SINGLE PILOT IFR PROGRAM OVERVIEW AND STATUS

John D. Shaughnessy
NASA Langley Research Center

ABSTRACT

The history of the General Aviation Single Pilot IFR research program at NASA LaRC was discussed in general terms. The program objective, justification, and technical approach were given. The facilities used to conduct the research were discussed briefly. A general overview of recent accomplishments, present activities and near term plans were given. (This overview is essentially section II of this report.)

SINGLE PILOT INSTRUMENT FLIGHT RULES RESEARCH PROGRAM.

OBJECTIVE: TO PROVIDE A TECHNOLOGY BASE TO ENHANCE SINGLE CREWMAN EFFECTIVENESS AND SAFETY IN FUTURE AIRCRAFT OPERATIONS AND AUTOMATED ATC SYSTEMS THROUGH EXPLOITATION OF MODERN COMPUTERS, CONTROLS, AND DISPLAYS.

JUSTIFICATION: GA IFR OPERATIONS ARE FORECASTED TO INCREASE FROM 18.5 MILLION IN 1981 TO 30.4 MILLION BY 1993, AND SPIFR ACCIDENTS DUE TO "PILOT ERROR" ARE FORECASTED TO INCREASE FROM ABOUT 150 PER YEAR TO 250 PER YEAR IN THE SAME TIME PERIOD. RESEARCH INTO MORE EFFICIENT METHODS FOR TRANSFERRING WEATHER INFORMATION TO THE PILOT, IMPROVING THE PILOT'S INTERFACE WITH AUTOMATION AND AIRCRAFT CONTROL, AND DEVELOPING NEW PRIMARY COCKPIT DISPLAY FORMATS AND INFORMATION TRANSFER CONCEPTS SHOULD PROVIDE A TECHNOLOGY BASE THAT WILL ALLOW FOR SAFER MORE EFFICIENT SPIFR OPERATIONS.

APPROACH: ANALYTICAL AND EXPERIMENTAL RESEARCH IS BEING CONDUCTED AT LANGLEY, IN INDUSTRY AND AT UNIVERSITIES. AT LaRC, VARIOUS SIMULATORS, AND NASA AIRCRAFT ARE BEING UTILIZED FOR THE EXPERIMENTAL EFFORTS. SINGLE CREWMAN FLIGHT OPERATIONS RESEARCH IS COORDINATED BETWEEN NASA, FAA, DoD & USER/MANUFACTURER ORGANIZATIONS.

SINGLE PILOT INSTRUMENT FLIGHT RESEARCH SIMULATOR

The general aviation (GA) simulator at LaRC has recently been upgraded to provide a valid simulation environment for research in full mission IFR studies. The simulator is constructed around a light twin GA aircraft cabin and is mounted on a two degree-of-freedom motion base (pitch -10° +15°, roll ±16°).

Control inputs in pitch and roll are applied through a standard yoke arrangement. This arrangement is reverse driven by hydraulic actuators in order to feed back aerodynamic control force cues. This allows a realistic simulation of aircraft controller forces in pitch and roll.

An out-the-window visual display is obtained by using a closed circuit TV system and a terrain model board. The system is called the visual landing display system (VLDS). The model board is scaled so as to encompass an area of approximately 2 x 6-1/2 miles. The model includes two airports, country and suburban terrain, and a small city. The model airports are equipped with runway, approach, and sequence flashing lights. Both night and day scenes and various ceilings and visibilities can be simulated.

The GA simulator is equipped with an oculometer. This system provides pilot look point information over an area defined by a pilot's view angle of 40° x 60°.

A high quality full range engine and airstream noise simulation has been developed and installed in the GA simulator. The system can be used to provide both the detrimental and beneficial effects of the real world aircraft noise environment.

The GA simulator incorporates a complete dual radio/ATC communications network capability.

