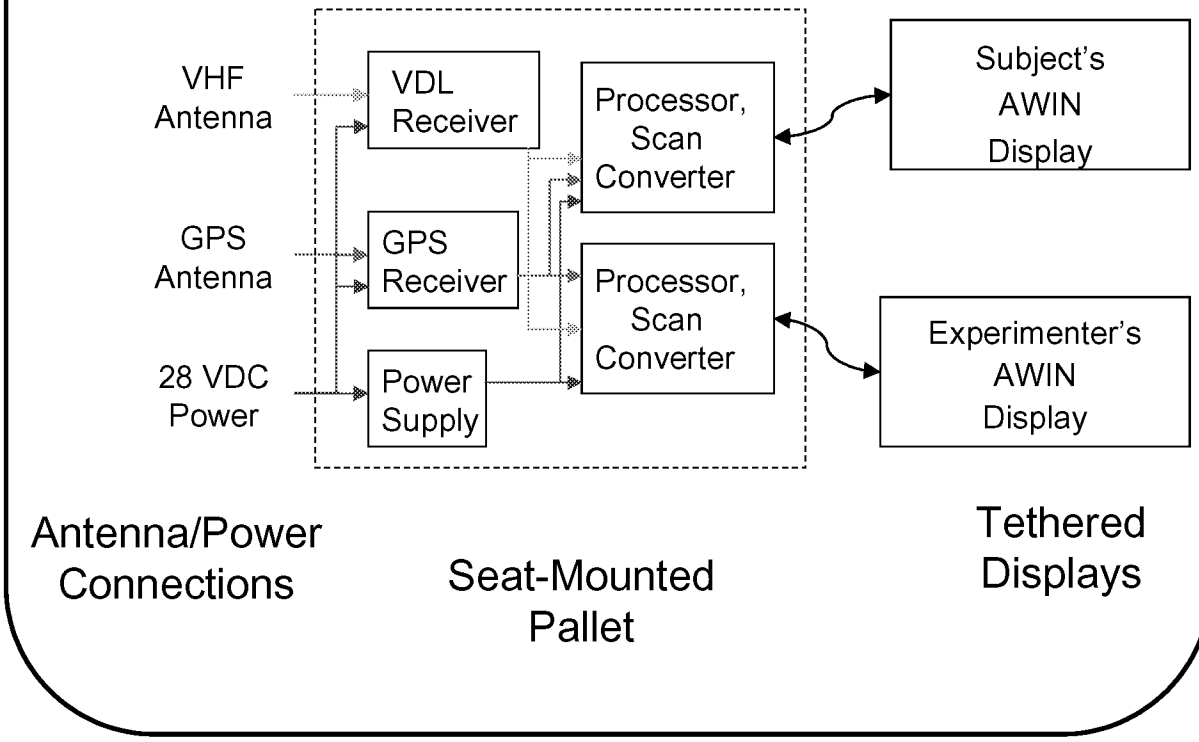


B200 Super King Air

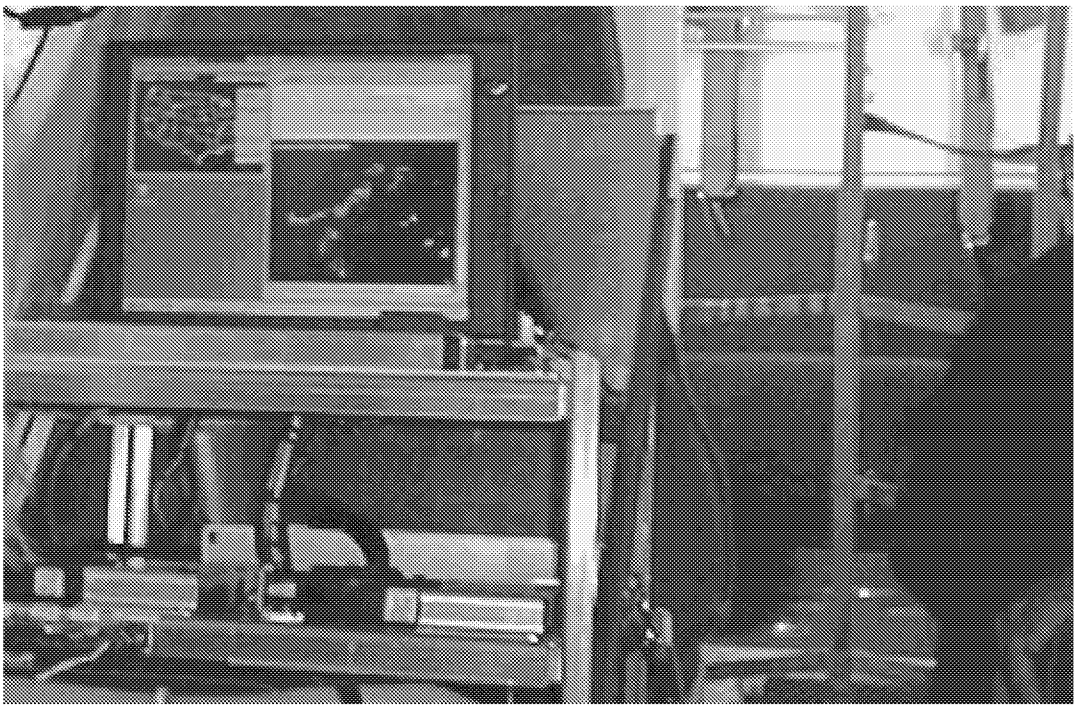




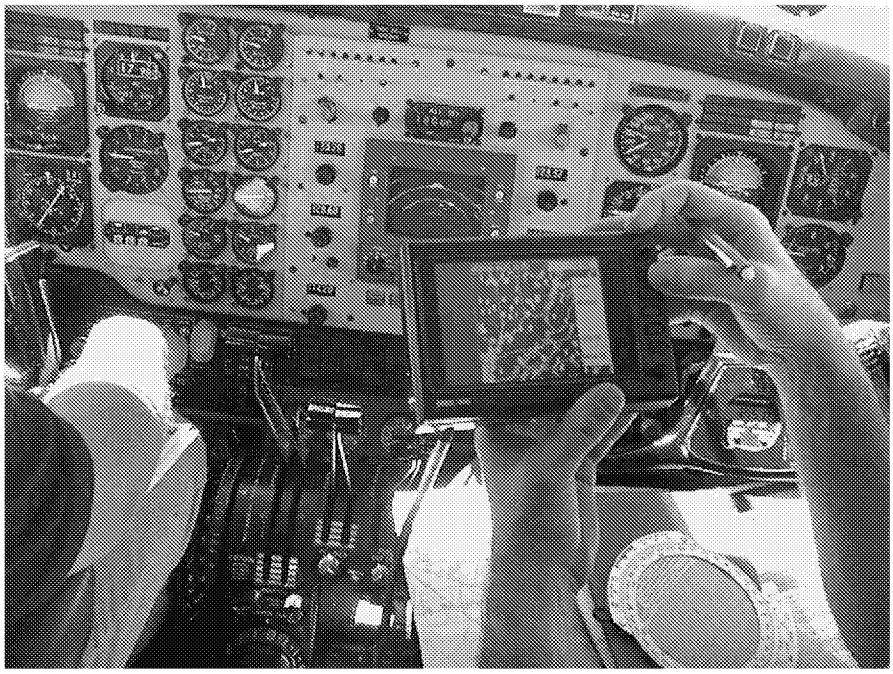
AWIN Architecture



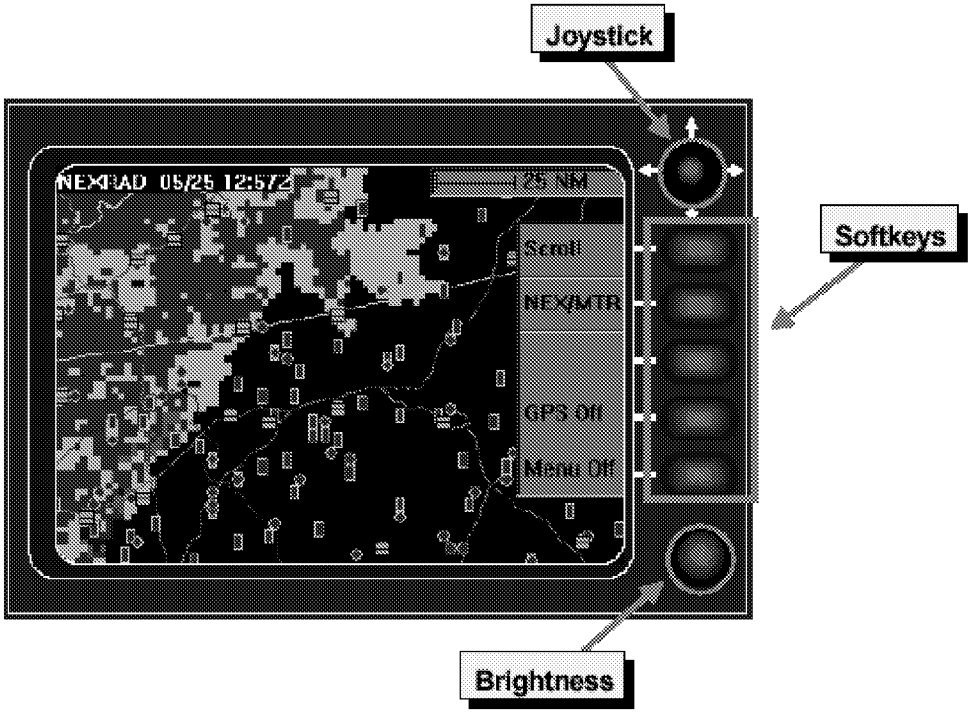
Equipment Pallet in the B200



