CONTROL/DISPLAY TRADE-OFF STUDY FOR SINGLE-PILOT INSTRUMENT FLIGHT RULE OPERATIONS

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CONTROL DISPLAY TRADE-OFF STUDY FOR SINGLE PILOT IFR OPERATIONS

Objectives

- Determine minimum autopilot functions and displays required to keep pilot workload at an acceptable level
- Determine what constitutes an acceptable level of workload
- Identify critical tasks
- Suggest specific experiments required to refine conclusions

Examples of critical tasks are: revised clearances in terminal area, transition from cruise to terminal area, last minute holding clearances, requirements to read charts and tune radios in turbulence or under poor lightning conditions.

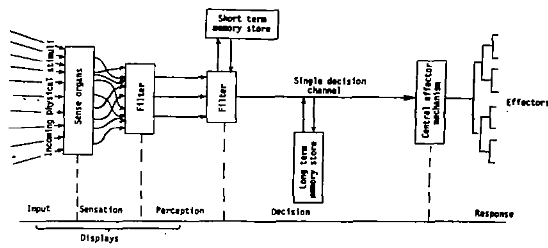
Specific experiments are discussed in more detail later in this presentation.

KEY ELEMENTS OF SPIFR PILOT WORKLOAD

- Mental Orientation
- Instrument Scan
- Mental Distractions
  - Malfunctioning Equipment
  - Weather (Clouds, Turb, Ice)
  - Communications

The key elements of SPIFR pilot workload are listed above. Later experimental work has revealed that the pilot interface with the controls and displays should be included in this list.

KEY ELEMENTS OF HUMAN INFORMATION PROCESSING



- Human operator can attend to only one thing at a time
- Simultaneous inputs held in short term memory
- Scanning behavior is guided by long term memory

A model is required to provide the basis for a systematic analysis of the single pilot IFR workload problem. The above model was used as a starting point (ref. 1). Examples of incoming physical stimuli are:

- Avionics and autopilot control settings
- Instrument readings
- Clearances from ATC
- Weather data
- Navigation information
  - Approach plates, enroute charts, STARs, SIDS
- Turbulence
- Malfunctions

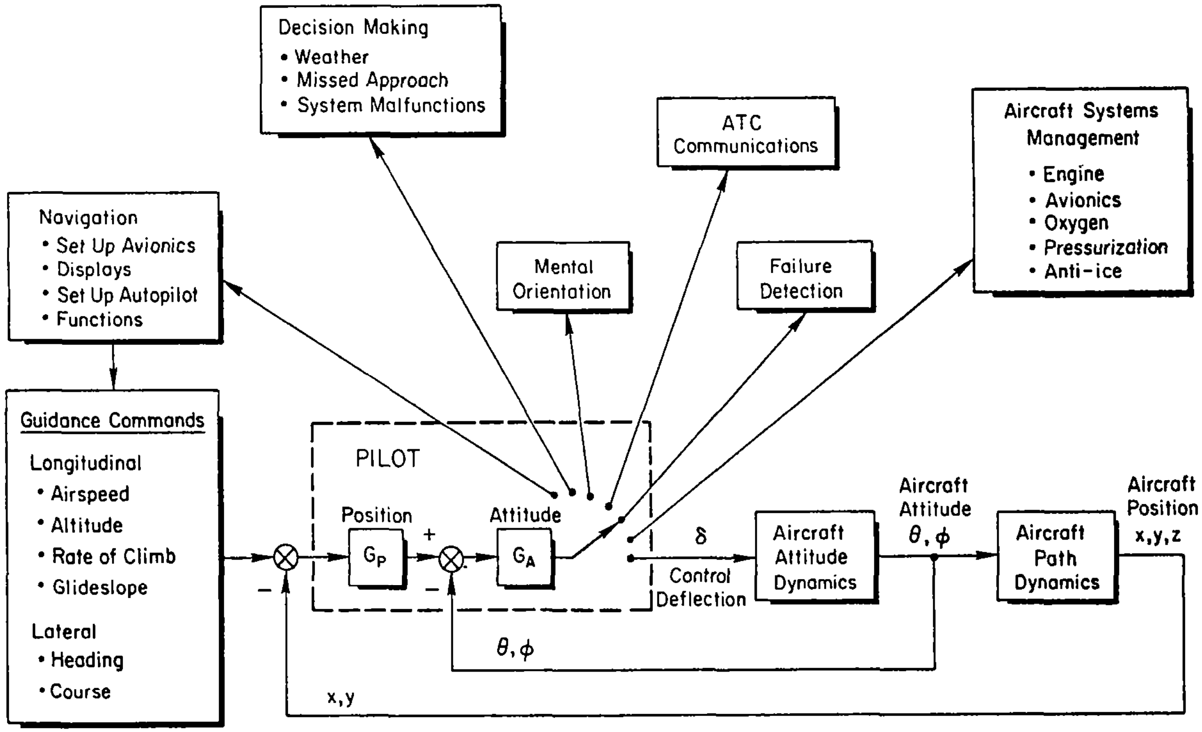
The following observations can be made about short term memory