The GA software program includes the simulation of two geographical areas, Atlanta and Washington/Norfolk. The Washington/Norfolk area, for example, encompasses an area approximately 170 x 180 miles. All VOR's and NDB's in the area are programmed with respect to the latitude/longitude, elevation, frequency, and coded identification. Twelve airports were also chosen in this area and all associated navaids with respect to these airports (ILS, LOM, OM, MM, etc) were programmed. All of the twelve airports, and their corresponding navaids, can be oriented to coincide with the VLDS runway.

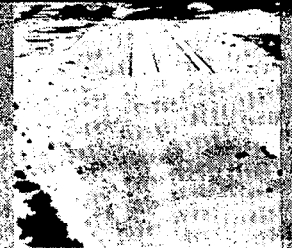
A complete autopilot capability, encompassing the pitch and roll control modes (heading select, altitude select, nav couplers, etc), has been installed on the GA simulator.

The simulator hardware and computer software allows the programming of any single or twin GA aircraft for which the stability derivatives exist. Presently, a Cessna 172 and a Cherokee 180 are programmed on the computer. A Cessna 402 is being developed and should be completed shortly.

GENERAL AVIATION SIMULATION STUDIES OF PROBLEMS IN THE SINGLE PILOT IFR (SPIFR) FLIGHT ENVIRONMENT

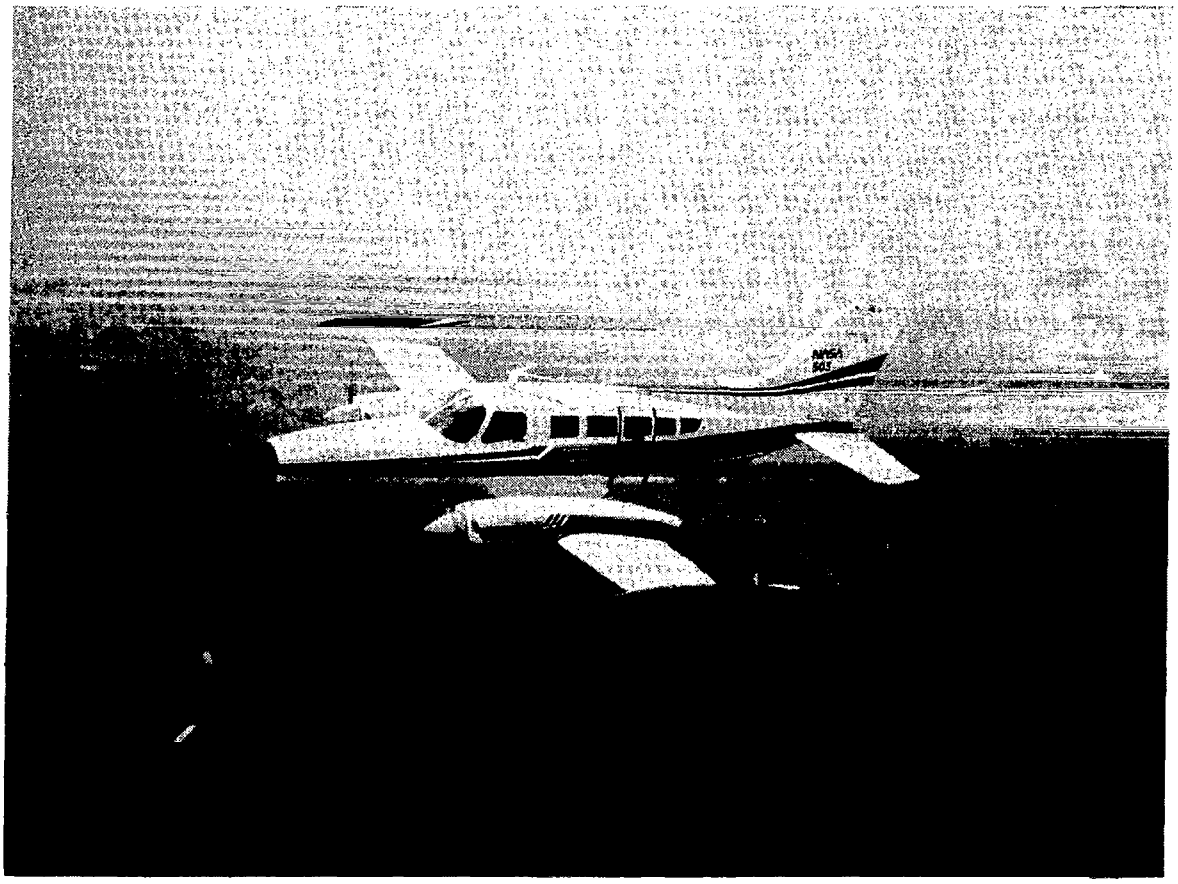
SIMULATOR CAPABILITY

- MOTION BASE
- CONTROL LOADER (YOKE)
- VLDS (VISUAL SCENE)
- SIDE WINDOW VIEW
- OCULOMETER
- ENGINE AND AIRSTREAM
- ATC STATIONS/COMMUNICATIONS
- ATLANTA OR NORFOLK/WASHINGTON AREA NAV AIDS
- AUTOPILOT
- VARIETY OF AIRPLANE TYPES



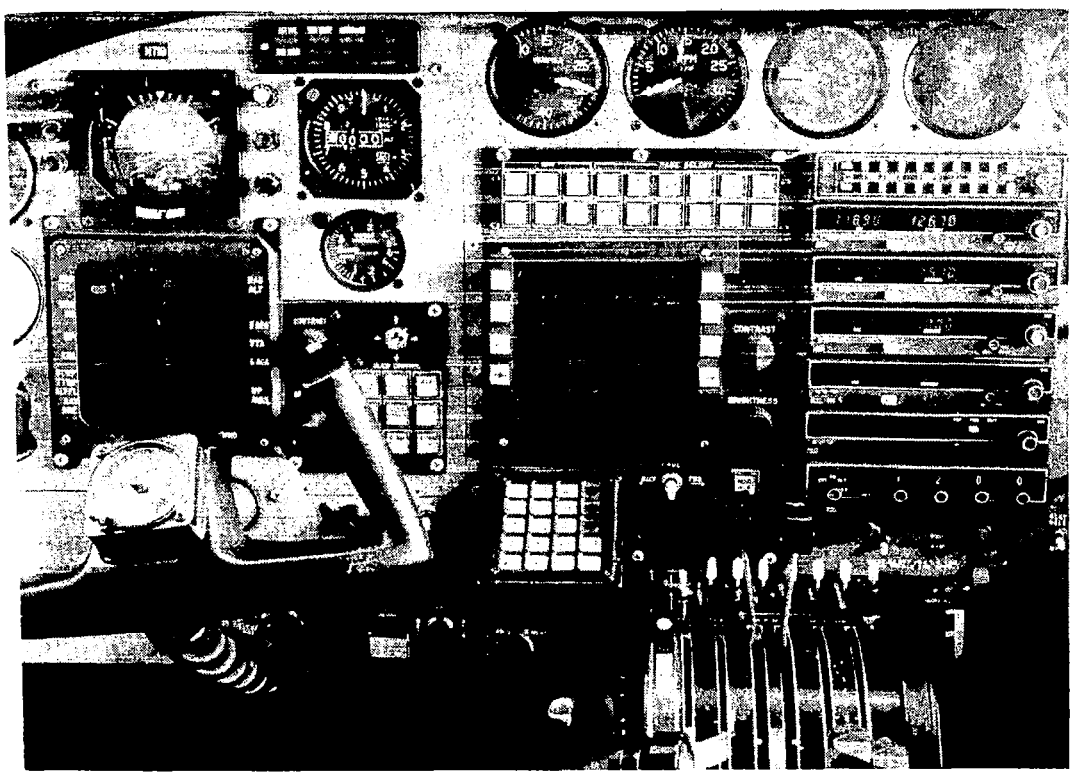
Cessna 402B

The NASA LaRC Cessna 402B is a research aircraft used in the Single Pilot Flight Management program. The instrument panel and nose baggage compartment have been modified to accept the DAAS research system displays and computer. The C402B is a turbo-charged twin engine airplane with performance characteristics typical of the general aviation aircraft used for business and corporate transportation.