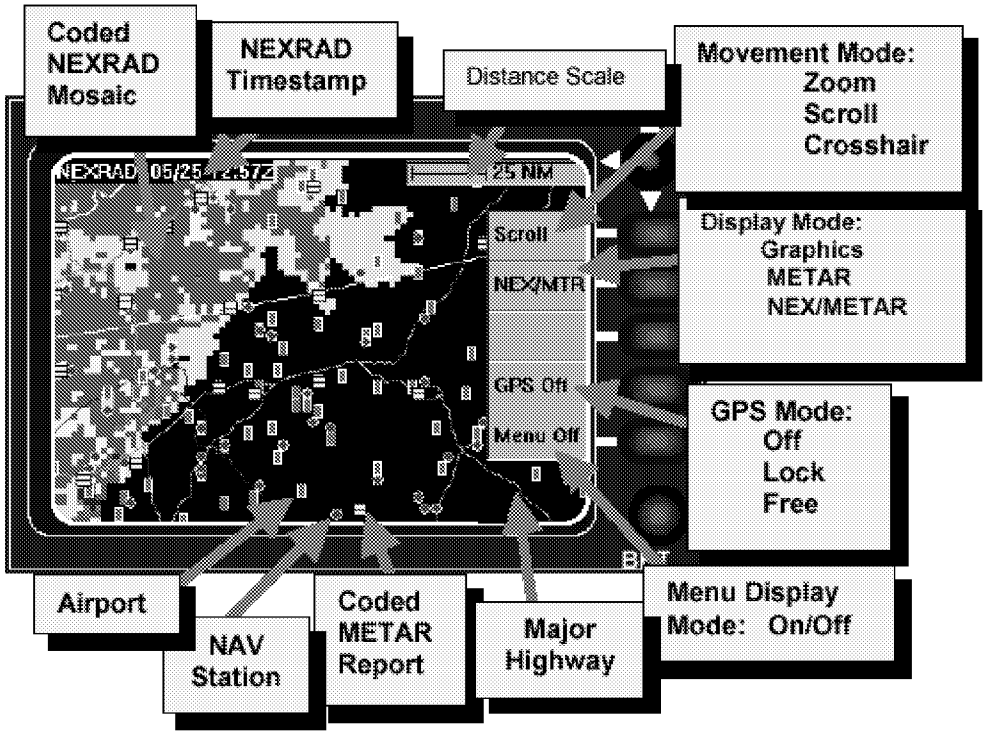
AWIN Display in B200



AWIN Input Devices



AWIN Display Elements



CoWS Experiment

- Motivation
- Objectives

- Participants
- Experimental Design
- Experimental Protocol

- Preliminary Results
- Conclusions

Experimental Motivation

- General aviation accident statistics
- The hazards of convective weather
- Aviation Weather INformation (AWIN) systems

Experimental Objectives

How do GA pilots use
different weather information sources
when approaching convective weather situations?