- It is prone to errors which arise as a result of false hypotheses.
- All but one piece of incoming data (physical stimuli) are stored in short term memory. Note that the data is "filtered" by the human operator to delete useless information.
- Much of the data in short term memory is wiped out if an overridingly important piece of information is received.
- One objective of the displays and controls should be to reduce the requirements on short term memory.

The following observations can be made about the long term memory.

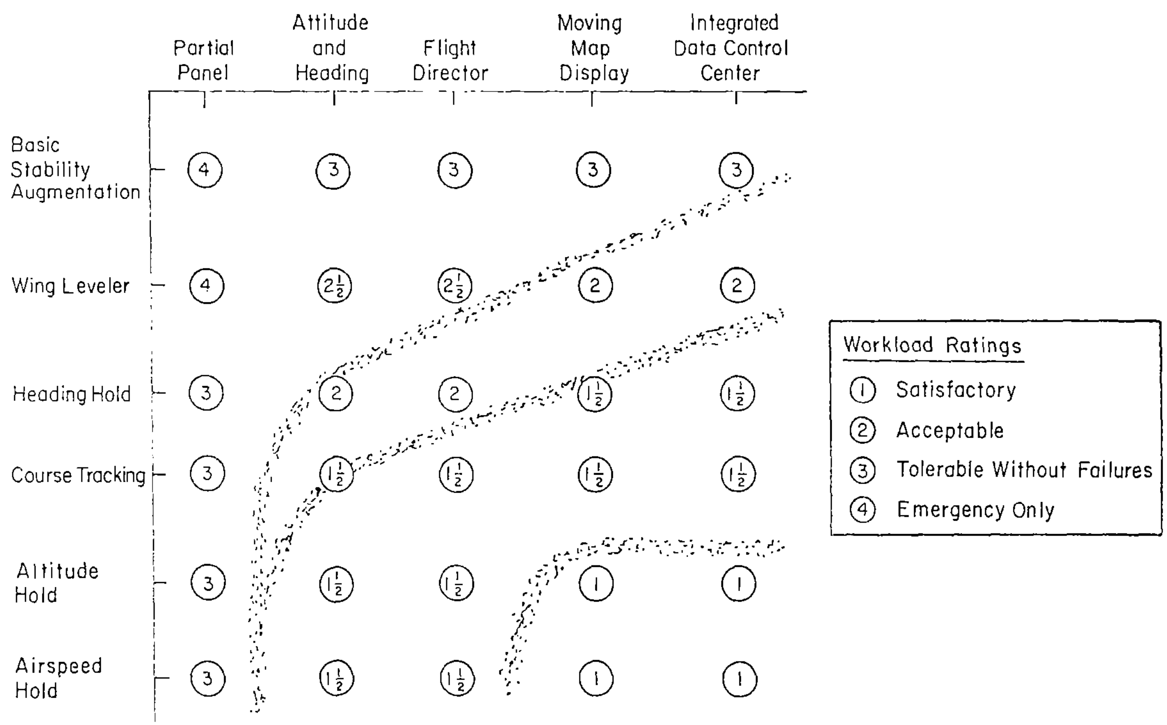
- It sets priorities on which items in short term memory get acted upon.
- It sets the scanning behavior.
- Its efficiency is strongly associated with IFR proficiency.