DAAS

The Digital Advanced Avionics System (DAAS) is a highly integrated flight control system consisting of a central integrated data/control console (IDCC) moving map display CRT, digital autopilot/flight director, navigation radios, airplane configuration monitoring/warning, and built-in test logic. After manual entry of navaid and waypoint data, the system automatically tunes navigation receivers and draws a moving map display. The autopilot/flight director can be commanded to follow the programmed flight path. Airplane operating checklists can be called up on the IDCC. Airplane distance to, time to, and fuel remaining at each programmed waypoint can be displayed on the IDCC. Airplane wing flap, landing gear, cowl flap, and trim positions as well as altitude, vertical speed, airspeed, and engine parameters are monitored and the pilot is alerted to out of tolerance conditions. The DAAS is implemented with a modular computer architecture to permit additional capabilities to be added. Various DAAS functions are allocated to individual microprocessor modules. The modules communicate over a common IEEE-488 bus. The addition of new features can be accomplished by adding a processor module to the bus. The DAAS system is installed in NASA Langley's Cessna 402B research airplane.



DEMONSTRATION ADVANCED AVIONICS SYSTEM (DAAS) CAPABILITIES

- AUTOPILOT/FLIGHT DIRECTOR
- 10 WAYPOINT RNAV/VNAV WITH AUTOMATIC VOR/DME TUNING
- ELECTRONIC MOVING MAP DISPLAY
- WEIGHT AND BALANCE COMPUTATIONS, TAKEOFF AND CRUISE PERFORMANCE
- DISPLAY OF TIME TO, DISTANCE TO, AND FUEL REMAINING AT EACH WAYPOINT
- MONITORING OF ENGINE PARAMETERS, AIRPLANE CONFIGURATION, AIRSPEED, AND RADAR ALTITUDE
- MODE S TRANSPONDER DATA LINK
- NAVIGATION SIMULATOR

SPIFR PROGRAM REVIEW OUTLINE

PROBLEM IDENTIFICATION RESEARCH

- o SINGLE PILOT IFR ACCIDENT DATA ANALYSIS
- o STUDY TO DETERMINE THE OPERATIONAL PROFILE AND PROBLEMS OF THE SPIFR PILOT
- o SPIFR PROBLEM DEFINITION CORRELATION STUDY

INFORMATION TRANSFER RESEARCH

- o EFFICIENT TRANSFER OF WEATHER INFORMATION TO THE PILOT
- o FLIGHT INVESTIGATION OF SIMULATED DATA LINK COMMUNICATIONS DURING SPIFR FLIGHT
- o STUDY TO DETERMINE POTENTIAL FLIGHT APPLICATIONS AND HUMAN FACTORS GUIDELINES OF VOICE INPUT/OUTPUT SYSTEMS

COCKPIT DISPLAYS RESEARCH

- o PILOT RESPONSE WITH CONVENTIONAL DISPLAYS
- o ADVANCED THREE DIMENSIONAL PICTORIAL DISPLAY FOR ENROUTE, TERMINAL AREA, AND FINAL APPROACH GUIDANCE

AIRCRAFT CONTROLS RESEARCH

- o SPIFR AUTOPILOT COMPLEXITY/BENEFIT TRADEOFF STUDY
- o AUTOMATIC TERMINAL APPROACH SYSTEM FOR SPIFR OPERATIONS
- o NONCONVENTIONAL HAND CONTROLLER STUDY
- o CONTROL/DISPLAY TRADEOFF STUDY

NASA CESSNA 402B/DEMONSTRATION ADVANCED AVIONICS SYSTEM (DAAS)

- o SYSTEM CAPABILITY/DESCRIPTION
- o LaRC UTILIZATION PLAN

PROGRAM OUTPUT

- o OVER 30 REPORTS PUBLISHED
- o GA WORKSHOP HELD