- Sources
  - Conventional aural (ATC, HIWAS, Flight watch),
  - Out-the-window visual scene + aural
  - AWIN display + aural
- Effects
  - Confidence, Workload, Information Sufficiency
  - *Situation awareness, decision quality, individual differences*

Participants

- 8 Check-out, 12 Experimental, 6 reported here
- Subject Requirements
  - local GA pilots
  - instrument rating
  - 50-1000 cross-country or 250 - 1000 total flight-hours
  - Has not worked for a scheduled air-carrier in prior year
  - Has not participated in the RTI FISDL simulation study
- Subjects clustered by cross-country hours
  - low (135), medium (379), high (738) *(p<.0001)*
  - 4 teams of 3 subjects (one of each level)

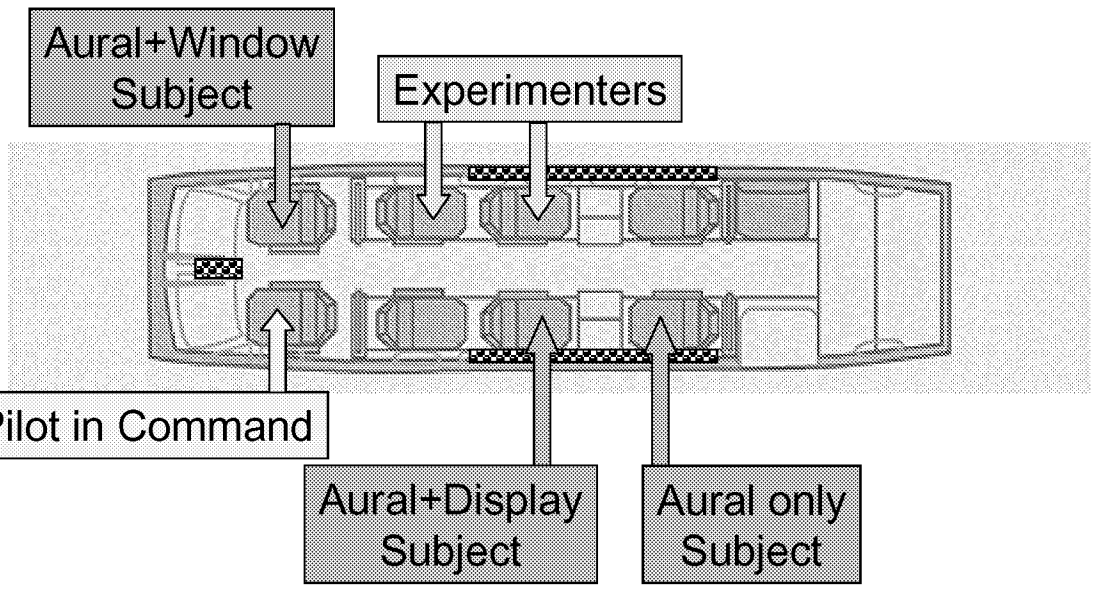
Inflight Experimental Conditions

- For each flight

	"IMC"	VMC
Without AWIN	**Aural Cues**	**Aural + Window**
With AWIN	**Aural + Display**	**Aural + Display + Window**

- For each subject (cue set condition)
  - 6 "proximity" observations of confidence
  - 1 observation of workload & information sufficiency
- Three flights per team

Experimental Conditions in B200



= Opaque covers for side windows & onboard radar

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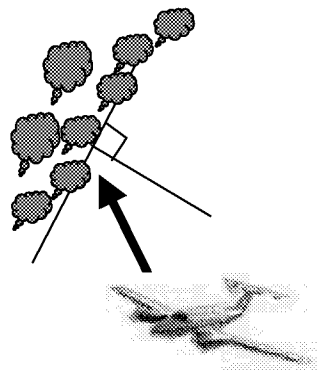
Scenarios

- Mission Motivations
  - wedding, graduation, job interview
- Flight Scenario
  - Flying IFR, but in VMC
  - NASA to destination, 1.5-2 hours
  - Convective fronts, moderate^{+} intensity
  - Approach front ~45^{o}



- Aircraft Performance ~ small single-engine
  - Cruising Altitude = 14000', above haze layer
  - Cruising Speed ~ 170kts true airspeed
  - not radar-equipped, no deicing equipment
  - not pressurized, but does have Oxygen