PILOT WORKLOAD MODEL FOR SPIFR OPERATION



This SPIFR pilot model was developed using the basic concepts of the more general model on the previous slide. Of particular importance is the fundamental concept that a human operator can only process one item of information at a time. The resulting "switching behavior" in the model is presumed to be guided by long term memory. Efficiency of the long term memory is a function of training and recent proficiency.

PILOT WORKLOAD RATINGS FOR TRANSITION FROM ENROUTE CRUISE TO FINAL APPROACH FIX IN HIGH DENSITY TERMINAL AREA



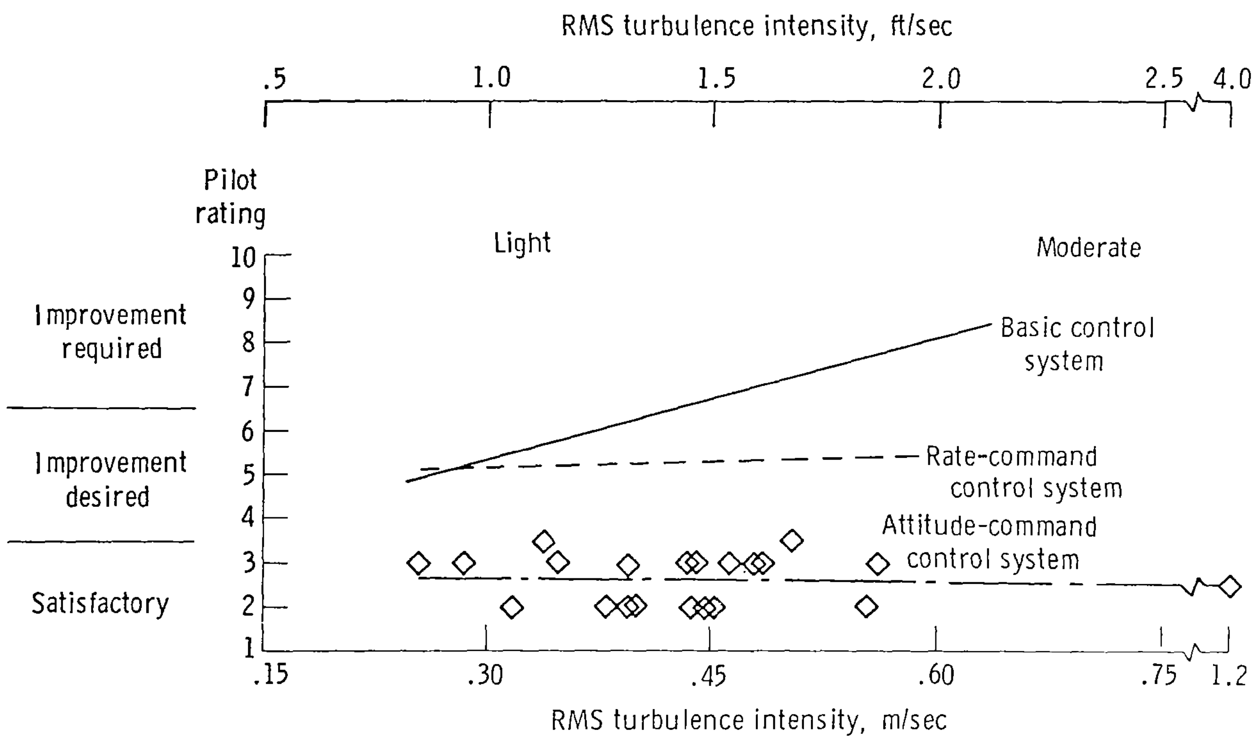
This is an example of how the results of the control/display trade-off are expected to look. The experimental matrix shall be based on this format.