Scenario Flight Paths

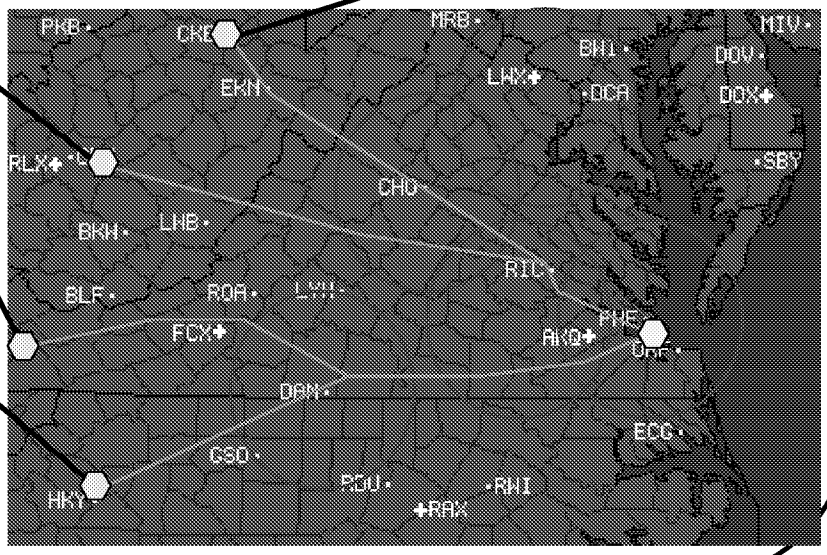
- Test range: 5 ground stations, 40nm radius
- Four destinations & flight paths

Charleston, WV

Clarksburg, WV

Abingdon, VA

Hickory, NC

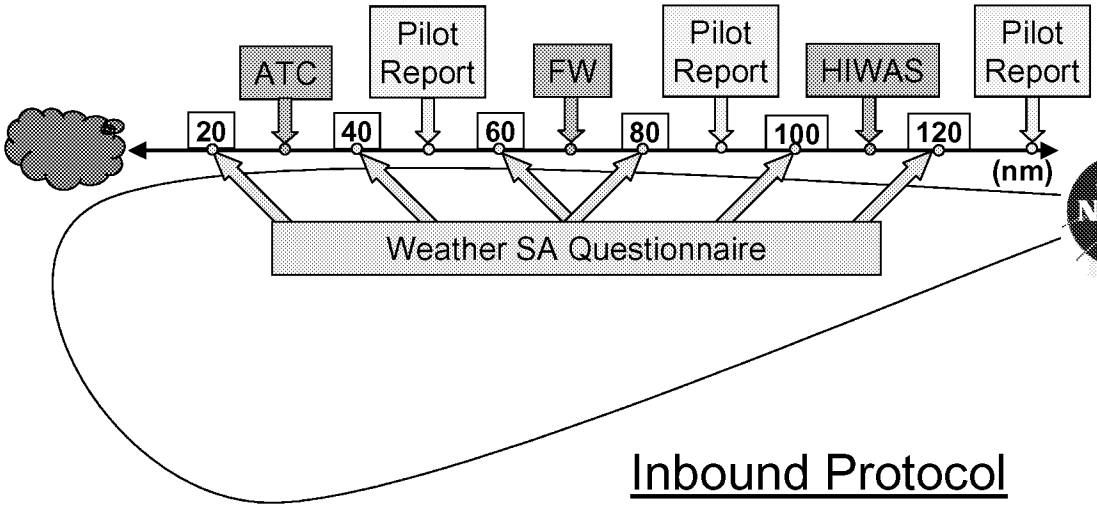


Experimental Protocol

- Preflight
  - Introduction to CoWS, assignment to conditions
  - Mission, route, and regional information briefing
  - Weather briefing
    - » *DUATS text & graphics,*
    - » *Audiotaped FSS briefing, twice*
    - » *Review*
    - » *Preflight SA questionnaire*
  - Intervening tasks
    - » *AWIN training, personality, risk, weather knowledge test*
- Flight
  - Outbound phase
  - Inbound phase
- Debriefing

In-flight Protocol

Outbound Protocol

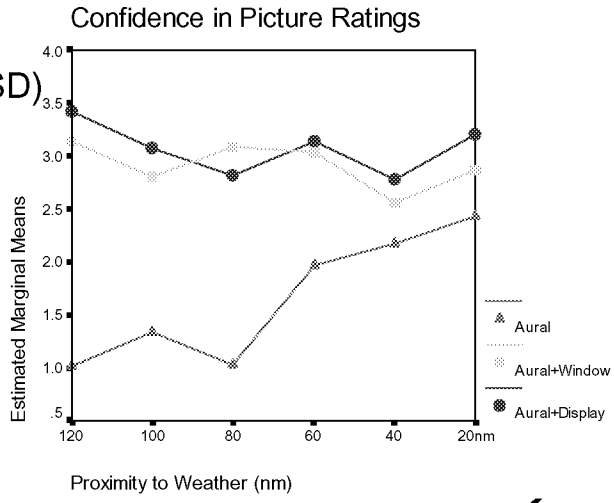


Inbound Protocol

- *Draw position & weather*
- *Inbound questionnaire*
- *Usability questionnaire*

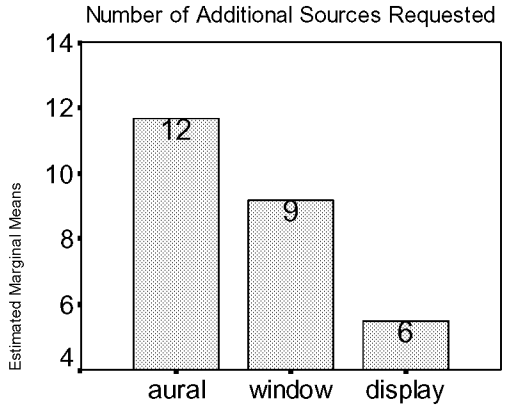
Preliminary Results - Confidence

- Summary of ANOVA
  - Cue set ~ Highly significant (*p<.0001*)
  - Proximity to weather ~ Not significant (*p=.691*)
  - Cue set X Proximity ~ Not significant (*p=.275*)
- Pair-wise comparisons (LSD)
  - Aural *v.* Window (*p<.0001*)
  - Aural *v.* Display (*p<.0001*)
  - Window *v.* Display (*p = .491*)



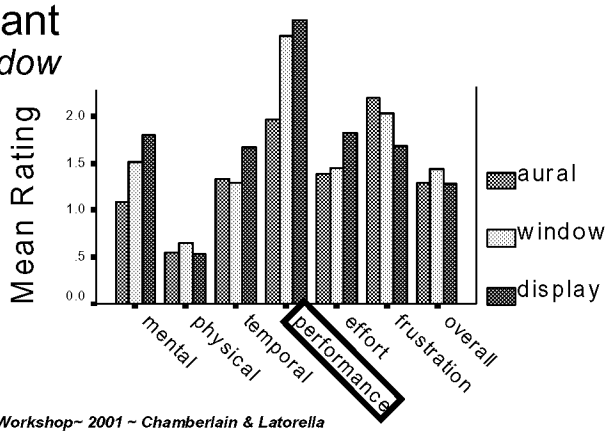
Preliminary Results - Information Sufficiency

- Summary of ANOVA
  - Cue set ~ Significant (*p<.061*)
- Pair-wise comparisons (LSD)
  - Aural *v.* Display *(p=.009)*
  - Window *v.* Display *(p=.094*
  - Aural *v.* Window *(p=.242)*



Preliminary Results - Workload

- Summary of ANOVA
  - Performance Rating
    - » *Cue set ~ Significant (p<.091)*
    - » *Subjects ~ Significant (p<.03)*
  - Physical Rating
    - » *Subjects ~ Significant (p<.02)*
- Pair-wise cue set comparisons (LSD)
  - Performance ~ not significant
    - » *Trend: Aural < Display, Window*
- *Subjects did report that workload was similar to that when actually flying.*



Conclusions

- Reliance on AWIN in IMC and close to hazards
  - As confident as visuals - possibly over-confident
  - Less likely to seek information from ground sources
  - Perceived performance similar to window condition
  - *Data is at least 6 minutes old, was as old as 30 minutes*

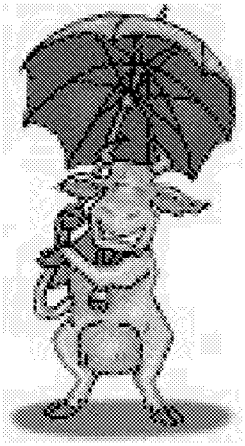
- Implications: design, training, & use guidelines
  - » ***RTCA FIS-B Minimum Aviation System Performance Standards.***
    - » Document: DO-267
    - » note added to indicate need for age v. timestamp
  - » ***Need more salient indication or alerting***

The Future of CoWS

- Other Experimental Results
  - Full data set - Effects of cues on inflight SA & decisions
    - » *proximity to convective frontal weather*
  - Effects of individual characteristics
    - » *personality, risk tolerance, weather knowledge*
  - Effects of weather graphics on preflight SA
- Usability Assessment of an available AWIN system
- Canned cues for subsequent comparative analysis
  - Onboard weather radar, AWIN radar mosaic,
  - Pilot observations, ground sources (ATC,FW, FSS),
  - HIWAS, video of external view.

CoWS

Convective Weather Sources



Questions?