DATA FOR CONTROL/DISPLAY TRADE-OFF

- Simulator Studies at LRC
  - Autopilot Complexity
  - ATAS
  - Follow me box
- Flight Tests at Dryden
- Demonstration Advanced Avionics System
- Princeton Navion
- Pilot Jury
- Aviation Safety Reporting System

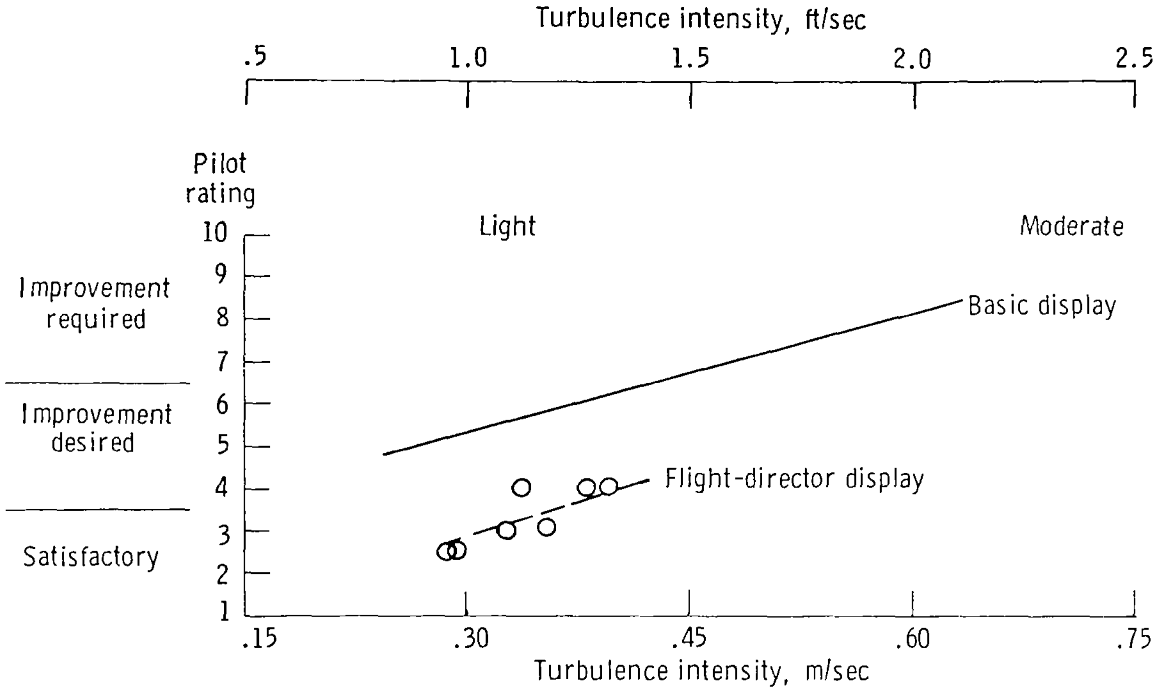
Data which exists and is being utilized in the current research is summarized above. The "pilot jury" was a concept wherein several pilots would hypothesize a level of workload for a given IFR scenario. Since the workshop, we have been fortunate enough to have been able to conduct a flight test program at NASA Langley in lieu of the pilot jury.

ILS APPROACH TASK — EFFECT OF AUGMENTATION



These are typical results from an in-flight experiment conducted at NASA Dryden Flight Research Center. They show that pitch attitude augmentation significantly improves pilot opinion for an instrument task in turbulence.

ILS APPROACH TASK — NO AUGMENTATION



These results from the NASA Dryden experiment show that displays are not as effective as augmentation in improving the piloting task in increasing levels of turbulence.

TENTATIVE CONCLUSIONS TO DATE

- Primary workload relief is derived from basic stability augmentation
- Complex autopilots can induce serious blunders -- Problem seems related to
  - Mind set
  - False hypothesis
  - Pilot interface with autopilot functions
- Need Displays to
  - Enhance positional awareness
  - Minimize likelihood of false hypothesis
- Need Experimental Data
  - Simulation
  - DAAS

An experiment has been conducted at NASA Langley utilizing three aircraft, a simulator, and four pilots. The results of this experiment are currently being analyzed and will be discussed in detail in the final report.

REFERENCE

1. Hurst, Ronald (Ed.): Pilot Error: A Professional Study of Contributory Factors. Crosby, Lockwood, Staples: London, 1976.